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INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIA--ETC(U)

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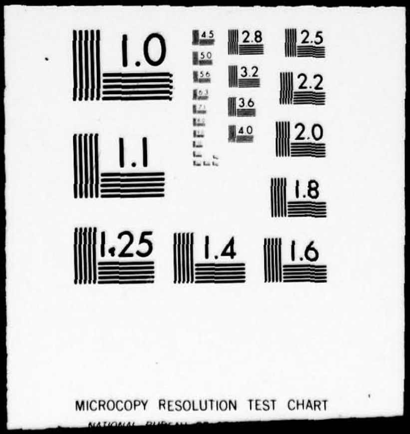

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INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIALS EXPOSED TO NATURAL WEATHERING

Volume I

ACTIVE INVESTIGATIONS

TECHNICAL REPORT NO. 6-553

June 1960

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

ARMY-MRC VICKSBURG, MISS.

THE CONTENTS OF THIS REPORT ARE NOT TO BE USED FOR ADVERTISING, PUBLICATION, OR PROMOTIONAL PURPOSES

(Issued August 1977)

INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIALS EXPOSED TO NATURAL WEATHERING

TECHNICAL REPORT NO. 6-553

June 1960

Supplements, Corrections, and Revisions
Distribution No. 14*

August 1977

VOLUME 1

ACTIVE INVESTIGATIONS

Item	Part	Section	Supplement, Correction, or Revision
1	Preface		Revised pp iii, iv, and new p v
2	Contents		New pp vii and viii
3	Conversion Factors		New p ix
4	Summary		New p xi
5	I		Revised Table 1 and reprinted Table 2
6	II	1	Revised sheet 3 of Table 1-TC-A
7	II	2	Revised sheet 8, and new sheets 9 and 10 of Table 1-TC-B
8	II	3	Revised sheet 2 of Table 1-SF
9	II	4	New sheet 2 of Table 1-CRMI-PB
10	II	5	Revised Table 1-CERL-FC (1 page)
11	II	6	Revised sheets 2 and 3 of Table 2-PR; revised sheet 2 of Table 5-PR; revised sheet 3 of Table 6-PR

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* TR 6-553 was issued in June 1960. Distributions of Supplements, Corrections, and Revisious are issued each year. This distribution, No. 14, brings the report up to date as of July 1977.

(Issued August 1977)

Item	Part	Section	Supplement, Correction, or Revision
12	II	7	Revised Table 1-WES-FC (1 page)
13	II	8	Revised sheet 5 of Table 1-CRMI-PD; revised sheet 3 and new sheet 4 of Table 2-CRMI-PD
14	II	9	Revised sheet 2 of Table 1-PQ
15	II	10	Revised sheet 2 of Table 1-SC; revised Table 2-SC (1 page)
16	II	11	Revised sheets 2, 3, and 4 of Table 1-BFS
17	II	12	Revised Table 1-SSFE (1 page)
18	II	13	Revised Table 1-TP (1 page)
19	II	14	Revised Table 1-4.5A (1 page)
20	II	15	A new item including Key (1 page), text (1 page), Tables 1 (1 page), 2 (2 pages), 3 (1 page), and 1-SIC (1 page)
21	II	16	A new item including Key (1 page), text (1 page), and Table 1-RCC (1 page)
22	II	17	Revised sheets 9, 10, 11, and 12 of Table 1-LTS
23	II	18	A new item including Key (1 page), text (1 page), Table 1, and Table 1-NED (1 page each)
24	II	22	Revised Table 1-MM (1 page)
25	II	25	Revised sheet 6 of Table 1-CRA
26	II	26	Revised Table 1-OD (1 page)
27	II	27	Revised sheet 2 of Tables 1-KCD and 2-KCD; revised Tables 3-KCD, 4-KCD, 5-KCD, 6-KCD, and 7-KCD (1 page each)
28	II	28	Revised Table 1-ED (1 page)
29	II	34	Revised Table 1-MCP (1 page)
30	II	35	Revised Tables 1-QA and 2-QA (1 page each)
31	II	37	Revised sheet 3 of Table 1-CAP
32	II	38	Revised sheet 2 of Table 1-MAWC
33	II	39	New sheet 3 of Table 1-CT
34	II	--	Revised Plate 2

(Issued May 1976)

INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIALS EXPOSED TO NATURAL WEATHERING

TECHNICAL REPORT NO. 6-553

June 1960

Supplements, Corrections, and Revisions
Distribution No. 13*

May 1976

VOLUME 1

ACTIVE INVESTIGATIONS

Item	Part	Section	Supplement, Correction, or Revision
✓1	Preface		Reprinted p iii; revised p iv
✓2	Contents		Revised p v and reprinted p vi
✓3	II		Revised Table 1 and reprinted Table 2
✓4	II	1	Revised sheet 3 of Table 1-TC-A
✓5	II	2	Revised sheets 8 and 9 of Table 1-TC-B
✓6	II	3	Revised sheet 2 of Table 1-SF
✓ 7	II	4	Revised Table 1-CRMI-PB (1 page)
✓ 8	II	5	A new item ~~including Key~~ (1 page), text (1 page), and Table 1-CERL-FC (1 page)
✓9	II	6	Revised sheets 2 and 3 of Table 2-PR; revised sheet 2 of Table 5-PR; revised sheet 3 of Table 6-PR
✓10	II	7	A new item ~~including~~ Key (1 page), text (1 page), and Table 1-WES-FC (1 page)
✓ 11	II	8	Revised sheet 5 of Table 1-CRMI-PD; revised sheet 3 of Table 2-CRMI-PD
✓ 12	II	9	Revised sheet 2 of Table 1-PQ

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* TR 6-553 was issued in June 1960. Distributions of Supplements, Corrections, and Revisions are issued each year. This distribution, No. 13, brings the report up to date as of June 1975.

(Issued May 1976)

Item	Part	Section	Supplement, Correction, or Revision
✓13	II	10	Revised sheet 1 and new sheet 2 of Table 1-SC; revised Table 2-SC (1 page)
✓14	II	11	Revised sheets 2, 3, and 4 of Table 1-BFS
✓15	II	12	Revised Table 1-SSFE (1 page)
✓16	II	13	Revised Table 1-TP (1 page)
✓17	II	14	Revised Table 1-4.5A (1 page)
✓18	II	17	Revised sheets 5, 6, 7, and 8 and new sheets 9, 10, 11, and 12 of Table 1-LTS
✓19	II	22	Revised Table 1-MM (1 page)
✓20	II	25	Revised sheet 6 of Table 1-CRA
✓21	II	26	Revised Table 1-OD (1 page)
✓22	II	27	Revised Key; reprinted sheet 3, revised sheet 4, new sheet 5; revised sheet 2 of Tables 1-KCD and 2-KCD; revised Tables 3-KCD, 4-KCD, and 5-KCD (1 page each); new Tables 6-KCD and 7-KCD (1 page each).
✓23	II	28	Revised Table 1-ED (1 page)
✓24	II	34	Revised Table 1-MCP (1 page)
✓25	II	35	Revised Tables 1-QA and 2-QA (1 page each)
✓26	II	37	Revised sheet 3 of Table 1-CAP
✓27	II	38	Revised sheet 2 of Table 1-MAWC
✓28	II	39	Revised sheet 2 of Table 1-CT
✓29	II	--	Revised Plate 2

(Issued Aug 1974)

INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIALS EXPOSED TO NATURAL WEATHERING

TECHNICAL REPORT NO. 6-553

June 1960

Supplements, Corrections, and Revisions
Distribution No. 12*

August 1974

VOLUME 1

ACTIVE INVESTIGATIONS

Item	Part	Section	Supplement, Correction, or Revision
1		Preface	Reprinted p iii; revised p iv
2		Contents	Revised p v and reprinted p vi
3			Revised p vii
4	I		Revised pp 3 and 6; reprinted pp 4 and 5
5	II		Revised p 9 and Table 1, deleted Table 3
6	II	1	Revised sheet 3 of Table 1-TC-A
7	II	2	New sheets 8 and 9 of Table 1-TC-B
8	II	3	Revised sheet 1 of Table 1-SF; new sheet 2 of Table 1-SF
9	II	4	Revised Table 1-CRMI-PB (1 page)
10	II	6	Revised sheets 2 and 3 of Table 2-PR; sheet 2 of Table 5-PR; and sheet 3 of Table 6-PR
11	II	8	Revised sheet 4 of Table 1-CRMI-PD; new sheet 5 of Table 1-CRMI-PD; revised sheet 3 of Table 2-CRMI-PD
12	II	9	Revised sheet 2 of Table 1-PQ
13	II	10	Revised Tables 1-SC and 2-SC (1 page each)

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* TR 6-553 was issued in June 1960. Distributions 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 were issued, respectively, in May 1962, August 1963, August 1964, August 1965, September 1966, September 1967, September 1968, September 1969, September 1970, January 1972, and January 1973. This distribution, No. 12, brings the report up to date as of August 1974.

(Issued Aug 1974)

Item	Part	Section	Supplement, Correction, or Revision
14	II	11	Revised sheets 2, 3, and 4 of Table 1-BFS
15	II	12	Revised Table 1-SSFE (1 page)
16	II	13	Revised Table 1-TP (1 page)
17	II	14	Revised Table 1-4.5A (1 page)
18	II	17	Revised sheets 5, 6, 7, and 8 of Table 1-LTS
19	II	22	Revised Table 1-MM (1 page)
20	II	25	Revised sheet 6 of Table 1-CRA
21	II	26	Revised Table 1-OD (1 page)
22	II	27	Revised sheet 2 of Tables 1-KCD and 2-KCD; revised Tables 3-KCD, 4-KCD, and 5-KCD (1 page each)
23	II	28	Revised Table 1-ED (1 page)
24	II	29	Reprinted p 1; revised p 2
25	II	30	Revised pp 1 and 2
26	II	34	Revised Table 1-MCP (1 page)
27	II	35	Revised Table 1-QA and 2-QA (1 page each)
28	II	37	Revised sheet 3 of Table 1-CAP
29	II	38	Revised sheet 2 of Table 1-MAWC
30	II	39	Revised sheet 2 of Table 1-CT
31	II	40	Revised Tables 1-MBC, 2-MBC, 3-MBC, and 4-MBC (1 page each)
32	II	--	Revised Plate 2

(Issued Jan 1973)

INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIALS EXPOSED TO NATURAL WEATHERING

TECHNICAL REPORT NO. 6-553

June 1960

Supplements, Corrections, and Revisions
Distribution No. 11*

January 1973

VOLUME 1

ACTIVE INVESTIGATIONS

Item	Part	Section	Supplement, Correction, or Revision
1	Preface		Revised pp iii and iv
2	Contents		Revised p v; reprinted p vi
3	I	--	Reprinted pp 1 and 5 and Tables 2 and 3; revised pp 2 and 6 and Table 1 (1 page)
4	II	--	Revised p 10
5	II	1	Revised sheet 3 of Table 1-TC-A
6	II	2	Revised sheets 6 and 7 of Table 1-TC-B
7	II	3	Revised Table 1-SF (1 page)
8	II	4	Revised Table 1-CRMI-PB (1 page)
9	II	5	Withdraw Section 5 from this volume (see Vol 2, COMPLETED INVESTIGATIONS, Program 22)
10	II	6	Revised sheet 2 of Table 1-PR; sheets 2 and 3 of Table 2-PR; sheet 2 of Table 5-PR; and sheet 2 of Table 6-PR. New sheets 3 of Tables 1-PR and 6-PR
11	II	7	Withdraw Section 7 from this volume (see Vol 2, COMPLETED INVESTIGATIONS, Program 23)

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* TR 6-553 was issued in June 1960. Distributions 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 were issued, respectively, in May 1962, August 1963, August 1964, August 1965, September 1966, September 1967, September 1968, September 1969, September 1970, and January 1972. This distribution, No. 11, brings the report up to date as of January 1973.

(Issued Jan 1973)

Item	Part	Section	Supplement, Correction, or Revision
12	II	8	Revised sheet 4 of Table 1-CRMI-PD and sheet 3 of Table 2-CRMI-PD
13	II	9	Revised sheet 2 of Table 1-PQ
14	II	10	Revised Tables 1-SC and 2-SC (1 page each)
15	II	11	Revised sheets 2, 3, and 4 of Table 1-BFS
16	II	12	Revised Table 1-SSFE (1 page)
17	II	13	A new item including Key (1 page), text (1 page), and Table 1-TP (1 page)
18	II	14	Revised Table 1-4.5A (1 page)
19	II	17	Revised sheets 5, 6, 7, and 8 of Table 1-LTS
20	II	22	Revised Table 1-MM (1 page)
21	II	25	Revised sheet 5 and new sheet 6 of Table 1-CRA
22	II	26	Revised Table 1-OD (1 page)
23	II	27	New sheets 2 of Tables 1- and 2-KCD; revised Tables 3-KCD, 4-KCD, and 5-KCD (1 page)
24	II	28	Revised Table 1-ED (1 page)
25	II	30	Reprinted p 1; revised p 2
26	II	34	Revised Table 1-MCP (1 page)
27	II	35	Revised Table 1-QA (1 page) and Table 2-QA (1 page)
28	II	37	Revised sheet 3 of Table 1-CAP
29	II	38	Revised sheet 2 of Table 1-MAWC
30	II	39	New sheet 2 of Table 1-CT (1 page)
31	II	40	Revised Tables 1-MBC, 2-MBC, 3-MBC, and 4-MBC
32	II	--	Revised Plates 1 and 2

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(Issued Jan 1972)

INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIALS EXPOSED TO NATURAL WEATHERING

TECHNICAL REPORT NO. 6-553

June 1960

Supplements, Corrections, and Revisions
Distribution No. 10*

January 1972

VOLUME 1

ACTIVE INVESTIGATIONS

Item	Part	Section	Supplement, Correction, or Revision
1	Preface		Revised pp iii and iv
2	I	--	Reprinted p 1; revised pp 2, 3, 4, 5, 6, Tables 1, 2, and 3
3	II	--	Revised p 11
4	II	1	Revised sheet 3 of Table 1-TC-A
5	II	2	Revised sheets 6 and 7 of Table 1-TC-B
6	II	3	Revised Table 1-SF (1 p)
7	II	4	Revised Table 1-CRMI-PB (1 p)
8	II	5	Revised Tables 1-PF and 2-PF (1 p ea)
9	II	6	Revised sheet 2 of Table 1-PR; revised sheets 2 and 3 of Table 2-PR; revised Table 3-PR (1 p); revised sheet 2 of Table 5-PR; revised sheet 2 of Table 6-PR
10	II	7	Revised Table 1-GLD (1 p)
11	II	8	Revised sheet 4 of Table 1-CRMI-PD; revised sheet 3 of Table 2-CRMI-PD
12	II	9	Revised sheet 2 of Table 1-PQ
13	II	10	Revised Tables 1-SC (1 p) and 2-SC (1 p)

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* TR 6-553 was issued in June 1960. Distributions 1, 2, 3, 4, 5, 6, 7, 8, and 9 were issued, respectively, in May 1962, August 1963, August 1964, August 1965, September 1966, September 1967, September 1968, September 1969, and September 1970. This distribution, No. 10, brings the report up to date as of January 1972.

(Issued Jan 1972)

Item	Part	Section	Supplement, Correction, or Revision
14	II	11	Reprinted p 1; revised p 2; revised sheets 2, 3, and 4 of Table 1-BFS
15	II	12	Revised Table 1-SSFE (1 p)
16	II	14	Revised Table 1-4.5A (1 p)
17	II	17	Revised p 1; revised sheets 5, 6, 7, and 8 of Table 1-LTS
18	II	22	Revised Table 1-MM (1 p)
19	II	25	Revised sheets 4 and 5 of Table 1-CRA
20	II	26	Revised Tables 1-OD (1 p) and 2-OD (1 p)
21	II	27	Revised Tables 1-KCD (1 p), 2-KCD (1 p), 3-KCD (1 p), 4-KCD (1 p), and 5-KCD (1 p)
22	II	28	Revised Table 1-ED (1 p)
23	II	29	Reprinted p 1; revised p 2
24	II	30	Reprinted p 1; revised p 2; revised sheets 2 and 5 of Table 1-WS; revised sheets 1 and 2 of Table 3-WS; revised sheets 1, 2, 3, and 4 of Table 4-WS
25	II	32	Revised p 1
26	II	34	Revised Table 1-MCP (1 p)
27	II	35	Revised Tables 1-QA (1 p) and 2-QA (1 p)
28	II	36	Revised Table 1-CRMI-PG (1 p)
29	II	37	Revised sheet 3 of Table 1-CAP
30	II	38	Revised sheet 2 of Table 1-MAWC
31	II	39	Revised sheets 1 and 2 of Table 1-CT
32	II	40	Revised key; revised p 1; revised Tables 1-MBC (1 p) and 2-MBC (1 p); new tables 3-MBC (1 p) and 4-MBC (1 p)
33	II		Revised Plate 1
34	II		Revised Plate 2
35	II		Revised Plate 3

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(Issued Sept 1970)

INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIALS EXPOSED TO NATURAL WEATHERING

TECHNICAL REPORT NO. 6-553
June 1960

Supplements, Corrections, and Revisions
Distribution No. 9*

September 1970

VOLUME I

ACTIVE INVESTIGATIONS

Item	Part	Section	Supplement, Correction, or Revision
1	Preface		Reprinted p iii; revised p iv
2	Contents		Revised p v; reprinted p vi
3	I	--	Revised Tables 1, 2, and 3 (1 p ea)
4	II	--	Revised p 11
5	II	1	Revised sheet 3 of Table 1-TC-A
6	II	2	Revised sheets 6 and 7 of Table 1-TC-B
7	II	3	Revised Table 1-SF (1 p)
8	II	4	Revised Table 1-CRMI-PB (1 p)
9	II	5	Revised Table 1-PF (1 p); new Table 2-PF (1 p)
10	II	6	Revised sheet 2 of Table 1-PR; revised sheets 2 and 3 of Table 2-PR; revised Table 3-PR (1 p); revised Table 4-PR (1 p); revised sheet 2 of Table 5-PR; revised sheet 2 of Table 6-PR
11	II	7	Revised Table 1-GLD (1 p)
12	II	8	Revised sheet 4 of Table 1-CRMI-PD; revised sheet 2 and new sheet 3 of Table 2-CRMI-PD
13	II	9	Revised sheet 2 of Table 1-PQ
14	II	10	Revised Tables 1-SC (1 p) and 2-SC (1 p)

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* TR 6-553 was issued in June 1960. Distributions 1, 2, 3, 4, 5, 6, 7, and 8 were issued, respectively, in May 1962, August 1963, August 1964, August 1965, September 1966, September 1967, September 1968, and September 1969. This distribution, No. 9, brings the report up to date as of September 1970.

(Issued Sept 1970)

Item	Part	Section	Supplement, Correction, or Revision
15	II	11	Revised sheets 2, 3, and 4 of Table 1-BFS; revised sheets 2, 3, and 4 of Table 2-BFS
16	II	12	Revised Table 1-SSFE (1 p)
17	II	13	Withdraw Section 13 from this volume (see Vol 2, COMPLETED INVESTIGATIONS, Program 21)
18	II	14	Revised Table 1-4.5A (1 p)
19	II	17	Revised sheets 5, 6, 7, and 8 of Table 1-LTS; revised sheets 1, 2, 3, and 4 of Table 2-LTS
20	II	22	Revised Table 1-MM (1 p)
21	II	25	Revised sheets 4 and 5 of Table 1-CRA
22	II	26	Revised Table 1-OD (1 p); revised Table 2-OD (1 p)
23	II	27	Revised Table 1-KCD (1 p); revised Table 2-KCD (1 p); revised Table 3-KCD (1 p); revised Table 4-KCD (1 p); revised Table 5-KCD (1 p)
24	II	28	Revised Table 1-ED (1 p)
25	II	29	Revised sheets 3 and 4 cf Table 1-AA; revised Table 2-AA (1 p)
26	II	30	Revised sheets 2 and 5 of Table 1-WS; revised sheets 2 and 3 of Table 2-WS; revised sheets 1 and 2 of Table 3-WS; revised sheets 2, 3, and 4 of Table 4-WS
27	II	31	Revised key, revised pp 1 and 2; revised Table 1-WPF (1 p)
28	II	32	Revised sheet 2 of Table 1-SS
29	II	34	Revised Table 1-MCP (1 p)
30	II	35	Revised Table 1-QA (1 p); revised Table 2-QA (1 p)
31	II	36	Revised p 1; revised Table 1-CRMI-PG (1 p)
32	II	37	Revised sheet 2 of Table 1-CAP; new sheet 3 of Table 1-CAP
33	II	38	Revised sheet 2 of Table 1-MAWC
34	II	39	Revised sheets 1 and 2 of Table 1-CT
35	II	40	Revised key; revised p 1; revised Table 1-MBC; new Table 2-MBC (1 p)
36	II	--	Revised Plates 1, 2, and 3 (1 p ea)

(Issued Sept 1970)

VOLUME 2

COMPLETED INVESTIGATIONS

Item	Part	Program	Supplement, Correction, or Revision
37			Revised Contents (1 p)
38	III	--	New p 3
39	III	21	A new item (including key (2 pp); 7 pp of text; and Tables 1-CRE, 2-CRE, and 3-CRE)

(Issued Sept 1969)

INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIALS EXPOSED TO NATURAL WEATHERING

TECHNICAL REPORT NO. 6-553
June 1960

Supplements, Corrections, and Revisions
Distribution No. 8*

September 1969

VOLUME I

ACTIVE INVESTIGATIONS

Item	Part	Section	Supplement, Correction, or Revision
1	Preface		Reprinted p iii; revised p iv
2	Contents		Revised p v; reprinted p vi
3	I	--	Reprinted p 5; revised p 6; revised Tables 1, 2, and 3 (1 p ea)
4	II	--	Revised p 11
5	II	1	Revised sheet 3 of Table 1-TC-A
6	II	2	Revised sheets 6 and 7 of Table 1-TC-B
7	II	3	Revised Table 1-SF (1 p)
8	II	4	Revised Table 1-CRMI-PB (1 p)
9	II	5	Revised Tables 1-PF and 2-PF (same page)
10	II	6	Revised sheet 2 of Table 1-PR; revised sheets 2 and 3 of Table 2-PR; revised Table 3-PR (1 p); revised sheet 1 and new sheet 2 of Table 5-PR; revised sheet 2 of Table 6-PR
11	II	7	Revised Table 1-GLD (1 p)
12	II	8	Revised sheet 3 and new sheet 4 of Table 1-CRMI-PD; revised sheet 2 of Table 2-CRMI-PD
13	II	9	Revised sheet 1 and new sheet 2 of Table 1-PQ
14	II	10	Revised Tables 1-SC (1 p) and 2-SC (1 p)

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* TR 6-553 was issued in June 1960. Distributions 1, 2, 3, 4, 5, 6, and 7 were issued, respectively, in May 1962, August 1963, August 1964, August 1965, September 1966, September 1967, and September 1968. This distribution, No. 8, brings the report up to date as of September 1969.

(Issued Sept 1969)

Item	Part	Section	Supplement, Correction, or Revision
15	II	11	Revised sheets 2, 3, and 4 of Table 1-BFS
16	II	12	A new item (including key; 1 p of text; and Table 1-SSFE (1 p)
17	II	13	Revised sheet 5, reprinted sheet 6, and revised sheet 7 of Table 1-CRE; revised sheet 2 of Table 2-CRE
18	II	14	A new item (including key; 1 p of text; and Table 1-4.5A (1 p))
19	II	17	Revised sheets 5, 6, 7, and 8 of Table 1-LTS
20	II	22	Revised Table 1-MM (1 p)
21	II	25	Revised sheets 4 and 5 of Table 1-CRA
22	II	26	Revised Table 1-OD (1 p); revised Table 2-OD (1 p)
23	II	27	Additional key (1 p); revised p 3 and new p 4; revised Table 1-KCD (1 p); revised Table 2-KCD (1 p); revised Table 3-KCD (1 p); revised Table 4-KCD (1 p); new Table 5-KCD (1 p)
24	II	28	Revised Table 1-ED (1 p)
25	II	30	Revised sheets 1, 2, 3, and 4, new sheet 5, and revised sheets 6 and 7 of Table 1-WS; revised sheets 1, 2, and 3 of Table 2-WS; revised sheets 1 and 2 of Table 3-WS; revised sheets 2, 3, and 4 of Table 4-WS
26	II	34	Revised Table 1-MCP (1 p)
27	II	35	Revised Table 1-QA (1 p); revised Table 2-QA (1 p)
28	II	36	Revised p 1; revised Table 1-CRMI-PG (1 p)
29	II	37	Revised sheet 2 of Table 1-CAP
30	II	38	Revised sheet 2 of Table 1-MAWC
31	II	39	Revised sheets 1 and 2 of Table 1-CT
32	II	40	A new item (including key; 1 p of text; and Table 1-MBC (1 p)
33	II	--	Revised Plates 1 and 2 (1 p ea)

(Issued Sept 1968)

INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIALS EXPOSED TO NATURAL WEATHERING

TECHNICAL REPORT NO. 6-553
June 1960

Supplements, Corrections, and Revisions
Distribution No. 7*

September 1968

VOLUME 1

ACTIVE INVESTIGATIONS

Item	Part	Section	Supplement, Correction, or Revision
1	Preface		Reprinted p iii; revised p iv
2	Contents		Revised pp v and vi
3	Conversion factors		Revised p vii
4	I	--	Revised pp 1, 2, 3, 4, 5, and 6; revised Tables 1, 2, and 3
5	II	1	Revised sheets 1, 2, and 3 of Table 1-TC-A
6	II	2	Revised sheets 5 and 6 of Table 1-TC-B; new sheet 7 of Table 1-TC-B
7	II	3	Revised Table 1-SF (1 p)
8	II	4	Revised p 1; revised Table 1-CRMI-PB (1 p)
9	II	5	Revised Tables 1-PF and 2-PF (same page)
10	II	6	Revised sheets 1 and 2 of Table 1-PR; revised sheet 2 and new sheet 3 of Table 2-PR; revised Table 3-PR (1 p); revised Table 4-PR (1 p); revised Table 5-PR (1 p); revised sheets 1 and 2 of Table 6-PR
11	II	7	Revised Table 1-GLD (1 p)
12	II	8	Revised p 1; revised sheets 2 and 3 of Table 1-CRMI-PD; revised sheets 1 and 2 of Table 2-CRMI-PD
13	II	9	Revised Table 1-PQ (1 p)
14	II	10	Revised Table 1-SC (1 p); revised Table 2-SC (1 p)

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* TR 6-553 was issued in June 1960. Distributions 1, 2, 3, 4, 5, and 6 were issued, respectively, in May 1962, August 1963, August 1964, August 1965, September 1966, and September 1967. This distribution, No. 7, brings the report up to date as of September 1968.

(Issued Sept 1968)

Item	Part	Section	Supplement, Correction, or Revision
15	II	11	Revised pp 1 and 2; revised sheet 2 and new sheets 3 and 4 of Table 1-BFS; revised sheet 2 and new sheets 3 and 4 of Table 2-BFS
16	II	13	Revised sheet 3, reprinted sheet 4, revised sheets 5, 6, and 7 of Table 1-CRE; revised sheet 2 of Table 2-CRE; revised sheets 3, 4, 5, and 6 of Table 3-CRE
17	II	17	Revised p 1; revised sheets 5, 6, 7, and 8 of Table 1-LTS; revised sheets 1, 2, 3, and 4 of Table 2-LTS
18	II	22	Revised Table 1-MM (1 p)
19	II	25	Revised sheets 3, 4, and 5 of Table 1-CRA
20	II	26	Revised Table 1-OD (1 p); revised Table 2-OD (1 p)
21	II	27	Revised Table 1-KCD (1 p); revised Table 2-KCD (1 p); revised Table 3-KCD (1 p); revised Table 4-KCD (1 p)
22	II	28	Revised Table 1-ED (1 p)
23	II	29	Revised sheets 3 and 4 of Table 1-AA; revised Table 2-AA (1 p)
24	II	30	Revised sheets 2 and 4 of Table 1-WS; revised sheets 2 and 3 of Table 2-WS; revised sheets 1 and 2 of Table 3-WS; revised sheets 2, 3, and 4 of Table 4-WS
25	II	32	Revised sheet 2 of Table 1-SS
26	II	34	Revised Table 1-MCP (1 p)
27	II	35	Revised Tables 1-QA and 2-QA (same page)
28	II	36	Revised Table 1-CRMI-PG (1 p)
29	II	37	Revised sheet 2 of Table 1-CAP
30	II	38	Revised sheet 1 and new sheet 2 of Table 1-MAWC
31	II	39	A new item (including key; 1 p of text; and Table 1-CT (2 pp))
32	II	--	Revised Plates 1, 2, and 3

(Issued Sept 1967)

INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIALS EXPOSED TO NATURAL WEATHERING

TECHNICAL REPORT NO. 6-553
June 1960

Supplements, Corrections, and Revisions
Distribution No. 6*

September 1967

VOLUME 1

ACTIVE INVESTIGATIONS

Item	Part	Section	Supplement, Correction, or Revision
1	Preface		Reprinted p iii; revised p iv
2	Contents		Revised pp v and vi
3	I	--	Revised Table 1; reprinted Table 2; revised Table 3
4	II	--	Revised p 11
5	II	1	Revised sheet 3 of Table 1-TC-A
6	II	2	Revised sheets 5 and 6 of Table 1-TC-B
7	II	3	Revised Table 1-SF
8	II	4	Revised Table 1-CRMI-PB
9	II	5	Revised Tables 1-PF and 2-PF (same page)
10	II	6	Reprinted p 5; new p 6; revised sheet 2 of Table 1-PR; revised sheets 1 and 2 of Table 2-PR; revised Table 4-PR; revised Table 5-PR; revised sheet 2 of Table 6-PR
11	II	7	Revised Table 1-GLD
12	II	8	Revised sheets 2 and 3 of Table 1-CRMI-PD; revised sheet 2 of Table 2-CRMI-PD
13	II	9	Revised Table 1-PQ
14	II	10	Revised Tables 1-SC and 2-SC
15	II	11	Revised sheets 1 and 2 of Table 1-BFS

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* TR 6-553 was issued in June 1960. Distributions 1, 2, 3, 4, and 5 were issued, respectively, in May 1962, August 1963, August 1964, August 1965, and September 1966. This distribution, No. 6, brings the report up to date as of September 1967.

(Issued Sept 1967)

Item	Part	Section	Supplement, Correction, or Revision
16	II	12	Withdraw Section 12 from this volume (see Vol 2, COMPLETED INVESTIGATIONS, Program 10)
17	II	13	Revised sheets 5 and 7 of Table 1-CRE; revised sheet 2 of Table 2-CRE
18	II	14	Withdraw Section 14 from this volume (see Vol 2, COMPLETED INVESTIGATIONS, Program 11)
19	II	15	Withdraw Section 15 from this volume (see Vol 2, COMPLETED INVESTIGATIONS, Program 13)
20	II	16	Withdraw Section 16 from this volume (see Vol 2, COMPLETED INVESTIGATIONS, Program 14)
21	II	17	Revised sheets 5, 6, 7, and 8 of Table 1-LTS
22	II	18	Withdraw Section 18 from this volume. The results of this study will be issued in Distribution No. 7 (1968) as Program 17 of Vol 2, COMPLETED INVESTIGATIONS
23	II	19	Withdraw Section 19 from this volume (see Vol 2, COMPLETED INVESTIGATIONS, Program 12)
24	II	20	Withdraw Section 20 from this volume (see Vol 2, COMPLETED INVESTIGATIONS, Program 15)
25	II	21	Withdraw Section 21 from this volume (see Vol 2, COMPLETED INVESTIGATIONS, Program 16)
26	II	22	Revised Table 1-MM
27	II	23	Withdraw Section 23 from this volume. The results of this study will be issued in Distribution No. 7 (1968) as Program 18 of Vol 2, COMPLETED INVESTIGATIONS
28	II	24	Withdraw Section 24 from this volume. The results of this study will be issued in Distribution No. 7 (1968) as Program 19 of Vol 2, COMPLETED INVESTIGATIONS
29	II	25	Revised sheets 4 and 5 of Table 1-CRA
30	II	26	Revised Tables 1-OD and 2-OD
31	II	27	Revised Table 1-KCD; revised Table 2-KCD; revised Table 3-KCD; revised Table 4-KCD
32	II	28	Revised Table 1-ED
33	II	30	Revised sheets 2 and 4 of Table 1-WS; revised sheets 1 and 2 of Table 3-WS; revised sheets 2, 3, and 4 of Table 4-WS
34	II	31	Revised p 1; new p 2; revised Table 1-WPF

(Issued Sept 1967)

Item	Part	Section	Supplement, Correction, or Revision
35	II	33	Withdraw Section 33 from this volume. The results of this study will be issued in Distribution No. 7 (1968) as Program 20 of Vol 2, COMPLETED INVESTIGATIONS
36	II	34	Revised Table 1-MCP
37	II	35	Revised Table 1-QA; revised Table 2-QA (same page)
38	II	36	Revised Table 1-CRMI-PG
39	II	37	Revised sheet 2 of Table 1-CAP
40	II	38	Revised Table 1-MAWC
41	II	--	Revised Plates 1 and 2

(Issued Sept 1966)

INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIALS EXPOSED TO NATURAL WEATHERING

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ACTIVE INVESTIGATIONS

Item	Part	Section	Supplement, Correction, or Revision
✓1		Preface	Reprinted p iii; revised p iv
✓2		Contents	Revised p v; reprinted p vi
✓3		Conversion Factors	(New section.) p vii
✓4		Summary	Revised p ix
✓5	I	--	Revised pp 1, 2, 3, and 4; new sheet 5; revised Tables 1, 2, and 3
✓6	II	--	Revised p 11
✓7	II	1	Revised sheet 3 of Table 1-TC-A**
✓8	II	2	Revised sheets 5 and 6 of Table 1-TC-B**
✓9	II	3	Revised Table 1-SF**
✓10	II	4	Revised Table 1-CRMI-PB**
✓11	II	5	Revised Tables 1-PF and 2-PF (same page)**

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* TR 6-553 was issued in June 1960. Distributions 1, 2, 3, and 4 were issued respectively in May 1962, August 1963, August 1964, and August 1965. This distribution, No. 5, brings the report up to date as of September 1966.

** Pulse velocities are not given for all specimens in these Treat Island programs for 1966. Values were obtained but they were determined with the James Soniscope ("V-scope") and appear to be too low when compared with previous readings taken with the McPhar Soniscope. An effort has been made to establish a factor for use in adjusting these readings, but has not yet been successful.

(Issued Sept 1966)

Item	Part	Section	Supplement, Correction, or Revision
✓12	II	6	Revised sheet 1 and new sheet 2 of Table 1-PR; revised sheets 1 and 2 of Table 2-PR; revised Table 3-PR; revised Table 5-PR; revised sheet 1 and new sheet 2 of Table 6-PR**
✓13	II	7	Revised Table 1-GLD
✓14	II	8	Revised sheets 2 and 3 of Table 1-CRMI-PD; revised sheet 2 of Table 2-CRMI-PD**
✓15	II	9	Revised Table 1-PQ
✓16	II	10	Revised Key; revised sheet 1; new sheet 2; revised Table 1-SC; new Table 2-SC
✓17	II	11	Revised sheets 1 and 2 of Table 1-BFS; revised sheets 1 and 2 of Table 2-BFS
✓18	II	12	Revised sheet 3 of Table 1-NBS
✓19	II	13	Revised sheets 5 and 7 of Table 1-CRE; revised sheet 2 of Table 2-CRE; revised sheets 3, 4, 5, and 6 of Table 3-CRE
✓20	II	14	Revised Table 1-ADB
✓21	II	15	Revised sheet 4 of Table 1-CRN
✓22	II	16	Revised sheet 6 of Table 1-VR; new sheets 7 and 8 of Table 1-VR
✓23	II	17	Revised sheet 1; revised sheets 5, 6, 7, and 8 of Table 1-LTS
✓24	II	18	Revised sheet 2 of Table 2-PCA
✓25	II	19	Revised Table 1-SY
✓26	II	20	Revised sheet 4 of Table 2-FLC
✓27	II	21	Revised sheet 2 of Table 1-FL
✓28	II	22	Revised Table 1-MM
✓29	II	23	Revised sheet 2 of Table 1-VP; revised Table 2-VP
✓30	II	24	Revised Table 1-PK
✓31	II	25	Revised sheets 4 and 5 of Table 1-CRA
✓32	II	26	Revised Table 1-OD; revised Table 2-OD
✓33	II	27	Revised Table 1-KCD; revised Table 2-KCD; revised Table 3-KCD; revised Table 4-KCD
✓34	II	28	Revised Table 1-ED
✓35	II	29	Revised sheet 2 of Table 1-AA; new sheets 3 and 4 of Table 1-AA; revised Table 2-AA

(Issued Sept 1966)

Item	Part	Section	Supplement, Correction, or Revision
36	II	30	New sheet 2 of Table 1-WS; revised sheets 3, 4, 5, and 6 of Table 1-WS; revised sheet 2 and new sheet 3 of Table 2-WS; revised sheets 1 and 2 of Table 3-WS; revised sheets 1, 2, and 4 of Table 4-WS
37	II	31	Revised Table 1-WPF
38	II	32	Revised Table 1-SS
39	II	33	Revised sheet 2 of Table 1-Z
40	II	34	Revised Table 1-MCP
41	II	35	Revised Table 1-QA
42	II	36	Revised Table 1-CRMI-PG
43	II	37	Revised sheet 1 and new sheet 2 of Table 1-CAP
44	II	38	Revised Table 1-MAWC
45	II	--	Revised Plates 1, 2, and 3

(Issued Aug 1965)

INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIALS EXPOSED TO NATURAL WEATHERING

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VOLUME 1

ACTIVE INVESTIGATIONS

Item	Part	Section	Supplement, Correction, or Revision
1	Preface and Contents		Reprinted p iii; revised p iv; reprinted p v; revised p vi
2	I	--	Revised sheets 1 and 2 of Table 1; reprinted Table 2; revised Table 3
3	II	1	Revised Key; revised sheet 1; revised sheets 1-3 of Table 1-TC-A
4	II	2	Revised sheet 1; revised sheets 1-5 and new sheet 6 of Table 1-TC-B
5	II	3	Corrected sheet 1; revised Table 1-SF
6	II	4	Corrected sheet 1; revised Table 1-CRMI-PB
7	II	5	Revised Tables 1-PF and 2-PF (same page)
8	II	6	Revised sheet 5; revised Table 1-PR; revised sheets 1 and 2 of Table 2-PR; revised Table 5-PR; new Table 6-PR

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* TR 6-553 was issued in June 1960. It was intended that there be issued annually thereafter a distribution of replacement and supplementary sheets by means of which the report would be kept up to date. Distributions 1, 2, and 3 were issued respectively in May 1962, August 1963, and August 1964. This distribution, No. 4, brings the report up to date as of August 1965. It is planned to issue future distributions annually as of August of each year. It is further planned that specimen testing at the various installations be accomplished in May in those years when such testing is to be done, and to schedule formal inspections of the specimens after the distribution of data including the results of such May inspections; thus formal inspections would probably be scheduled during September of any year in which it might be determined that a formal inspection should be made.

(Issued Aug 1965)

Item	Part	Section	Supplement, Correction, or Revision
9	II	7	Revised Table 1-GLD
10	II	8	Corrected sheet 1; revised sheets 2 and 3 of Table 1-CRMI-PD; revised sheet 2 of Table 2-CRMI-PD
11	II	9	Corrected sheet 1, reprinted sheet 2, revised Table 1-PQ
12	II	10	Revised Table 1-SC
13	II	11	Revised sheets 1 and 2 of Table 1-BFS
14	II	12	Revised sheet 1; revised sheet 3 of Table 1-NBS
15	II	13	Corrected sheet 1, reprinted sheet 2, corrected sheet 3, reprinted sheet 4; revised sheets 5 and 7 of Table 1-CRE; revised sheet 2 of Table 2-CRE
16	II	14	Revised Table 1-ADB
17	II	15	Revised sheet 4 of Table 1-CRN
18	II	16	Revised sheets 4, 5, and 6 of Table 1-VR
19	II	17	Revised sheet 4 of Table 1-LTS; new sheets 5, 6, 7, and 8 of Table 1-LTS
20	II	18	Corrected sheet 1; revised sheet 2 of Table 2-PCA
21	II	19	Corrected sheet 1; revised Table 1-SY
22	II	20	Revised sheet 4 of Table 2-FLC
23	II	21	Revised sheet 2 of Table 1-FL
24	II	22	Revised Key; revised Table 1-MM
25	II	23	Revised sheet 2 of Table 1-VP; revised Table 2-VP
26	II	24	Revised Table 1-PK
27	II	25	Revised sheets 4 and 5 of Table 1-CRA
28	II	26	Revised Key; revised sheet 1; revised Table 1-OD; new Table 2-OD
29	II	27	Revised Table 1-KCD; revised Table 2-KCD; revised Table 3-KCD; revised Table 4-KCD
30	II	28	Corrected sheet 1; revised Table 1-ED
31	II	30	Revised sheets 1 and 3 of Table 1-WS; revised sheets 1 and 2 of Table 3-WS; revised sheets 1, 2, and 3 and new sheet of Table 4-WS
32	II	33	Corrected sheet 1; corrected sheet 1 and revised sheet 2 of Table 1-Z
33	II	34	Revised Table 1-MCP
34	II	35	Corrected sheet 1; revised Table 1-QA

(Issued Aug 1965)

Item	Part	Section	Supplement, Correction, or Revision
35	II	36	Corrected Key and sheet 1; revised Table 1-CRMI-PG
36	II	37	Corrected Key; revised Table 1-CAP
37	II	38	(New section). Key, sheet 1, and Table 1-MAWC
38			Revised Plates 1 and 2

(Revised August 1977)

PREFACE

The establishment of exposure stations, and the conduct of programs of investigation relative to the durability of concrete exposed to natural weathering have been authorized from time to time by the Office, Chief of Engineers. The initial installation of concrete specimens at an exposure station was made at Treat Island, Maine, in 1936 by the Concrete Laboratory of the Passamaquoddy Tidal Power Project. In 1939 the Office, Chief of Engineers, authorized the Central Concrete Laboratory, North Atlantic Division, to develop data relative to the durability of concrete exposed to severe weathering. Under this authorization specimens were prepared and installed at exposure stations in Maine, Florida, and New York. In 1946, the Office, Chief of Engineers, directed the Concrete Research Division (now Concrete Laboratory) of the U. S. Army Engineer Waterways Experiment Station (WES) (successor to the Central Concrete Laboratory) to continue the work in connection with these exposure stations. Further authority 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." Additional authorizations have been provided since that time for the making and installing of specific specimens at these exposure stations. Installation and testing of specimens at the Florida station was discontinued in November 1971.

Results of these various investigations have been reported from time to time in the reports listed below.

1. Corps of Engineers, Central Concrete Laboratory, Cement Durability Program, First Interim Report, June 1942.

2. ________, Concrete Research, Laboratory Studies of Concrete Containing Air-Entraining Admixtures, Second Interim Report, Part I, July 1945.

(Revised August 1977)

3. Waterways Experiment Station, Concrete Research, Third Interim Report, Durability of Concrete Exposed to Natural Weathering, Technical Memorandum No. 6-226, August 1947.

4. __________, Concrete Research, Third Interim Report, Supplement No. 1, Durability of Concrete Exposed to Natural Weathering, Technical Memorandum No. 6-226, June 1950.

5. __________, Investigation of Durability of Concrete Exposed to Natural Weathering, Report No. 5, Summary of Results 1936-1953, Technical Memorandum No. 6-226, May 1954.

6. __________, Cement Durability Program, Long-Term Field Exposure of Concrete Columns, Technical Report C-72-2, August 1972.

7. Roshore, E. C. and Houston, B. J., Investigation of Plastic and Rubber-Based Coatings Used in Lieu of Rubbed Finishes on Formed Concrete Surfaces, sponsored by the Assistant Secretary of the Army (R&D), Department of the Army; Miscellaneous Paper No. 6-864, November 1966.

8. Houston, B. J., Investigation of Nonmetallic Waterstops; Preliminary Laboratory and Field Exposure Tests, sponsored by Office, Chief of Engineers, U. S. Army; Technical Report No. 6-546, Report No. 1, May 1960.

9. __________, Investigation of Nonmetallic Waterstops; Progress Report of Laboratory and Field Exposure Tests, sponsored by Office, Chief of Engineers, U. S. Army; Technical Report No. 6-546, Report No. 3, June 1963.

10. __________, Investigation of Nonmetallic Waterstops Effect of Exposure, sponsored by Office, Chief of Engineers, U. S. Army; Technical Report No. 6-546, Report No. 6, January 1968.

11. Kennedy, T. B., Tensile Crack Exposure Tests, CWI Item No. 026, Tensile Crack Exposure Test for Reinforced Concrete Beams, Technical Memorandum No. 6-412, U. S. Army Engineer Waterways Experiment Station, CE, July 1955.

12. Roshore, E. C., Durability and Behavior of Prestressed Concrete Beams, Pretensioned Concrete Investigation; Progress to July 1960, Technical Report No. 6-570, Report 1, June 1961.

13. __________, Tensile Crack Exposure Tests; Results of Tests of Reinforced Concrete Beams, Technical Memorandum No. 6-412, Report 2, November 1964.

(Issued August 1977)

14. Roshore, E. C., Durability and Behavior of Prestressed Concrete Beams; Posttensioned Concrete Investigation, Progress to July 1966, Technical Report No. 6-570, Report No. 6-570, Report 2, March 1967.
15. ________, Field Exposure Tests of Reinforced Concrete Beams, Miscellaneous Paper No. 6-868, January 1967.
16. ________, Durability and Behavior of Prestressed Concrete Beams; Laboratory Tests of Weathered Pretensioned Beams, Technical Report No. 6-570, Report 3, October 1971.
17. O'Neil, E. F., Durability and Behavior of Prestressed Concrete Beams; Posttensioned Concrete Beam Investigation with Laboratory Tests from June 1961 to September 1975, Technical Report No. 6-570, Report 4, February 1977.
18. ________, Durability and Behavior of Prestressed Concrete Beams; Laboratory Tests of Weathered Pretensioned Beams, Technical Report No. 6-570, Report 5, June 1976.

This report summarizes all investigations made to date, and is issued in loose-leaf form in order that it may be kept up to date by the addition of new material or revision of old material, as appropriate. The report is made up of two volumes: Volume 1 (this volume) summarizes the test results of investigations which are still active, and Volume 2 summarizes the findings of completed investigations.

The major part of the work reported herein and the preparation of this report constitute part of Civil Works Investigation Item ES-630, "Field Exposure Durability Studies of Concrete." The studies were made by the Concrete Laboratory, Waterways Experiment Station. Personnel actively engaged in the direction and conduct of the work include Ms. K. Mather, Messrs. B. Mather, John Scanlon, B. R. Sullivan, R. V. Tye, Jr., E. E. McCoy, E. C. Roshore, H. T. Thornton, R. E. Black, Dale Glass, and G. S. Harris. Mr. Thornton prepared this distribution.

During the preparation of this report COL Edmund H. Lang, CE, was Director of the Waterways Experiment Station, and Mr. J. B. Tiffany was Technical Director. During the preparation of this distribution of the Supplements, Corrections, and Revisions, COL John L. Cannon, CE, was Commander and Director and Mr. F. R. Brown was Technical Director.

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Section 8: Cement-Replacement Materials Investigation, Phase D (CW R&D)

Section 9: Passamaquoddy Tidal Power Project

Section 10: Missouri River Division Program

Section 11: Portland Blast-Furnace Slag Cement Investigation (CW R&D)

Section 12: Specimen Size-Frost Effects Program (CW R&D)

Section 13: Trumbull Pond Dam Prisms (NED)

Section 14: Investigation of 4-1/2-in.-Aggregate Concrete (CW R&D)

Section 15: Sulfur-Infiltrated Concrete (Canadian)

Section 16: Roller Compacted Concrete (NPD)

Section 17: Longtime Study, Waterways Experiment Station (CW R&D)

Section 18: Charles River Dam-Smelt Brook Protection Project (NED)

(Issued August 1977)

CONTENTS (Continued)

Section 22: Mt. Morris Dam Cores (Buffalo)
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Section 29: Alkali-Aggregate Reactivity Investigation (CW R&D)
Section 30: Nonmetallic Waterstop Investigation (CW, LMVD)
Section 31: Woven Plastic Test Program (CW R&D)
Section 32: National Bureau of Standards Supersulfate Cement Program
Section 34: Membrane Curing Program (CW R&D)
Section 35: Quality Aggregate Investigation (CW R&D)
Section 36: Cement-Replacement Materials Investigation, Phase G (CW R&D)
Section 37: Maximum Size of Coarse Aggregate Program (CW R&D)
Section 38: Maximum Allowable Water-Cement Ratio Investigation (CW R&D)
Section 39: Curing Investigation (CW R&D)
Section 40: Investigation of Plastic Based Mortar Coatings (CW R&D)
PLATES 1-3

(Issued August 1977)

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

1 inch = 25.4 millimetres

1 inch = 2.54 centimetres

1 foot = 30.48 centimetres

1 foot = 0.3048 metre

37°F = 2.8°C

-10°F = -23.4°C

28°F = -2.2°C

70°F = 21.1°C

1 lb = 0.453592 kilogram

1 bag of cement = 94 lb of cement = 42.637648 kilograms of cement

1 cu yd = 0.764555 cubic metre

1 gal (U. S.) = 3785.412 cubic centimetres

1 gal (U. S.) = 3.785412 cubic decimetres

1 cu ft = 0.028317 cubic metre

1 ton = 2000 lb = 907.184 kilograms

1 psi = 0.006894757 megapascals

1 fps = 0.3048 metre/second

1 lb/cu ft = 16.018477 kilograms/cubic metre

1 bag/cu yd = 55.767928 kilograms/cubic metre

1 gal/bag = 88.781398 cubic centimetres/kilogram

3-1/2 by 4-1/2 by 16 in. = approximately 9 by 11-1/2 by 41 centimetres

6 by 6 by 30 in. = approximately 15 by 15 by 76 centimetres

6 by 6 by 48 in. = approximately 15 by 15 by 122 centimetres

18 by 18 by 36 in. = approximately 46 by 46 by 91 centimetres

(Issued August 1977)

SUMMARY

To assess the durability of concrete and other materials used in concrete construction when exposed to natural weathering, the Corps of Engineers maintains severe-, mild-, moderate-, and nonweathering exposure stations at various locations in the United States. Specimens from actual structures and experimental specimens in which the amounts or kinds of components are varied are exposed until they fail or until testing is completed, whichever occurs first. The specimens are inspected periodically, and tested to determine their dynamic modulus of elasticity and pulse velocity. This report, in two volumes, describes the exposure stations, test methods used, the specimens, and lists test results to date. Volume 1 contains the active investigations, and volume 2 the completed investigations. These volumes are in loose-leaf form so that new or revised data can be added to volume 1, and completed studies can be transferred from volume 1 to volume 2. A preliminary report was prepared in June 1959, but the first complete edition was issued in June 1960. Revisions will be distributed annually.

(Reprinted Jan 1973)

INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIALS EXPOSED TO NATURAL WEATHERING

PART I: INTRODUCTION

1. The ultimate test of the durability of concrete is its performance under the exposure conditions in which it is to serve. Although laboratory tests yield valuable indications of probable durability, the potential disrupting influences in nature are so numerous and variable that actual field exposures are highly desirable to assess the durability of concrete when exposed to natural weathering. To this end, exposure stations have been provided at several locations in the United States.

Severe-Weathering Station, Treat Island, Maine

2. The severe-weathering exposure station is located at Treat Island in Cobscook Bay near Eastport, Maine. This station has been in use since 1936 and is an ideal location for these tests, providing twice-daily tide reversals, together with severe winters. The specimens are installed at mean-tide elevation and the alternate conditions of immersion of the specimens in sea water, then exposure to cold air, provide numerous cycles of freezing-and-thawing of the concrete during the winter. The effect of the relatively cool summers is to lessen, in general, autogenous healing and chemical reactions in the concrete. The tidal range is a mean of about 18 ft,* with a maximum of about 28 ft and a minimum of about 13 ft. Prior to September 1963, the half-tide exposure rack, on which most of the specimens are installed (the rest are on the beach), had a roof over it to eliminate differences in exposure due to sunlight and wind. In September 1963, the exposure-rack specimens were moved onto a new rack. This new rack contained no roof and the specimens are therefore exposed to sunlight and wind as are the beach specimens.

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* A table of factors for converting British units of measurement to metric units is included on page vii.

3. In winter, the combination of air and water temperatures creates a condition in which specimens at the mean-tide elevation are thawed to a temperature of about 37 F when covered with water, and are frozen to temperatures as low as -10 F when exposed in air. A recording thermometer, the bulb of which is embedded in the center of a concrete specimen, records these temperatures. A cycle of freezing-and-thawing consists of the reduction of the temperature at the center of a concrete specimen to below 28 F, and its subsequent rise to above that figure. During an average winter, the specimens are subjected to over 100 cycles of freezing-and-thawing. In eleven winters, from 1960 to 1972, the number of annual cycles has ranged from 89 to 185, with the average being 145.

Mild-Weathering Station, St. Augustine, Fla.

4. The mild-weathering exposure station located in Salt-Run, off Anastasia Island near St. Augustine, Fla., was discontinued in November 1971. This station was established to provide information on the effects of sea water on concrete specimens apart from the effects of freezing-and-thawing. The specimens were installed at mean-tide elevation and, therefore, were subject to twice-daily tide reversals. The mean water temperature of about 70 F was found to be conducive to attack on concrete specimens by the dissolved salts in the sea water.

5. In September 1964, Hurricane "Dora" struck the St. Augustine area, breaching the bar between Salt-Run and the open sea and depositing a large quantity of sand on the exposure rack. In February 1966, an inspection party established that the continuing deposition of sand did not seriously alter the exposure conditions and no immediate action as a result of it was indicated. It became obvious, however, by mid-1971 that the sand deposits, which had by then become extensive, and the accelerating deterioration of the facility dictated its abandonment. A firm decision concerning the possible reestablishment of the mild-weathering station at another site has not yet been reached.

Moderate-Weathering Exposure Stations

6. The moderate-weathering exposure station was located outdoors at West Point, N. Y., from September 1940 to April 1942, then at Mt. Vernon, N. Y., from 1942 to 1946. Specimens for moderate exposure were stored outdoors at the U. S. Army Engineer Waterways Experiment Station Jackson Installation, Jackson, Miss., until October 1969. Here specimens were exposed to rain, occasionally ice or snow, cold, and strong sunlight, but were supported above the ground and allowed to drain freely. Moderate-weathering exposure was discontinued after October 1969.

Nonweathering Exposure Stations

7. A nonweathering exposure station was located in 1940 inside the laboratory buildings at West Point, N. Y., and later indoors at Mt. Vernon, N. Y., until 1946. Since that time, specimens for nonweathering exposure have been stored inside the Concrete Laboratory building at the Jackson Installation.

Composition of Sea Water at Treat Island, Maine, and St. Augustine, Fla.

	Parts per Million	
Constituent	Treat Island (Sampled in 1959)	Salt-Run (Sampled in 1958)
Total solids	35,275	38,770
Suspended solids	--	160
Dissolved solids	--	38,610
Calcium	370	430
Magnesium	1,175	1,340
Sodium	9,500	11,130
Potassium	370	450
Chloride	17,100	20,460
Sulfate	2,385	2,780

Test Methods

Frequency readings

8. The concrete specimens at all installations are subjected to test

for fundamental transverse frequency (Test Method CRD-C 18-59*) at regular intervals** during exposure, unless their shape or size prevents. 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 size, shape, and weight of the specimens, the dynamic modulus of elasticity (E) is determined. The moduli so determined are expressed as percentages of the initial dynamic modulus obtained at installation (%E). A specimen is considered as having failed if this percentage (%E) drops below 50 during the exposure.

Pulse velocity readings

9. The concrete specimens at all installations are subjected to pulse velocity tests (Test Method CRD-C 51-57) at regular intervals during exposure, unless their size or shape prevents. The test instrument measures the time of travel of a sound pulse through a concrete specimen. From the travel time and the path length, values for velocity of sound in concrete (V) are calculated. The square of the velocity thus determined is expressed as a percentage of the square of initial velocity obtained at installation ($\%V^2$). Example:

V_o = velocity of sound in a certain specimen at installation.

V_t = velocity of sound in this same specimen at a later date.

Therefore

$$\%V^2 \text{ (at time t)} = \frac{V_t^2}{V_o^2}$$

10. Pulse velocity readings on test specimens are taken through various paths depending upon specimen size, shape, and type of specimen. For example, one pulse velocity reading is taken through an 18- by 18- by 36-in. prism from the center of one 18- by 18-in. face to the center of

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* U. S. Army Engineer Waterways Experiment Station, CE, Handbook for Concrete and Cement, Aug 1949 (with quarterly supplements), Vicksburg, Miss.

** The specimens at St. Augustine were tested every two years; the specimens at all other stations are tested annually.

the 18- by 18-in. face on the other end; this provides a 36-in. path. This same path is used, if possible, each time the specimen is tested. A 2-ft cube is tested by transmitting the ultrasonic pulse from the center of one 2- by 2-ft face to the center of the opposite 2- by 2-ft face. Two such readings are taken for each 2-ft cube (paths normal to each other) and averaged to give the pulse velocity reading. The same two paths are used, if possible, each time the specimen is tested.

Visual inspection

11. All specimens are visually inspected periodically at all exposure stations to ascertain their condition. Those specimens not amenable to quantitative testing are inspected more thoroughly at times comparable to the testing periods to determine their condition and to permit comparisons of the durability of these specimens.

Criteria of failure

12. Specimens are regarded as having failed when they separate into pieces, when the %E is 50 or less, or when deterioration has progressed to such a point that reliable determinations of fundamental frequency and pulse velocity cannot be obtained. Specimens that have been broken in handling are so listed and not as "failed."

Specimen size

13. Test specimens of various sizes and shapes have been used from time to time as outdoor exposure specimens. In December 1963, however, it was specified in the Handbook for Concrete and Cement* that specimens for outdoor exposure shall be 18 in. in height and depth, and 36 in. in length. The 18- by 18- by 36-in. prism was selected instead of a 2-ft cube because it (a) afforded a longer path length for pulse velocity readings, (b) contained less concrete and therefore weighed less, and (c) was more amenable to tests for fundamental transverse frequency. With a 36-in. path a smaller percentage of error is introduced into pulse velocity calculations because of minor variations in the measurement of path length than with a 24-in. path. A lighter specimen reduces handling and shipping costs and a specimen with a length-to-width ratio of 2 to 1 (prism) is less difficult

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* U. S. Army Engineer Waterways Experiment Station, op. cit.

to excite in the fundamental flexural mode than a specimen with a length-to-width ratio of 1 to 1 (cube). In 1968, with the 18- by 18- by 36-in. prism as the outdoor exposure specimen and with enough exposure rack space available for the proper installation of a large number of prisms on their nodal points, large mass concrete specimens were tested for both fundamental flexural frequency and pulse velocity on a regular basis (see Section 39, Part II) for the first time at Treat Island, Maine.

Summary of Specimens

Treat Island exposure

14. Plate 1 gives a summary and the layout of the test specimens installed on the beach at Treat Island, Maine. The summary indexes each group of specimens on the beach by the section number given them in Part II of this report. Plate 2 gives the arrangement of test specimens on the exposure rack and also indexes each group by section number. Table 1 is a recapitulation of all specimens exposed at Treat Island and indexes each group by section number.

St. Augustine exposure

15. Plate 3 gives in detail the arrangement of test specimens on the exposure rack at St. Augustine, Fla., in November 1971 when that station was discontinued, and indexes each group by section number. Table 2 lists each group of test specimens exposed at St. Augustine and indexes them by section number.

(Revised August 1977)

Table 1

Recapitulation of Specimens Exposed at Treat Island, Maine

Location			Specimens				Section
Section	Row	Program of Investigation	Size and Kind	No. Installed	No. Left	Date Installed	No. in This Vol
Beach	2	Tensile Crack Specimens, Series A	7-ft-9-in.-long beams	82	0	Nov 1951	1
Beach	1	Tensile Crack Specimens, Series B	7-ft-9-in.-long beams	76	75	Nov 1954	2
Rack	9	Stewart Field Spheres	1-ft spheres	24	12	May 1954	3
Beach	2	Cement-Replacement Materials Investigation, Phase B	18- by 18- by 36-in. prisms	21	6	Dec 1953	4
Beach	2	Prestressed Concrete Program	4-1/2- by 9- by 81-in. beams	16	0	Oct 1958	6
Rack	3	Prestressed Concrete Program	3-1/2- by 4-1/2- by 16-in. beams	72	57	Oct 1958	6
Beach	2	Prestressed Concrete Program	10- by 16- by 96-in. beams	20	12	June 1961	6
Rack	4	Cement-Replacement Materials Investigation, Phase D	10- by 20-in. cores	75	21	Oct 1958	8
Beach	1	Cement-Replacement Materials Investigation, Phase D	2-ft cubes	20	4	Oct 1958	8
Rack	8	Passamaquoddy Project	5- by 5- by 60-in. columns	43	1	June 1936	9
Rack	5	Missouri River Division Program	3-1/2- by 4-1/2- by 16-in. beams	12	5	Sept 1963	10
Rack	5	Missouri River Division Program	3- by 4-1/2- by 16-in. beams	3	2	Nov 1965	10
Rack	5	Portland Blast-Furnace Slag Cement Investigation	3-1/2- by 4-1/2- by 16-in. beams	108	66	May 1956	11
Rack	3	Specimen Size-Frost Effects Investigation	3-1/2- by 4-1/2- by 16-in. beams	9	9	Dec 1968	12
Rack	2	↓	6- by 6- by 30-in. beams	3	3	Dec 1968	12
Rack	3		2-ft cubes	3	3	Dec 1968	12
Rack	2		18- by 18- by 36-in. prisms	3	3	Dec 1968	12
Rack	3	Trumbull Pond Dam Prisms	18- by 18- by 36-in. prisms	6	6	June 1972	13
Rack	2	Investigation of 4-1/2-in. Aggregate Concrete	18- by 18- by 36-in. prisms	12	5	Dec 1968	14
Rack	3	Longtime Study, Waterways Experiment Station	3-1/2- by 4-1/2- by 16-in. beams	198	196	May 1955	17
Rack	4	Mt. Morris Dam Cores	10-in.-diam by 18-in. cores	11	3	Oct 1949	22
Rack	2	Air-Entraining Admixture Study	6- by 6- by 30-in. prisms	90	13	Nov 1944	25
Rack	2	Omaha District Aggregate Program	6- by 6- by 30-in. beams	6	3	Dec 1956	26
Rack	2	Omaha District Aggregate Program	↓	3	0	Nov 1964	26
Rack	2	Kansas City District Aggregate Program		18	6	Jan 1958	27
Rack	2	↓		18	1	May 1959	27
Rack	2			9	5	Nov 1962	27
Rack	2			9	5	Dec 1963	27
Rack	2			3	3	May 1969	27
Rack	2			3	3	July 1974	27
Rack	2			3	3	July 1974	27
Beach	1	Eufaula Dam Aggregates Study	2-ft cubes	3	3	Oct 1958	28
Rack	N wall	Nonmetallic Waterstop Investigation	Waterstop pieces	54	16	May 1957	30
--	--	↓	Embedded waterstop pieces	27	0	May 1957	30
Rack	N wall		Waterstop pieces	30	0	Nov 1957	30
--	--		Embedded waterstop pieces	15	0	Nov 1957	30
Rack	N wall		Waterstop pieces	2	0	Aug 1958	30
--	--		Embedded waterstop pieces	1	0	Aug 1958	30
Rack	5	Woven Plastic Test Program	13-in. squares	160	0	Nov 1963	31
--	--	Woven Plastic Test Program	13-in. squares	80	0	Apr 1967	31
Rack	5	Woven Plastic Test Program	13-in. squares	22	0	Mar 1970	31
Top of wharf		Membrane Curing Program	Box specimens	14	14	June 1946	34
Beach	2	Quality Aggregate Investigation	2-ft cubes	10	0	Nov 1962	35
Beach	A-1	Quality Aggregate Investigation	2-ft cubes	6	2	Dec 1963	35
Beach	2	Cement-Replacement Materials Investigation, Phase G	18- by 18- by 36-in. prisms	2	0	Nov 1962	36
Beach	2	Maximum Size of Coarse Aggregate Program	↓	18	9	Dec 1963	37
Beach	A-1	Maximum Allowable Water-Cement Ratio Investigation		24	12	Dec 1964	38
Rack	1	Curing Investigation		56	56	June 1968	39
Rack	5	Investigation of Plastic Based Mortar Coatings	10- by 10- by 3-in. mortar-coated panels	8	8	July 1969	40
Rack	5	Investigation of Plastic Based Mortar Coatings	10- by 10- by 3-in. mortar-coated panels	8	8	Nov 1969	40
Rack	5	Investigation of Plastic Based Mortar Coatings	10- by 10- by 3-in. mortar-coated panels	16	16	Dec 1970	40
Rack	3	CERL Fibrous Concrete	3-1/2- by 4-1/2- by 16-in. beams	30	10	Jan 1975	5
Rack	4 & 6	WES Fibrous Concrete	9- by 9- by 45-in. beams	17	17	June 1975	7
Rack	5	WES Fibrous Concrete	6- by 6- by 30-in. beams	12	12	June 1975	7
Rack	5	WES Fibrous Concrete	6- by 6- by 36-in. beams	21	21	June 1975	7
Rack	9	Sulfur-Infiltrated Concrete	4- by 8-in. cylinders	18	18	Aug 1976	15
Rack	9	Sulfur-Infiltrated Concrete	3- by 6-in. cylinders	36	36	Aug 1976	15
Rack	6	Roller-Compacted Concrete	12- by 12- by 36-in. beams	6	6	July 1977	16
Rack	6	Charles River - Smelt Brook	6- by 6- by 24-in. beams	18	18	Aug 1976	18

-- Dashed lines in "Section" and "Row" columns indicate that these specimens are no longer on the exposure rack.

(Reprinted August 1977)

Table 2

Recapitulation of Specimens Exposed at St. Augustine, Fla.

Program of Investigation	Specimens Size and Kind	No. Installed	No. Left	Date Installed	Sec. No. in This Vol
Prestressed Concrete Program	4-1/2- by 9- by 81-in. beams	3	1	Oct 1959	6
Portland Blast-Furnace Slag Cement Investigation	3-1/2- by 4-1/2- by 16-in. beams	108	93	Aug 1956	11
	8-1/2- by 8-1/2- by 12-in. prisms	45	0	Aug 1956	11
Longtime Study Waterways Experiment Station	3-1/2- by 4-1/2- by 16-in. beams	198	195	Aug 1955	17
Alkali-Aggregate Reactivity Investigation	6- by 6- 30-in. beams	72	45	Aug 1955	29
	6- by 6- by 30-in. beams	36	30	Aug 1956	29
National Bureau of Standards Supersulfate Cement Program	3- by 4- by 16-in. beams	27	19	Nov 1957	32

Note: Installation and testing of specimens at St. Augustine, Fla., was discontinued in November 1971.

PART II: PROGRAMS OF INVESTIGATION

16. A large number of investigational programs are in progress at the exposure stations. These programs involve varying numbers of specimens, installed at one or all exposure stations. The purposes of the different programs also have been varied. In general, they have constituted investigations of cements, aggregates, construction methods, admixtures, or combinations of these variables. The remainder of this report is devoted to a discussion of these test programs and to a presentation of the exposure records of the test specimens involved.

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16. During the inspection of the Treat Island Exposure Station in July 1966, representatives of the Office, Chief of Engineers, recommended that the Treat Island exposure of test specimens in the following 13 programs be discontinued during FY 1967 provided the sponsoring agencies concurred.

Program of Investigation	Section No. in this Volume
National Bureau of Standards Program	12
Cement Durability Program	13
Rome Air Depot Program	14
Natural Cement Investigation	15
Resin Air-entraining Agent Program	16
Long-time Study, Waterways Experiment Station	17
Long-time Study, Portland Cement Association	18
Syracuse Air Base Beams	19
Field and Laboratory Correlation Program	20
Form Lining Investigation	21
Vacuum Treatment Investigation	23
Preplaced Aggregate Cores	24
Cooperative Study of Air-entrained Concrete	33

17. Eleven of the 13 programs listed above were discontinued in FY 1967. Subsequent correspondence has established that the Long-time Study, Waterways Experiment Station, Section 17, will continue active. The Cement Durability Study, Section 13, was discontinued in FY 1971. Data will no longer be collected from specimens at St. Augustine, Fla.

Tensile Crack Specimens, Series A*

In November 1951, 82 reinforced-concrete beams were installed at half-tide elevation on the beach at Treat Island. The purpose of this installation is to determine, for different types of reinforcing steel, the relation between the degree of tensile stress in the steel and the resistance of reinforced concrete to severe natural weathering.

The beams were 7 ft 9 in. long and were made of concrete with a nominal compressive strength of 3500 psi at 28 days age. Air-entrained (4-1/2 ± 1/2%) and nonair-entrained concrete were used. Seventy-four beams were reinforced with rail-steel bars, of which 64 had deformations conforming to ASTM Designation A 305-50T, and the other 10 had old-style deformations. Eight beams were reinforced with billet-steel bars having deformations conforming to ASTM Designation A 305-50T. Coverage over the steel was either 3/4 in. or 2 in., and bars were placed in either bottom or top position when the concrete was placed. Aggregates were a manufactured limestone sand and a crushed limestone coarse aggregate (1-in. maximum size). Type II cement was used, with the cement factors ranging from 5.20 (for the plain concrete) to 5.35 (for the air-entrained concrete) bags per cu yd. The air-entraining agent was admixture P. The water-cement ratio (by weight) used was 0.60 for the air-entrained concrete and 0.70 for the plain concrete.

Seventy-two beams were yoked and stressed by third-point loading; loads ranged from 20,000 to 50,000 psi. The remaining 10 beams were controls.

Table 1-TC-A lists these specimens and gives their exposure record along with other pertinent information.

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* See U. S. Army Engineer Waterways Experiment Station, CE, Tensile Crack Exposure Tests, by T. B. Kennedy, and Tensile Crack Exposure Tests, Results of Tests of Reinforced Concrete Beams, 1955-1963, by E. C. Roshore, Technical Memorandum No. 6-412, Reports 1 and 2 (Vicksburg, Miss., July 1955 and November 1964).

(Revised Sept 1968)

Table 1-TC-A

Section 1

Record of Observation and Testing of Large-Beam Tensile Crack Specimens, Series A, 1951- (Installed Nov 1951)

Beach Row 2

						1951-1956 Readings										
						0 Cycl 1951	101 Cycl 1952	186 Cycles, 1953			297 Cycles 1954		442 Cycles 1955		609 Cycles 1956	
Beam No.	Nominal Stress psi	Steel Position*	Cover in.	Type** Steel Deformation	Plain or Air-entr Concrete	Condition	Condition	Condition	Pulse Veloc fps	$\%V^2$	Condition	$\%V^2$	Condition	$\%V^2$	Condition	$\%V^2$
1	20,000	T	3/4	RS	Air	100	93	93	12,345	100	83	143	76	153	64	157
2	20,000	T	3/4	RS	Air	100	96	91	13,425	100	82	129	91	131	77	135
3	20,000	B	3/4	RS	Air	100	96	95	14,965	100	89	86	78	102	69	105
4	20,000	B	3/4	RS	Air	100	93	85	15,505	100	84	91	91	95	76	98
5	30,000	T	3/4	RS	Air	100	93	98	12,120	100	95	82	92	102	77	138
6	30,000	T	3/4	RS	Air	100	93	89	15,230	100	91	60	89	49	84	107
7	30,000	B	3/4	RS	Air	100	96	100	12,245	100	91	124	79	144	47	149
8	30,000	B	3/4	RS	Air	100	96	95	13,605	100	91	94	94	116	82	124
9	40,000	T	3/4	RS	Air	100	89	85	14,600	100	82	100	94	112	78	113
10	40,000	T	3/4	RS	Air	100	93	100	13,455	100	92	104	89	112	76	130
11	40,000	B	3/4	RS	Air	100	89	85	13,130	100	82	79	91	70	70	134
12	40,000	B	3/4	RS	Air	100	93	98	13,335	100	94	80	89	113	80	131
13	50,000	T	3/4	RS	Air	100	96	100	13,575	100	95	77	86	75	78	121
14	50,000	T	3/4	RS	Air	100	93	88	12,685	100	80	52	89	126	80	151
15	50,000	B	3/4	RS	Air	100	93	95	12,000	100	89	[illegible]	86	100	85	163
16	50,000	B	3/4	RS	Air	100	93	83	12,550	100	82	92	92	92	86	147
17	None	B	3/4	RS	Air	100	96	90	15,190	100	87	94	89	104	82	96
18	None	B	3/4	RS	Air	100	96	100	15,190	100	95	96	100	99	90	90
19	20,000	T	3/4	RS	Plain	100	54	25F	10,150	100						
20	20,000	B	3/4	RS	Plain	100	26	3F								
21	20,000	B	3/4	RS	Plain	100	87	81	16,090	100	60	--	F			
22	20,000	B	3/4	RS	Plain	100	78	58	15,465	100	23	--	F			
23	20,000	B	3/4	OS	Plain	100	53	10F								
24	20,000	B	3/4	OS	Plain	100	83	57	13,305	100	F					
25	30,000	T	3/4	RS	Plain	100	61	20	--	--	F					
26	30,000	B	3/4	RS	Plain	100	25	F								
27	30,000	B	3/4	RS	Plain	100	86	81	14,390	100	81	--	F			
28	30,000	B	3/4	RS	Plain	100	83	28	14,020	100	3F					
29	30,000	B	3/4	OS	Plain	100	F									
30	30,000	B	3/4	OS	Plain	100	75	84	13,795	100	F					
31	40,000	T	3/4	RS	Plain	100	8F									
32	40,000	T	3/4	RS	Plain	100	F									
33	40,000	T	3/4	RS	Plain	100	71	68	14,495	100	32	--	F			
34	40,000	B	3/4	RS	Plain	100	50	27	14,530	100	F					
35	40,000	B	3/4	RS	Plain	100	25	5F								
36	40,000	B	3/4	RS	Plain	100	93	42	13,575	100	F					
37	50,000	T	3/4	RS	Plain	100	25	8F								
38	50,000	T	3/4	RS	Plain	100	64	33	12,765	100	F					
39	50,000	T	3/4	RS	Plain	100	64	F								
40	50,000	B	3/4	RS	Plain	100	25	F								
41	50,000	B	3/4	RS	Plain	100	83	40	13,795	100	23	--	F			
42	50,000	B	3/4	RS	Plain	100	32	22	13,425	100	F					
43	None	T	3/4	RS	Plain	100	58	57	15,915	100	35	--	17	--	F	
44	None	B	3/4	RS	Plain	100	50	32	12,605	100	17	--	F			
45	None	B	3/4	RS	Plain	100	61	46	10,100	100	20	--	F			
46	None	B	3/4	OS	Plain	100	64	43	9,315	100	8	--	F			
47	20,000	T	2	RS	Plain	100	70	54	11,740	100	20	--	F			
48	20,000	[illegible]	2	RS	Plain	100	50	27	--	--	F					
49	20,000	B	2	RS	Plain	100	75	68	13,245	100	23	--	F			
50	20,000	B	2	RS	Plain	100	92	46	12,795	100	F					
51	20,000	B	2	OS	Plain	100	57	F								
52	20,000	[illegible]	2	OS	Plain	100	75	44	12,930	100	F					
53	30,000	[illegible]	2	RS	Plain	100	50	29	--	--	F					
54	30,000	B	2	RS	Plain	100	46	F								
55	30,000	[illegible]	2	RS	Plain	100	75	41	9,130	100	F					
56	30,000	B	2	RS	Plain	100	39	F								
57	30,000	B	2	OS	Plain	100	87	46	13,605	100	F					
58	30,000	B	2	OS	Plain	100	F									
59	40,000	T	2	RS	Plain	100	67	66	13,985	100	39	--	F			
60	40,000	T	2	RS	Plain	100	58	46	10,990	100	F					

(Continued)

Note: Condition ratings are expressed numerically; i.e., 100 denotes perfect condition, F denotes specimen failed.

-- Dashed lines in the "Pulse Veloc" or "$\%V^2$" columns indicate that a pulse velocity reading was not taken because of the poor condition of the beam.

* T = near top of beam.
B = near bottom of beam.

** RS = rail steel with deformations conforming to ASTM Designation A 305-50T.
OS = old style (does not meet ASTM Designation A 305-50T deformation requirements).
BS = billet-steel with deformations conforming to ASTM Designation A 305-50T.

(Revised Sept 1968)

Table 1-TC-A (Continued)

Section 1

Beach Row 2

Beam No.	Nominal Stress psi	Steel Position	Cover in.	Type Steel Deformation	Plain or Air-entr Concrete	1951-1956 Readings 0 Cycl 1951	101 Cycl 1952	186 Cycles, 1953			297 Cycles 1954		442 Cycles 1955		609 Cycles 1956	
						Condition	Condition	Condition	Pulse Veloc fps	$\%V^2$	Condition	$\%V^2$	Condition	$\%V^2$	Condition	$\%V^2$
61	40,000	T	2	RS	Plain	100	F									
62	40,000	B	2	RS	Plain	100	43	27	9,330	100	F					
63	40,000	B	2	RS	Plain	100	88	64	14,220	100	37	--	F			
64	40,000	B	2	RS	Plain	100	61	25	12,765	100	F					
65	50,000	T	2	RS	Plain	100	F									
66	50,000	T	2	RS	Plain	100	50	5	--	--	F					
67	50,000	T	2	RS	Plain	100	68	52	13,515	100	42	--	F			
68	50,000	B	2	RS	Plain	100	87	83	14,150	100	80	114	F			
69	50,000	B	2	RS	Plain	100	67	58	12,765	100	34	--	F			
70	50,000	B	2	RS	Plain	100	42	29	10,850	100	23	--	F			
71	None	T	2	RS	Plain	100	58	41	12,850	100	30	--	14	--	F	
72	None	T	2	RS	Plain	100	68	59	12,295	100	47	--	17	--	F	
73	None	B	2	RS	Plain	100	29	25	10,325	100	9	--	F			
74	None	B	2	OS	Plain	100	29	23	--	---	8	--	F			
75	20,000	B	3/4	BS	Plain	100	93	81	13,485	100	30	--	F			
76	20,000	B	3/4	BS	Air	100	96	100	14,780	100	91	--	F			
77	20,000	B	2	BS	Plain	100	86	59	13,160	100	31	--	F			
78	20,000	B	2	BS	Air	100	96	100	14,495	100	94	--	F			
79	30,000	B	3/4	BS	Plain	100	89	40	12,295	100	F					
80	30,000	B	3/4	BS	Air	100	93	93	11,110	100	87	--	F			
81	30,000	B	2	BS	Plain	100	89	65	13,575	100	28	--	F			
82	30,000	B	2	BS	Air	100	93	100	11,930	100	89	--	F			

Beach Row 2

						1957-1962 Readings 753 Cycles 1957		824 Cycles 1958		974 Cycles 1959†		1045 Cycles 1960		1186 Cycles 1961		1275 Cycles 1962	
						Condition	$\%V^2$	Condition	$\%V^2$	Condition	$\%V^2$	Condition	$\%V^2$	Condition	$\%V^2$	Condition	$\%V^2$
1	20,000	T	3/4	RS-"A"	Air	76	143	70	144	26	142	26	129	29	155	27	145
2	20,000	T	3/4	RS-"A"	Air	71	127	65	128	55	114	55	125	48	139	50	127
3	20,000	B	3/4	RS-"A"	Air	73	105	79	106	26	104	26	104	32	105	30	98
4	20,000	B	3/4	RS-"B"	Air	64	94	72	95	46	91	46	97	44	99	44	96
5	30,000	T	3/4	RS-"B"	Air	79	152	80	154	63	147	63	151	61	158	60	153
6	30,000	T	3/4	RS-"B"	Air	80	92	78	95	73	81	73	85	63	102	60	90
7	30,000	B	3/4	RS-"B"	Air	32	150	35	149	25	137	25	152	34	157	32	154
8	30,000	B	3/4	RS-"B"	Air	76	117	71	118	75	107	75	126	62	112	60	108
9	40,000	T	3/4	RS-"A"	Air	77	108	75	109	66	102	66	103	64	105	63	98
10	40,000	T	3/4	RS-"A"	Air	81	---	79	135	67	126	67	120	66	120	63	110
11	40,000	B	3/4	RS-"A"	Air	64	126	57	127	51	108	51	114	50	141	50	120
12	40,000	B	3/4	RS-"A"	Air	80	131	81	126	75	111	75	118	61	132	59	112
13	50,000	T	3/4	RS-"B"	Air	74	115	81	120	59	118	59	82	51	127	48	108
14	50,000	T	3/4	RS-"B"	Air	65	140	70	144	60	94	60	91	60	129	58	121
15	50,000	B	3/4	RS-"B"	Air	78	169	69	149	59	104	59	138	57	134	57	118
16	50,000	B	3/4	RS-"B"	Air	76	143	84	139	57	104	57	144	55	143	56	143
17	None	B	3/4	RS-"A"	Air	71	99	74	100	66	91	††					
18	None	B	3/4	RS-"A"	Air	79	98	73	100	67	93	67	90	56	88	54	182

(Continued)

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† Hardware on all remaining loaded specimens was replaced in May 1959. The condition of these remaining specimens is adjudged either annually or biennially by a panel of observers and is expressed numerically.

†† Exposure testing on this beam was discontinued in January 1960, as a piece of steel had to be removed from it for additional testing.

(Revised August 1977)

Table 1-TC-A (Continued)

Section 1

Beach Row 2

Beam No.	Nominal Stress psi	Steel Position	Cover in.	Type Steel Deformation	Plain or Air-entr Concrete	1963-1967 Readings: 1381 Cycles 1963		1516 Cycles 1964		1679 Cycles 1965		1809 Cycles 1966		1965 Cycles 1967	$\%V^2$§		
						Condition	$\%V^2$	Condition	$\%V^2$	Condition	$\%V^2$	Condition	$\%V^2$	Condition	Before Unloading	Not Loaded	After Reloading
1	20,000	T	3/4	RS-"A"	Air	29	103	26	111	‡	86	24	‡‡	‡	100		88
2	20,000	T	3/4	RS-"A"	Air	46	90	44	84		70	39			89		66
3	20,000	B	3/4	RS-"A"	Air	39	70	30	69		62	28			68		57
4	20,000	B	3/4	RS-"A"	Air	46	65	44	63		46	42			64		56
5	30,000	T	3/4	RS-"B"	Air	57	107	54	103		70	50			82		57
6	30,000	T	3/4	RS-"B"	Air	71	67	60	57		41	61			47		23
7	30,000	B	3/4	RS-"B"	Air	32	104	31	95		97	31			98		49
8	30,000	B	3/4	RS-"B"	Air	59	85	63	78		52	62			83		54
9	40,000	T	3/4	RS-"A"	Air	60	91	63	65		42	62			48		49
10	40,000	T	3/4	RS-"A"	Air	67	98	66	71		52	60			56		49
11	40,000	B	3/4	RS-"A"	Air	51	91	50	81		57	46			71		44
12	40,000	B	3/4	RS-"A"	Air	61	86	59	83		60	55			66		49
13	50,000	T	3/4	RS-"B"	Air	48	78	51	85		57	34			70		45
14	50,000	T	3/4	RS-"B"	Air	60	88	60	90		63	58			60		19
15	50,000	B	3/4	RS-"B"	Air	56	109	58	60		51	56			82		63
16	50,000	B	3/4	RS-"B"	Air	55	100	55	78		51	55			78		56
18	None	B	3/4	RS-"A"	Air	65	81	55	66		52	60				52	

Beam No.	Nominal Stress psi	Steel Position	Cover in.	Type Steel Deformation	Plain or Air-entr Concrete	1968-1973 Readings: 2150 Cycles 1968		2304 Cycles 1969		2457 Cycles 1970		2626 Cycles 1971		2783 Cycles 1972		2923 Cycles 1973	
						Condition	$\%V^2$	Condition	$\%V^2$#	Condition	$\%V^2$#	Condition	$\%V^2$	Condition	$\%V^2$	Condition	$\%V^2$
1	20,000	T	3/4	RS-"A"	Air	24	84	29	63	29	56	26	30	28	31	24	‡‡
2	20,000	T	3/4	RS-"A"	Air	39	50	46	36	46	38	29	23	42	30	17	
3	20,000	B	3/4	RS-"A"	Air	28	58	28	47	31	36	28	34	28	54	29	
4	20,000	B	3/4	RS-"A"	Air	37	49	37	45	38	32	16	32	30	27	30	
5	30,000	T	3/4	RS-"B"	Air	50	87	54	44	54	64	54	51	54	40	52	
6	30,000	T	3/4	RS-"B"	Air	57	40	56	23	57	37	52	30	47	20	91	
7	30,000	B	3/4	RS-"B"	Air	31	49	33	46	33	66	33	50	32	38	31	
8	30,000	B	3/4	RS-"B"	Air	55	47	55	34	61	54	48	41	50	29	44	
9	40,000	T	3/4	RS-"A"	Air	56	48	59	21	59	30	50	24	22	##	21	
10	40,000	T	3/4	RS-"A"	Air	47	49	50	26	62	38	22	29	22	##	72	
11	40,000	B	3/4	RS-"A"	Air	46	68	47	24	49	30	45	25	42	25	46	
12	40,000	B	3/4	RS-"A"	Air	50	62	51	22	58	32	45	29	51	31	46	
13	50,000	T	3/4	RS-"B"	Air	28	51	22	37	19	55	18	40	17	28	16	
14	50,000	T	3/4	RS-"B"	Air	58	63	58	37	58	53	55	25	58	25	50	
15	50,000	B	3/4	RS-"B"	Air	54	60	51	26	56	34	50	37	34	29	Failed	
16	50,000	B	3/4	RS-"B"	Air	53	57	54	26	52	36	53	36	50	32	Damaged	
18	None	B	3/4	RS-"A"	Air	55	49	55	22	53	34	55	27	55	36		

Beam No.	Nominal Stress psi	Steel Position	Cover in.	Type Steel Deformation	Plain or Air-entr Concrete	1974- Readings: 3059 Cycles 1974		3171 Cycles 1975	
						Condition	$\%V^2$	Condition	$\%V^2$
1	20,000	T	3/4	RS-"A"	Air	26	‡‡	23	30
2	20,000	T	3/4	RS-"A"	Air	31		20	30
3	20,000	B	3/4	RS-"A"	Air	‖			
4	20,000	B	3/4	RS-"A"	Air	Unloaded			
5	30,000	T	3/4	RS-"B"	Air	52		51	45
6	30,000	T	3/4	RS-"B"	Air	44		40	47
7	30,000	B	3/4	RS-"B"	Air	33		30	40
8	30,000	B	3/4	RS-"B"	Air	50		30	57
9	40,000	T	3/4	RS-"A"	Air	‖			
10	40,000	T	3/4	RS-"A"	Air	Unloaded			
11	40,000	B	3/4	RS-"A"	Air	43		41	62
12	40,000	B	3/4	RS-"A"	Air	49		45	52
13	50,000	T	3/4	RS-"B"	Air	‖			
14	50,000	T	3/4	RS-"B"	Air	Unloaded			
15	50,000	B	3/4	RS-"B"	Air	‖			
16	50,000	B	3/4	RS-"B"	Air	Damaged			
18	None	B	3/4	RS-"A"	Air				

NOTE: All beams returned to laboratory for testing.

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‡ In 1965 and 1967 the condition of specimens was not rated by panel of observers.

‡‡ Satisfactory pulse velocity readings were not obtained in 1966, 1973, and 1974 due to malfunction of testing equipment.

§ Channel iron on all loaded beams was replaced with stainless steel channel in June 1967. Pulse velocity readings were therefore taken on all loaded beams before unloading and after reloading with stainless steel channel.

Some pulse velocity readings obtained in 1969 and 1970 are not believed to be valid due to the power limitations of the test equipment; these $\%V^2$ readings are therefore questionable.

Unable to obtain satisfactory reading.

‖ Returned to laboratory.

Tensile Crack Specimens, Series B*

In November 1954, 76 reinforced-concrete beams were installed at half-tide elevation on the beach at Treat Island. The purpose of this installation is to compare the relative resistance to weathering of highly stressed reinforced-concrete beams containing (a) reinforcement bars deformed to conform to ASTM Designation A 305-50T, and (b) bars with old-style deformations.

The beams were 7 ft 9 in. long and were made of air-entrained concrete with a nominal compressive strength of 3500 psi at 28 days age. All of the beams were reinforced with rail-steel bars; the bars in half of the beams had deformations conforming to ASTM Designation A 305-50T, and those in the other half had old-style deformations. All steel was placed with a nominal cover of 2 in. from either the top or bottom of the beam, depending on whether the bar was in the top or the bottom of the mold when the concrete was placed. Aggregates were a manufactured limestone sand and a crushed limestone coarse aggregate (1-in. maximum size). Type II cement was used, with the cement factors ranging from 5.25 to 5.38 bags per cu yd. The air-entraining admixture was admixture R; the water-cement ratio (by weight) was 0.58; the air content ranged from 5.0 to 7.0 per cent.

Sixty-four of the beams were yoked and stressed by third-point loadings; the loads ranged from 20,000 to 50,000 psi. The remaining 12 beams were controls and were not loaded.

Table 1-TC-B lists these specimens and gives their exposure record along with other pertinent information.

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* See report to Office, Chief of Engineers, Tensile Crack Exposure Tests - Progress Report - Second Series of Tests (July 1955).

U. S. Army Engineer Waterways Experiment Station, CE, Tensile Crack Exposure Tests; Results of Tests of Reinforced Concrete Beams, 1955-1963, by E. C. Roshore, Technical Memorandum No. 6-412, Report No. 2 (Vicksburg, Miss., November 1964).

(Revised Aug 1965)

Table 1-TC-B

Section 2

Record of Observation and Testing of Large-beam Tensile Crack Specimens, Series B, 1954- (Installed Nov 1954)

Beach Row 1

Beam No.	Nominal Stress psi	Steel Position*	Type** Steel Deformation	1954-1958 Readings										
				0 Cycles, 1954			143 Cycles 1955	310 Cycles 1956	454 Cycles, 1957			525 Cycles, 1958		
				Condition	Pulse Veloc fps	$\%V^2$	Condition	Condition	Condition	$\%V^2$	Max Crack Width† 1/1000 in.	Condition	$\%V^2$	Max Crack Width† 1/1000 in.
83	20,000	B	A-305	Sound	10,890	100	100	91	87	173	10	88	173	10
84	20,000	B	A-305	Sound	11,150	100	100	91	88	168	5	84	170	10
85	20,000	B	OS	Sound	11,720	100	100	90	84	157	10	83	153	10
86	20,000	B	OS	Sound	11,470	100	100	87	82	170	10	84	155	10
87	20,000	B	A-305	Sound	10,640	100	100	82	74	171	5	77	183	5
88	20,000	B	A-305	Sound	10,470	100	100	84	76	175	10	77	200	10
89	20,000	B	OS	Sound	11,255	100	100	84	87	162	10	87	167	10
90	20,000	B	OS	Sound	11,300	100	100	83	83	160	10	82	169	10
91	30,000	B	A-305	Sound	11,540	100	93	90	79	146	10	76	151	15
92	30,000	B	A-305	Sound	11,540	100	100	90	82	161	10	81	166	10
93	30,000	B	OS	Sound	12,120	100	100	87	80	151	15	80	152	15
94	30,000	B	OS	Sound	11,605	100	100	87	82	145	20	80	169	20
95	30,000	B	A-305	Sound	11,905	100	100	92	84	154	10	80	156	10
96	30,000	B	A-305	Sound	11,195	100	100	90	86	162	10	80	174	10
97	30,000	B	OS	Sound	11,385	100	100	86	86	152	15	86	154	15
98	30,000	B	OS	Sound	11,385	100	100	92	85	149	20	87	159	20
99	40,000	B	A-305	Sound	10,290	100	100	88	87	190	15	84	202	15
100	40,000	B	A-305	Sound	10,435	100	100	88	87	190	10	88	188	15
101	40,000	B	OS	Sound	10,400	100	98	82	82	195	15	79	191	20
102	40,000	B	OS	Sound	10,455	100	100	84	82	167	20	81	203	20
103	40,000	B	A-305	Sound	8,915	100	95	83	80	228	10	76	246	20
104	40,000	B	A-305	Sound	8,585	100	94	82	78	248	25	73	269	25
105	40,000	B	OS	Sound	9,230	100	100	86	91	246	10	92	237	20
106	40,000	B	OS	Sound	9,435	100	100	80	80	236	25	84	238	30
107	50,000	B	A-305	Sound	10,310	100	100	86	80	195	15	80	191	15
108	50,000	B	A-305	Sound	11,385	100	98	86	77	147	20	80	156	20
109	50,000	B	OS	Sound	8,915	100	91	74	72	274	20	80	273	20
110	50,000	B	OS	Sound	10,170	100	92	74	73	199	25	76	201	25
111	50,000	B	A-305	Sound	9,130	100	99	79	74	251	20	76	252	25
112	50,000	B	A-305	Sound	9,160	100	100	86	86	242	20	86	255	25
113	50,000	B	OS	Sound	8,850	100	93	70	64	243	25	69	279	25
114	50,000	B	OS	Sound	8,525	100	100	77	77	250	30	76	269	30
115	None	B	A-305	Sound	12,985	100	96	86	84	115	0	82	122	0
116	None	B	A-305	Sound	13,015	100	100	88	84	110	0	80	111	0
117	None	B	A-305	Sound	13,245	100	100	94	93	114	10	90	116	10
118	None	B	OS	Sound	13,250	100	98	76	65	111	0	69	119	0
119	None	B	OS	Sound	13,130	100	100	91	90	119	0	86	112	0
120	None	B	OS	Sound	13,185	100	100	88	89	115	0	85	115	0
121	20,000	T	A-305	Sound	9,600	100	96	87	80	218	35	81	234	35
122	20,000	T	A-305	Sound	9,570	100	96	87	86	237	10	85	225	20
123	20,000	T	OS	Sound	9,870	100	100	86	86	205	10	76	229	10
124	20,000	T	OS	Sound	9,675	100	100	84	86	216	10	73	231	15
125	20,000	T	A-305	Sound	12,960	100	100	86	86	120	15	86	131	15
126	20,000	T	A-305	Sound	13,160	100	100	79	80	122	35	87	127	35
127	20,000	T	OS	Sound	13,365	100	100	94	90	132	10	93	122	10
128	20,000	T	OS	Sound	13,015	100	100	92	90	135	10	92	132	10
129	30,000	T	A-305	Sound	9,755	100	97	83	75	224	15	74	227	15
130	30,000	T	A-305	Sound	9,820	100	98	83	83	230	20	77	230	20
131	30,000	T	OS	Sound	11,675	100	96	81	76	136	20	75	155	25
132	30,000	T	OS	Sound	11,675	100	96	77	76	159	30	80	150	30
133	30,000	T	A-305	Sound	13,070	100	100	88	88	115	10	88	125	10
134	30,000	T	A-305	Sound	12,820	100	100	88	88	120	15	87	130	15
135	30,000	T	OS	Sound	12,875	100	93	87	78	141	15	80	142	20
136	30,000	T	OS	Sound	11,340	100	95	86	80	158	10	81	149	15
137	40,000	T	A-305	Sound	10,510	100	91	88	70	148	20	76	127	20

(Continued)

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* T = near top of beam.
B = near bottom of beam.

** A-305 = deformation conforming to ASTM Designation A 305-50T.
OS = old style deformations (does not meet ASTM Designation A 305-50T deformation requirements).

† From 1956, the widths of cracks in these specimens were measured with a measuring magnifier (least reading = 0.005 in.).

(Revised Aug 1965)

Table 1-TC-B (Continued)

Beach Row 1

				1954-1958 Readings										
				0 Cycles, 1954			143 Cycles 1955	310 Cycles 1956	454 Cycles, 1957			525 Cycles, 1958		
Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	Condition	Pulse Veloc fps	$\%V^2$	Condition	Condition	Condition	$\%V^2$	Max Crack Width 1/1000 in.	Condition	$\%V^2$	Max Crack Width 1/1000 in.
138	40,000	T	A-305	100	10,490	100	92	89	74	177	25	78	182	25
139	40,000	T	OS	100	12,095	100	88	78	72	132	15	72	150	15
140	40,000	T	OS	100	12,225	100	90	76	71	129	15	74	148	15
141	40,000	T	A-305	100	9,275	100	99	84	78	249	15	70	241	20
142	40,000	T	A-305	100	9,570	100	100	85	76	228	15	78	227	20
143	40,000	T	OS	100	9,375	100	94	82	76	224	25	84	234	25
144	40,000	T	OS	100	9,390	100	95	86	84	231	40	84	238	40
145	50,000	T	A-305	100	9,435	100	96	82	82	243	40	84	253	40
146	50,000	T	A-305	100	9,345	100	94	81	78	238	30	81	255	30
147	50,000	T	OS	100	8,970	100	86	66	68	272	85	72	249	85
148	50,000	T	OS	100	8,900	100	82	67	67	260	75	70	260	75
149	50,000	T	A-305	100	9,105	100	99	83	78	225	40	88	235	40
150	50,000	T	A-305	100	9,175	100	100	82	82	235	25	86	259	30
151	50,000	T	OS	100	11,130	100	92	80	76	180	15	72	164	15
152	50,000	T	OS	100	10,655	100	88	78	72	195	25	74	181	25
153	None	T	A-305	100	12,475	100	94	86	74	120	0	72	121	0
154	None	T	A-305	100	12,795	100	100	92	87	117	0	88	132	0
155	None	T	A-305	100	12,875	100	100	90	86	115	0	80	120	0
156	None	T	OS	100	13,045	100	100	91	90	120	0	82	118	0
157	None	T	OS	100	12,630	100	98	86	80	120	0	75	124	0
158	None	T	OS	100	12,710	100	99	78	61	120	10	70	119	15

Beach Row 1

				1959-1961 Readings								
				675 Cycles, 1959			746 Cycles, 1960			887 Cycles, 1961		
				Condition	$\%V^2$	Max Crack Width 1/1000 in.	Condition††	$\%V^2$	Max Crack Width 1/1000 in.	Condition	$\%V^2$	Max Crack Width 1/1000 in.
83	20,000	B	A-305	84	161	15	84	180	10	75	192	10
84	20,000	B	A-305	86	161	20	86	159	10	77	179	10
85	20,000	B	OS	91	143	15	91	158	10	79	146	10
86	20,000	B	OS	82	150	15	82	137	10	68	172	10
87	20,000	B	A-305	72	176	15	72	128	10	61	187	10
88	20,000	B	A-305	73	181	10	73	133	10	68	174	10
89	20,000	B	OS	86	160	15	86	152	10	73	153	10
90	20,000	B	OS	78	158	10	78	147	10	74	151	10
91	30,000	B	A-305	80	140	15	80	107	10	71	155	10
92	30,000	B	A-305	82	154	10	82	162	10	67	159	10
93	30,000	B	OS	80	152	30	80	108	20	71	151	15
94	30,000	B	OS	75	158	25	75	113	30	69	158	25
95	30,000	B	A-305	85	144	25	85	142	15	79	159	10
96	30,000	B	A-305	85	162	20	85	167	15	69	168	15
97	30,000	B	OS	78	147	20	78	133	10	65	168	10
98	30,000	B	OS	78	145	20	78	151	15	63	164	10
99	40,000	B	A-305	77	189	25	77	174	15	62	215	15
100	40,00	B	A-305	78	179	25	78	167	15	70	205	10
101	40,000	B	OS	70	181	35	70	135	30	65	177	25
102	40,000	B	OS	68	188	45	68	137	20	67	190	15
103	40,000	B	A-305	72	233	25	72	197	15	61	224	15
104	40,000	B	A-305	66	250	25	66	267	20	65	243	20
105	40,000	B	OS	86	224	20	86	165	15	72	219	15
106	40,000	B	OS	66	223	20	66	158	15	56	253	15
107	50,000	B	A-305	68	180	20	68	132	15	53	199	15
108	50,000	B	A-305	75	146	25	75	107	20	58	145	15
109	50,000	B	OS	68	254	35	68	228	25	67	221	25
110	50,000	B	OS	57	192	35	57	169	30	56	191	25
111	50,000	B	A-305	59	243	30	59	167	20	58	226	20
112	50,000	B	A-305	77	237	30	77	168	20	66	228	15

(Continued)

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†† Hardware was replaced on all loaded specimens in May 1959. The condition of these specimens is adjudged either annually or biennially by a panel of observers during the formal inspection, and is expressed numerically, i.e. 100 denotes perfect condition.

(Revised Aug 1965)

Table 1-TC-B (Continued)

Beach Row 1

				1959-1961 Readings								
				675 Cycles, 1959			746 Cycles, 1960			887 Cycles, 1961		
Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	Condition	$\%V^2$	Max Crack Width 1/1000 in.	Condition	$\%V^2$	Max Crack Width 1/1000 in.	Condition	$\%V^2$	Max Crack Width 1/1000 in.
113	50,000	B	OS	62	238	30	62	173	25	50	229	20
114	50,000	B	OS	64	255	35	64	192	25	54	265	20
115	None	B	A-305	78	113	0	78	112	0	69	131	0
116	None	B	A-305	80	107	0	80	114	0	74	115	5
117	None	B	A-305	80	105	20	80	109	10	68	117	10
118	None	B	OS	55	111	0	55	112	0	46	104	0
119	None	B	OS	70	104	0	70	111	0	67	123	0
120	None	B	OS	59	105	0	59	112	0	59	119	0
121	20,000	T	A-305	80	221	15	80	165	10	77	230	10
122	20,000	T	A-305	82	213	15	82	156	10	70	226	10
123	20,000	T	OS	77	216	20	77	158	10	61	231	10
124	20,000	T	OS	82	217	20	82	196	15	65	230	10
125	20,000	T	A-305	70	124	20	70	89	10	68	124	10
126	20,000	T	A-305	77	118	10	77	84	10	77	120	10
127	20,000	T	OS	86	121	15	86	130	10	75	137	10
128	20,000	T	OS	82	120	20	82	133	10	75	132	10
129	30,000	T	A-305	65	214	15	65	135	10	55	159	10
130	30,000	T	A-305	81	213	15	81	202	10	66	164	10
131	30,000	T	OS	75	144	15	75	114	15	75	142	15
132	30,000	T	OS	72	147	25	72	115	20	61	145	15
133	30,000	T	A-305	77	119	20	77	118	15	63	121	10
134	30,000	T	A-305	78	122	25	78	133	15	66	121	10
135	30,000	T	OS	73	134	30	73	96	20	66	121	10
136	30,000	T	OS	77	148	25	77	112	20	66	149	15
137	40,000	T	A-305	64	173	25	64	164	20	51	167	20
138	40,000	T	A-305	68	171	40	68	183	30	57	194	25
139	40,000	T	OS	75	139	35	75	145	20	69	129	15
140	40,000	T	OS	70	136	30	70	149	15	69	145	15
141	40,000	T	A-305	68	231	25	68	218	25	55	267	20
142	40,000	T	A-305	73	228	20	73	193	15	60	220	15
143	40,000	T	OS	66	223	20	66	169	15	65	225	15
144	40,000	T	OS	75	226	25	75	171	20	63	209	20
145	50,000	T	A-305	70	236	25	70	170	20	71	224	15
146	50,000	T	A-305	64	235	30	64	173	20	55	237	15
147	50,000	T	OS	61	232	105	61	221	100	59	271	90
148	50,000	T	OS	64	242	110	64	258	90	64	268	85
149	50,000	T	A-305	70	228	30	70	164	15	70	224	20
150	50,000	T	A-305	66	240	35	66	165	25	67	224	15
151	50,000	T	OS	68	155	30	68	170	25	60	156	25
152	50,000	T	OS	61	173	35	61	197	30	55	179	25
153	None	T	A-305	55	116	0	55	123	0	51	128	0
154	None	T	A-305	80	114	0	80	123	0	77	115	0
155	None	T	A-305	77	116	0	77	106	0	72	136	0
156	None	T	OS	88	111	0	88	117	0	82	125	0
157	None	T	OS	70	115	0	70	123	0	67	131	0
158	None	T	OS	54	117	20	54	125	15	53	123	10

Beach Row 1

				1962-1964 Readings								
				976 Cycles, 1962			1082 Cycles, 1963			1217 Cycles, 1964		
				Condition	$\%V^2$	Max Crack Width 1/1000 in.	Condition	$\%V^2$	Max Crack Width 1/1000 in.	Condition	$\%V^2$	Max Crack Width 1/1000 in.
83	20,000	B	A-305	68	192	10	80	131	20	68	118	15
84	20,000	B	A-305	75	174	10	82	126	20	70	116	15
85	20,000	B	OS	77	162	15	87	101	30	74	107	20
86	20,000	B	OS	73	159	10	80	112	25	67	103	20
87	20,000	B	A-305	58	174	10	72	127	20	58	127	10
88	20,000	B	A-305	61	184	10	61	137	10	52	130	10
89	20,000	B	OS	71	173	10	86	114	20	72	121	15
90	20,000	B	OS	67	171	10	66	100	20	66	115	15
91	30,000	B	A-305	71	143	15	70	112	30	70	100	25
92	30,000	B	A-305	67	150	15	66	108	35	72	106	20

(Continued)

(Revised Aug 1965)

Table 1-TC-B (Continued)

Beach Row 1

				1962-1964 Readings								
				976 Cycles, 1962			1082 Cycles, 1963			1217 Cycles, 1964		
Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	Condition	%V^2	Max Crack Width 1/1000 in.	Condition	%V^2	Max Crack Width 1/1000 in.	Condition	%V^2	Max Crack Width 1/1000 in.
93	30,000	B	OS	71	136	20	70	106	40	70	91	30
94	30,000	B	OS	69	163	25	69	133	40	69	109	30
95	30,000	B	A-305	79	148	15	94	105	30	76	100	20
96	30,000	B	A-305	69	162	20	81	120	35	69	107	25
97	30,000	B	OS	64	147	10	64	109	30	65	60	25
98	30,000	B	OS	64	154	15	63	111	25	63	105	25
99	40,000	B	A-305	62	180	15	62	136	30	62	83	20
100	40,000	B	A-305	64	212	15	75	143	25	64	132	15
101	40,000	B	OS	64	184	25	62	136	30	65	122	25
102	40,000	B	OS	67	206	20	66	143	35	67	127	30
103	40,000	B	A-305	59	210	15	72	143	40	61	174	30
104	40,000	B	A-305	66	258	25	77	154	50	65	197	35
105	40,000	B	OS	72	258	20	72	145	30	72	169	20
106	40,000	B	OS	56	244	15	66	139	30	56	165	30
107	50,000	B	A-305	54	194	15	53	131	30	53	138	25
108	50,000	B	A-305	59	134	15	57	107	30	58	110	30
109	50,000	B	OS	68	192	25	68	183	50	67	175	50
110	50,000	B	OS	55	197	25	55	148	45	56	140	50
111	50,000	P	A-305	58	256	25	57	163	50	58	177	30
112	50,000	B	A-305	66	267	15	65	159	30	65	177	25
113	50,000	B	OS	49	204	15	49	170	30	50	177	25
114	50,000	B	OS	54	285	20	54	183	35	54	194	35
115	None	B	A-305	66	113	0	78	93	0	64	93	0
116	None	B	A-305	70	112	5	80	76	15	80	89	10
117	None	B	A-305	73	120	10	67	76	30	68	93	30
118	None	B	OS	44	96	0	55	76	0	44	84	0
119	None	B	OS	58	124	0	70	74	0	58	97	0
120	None	B	OS	58	114	0	70	80	0	57	98	0
121	20,000	T	A-305	74	236	10	87	156	10	80	159	10
122	20,000	T	A-305	69	227	10	82	140	10	75	151	20
123	20,000	T	OS	61	238	10	72	139	20	72	154	25
124	20,000	T	OS	65	229	10	77	148	25	65	148	20
125	20,000	T	A-305	64	134	10	70	82	10	64	82	5
126	20,000	T	A-305	77	115	10	90	77	20	77	88	10
127	20,000	T	OS	80	130	10	82	87	20	82	77	20
128	20,000	T	OS	70	138	10	69	90	20	70	87	20
129	30,000	T	A-305	55	225	10	65	137	20	55	154	15
130	30,000	T	A-305	66	228	15	55	119	30	66	155	25
131	30,000	T	OS	74	133	15	74	83	40	74	108	40
132	30,000	T	OS	61	143	10	61	84	20	61	108	35
133	30,000	T	A-305	63	125	10	74	85	20	63	88	20
134	30,000	T	A-305	66	128	10	66	87	20	66	86	20
135	30,000	T	OS	62	131	15	73	77	30	67	89	15
136	30,000	T	OS	66	159	15	77	104	20	66	114	20
137	40,000	T	A-305	51	154	20	51	130	40	51	112	35
138	40,000	T	A-305	57	187	20	57	132	40	57	108	40
139	40,000	T	OS	67	139	15	69	98	30	68	97	20
140	40,000	T	OS	69	140	10	69	100	30	69	87	25
141	40,000	T	A-305	55	247	15	55	155	35	55	165	35
142	40,000	T	A-305	63	218	15	59	150	30	60	174	30
143	40,000	T	OS	65	236	15	65	152	35	66	167	35
144	40,000	T	OS	64	226	15	75	152	40	63	148	35
145	50,000	T	A-305	71	257	25	70	176	40	70	160	40
146	50,000	T	A-305	55	175	20	64	165	40	54	168	40
147	50,000	T	OS	60	266	100	59	177	180	60	173	160
148	50,000	T	OS	64	278	90	63	175	140	64	175	125
149	50,000	T	A-305	70	170	20	70	167	40	70	164	40
150	50,000	T	A-305	67	248	20	66	171	40	67	164	50
151	50,000	T	OS	60	176	25	59	120	50	60	119	50
152	50,000	T	OS	54	195	25	54	125	55	54	128	50

(Continued)

(Revised Sept 1968)

Table 1-TC-B (Continued)

Beach Row 1

Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	1962-1964 Readings 976 Cycles, 1962 Condition	976 Cycles, 1962 $\%V^2$	976 Cycles, 1962 Max Crack Width 1/1000 in.	1082 Cycles, 1963 Condition	1082 Cycles, 1963 $\%V^2$	1082 Cycles, 1963 Max Crack Width 1/1000 in.	1217 Cycles, 1964 Condition	1217 Cycles, 1964 $\%V^2$	1217 Cycles, 1964 Max Crack Width 1/1000 in.
153	None	T	A-305	47	121	0	55	97	0	51	94	0
154	None	T	A-305	74	118	0	80	92	0	80	97	0
155	None	T	A-305	71	121	0	77	91	0	77	90	0
156	None	T	OS	81	123	0	88	89	0	75	97	0
157	None	T	OS	60	118	0	70	88	0	64	91	0
158	None	T	OS	53	123	15	63	88	25	53	90	15

Beach Row 1

				1965-1967 Readings												
				1380 Cycles, 1965			1510 Cycles, 1966			1666 Cycles, 1967						
											$\%V^2$			Max Crack Width 1/1000 in.		
				Condition	$\%V^2$	Max Crack Width 1/1000 in.	Condition	$\%V^2$	Max Crack Width 1/1000 in.	Condition	Before Unloading§	Not Loaded	After Reloading	Before Unloading§	Not Loaded	After Reloading
83	20,000	B	A-305	‡	93	5	65	‡‡	10	‡	116		99	10		10
84	20,000	B	A-305		90	10	70		15		93		116	15		15
85	20,000	B	OS		65	10	72		10		85		58	10		10
86	20,000	B	OS		83	15	66		15		83		56	15		20
87	20,000	B	A-305		104	10	52		15		125		95	15		15
88	20,000	B	A-305		120	5	50		5		97		64	5		10
89	20,000	B	OS		109	5	69		5		92		66	5		15
90	20,000	B	OS		102	10	66		10		108		88	10		10
91	30,000	B	A-305		65	15	70		15		83		54	15		20
92	30,000	B	A-305		67	15	78		15		83		60	15		25
93	30,000	B	OS		69	20	68		25		95		81	25		40
94	30,000	B	OS		62	25	64		35		86		110	35		50
95	30,000	B	A-305		74	15	72		20		100		85	25		30
96	30,000	B	A-305		104	15	68		25		111		57	25		25
97	30,000	B	OS		71	20	62		20		84		61	20		30
98	30,000	B	OS		70	20	63		25		85		64	20		35
99	40,000	B	A-305		94	20	62		30		106		75	25		30
100	40,000	B	A-305		94	15	64		30		106		83	30		30
101	40,000	B	OS		84	35	62		50		86		74	50		55
102	40,000	B	OS		79	30	65		50		98		80	45		50
103	40,000	B	A-305		138	30	52		35		117		93	35		40
104	40,000	B	A-305		148	25	65		30		137		114	30		45
105	40,000	B	OS		120	20	71		30		139		96	30		35
106	40,000	B	OS		118	20	56		30		154		123	25		35
107	50,000	B	A-305		110	25	52		30		129		90	25		35
108	50,000	B	A-305		77	25	58		25		105		57	25		30
109	50,000	B	OS		97	40	66		45		166		105	45		55
110	50,000	B	OS		96	40	55		40		128		111	45		50
111	50,000	B	A-305		104	30	54		30		170		90	25		40
112	50,000	B	A-305		143	25	63		30		127		86	25		35
113	50,000	B	OS		147	20	49		30		119		97	35		45
114	50,000	B	OS		177	25	53		40		172		144	40		55
115	None	B	A-305		76	0	60		0			73			0	
116	None	B	A-305		83	10	65		10			50			10	
117	None	B	A-305		60	20	68		10			69			10	
118	None	B	OS		84	0	41		0			69			0	
119	None	B	OS		59	0	52		0			71			0	
120	None	B	OS		64	0	54		0			68			0	
121	20,000	T	A-305		113	10	87		15		147		113	15		15
122	20,000	T	A-305		136	10	82		10		129		143	10		15
123	20,000	T	OS		136	15	72		15		141		83	15		30
124	20,000	T	OS		143	10	71		15		144		97	15		25
125	20,000	T	A-305		79	5	64		5		84		53	5		10
126	20,000	T	A-305		82	5	77		10		82		62	10		10
127	20,000	T	OS		64	5	82		5		65		64	5		10
128	20,000	T	OS		66	5	70		10		69		87	5		5
129	30,000	T	A-305		136	15	65		20		117		77	15		15
130	30,000	T	A-305		106	20	77		20		132		79	15		25
131	30,000	T	OS		71	30	74		45		60		48	45		50
132	30,000	T	OS		83	30	61		30		86		56	30		40

(Continued)

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‡ In 1965 and 1967 the condition of specimens was not rated by panel of observers.

‡‡ Satisfactory pulse velocity readings were not obtained in 1966 due to malfunction of testing equipment.

§ Channel iron on all loaded beams was replaced with stainless steel channel in June 1967. Readings were therefore taken on all loaded beams before unloading and after reloading with stainless steel channel.

(Revised Jan 1973)

Table 1-TC-B (Continued)

Beach Row 1

				1965-1967 Readings											
				1380 Cycles, 1965			1510 Cycles, 1966			1666 Cycles, 1967					
											%V^2			Max Crack Width 1/1000 in.	
Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	Condition	%V^2	Max Crack Width 1/1000 in.	Condition	%V^2	Max Crack Width 1/1000 in.	Condition	Before Unloading§	Not Loaded	After Reloading	Before Unloading§	Not Loaded	After Reloading
133	30,000	T	A-305	‡	59	15	63	‡‡	15	‡	82		52	10		15
134	30,000	T	A-305		83	15	72		20		84		68	10		15
135	30,000	T	OS		75	15	67		25		65		44	30		30
136	30,000	T	OS		89	25	65		30		79		58	30		35
137	40,000	T	A-305		73	40	51		55		91		72	55		70
138	40,000	T	A-305		83	40	57		50		98		97	50		75
139	40,000	T	OS		57	20	67		30		70		61	30		35
140	40,000	T	OS		70	20	69		35		74		56	30		35
141	40,000	T	A-305		106	30	55		30		155		93	30		45
142	40,000	T	A-305		116	30	59		35		135		93	35		40
143	40,000	T	OS		143	25	65		25		119		111	25		30
144	40,000	T	OS		118	35	62		45		109		95	45		60
145	50,000	T	A-305		139	30	70		45		103		88	45		70
146	50,000	T	A-305		120	30	53		35		114		76	30		45
147	50,000	T	OS		98	100	59		125		162		98	115		125
148	50,000	T	OS		116	85	64		100		157		137	100		120
149	50,000	T	A-305		147	35	69		50		124		60	45		50
150	50,000	T	A-305		150	40	65		40		145		65	35		50
151	50,000	T	OS		71	35	57		35		111		64	35		45
152	50,000	T	OS		82	35	54		45		102		70	40		45
153	None	T	A-305		96	0	44		0			74			0	
154	None	T	A-305		75	0	67		0			73			0	
155	None	T	A-305		67	0	77		0			70			0	
156	None	T	OS		74	0	66		0			69			0	
157	None	T	OS		64	0	60		0			87			0	
158	None	T	OS		53	15	52		10			68			10	

Beach Row 1

				1968-1972 Readings														
				1851 Cycles, 1968			2005 Cycles, 1969			2158 Cycles, 1970			2327 Cycles, 1971			2484 Cycles, 1972		
				Condition	%V^2	Max Crack Width 1/1000 in.	Condition	%V^2#	Max Crack Width 1/1000 in.	Condition	%V^2#	Max Crack Width 1/1000 in.	Condition	%V^2	Max Crack Width 1/1000 in.	Condition	%V^2	Max Crack Width 1/1000 in.
83	20,000	B	A-305	65	116	15	62	40	15	59	69	15	60	62	15	59	46	10
84	20,000	B	A-305	68	95	15	68	37	20	67	71	20	66	51	15	64	43	10
85	20,000	B	OS	72	61	20	72	28	20	71	53	25	70	51	25	69	38	25
86	20,000	B	OS	66	84	15	66	35	20	64	57	20	64	55	25	65	36	25
87	20,000	B	A-305	52	93	20	53	41	25	52	63	25	47	58	30	47	48	25
88	20,000	B	A-305	50	84	20	54	44	25	59	70	25	51	68	20	51	39	25
89	20,000	B	OS	69	75	20	67	42	20	68	73	20	68	67	25	66	53	30
90	20,000	B	OS	63	104	10	64	37	15	65	61	25	62	58	30	60	42	30
91	30,000	B	A-305	70	85	20	70	35	20	70	56	25	69	53	25	69	38	20
92	30,000	B	A-305	76	66	20	67	35	20	67	55	20	66	51	25	67	37	20
93	30,000	B	OS	68	53	40	66	32	40	64	51	40	64	49	40	62	36	25
94	30,000	B	OS	64	78	50	66	35	50	67	60	55	68	55	55	65	35	50
95	30,000	B	A-305	72	100	35	72	34	35	68	53	40	68	50	35	68	36	25
96	30,000	B	A-305	68	109	30	67	41	35	66	68	35	65	59	30	66	45	20
97	30,000	B	OS	62	76	30	64	34	35	61	61	35	61	56	35	62	37	40
98	30,000	B	OS	63	87	30	62	34	30	62	58	35	61	54	40	62	36	40
99	40,000	B	A-305	62	110	35	60	70	35	59	58	35	59	53	40	59	37	40
100	40,000	B	A-305	64	75	30	63	37	30	60	60	35	57	52	35	58	37	35
101	40,000	B	OS	62	86	60	61	39	70	61	59	70	61	52	75	60	40	75
102	40,000	B	OS	65	98	50	64	33	50	64	50	55	62	49	60	64	42	60
103	40,000	B	A-305	51	79	45	53	50	50	53	75	50	51	71	55	52	58	50
104	40,000	B	A-305	65	99	45	62	52	50	62	79	50	59	76	50	55	77	50
105	40,000	B	OS	71	111	45	71	56	45	68	87	45	67	84	50	70	90	40
106	40,000	B	OS	54	81	50	54	46	55	54	73	55	54	67	50	52	79	50
107	50,000	B	A-305	52	92	40	52	33	45	52	54	45	52	52	50	52	44	40

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‡ In 1965 and 1967 the condition of specimens was not rated by panel of observers.

‡‡ Satisfactory pulse velocity readings were not obtained in 1966 due to malfunction of testing equipment.

§ Channel iron on all loaded beams was replaced with stainless steel channel in June 1967. Readings were therefore taken on all loaded beams before unloading and after reloading with stainless steel channel.

Some pulse velocity readings obtained in 1969 and 1970 are not believed to be valid due to the power limitations of the test equipment; these %V^2 readings are therefore questionable.

(Revised Jan 1973)

Table 1-TC-B (Concluded)

Section 2

Beach Row 1

				1968-1972 Readings														
				1851 Cycles, 1968			2005 Cycles, 1969			2158 Cycles, 1970			2327 Cycles, 1971			2484 Cycles, 1972		
Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	Condition	%V^2	Max Crack Width 1/1000 in.	Condition	%V^2#	Max Crack Width 1/1000 in.	Condition	%V^2#	Max Crack Width 1/1000 in.	Condition	%V^2	Max Crack Width 1/1000 in.	Condition	%V^2	Max Crack Width 1/1000 in.
108	50,000	B	A-305	57	73	40	57	26	45	57	41	45	55	40	45	56	37	50
109	50,000	B	OS	66	149	50	66	59	50	66	99	55	66	91	55	66	64	50
110	50,000	B	OS	55	117	50	55	56	50	55	95	55	55	81	50	56	47	50
111	50,000	B	A-305	53	91	50	55	52	50	56	79	50	51	72	50	53	62	40
112	50,000	B	A-305	63	93	40	63	50	45	63	76	45	62	71	40	63	65	40
113	50,000	B	OS	49	103	55	49	53	55	48	92	60	48	86	60	48	59	60
114	50,000	B	OS	53	180	55	52	42	65	52	64	65	50	62	70	50	64	70
115	None	B	A-305	59	68	0	59	26	0	58	43	0	56	39	0	58	32	0
116	None	B	A-305	65	58	5	67	25	0	67	38	0	66	36	0	65	29	0
117	None	B	A-305	65	68	0	65	28	0	65	43	0	67	40	0	65	30	0
118	None	B	OS	40	66	0	39	27	0	43	43	0	44	41	0	36	44	0
119	None	B	OS	52	67	0	53	30	0	56	49	0	52	47	0	51	21	0
120	None	B	OS	54	69	0	56	27	0	56	43	0	55	41	0	54	27	0
121	20,000	T	A-305	87	91	25	74	49	25	74	79	25	71	73	25	74	86	30
122	20,000	T	A-305	82	85	25	70	52	30	69	81	25	67	77	20	68	54	25
123	20,000	T	OS	72	119	30	61	47	35	61	76	40	61	74	35	60	51	40
124	20,000	T	OS	71	111	35	65	59	40	65	98	40	65	92	45	65	51	50
125	20,000	T	A-305	64	45	20	60	34	20	59	59	25	58	33	25	60	33	30
126	20,000	T	A-305	77	63	20	77	34	25	76	60	25	77	49	30	76	42	30
127	20,000	T	OS	76	68	10	69	28	10	70	42	10	68	37	20	68	22	15
128	20,000	T	OS	69	69	5	69	27	5	70	47	10	68	43	15	67	25	15
129	30,000	T	A-305	60	90	20	55	50	25	55	77	30	53	73	35	55	56	40
130	30,000	T	A-305	71	84	35	66	45	35	65	69	35	62	66	35	63	54	35
131	30,000	T	OS	74	56	50	73	34	50	74	52	50	72	47	55	72	53	50
132	30,000	T	OS	61	84	40	61	35	50	61	54	50	58	51	50	58	42	40
133	30,000	T	A-305	63	45	20	63	26	25	63	44	30	61	43	30	61	40	30
134	30,000	T	A-305	66	61	25	66	28	25	66	47	25	64	45	25	65	45	30
135	30,000	T	OS	62	53	35	61	28	30	61	44	30	61	42	35	60	32	40
136	30,000	T	OS	65	63	35	63	33	30	64	50	25	61	48	25	62	56	25
137	40,000	T	A-305	51	89	70	49	##	70	49	50	70	49	50	75	49	47	70
138	40,000	T	A-305	57	106	70	56	37	70	56	60	75	56	56	70	56	45	60
139	40,000	T	OS	67	92	35	67	26	40	66	39	45	66	38	45	66	32	40
140	40,000	T	OS	69	82	35	70	29	40	68	53	40	67	49	40	68	32	40
141	40,000	T	A-305	55	99	55	54	52	55	54	91	60	53	84	60	53	67	60
142	40,000	T	A-305	59	111	50	58	50	55	57	80	60	57	84	65	62	59	60
143	40,000	T	OS	65	116	30	64	48	35	64	74	35	64	71	30	64	61	25
144	40,000	T	OS	61	115	55	61	51	60	61	80	65	61	73	70	61	61	60
145	50,000	T	A-305	68	101	65	66	50	70	65	84	65	56	79	65	54	63	60
146	50,000	T	A-305	52	98	50	51	68	55	49	116	55	48	96	55	47	55	60
147	50,000	T	OS	Failed§§														
148	50,000	T	OS	Damaged ‖														
149	50,000	T	A-305	68	126	45	68	50	55	68	83	60	67	77	55	68	60	50
150	50,000	T	A-305	65	142	50	65	62	50	64	86	50	65	80	50	65	54	50
151	50,000	T	OS	57	79	50	58	30	50	57	49	55	57	45	55	57	39	50
152	50,000	T	OS	54	111	50	54	40	55	54	66	55	54	63	50	54	31	50
153	None	T	A-305	44	72	0	44	30	0	46	48	0	43	45	0	44	33	0
154	None	T	A-305	61	64	0	62	29	0	62	45	0	55	44	0	57	34	0
155	None	T	A-305	66	63	0	65	30	0	66	44	0	66	40	0	65	32	0
156	None	T	OS	66	74	0	68	29	0	63	46	0	66	31	0	66	35	0
157	None	T	OS	60	79	0	60	29	0	60	46	0	56	44	0	52	32	0
158	None	T	OS	52	67	10	53	33	10	53	52	10	52	45	15	53	66	10

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§§ Beam failed but left under exposure.

‖ Damaged when beam 147 failed, but left under exposure.

\# Some pulse velocity readings obtained in 1969 and 1970 are not believed to be valid due to the power limitations of the test equipment; these %V^2 readings are therefore questionable.

\## A pulse velocity reading was not obtained on this specimen.

(Revised August 1977)

Table 1-TC-B (Continued)

Section 2

Beach Row 1

				1973-1976 Readings											
				2624 Cycles, 1973			2760 Cycles, 1974			2872 Cycles, 1975			3018 Cycles, 1976		
Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	Condition	$\%V^2$	Max Crack Width 1/1000 in.	Condition	$\%V^2$	Max Crack Width 1/1000 in.	Condition	$\%V^2$	Max Crack Width 1/1000 in.	Condition	$\%V^2$	Max Crack Width 1/1000 in.
83	20,000	B	A-305	59	**	10	53	**	5	59	74	10	46	66	15
84	20,000	B	A-305	63		10	67		10	65	67	15	64	74	25
85	20,000	B	OS	72		25	71		20	71	72	25	66	73	20
86	20,000	B	OS	66		20	66		20	66	66	20	63	65	20
87	20,000	B	A-305	46		15	48		15	45	70	20	47	105	20
88	20,000	B	A-305	50		10	49		15	49	68	20	51	69	15
89	20,000	B	OS	64		20	66		20	65	76	25	64	76	25
90	20,000	B	OS	61		20	60		20	60	60	30	57	97	20
91	30,000	B	A-305	69		20	68		20	67	56	30	68	55	25
92	30,000	B	A-305	67		15	66		15	66	83	20	51	80	20
93	30,000	B	OS	64		25	66		40	64	53	35	64	53	50
94	30,000	B	OS	67		55	67		70	64	57	70	61	65	70
95	30,000	B	A-305	68		20	68		15	67	78	25	62	77	25
96	30,000	B	A-305	65		20	66		20	67	53	25	62	80	20
97	30,000	B	OS	63		40	63		30	61	59	50	62	58	40
98	30,000	B	OS	59		50	58		50	60	63	50	58	62	50
99	40,000	B	A-305	59		50	59		60	59	57	50	57	58	60
100	40,000	B	A-305	58		40	56		30	57	73	50	53	71	50
101	40,000	B	OS	58		60	60		70	60	53	75	58	52	75
102	40,000	B	OS	61		60	63		60	63	46	70	59	49	100
103	40,000	B	A-305	50		60	51		60	48	89	60	47	94	60
104	40,000	B	A-305	57		60	58		50	58	76	55	57	81	55
105	40,000	B	OS	69		50	70		50	68	110	55	64	108	70
106	40,000	B	OS	52		50	52		50	52	63	70	48	66	70
107	50,000	B	A-305	51		50	51		60	51	38	55	51	38	(1-in. spall)
108	50,000	B	A-305	55		50	52		50	54	37	55	57	38	(1/2-in. spall)
109	50,000	B	OS	66		60	66		70	66	62	60	64	126	(1-1/2 in. spall)
110	50,000	B	OS	55		60	55		60	53	57	60	55	100	75
111	50,000	B	A-305	51		40	50		50	51	83	50	49	92	75
112	50,000	B	A-305	63		60	62		70	58	74	60	61	103	75
113	50,000	B	OS	48		80	48		80	48	75	80	47	76	(1/4-in. spall)
114	50,000	B	OS	51		70	52		60	52	71	75	51	138	100
115	None	B	A-305	63		0	57		0	56	79		47	79	
116	None	B	A-305	65		0	58		0	57	82		55	79	
117	None	B	A-305	43		0	45		0	48	42		35	42	
118	None	B	OS	34		0	35		0	38	61		35	65	
119	None	B	OS	56		0	49		0	49	40		50	43	
120	None	B	OS	53		0	54		0	48	83		52	80	
121	20,000	T	A-305	74		30	72		25	72	97	35	72	98	25
122	20,000	T	A-305	69		20	68		15	67	90	25	69	102	30
123	20,000	T	OS	60		50	61		50	60	90	50	60	103	60
124	20,000	T	OS	64		40	64		40	62	86	50	61	81	50
125	20,000	T	A-305	60		25	59		20	56	55	30	57	56	30
126	20,000	T	A-305	76		25	77		25	74	57	30	75	58	30
127	20,000	T	OS	65		15	67		20	66	57	20	67	56	20
128	20,000	T	OS	58		10	67		10	64	61	20	68	59	15
129	30,000	T	A-305	54		50	52		40	54	75	50	52	98	50
130	30,000	T	A-305	63		50	63		50	63	70	60	61	111	65
131	30,000	T	OS	72		60	72		60	70	62	70	72	62	75
132	30,000	T	OS	59		60	59		60	58	71	60	51	83	75
133	30,000	T	A-305	60		50	61		50	58	83	50	57	78	50
134	30,000	T	A-305	64		60	64		50	64	60	65	62	61	75
135	30,000	T	OS	61		40	61		40	61	50	40	61	46	40
136	30,000	T	OS	65		20	65		30	62	82	30	63	86	30
137	40,000	T	A-305	49		80	50		70	49	66	85	49	67	90
138	40,000	T	A-305	56		75	55		80	56	68	75	55	67	75
139	40,000	T	OS	66		50	65		60	65	92	50	64	68	50
140	40,000	T	OS	67		45	67		40	67	65	55	66	67	60
141	40,000	T	A-305	53		60	53		60	52	75	60	58	105	60
142	40,000	T	A-305	53		40	59		50	54	70	50	61	86	50
143	40,000	T	OS	64		40	63		40	62	78	50	64	114	75
144	40,000	T	OS	61		60	61		70	55	72	65	59	91	(1/4-in. spall)
145	50,000	T	A-305	60		80	54		80	52	68	80	54	116	125
146	50,000	T	A-305	46		50	48		60	44	72	70	46	84	80

** Satisfactory pulse velocity readings were not obtained in 1973 and 1974.

Table 1-TC-B (Continued)

				1977- Readings		
				3095 Cycles, 1977		
Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	Condition	ΣV^2	Max Crack Width 1/1000 in.
83	20,000	B	A-305	22	80	15
84	20,000	B	A-305	60	74	25
85	20,000	B	OS	68	88	25
86	20,000	B	OS	65	69	25
87	20,000	B	A-305	46	66	20
88	20,000	B	A-305	51	53	20
89	20,000	B	OS	63	46	25
90	20,000	B	OS	58	59	25
91	30,000	B	A-305	68	60	25
92	30,000	B	A-305	65	84	25
93	30,000	B	OS	63	51	55
94	30,000	B	OS	63	68	70
95	30,000	B	A-305	60	76	25
96	30,000	B	A-305	64	86	25
97	30,000	B	OS	62	76	50
98	30,000	B	OS	59	63	50
99	40,000	B	A-305	56	92	60
100	40,000	B	A-305	56	72	55
101	40,000	B	OS	56	54	80
102	40,000	B	OS	58	53	100
103	40,000	B	A-305	47	86	60
104	40,000	B	A-305	64	62	60
105	40,000	B	OS	65	82	75
106	40,000	B	OS	66	69	70
107	50,000	B	A-305	50	46	(1-in. spall)
108	50,000	B	A-305	53	44	(5/8-in. spall)
109	50,000	B	OS	65	115	(1-1/2 in. spall)
110	50,000	B	OS	53	94	75
111	50,000	B	A-305	50	68	75
112	50,000	B	A-305	59	67	75
113	50,000	B	OS	47	79	(1/4-in. spall)
114	50,000	B	OS	51	101	100
115	None	B	A-305	51	78	
116	None	B	A-305	57	76	
117	None	B	A-305	59	44	
118	None	B	OS	44	64	
119	None	B	OS	55	43	
120	None	B	OS	54	79	
121	20,000	T	A-305	70	92	35
122	20,000	T	A-305	67	97	35
123	20,000	T	OS	59	65	60
124	20,000	T	OS	63	71	60
125	20,000	T	A-305	57	54	30
126	20,000	T	A-305	75	54	30
127	20,000	T	OS	66	68	20
128	20,000	T	OS	67	65	20
129	30,000	T	A-305	52	93	50
130	30,000	T	A-305	60	83	60
131	30,000	T	OS	70	49	75
132	30,000	T	OS	54	53	75
133	30,000	T	A-305	58	91	50
134	30,000	T	A-305	62	72	75
135	30,000	T	OS	61	43	40
136	30,000	T	OS	62	59	40
137	40,000	T	A-305	49	79	100
138	40,000	T	A-305	55	77	75
139	40,000	T	OS	65	89	55
140	40,000	T	OS	65	81	60
141	40,000	T	A-305	59	94	60
142	40,000	T	A-305	57	86	60
143	40,000	T	OS	62	81	75
144	40,000	T	OS	57	93	(3/8-in. spall)
145	50,000	T	A-305	52	89	125
146	50,000	T	A-305	47	73	80

Table 1-TC-B (Continued)

Beach Row 1

				1973-1976 Readings											
				2624 Cycles, 1973			2760 Cycles, 1974			2872 Cycles, 1975			3018 Cycles, 1976		
Beam No.	Nominal Stress psi	Steel Position	Type Steel Deformation	Condition	$\%V^2$	Max Crack Width 1/1000 in.	Condition	$\%V^2$	Max Crack Width 1/1000 in.	Condition	$\%V^2$	Max Crack Width 1/1000 in.	Condition	$\%V^2$	Max Crack Width 1/1000 in.
148	50,000	T	OS		##		Unloaded	##	--	--	--	--	--	--	--
149	50,000	T	A-305	68		75	66		500¶	61	73	500	61	100	(4-in. spall)
150	50,000	T	A-305	65		60	65		70	62	61	70	64	104	75
151	50,000	T	OS	57		70	58		70	57	62	60	56	63	(1/2-in. spall)
152	50,000	T	OS	54		60	54		55	51	52	50	53	52	50
153	None	T	A-305	44		0	36		0	16	50		26	52	
154	None	T	A-305	55		0	54		0	54	84		55	81	
155	None	T	A-305	76		0	65		0	61	82		65	81	
156	None	T	OS	52		0	27		0	25	83		22	81	
157	None	T	OS	52		0	51		0	49	83		50	90	
158	None	T	OS	51		0	50		0	50	74		51	79	(2-in. spall)

				1977- Readings		
				3095 Cycles, 1977		
				Condition	$\%V^2$	Max Crack Width 1/1000 in.
148	50,000	T	OS	--	--	--
149	50,000	T	A-305	64	67	(4-in. spall)
150	50,000	T	A-305	63	65	75
151	50,000	T	OS	53	63	(5/8-in. spall)
152	50,000	T	OS	53	67	50
153	None	T	A-305	29	53	
154	None	T	A-305	55	74	
155	None	T	A-305	65	82	
156	None	T	OS	23	82	
157	None	T	OS	54	80	
158	None	T	OS	50	68	

\## Satisfactory pulse velocity readings were not obtained in 1973 and 1974.

¶ One rebar failed during winter of 1973-1974.

Stewart Field Spheres*

Twenty-four air-entrained concrete spheres were installed on the beach at Treat Island in May 1954 for soniscope studies. These spheres are 12 in. in diameter and were fabricated in March and April of 1943. They had previously been exposed at Treat Island during the period from October 1943 to May 1949 as a part of the Stewart Field Program. This previous exposure (approximately 600 cycles of freezing-and-thawing) had no appreciable effect on the spheres. Spheres were selected for this exposure primarily because the concrete in a sphere is in a relatively stress-free condition with no corners.

Table 1-SF lists these specimens and gives their exposure record along with pertinent mixture data.

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* See Corps of Engineers, Central Concrete Laboratory, Concrete Investigation, Stewart Field, Newburgh, New York, First Interim Report (March 1943); Second Interim Report (April 1943); Final Report (April 1944).

(Revised Aug 1974)

Table 1-SF

Mixture Data and Record of Testing of Stewart Field Spheres

1954- (Installed May 1954)

Exposure Rack, Row 9 (W to E)

						1954-1962 Readings										
	Aggregate Combination					1954										
Sphere No.	Fine	Coarse	Water-Cement Ratio gal/bag	Cement Factor bags/cu yd	Air %	Pulse Veloc fps	$\%V^2$	1955 $\%V^2$	1956 $\%V^2$	1957 $\%V^2$	1958 $\%V^2$	1959 $\%V^2$	1960 $\%V^2$	1961 $\%V^2$	1962 $\%V^2$
11A	Nat. sand A	Nat. gravel A	4.5	7.2	3.2	14,925	100	94	106	103	113	*			
11B	Nat. sand A	Nat. gravel A	4.5	7.1	4.0	14,085	100	109	131	97	123	105	102	123	119
11G	Nat. sand A	Nat. gravel A	4.5	7.0	2.9	13,890	100	112	127	116	131	103	109	119	115
12D	Nat. sand A	Nat. gravel A	5.0	6.2	2.3	14,925	100	97	117	94	94	87	92	117	94
13D	Nat. sand A	Nat. gravel A	5.5	5.3	4.7	16,665	100	100	111	94	100	85	91	103	73
21A	Crushed	Nat. gravel A	4.5	7.3	4.5	14,495	100	106	109	106	116	106	113	137	113
21B	Crushed	Nat. gravel A	4.5	7.3	4.3	14,925	100	100	128	109	124	113	124	125	117
22A	Crushed	Nat. gravel A	5.0	6.4	4.8	13,700	100	106	119	116	123	113	120	130	139
22B	Crushed	Nat. gravel A	5.0	6.4	4.7	13,335	100	118	115	115	109	115	132	162	133
23A	Crushed	Nat. gravel A	5.5	5.6	4.5	14,085	100	106	123	106	119	100	106	135	131
23B	Crushed	Nat. gravel A	5.5	5.6	4.6	13,890	100	112	127	116	127	106	109	135	140
31D	Nat. sand B	Nat. gravel A	4.5	6.5	4.3	14,925	100	106	121	110	125	110	110	121	113
33D	Nat. sand B	Nat. gravel A	5.5	5.0	4.8	13,890	100	115	131	112	135	107	100	139	135
52D	Blend A	Nat. gravel A	5.0	5.9	3.8	14,495	100	109	132	106	109	106	Failed		
53A	Blend B	Nat. gravel A	5.5	5.2	5.1	13,890	100	112	127	116	120	110	120	131	131
53E	Blend A	Nat. gravel A	5.5	5.1	4.3	13,890	100	115	135	116	123	107	119	127	103
71A	Crushed	Rock C	4.5	7.4	6.8	18,520	100	87	90	90	100	76	87	96	93
73D	Crushed	Rock C	5.5	5.8	2.9	17,240	100	97	104	104	108	94	97	111	100
81A	Nat. sand B	Rock C	4.5	7.0	4.9	16,665	100	97	123	110	114	96	106	124	85
83A	Nat. sand B	Rock C	5.5	5.3	7.7	16,950	100	73	100	88	100	97	83	85	85
83D	Nat. sand B	Rock C	5.5	5.3	4.1	16,395	100	103	128	111	100	85	94	107	66
83E	Nat. sand B	Rock C	5.5	5.3	3.9	16,395	100	103	128	111	123	97	104	123	83
92E	Blend C	Rock C	5.0	6.3	3.9	16,130	100	114	127	110	122	103	114	132	110
13G	Nat. sand A	Nat. gravel A	5.5	5.2	3.8	15,385	100	89	106	94	**	114	94	106	94

Exposure Rack, Row 9 (W to E)

						1963-1972 Readings									
						1963 $\%V^2$	1964 $\%V^2$	1965 $\%V^2$	1966 $\%V^2$	1967 $\%V^2$	1968 $\%V^2$	1969 $\%V^2$	1970 $\%V^2$	1971 $\%V^2$	1972 $\%V^2$
11B	Nat. sand A	Nat. gravel A	4.5	7.1	4.0	90	112	119	†	87	119	123	103	83	58
11G	Nat. sand A	Nat. gravel A	4.5	7.0	2.9	87	61	87		Failed					
12D	Nat. sand A	Nat. gravel A	5.0	6.2	2.3	106	103	121		82	92	89	87	33	43
13D	Nat. sand A	Nat. gravel A	5.5	5.3	4.7	83	115	119		64	85	91	78	48	47
21A	Crushed	Nat. gravel A	4.5	7.3	4.5	132	128	157		61	120	120	113	76	69
21B	Crushed	Nat. gravel A	4.5	7.3	4.3	110	117	143		62	106	109	106	64	80
22A	Crushed	Nat. gravel A	5.0	6.4	4.8	130	139	139		37	85	88	83	81	100
22B	Crushed	Nat. gravel A	5.0	6.4	4.7	151	146	125		103	90	55	50	Failed	
23A	Crushed	Nat. gravel A	5.5	5.6	4.5	123	112	123		79	119	116	103	85	65
23B	Crushed	Nat. gravel A	5.5	5.6	4.6	131	135	140		106	149	139	109	85	75
31D	Nat. sand B	Nat. gravel A	4.5	6.5	4.3	117	117	106		41	40	Failed			
33D	Nat. sand B	Nat. gravel A	5.5	5.0	4.8	127	127	139		92	131	109	95	Failed	
53A	Blend B	Nat. gravel A	5.5	5.2	5.1	127	127	135		77	123	112	103	85	47
53E	Blend A	Nat. gravel A	5.5	5.1	4.3	123	123	135		87	139	106	100	83	49
71A	Crushed	Rock C	4.5	7.4	6.8	96	87	90		36	71	46	43	19	NR
73D	Crushed	Rock C	5.5	5.8	2.9	111	50	69		Failed					
81A	Nat. sand B	Rock C	4.5	7.0	4.9	138	103	97		30	46	25	NR	Failed	
83A	Nat. sand B	Rock C	5.5	5.3	7.7	91	82	Failed							
83D	Nat. sand B	Rock C	5.5	5.3	4.1	97	63	33		Failed					
83E	Nat. sand B	Rock C	5.5	5.3	3.9	88	85	49		13	Failed				
92E	Blend C	Rock C	5.0	6.3	3.9	127	123	154		74	131	123	103	78	53
13G	Nat. sand A	Nat. gravel A	5.5	5.2	3.8	110	110	114		58	114	86	77	61	51

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* Specimen 11A disappeared between May 1958 and May 1959.

** This specimen could not be found to test in 1958, but it was later found in another location on the beach and reinstalled.

† Satisfactory pulse velocity readings were not obtained in 1966 due to malfunction of testing equipment.

NR A satisfactory reading was not obtained although an attempt was made to obtain one.

(Revised August 1977)

Table 1-SF (Continued)

Exposure Rack, Row 9 (W to E)

Sphere No.	Aggregate Combination		Water-Cement Ratio gal/bag	Cement Factor bags/cu yd	Air %	1973- Readings				
	Fine	Coarse				1973 $\%V^2$	1974 $\%V^2$	1975 $\%V^2$	1976 $\%V^2$	1977 $\%V^2$
11B	Nat. sand A	Nat. gravel A	4.5	7.1	4.0	52	49	33	NR	Failed
12D	Nat. sand A	Nat. gravel A	5.0	6.2	2.3	NR	NR	NR	NR	NR
13D	Nat. sand A	Nat. gravel A	5.5	5.3	4.7	NR	NR	NR	NR	NR
21A	Crushed	Nat. gravel A	4.5	7.3	4.5	66	60	80	73	73
21B	Crushed	Nat. gravel A	4.5	7.3	4.3	78	76	72	62	65
22A	Crushed	Nat. gravel A	5.0	6.4	4.8	95	93	88	81	83
23A	Crushed	Nat. gravel A	5.5	5.6	4.5	62	62	70	65	62
23B	Crushed	Nat. gravel A	5.5	5.6	4.6	43	40	67	61	63
53A	Blend B	Nat. gravel A	5.5	5.2	5.1	NR	NR	NR	Failed	
53E	Blend A	Nat. gravel A	5.5	5.1	4.3	NR	NR	NR	Failed	
71A	Crushed	Rock C	4.5	7.4	6.8	Failed				
92E	Blend C	Rock C	5.0	6.3	3.9	NR	NR	NR	Failed	
13G	Nat. sand A	Nat. gravel A	5.5	5.2	3.8	NR	NR	NR	Failed	

NR A satisfactory reading was not obtained although an attempt was made to obtain one.

Cement-Replacement Materials Investigation, Phase B*

In December 1953, 21 concrete prisms (18 by 18 by 36 in.) were installed at half-tide elevation on the beach at Treat Island as a part of Phase B of the Cement-Replacement Materials Investigation.* Phase B involved the proportioning, outdoor mixing, and placing of mass concrete, using 2-cu-yd batching, mixing, and placing equipment. The purpose of this installation is to develop information about the durability of Phase B concretes.

The prisms were made from seven different concrete mixtures (3 prisms per mixture); the coarse and fine aggregate used in all mixtures was a crushed limestone. All concrete mixtures were air-entrained; the air-entraining admixture was admixture G. The mixture data are tabulated below. Table 1-CRMI-PB lists the concrete specimens exposed as a part of this program and gives their exposure record,

Mixture Data

Mix No.	Date Cast 1953	Portland Cement Type	Portland Cement % Used	Replacement Material Type	Replacement Material % Used	Max Size Coarse Aggr	Cement Factor bags/cu yd	Water-Cement Ratio by wt	Slump in.	Air* %	Specimen No.
a	4-7	II	100	None	None	6 in.	2.52	0.8	2-1/4	6.0	B-10
									2-3/4	6.7	B-11
									3-1/4	5.1	B-12
b	4-14	II	100	None	None	3 in.	2.91	0.8	3/4	5.9	B-30
									2-1/2	6.8	B-31
									1-1/2	5.6	B-32
c	4-28	II	100	None	None	3 in.	4.76	0.5	2-1/2	7.2	B-61
									1-1/2	2.5	B-62
									1/4	1.2	B-63
d	4-21	II	55**	Fly ash	45**	6 in.	2.16	0.8	2	5.4	B-46
									1-1/2	4.8	B-47
									2-1/2	5.0	B-48
e	5-19	II	65**	Nat. cem	35**	6 in.	2.33	0.8	1-1/2	5.3	B-109
									3	5.7	B-110
									3-1/4	5.2	B-111
f	5-6	II	55**	Fly ash	45**	3 in.	2.49	0.8	2-1/2	5.7	B-77
									2-1/2	5.4	B-78
									2	5.9	B-79
g	5-12	II	65**	Nat. cem	35**	3 in.	2.68	0.8	1/2	6.0	B-93
									2	7.2	B-94
									2	6.3	B-95

* Air content of that portion of the concrete containing aggregate smaller than 1-1/2 in. in size.
** Per cent by solid volume.

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* See U. S. Army Engineer Waterways Experiment Station, CE, Investigation of Cement-Replacement Materials; Preliminary Field Investigations (Phase B), Miscellaneous Paper No. 6-123, Report No. 4 (Vicksburg, Miss., April 1956).

(Revised May 1976)

Table 1-CRMI-PB

Record of Testing of Prisms Made for Cement-Replacement Materials Investigation, Phase B, 1953- (Installed December 1953)

Beach Row 2

				1953-1963 Readings										
Mix No.	Specimen No.	Portland Cement %	Max Aggr Size in.	0 Cycles 1953 $\%V^2$	110 Cycles 1954 $\%V^2$	255 Cycles 1955 $\%V^2$	422 Cycles 1956 $\%V^2$	566 Cycles 1957 $\%V^2$	637 Cycles 1958 $\%V^2$	787 Cycles 1959 $\%V^2$	858 Cycles 1960 $\%V^2$	999 Cycles 1961 $\%V^2$	1088 Cycles 1962 $\%V^2$	1194 Cycles 1963 $\%V^2$
a	B-10	100	6	100	100	106	111	96	101	88	90	85	Failed	
	B-11			100	107	115	114	108	108	104	102	99	75	92
	B-12			100	106	113	112	105	106	103	98	92	Failed	
b	B-30	100	3	100	94	100	100	92	95	95	97	94	102	97
	B-31			100	93	97	98	92	94	88	89	93	88	86
	B-32			100	94	98	97	93	93	88	94	93	90	95
c	B-61	100	3*	100	88	97	97	91	93	90	93	91	97	99
	B-62			100	63**	95	94	90	93	87	89	92	88	92
	B-63			100	62**	97	99	91	93	88	93	91	93	87
d	B-46	55†	6	100	86	92	79	59	††	††	††	††	Failed	
	B-47			100	90	97	97	85	91	††	††	††	Failed	
	B-48			100	94	99	96	93	96	83	††	††	††	††
e	B-109	65‡	6	100	95	98	99	89	91	74	75	66	Failed	
	B-110			100	93	99	97	88	90	82	83	81	65	82
	B-111			100	95	100	99	93	96	85	91	89	90	84
f	B-77	55†	3	100	95	101	104	93	94	††	††	††	††	††
	B-78			100	106	103	103	94	92	88	††	††	††	††
	B-79			100	94	101	99	97	89	††	††	††	††	††
g	B-93	65‡	3	100	92	96	102	91	95	86	92	90	90	90
	B-94			100	94	101	99	98	93	91	95	91	91	90
	B-95			100	96	100	98	94	90	87	89	88	76	81

				1964-1975 Readings											
				1329 Cycles 1964 $\%V^2$	1492 Cycles 1965 $\%V^2$	1622 Cycles 1966 $\%V^2$	1778 Cycles 1967 $\%V^2$	1963 Cycles 1968 $\%V^2$	2117 Cycles 1969 $\%V^2$	2270 Cycles 1970 $\%V^2$	2439 Cycles 1971 $\%V^2$	2596 Cycles 1972 $\%V^2$	2736 Cycles 1973 $\%V^2$	2782 Cycles 1974 $\%V^2$	2894 Cycles 1975 $\%V^2$
a	B-11	100	6	81	75	‡‡	66	73	††	††					
b	B-30	100	3	90	92	82	93	93	89	84	68	68	§	81	76
	B-31			79	80	65	73	77	69	65	55	NR	§	74	85
	B-32			88	87	73	86	88	79	72	67	70	§	88	93
c	B-61	100	3*	93	106	91	95	92	91	86	88	88	§	116	102
	B-62			94	95	87	86	86	78	74	66	73	§	103	100
	B-63			89	49	Failed									
d	B-48	55†	6	††	Failed										
e	B-110	65‡	6	72	64	57	59	59	20	††					
	B-111			77	74	58	66	67	58	††					
f	B-77	55†	3	††	Failed										
	B-78			††	Failed										
	B-79			††	Failed										
g	B-93	65‡	3	95	92	83	92	91	88	79	77	78	§	88	90
	B-94			82	77	75	71	74	69	65	Failed				
	B-95			69	64	63	58	59	57	54	Failed				

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* Water-cement ratio (by wt), 0.5; that of all other specimens, 0.8.

** These two values are inconsistent with previous and subsequent readings and are presumed incorrect.

† 45% fly ash used as replacement material.

†† End of specimen too rough to obtain satisfactory reading.

‡ 35% natural cement used as replacement material.

‡‡ Satisfactory pulse velocity reading was not obtained on this prism in 1966; the reading obtained was spurious and was thrown out.

§ Satisfactory pulse velocity reading was not obtained on this specimen in 1973 due to equipment malfunction.

Table 1-CRMI-PB (Continued)

Record of Testing of Prisms Made for Cement-Replacement Materials Investigation, Phase B, 1953- (Installed December 1953)

Beach Row 2

				1976- Readings	
Mix No.	Specimen No.	Portland Cement %	Max Aggr Size in.	3040 Cycles 1976 $\%V^2$	3117 Cycles 1977 $\%V^2$
a	B-11	100	6		
b	B-30	100	3	75	70
	B-31			89	61
	B-32			91	101
c	B-61	100	3*	96	108
	B-62			96	97
	B-63				
d	B-48	55†	6		
e	B-110	65‡	6		
	B-111				
f	B-77	55†	3		
	B-78				
	B-79				
g	B-93	65‡	3	88	90
	B-94				
	B-95				

(Sheet 2)

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* Water-cement ratio (by wt), 0.5; that of all other specimens, 0.8.

† 45% fly ash used as replacement material.

‡ 35% natural cement used as replacement material.

Table 1-CERL-FC

Record of Testing of Concrete Beams for CERL Fibrous Concrete Program

Installed January 1975

Rack Row 3

			1975- Readings								
			Jan 1975 0 cycles			Jun 1975 66 cycles		1976 212 cycles		1977 289 cycles	
Mix No.	Beam No.	Flaw in.	%E	fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
0-1	0	0	100	14,150	100	110	161	110	102	110	94
	1	0	100	14,000	100	104	145	109	104	109	87
	2	0	100	13,855	100	105	148	††			
	3	H.L.*	100	13,040	100	**	**	††			
	4	1/16†	100	13,435	100	**	**	††			
	5	1/8	100	13,300	100	**	**	††			
0-2	10	0	100	13,435	100	102	157	103	94	105	94
	11	0	100	13,570	100	100	158	99	100	101	94
	12	0	100	13,435	100	101	165	††			
	13	H.L.	100	13,300	100	101	160	††			
	14	1/16	100	12,545	100	85	176	††			
	15	1/8	100	12,545	100	90	156	††			
0-3	20	0	100	14,150	100	104	153	104	104	108	94
	21	0	100	14,300	100	104	154	105	96	109	94
	22	0	100	14,150	100	101	157	††			
	23	H.L.	100	13,855	100	100	168	††			
	24	1/16	100	13,435	100	79	161	††			
	25	1/8	100	13,570	100	93	150	††			
0-4	30	0	100	13,855	100	101	155	111	96	111	102
	31	0	100	13,570	100	108	154	113	106	115	89
	32	0	100	13,855	100	102	160	††			
	33	H.L.	100	13,435	100	102	153	††			
	34	1/16	100	13,040	100	100	159	††			
	35	1/8	100	12,915	100	78	170	††			
0-5	40	0	100	14,150	100	100	161	114	112	113	98
	41	0	100	14,150	100	103	157	104	107	109	98
	42	0	100	14,000	100	101	174	††			
	43	H.L.	100	13,855	100	97	164	††			
	44	1/16	100	13,170	100	77	172	††			
	45	1/8	100	12,915	100	72	158	††			

* Hairline crack.

** Unable to obtain reading in June 1975.

† In two pieces.

†† Shipped to CERL in July 1976 for laboratory tests.

CERL Fibrous Concrete Program

In January 1975, 30 concrete beams (3-1/2 by 4-1/2 by 16 in.) were installed at half-tide elevation on the exposure rack at Treat Island, Maine, to determine the effects of the seawater and the freezing and thawing action on the flexural strength and other properties of various fiber concretes. Half the beams were cracked for testing.

The beams were made from five different concrete mixtures (6 beams per mixture); natural coarse (3/8-in. max) and fine aggregate were used in all mixtures. All mixtures were air-entrained (admixture A), and a water-reducing admixture (admixture B) was used in all mixtures. Type III portland cement was used in the amount of 8.0 cwt per cu yd with a water-cement ratio of 0.5 in all mixtures. Concrete mixture data are tabulated below. Table 1-CERL-FC gives the exposure record of the specimens.

Concrete Mixture Data

Mixture	Fiber Type	Fiber Length, in.	Slump, In.	Air Content %	Fiber Ratio by Wt
0-1	A	1/2	0	10.0	0.01
0-2	B	1	1	8.0	0.02
0-3	C	1	8	3.5	0.05
0-4	D	--	0	4.5	0.05
0-5	E	2-1/2	7	2.5	0.05

Prestressed Concrete Program

The purpose of this installation is to develop information on the effect of prestressing on the durability of concrete beams.

In October 1958, 16 prestressed (pretensioned) concrete beams (4-1/2 by 9 by 81 in.) were installed at half-tide elevation on the beach at Treat Island. Each beam contains nine nominal 1/4-in. (1 by 7) strands of high-strength steel wire. In 14 of the 16 beams the strands were tensioned to approximately 70% of their ultimate strength prior to placement of the concrete around them (approximately 3 tons each strand); the strands in the other two beams were not tensioned. Each of these 16 beams contains four sets of gage points with which strains are measured. Twelve of the 16 beams are loaded flexurally (third-point) in pairs. Two intensities of loading are used; in one case the compression due to prestressing is just balanced (100%), and in the other case the compression is exceeded so that approximately 200-psi tension exists in the bottom fibers of the beams (108%). The other four beams are nonloaded controls.

The concrete mixtures represented both air-entrained (admixture II) and nonair-entrained concrete of the following characteristics:

Water-cement Ratio gal/bag	Cement	Nominal Compressive Strength psi	Slump, in.	Cement Factor bags/cu yd
5.85-6.22	Type III (high-early)	6000	1-3/4 ± 1/2	6.1-6.3

The aggregates used were manufactured limestone sand and limestone rock (3/4-in. maximum size).

Table 1-PR lists these specimens and gives their exposure record along with other pertinent information.

Eight additional prestressed beams (4-1/2 by 9 by 81 in.) are exposed in the laboratory as control beams (loaded and nonloaded).

In addition, in October 1958, 72 conventional concrete beams (3-1/2 by 4-1/2 by 16 in.) were installed on the Treat Island exposure rack to determine the field durability of the concrete mixes. These beams were fabricated from the same concrete batches (3 beams from each of 24 batches) as the large beams, and therefore have the same mixture characteristics.

Table 2-PR lists these specimens and gives their exposure record along with other pertinent information.

Companion specimens to the small beams (3-1/2 by 4-1/2 by 16 in.) were subjected to freezing-and-thawing tests in the laboratory. The results of these tests are given below:

Batch No.	Avg %E at 300 Cycles	Batch No.	Avg %E at 300 Cycles
1	92	13	93
2	89	14	90
3	64	15	4
4	86	16	3
5	91	17	91
6	86	18	70
7	89	19	91
8	84	20	91
9	89	21	87
10	95	22	89
11	88	23	5
12	93	24	5

St. Augustine Installation (1959)

In October 1959, three prestressed (pretensioned) concrete beams (4-1/2 by 9 by 81 in.) were installed on the exposure rack at St. Augustine, Fla. Each beam contains nine nominal 1/4-in. (1 by 7) strands of high-strength steel wire. The strands in all three beams were tensioned to approximately 70% of their ultimate strength prior to placement of the concrete around them (approximately 3 tons per strand). Each beam also contains four sets of gage points for length change measurements. At installation, two of the beams were yoked together and loaded flexurally (third point) until cracks appeared in both beams. The other beam is an unloaded control.

The concrete mixture used in these beams was air-entrained (admixture M) concrete of the following characteristics:

Cement	Air Content %	Water-cement Ratio gal/bag	Nominal Compressive Strength psi	Slump, in.	Cement Factor bags/cu yd
Type III (high-early)	4.3-4.8	5.85	6000	1-3/4 ± 1/2	6.00-6.03

The aggregates used were manufactured limestone sand and limestone rock (3/4-in. maximum size).

Table 3-PR lists these specimens and gives their exposure record.

Posttensioned Phase (1961 Installation)

The primary purpose of this installation is the exposure testing of end anchorages and end-anchorage protection for several systems of posttensioning. While not being introduced as variables the following additional effects will be observed and studied in the beam specimens:

- a. Durability of thin web sections
- b. Behavior of grout
- c. Exposure effects on posttensioning steel and conventional reinforcing steel
- d. Effect of eccentricity of loading

In June 1961, 20 posttensioned beams (nominal size, 10- by 16- by 96-in.) were installed at half-tide elevation on the beach at Treat Island. These beams represent four typical posttensioning systems: Systems A and B (six beams each), Systems C and D (four beams each). Each beam contains one sheathed steel tendon* which was stressed in accordance with the recommendations of the particular system. The end-anchorage components of all beams are provided with 1-1/2 in. of cover. This cover consists of either air-entrained concrete, sand-cement mortar, or epoxy concrete.

The concrete beams are made of air-entrained concrete and in addition to the posttensioning steel, contain steel for reinforcing. This reinforcing has been provided with 3/4 ± 1/4 in. of cover.

The concrete mixtures in the test beams proper (excluding grout and anchorage protection) have the following characteristics:

Cement	Air Content %	Water-cement Ratio (by wt)	Nominal Compressive Strength psi	Slump, in.	Cement Factor bags/cu yd
Type III (high-early)	4.0-5.0	0.52 (5.85 gal/bag)	6000	1-1/2 to 2	5.98-6.05

The aggregates used in the test beams proper were manufactured limestone sand and limestone rock (3/4-in. maximum size).

The concrete mixtures used for end-anchorage protection contained the same aggregates and have the following characteristics:

Cement	Air Content %	Water-cement Ratio (by wt)	Nominal Compressive Strength psi	Slump, in.	Cement Factor bags/cu yd
Type III (high-early)	3.5-5.0	0.80 (9.03 gal/bag)	3000	1-1/4 to 2	3.90-3.96

The sand-cement mortar used for end-anchorage protection contained manufactured limestone sand and had the following characteristics:

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* All tendons except that of beam 13 were grouted.

Cement	Water-cement Ratio (by wt)	28-day Compressive Strength psi	Cement Factor bags/cu yd
Type III (high-early)	0.44 (4.97 gal/bag)	6930-10,400	10.90

The epoxy concrete used for end-anchorage protection contained the same limestone aggregates and had the following characteristics:

Cement	Max Aggr Size, in.	Mixture Proportions (by wt) Epoxy Binder:Sand:Coarse Aggregate	28-day Compressive Strength psi
None	3/4	2.83:7.00:10.00	9320-11,320

The steel tendon in 19 of the 20 test beams was pressure-grouted after posttensioning using a grout of the following characteristics:

Cement	Water-cement Ratio (by wt)	7-day Compressive Strength psi	3-day Expansion %
Type III (high-early)	0.40-0.49 (4.51-5.53 gal/bag)	3640-7400	0-7

The grout used for beam 14 contained a natural sand (100% passing No. 30 sieve). All grouts contained a small amount of aluminum powder.

This program of investigation is being conducted in cooperation with the Reinforced Concrete Research Council, and the test beams and variables were designed in accordance with their recommendations.

Tables 4-PR, 5-PR, and 6-PR give additional information and exposure records of these beams.

Reports Published

Four U. S. Army Engineer Waterways Experiment Station reports concerned with the prestressed concrete program have been issued since 1958. These reports are listed below:

a. Roshore, E. C., "Durability and Behavior of Prestressed Concrete Beams; Pretensioned Concrete Investigation, Progress to July 1960," Technical Report No. 6-570, Report 1, June 1961, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

b. __________, "Durability and Behavior of Pretensioned-Prestressed Concrete Beams," Miscellaneous Paper No. 6-611, December 1963, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

c. __________, "Durability of Prestressed Concrete Beams," Miscellaneous Paper No. 6-665, July 1964, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

d. __________, "Durability and Behavior of Prestressed Concrete Beams; Posttensioned Concrete Investigation, Progress to July 1966," Technical Report No. 6-570, Report 2, March 1967, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

(Revised Sept 1968)

Table 1-PR

Record of Testing of Large, Prestressed Beams

Treat Island Exposure

1958- (Installed October 1958)

Beach Row 2 (W to E)

				1958-1961 Readings							
				0 Cycles 1958		150 Cycles, 1959		221 Cycles, 1960		362 Cycles, 1961	
Beam* No.	Type Concrete	Strands Pretensioned	Loaded Flexurally, %	Pulse Veloc fps	$\%V^2$	$\%V^2$	Condition†	$\%V^2$	Condition†	$\%V^2$	Condition†
3**	Air	No	0	15,100	100	106	2	108	1	104	3
4	Air	No	0	15,235	100	106	1	107	1	105	4
7**	Air	Yes	0	15,270	100	102	1	103	2	103	4
8	Air	Yes	0	15,205	100	104	1	107	2	105	4
11**	Air	Yes	108	15,235	100	106	1	105	1	106	4
12	Air	Yes	108	15,135	100	105	1	106	2	106	4
13**	Air	Yes	108	15,170	100	104	1	104	2	109	4
14	Air	Yes	108	15,555	100	104	1	104	2	104	4
15	Plain	Yes	108	15,375	100	Failed					
16	Plain	Yes	108	15,375	100	Failed					
19**	Air	Yes	100	14,965	100	107	1	107	2	107	4
20	Air	Yes	100	15,205	100	106	1	108	1	105	4
21	Air	Yes	100	15,340	100	106	1	107	2	105	3
22**	Air	Yes	100	15,270	100	106	1	104	1	104	3
23	Plain	Yes	100	15,445	100	Failed					
24	Plain	Yes	100	15,590	100	Failed					

				1962-1965 Readings							
				451 Cycles 1962		557 Cycles 1963		692 Cycles 1964		855 Cycles 1965	
				$\%V^2$	Condition†	$\%V^2$	Condition†	$\%V^2$	Condition†	$\%V^2$	Condition†
3**	Air	No	0	105	3	111	4	100	9	103	††
4	Air	No	0	104	4	111	4	157	11	105	
7**	Air	Yes	0	102	4	109	4	102	18	109	
8	Air	Yes	0	97	3	105	4	100	12	72	
11**	Air	Yes	108	99	3	107	4	99	4	104	
12	Air	Yes	108	96	3	107	4	100	4	105	
13**	Air	Yes	108	98	3	107	4	101	6	110	
14	Air	Yes	108	94	3	104	4	103	3	104	
19**	Air	Yes	100	98	3	110	4	103	4	108	
20	Air	Yes	100	97	3	104	3	108	3	102	
21	Air	Yes	100	94	3	105	3	99	3	105	
22**	Air	Yes	100	96	3	119	4	100	5	99	

(Continued)

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* For purposes of comparison with the results of tests of the small beams listed in table 2-PR, it should be noted that the beam numbers of the large beams are also their batch numbers.

** In June 1963 epoxy pads were removed from both ends of one beam in each pair. This was done to equalize exposure conditions as some epoxy pads had become disengaged.

† The condition of these specimens is adjudged either annually or biennially by a panel of observers. The beams are examined carefully for cracks, cracks bordered by iron stain, degree of surface scaling (light, moderate, or heavy), rust spots, etc., and a numerical value of condition is assigned to each beam based on the severity of the defects observed. A numerical value of 0 denotes perfect condition; all beams had a condition rating of 0 when they were installed. The higher the condition numerical rating, the greater the deterioration. When a beam breaks in two due to load or accumulates a condition rating of 100 it is considered to have failed.

†† In 1965 the condition of the specimens was not rated by a panel of observers.

(Revised Jan 1973)

Table 1-PR (Continued)

Beach Row 2 (W to E)

				1966-1967 Readings					
				985 Cycles, 1966		1141 Cycles, 1967			
						%V^2			
Beam No.	Type Concrete	Strands Pretensioned	Loaded Flexurally %	%V^2	Condition	Before Unloading‡‡	Not Loaded	After Reloading	Condition
3	Air	No	·0	‡	11		101		§§
4	Air	No	0		20		100		
7	Air	Yes	0		24		105		
8	Air	Yes	0		24		103		
11	Air	Yes	108		4	Failed (Condition rating = 100)			
12	Air	Yes	108		5	104		(Not reloaded)§	
13	Air	Yes	108		5	106		100	
14	Air	Yes	108		4	107		100	
19	Air	Yes	100		6	Failed (Condition rating = 100)			
20	Air	Yes	100		18	107		(Not reloaded)§	
21	Air	Yes	100		6	106		101	
22	Air	Yes	100		4	106		99	

Beach Row 2 (W to E)

				1968-1971 Readings							
				1326 Cycles, 1968		1480 Cycles, 1969		1633 Cycles, 1970		1802 Cycles, 1971	
				%V^2	Condition	%V^2	Condition	%V^2	Condition	%V^2	Condition
3	Air	No	0	104	11	101	8	98	5	89	5
4	Air	No	0	103	34 (Returned to laboratory in 1968)						
7	Air	Yes	0	100	36	100	34	96	27	Failed	100
8	Air	Yes	0	104	36 (Returned to laboratory in 1968)						
12	Air	Yes	108	89	6	95	7	94	14	86	20
13	Air	Yes	108	Failed	100						
14	Air	Yes	108	99	4	91	7	89	7	78	12
20	Air	Yes	100	96	19	‖	27	‖	73	Failed	100
21	Air	Yes	100	100	6	96	4	93	5	‖ ‖	6
22	Air	Yes	100	100	4	92	4	90	5	72	6

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‡ Satisfactory pulse velocity readings were not obtained in 1966 due to malfunction of testing equipment.

‡‡ Channel iron on all loaded beams was replaced with stainless steel channel in June 1967. Pulse velocity readings were therefore taken on all loaded beams before unloading and after reloading with stainless steel channel.

§ Due to failure of companion beam.

§§ In 1967 the condition of the specimens was not rated by a panel of observers.

‖ End of specimen was too rough to obtain satisfactory pulse velocity reading.

‖ ‖ Reading could not be obtained.

Table 1-PR (Concluded)

Beach Row 2 (W to E)

				1972 Reading	
			Loaded	1959 Cycles, 1972	
Beam No.	Type Concrete	Strands Pretensioned	Flexurally %	$\%V^2$	Condition
3	Air	No	0	#	#
12	Air	Yes	108		
14	Air	Yes	108		
21	Air	Yes	100		
22	Air	Yes	100		

Readings discontinued after 1971 inspection.

(Revised Sept 1967)

Table 2-PR

Record of Testing of Small, Conventional Beams Made from Same Concrete Batches as Large Beams

Treat Island Exposure

1958- (Installed October 1958)

Exposure Rack, Row 3 (W to E)

			1958- Readings									
Beam No.	Batch No.	Type Concrete	0 Cycles 1958 %E	150 Cycles 1959 %E	221 Cycles 1960 %E	362 Cycles 1961 %E	451 Cycles 1962 %E	557 Cycles 1963 %E	692 Cycles 1964 %E	855 Cycles 1965 %E	985 Cycles 1966 %E	1141 Cycles 1967 %E
6770	1	Air	100	108	109	102	105	106	104	104	104	104
6772			100	105	102	97	101	102	99	99	101	102
6774			100	104	103	98	102	101	100	100	101	103
6776	2	Air	100	103	101	95	98	98	97	96	94	94
6778			100	108	105	99	102	103	100	100	100	99
6780			100	109	106	100	103	103	99	100	101	101
6782	3	Air	100	106	103	98	98	98	100	99	98	100
6784			100	107	105	99	105	106	100	100	99	99
6786			100	108	105	98	103	103	100	99	99	100
6788	4	Air	100	104	102	96	100	98	97	96	97	96
6790			100	106	105	99	101	103	99	100	101	103
6792			100	108	106	100	103	103	101	102	103	104
6804	5	Air	*									
6806			100	107	105	99	103	103	99	100	100	101
6808			100	107	105	99	102	96	98	99	97	98
6810	6	Air	*									
6812			100	106	103	97	100	99	95	94	94	95
6814			100	105	103	98	101	101	104	101	97	98
6816	7	Air	100	109	103	95	97	97	94	93	91	91
6818			100	106	101	93	93	93	91	90	88	89
6820			100	104	100	91	92	91	87	86	86	87
6822	8	Air	100	104	101	95	98	96	96	94	94	93
6824			100	101	99	93	95	88	91	91	90	91
6826			100	104	102	96	97	91	89	88	86	86
6828	9	Air	100	108	105	99	99	101	97	93	95	95
6830			100	104	101	94	107	97	92	92	90	92
6832			100	108	106	99	101	100	96	94	93	92
6834	10	Air	100	106	104	97	99	98	95	94	93	93
6836			100	105	103	97	99	98	96	94	96	96
6838			100	109	107	101	104	106	102	100	101	100
6846	11	Air	100	109	106	100	103	103	101	101	101	101
6848			100	106	104	98	100	100	94	94	92	90
6850			100	107	105	98	99	101	94	95	93	93
6852	12	Air	100	108	104	97	101	99	99	97	97	97
6854			100	107	104	98	102	100	98	97	97	97
6856			100	106	104	98	100	99	96	95	94	93
6858	13	Air	100	106	103	96	98	96	95	93	91	91
6860			100	107	104	97	100	99	96	94	94	92
6862			100	107	105	99	103	104	102	102	103	101
6864	14	Air	100	106	104	100	102	102	101	99	101	99
6866			100	108	105	99	103	102	100	100	98	98
6868			100	108	105	99	102	102	101	99	99	99
6870	15	Plain	100	107	106	100	103	101	96	92	92	93
6872			100	104	102	97	97	101	101	100	98	98
6874			100	105	104	98	101	101	97	96	100	94
6876	16	Plain	100	105	102	92	95	94	90	90	88	89
6878			100	104	102	94	96	96	95	91	91	93
6880			100	106	108	101	101	98	102	96	98	98
6882	17	Air	100	107	105	99	103	101	101	101	101	100
6884			100	107	106	99	102	102	101	101	102	102
6886			100	108	105	100	103	103	101	102	101	101
6888	18	Air	100	107	105	100	104	102	101	101	101	102
6890			100	106	106	100	101	103	101	100	101	101
6892			100	109	107	101	104	107	104	104	100	99

(Continued)

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* Lost overboard.

(Revised August 1977)

Table 2-PR (Continued)

Exposure Rack, Row 3 (W to E)

			1958-1967 Readings									
Beam No.	Batch No.	Type Concrete	0 Cycles 1958 %E	150 Cycles 1959 %E	221 Cycles 1960 %E	362 Cycles 1961 %E	451 Cycles 1962 %E	557 Cycles 1963 %E	692 Cycles 1964 %E	855 Cycles 1965 %E	985 Cycles 1966 %E	1141 Cycles 1967 %E
6894	19	Air	100	104	103	97	99	101	97	97	97	93
6896			100	103	101	95	98	92	97	95	96	95
6898			100	107	105	99	103	105	103	101	102	102
6900	20	Air	100	107	105	99	104	105	104	103	108	108
6902			100	108	105	99	104	105	104	103	104	103
6904			100	107	105	99	102	102	102	101	103	103
6906	21	Air	100	105	103	98	101	102	96	98	100	100
6908			100	105	104	98	101	102	99	100	101	101
6910			100	105	103	98	101	104	101	101	97	99
6912	22	Air	100	105	103	98	102	104	103	102	102	103
6914			100	102	101	96	99	100	100	100	100	102
6916			100	105	103	98	101	102	100	100	100	101
6918	23	Plain	100	108	107	99	97	91	86	87	84	87
6920			100	109	107	95	88	80	70	65	43 Failed	
6922			100	105	104	99	100	101	104	106	106	108
6924	24	Plain	100	108	106	101	103	106	106	106	106	107
6926			100	103	100	95	95	93	95	92	90	94
6928			100	106	103	95	92	93	86	82	48 Failed	

			1968- Readings									
			1326 Cycles 1968 %E	1480 Cycles 1969 %E	1633 Cycles 1970 %E	1802 Cycles 1971 %E	1959 Cycles 1972 %E	2099 Cycles 1973 %E	2235 Cycles 1974 %E	2347 Cycles 1975 %E	2493 Cycles 1976 %E	2570 Cycles 1977 %E
6770	1	Air	104	102	99	95	95	104	106	108	119	130
6772			99	100	98	95	95	141	147	147	158	108
6774			99	101	101	99	98	145	145	146	144	144
6776	2	Air	92	94	90	88	88	93	101	103	99	103
6778			99	98	94	92	90	94	99	102	98	104
6780			102	98	96	91	90	101	100	101	99	110
6782	3	Air	98	98	96	91	91	91	93	95	95	95
6784			98	96	96	91	89	91	92	94	94	110
6786			98	98	97	95	94	90	92	96	93	92
6788	4	Air	95	95	93	95	94	89	89	92	89	92
6790			101	101	99	101	99	95	103	103	107	109
6792			101	105	103	98	100	100	102	106	108	100
6806	5	Air	99	99	97	90	91	89	91	91	96	98
6808			93	96	96	90	94	89	94	95	97	84
6812	6	Air	88	93	91	91	82	82	85	86	84	80
6814			94	98	98	88	90	92	92	93	90	74
6816	7	Air	90	87	89	83	87	78	80	80	75	70
6818			86	84	86	84	84	79	79	79	74	59
6820			84	82	84	82	83	75	72	74	62	87
6822	8	Air	91	86	88	88	87	87	89	89	82	64
6824			87	83	87	74	74	83	84	86	80	79
6826			83	83	82	88	89	76	76	79	80	80
6828	9	Air	91	89	89	79	81	83	80	82	75	60
6830			88	84	86	74	73	71	71	73	53	136
6832			88	84	86	85	86	86	79	81	77	117
6834	10	Air	92	88	90	92	90	84	85	85	78	88
6836			94	91	93	87	90	85	85	89	81	90
6838			100	97	98	95	94	90	90	92	90	86
6846	11	Air	100	95	97	88	87	85	87	89	87	82
6848			90	88	90	84	83	76	78	78	78	90
6850			92	88	90	90	89	87	89	90		
6852	12	Air	96	93	96	89	89	92	92	92	88	97
6854			94	94	93	90	89	86	87	89	92	89
6856			90	92	91	82	83	84	82	83	89	105

(Continued)

(Revised August 1977)

Table 2-PR (Continued)

Exposure Rack, Row 3 (W to E)

Beam No.	Batch No.	Type Concrete	1968- Readings									
			1326 Cycles 1968 %E	1480 Cycles 1969 %E	1633 Cycles 1970 %E	1802 Cycles 1971 %E	1959 Cycles 1972 %E	2099 Cycles 1973 %E	2235 Cycles 1974 %E	2347 Cycles 1975 %E	2493 Cycles 1976 %E	2570 Cycles 1977 %E
6858	13	Air	90	90	90	87	87	85	86	88	88	89
6860			91	90	92	99	99	88	87	88	88	90
6862			102	101	99	96	96	102	104	104	107	109
6864	14	Air	99	96	97	90	91	95	94	96	93	93
6866			98	98	96	90	91	90	90	91	90	85
6868			97	96	95	97	92	90	91	93	89	90
6870	15	Plain	87	85	84	Failed						
6872			97	95	93	Failed						
6874			92	90	91	Failed						
6876	16	Plain	79	77	Failed							
6878			79	76	Failed							
6880			82	79	Failed							
6882	17	Air	99	97	Disappeared from exposure rack							
6884			102	100	Disappeared from exposure rack							
6886			100	96	98	97	96	99	99	100	92	99
6888	18	Air	102	100	97	95	94	96	96	97	97	98
6890			100	101	99	94	93	94	95	95	95	82
6892			102	101	104	103	102	106	107	107	103	109
6894	19	Air	95	92	90	88	87	89	91	92	73	80
6896			96	96	88	87	85	85	86	87	53	111
6898			103	101	103	100	98	109	109	108	119	84
6900	20	Air	108	107	105	101	98	110	110	111	120	109
6902			105	103	102	100	99	109	104	107	107	108
6904			101	98	101	110	111	117	116	117	121	115
6906	21	Air	96	92	96	107	109	114	114	114	124	103
6908			100	102	99	105	106	113	113	114	118	118
6910			101	100	95	107	111	109	117	116	119	113
6912	22	Air	103	103	101	109	108	110	111	111	113	103
6914			102	100	98	108	106	113	112	112	114	128
6916			101	102	100	114	113	114	115	115	117	117
6918	23	Plain	76	74	74	94	95	115	113	114	111	112
6922			107	Failed								
6924	24	Plain	106	Failed								
6926			92	Failed								

(Revised Jan 1972)

Table 3-PR

Record of Testing of Large, Prestressed Beams

St. Augustine Exposure

1959- (Installed October 1959)

				1959			1960	
Beam No.*	Type Concrete	Strands Pretensioned	Loaded Flexurally %	Pulse Velocity fps	$\%V^2$	Max Crack Width 1/1000 in.	$\%V^2$	Max Crack Width 1/1000 in.
6	Air	Yes	0	14,900	100	0	107	0
10	Air	Yes	189	15,065	100	10	102	10
18	Air	Yes	189	14,935	100	5	106	5

				1962		1964		1966	
Beam No.*	Type Concrete	Strands Pretensioned	Loaded Flexurally %	$\%V^2$	Max Crack Width 1/1000 in.	$\%V^2$	Max Crack Width 1/1000 in.	$\%V^2$	Max Crack Width 1/1000 in.
6	Air	Yes	0	109	0	106	0	106	0
10	Air	Yes	189	101	8	99	10	109	20
18	Air	Yes	189	106	5	105	15	108	40

				1968		1970		1971	
Beam No.*	Type Concrete	Strands Pretensioned	Loaded Flexurally %	$\%V^2$	Max Crack Width 1/1000 in.	$\%V^2$	Max Crack Width 1/1000 in.	$\%V^2$	Max Crack Width 1/1000 in.
6	Air	Yes	0	87	0	94	0		0‡
10	Air	Yes	189**	93†	20†				
18	Air	Yes	189**	91†	45 (Failed in 1968)†				

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* Beam numbers of these large beams are also their batch numbers.

** In 1968, during reloading operation, beam 18 failed, releasing the load on both specimens. This pair could therefore not be reloaded to proper load.

† Returned to laboratory in the spring of 1969.

‡ Testing has been discontinued.

Table 4-PR

General Information, Posttensioned Beams at Treat Island

(Installed June 1961)

Beam No.	Post-tensioning System	Eccentricity in.	Total Post-tensioning Force, lb	Type of End Protection (See Notes)	
				Landward End	Seaward End
1	A	0	84,000	Flush (1)	Ext (5)
2	A	0	85,000	Ext (4)	Ext (2)
3	A	3	80,000	Ext (3)	Ext (1)
4	A	2	83,000	Ext (7)	Flush (7)
5	A	2	82,000	Ext (6)	Flush (6)
6	A	1	84,000	Flush (9)	Ext (8)
7	B	0	70,000	Ext (1)†	Flush (1)
8	B	2	70,000	Ext (2)	Ext (4)
9	B	3	70,000	Ext (3)†	Ext (5)
10	B	3	70,000	Flush (6)	Ext (6)
11	B	1	70,000	Flush (7)	Ext (7)
12	B	1	70,000	Ext (8)	Flush (9)
13*	C	0	70,000	Ext (1)	Ext (3)
14	C	1	64,000	Ext (2)	Ext (4)
15	C	3	70,500	Ext (5)	Ext (6)
16	C	2	70,000	Ext (7)	Ext (8)
17	D	3	99,000	Ext (1)†	Ext (3)†
18	D	0	99,000	Ext (4)	Ext (2)
19	D	2	99,000	Ext (5)†	Ext (6)†
20	D	1	99,000	Ext (8)	Ext (7)

Note: The end-anchorage protection consists of cover for Flush anchorages and External (Ext) anchorages. In the case of flush anchorages the protection simply fills the recess in the end of the beams. For external anchorages the protection forms an extension of a rectangular section corresponding to the outline of the end blocks at the ends of the beam. The variables are:

(1) Concrete placed against a cold joint with no surface treatment and no reinforcement. [Ext (1) and Flush (1)]

(2) Concrete placed against a cold joint with no surface treatment but with reinforcement. [Ext (2)]

(3) Concrete placed against a bush-hammered surface and with no reinforcement. [Ext (3)]

(4) Concrete placed against a bush-hammered surface but with reinforcement. [Ext (4)]

(5) Concrete placed against a surface that has been treated with a retarding agent and no reinforcement. [Ext (5)]

(6) Concrete bonded to the ends of the beam with an epoxy adhesive and no reinforcement. [Ext (6) and Flush (6)]

(7) Epoxy concrete without reinforcement. [Ext (7) and Flush (7)]

(8) Epoxy concrete with reinforcement. [Ext (8)]

(9) Sand-cement mortar with aluminum powder additive, comparatively dry and well tamped. [Flush (9)]

* Tendon in this beam was an unbonded coated tendon (not grouted).

† End protection has become detached.

(Revised Sept 1969)

Table 5-PR

Record of Testing of Posttensioned Beams

1961- (Installed June 1961)

Beach Row 2 (W to E)

	0 Cycles, 1961					89 Cycles, 1962			195 Cycles, 1963			330 Cycles, 1964		
						%V^2			%V^2			%V^2		
Beam No.	Trans Pulse Veloc fps	%V^2	Long. Pulse Veloc fps	%V^2	Condition*	Trans	Long.	Condition*	Trans	Long.	Condition*	Trans	Long.	Condition*
1	15,000	100	14,295	100	0	116	116	17	††	118	18	134	111	25
2	17,375	100	15,020	100	0	84	104	11		106	18	213	103	24
3	16,040	100	14,435	100	0	117	108	18		109	23	122	106	24
4	17,670	100	14,435	100	0**	113	112	19		115	20	231	111	24
5	15,795	100	14,735	100	0	117	105	17		110	28	122	104	25
6	17,090	100	14,610	100	0	100	107	12		109	22	146	106	17
7	17,375	100	14,760	100	0**	83	104	7		109	19	196	104	20
8	16,290	100	14,575	100	0†	98	104	20		102	31	140	93	45
9	17,230	100	14,825	100	0**	102	109	18		108	23	176	102	24
10	17,670	100	15,105	100	0**	95	105	14		106	21	173	105	19
11	18,450	100	15,160	100	0**	100	101	8		105	13	182	99	12
12	17,820	100	14,840	100	0**	88	100	16		105	25	152	102	24
13	16,680	100	16,120	100	0**	103	85	11		103	12	152	99	16
14	17,230	100	14,720	100	0**	83	94	25		103	38	157	98	41
15	17,975	100	14,625	100	0**	111	95	15		107	18	178	103	17
16	17,670	100	14,770	100	0**	119	103	10		108	15	156	103	13
17	17,670	100	14,790	100	0	100	78	16		99	46	153	91	50
18	17,820	100	14,020	100	0**	70	81	8		113	16	123	87	22
19	18,785	100	14,950	100	0**	88	107	12		92	15	176	104	41
20	18,615	100	14,765	100	0**	98	105	10		107	15	192	103	16

	493 Cycles, 1965			623 Cycles, 1966			779 Cycles, 1967			964 Cycles, 1968		
	%V^2			%V^2			%V^2			%V^2		
	Trans	Long.	Condition	Trans	Long.	Condition	Trans	Long.	Condition	Trans	Long.	Condition
1	134	121	‡	††	††	35	139	120	‡	131	116	44
2	134	101				22	92	85		98	87	27
3	145	96				38	98	85		120	85	44
4	126	112				29	100	115		91	103	38
5	158	72				28	106	107		106	108	28
6	149	115				31	98	109		88	107	33
7	131	80				29	92	103		87	76	37
8	149	95				68	95	85		99	85	68
9	111	73				41	88	57		91	61	47
10	129	103				25	82	81		99	80	30
11	128	102				22	95	104		108	101	22
12	104	83				41	98	108		106	105	42
13	118	98				30	90	100		73	103	32
14	111	146				48	98	90		96	87	54
15	122	107				25	86	84		80	85	27
16	154	113				19	80	106		89	108	26
17	139	130				74	88	117		75	119	76
18	124	83				39	57	82		79	82	45
19	112	107				48	86	51		83	56	72
20	114	109				25	87	105		84	105	26

(Continued)

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* The condition of these specimens is adjudged by a panel of observers either annually or biennially and is expressed numerically. The observers examine and rate the five parts of each beam, which are: part A (landward end anchorage protection), part B (bond between landward end anchorage protection and part C), part C (beam proper including web), part D (bond between seaward end anchorage protection and part C), and part E (seaward end anchorage protection). The surface conditions of parts A, C, and E are rated as to degree (slight, moderate, or heavy) of scaling, spalling, or cracking. Also the number of rust spots, length of reinforcing exposed, number of cracks, etc., are noted. Parts B and D are rated as to the tightness of the bond, if there is a separation, etc. The score of the five parts of the beam is then summed to give a numerical condition rating for the entire beam. A rating of 0 indicates perfect condition and although a score for failure of the entire beam has not as yet been assigned, a score indicating failure would be expressed by a condition rating of the order of 150 to 200. See footnote to table 6-PR for a failing score for beam parts A, B, D, and E.

** These beams were chipped in several places during shipment and placement.

† This beam was chipped in several places during shipment and placement, which resulted in exposure of 3 in. of reinforcing.

†† 1963 transverse readings, 1966 transverse readings, and 1966 longitudinal readings were not satisfactory because of malfunction of testing equipment.

‡ In 1965 and 1967 the condition of the specimens was not rated by a panel of observers.

(Revised August 1977)

Table 5-PR (Continued)

Beach Row 2 (W to E)

Beam No.	1118 Cycles, 1969			1271 Cycles, 1970			1440 Cycles, 1971			1597 Cycles, 1972			1737 Cycles, 1973		
	$\%V^2$		Condition	$\%V^2$		Condition	$\%V^2$		Condition	$\%V^2$		Condition	$\%V^2$		Condition
	Trans	Long.		Trans	Long.		Trans	Long.		Trans	Long.		Trans	Long.	
1	128	96	26	130	94	31	93	88	26	85	84	28	§	§	29
2	98	84	31	89	87	30	60	73	33	62	75	34			37
3	105	87	33	105	90	28	79	73	26	40	66	32			22
4	100	110	26	82	111	39	57	85	36	60	88	30			31
5	112	92	23	103	94	30	73	78	33	41	65	26			21
6	92	100	23	85	101	27	62	75	28	58	70	22			31
7	87	95	31	81	96	49	60	83	48	56	80	54			45
8	108	89	67	95	90	52	71	‡‡	49	63	‡‡	52			47
9	89	60	36	79	62	53	56	‡‡	48	34	‡‡	39			54
10	92	80	29	82	85	29	58	‡‡	31	33	‡‡	34			32
11	87	79	20	76	81	26	61	62	27	43	50	18			12
12	88	64	24	81	64	30	70	77	40	22	65	26			41
13	74	73	30	76	74	27	75	‡‡	30	37	‡‡	21			23
14	85	97	37	82	97	35	63	64	45	48	63	36			46
15	74	98	23	69	100	26	62	69	26	26	69	24			43
16	81	96	21	78	98	22	70	74	20	26	95	26			19
17	72	85	69	76	99	75	64	‡‡	70	45	‡‡	70			70
18	76	75	50	74	88	46	66	63	42	30	76	34			41
19	76	‡‡	68	74	‡‡	71	62	‡‡	65	37	‡‡	69			67
20	78	97	37	83	98	34	54	77	32	56	92	30			41

Beam No.	1873 Cycles, 1974			1985 Cycles, 1975			2131 Cycles, 1976			2208 Cycles, 1977		
	$\%V^2$		Condition	$\%V^2$		Condition	$\%V^2$		Condition	$\%V^2$		Condition
	Trans	Long.		Trans	Long.		Trans	Long.		Trans	Long.	
1	§	§	32	§§								
2			40	60	60	46	53	58	47	52	54	52
3			§§									
4			35	‡	114	16	‡‡	93	35	‡‡	83	39
5			30	††	113	24	‡‡	104	29	‡‡	101	41
6			40	§§								
7			53	‡	85	46	‡‡	84	56	‡‡	74	68
8			54	70	57	44	54	57	59	55	55	75
9			§§									
10			50	62	94	38	32	95	56	29	84	64
11			22	§§								
12			65	65	103	29	57	93	44	57	87	41
13			§§									
14			51	60	67	36	53	68	55	53	64	59
15			§§									
16			41	52	111	18	46	106	40	45	90	44
17			77	§	§	72	‡‡	‡‡	82	‡‡	‡‡	93
18			47	61	86	33	47	87	60	48	80	55
19			§§									
20			42	51	90	32	41	91	50	41	88	55

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‡‡ A satisfactory reading was not obtained.
§ Satisfactory pulse velocity readings were not obtained in 1973 and 1974.
§§ Shipped back to Concrete laboratory.

(Revised Sept 1968)

Table 6-PR

Posttensioned Beams (Installed June 1961)

Summary of Condition of End-Anchorage Protection 1961-

Beach Row 2

Type of End Protection	No. of Beam Ends Used	Average Condition*				
		0 Cycles 1961	89 Cycles 1962	195 Cycles 1963	330 Cycles 1964	493 Cycles 1965
Flush (1)	2	0	0	0	1	**
Flush (6)	2	0	0	0	0	
Flush (7)	2	0	1	1	2	
Flush (9)	2	0	0	0	0	
Ext (1)	4	0	3	6	7	
Ext (2)	4	0	4	6	10	
Ext (3)	4	0	1	4	10	
Ext (4)	4	0	5	6	11	
Ext (5)	4	0	1	1	3	
Ext (6)	4	0	2	4	9	
Ext (7)	4	0	0	0	1	
Ext (8)	4	0	0	0	1	
Total	40					

(Condition)

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* The condition of anchorage protection is adjudged by a panel of observers either annually or biennially; the condition is expressed numerically. The observers examine and rate four of the five parts of each beam: part A (landward end anchorage protection), part B (bond between landward end anchorage protection and beam), part D (bond between seaward end anchorage protection and beam), and part E (seaward end anchorage protection). The condition rating for any one type of end protection is the sum of the scores of parts A and B or parts D and E. A rating of 0 indicates perfect condition while a rating of 28 is equal to failure for an end protection. The average condition rating shown for a given type of end protection is the average score for all protection of that type in this program.

** In 1965 the condition of the specimens was not rated by a panel of observers.

(Revised Jan 1973)

Table 6-PR (Continued)

Section 6

Beach Row 2

Type of End Protection	No. of Beam Ends Used	Average Condition					
		623 Cycles 1966	779 Cycles 1967	964 Cycles 1968	1118 Cycles 1969	1271 Cycles 1970	1440 Cycles 1971
Flush (1)	2	2	††	2	0	0	2
Flush (6)	2	0		0	0	0	0
Flush (7)	2	2		2	4	2	6
Flush (9)	2	2		2	0	0	0
Ext (1)	4	11†		12†	13†	16‡	17‡
Ext (2)	4	11		12	14	10	12
Ext (3)	4	10†		12†	14†	16‡	13‡
Ext (4)	4	13		15	15	12	14
Ext (5)	4	2		9†	10†	9†	11†
Ext (6)	4	9†		9†	12†	10†	12†
Ext (7)	4	1		1	4	2	5
Ext (8)	4	4		4	4	4	10
Total	40						

(Continued)

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† One end protection has failed.

†† In 1967 the condition of the specimens was not rated by a panel of observers.

‡ Two end protections have failed.

(Sheet 2)

(Revised August 1977)

Table 6-PR (Continued)

Beach Row 2

Type of End Protection	No. of Beam Ends Used	Average Condition					
		1597 Cycles 1972	1737 Cycles 1973	1873 Cycles 1974	1985 Cycles 1975	2131 Cycles 1976	2208 Cycles 1977
Flush (1)	2	2	1	5	3§	4§	6§
Flush (6)	2	0	0	6	0	1	0
Flush (7)	2	4	2	5	1§	6§	6§
Flush (9)	2	0	0	7	2§	3§	0§
Ext (1)	4	16	17	‡‡			
Ext (2)	4	10	10	12	12	15	12
Ext (3)	4	16	16	‡‡			
Ext (4)	4	12	18	14	13	17	15
Ext (5)	4	10	14	‡‡			
Ext (6)	4	14	17	‡‡			
Ext (7)	4	4	4	6	3§§	4§§	4§§
Ext (8)	4	4	11	14	7§§	9§§	8§§
Total	40						

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‡‡ Data incomplete; beams were shipped back to concrete laboratory.
§ Based on 1 beam end.
§§ Based on 3 beams ends.

WES Fibrous Concrete Program

In July 1975, 50 concrete beams were installed at half-tide elevation on the exposure rack at Treat Island, Maine, to determine the effects of sea water and freezing and thawing action on the flexural strength and other properties of various fiber concretes.

The beams were made from nine different mixtures. The fine and coarse aggregates were manufactured limestone sand and 3/4-in. maximum limestone, respectively. All mixtures contained a water-reducing admixture (admixture B), and five mixtures contained an air-entraining admixture (admixture A). Type II portland cement was used in the amount of 7.89 cwt per cu yd except for mixtures N and O, which contained 11.0 cwt per cu yd. The water cement ratio was 0.45 for all mixtures.

The number and types of beams exposed are: twelve 6 by 6 by 30 in., twenty-one 6 by 6 by 36 in., and seventeen 9 by 9 by 45 in. The 9 by 9 by 45-in. beams were yoked and stressed by third-point loadings to working loads of 35 percent of ultimate. Table 1-WES-FC gives the exposure record of the specimens. More mixture data are tabulated below:

Concrete Mixture Data

Mixture	Fiber Type	Fiber Length, in.	Slump, in.	Air Content %	Fiber Ratio by Wt
H	None	--	5 3/4	2.5	--
I	C	3/4	2 1/2	1.8	0.04
J	None	--	7	8.5	--
K	C	3/4	4	8.5	0.04
L	A	1	2	1.9	0.04
M	A	1	3	7.0	0.04
N	D	1	1	3.6	0.01
O	D	1	2	7.0	0.01
P	B	1	2 3/4	7.0	0.04

(Revised August 1977)

Table 1-WES-FC

Record of Testing of Concrete Beams for WES Fibrous Concrete Program

Installed July 1975

Rack Rows 4 and 6

		1975- Readings						
		Jul 1975 0 Cycles			1976 146 Cycles		1977 223 Cycles	
Beam No.	Load, lb	%E	fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
						9- by 9- by 45-in. Beams		
H-3	2720	*	16,095	100	*	103	*	102
I-1	4340		15,560			97		97
I-3			16,375			101		98
J-1			14,315			103		102
J-3			14,590			106		105
K-1			14,590			104		102
K-3			14,260			103		100
L-1			16,520			94		93
L-3			16,305			99		101
M-1			14,590			98		99
M-3			15,060			101		100
N-1			14,765			108		103
N-3			14,705			103		103
0-1			14,150			108		107
0-3			14,370			104		105
P-1			14,940			106		103
P-2			15,245			109		105
						6- by 6- by 30-in. Beams		
H-7	None	100	16,235	100	98	105	106	103
H-8			15,725		102	105	109	100
H-15			15,825		106	107	110	101
H-16			15,825		102	108	108	99
I-8			15,925		120	105	116	97
K-8			14,970		109	109	125	99
L-7			16,130		94	108	109	100
L-8			16,130		103	108	103	101
M-7			14,125		100	102	103	94
0-8			13,890		100	103	103	101
0-16			15,245		88	110	97	100
P-8			14,705		106	105	106	100
						6- by 6- by 36-in. Beams		
I-7	None	100	15,875	100	119	103	96	98
I-15			16,130		105	109	114	102
J-7			14,495		103	106	112	99
J-8			14,495		109	104	118	96
J-15			14,495		100	104	100	97
J-16			14,565		115	109	106	103
K-7			14,780		103	106	109	98
K-15			14,565		106	106	103	101
K-16			14,285		102	109	100	102
L-15			14,635		104	104	108	101
L-16			14,635		103	103	106	100
M-8			14,085		205	109	210	99
M-15			15,075		100	104	109	99
M-16			14,850		112	109	109	102
N-7			14,150		118	105	106	109
N-8			14,085		112	102	124	99
N-15			14,020		109	106	112	101
N-16			14,020		100	110	112	102
0-7			13,825		106	110	109	103
0-15			12,710		97	108	103	102
P-7			14,635		109	107	109	98

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* Loaded beams not tested for %E.

Cement-Replacement Materials Investigation, Phase D*

In October 1958, 75 concrete cores (10 in. in diameter by 20 in. long) were installed on the Treat Island exposure rack as a part of Phase D of the Cement-Replacement Materials Investigation. The purpose of this installation is to determine the durability of mass concrete of several cement factors containing certain cement-replacement materials. The cores were diamond-drilled from twenty-five 1000-cu-ft mass concrete blocks (3 core sections per block) which were fabricated as a part of this investigation.

Also in October 1958, 20 mass concrete cubes (8 cu ft) were installed at half-tide elevation on the beach at Treat Island. These cubes were companion specimens to 18 of the 25 large blocks, and therefore to 54 of the 75 cores. Cubes numbered 10 and 10A are duplicates, as are 11 and 11A. Successful completion of the laboratory heat studies, for which the cubes were originally made, required that two additional cubes (10A and 11A) be fabricated. This provided the two additional cubes for this field exposure, making a total of 20 cubes instead of 18.

The aggregates used in these concrete specimens were limestone rock (6-in. maximum size) and manufactured limestone sand.

Table 1-CRMI-PD lists the concrete cores and gives their exposure record along with mixture data; table 2-CRMI-PD gives the same information for the concrete cubes.

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* See U. S. Army Engineer Waterways Experiment Station, CE, Investigation of Cement-Replacement Materials; Performance of Various Materials in Mass Concrete, Field Study (Phase D), Miscellaneous Paper No. 6-123, Report No. 6 (Vicksburg, Miss., May 1957).

(Revised Aug 1963)

Table 1-CRMI-PD

Mixture Data and Record of Testing of Cores from Cement-replacement Materials Investigation,

Phase D, 1958- (Installed October 1958)

Exposure Rack, Row 4, West to East

	Cementitious Mat'l					1958-1962 Readings										
						0 Cycles 1958			150 Cycles 1959		221 Cycles 1960		362 Cycles 1961		451 Cycles 1962	
Core No.	Type II Portland Cement %	Replacement Material %	Nominal Cement Factor bags/cu yd	Water-cement Ratio by Wt*	Air Content %**	%E	Pulse Veloc fps	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
1T	100	0	1-3/4	0.93	6.1-6.6	100	13,950	100	91	105	89	106	80	98	82	102
1M						100	14,910	100	102	100	102	100	92	93	91	85
1B						100	14,570	100	95	102	96	101	92	100	90	93
2T	65	Nat cem	1-3/4	0.96	1.7-8.2	100	14,965	100	80	98	81	100	81	79	58	†
2M		35				100	14,480	100	84	95	89	97	89	102	77	95
2B						100	15,675	100	91	93	96	92	89	91	91	90
3T	70	Cal sh	1-3/4	1.01	5.3-5.8	100	14,920	100	116	95	112	93	105	83	105	†
3M		30				100	15,725	100	95	88	113	91	96	85	107	†
3B						100	16,190	100	98	92	101	96	96	92	99	32
4T	88	Unc D	1-3/4	0.98	5.4-6.4	100	14,875	100	100	95	91	95	83	83	93	†
4M		12				100	16,580	100	99	89	95	92	90	84	103	72
4B						100	14,700	100	101	102	100	103	92	100	106	90
5T	100	0	2-1/4	0.73	3.9-6.1	100	16,020	100	98	98	97	96	89	102	90	52
5M						100	17,160	100	93	92	94	100	86	90	88	98
5B						100	15,240	100	103	102	99	113	96	110	97	112
6T	75	Pumicite	2-1/4	0.77	5.7-7.4	100	14,975	100	100	86	118	89	106	95	110	35
6M		25				100	16,140	100	99	91	103	95	96	91	90	87
6B						100	17,835	100	99	80	103	82	97	81	92	77
7T	50	Slag	2-1/4	0.76	4.7-6.6	100	16,395	100	110	93	107	96	95	96	98	50
7M		50				100	17,185	100	111	89	102	91	92	89	96	92
7B						100	17,125	100	104	87	107	97	98	100	100	111
8T	65	Nat cem	2-1/4	0.76	5.7-6.4	100	15,245	100	108	100	109	101	101	110	94	104
8M		35				100	16,135	100	91	94	92	96	84	98	87	102
8B						100	15,195	100	88	110	97	111	87	119	91	119
9T	70	Cal sh	2-1/4	0.79	5.9-6.3	100	15,385	100	102	93	93	86	Broken in handling			
9M		30				100	15,580	100	78	96	80	98	70	104	76	99
9B						100	16,080	100	104	89	113	93	102	103	98	91
10T	88	Unc D	2-1/4	0.80	5.5-6.2	100	15,195	100	101	112	102	120	96	100	90	88
10M		12				100	15,380	100	93	96	99	102	90	106	87	110
10B						100	15,435	100	105	95	105	100	98	100	98	101
11T	70	Fly ash	2-1/4	0.73	5.5-6.2	100	16,345	100	106	93	112	89	105	93	100	†
11M		30				100	17,805	100	91	80	87	81	84	77	99	49
11B						100	16,345	100	111	94	115	101	106	106	103	†
12T	100	0	3	0.55	6.3-7.4	100	14,990	100	104	96	106	114	93	110	97	100
12M						100	16,140	100	95	93	94	103	89	98	89	118
12B						100	14,990	100	102	102	102	114	96	115	94	117
13T	75	Pumicite	3	0.58	6.2-7.6	100	15,480	100	104	93	109	99	106	102	108	77
13M		25				100	16,395	100	115	100	124	101	112	108	112	113
13B						100	16,135	100	104	91	106	93	98	98	100	113
14T	50	Slag	3	0.60	5.8-6.3	100	16,840	100	107	91	110	96	100	96	99	52
14M		50				100	16,580	100	102	91	106	99	99	92	96	104
14B						100	17,565	100	105	76	104	77	96	82	97	87
15T	65	Nat cem	3	0.56	6.5-8.7	100	15,875	100	99	98	100	100	95	100	96	104
15M		35				100	16,415	100	97	96	99	105	91	100	93	106
15B						100	16,625	100	91	92	97	97	87	92	88	113
16T	75	Cal sh	3	0.59	5.7-7.4	100	16,125	100	99	93	99	95	91	98	97	40
16M		25				100	16,090	100	86	91	87	103	78	102	82	96
16B						100	15,425	100	100	96	107	105	96	104	94	82

(Continued)

Note: Nat cem = natural cement; cal sh = calcined shale; unc D = uncalcined diatomite; slag = blast-furnace slag.

* Ratio of water to cementitious material based on total weight.

** Air content of that portion of the concrete containing aggregate smaller than 1-1/2 in. in size.

† End of specimen too rough to obtain satisfactory reading.

(Revised Sept 1968)

Table 1-CRMI-PD (Continued)

Exposure Rack, Row 4 (W to E)

Core No.	Cementitious Mat'l		Nominal Cement Factor bags/ cu yd	Water-Cement Ratio by Wt	Air Content %	1958-1962 Readings										
	Type II Portland Cement %	Replacement Material %				0 Cycles 1958			150 Cycles 1959		221 Cycles 1960		362 Cycles 1961		451 Cycles 1962	
						%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
17T	92	Unc D	3	0.55	5.3-7.4	100	16,560	100	98	96	103	101	99	104	96	121
17M		8				100	17,200	100	92	94	95	96	87	98	83	98
17B						100	15,925	100	95	104	96	103	87	106	88	108
18T	70	Fly ash	3	0.55	6.1-7.7	100	15,675	100	100	100	102	104	93	108	89	110
18M		30				100	16,675	100	101	96	105	100	98	100	96	100
18B						100	16,560	100	111	94	114	97	107	98	108	106
19T	100	0	4	0.42	6.9-7.9	100	16,020	100	103	100	105	100	95	104	95	106
19M						100	16,750	100	97	94	98	103	91	104	90	109
19B						100	16,575	100	100	92	100	97	93	100	92	109
20T	75	Pumicite	4	0.45	5.7-8.5	100	16,445	100	112	93	114	95	107	100	110	106
20M		25				100	16,300	100	110	94	114	106	106	102	107	104
20B						100	16,395	100	110	93	114	96	105	89	107	106
21T	50	Slag	4	0.44	5.4-6.8	100	16,170	100	100	95	110	99	101	100	99	100
21M		50				100	15,375	100	95	102	106	111	100	104	98	106
21B						100	16,720	100	104	94	107	97	99	100	98	98
22T	80	Nat cem	4	0.43	3.9-7.4	100	15,295	100	100	104	68	102	67	102	Bkn in handling	
22M		20				100	16,140	100	92	91	93	107	86	94	86	106
22B						100	16,840	100	97	91	98	96	99	94	94	102
23T	80	Cal sh	4	0.45	4.5-6.1	100	16,185	100	100	93	104	100	95	88	99	58
23M		20				100	16,700	100	97	87	103	98	94	96	95	106
23B						100	16,610	100	101	91	101	97	94	98	94	106
24T	94	Unc D	4	0.42	6.5-7.8	100	15,335	100	102	100	103	107	95	112	96	117
24M		6				100	15,240	100	102	104	106	115	97	112	97	108
24B						100	16,460	100	99	94	100	105	92	100	93	104
25T	70	Fly ash	4	0.44	6.3-8.6	100	15,525	100	105	91	107	95	96	95	94	102
25M		30				100	16,030	100	109	93	114	104	110	100	93	100
25B						100	16,490	100	106	91	109	96	100	96	101	104

Exposure Rack, Row 4 (W to E)

						1963-1968 Readings											
						557 Cycles 1963		692 Cycles 1964		855 Cycles 1965		985 Cycles 1966		1141 Cycles 1967		1326 Cycles 1968	
						%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
1T	100	0	1-3/4	0.93	6.1-6.6	80	87	80	77	64	†	37F	†				
1M						NR	84	NR	†	NR	†	Failed					
1B						88	103	77	83	68	108	64	70	57	66	57	†
2T	65	Nat cem	1-3/4	0.96	1.7-8.2	41F	†										
2M		35				NR	96	NR	†	74	†	Failed					
2B						NR	76	NR	67	95	103	88	†	82	†	82	†
3T	70	Cal sh	1-3/4	1.01	5.3-5.8	NR	†	NR	†	Failed							
3M		30				109	†	NR	†	NR	†	Failed					
3B						NR	51	67	†	75	†	Failed					
4T	88	Unc lD	1-3/4	0.98	5.4-6.4	37F	†										
4M		12				NR	†	NR	†	89	†	Failed					
4B						87	103	NR	90	98	†	Failed					
5T	100	0	2-1/4	0.73	3.9-6.1	89	99	87	104	86	108	82	43	75	42	75	98
5M						86	105	86	101	77	107	77	80	71	88	73	73
5B						97	109	88	115	88	127	85	49	64	49	64	95
6T	75	Pumicite	2-1/4	0.77	5.7-7.4	89	33	NR	66	109	†	132	†	Failed			
6M		25				72	88	71	39	54	†	Failed					
6B						NR	66	75	70	79	†	53	†	Failed			
7T	50	Slag	2-1/4	0.76	4.7-6.6	86	41	81	†	79	†	Failed					
7M		50				NR	29	70	66	67	†	Failed					
7B						99	105	87	97	81	97	87	87	73	74	70	71

(Continued)

Note: NR denotes satisfactory reading was not obtained although an attempt was made to obtain a satisfactory reading.
F denotes specimen failed.
† End of specimen too rough to obtain satisfactory reading.

(Revised Sept 1969)

Table 1-CRMI-PD (Continued)

Exposure Rack, Row 4 (W to E)

Core No.	Cementitious Mat'l Type II Portland Cement %	Replacement Material %	Nominal Cement Factor bags/cu yd	Water-Cement Ratio by wt	Air Content %	1963-1968 Readings 557 Cycles 1963		692 Cycles 1964		855 Cycles 1965		985 Cycles 1966		1141 Cycles 1967		1326 Cycles 1968	
						%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
8T	65	Nat cem	2-1/4	0.76	5.7-6.4	97	109	79	105	77	113	85	65	76	64	Failed	
8M		35				85	112	88	103	85	97	93	†	82	†	81	†
8B						89	113	87	105	76	111	70	96	68	91	68	96
9M	70	Cal sh	2-1/4	0.79	5.9-6.3	NR	104	100	95	Broken in handling							
9B		30				95	98	95	94	86	92	91	67	81	70	76	†
10T	88	Unc D	2-1/4	0.80	5.5-6.2	92	97	92	91	78	72	81	66	79	66	69	67
10M		12				81	94	89	99	78	104	75	65	72	69	69	75
10B						93	68	95	92	92	102	83	65	81	64	78	84
11T	70	Fly ash	2-1/4	0.73	5.5-6.2	NR	†	97	†	92	†	Failed					
11M		30				NR	48	NR	†	Broken in handling							
11B						109	104	101	91	84	91	75	69	Failed			
12T	100	0	3	0.55	6.3-7.4	87	117	87	119	83	106	81	91	79	76	72	95
12M						83	107	83	103	77	91	77	84	68	87	71	89
12B						NR	138	79	119	71	129	74	93	69	91	72	†
13T	75	Pumicite	3	0.58	6.2-7.6	110	69	99	58	104	116	111	†	92	†	95	†
13M		25				111	115	115	110	106	103	106	93	103	93	101	94
13B						101	107	97	103	100	107	101	94	96	93	99	91
14T	50	Slag	3	0.60	5.8-6.3	92	98	87	89	82	81	83	68	80	68	Failed	
14M		50				92	101	98	98	86	87	86	73	84	67	85	†
14B						93	74	91	NR	82	77	80	†	Failed			
15T	65	Nat cem	3	0.56	6.5-8.7	94	103	90	106	88	110	89	82	88	85	85	93
15M		35				93	72	87	110	87	103	86	94	81	89	80	92
15B						91	92	86	99	83	100	81	73	80	89	76	74
16T	75	Cal sh	3	0.59	5.7-7.4	95	101	93	94	83	103	87	72	82	82	75	78
16M		25				79	119	75	91	70	97	59	67	56	69	Failed	
16B						91	109	78	NR	79	117	76	68	75	70	55	78
17T	92	Unc D	3	0.55	5.3-7.4	96	102	84	108	82	99	85	89	82	73	76	84
17M		8				80	104	87	98	76	85	82	82	81	73	65	84
17B						86	114	85	98	82	99	81	85	78	82	75	93
18T	70	Fly ash	3	0.55	6.1-7.7	93	107	86	109	87	113	84	†	82	†	73	†
18M		30				92	59	91	98	84	111	91	73	87	70	72	70
18B						108	106	110	104	107	99	109	91	106	89	106	94
19T	100	0	4	0.42	6.9-7.9	93	101	90	111	83	89	83	87	79	90	78	98
19M						90	90	90	108	85	85	82	74	78	†	59	†
19B						92	70	93	112	78	105	78	92	74	94	79	100
20T	75	Pumicite	4	0.45	5.7-8.5	110	107	110	107	107	107	102	87	99	89	96	93
20M		25				107	116	105	112	101	95	101	93	95	87	97	96
20B						108	104	110	106	104	94	108	87	106	87	103	93
21T	50	Slag	4	0.44	5.4-6.8	97	63	91	93	87	89	89	81	79	77	73	81
21M		50				NR	97	Failed									
21B						95	93	93	102	81	82	81	65	Failed			
22M	80	Nat cem	4	0.43	3.9-7.4	87	107	87	109	67	104	67	106	64	108	64	102
22B		20				94	109	95	95	93	100	96	†	93	†	96	†
23T	80	Cal sh	4	0.45	4.5-6.1	90	118	84	95	58	110	63	82.	60	80	60	80
23M		20				95	111	92	118	86	102	82	85	77	85	69	82
23B						93	100	78	97	83	101	80	89	77	91	70	86
24T	94	Unc D	4	0.42	6.5-7.8	82	112	79	114	78	102	78	90	76	98	77	100
24M		6				95	119	93	113	88	120	91	93	83	87	89	91
24B						93	114	95	109	89	103	88	86	82	94	††	††
25T	70	Fly ash	4	0.44	6.3-8.6	86	108	74	101	77	111	71	55	68	58	54	58
25M		30				96	107	89	111	78	104	71	79	67	83	54	†
25B						102	102	100	99	97	93	97	88	92	80	51	84

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† End of specimen too rough to obtain satisfactory reading.

†† Broken in handling in 1968.

(Revised Aug 1974)

Table 1-CRMI-PD (Continued)

Exposure Rack, Row 4 (W to E)

Core No.	Cementitious Mat'l		Nominal Cement Factor bags/ cu yd	Water-Cement Ratio by wt	Air Content %	1969-1973 Readings									
	Type II Portland Cement %	Replacement Material %				1480 Cycles 1969		1633 Cycles 1970		1802 Cycles 1971		1959 Cycles 1972		2099 Cycles 1973	
						%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
1B	100	0	1-3/4	0.93	6.1-6.6	Failed	†								
2B	65	Nat cem 35	1-3/4	0.96	1.7-8.2	Failed	†								
5T	100	0	2-1/4	0.73	3.9-6.1	72	81	69	71	72	49	NR	62	NR	Failed
5M						72	69	67	60	70	50	NR	44	72	50
5B						63	85	61	81	60	34	55	44	51	69
7B	50	Slag 50	2-1/4	0.76	4.7-6.6	NR	66	71	62	Failed	†				
8M	65	Nat cem 35	2-1/4	0.76	5.7-6.4	78	†	82	†	Failed	†				
8B						67	88	65	82	Failed	†				
9B	70	Cal sh 30	2-1/4	0.79	5.9-6.3	NR	†	Failed	†						
10T	88	Unc D 12	2-1/4	0.80	5.5-6.2	68	†	NR	†						
10M						66	68	67	63	66	†	NR	†		
10B						76	71	74	68	72	†	NR	†		
12T	100	0	3	0.55	6.3-7.4	72	81	68	77	68	52	64	44	62	32
12M						70	84	69	72	63	58	58	55	50	54
12B						71	†	72	†	Failed	†				
13T	75	Pumicite 25	3	0.58	6.2-7.6	93	†	98	†	94	†	90	†	76	†
13M						99	91	108	78	104	54	98	49	85	57
13B						97	91	107	80	98	43	100	47	100	32
14M	50	Slag 50	3	0.60	5.8-6.3	Failed	†								
15T	65	Nat cem 35	3	0.56	6.5-8.7	85	88	84	77	77	47	74	83	75	65
15M						81	87	83	81	76	69	80	77	72	67
15B						75	68	78	63	67	†	NR	†		
16T	75	Cal sh 25	3	0.59	5.7-7.4	74	69	73	65	67	†	NR	†		
16B						50F	†								
17T	92	Unc D 8	3	0.55	5.3-7.4	75	76	71	68	61	45	NR	48	NR	Failed
17M						65	73	66	65	64	43	66	61	56	58
17B						74	82	76	75	75	62	84	68	46	58
18T	70	Fly ash 30	3	0.55	6.1-7.7	72	†	NR	†						
18M						87	70	Failed	48						
18B						104	91	114	68	104	64	106	46	106	74
19T	100	0	4	0.42	6.9-7.9	77	93	78	79	69	45	72	67	72	86
19M						58	†	Failed	†						
19B						76	98	77	75	73	67	71	56	66	70
20T	75	Pumicite 25	4	0.45	5.7-8.5	96	84	88	78	81	44	87	42	48	40
20M						96	93	102	83	93	61	88	61	84	79
20B						104	87	111	78	102	62	97	60	97	71
21T	50	Slag 50	4	0.44	5.4-6.8	73	67	NR	48	69	†	Failed	†		
22M	80	Nat cem 20	4	0.43	3.9-7.4	62	106	61	93	59	75	Failed	†		
22B						95	†	NR	†	90	†	Failed	†		
23T	80	Cal sh 20	4	0.45	4.5-6.1	59	†	59	†	53	†	Failed	†		
23M						69	84	73	74	60	46	57	29	52	76
23B						69	86	68	81	66	32	65	40	52	69
24T	94	Unc D 6	4	0.42	6.5-7.8	75	88	77	82	75	35	77	34	75	90
24M						87	87	87	81	88	37	85	69	82	78
24B						††	††								
25T	70	Fly ash 30	4	0.44	6.3-8.6	50F	91								
25M						50F	†								
25B						Failed	†								

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† End of specimen too rough to obtain satisfactory reading.

†† Broken in handling in 1968.

NR Satisfactory reading was not obtained although an attempt was made to obtain one.

F Denotes specimen has failed.

(Revised August 1977)

Table 1-CRMI-PD (Continued)

Exposure Rack, Row 4 (W to E)

	Cementitious Mat'l					1974-1977 Readings							
						2235 Cycles 1974		2347 Cycles 1975		2493 Cycles 1976		2570 Cycles 1977	
Core No.	Type II Portland Cement %	Replacement Material %	Nominal Cement Factor bags/ cu yd	Water-Cement Ratio by wt	Air Content %	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
5M	100	0	2-1/4	0.73	3.9-6.1	70	53	70	94	60	75	64	Broken
5B						NR	69	NR	NR	Failed			
12T	100	0	3	0.55	6.3-7.4	62	92	62	93	60	73	46	65
12M						48	68	NR	96	Failed			
13T	75	Pumicite	3	0.58	6.2-7.6	73	†	--	--	Failed			
13M		25				NR	66	Failed	Failed				
13B						96	89	96	113	NR	88	75	79
15T	65	Nat cem	3	0.56	6.5-8.7	70	91	70	94	68	94	60	88
15M		35				63	94	62	120	60	67	51	71
17M	92	Unc D	3	0.55	5.3-7.4	50	64	Failed	Failed				
17B		8				77	95	78	117	69	77	80	NR
18B	70	Fly ash 30	3	0.55	6.1-7.7	106	100	106	123	88	77	49	68
19T	100	0	4	0.42	6.9-7.9	68	96	69	120	96	79	87	73
19B						67	94	66	135	49	78	Failed	
20T	75	Pumicite	4	0.45	5.7-8.5	48	67	51	51	NR	49	Failed	
20M		25				84	76	84	96	71	86	36	67
20B						97	79	102	115	68	80	89	64
23M	80	Cal sh	4	0.45	4.5-6.1	52	66	55	116	55	91	Failed	
23B		20				52	73	51	94	42	93	67	78
24T	94	Unc D	4	0.42	6.5-7.8	75	91	72	116	61	104	61	87
24M		6				82	93	84	131	94	90	61	81

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† End of specimen too rough to obtain satisfactory reading.

NR Satisfactory reading was not obtained although an attempt was made to obtain one.

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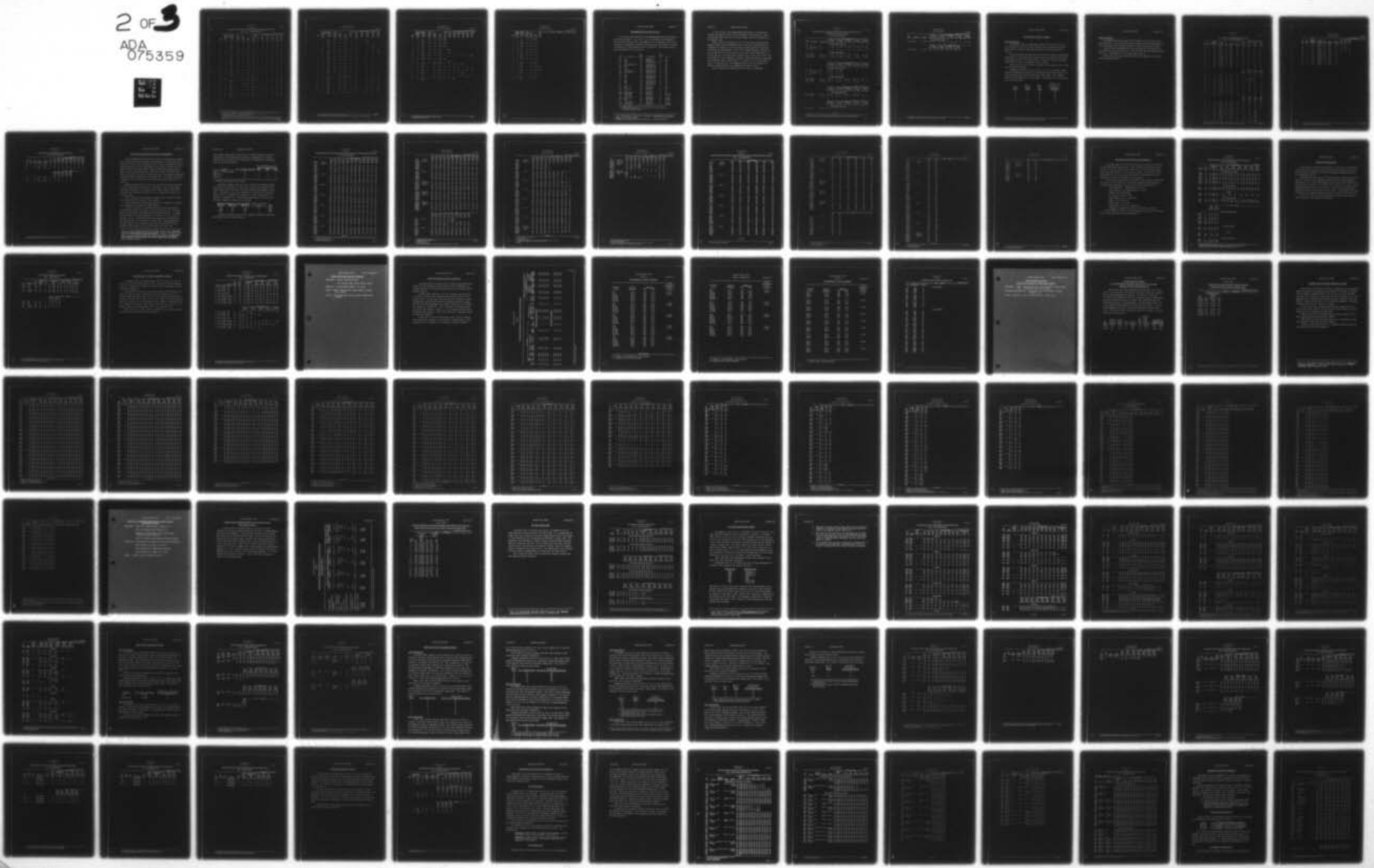

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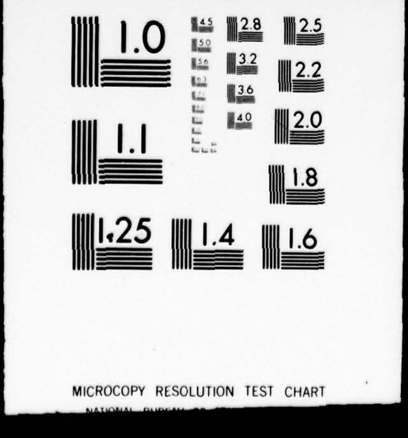

MICROCOPY RESOLUTION TEST CHART

(Revised Sept 1968)

Table 2-CRMI-PD

Mixture Data and Record of Testing of Cubes from Cement-Replacement Materials Investigation, Phase D, 1958- (Installed October 1958)

Beach Row 1 (W to E)

	Cementitious Mat'l					1958-1963 Readings						
						0 Cycles 1958		150 Cycles 1959	221 Cycles 1960	362 Cycles 1961	451 Cycles 1962	557 Cycles 1963
Cube No.	Type II Portland Cement %	Replacement Material %	Nominal Cement Factor bags/cu yd	Water-Cement Ratio by Wt*	Air Content %**	Pulse Veloc fps	$\%V^2$	$\%V^2$	$\%V^2$	$\%V^2$	$\%V^2$	$\%V^2$
1	100	0	1-3/4	0.93	6.1-6.6	15,625	100	93	88	81	84	†
2	65	Nat cem 35	1-3/4	0.96	1.7-8.2	14,185	100	96	105	103	109	52
3	70	Cal sh 30	1-3/4	1.01	5.3-5.8	15,150	100	97	103	103	106	50
4	88	Unc D 12	1-3/4	0.98	5.4-6.4	15,265	100	98	104	112	104	112
5	100	0	2-1/4	0.73	3.9-6.1	16,000	100	95	101	105	108	97
6	75	Pumicite 25	2-1/4	0.77	5.7-7.4	16,130	100	90	99	102	98	98
7	50	Slag 50	2-1/4	0.76	4.7-6.6	15,875	100	97	105	107	94	107
8	65	Nat cem 35	2-1/4	0.76	5.7-6.4	15,625	100	98	106	108	98	107
9	70	Cal sh 30	2-1/4	0.79	5.9-6.3	15,625	100	97	110	108	97	97
10	88	Unc D 12	2-1/4	0.80	5.5-6.2	15,625	100	103	105	100	103	††
10A	88	Unc D 12	2-1/4	0.80	5.5-6.2	16,130	100	100	105	98	98	105
11	70	Fly ash 30	2-1/4	0.73	5.5-6.2	15,875	100	98	115	116	117	109
11A	70	Fly ash 30	2-1/4	0.73	5.5-6.2	15,265	100	100	119	115	104	110
12	100	0	3	0.55	6.3-7.4	16,395	100	97	104	105	98	103
13	75	Pumicite 25	3	0.58	6.2-7.6	16,395	100	97	109	115	102	119
14	50	Slag 50	3	0.60	5.8-6.3	16,395	100	100	117	111	91	117
15	65	Nat cem 35	3	0.56	6.5-8.7	16,395	100	98	96	105	107	98
16	75	Cal sh 25	3	0.59	5.7-7.4	16,130	100	98	98	105	102	105
17	92	Unc D 8	3	0.55	5.3-7.4	16,395	100	98	105	111	109	112
18	70	Fly ash 30	3	0.55	6.1-7.7	16,665	100	97	97	97	97	96

(Continued)

Note: Nat cem = natural cement; cal sh = calcined shale; unc D = uncalcined diatomite; slag = blast-furnace slag.

* Ratio of water to cementitious material based on total weight.

** Air content of that portion of the concrete containing aggregate smaller than 1-1/2 in. in size.

† End of specimen too rough to obtain satisfactory reading.

†† The Resident Inspector did not clean this cube specimen in 1963, and as a result proper pulse velocity readings could not be taken. The cube was left uncleaned so that the Chief, Concrete Division, and other members of the November 1963 inspection party could observe how much seaweed would accumulate on a test specimen if it were not cleaned during the summer.

(Sheet 1)

(Revised Sept 1970)

Table 2-CRMI-PD (Continued)

Beach Row 1 (W to E)

Cube No.	Cementitious Mat'l Type II Portland Cement %	Cementitious Mat'l Replacement Material %	Nominal Cement Factor bags/ cu yd	Water-Cement Ratio by Wt	Air Content %	1964- Readings 692 Cycles 1964 $\%V^2$	855 Cycles 1965 $\%V^2$	985 Cycles 1966 $\%V^2$	1141 Cycles 1967 $\%V^2$	1326 Cycles 1968 $\%V^2$	1480 Cycles 1969 $\%V^2$
1	100	0	1-3/4	0.93	6.1-6.6	†	Failed				
2	65	Nat cem 35	1-3/4	0.96	1.7-8.2	35	†	‡	Failed		
3	70	Cal sh 30	1-3/4	1.01	5.3-5.8	74	†		Failed		
4	88	Unc D 12	1-3/4	0.98	5.4-6.4	87	41		†	Failed	
5	100	0	2-1/4	0.73	3.9-6.1	91	105		91	78	65
6	75	Pumicite 25	2-1/4	0.77	5.7-7.4	92	110		†	†	Failed
7	50	Slag 50	2-1/4	0.76	4.7-6.6	78	110		83	86	†
8	65	Nat cem 35	2-1/4	0.76	5.7-6.4	103	103		82	62	†
9	70	Cal sh 30	2-1/4	0.79	5.9-6.3	103	114		82	85	†
10	88	Unc D 12	2-1/4	0.80	5.5-6.2	86	110		81	95	†
10A	88	Unc D 12	2-1/4	0.80	5.5-6.2	88	103		49	47	†
11	70	Fly ash 30	2-1/4	0.73	5.5-6.2	107	110		112	97	79
11A	70	Fly ash 30	2-1/4	0.73	5.5-6.2	98	105		97	90	†
12	100	0	3	0.55	6.3-7.4	101	103		78	78	57
13	75	Pumicite 25	3	0.58	6.2-7.6	121	123		113	100	103
14	50	Slag 50	3	0.60	5.8-6.3	107	103		109	107	105
15	65	Nat cem 35	3	0.56	6.5-8.7	94	105		97	107	86
16	75	Cal sh 25	3	0.59	5.7-7.4	97	112		102	105	95
17	92	Unc D 8	3	0.55	5.3-7.4	113	123		121	103	102
18	70	Fly ash 30	3	0.55	6.1-7.7	101	103		100	94	88

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† End of specimen too rough to obtain satisfactory reading.

‡ Satisfactory pulse velocity readings were not obtained in 1966 due to malfunction of testing equipment.

(Revised August 1977)

Table 2-CRMI-PD (Continued)

Beach Row 1 (W to E)

	Cementitious Mat'l					1970-1976 Readings						
Cube No.	Type II Portland Cement %	Replacement Material %	Nominal Cement Factor bags/cu yd	Water-Cement Ratio by Wt	Air Content %	1633 Cycles 1970 $\%V^2$	1802 Cycles 1971 $\%V^2$	1959 Cycles 1972 $\%V^2$	2099 Cycles 1973 $\%V^2$	2238 Cycles 1974 $\%V^2$	2350 Cycles 1975 $\%V^2$	2496 Cycles 1976 $\%V^2$
5	100	0	2-1/4	0.73	3.9-6.1	Failed						
7	50	Slag 50	2-1/4	0.76	4.7-6.6	Failed						
8	65	Nat cem 35	2-1/4	0.76	5.7-6.4	Failed						
9	70	Cal sh 30	2-1/4	0.79	5.9-6.3	Failed						
10	88	Unc D 12	2-1/4	0.80	5.5-6.2	†	Failed					
10A	88	Unc D 12	2-1/4	0.80	5.5-6.2	†	Failed					
11	70	Fly ash 30	2-1/4	0.73	5.5-6.2	74	71	60	‡‡	83	51	Failed
11A	70	Fly ash 30	2-1/4	0.73	5.5-6.2	Failed						
12	100	0	3	0.55	6.3-7.4	†	Failed					
13	75	Pumicite 25	3	0.58	6.2-7.6	94	15	NR	‡‡	Failed		
14	50	Slag 50	3	0.60	5.8-6.3	100	82	66	‡‡	65	38	31
15	65	Nat cem 35	3	0.56	6.5-8.7	82	48	49	‡‡	44	NR	NR
16	75	Cal sh 25	3	0.59	5.7-7.4	91	NR	91	‡‡	Failed		
17	92	Unc D 8	3	0.55	5.3-7.4	98	85	77	‡‡	71	NR	NR
18	70	Fly ash 30	3	0.55	6.1-7.7	85	15	Failed				

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† End of specimen too rough to obtain satisfactory reading.

‡‡ Equipment malfunctioned in 1973.

(Issued August 1977)

Table 2-CRMI-PD (Continued)

Beach Row 1 (W to E)

	Cementitious Mat'l					1977- Readings
Cube No.	Type II Portland Cement %	Replacement Material %	Nominal Cement Factor bags/cu yd	Water-Cement Ratio by Wt	Air Content %	2573 Cycles 1977 %V^2
5	100	0	2-1/4	0.73	3.9-6.1	
7	50	Slag 50	2-1/4	0.76	4.7-6.6	
8	65	Nat cem 35	2-1/4	0.76	5.7-6.4	
9	70	Cal sh 30	2-1/4	0.79	5.9-6.3	
10	88	Unc D 12	2-1/4	0.80	5.5-6.2	
10A	88	Unc D 12	2-1/4	0.80	5.5-6.2	
11	70	Fly ash 30	2-1/4	0.73	5.5-6.2	
11A	70	Fly ash 30	2-1/4	0.73	5.5-6.2	
12	100	0	3	0.55	6.3-7.4	
13	75	Pumicite 25	3	0.58	6.2-7.6	
14	50	Slag 50	3	0.60	5.8-6.3	Failed
15	65	Nat cem 35	3	0.56	6.5-8.7	Failed
16	75	Cal sh 25	3	0.59	5.7-7.4	
17	92	Unc D 8	3	0.55	5.3-7.4	89
18	70	Fly ash 30	3	0.55	6.1-7.7	

Passamaquoddy Tidal Power Project*

In connection with studies for the Passamaquoddy Tidal Power Project, 43 concrete columns** (5 by 5 by 60 in.) were installed on the exposure rack at Treat Island in 1936. The purpose of the installation was to find the cement and aggregate combination that would give the greatest assurance of durability for the proposed concrete structures. The mixture data for these 43 specimens were as follows:

Spec No.	Cement	Cement Factor bags/cu yd	Coarse Aggregate	Sand-aggregate Ratio %	Water
B-14	Type I	5.25	Natural gravel A	34	Tap
B-19	Type I	5.25	Natural gravel A	30	Tap
B-26	Type I	5.25	Natural gravel A	28	Tap
B-31	Type I	5.25	Crushed diabase rock B	30	Tap
B-36	Type I	5.25	Crushed diabase rock C	34	Tap
B-39	Type I, 50%; other PC, 50%*	5.25	Crushed diabase rock C	34	Tap
B-46	Natural, 21%; Type I, 79%	5.25	Crushed diabase rock C	34	Tap
B-51	Type I	5.25	Crushed diabase rock B	32	Tap
B-56	Type I	5.25	Crushed diabase rock B	34	Tap
B-61	Type I	5.25	Crushed diabase rock B	36	Tap
B-66	Type I	5.25	Crushed diabase rock B	38	Tap
B-71	Aluminous cement	5.25	Crushed diabase rock C	34	Tap
B-76	Pozzolan, 15%; Type I, 85%	5.25	Crushed diabase rock C	34	Tap
B-81	Portland, pozzolan	5.25	Crushed diabase rock C	34	Tap
B-86	Type I	5.25	Crushed diabase rock C	34	Tap
B-88**	Type I	5.64	Crushed diabase rock B	40	Tap
D-1	Type I	5.25	Crushed diabase rock B	38	Tap
D-2	Type I	5.25	Crushed diabase rock B	36	Tap
D-3	Type I	5.50	Crushed diabase rock B	38	Tap
D-4	Type I	5.50	Crushed diabase rock C	36	Tap
D-5	Type I	5.50	Crushed diabase rock C	38	Tap
D-6	Type I	5.50	Crushed diabase rock C	34	Tap
D-7	Type I	5.25	Crushed diabase rock C	36	Tap
D-8	Type I	5.50	Crushed diabase rock C	40	Tap
D-9	Type I	5.25	Crushed diabase rock C	38	Tap
S-3-R†	Type I	5.00	Natural gravel A	32	Tap
S-5	Aluminous cement	5.00	Natural gravel A	32	Tap
S-7	Type I	5.00	Natural gravel A	32	Sea (conc)
S-2	Type I	5.00	Natural gravel A	32	Tap
S-4-R†	Aluminous cement	5.00	Natural gravel A	32	Tap
S-8-R†	Type I	5.00	Natural gravel A	32	Sea (conc)
S-10	Portland, pozzolan	5.00	Natural gravel A	32	Tap
S-11-R†	Portland, pozzolan	5.00	Natural gravel A	32	Tap
S-13-R†	Aluminous cement	5.00	Natural gravel A	32	Sea (normal)
S-14	Aluminous cement	5.00	Natural gravel A	32	Sea (normal)
S-16	Portland, pozzolan	5.00	Natural gravel A	32	Sea (conc)
S-17-R†	Portland, pozzolan	5.00	Natural gravel A	32	Sea (conc)
S-20-R†	Type I	5.00	Natural gravel A	32	Sea (normal)
S-21	Type I	5.00	Natural gravel A	32	Sea (normal)
S-22	Aluminous cement	5.00	Natural gravel A	32	Sea (conc)
S-23-R†	Aluminous cement	5.00	Natural gravel A	32	Sea (conc)
S-25	Portland, pozzolan	5.00	Natural gravel A	32	Sea (normal)
S-26-R†	Portland, pozzolan	5.00	Natural gravel A	32	Sea (normal)

Note: Maximum size aggregate, 2 in.; fine aggregate, natural sand (A); 5- by 5- by 60-in. columns; water-cement ratio, 6 gal per bag.

* This cement does not meet all of the present specifications for any of the types of portland cement.

** Fine aggregate was manufactured sand (B).

† Specimen contains 3/4-in. reinforcing bar.

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* See Passamaquoddy Tidal Power Development, Final Report of Concrete Tests (15 September 1936).

** Columns are molded with the long axis in a vertical position.

In October 1940, after approximately 600 cycles of freezing-and-thawing, the exposure of all but six specimens was discontinued. These six specimens were selected as the most durable, and were reinstalled on the exposure rack.

Three of the six specimens (B-14, B-39, and B-86) contained plain portland cement which was manufactured by a mill which permitted the introduction of crusher oil into the cement (thereby possibly introducing involuntary air-entrainment). These three columns contained concrete having a cement factor of 5.25 bags per cu yd, and a water-cement ratio of 6.0 gal per bag. The other three columns (S-4-R, S-13-R, and S-23-R), each containing one 3/4-in.-diameter, deformed, reinforcing steel bar, were made with aluminous cement (cement factor = 5.0 bags per cu yd, water-cement ratio = 6.0 gal per bag). The aggregate used in all six columns was a granitic sand and gravel (2-in. maximum size) from an esker.

Table 1-PQ gives the exposure record of these six specimens.

(Revised Sept 1969)

Table 1-PQ

Record of Observations of Concrete Columns Containing Cement-Aggregate Combinations Proposed for Passamaquoddy Tidal Power Project Structures

1936- (Installed in 1936)

			1936-1941 Observations									
			1936		1937		1938		1940		1941	
Speci-men	Type Cement	Type Water	Cycles	Condi-tion	* Cycles	Condi-tion	Cycles	Condi-tion	Cycles	Condi-tion	Cycles	Condi-tion
			Specimens Without Reinforcing Bar									
B-14	Type I	Tap	0	Sound	422	Vy good	598	Vy good	759	Vy good	916	Good
B-39	Type I, 50%; other PC, 50%**	Tap	0	Sound	378	Vy good	554	Vy good	715	Vy good	872	Good
B-86	Type I	Tap	0	Sound	361	Excel.	537	Vy good	698	Vy good	855	Vy good
			Specimens with Reinforcing Bar									
S-4-R	Aluminous	Tap	0	Sound	288	Excel.	464	Excel.	625	Good	782	Good
S-13-R	Aluminous	Sea (normal)	0	Sound	288	Vy good	464	Good	625	Good	782	Good
S-23-R	Aluminous	Sea (conc)	0	Sound	288	Vy good	464	Good	625	Good	782	Good

			1942-1958 Observations									
			1942		1943		1948		1957		1958	
			Cycles	Condi-tion	Cycles	Condi-tion	Cycles	Condi-tion	Cycles	Condi-tion	Cycles	Condi-tion
			Specimens Without Reinforcing Bar									
B-14	Type I	Tap	1082	Fair	1270	Failed						
B-39	Type I, 50%; other PC, 50%**	Tap	1038	Fair	1226	Failed						
B-86	Type I	Tap	1021	Good	1209	Failed						
			Specimens with Reinforcing Bar									
S-4-R	Aluminous	Tap	948	Fair	1136	Fair	1742	Fair	2850	Poor	2921	Poor
S-13-R	Aluminous	Sea (normal)	948	Good	1136	Good	1742	Fair	2850	Fair	2921	Fair
S-23-R	Aluminous	Sea (conc)	948	Good	1136	Good	1742	Poor	2850	Failed		

Exposure Rack, Row 2, West End

			1959-1963 Observations									
			1959		1960		1961		1962		1963	
			Cycles	Condi-tion	Cycles	Condi-tion	Cycles	Condi-tion	Cycles	Condi-tion	Cycles	Condi-tion
			Specimens with Reinforcing Bar									
S-4-R	Aluminous	Tap	3071	Poor	3142	Poor	3283	Poor	3372	Failed		
S-13-R	Aluminous	Sea (normal)	3071	Fair	3142	Fair	3283	Fair	3372	Fair	3478	Fair

Exposure Rack, Row 8, West End

			1964-1968 Observations									
			1964		1965		1966		1967		1968	
			Cycles	Condi-tion	Cycles	Condi-tion	Cycles	Condi-tion	Cycles	Condi-tion	Cycles	Condi-tion
			Specimens with Reinforcing Bar									
S-13-R	Aluminous	Sea (normal)	3613	Fair	3776	Fair	3906	Fair	4062	Fair	4247	Fair

(Continued)

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* Specimens were installed on different dates in 1936; hence different numbers of freezing-and-thawing cycles.

** This cement does not meet all of the present specifications for any of the types of portland cement.

(Revised August 1977)

Table 1-PQ (Continued)

Exposure Rack, Row 8, West End

			1969-1973 Observations									
			1969		1970		1971		1972		1973	
Specimen	Type Cement	Type Water	Cycles	Condition	Cycles	Condition	Cycles	Condition	Cycles	Condition	Cycles	Condition
			Specimens with Reinforcing Bar									
S-13-R	Aluminous	Sea (normal)	4401	Fair	4554	Fair	4723	Fair	4880	Fair	5020	Fair

			1974- Observations							
			1974		1975		1976		1977	
			Cycles	Condition	Cycles	Condition	Cycles	Condition	Cycles	Condition
S-13-R	Aluminous	Sea (normal)	5159	Fair	5271	Fair*	5417	Fair	5494	Fair

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* Approximately 6 in. sawed off one end in 1975 for laboratory tests by PCA.

Missouri River Division Program

1963 installation

In September 1963, 12 sawed mortar beams (3-1/2 by 4-1/2 by 16 in.) were installed on the Treat Island exposure rack to provide field durability data on specimens from various projects in the Missouri River Division.

This installation was made up of five series of beams; the specimens* represented five different mortar mixtures and were sawed from 3-ft-square by nominally 3-1/2-in.-thick test panels. The mortar was placed pneumatically (shot) in each of the panels at each jobsite.

Table 1-SC lists the specimens and gives their exposure record along with other pertinent data.

Companion specimens (3-1/2 by 4-1/2 by 16 in.) to the Treat Island exposure specimens were subjected to laboratory freezing-and-thawing tests in the Missouri River Division Laboratory, Omaha, Nebr. The companion beams were also sawed from the test panels. The results of the laboratory tests are given below:

Mixture No.	No. of Beams Tested	Age at Test days	Avg %E at 300 Cycles of Freezing-and-Thawing
1	3	14	78
2	3	14	29
3	3	90	14
4	3	90	6
5	3	21	3

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* Four of the beams contained mesh reinforcing.

1965 installation

In November 1965, three sawed concrete beams (3 by 4-1/2 by 16 in.) were installed on the Treat Island exposure rack to provide field durability data on specimens from a specific project in the Missouri River Division.

The specimens represented one concrete mixture and were sawed from a 3-ft-square by 3-in.-thick test slab. The test slab was placed pneumatically (shot) as a reinforcement to rock slope bank protection.

Table 2-SC lists the specimens and gives their exposure record along with other pertinent data.

(Revised May 1976)

Table 1-SC

Record of Testing of Mortar Beams, Missouri River Division Program

1963 - (Installed September 1963)

Exposure Rack, Row 5 (W to E)

Beam No.	Mixture No.	Cement/ Aggregate Ratio as Shot (by wt)	Position of Panel When Shot	Type Cement	Fine Aggregate	Reinforcing Mesh	0 Cycles 1963 %E	135 Cycles 1964 %E	298 Cycles 1965 %E	428 Cycles 1966 %E
1A	1	1:3.5	Vertical	II, A	Sand A	Yes	100	99	101	100
1B	1	1:3.5	Vertical	II, A	Sand A	Yes	100	99	99	100
2A	2	1:4.0	Vertical	II, A	Sand A	No	100	119	120	127
2B	2	1:4.0	Vertical	II, A	Sand A	No	100	92	89	97
2C	2	1:4.0	Vertical	II, A	Sand A	Yes	100	122	124	126
2D	2	1:4.0	Vertical	II, A	Sand A	Yes	100	99	101	116
3A	3	1:3.8	Horizontal	II, B	Sand B	No	100	125	124	125
3B	3	1:3.8	Horizontal	II, B	Sand B	No	100	125	125	127
4A	4	1:3.8	Vertical	II, B	Sand B	No	100	73	74	93
4B	4	1:3.8	Vertical	II, B	Sand B	No	100	101	105	112
5A	5	1:3.5	Vertical	I, C	Sand C	No	100	101	102	105
5B	5	1:3.5	Vertical	I, C	Sand C	No	100	101	102	101
							584 Cycles 1967 %E	769 Cycles 1968 %E	923 Cycles 1969 %E	1076 Cycles 1970 %E
1A	1	1:3.5	Vertical	II, A	Sand A	Yes	100	99	100	100
1B	1	1:3.5	Vertical	II, A	Sand A	Yes	102	102	100	104
2A	2	1:4.0	Vertical	II, A	Sand A	No	125	125	127	136
2B	2	1:4.0	Vertical	II, A	Sand A	No	97	Broken in handling		
2C	2	1:4.0	Vertical	II, A	Sand A	Yes	123	123	125	133
2D	2	1:4.0	Vertical	II, A	Sand A	Yes	121	123	126	133
3A	3	1:3.8	Horizontal	II, B	Sand B	No	125	134	136	143
3B	3	1:3.8	Horizontal	II, B	Sand B	No	127	129	129	143
4A	4	1:3.8	Vertical	II, B	Sand B	No	91	62	65	68
4B	4	1:3.8	Vertical	II, B	Sand B	No	110	114	110	NR
5A	5	1:3.5	Vertical	I, C	Sand C	No	103	102	105	NR
5B	5	1:3.5	Vertical	I, C	Sand C	No	101	83	81	NR
							1245 Cycles 1971 %E	1402 Cycles 1972 %E	1542 Cycles 1973 %E	1681 Cycles 1974 %E
1A	1	1:3.5	Vertical	II, A	Sand A	Yes	97	96	95	96
1B	1	1:3.5	Vertical	II, A	Sand A	Yes	103	102	94	104
2A	2	1:4.0	Vertical	II, A	Sand A	No	129	141	116	123
2C	2	1:4.0	Vertical	II, A	Sand A	Yes	128	110	96	105
2D	2	1:4.0	Vertical	II, A	Sand A	Yes	91	88	81	77
3A	3	1:3.8	Horizontal	II, B	Sand B	No	130	NR	Failed	
3B	3	1:3.8	Horizontal	II, B	Sand B	No	124	NR	Failed	
4A	4	1:3.8	Vertical	II, B	Sand B	No	63	NR	Failed	
4B	4	1:3.8	Vertical	II, B	Sand B	No	NR	NR	Failed	
5A	5	1:3.5	Vertical	I, C	Sand C	No	NR	NR	Failed	
5B	5	1:3.5	Vertical	I, C	Sand C	No	NR	NR	Failed	

NR A satisfactory reading was not obtained although an attempt was made to obtain one.

(Sheet 1)

(Revised August 1977)

Table 1-SC (Continued)

Exposure Rack, Row 5 (W to E)

Beam No.	Mixture No.	Cement/ Aggregate Ratio as Shot (by wt)	Position of Panel When Shot	Type Cement	Fine Aggregate	Reinforcing Mesh	Readings		
							1793 Cycles 1975 %E	1939 Cycles 1976 %E	1975-2016 Cycles 1977 %E
1A	1	1:3.5	Vertical	II, A	Sand A	Yes	96	101	102
1B	1	1:3.5	Vertical	II, A	Sand A	Yes	104	Failed	
2A	2	1:4.0	Vertical	II, A	Sand A	No	123	128	91
2C	2	1:4.0	Vertical	II, A	Sand A	Yes	105	121	107
2D	2	1:4.0	Vertical	II, A	Sand A	Yes	78	81	NR*
3A	3	1:3.8	Horizontal	II, B	Sand B	No			
3B	3	1:3.8	Horizontal	II, B	Sand B	No			
4A	4	1:3.8	Vertical	II, B	Sand B	No			
4B	4	1:3.8	Vertical	II, B	Sand B	No			
5A	5	1:3.5	Vertical	I, C	Sand C	No			
5B	5	1:3.5	Vertical	I, C	Sand C	No			

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* NR denotes a satisfactory reading could not be obtained.

(Revised August 1977)

Table 2-SC

Section 10

Record of Testing of Concrete Beams, Missouri River Division Program

1965- (Installed November 1965)

Exposure Rack, Row 5 (W to E)

						1965-1972 Readings							
Beam No.	Mixture No.	Type Cement	Fine Aggregate	Coarse Aggregate	Air Content %	0 Cycles 1965 %E	130 Cycles 1966 %E	286 Cycles 1967 %E	471 Cycles 1968 %E	625 Cycles 1969 %E	778 Cycles 1970 %E	947 Cycles 1971 %E	1104 Cycles 1972 %E
SC-1	6	I, D	Sand D	Gravel A	7.5	100	92	94	100	100	101	96	65
SC-2	6	I, D	Sand D	Gravel A	7.5	100	97	99	96	94	91	73	49
SC-3	6	I, D	Sand D	Gravel A	7.5	100	102	102	100	102	102	80	65

						1973- Readings				
						1244 Cycles 1973 %E	1383 Cycles 1974 %E	1495 Cycles 1975 %E	1641 Cycles 1976 %E	1718 Cycles 1977 %E
SC-1	6	I, D	Sand D	Gravel A	7.5	89	81	80	82	NR
SC-2	6	I, D	Sand D	Gravel A	7.5	NR	Failed			
SC-3	6	I, D	Sand D	Gravel A	7.5	45	NR	NR	NR	NR

NR denotes no reading was obtained even though an attempt was made to obtain one.

Portland Blast-Furnace Slag Cement Investigation*

This investigation was initiated in FY 1955 to evaluate the performance of blast-furnace slag cement and determine how its performance compares with that of type II portland cement. Twelve air-entrained concrete mixtures were used in the investigation, the difference between the mixtures being the type cement used. Eight portland blast-furnace slag cements, one type II portland cement, and three blends of portland blast-furnace slag cement and natural cement were used. The aggregates used were limestone (3/4-in. maximum size) and natural sand. The cement factor was 5.5 bags per cu yd for all mixtures, and the air content was 6.0 ± 0.5 percent.

Eighteen beams (3-1/2 by 4-1/2 by 16 in.) were fabricated from each of the 12 concrete mixtures (total of 216 beams). Half of these beams (108) were installed on the exposure rack at Treat Island in May 1956; the other half (108) were installed on the St. Augustine exposure rack in August 1956.

Table 1-BFS lists the specimens exposed at Treat Island and gives their exposure record along with their cements.

Table 2-BFS lists the specimens exposed at St. Augustine, and gives their exposure record along with their cements.

In 1956 the question of whether reinforcing steel surrounded by portland blast-furnace slag cement concrete was more prone to corrosion than that surrounded by portland-cement concrete was raised. To answer this question, 45 concrete prisms (8-1/2 by 8-1/2 by 12 in.), each containing 4 pieces of reinforcing bars, were fabricated and installed on the exposure rack at St. Augustine in August 1956. The aggregates and concrete mixtures were the same as those used to fabricate the beams described above except that only three cements were used: two

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* See U. S. Army Engineer Waterways Experiment Station, CE, Investigation of Portland Blast-Furnace Slag Cements, Technical Report No. 6-445, also U. S. Army Engineer Waterways Experiment Station, CE, Investigation of Portland Blast-Furnace Slag Cements; Supplementary Data, by Bryant Mather, Technical Report No. 6-445, Report No. 2 (Vicksburg, Miss., September 1965).

blast-furnace slag cements and one type II portland cement. No tests of these prisms were scheduled while they were undergoing field exposure. They were to be returned to the laboratory for examination in accordance with the following schedule:

Cement	No. of Prisms Installed	No. of Prisms to be Returned to Laboratory in: 1958	1960	1961
Type II, portland cement	15	6	6	3
PBFS* No. 1	15	6	6	3
PBFS* No. 2	15	6	6	3

* Portland blast-furnace slag cement.

Specimens examined after two, four, and five years exposure showed the same relative relation of cement type to amount of corrosion of embedded steel, with the amount of rusting increasing with length of exposure. A "pinpoint" of rust was considered as 1 unit area of corrosion; spots 1/16 in. in diameter were regarded as 4 units; those 1/8 in. in diameter as 16 units, etc. Total average rusted area on all bars, per specimen, arranged by cements was as follows:

Average Rusted Area on Bars, by Cement: Type II	PBFS No. 1	PBFS No. 2	Length of Exposure years	Date
173	17	79	2	1958
1877	60	258	4	1960
2827	111	427	5	1961

Testing of specimens exposed at St. Augustine exposure station was discontinued after the 1970 inspection.

(Revised Sept 1967)

Table 1-BFS

Record of Testing of Concrete Beams Made for Portland Blast-furnace Slag Cement Investigation, Exposed at Treat Island

1956- (Installed May 1956)

Exposure Rack, Row 5 (W to E)

		1956-1967 Readings											
Beam No.	Cement	0 Cycles 1956 %E	144 Cycles 1957 %E	215 Cycles 1958 %E	365 Cycles 1959 %E	436 Cycles 1960 %E	577 Cycles 1961 %E	666 Cycles 1962 %E	772 Cycles 1963 %E	907 Cycles 1964 %E	1070 Cycles 1965 %E	1200 Cycles 1966 %E	1356 Cycles 1967 %E
1ST-2	PBFS* No. 3	100	109	117	115	**							
1ST-4		100	111	117	116	114	109	112	112	110	110	110	108
1ST-6		100	111	119	116	115	110	122	116	117	120	119	115
1ST-8		100	117	123	125	121	117	118	118	114	114	114	114
1ST-10		100	116	121	122	122	115	115	112	111	110	109	108
1ST-12		100	116	125	126	125	118	116	116	113	113	113	112
1ST-14		100	108	115	119	117	112	111	114	112	111	112	112
1ST-16		100	108	115	118	117	109	110	110	107	109	111	110
1ST-18		100	109	117	119	118	112	113	114	111	111	109	109
2ST-20	PBFS No. 4	100	118	125	128	125	119	121	122	117	118	119	118
2ST-22		100	121	130	129	125	118	122	123	119	119	119	119
2ST-24		100	120	128	133	128	122	126	124	120	120	122	120
2ST-26		100	123	134	135	**							
2ST-28		100	123	134	134	133	123	128	126	126	125	124	123
2ST-30		100	122	133	134	131	122	127	127	125	124	124	124
2ST-32		100	122	132	134	132	127	129	129	128	127	125	123
2ST-34		100	121	130	131	130	125	124	126	122	122	124	124
2ST-36		100	120	136	130	126	121	123	122	122	120	121	120
3ST-38	PBFS No. 1	100	119	128	130	141	122	124	123	127	126	128	126
3ST-40		100	113	123	124	**							
3ST-42		100	118	128	130	128	122	127	126	122	122	122	122
3ST-44		100	128	138	139	138	130	129	128	119	114	112	112
3ST-46		100	122	128	132	131	122	123	122	115	114	112	110
3ST-48		100	122	128	132	131	122	122	123	121	120	119	115
3ST-50		100	124	131	135	134	125	127	128	128	120	120	119
3ST-52		100	123	130	134	133	124	126	126	125	121	119	119
3ST-54		100	123	132	134	132	124	125	125	125	123	123	121
4ST-56	PBFS No. 2	100	119	128	131	128	121	123	124	128	125	125	125
4ST-58		100	118	126	128	**							
4ST-60		100	114	123	124	124	117	123	121	127	128	128	125
4ST-62		100	125	130	136	133	126	128	127	126	126	122	121
4ST-64		100	126	135	136	135	126	131	130	130	125	121	120
4ST-66		100	127	134	135	134	124	128	127	126	123	123	123
4ST-68		100	118	125	130	128	121	123	125	123	121	120	119
4ST-70		100	117	125	129	128	121	122	121	121	121	120	120
4ST-72		100	120	127	132	130	123	124	126	126	120	120	120
5ST-74	PBFS No. 5	100	105	112	114	112	106	110	110	110	110	108	108
5ST-76		100	106	113	113	112	105	110	107	104	105	105	104
5ST-78		100	110	116	117	116	109	111	111	109	109	110	109
5ST-80		100	116	123	122	**							
5ST-82		100	117	125	124	123	115	116	114	114	114	115	116
5ST-84		100	120	124	124	122	114	117	113	113	112	111	111
5ST-86		100	115	122	124	122	115	116	114	113	115	113	111
5ST-88		100	112	118	121	119	112	113	112	110	112	112	112
5ST-90		100	114	122	123	120	112	115	114	108	108	108	106
6ST-92	PBFS No. 6	100	121	129	131	130	121	125	123	118	120	118	118
6ST-94		100	124	132	135	**							
6ST-96		100	123	133	134	134	124	128	128	127	127	127	124
6ST-98		100	125	134	134	133	125	124	120	119	117	122	122
6ST-100		100	124	135	137	132	124	124	125	116	117	121	119
6ST-102		100	124	133	136	136	127	127	128	123	121	126	125
6ST-104		100	120	130	130	128	121	121	121	117	116	119	119
6ST-106		100	126	135	134	134	125	125	124	120	119	119	117
6ST-108		100	123	129	131	129	120	120	120	117	115	117	118
7ST-110	PBFS No. 7	100	114	124	126	**							
7ST-112		100	116	124	126	125	118	117	121	120	118	118	117
7ST-114		100	115	124	124	124	120	121	120	116	116	118	117
7ST-116		100	121	129	131	131	122	123	125	123	121	123	121
7ST-118		100	122	130	133	130	124	127	126	125	125	123	123
7ST-120		100	121	131	134	134	123	125	126	125	121	122	121
7ST-122		100	117	126	128	126	118	121	120	120	116	118	117
7ST-124		100	115	122	126	125	117	119	118	116	114	115	115
7ST-126		100	114	123	127	125	118	119	120	115	113	115	115

(Continued)

Note: From 1956 to 1958 the wooden tie-downs were resting directly on these specimens; thereafter they were spaced so as not to touch the concrete.

* Portland blast-furnace slag cement.

** Returned to laboratory 1959.

(Revised August 1977)

Table 1-BFS (Continued)

Exposure Rack, Row 5 (W to E)

		1956-1967 Readings											
Beam No.	Cement	0 Cycles 1956 %E	144 Cycles 1957 %E	215 Cycles 1958 %E	365 Cycles 1959 %E	436 Cycles 1960 %E	577 Cycles 1961 %E	666 Cycles 1962 %E	772 Cycles 1963 %E	907 Cycles 1964 %E	1070 Cycles 1965 %E	1200 Cycles 1966 %E	1356 Cycles 1967 %E
8ST-128	Type II PC†	100	121	128	130	125	120	120	121	121	118	121	120
8ST-130		100	117	123	125	123	116	114	116	116	114	114	114
8ST-132		100	120	126	126	122	115	114	112	108	108	110	110
8ST-134		100	125	133	134	132	123	125	123	122	118	120	118
8ST-136		100	123	132	132	**							
8ST-138		100	123	129	133	128	120	122	121	115	115	117	115
8ST-140		100	123	130	132	128	120	120	122	120	120	120	119
8ST-142		100	123	130	131	129	119	121	123	118	116	116	116
8ST-144		100	127	135	136	132	124	126	122	122	122	122	123
9ST-146	PBFS* No. 8	100	112	120	120	120	110	115	116	112	112	111	111
9ST-148		100	112	120	120	120	113	111	113	111	111	111	111
9ST-150		100	112	121	122	121	114	116	116	113	113	115	115
9ST-152		100	114	122	124	122	116	117	116	114	113	116	118
9ST-154		100	113	123	123	123	114	116	117	114	114	114	115
9ST-156		100	110	119	119	**							
9ST-158		100	111	117	118	117	107	108	106	103	105	103	104
9ST-160		100	109	116	117	118	110	111	109	107	103	105	105
9ST-162		100	111	118	120	119	110	110	108	106	102	106	106
10ST-164	Blend: No. 2	100	116	124	128	127	120	120	119	118	116	118	117
10ST-166	PBFS, 80%;	100	115	120	123	120	113	115	116	109	109	109	110
10ST-168	nat cem A,	100	107	113	115	111	104	107	103	101	98	91	93
10ST-170	20%††	100	114	121	123	**							
10ST-172		100	113	121	122	122	112	111	111	107	105	103	105
10ST-174		100	110	117	120	117	108	110	108	105	103	100	99
10ST-176		100	112	119	122	119	111	113	111	109	106	106	110
10ST-178		100	111	118	120	118	110	110	111	110	108	106	108
10ST-180		100	111	117	119	117	108	109	107	102	104	101	101
11ST-182	Blend: No. 2	100	109	115	115	113	104	108	102	97	94	92	93
11ST-184	PBFS, 75%;	100	105	110	113	113	101	103	101	94	89	89	89
11ST-186	nat cem A,	100	108	114	116	114	102	105	103	96	94	92	92
11ST-188	25%	100	119	125	129	128	120	121	121	118	119	118	117
11ST-190		100	111	118	120	**							
11ST-192		100	109	117	118	116	106	102	108	106	113	115	117
11ST-194		100	110	118	117	116	104	106	103	95	72	78	77
11ST-196		100	106	114	111	109	93	92	92	83	81	94	93
11ST-198		100	106	113	115	112	101	103	101	95	92	90	90
12ST-200	Blend: No. 2	100	106	110	112	110	100	105	100	95	92	90	90
12ST-202	PBFS, 70%;	100	101	109	109	105	83	95	94	92	89	80	81
12ST-204	nat cem A,	100	99	103	103	101	88	89	89	84	75	72	71
12ST-206	30%	100	100	104	100	100	84	87	78	74	70	62	60
12ST-208		100	102	106	104	104	90	92	88	79	74	69	69
12ST-210		100	111	117	116	116	103	107	103	100	95	97	97
12ST-212		100	113	120	126	121	109	110	110	107	104	101	100
12ST-214		100	117	123	126	124	114	118	118	111	106	104	107
12ST-216		100	120	126	128	**							

		1968- Readings									
		1541 Cycles 1968 %E	1695 Cycles 1969 %E	1848 Cycles 1970 %E	2017 Cycles 1971 %E	2174 Cycles 1972 %E	2314 Cycles 1973 %E	2453 Cycles 1974 %E	2565 Cycles 1975 %E	2711 Cycles 1976 %E	2788 Cycles 1977 %E
1ST-4	PBFS No. 3	109	110	112	112	100	Failed				
1ST-6		120	117	120	121	105	Failed				
1ST-8		112	114	113	114	99	Failed				
1ST-10		113	114	110	103	103	97	97	98	148	116
1ST-12		111	112	112	111	116	100	102	102	127	NR
1ST-14		113	114	108	108	110	98	98	100	102	102
1ST-16		106	102	102	102	121	75	79	79	NR	NR
1ST-18		105	103	103	109	116	104	150	152	NR	NR
2ST-20	PBFS No. 4	114	118	116	117	122	122	153	153	NR	NR
2ST-22		117	121	119	121	123	154	154	160	NR	NR
2ST-24		120	125	120	122	118	123	118	123	184	191
2ST-28		125	123	119	124	123	109	98	100	147	NR
2ST-30		123	125	118	123	127	110	117	118	122	141
2ST-32		125	126	120	128	128	110	111	112	121	136
2ST-34		119	120	114	118	116	123	124	128	134	135
2ST-36		117	118	114	119	115	119	165	165	NR	NR

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* Portland blast-furnace slag cement.

** Returned to laboratory 1959.

† Portland cement.

†† Nat cem = natural cement.

NR A satisfactory reading was not obtained although an attempt was made to obtain one.

(Revised August 1977)

Table 1-BFS (Continued)

Exposure Rack, Row 5 (W to E)

		1968- Readings									
Beam No.	**Cement**	1541 Cycles 1968 %E	1695 Cycles 1969 %E	1848 Cycles 1970 %E	2017 Cycles 1971 %E	2174 Cycles 1972 %E	2314 Cycles 1973 %E	2453 Cycles 1974 %E	2565 Cycles 1975 %E	2711 Cycles 1976 %E	2788 Cycles 1977 %E
3ST-38	PBFS* No. 1	126	126	124	121	118	97	105	107	NR	NR
3ST-42		122	123	118	117	115	128	M			
3ST-44		103	102	94	NR	D					
3ST-46		99	98	97	NR	D					
3ST-48		115	116	NR	NR	D					
3ST-50		119	121	114	117	D					
3ST-52		117	118	111	114	D					
3ST-54		126	128	138	NR	D					
4ST-56	PBFS No. 2	125	126	125	128	116	NR	98	98	118	114
4ST-60		125	126	125	132	NR	NR	NR	NR	D	
4ST-62		113	116	106	113	NR	NR	M	M		
4ST-64		122	122	124	120	NR	NR	NR	NR	D	
4ST-66		120	123	115	116	NR	NR	M	M		
4ST-68		119	119	114	119	NR	NR	M	M		
4ST-70		121	119	110	114	107	140	137	142	136	124
4ST-72		120	120	113	118	NR	NR	M	M		
5ST-74	PBFS No. 5	106	110	114	111	104	105	107	107	NR	D
5ST-76		103	104	102	99	92	94	NR	NR	D	
5ST-78		109	107	107	103	97	100	97	99	133	137
5ST-82		111	111	112	107	104	104	M	M		
5ST-84		108	110	108	99	97	99	100	101	114	113
5ST-86		111	109	108	104	102	97	99	99	D	
5ST-88		110	110	107	105	102	96	88	90	96	96
5ST-90		103	102	102	96	95	70	77	78	100	106
6ST-92	PBFS No. 6	120	120	120	116	112	101	111	111	106	NR
6ST-96		126	124	125	120	115	114	114	115	NR	NR
6ST-98		120	121	115	110	107	113	113	114	D	
6ST-100		119	118	117	112	110	108	108	111	NR	D
6ST-102		125	124	124	120	116	117	117	117	NR	D
6ST-104		116	114	113	110	108	104	104	106	108	112
6ST-106		117	119	117	112	105	87	NR	NR	D	
6ST-108		117	115	113	106	92	92	93	95	91	NR
7ST-112	PBFS No. 7	118	117	117	109	106	105	103	105	103	NR
7ST-114		118	116	116	114	106	109	108	110	104	NR
7ST-116		122	121	119	114	114	109	107	112	110	NR
7ST-118		125	126	122	116	111	114	113	114	114	NR
7ST-120		122	118	118	114	107	109	107	112	115	118
7ST-122		114	114	109	100	100	97	96	98	98	NR
7ST-124		109	111	107	95	103	92	92	94	92	94
7ST-126		112	113	111	108	106	103	126	127	130	132
8ST-128	Type II PC†	118	116	114	114	123	123	118	120	118	119
8ST-130		114	112	110	116	105	114	114	116	105	115
8ST-132		108	110	108	109	99	107	107	111	112	117
8ST-134		120	119	118	113	105	123	121	122	122	124
8ST-138		117	115	115	111	104	119	116	118	114	117
8ST-140		119	121	119	107	104	114	132	130	131	121
8ST-142		116	114	116	112	109	111	119	117	118	119
8ST-144		121	120	118	114	111	111	118	118	142	146
9ST-146	PBFS No. 8	112	110	108	106	102	112	114	114	NR	D
9ST-148		113	111	111	109	105	116	119	118	↓	↓
9ST-150		117	116	114	116	112	119	120	120	↓	↓
9ST-152		116	114	114	114	123	118	174	160	↓	↓
9ST-154		113	110	112	112	121	139	NR	NR	↓	↓
9ST-158		101	100	100	100	115	83	NR	NR	↓	↓
9ST-160		105	105	103	101	109	88	NR	NR	↓	↓
9ST-162		106	104	105	107	116	104	105	105	↓	↓
10ST-164	Blend: No. 2 PBFS, 80%; nat cem A, 20%††	114	116	114	106	NR	96	100	102	↓	↓
10ST-166		102	100	98	108	109	93	96	96	↓	↓
10ST-168		82	82	83	92	85	85	NR	NR	↓	↓
10ST-172		101	101	101	74	D				↓	↓
10ST-174		99	101	99	103	97	101	102	102	↓	↓
10ST-176		106	104	102	103	96	76	91	89	↓	↓
10ST-178		102	103	101	97	95	80	NR	NR	↓	↓
10ST-180		93	91	91	Broken						

(Continued)

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* Portland blast-furnace slag cement.
† Portland cement.
†† Nat cem = natural cement.
NR A satisfactory reading was not obtained although an attempt was made to obtain one.
D Specimens so deteriorated that no reading can be obtained.
M Missing.

(Revised August 1977)

Table 1-BFS (Continued)

Exposure Rack, Row 5 (W to E)

		1968- Readings									
Beam No.	**Cement**	1541 Cycles 1968 %E	1695 Cycles 1969 %E	1848 Cycles 1970 %E	2017 Cycles 1971 %E	2174 Cycles 1972 %E	2314 Cycles 1973 %E	2453 Cycles 1974 %E	2565 Cycles 1975 %E	2711 Cycles 1976 %E	2788 Cycles 1977 %E
11ST-182	Blend: No. 2	85	82	84	62	68	NR	NR	NR	D	D
11ST-184	PBFS, 75%;	80	76	81	52	56	NR	NR	NR	↓	↓
11ST-186	nat cem A,	82	78	76	Broken					↓	↓
11ST-188	25%	110	106	104	94	86	NR	NR	NR	↓	↓
11ST-192		108	106	108	Broken					↓	↓
11ST-194		69	64	66	Broken					↓	↓
11ST-196		68	Failed							↓	↓
11ST-198		86	82	75	66	62	NR	NR	NR	↓	↓
12ST-200	Blend: No. 2	84	80	81	73	68	NR	NR	NR	↓	↓
12ST-202	PBFS,* 70%;	Failed								↓	↓
12ST-204	nat cem A,	Failed								↓	↓
12ST-206	30%††	Failed								↓	↓
12ST-208		Failed								↓	↓
12ST-210		86	83	87	80	81	NR	NR	NR	↓	↓
12ST-212		92	91	Failed						↓	↓
12ST-214		95	93	96	Failed					↓	↓

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* Portland blast-furnace slag cement.

†† Nat cem = natural cement.

NR A satisfactory reading was not obtained although an attempt was made to obtain one.

D Specimens so deteriorated that no reading can be obtained.

(Revised Sept 1966)

Table 2-BFS

Record of Testing of Concrete Beams Made for Portland Blast-furnace Slag Cement Investigation, Exposed at St. Augustine

1956- (Installed August 1956)

		1956-1966 Readings					
Beam No.	Cement	1956 %E	1958 %E	1960 %E	1962 %E	1964 %E	1966 %E
1SA-1	PBFS* No. 3	100	113	118	116	118	125
1SA-3		100	112	119	118	120	118
1SA-5		100	115	127	119	121	129
1SA-7		100	116	128	116	123	122
1SA-9		100	116	130	119	121	120
1SA-11		100	118	131	120	122	122
1SA-13		100	107	118	107	109	109
1SA-15		100	107	117	108	110	108
1SA-17		100	107	118	109	110	111
2SA-19	PBFS No. 4	100	122	136	139	144	141
2SA-21		100	123	137	126	127	128
2SA-23		100	121	135	123	125	124
2SA-25		100	127	142	117	118	118
2SA-27		100	126	139	128	129	129
2SA-29		100	127	142	130	130	131
2SA-31		100	119	125	118	120	121
2SA-33		100	116	120	113	115	115
2SA-35		100	119	125	118	118	120
3SA-37	PBFS No. 1	100	123	137	125	130	130
3SA-39		100	123	134	125	127	127
3SA-41		100	125	138	128	131	132
3SA-43		100	129	142	139	142	142
3SA-45		100	131	147	136	139	139
3SA-47		100	130	142	139	142	142
3SA-49		100	126	147	119	120	119
3SA-51		100	123	136	117	103	117
3SA-53		100	123	136	114	93	116
4SA-55	PBFS No. 2	100	123	137	137	119	138
4SA-57		100	123	136	125	130	131
4SA-59		100	122	136	126	129	129
4SA-61		100	131	144	131	134	134
4SA-63		100	134	145	135	136	137
4SA-65		100	133	145	133	133	134
4SA-67		100	119	130	119	134	134
4SA-69		100	115	124	112	127	118
4SA-71		100	114	121	112	112	113
5SA-73	PBFS No. 5	100	117	126	117	131	116
5SA-75		100	117	129	116	118	117
5SA-77		100	118	129	117	118	118
5SA-79		100	114	123	114	116	111
5SA-81		100	115	127	114	117	116
5SA-83		100	115	127	115	115	115
5SA-85		100	113	123	113	115	114
5SA-87		100	114	123	116	118	118
5SA-89		100	115	128	113	116	115
6SA-91	PBFS No. 6	100	127	140	130	130	130
6SA-93		100	128	136	121	146	125
6SA-95		100	129	131	123	123	125
6SA-97		100	121	135	124	125	127
6SA-99		100	122	128	121	121	122
6SA-101		100	120	127	115	117	117
6SA-103		100	125	134	127	125	127
6SA-105		100	125	131	123	129	127
6SA-107		100	122	138	124	125	125
7SA-109	PBFS No. 7	100	122	130	121	121	121
7SA-111		100	122	128	116	118	118
7SA-113		100	123	128	119	117	126
7SA-115		100	131	143	131	132	128
7SA-117		100	131	140	130	127	128
7SA-119		100	130	140	128	129	129
7SA-121		100	122	130	118	119	119
7SA-123		100	121	129	120	120	118
7SA-125		100	120	128	116	118	125

(Continued)

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* Portland blast-furnace slag cement.

(Revised Sept 1970)

Table 2-BFS (Continued)

		1956-1966 Readings					
Beam No.	Cement	1956 %E	1958 %E	1960 %E	1962 %E	1964 %E	1966 %E
8SA-127	Type II PC**	100	126	134	121	126	121
8SA-129		100	126	136	124	122	124
8SA-131		100	126	134	122	121	121
8SA-133		100	125	132	120	120	123
8SA-135		100	125	132	120	120	121
8SA-137		100	125	136	122	122	115
8SA-139		100	128	135	120	120	122
8SA-141		100	131	137	125	125	132
8SA-143		100	129	135	120	120	132
9SA-145	PBFS* No. 8	100	121	130	116	116	114
9SA-147		100	119	128	117	117	113
9SA-149		100	119	128	117	117	111
9SA-151		100	117	124	112	112	110
9SA-153		100	115	124	115	117	117
9SA-155		100	114	116	107	107	109
9SA-157		100	120	129	117	117	119
9SA-159		100	122	130	117	119	121
9SA-161		100	120	129	117	119	118
10SA-163	Blend: No. 2	100	123	131	117	122	122
10SA-165	PBFS, 80%;	100	124	134	120	122	122
10SA-167	nat cem A,	100	128	138	126	135	126
10SA-169	20%†	100	124	127	117	118	113
10SA-171		100	122	130	123	124	124
10SA-173		100	123	130	114	115	120
10SA-175		100	124	135	118	119	122
10SA-177		100	124	136	124	125	123
10SA-179		100	126	137	125	127	126
11SA-181	Blend: No. 2	100	125	133	120	123	123
11SA-183	PBFS, 75%;	100	123	131	119	119	119
11SA-185	nat cem A,	100	124	130	118	119	126
11SA-187	25%	100	128	138	123	123	128
11SA-189		100	129	138	122	124	128
11SA-191		100	127	136	125	126	130
11SA-193		100	123	131	122	124	119
11SA-195		100	123	130	118	120	120
11SA-197		100	126	137	122	124	126
12SA-199	Blend: No. 2	100	121	129	117	124	121
12SA-201	PBFS, 70%;	100	118	125	114	120	109
12SA-203	nat cem A,	100	121	127	111	111	120
12SA-205	30%	100	125	129	127	128	123
12SA-207		100	124	131	119	119	121
12SA-209		100	122	128	117	116	118
12SA-211		100	122	129	118	119	126
12SA-213		100	130	138	125	125	130
12SA-215		100	131	140	127	128	Lost

		1968- Readings	
		1968 %E	1970 %E
1SA-1	PBFS No. 3	125	Lost
1SA-3		118	117
1SA-5		121	121
1SA-7		123	121
1SA-9		118	118
1SA-11		120	119
1SA-13		103	103
1SA-15		107	107
1SA-17		108	107
2SA-19	PBFS No. 4	136	133
2SA-21		124	122
2SA-23		117	117
2SA-25		112	112
2SA-27		133	134
2SA-29		135	135
2SA-31		122	121
2SA-33		115	113
2SA-35		120	120

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* Portland blast-furnace slag cement.

** PC = portland cement.

† Nat cem = natural cement.

(Revised Sept 1970)

Table 2-BFS (Continued)

		1968- Readings	
Beam No.	Cement	1968 %E	1970 %E
3SA-37	PBFS* No. 1	132	131
3SA-39		123	Lost
3SA-41		129	Lost
3SA-43		141	141
3SA-45		139	136
3SA-47		141	140
3SA-49		119	117
3SA-51		117	116
3SA-53		114	114
4SA-55	PBFS No. 2	138	134
4SA-57		126	Lost
4SA-59		129	128
4SA-61		135	135
4SA-63		140	139
4SA-65		137	137
4SA-67		139	135
4SA-69		114	113
4SA-71		114	114
5SA-73	PBFS No. 5	118	118
5SA-75		119	119
5SA-77		119	119
5SA-79		113	113
5SA-81		118	118
5SA-83		115	113
5SA-85		112	Lost
5SA-87		118	Lost
5SA-89		111	110
6SA-91	PBFS No. 6	123	123
6SA-93		131	131
6SA-95		125	123
6SA-97		127	125
6SA-99		126	Lost
6SA-101		119	Lost
6SA-103		131	Lost
6SA-105		132	Lost
6SA-107		129	Lost
7SA-109	PBFS No. 7	126	Lost
7SA-111		119	Lost
7SA-113		126	Lost
7SA-115		124	124
7SA-117		128	127
7SA-119		131	128
7SA-121		121	120
7SA-123		121	119
7SA-125		125	124
8SA-127	Type II PC**	124	122
8SA-129		120	118
8SA-131		121	121
8SA-133		121	119
8SA-135		122	122
8SA-137		116	115
8SA-139		118	117
8SA-141		138	138
8SA-143		128	128
9SA-145	PBFS No. 8	112	112
9SA-147		110	109
9SA-149		111	109
9SA-151		111	109
9SA-153		116	114
9SA-155		109	107
9SA-157		119	118
9SA-159		119	118
9SA-161		120	120
10SA-163	Blend: No. 2 PBFS, 80%; nat cem A, 20%†	121	121
10SA-165		107	105
10SA-167		122	121
10SA-169		110	109
10SA-171		123	121
10SA-173		117	115
10SA-175		121	121
10SA-177		118	117
10SA-179		131	130

(Continued)

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* Portland blast-furnace slag cement.

** PC = portland cement.

† Nat cem = natural cement.

(Revised Sept 1970)

Table 2-BFS (Concluded)

		1968- Readings	
Beam No.	Cement	1968 %E	1970 %E
11SA-181	Blend: No. 2 PBFS,* 75%; nat cem A, 25%†	125	123
11SA-183		118	116
11SA-185		126	126
11SA-187		121	120
11SA-189		132	131
11SA-191		129	127
11SA-193		112	111
11SA-195		118	117
11SA-197		131	131
12SA-199	Blend: No. 2 PBFS, 70%; nat cem A, 30%	120	120
12SA-201		110	110
12SA-203		121	118
12SA-205		129	128
12SA-207		119	119
12SA-209		124	122
12SA-211		126	124
12SA-213		125	125

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* Portland blast-furnace slag cement.

† Nat cement = natural cement.

Specimen Size-Frost Effects Investigation

In December 1968, 18 concrete specimens (four sizes) were installed on the Treat Island exposure rack. This installation consisted of nine 3-1/2- by 4-1/2- by 16-in. beams, three 6- by 6- by 30-in. beams, three 2-ft cubes, and three 18- by 18- by 36-in. prisms. The purpose of this installation was to develop data on the effect of specimen size on the durability of concrete specimens in tidal exposure.

The four sizes of concrete test specimens were made from six batches of the same concrete mixture. The mixture contained crushed limestone fine and coarse aggregates and had the following characteristics:

Coarse aggregate - 100% passing 1-in. sieve
Fine aggregate - 98-100% passing No. 4 sieve
Cement - type II portland
Air content - 4-1/2 ± 1/2%
Water-cement ratio - 5.5 gal/bag
Slump - 2-1/2 ± 1/2 in.
Sand content - 36 to 42%
Cement factor - 6.0 ± 0.3 bags/cu yd
Compressive strength at 28 days age (nominal) - 5000 psi

Table 1-SSFE lists these concrete specimens and gives their exposure record along with other pertinent information.

(Revised August 1977)

Table 1-SSFE

Record of Testing of Concrete Specimens for Specimen Size-Frost Effects Investigation

1968- (Installed Dec 1968)

Exposure Rack

Specimen No.	Air Content* %	1968-1975 Readings																
		0 Cycles, 1968			139 Cycles 1969		292 Cycles 1970		461 Cycles 1971		618 Cycles 1972		758 Cycles 1973		897 Cycles 1974		1009 Cycles 1975	
		%E	Pulse Veloc fps	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
3-1/2- by 4-1/2- by 16-in. Beams																		
ROS-4A	4.3	100	15,465	100	102	107	107	100	118	91	118	102	115	96	116	119	116	80
ROS-4B	4.3	100	15,930	100	104	99	110	96	119	82	119	96	117	94	118	110	118	57
ROS-4C	4.3	100	16,420	100	101	95	108	89	119	78	119	89	119	93	118	105	119	64
ROS-5A	4.6	100	15,740	100	102	104	108	101	118	86	120	94	121	101	120	95	118	66
ROS-5B	4.6	100	16,420	100	100	100	109	93	119	79	117	85	117	103	118	111	118	70
ROS-5C	4.6	100	16,420	100	99	95	110	91	120	83	118	91	118	98	119	105	118	70
ROS-6A	4.2**	100	16,120	100	101	99	111	94	119	84	117	96	117	96	116	105	117	73
ROS-6B	4.2**	100	16,320	100	100	94	110	88	118	75	116	90	118	99	120	103	120	70
ROS-6C	4.2**	100	16,320	100	101	90	110	84	117	75	115	84	120	104	119	105	120	67
6- by 6- by 30-in. Beams																		
ROS-1	4.0	100	14,795	100	100	114	115	112	111	92	109	99	109	112	109	127	109	152
ROS-2	4.4**	100	14,705	100	102	116	126	111	121	90	118	99	116	101	118	123	116	150
ROS-3	4.8	100	15,335	100	100	105	108	104	101	81	102	98	104	98	104	113	104	130
2-ft Cubes																		
ROS-1	4.0	100	15,210	100	†	101	†	99	†	82	†	101	†	102	†	119	†	150
ROS-2	4.4**	100	15,265	100	†	100	†	94	†	78	†	93	†	103	†	112	†	141
ROS-3	4.8	100	15,150	100	†	100	†	97	†	80	†	100	†	97	†	110	†	106
18- by 18- by 36-in. Prisms																		
ROS-4	4.3	100	15,750	100	94	102	106	99	107	89	105	95	108	105	109	105	109	109
ROS-5	4.6	100	15,545	100	94	102	102	100	114	87	116	99	116	105	116	108	116	111
ROS-6	4.2**	100	15,425	100	97	103	108	100	108	90	108	101	108	111	108	108	108	109

		1976- Readings			
		1155 Cycles 1976		1232 Cycles 1977	
		%E	%V^2	%E	%V^2
3-1/2- by 4-1/2- by 16-in. Beams					
ROS-4A	4.3	113	113	113	91
ROS-4B	4.3	116	105	116	87
ROS-4C	4.3	121	100	117	85
ROS-5A	4.6	102	116	114	87
ROS-5B	4.6	119	105	120	89
ROS-5C	4.6	121	100	120	87
ROS-6A	4.2**	118	98	117	93
ROS-6B	4.2**	115	100	117	89
ROS-6C	4.2**	117	105	117	70
6- by 6- by 30-in. Beams					
ROS-1	4.0	109	119	107	116
ROS-2	4.4**	112	114	119	116
ROS-3	4.8	100	100	102	101
2-ft Cubes					
ROS-1	4.0	†	112	†	112
ROS-2	4.4**	†	100	†	106
ROS-3	4.8	†	102	†	108
18- by 18- by 36-in. Prisms					
ROS-4	4.3	106	108	107	103
ROS-5	4.6	118	110	118	106
ROS-6	4.2**	112	110	112	104

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* Air content determined on each batch; six batches of concrete were made for this investigation.

** Slump was 2-1/4 in. for these batches; slump of all other batches of concrete was 2 in.

† Unable to obtain satisfactory flexural frequency reading on these cubes.

Trumbull Pond Dam Prisms

In June 1972, six concrete prisms (18 by 18 by 36 in.) were installed on the Treat Island exposure rack to determine the durability of two interior mass concrete mixtures containing the aggregate being considered for use in Trumbull Pond Dam.

The prisms were made from two concrete mixtures (three prisms per mixture); the fine and coarse aggregates used were pit-run sand and gravel, maximum size 6 in., from an undeveloped on-site source. Both concrete mixtures were air entrained (5 ± 1 percent) with a slump of 2 ± 1/2 in. Type II portland cement was used in both mixtures, with one mixture containing a replacement material (35 percent by solid volume). Water-cement ratios were 0.66 and 0.63, by weight; cement factors were 2.90 and 3.15 bags per cu yd.

Table 1-TP lists these concrete specimens and gives their exposure record along with other pertinent information.

(Revised August 1977)

Table 1-TP

Record of Testing of Trumbull Pond Dam Concrete Prisms

1972- (Installed June 1972)

Exposure Rack, Row 3

Prism No.	Replacement Material	Water-Cement Ratio by Wt	Cementitious Material, lb/cu yd		1972-1975 Readings								
			Type II Portland Cement	Fly Ash	0 Cycles, 1972			140 Cycles 1973		276 Cycles 1974		388 Cycles 1975	
					%E	Pulse Velocity fps	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
Cem-1	None	0.66	273	0	100	13,760	100	113	111	113	103	109	98
Cem-2	None	0.66	273	0	100	13,890	100	117	101	115	106	114	127
Cem-3	None	0.66	273	0	100	14,220	100	101	108	100	105	99	126
FA-1	Fly ash*	0.63	192	79	100	13,335	100	118	103	113	108	108	107
FA-2	Fly ash*	0.63	192	79	100	13,275	100	125	116	121	106	116	98
FA-3	Fly ash*	0.63	192	79	100	13,335	100	120	92	106	58	106	End gone

					1976- Readings			
					534 Cycles 1976		611 Cycles 1977	
					%E	%V^2	%E	%V^2
Cem-1	None	0.66	273	0	75	NR	NR	NR
Cem-2	None	0.66	273	0	109	102	77	106
Cem-3	None	0.66	273	0	100	91	47	97
FA-1	Fly ash*	0.63	192	79	119	NR	62	NR
FA-2	Fly ash*	0.63	192	79	106	NR	NR	NR
FA-3	Fly ash*	0.63	192	79	--	--	--	--

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* 35 percent replacement by solid volume; all prisms contain type II portland cement.

NR denotes a satisfactory reading could not be obtained.

Investigation of 4-1/2-in. Aggregate Concrete

In December 1968, 12 concrete prisms (18 by 18 by 36 in.) were installed on the Treat Island exposure rack. The purpose of this installation was to determine the durability of mass concrete containing 4-1/2-in. maximum size aggregate.

The prisms were made from six concrete mixtures (two prisms per mixture); the fine and coarse aggregates used in all mixtures were of a crushed limestone, maximum size 4-1/2 in. Each concrete mixture was air-entrained (5 ± 1%) with a slump of 2 ± 1/2 in. Type II portland cement was used in all mixtures, and three mixtures also contained a replacement material (30% by solid volume). Water-cement ratios were 0.8, 0.9, or 1.0, by weight; cement factors varied from 1.84 to 2.40 bags per cu yd.

Table 1-4.5A lists these concrete specimens and gives their exposure record along with other pertinent information.

(Revised August 1977)

Table 1-4.5A

Record of Testing of Prisms Made for Investigation of 4-1/2-in. Aggregate Concrete

1968- (Installed Dec 1968)

Exposure Rack, Row 2

					1968-1972 Readings												
					0 Cycles, 1968			139 Cycles 1969		292 Cycles 1970		461 Cycles 1971		618 Cycles 1972			
Prism No.	Date Made	Replacement Material	Water-Cement Ratio by Wt	Cement Factor bags/cu yd	%E	Pulse Veloc fps	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2		
Mix 1, Rd 1	Oct 1967	None	0.8	2.30	100	16,130	100	87	102	106	99	105	73	91	62		
Rd 2	Oct 1967	None	0.8	2.30	100	16,130	100	96	101	105	99	104	61	91	NR**		
Mix 2, Rd 1	Nov 1967	None	0.9	2.04	100	15,705	100	99	103	102	100	101	83	89	81		
Rd 2	Dec 1967	None	0.9	2.04	100	16,045	100	99	99	91	92	87	66	NR	43		
Mix 3, Rd 1	Apr 1968	None	1.0	1.84	100	15,705	100	95	103	88	95	83	69	82	NR		
Rd 2	July 1968	None	1.0	1.84	100	15,750	100	97	103	110	99	109	75	Failed	NR		
Mix 4, Rd 1	Apr 1968	Fly ash*	0.8	2.40	100	16,440	100	93	104	122	98	108	76	110	86		
Rd 2	July 1968	Fly ash*	0.8	2.40	100	16,045	100	89	99	120	96	116	79	111	91		
Mix 5, Rd 1	June 1968	Fly ash*	0.9	2.14	100	15,790	100	95	111	106	107	106	86	99	96		
Rd 2	July 1968	Fly ash*	0.9	2.14	100	15,665	100	90	108	103	105	103	84	100	65		
Mix 6, Rd 1	July 1968	Fly ash*	1.0	1.94	100	15,625	100	101	102	65	97	Failed	78	Failed	58		
Rd 2	July 1968	Fly ash*	1.0	1.94	100	15,545	100	97	107	105	96	103	75	84	84		

					1973-1977 Readings									
					758 Cycles 1973		894 Cycles 1974		1006 Cycles 1975		1152 Cycles 1976		1229 Cycles 1977	
					%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
Mix 1, Rd 1	Oct 1967	None	0.8	2.30	77	86	75	61	72	67	93	14	90	18
Rd 2	Oct 1967	None	0.8	2.30	NR	--	Failed							
Mix 2, Rd 1	Nov 1967	None	0.9	2.04	92	92	NR	98	Failed					
Rd 2	Dec 1967	None	0.9	2.04	Failed									
Mix 3, Rd 1	Apr 1968	None	1.0	1.84	NR	NR	Failed							
Rd 2	July 1968	None	1.0	1.84	Failed	NR								
Mix 4, Rd 1	Apr 1968	Fly ash*	0.8	2.40	101	98	92	92	92	95	95	37	--	Failed
Rd 2	July 1968	Fly ash*	0.8	2.40	107	103	100	96	100	108	Failed			
Mix 5, Rd 1	June 1968	Fly ash*	0.9	2.14	95	111	86	103	86	111	66	50	73	48
Rd 2	July 1968	Fly ash*	0.9	2.14	93	104	87	105	81	107	79	11	Failed	
Mix 6, Rd 1	July 1968	Fly ash*	1.0	1.94	Failed	95	Failed							
Rd 2	July 1968	Fly ash*	1.0	1.94	73	93	NR	78	Failed					

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* 30% replacement by solid volume; all prisms contain type II portland cement.

** NR denotes a satisfactory reading could not be obtained.

(Issued August 1977) Key to Section 15

Sulfur-Infiltrated Concrete (Canadian)

Aggregates: Coarse, limestone, Ottawa

Fine, natural sand, Ottawa Valley, Ottawa

Admixture: Air-entraining, DAREX, W. R. Grace

Cement: Type I (CSA type 10), Canada Cement La Farge, Hull, Quebec

Sulfur: 99.9 percent pure sulfur obtained commercially (Ottawa)

Sulfur-Infiltrated Concrete (Canadian)

In January 1976, the Canada Centre for Mineral and Energy Technology received permission from the Office, Chief of Engineers, to install specimens of sulfur-infiltrated concrete at the Treat Island exposure station.

In August 1976, eighteen 4- by 8-in. cylinders and thirty-six 3- by 6-in. cylinders were installed at half-tide elevation on the exposure rack. The cylinders were made from nine different concrete mixtures that included air-entrained and nonair-entrained concrete. The fine and coarse aggregates were natural sand and 1/2-in.-maximum size limestone, respectively. Type I (CSA Type 10) portland cement was used in the mixtures. Tables 1, 2, and 3 contain pertinent data on mixtures and specimens. Table 1-SIC contains the exposure records of installed specimens.

In July 1977, 15 sulfur-infiltrated precast concrete elements were installed as additions to the program. Pertinent data on these specimens will be included as the information becomes available.

(Issued August 1977)

Table 1

Mix Data and Properties of Uninfiltrated Concrete Specimens

	Mix Data						Properties of Fresh Concrete			Properties of Hardened Concrete (Uninfiltrated)				
											3- × 6-in. Cylinder Compressive Strength,* psi		4- × 8-in. Cylinder Compressive Strength,* psi	
Mix No.	Aggr Max Size in.	Fine/ Coarse Aggr	Cement Content lb/cu yd	Water/Cement Ratio by Wt	Aggr/ Cement	AEA cc/cu yd	Slump in.	Unit Weight lb/cu yd	Air %	1-Day Density lb/cu yd	48-hr	28-day	48-hr	28-day
						Nonair-Entrained Concrete								
81	1/2	50/50	490	0.69	6.4	--	5-1/2	3953	2.6	148	1260	3615	1375	3860
82	1/2	50/50	444	0.68	7.2	--	2	3942	2.8	148	1450	4030	1530	3920
83	1/2	50/50	443	0.68	7.2	--	2-1/2	3931	2.9	148	1505	4245	1410	3940
84	1/2	50/50	444	0.68	7.2	--	2-1/4	3942	2.5	148	1275	4035	1275	3840
85	1/2	50/50	444	0.68	7.2	--	1-3/4	3942	2.1	148	1380	4105	1375	3890
						Air-Entrained Concrete								
86	1/2	50/50	414	0.61	7.2	80	3-1/2	3650	8.0	137	1090	3890	1275	3600
87	1/2	50/50	421	0.68	7.2	80	4-1/2	3737	8.0	138	1060	3060	1255	2895
88	1/2	50/50	384	0.67	7.9	80	3-1/2	3672	8.2	137	885	2725	1015	2630
89	1/2	50/50	392	0.67	7.9	80	3-1/2	3748	7.0	139	1025	2830	1095	2790

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* Average of two specimens.

Table 2

Infiltrated 3- × 6-in. Cylinders

Specimen No.	Density lb/cu yd	Sulfur		48-hr Compressive Strength psi
		g	%*	
81-5	157.4	187	11.8	11,040
81-6	156.9	184	11.7	10,475
81-7**	156.5	180	11.6	
81-8**	156.6	169	11.0	
81-9**	157.2	201	12.9	
81-10**	156.8	197	12.7	
82-5	157.7	191	12.3	11,605
82-6	158.0	197	12.8	11,180
82-7**	157.8	198	12.8	
82-8**	157.7	202	12.9	
82-9**	157.8	199	12.7	
82-10**	157.9	197	12.9	
83-5	156.6	197	12.6	11,040
83-6	157.2	203	13.2	10,900
83-7**	157.8	200	12.8	
83-8**	157.2	204	13.0	
83-9**	157.4	207	13.4	
83-10**	157.7	198	12.7	
84-5	158.2	200	12.7	10,970
84-6	156.2	205	13.2	11,325
84-7**	158.5	204	13.4	
84-8**	158.5	199	13.0	
84-9**	158.5	205	13.5	
84-10**	158.4	204	13.1	
85-5	157.6	209	13.6	12,170
85-6	158.2	206	13.3	11,605
85-7**	158.2	203	13.1	
85-8**	158.4	194	12.3	
85-9**	158.2	207	13.1	
85-10**	158.2	210	13.5	

(Continued)

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* Weight of sulfur/weight of dry specimen.

** Exposed Treat Island specimens.

Table 2 (Continued)

Specimen No.	Density lb/cu yd	Sulfur g	Sulfur %*	48-hr Compressive Strength psi
86-5	151.2	223	15.0	10,190
86-6	151.5	237	16.2	9,910
86-7**	150.3	236	16.1	
86-8**	150.2	226	15.6	
86-9**	151.3	239	16.5	
86-10**	151.5	252	17.9	
87-5	155.0	283	19.6	12,030
87-6	155.4	276	19.0	11,750
87-7**	154.5	286	19.9	
87-8**	155.0	284	19.6	
87-9**	154.9	285	19.7	
87-10**	155.6	282	19.3	
88-5	155.1	293	20.4	12,030
88-6	155.2	284	19.5	11,890
88-7**	155.0	281	19.7	
88-8**	155.1	291	20.5	
88-9**	155.0	294	20.5	
88-10**	154.9	288	20.3	
89-5	155.2	287	20.4	11,040
89-6	155.2	276	19.3	11,180
89-7**	155.9	279	19.1	
89-8**	155.5	277	19.2	
89-9**	155.7	276	18.9	
89-10**	155.7	278	19.6	

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* Weight of sulfur/weight of dry specimen.

** Exposed Treat Island specimens.

Table 3

Infiltrated 4- × 8-in. Cylinders

Specimen No.	Density lb/cu yd	Sulfur g	Sulfur %	48-hr Compressive Strength psi
81-5	154.0	394	10.6	10,110
81-6*	153.5	369	9.9	
81-7*	153.9	386	10.4	
82-5	156.0	435	11.7	10,030
82-6*	155.2	416	11.1	
82-7*	156.1	438	12.0	
83-5	154.6	398	10.6	10,030
83-6*	153.8	388	10.7	
83-7*	154.1	411	11.1	
84-5	155.4	409	11.0	10,670
84-6*	155.3	401	10.9	
84-7*	155.9	412	11.1	
85-5	157.8	415	11.3	11,385
85-6*	157.4	449	12.3	
85-7*	156.9	447	12.3	
86-5	153.1	518	14.9	7,800
86-6*	146.2	446	13.1	
86-7*	146.3	460	13.2	
87-5	153.1	614	18.1	11,545
87-6*	154.0	641	18.6	
87-7*	152.4	591	17.1	
88-5	152.0	619	18.5	10,030
88-6*	152.2	604	17.5	
88-7*	152.5	592	17.2	
89-5	155.9	660	18.8	11,465
89-6*	156.0	638	18.3	
89-7*	155.7	641	18.6	

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* Exposed Treat Island specimens.

Table 1-SIC

Sulfur-Infiltrated Concrete Specimens (Installed August 1976)

Exposure Rack, Row 9

Specimen No.	1976- Readings 0 Cycles, 1976 Pulse Veloc, fps	 77 Cycles, 1977 %V^2
4- × 8-in. Cylinders		
81-6	14,620	96
82-6	15,360	89
83-6	15,360	93
84-6	15,505	87
85-6	16,500	79
86-6	14,185	80
87-6	15,875	83
88-6	15,505	86
89-6	16,105	85
81-7	15,150	88
82-7	16,835	77
83-7	15,360	89
84-7	15,875	87
85-7	16,665	81
86-7	13,550	101
87-7	16,180	78
88-7	15,505	87
89-7	16,025	85
3- × 6-in. Cylinders		
81-7	15,150	110
81-8	14,880	120
81-9	14,970	109
81-10	15,060	108
82-7	15,245	108
82-8	15,430	106
82-9	15,625	107
82-10	15,625	107
83-7	15,060	108
83-8	15,245	105
83-9	15,335	104
83-10	15,245	102
84-7	15,245	112
84-8	15,825	98
84-9	15,825	111
84-10	15,430	109
85-7	15,825	104
85-8	15,430	109
85-9	15,430	109
85-10	15,060	115
86-7	13,890	112
86-8	14,285	106
86-9	14,970	97
86-10	14,795	112
87-7	15,150	110
87-8	14,705	117
87-9	14,705	117
87-10	14,705	109
88-7	14,970	109
88-8	14,880	120
88-9	14,705	109
88-10	14,880	120
88-7	14,880	113
89-8	14,970	102
89-9	14,795	102
89-10	14,970	102

Roller Compacted Concrete

North Pacific Division - Walla Walla District

Aggregates: Coarse - natural minus 3-in. pit-run gravel, Benton County Pit. Fine-Benton County pit-run sand.

Air-Entraining Admixture: Neutralized vinsol Resin (NVX), Hercules Powder Co.

Cement: Sun Types I and II, Oregon Cement Co., Lime, Oreg.

Roller Compacted Concrete

U. S. Army Engineer Division, North Pacific, U. S. Army Engineer District, Walla Walla, CE.

In July 1977, six roller compacted concrete beams (12 by 12 by 36 in.) were installed on the Treat Island exposure rack for the North Pacific Division Materials Laboratory. The mixes, No. 17257 and No. 17258, are considered as interior and exterior mixes, respectively, and were designed and tested for Zintel Canyon Optimum Gravity Dam (Walla Walla District), Kennewick, Wash. Portland cement types I and II and air-entraining admixture were used in both mixtures. Fine and coarse aggregates used were pit-run sand and gravel (natural minus 3 in.). Table 1-RCC gives the exposure record of the beams. More mixture data are given below:

Mix No.	Cement Content lb/cu yd	Water/ Cement Ratio	Vebe sec	A.E.A. ml/cu yd	Air Con-tent %	Theoretical Unit Weight lb/cu ft	Compressive Strength, psi	
							28-day	90-day
17257	100	1.95	11	2000	2.4	153.8	610	1090
17258	200	0.98	17	1700	1.2	154.4	1920	2280

Table 1-RCC

Record of Testing for Roller Compacted Concrete

(Installed at Treat Island in August 1977)

Exposure Rack, Row 6

	1977- Readings		
	0 Cycles, 1977		
Beam No.	%E	Pulse Velocity fps	$\%V^2$
17257-7	100	13,160	100
17257-8	100	12,930	100
17257-9	100	13,045	100
17258-7	100	14,020	100
17258-8	100	14,150	100
17258-9	100	14,425	100

Longtime Study, Waterways Experiment Station*

This study was initiated in FY 1955 in cooperation with the Portland Cement Association to investigate the durability of concretes containing selected cements. Eighteen beams (3-1/2 by 4-1/2 by 16 in.) were made with each of 22 cements, the cement factor being 6.0 bags per cu yd. The aggregates were a manufactured limestone sand and a limestone coarse aggregate. Resin soap was used as an air-entraining admixture in the amount necessary to give an air content of 6 ± 1/2%.

In July 1955, half of these beams (198) were installed on the exposure rack at Treat Island, and the other half were installed on the exposure rack at St. Augustine in August 1955.

Table 1-LTS lists the specimens exposed at Treat Island and gives their exposure record along with their cements.

Table 2-LTS lists the specimens exposed at St. Augustine and gives their exposure record along with their cements.

Testing of specimens exposed at St. Augustine exposure station was discontinued after the 1970 inspection.

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* See U. S. Army Engineer Waterways Experiment Station, CE, Cement Performance in Concrete, by Bryant Mather, Technical Report No. 6-787 (Vicksburg, Miss., September 1967).

Table 1-LTS (Continued)

Exposure Rack, Row 3 (W to E)

						1955-1964 Readings																			
	Cement		0 Cycles, 1955			167 Cycles 1956		311 Cycles 1957		382 Cycles 1958		532 Cycles 1959		603 Cycles 1960		744 Cycles 1961		833 Cycles 1962		939 Cycles 1963		1074 Cycles 1964	
Specimen No.	Type	Program No.	%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
5741C	III	33†	100	15,080	100	104	98	103	107	110	108	111	93	112	101	106	100	110	113	111	101	111	103
5742C			100	14,980	100	106	99	105	107	111	116	112	92	113	104	Lost							
5743C			100	15,080	100	103	99	102	106	108	113	109	95	111	104	106	99	109	111	112	121	112	104
5744C	I	14**	100	15,645	100	119	96	118	105	126	108	125	90	125	103	116	94	120	105	122	117	121	105
5745C			100	15,535	100	106	96	107	105	114	113	113	92	114	104	107	95	110	110	112	111	112	105
5746C			100	15,465	100	107	99	105	104	113	115	113	93	114	106	108	100	111	109	114	116	113	112
5747C	II	24**	100	15,180	100	111	103	109	107	117	115	118	94	118	106	112	106	114	114	115	116	117	110
5748C			100	15,215	100	111	103	110	106	117	112	118	91	118	104	111	103	115	113	118	113	117	103
5749C			100	15,320	100	108	102	107	108	114	112	114	89	115	105	109	100	111	113	117	113	113	101
5750C	I	19A	100	14,680	100	114	106	113	112	120	120	120	96	121	108	115	105	120	117	122	121	121	113
5751C			100	14,650	100	113	105	112	112	120	114	121	97	122	110	117	105	118	114	126	123	126	114
5752C			100	14,715	100	113	108	113	116	121	120	122	102	123	112	117	109	122	113	123	116	123	117
5753C	I	18	100	15,115	100	113	107	102	112	118	116	119	96	119	110	112	103	114	118	114	123	112	104
5754C			100	15,115	100	112	104	111	111	118	118	119	96	119	108	113	107	115	119	118	121	113	102
5755C			100	15,045	100	110	107	109	109	116	117	117	94	118	108	113	108	116	119	119	124	115	110
5756C	IV	43*	100	14,650	100	117	110	116	113	124	121	125	98	125	109	118	112	121	118	127	120	126	114
5757C			100	14,810	100	116	108	116	115	123	121	124	97	124	107	116	107	118	118	121	120	120	111
5758C			100	14,980	100	114	106	112	110	120	120	121	98	120	107	114	101	116	116	117	119	115	109
5759C	II	22††	100	15,465	100	111	105	110	107	117	120	117	94	119	106	113	100	117	119	120	109	120	110
5760C			100	15,465	100	112	107	109	109	117	118	119	94	120	107	115	118	118	116	119	105	119	109
5761C			100	15,395	100	119	108	117	111	125	121	127	95	128	105	123	108	128	109	129	106	128	107
5762C	IV	43*	100	14,945	100	117	115	116	116	123	124	124	95	124	108	117	110	120	118	121	113	121	113
5763C			100	15,150	100	117	111	115	111	123	121	122	97	122	107	114	108	113	117	112	127	112	110
5764C			100	15,150	100	114	113	113	109	120	118	121	95	122	107	116	106	120	117	120	119	122	107
5765C	II	25†	100	15,150	100	112	114	110	111	117	115	118	101	119	108	113	103	115	113	118	118	117	109
5766C			100	15,395	100	112	110	111	108	120	119	121	94	122	106	116	104	120	116	125	115	121	107
5767C			100	15,535	100	111	107	111	111	117	114	118	89	118	103	114	100	115	113	117	112	116	104
5768C	II	23	100	15,755	100	105	106	104	107	110	109	112	89	112	104	107	101	110	110	110	104	106	101
5769C			100	15,795	100	107	103	105	109	112	108	113	85	114	101	108	100	114	109	114	101	111	100
5770C			100	15,830	100	105	96	104	107	110	107	111	86	112	101	108	100	111	110	110	106	110	98
5771C	I	17	100	15,755	100	106	97	104	103	110	108	111	90	112	99	106	100	108	111	107	107	108	99
5772C			100	15,505	100	106	103	105	106	112	111	112	90	113	103	108	104	112	113	112	117	112	104
5773C			100	15,395	100	104	103	102	109	108	117	108	89	107	104	101	103	105	101	106	117	101	103
5774C	IV	43A*	100	14,845	100	118	101	116	104	125	110	127	90	128	102	121	111	123	115	125	133	126	118
5775C			100	14,845	100	118	116	118	116	124	122	125	100	126	114	119	114	123	127	125	133	124	120
5776C			100	14,585	100	122	122	121	120	129	131	130	101	133	118	126	114	129	123	132	118	132	122
5777C	I	16	100	15,150	100	107	111	105	108	113	119	116	94	115	107	110	110	114	103	116	122	117	112
5778C			100	15,320	100	108	108	107	111	114	118	115	91	116	106	109	103	113	104	115	128	115	104
5779C			100	15,430	100	109	107	107	109	114	118	116	91	117	106	111	105	115	112	116	111	119	102
5780C	III	31††	100	14,980	100	106	106	105	110	111	115	113	97	113	108	107	111	112	110	115	118	114	102
5781C			100	14,910	100	109	107	108	109	112	119	111	96	113	107	108	109	114	112	119	108	117	106
5782C			100	14,945	100	109	105	107	108	114	116	114	92	115	108	112	105	118	106	123	118	124	106
5783C	III	33†	100	15,115	100	105	104	104	105	110	110	112	94	113	104	108	99	114	113	117	115	115	107
5784C			100	15,115	100	105	102	104	104	109	111	113	91	113	103	108	102	114	107	116	115	118	109
5785C			100	15,355	100	104	102	103	103	110	109	111	92	112	102	107	97	113	104	116	114	116	107
5786C	I	12††	100	15,680	100	104	104	101	107	107	113	107	93	106	105	98	95	100	108	102	105	99	102
5787C			100	15,720	100	105	105	102	109	108	116	108	92	107	104	100	102	102	104	102	112	102	100
5788C			100	15,755	100	107	103	105	110	111	117	112	86	111	103	104	99	106	107	108	109	106	106
5789C	I	19B	100	15,795	100	106	99	104	104	110	109	112	83	112	95	107	99	112	104	113	106	113	102
5790C			100	15,355	100	105	106	104	108	110	113	111	90	110	102	105	101	109	115	111	109	111	109
5791C			100	15,505	100	105	102	102	109	109	117	111	90	111	104	105	100	108	110	111	105	109	104
5792C	I	19C	100	15,570	100	107	101	105	106	111	113	112	92	114	98	107	101	111	110	113	99	113	96
5793C			100	15,505	100	106	103	104	104	111	114	113	93	112	96	106	101	110	96	112	95	114	95
5794C			100	15,285	100	105	107	104	105	110	117	111	93	112	104	109	102	124	110	129	108	129	103

(Continued)

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* Cements 43 and 43A made at same plant.

** Cements 14, 24, and 41 made at same plant.

† Cements 25 and 33 made from same major raw materials.

†† Cements 12, 22, and 31 made at same plant.

(Revised Aug 1964)

Table 1-LTS (Continued)

Exposure Rack, Row 3 (W to E)

Spec-imen No.	Cement		1955-1964 Readings																						
			0 Cycles, 1955			167 Cycles 1956		311 Cycles 1957		382 Cycles 1958		532 Cycles 1959		603 Cycles 1960		744 Cycles 1961		833 Cycles 1962		939 Cycles 1963		1074 Cycles 1964	
	Type	Pro-gram No.	%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
5795C	I	14**	100	15,720	100	105	99	104	101	110	112	110	87	111	97	106	97	122	107	124	102	123	101
5796C			100	15,985	100	100	97	99	99	104	111	105	85	106	95	101	96	104	105	106	107	103	100
5797C			100	15,795	100	101	101	100	100	103	111	103	88	104	88	100	101	103	106	106	101	101	103
5798C	I	11	100	15,645	100	105	104	104	103	109	111	109	89	110	101	105	103	108	107	113	105	112	105
5799C			100	15,720	100	108	104	104	105	112	113	114	87	115	100	110	99	114	107	120	108	117	101
5800C			100	15,720	100	106	103	104	104	111	115	112	88	113	98	108	105	112	105	115	112	115	101
5801C	II	21	100	15,335	100	107	101	105	107	113	115	113	92	114	106	109	97	113	106	116	112	115	106
5802C			100	15,570	100	106	100	105	104	111	117	111	95	111	97	106	103	108	108	110	107	110	101
5803C			100	15,830	100	105	97	104	103	109	110	110	90	111	100	106	99	109	107	110	98	110	104
5804C	V	51	100	15,795	100	107	99	105	103	112	115	113	92	113	101	107	97	109	103	109	112	110	100
5805C			100	15,465	100	107	104	107	105	113	118	115	93	114	104	107	103	110	118	111	115	111	98
5806C			100	15,535	100	107	101	106	103	113	115	114	92	113	103	106	103	109	114	108	104	108	93
5807C	I	18	100	15,680	100	102	101	101	101	107	111	107	91	106	101	101	101	102	116	103	107	101	91
5808C			100	15,465	100	108	104	107	102	113	116	115	95	115	103	112	112	115	115	119	113	117	93
5809C			100	15,180	100	106	105	105	105	112	114	112	97	111	105	106	106	109	118	113	114	109	97
5810C	II	24**	100	15,465	100	105	101	103	99	109	107	108	89	107	99	101	99	106	106	107	109	107	93
5811C			100	15,570	100	103	102	102	102	108	108	108	89	107	98	101	97	105	106	107	99	106	94
5812C			100	15,570	100	108	101	106	104	113	108	114	89	113	96	107	99	110	108	115	110	113	102
5813C	I	13	100	15,505	100	106	104	105	107	112	114	112	90	111	101	104	99	108	100	109	107	108	99
5814C			100	15,795	100	105	100	103	101	109	109	108	87	105	96	97	91	98	109	99	101	96	98
5815C			100	15,535	100	106	103	105	105	109	116	110	92	108	97	100	95	104	109	102	104	105	100
5816C	IV	41**	100	15,285	100	111	106	110	106	115	109	117	95	117	104	111	98	115	110	122	103	117	100
5817C			100	15,795	100	106	98	105	99	110	105	111	89	112	96	105	95	108	107	110	112	110	98
5818C			100	15,355	100	108	100	107	102	111	116	113	91	113	101	108	103	111	109	111	112	111	105
5819C	I	19A	100	14,910	100	108	107	107	105	111	122	113	91	115	104	109	105	113	115	117	113	117	104
5820C			100	14,945	100	110	108	110	103	114	120	118	97	118	104	113	103	118	106	121	103	121	111
5821C			100	14,910	100	112	109	111	115	115	122	120	96	121	107	115	110	120	118	122	113	120	101
5822C	I	15	100	15,795	100	102	100	101	101	103	113	105	88	106	98	100	99	103	113	106	111	105	98
5823C			100	15,720	100	101	102	99	100	102	106	103	89	104	101	99	97	102	112	103	107	102	106
5824C			100	15,680	100	103	103	102	101	105	112	107	91	109	98	103	92	105	111	106	105	105	99
5825C	I	19C	100	15,250	100	103	105	102	101	106	103	107	94	110	103	105	103	108	112	112	115	111	103
5826C			100	15,320	100	104	104	103	102	106	111	108	93	110	100	105	101	109	116	111	110	112	107
5827C			100	15,215	100	104	106	104	105	107	116	109	94	110	104	105	110	109	112	111	113	109	97
5828C	I	11	100	16,020	100	101	101	99	97	105	108	107	85	109	101	105	97	108	102	111	117	110	102
5829C			100	16,060	100	99	98	98	97	102	110	104	87	106	96	102	98	105	99	109	110	106	99
5830C			100	15,535	100	102	105	101	102	105	117	107	100	106	103	101	98	104	110	107	104	108	102
5831C	I	19A	100	15,180	100	107	104	106	105	111	118	113	94	113	104	106	104	109	112	111	108	109	108
5832C			100	15,250	100	106	103	105	109	110	118	112	95	111	102	104	100	108	117	110	108	108	105
5833C			100	15,080	100	108	103	108	108	113	115	116	97	118	102	112	103	116	107	118	106	118	102
5834C	IV	43A*	100	14,845	100	113	110	113	114	119	125	121	101	122	110	114	109	117	112	118	114	116	119
5835C			100	14,945	100	112	111	113	117	117	125	120	99	121	109	114	110	118	115	119	120	119	118
5836C			100	15,535	100	111	101	110	102	117	113	119	92	120	101	113	104	115	113	115	107	116	106
5837C	I	18	100	15,610	100	108	99	106	100	112	114	116	90	115	98	108	100	111	104	111	117	109	104
5838C			100	15,320	100	108	105	107	103	112	117	114	95	116	105	111	105	114	109	115	110	116	103
5839C			100	15,570	100	106	101	107	100	110	115	112	92	112	99	105	115	107	107	106	104	106	95
5840C	I	15	100	15,720	100	102	98	101	101	106	112	107	93	106	99	99	93	97	106	100	93	100	93
5841C			100	15,755	100	104	97	102	98	107	110	110	91	110	98	104	99	107	95	106	99	106	92
5842C			100	15,645	100	102	98	102	101	105	108	107	98	107	100	99	91	101	102	100	98	97	92
5843C	III	33†	100	15,215	100	102	99	100	101	104	114	106	95	107	97	101	105	105	106	105	111	106	91
5844C			100	15,395	100	103	98	101	99	106	113	108	90	109	97	105	97	106	103	111	104	109	88
5845C			100	15,355	100	103	98	102	99	107	114	108	92	109	97	104	93	107	103	112	113	111	100
5846C	IV	43*	100	14,980	100	111	107	111	102	115	121	117	96	117	103	112	105	114	114	117	118	115	111
5847C			100	15,250	100	107	104	106	100	111	118	112	92	110	104	103	99	102	111	100	111	100	103
5848C			100	15,610	100	105	98	104	97	108	113	109	89	107	97	100	105	105	107	99	111	101	99

(Continued)

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* Cements 43 and 43A made at same plant.

** Cements 14, 24, and 41 made at same plant.

† Cements 25 and 33 made from same major raw materials.

(Revised Aug 1965)

Table 1-LTS (Continued)

Specimen No.	Cement		1955-1964 Readings																						
			0 Cycles, 1955			167 Cycles 1956		311 Cycles 1957		382 Cycles 1958		532 Cycles 1959		603 Cycles 1960		744 Cycles 1961		833 Cycles 1962		939 Cycles 1963		1074 Cycles 1964	
	Type	Program No.	%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
5849C	I	16	100	15,985	100	100	92	100	92	103	117	104	89	107	103	103	95	106	109	106	99	107	100
5850C			100	15,680	100	105	97	105	99	109	116	113	90	114	101	109	102	111	107	116	110	116	102
5851C			100	15,830	100	105	96	105	93	109	117	110	90	111	98	107	96	110	111	111	117	109	100
5852C	I	13	100	15,505	100	106	99	106	105	110	122	112	93	111	102	105	99	110	114	110	110	110	102
5853C			100	15,795	100	105	97	104	102	108	115	111	90	110	96	104	100	109	106	108	111	108	99
5854C			100	15,535	100	107	97	107	106	111	119	113	93	113	101	107	93	110	103	111	112	106	108
5855C	III	31††	100	15,045	100	105	105	103	105	105	122	108	94	109	104	104	98	107	107	107	114	106	108
5856C			100	15,115	100	103	99	101	92	105	93	104	92	103	101	98	96	97	96	100	110	99	102
5857C			100	14,910	100	103	105	101	104	104	118	107	96	108	103	102	105	105	106	108	113	107	105
5858C	II	24**	100	15,285	100	106	100	106	101	110	118	110	90	112	101	108	102	110	107	113	110	113	104
5859C			100	15,320	100	106	98	106	99	110	114	110	90	111	96	106	100	113	105	113	105	111	107
5860C			100	15,570	100	102	97	100	98	103	114	102	89	100	92	94	96	96	104	94	109	91	103
5861C	I	14**	100	15,320	100	105	102	103	100	108	118	109	92	108	96	101	94	105	105	105	110	104	99
5862C			100	15,795	100	104	98	103	96	108	110	109	85	108	92	104	92	108	99	111	101	108	100
5863C			100	15,465	100	105	100	105	102	110	116	111	90	111	99	106	93	109	108	110	110	110	105
5864C	II	23	100	15,610	100	104	98	103	100	107	115	109	89	109	99	104	98	107	101	109	107	107	103
5865C			100	15,645	100	102	98	102	101	106	113	107	87	105	99	98	96	101	103	100	113	100	95
5866C			100	15,905	100	101	91	100	98	105	115	107	88	105	102	98	96	101	101	102	109	100	93
5867C	II	21	100	15,180	100	105	105	105	105	110	117	112	94	111	106	107	104	109	107	109	115	109	109
5868C			100	15,250	100	107	101	107	103	112	120	114	92	113	103	107	104	111	107	112	115	109	108
5869C			100	15,180	100	107	104	106	101	112	120	114	94	115	106	110	106	113	109	115	115	113	108
5870C	I	19B	100	15,320	100	105	102	104	99	108	118	110	94	110	103	106	105	111	109	112	118	110	102
5871C			100	15,795	100	105	98	104	95	107	110	109	86	112	95	108	93	112	101	113	111	111	95
5872C			100	15,795	100	102	101	101	96	104	109	105	86	104	93	99	92	102	99	103	105	101	94
5873C	I	12††	100	15,870	100	100	96	98	97	100	117	100	88	98	96	92	96	94	98	92	100	92	91
5874C			100	15,830	100	101	98	100	99	104	117	105	90	105	98	100	92	103	111	104	105	100	101
5875C			100	15,505	100	105	101	104	104	108	121	110	91	111	99	106	100	110	110	113	110	112	107
5876C	V	51	100	15,285	100	106	104	106	107	113	123	115	94	115	102	108	106	111	115	110	119	109	110
5877C			100	15,320	100	106	102	105	105	111	121	112	94	111	103	103	100	106	113	106	119	103	104
5878C			100	15,180	100	111	100	112	108	117	124	119	97	121	108	115	105	118	116	117	118	118	111
5879C	IV	41**	100	15,215	100	109	100	109	104	115	123	115	94	116	107	110	100	114	110	115	116	114	100
5880C			100	15,010	100	110	102	110	107	114	123	115	94	116	104	109	99	115	113	113	114	114	110
5881C			100	15,355	100	107	101	106	101	111	117	111	88	112	99	107	101	109	98	108	111	106	100
5882C	I	17	100	15,795	100	104	94	104	96	108	113	110	90	111	96	104	99	108	106	106	106	103	103
5883C			100	15,535	100	106	98	104	101	110	122	112	93	112	100	107	99	109	103	110	107	110	101
5884C			100	15,570	100	103	98	102	99	106	117	109	99	110	101	105	97	109	107	110	112	107	99
5885C	II	25†	100	15,395	100	106	101	104	102	112	119	114	96	114	96	108	103	110	107	112	117	112	107
5886C			100	15,355	100	108	105	107	105	112	122	113	97	114	105	108	101	112	109	113	118	113	110
5887C			100	15,250	100	109	105	111	105	114	121	116	103	117	104	114	107	118	106	119	119	121	108
5888C	II	22††	100	15,795	100	111	98	111	99	115	115	117	89	118	99	114	99	119	109	118	111	118	102
5889C			100	15,355	100	106	105	105	104	109	103	111	87	111	90	106	103	108	113	110	118	108	109
5890C			100	15,505	100	107	105	105	102	112	113	114	93	114	103	110	102	116	105	124	114	126	107

(Continued)

** Cements 14, 24, and 41 made at same plant.

† Cements 25 and 33 made from same major raw materials.

†† Cements 12, 22, and 31 made at same plant.

(Revised May 1976)

Table 1-LTS (Continued)

(Installed at Treat Island in July 1955)

Specimen No.	Cement		1965-1974 Readings																			
	Type	Program No.	1237 Cycles 1965		1367 Cycles 1966		1523 Cycles 1967		1708 Cycles 1968		1862 Cycles 1969		2015 Cycles 1970		2184 Cycles 1971		2341 Cycles 1972		2481 Cycles 1973		2617 Cycles 1974	
			%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
5693C	IV	43A*	121	127	122	131	120	125	119	133	116	122	116	113	114	‡	109	‡	110	‡	109	‡
5694C			118	125	120	129	115	123	120	136	115	123	119	112	119	‡	115	‡	123	‡	115	‡
5695C			114	121	115	129	113	121	111	128	107	109	105	99	97	‡	95	‡	95	‡	99	‡
5696C	II	21	108	100	106	120	106	113	104	118	102	106	104	99	100	‡	98	‡	96	‡	94	‡
5697C			111	121	112	109	111	118	111	121	109	106	111	97	109	‡	108	‡	108	‡	111	‡
5698C			112	122	109	124	107	120	111	128	109	115	108	105	108	‡	101	‡	101	‡	100	‡
5699C	IV	41**	116	119	113	126	112	114	113	125	111	107	112	95	114	‡	107	‡	107	‡	108	‡
5700C			116	119	114	110	114	112	115	115	114	107	115	98	115	‡	113	‡	110	‡	110	‡
5701C			111	113	111	110	109	108	111	117	107	105	107	96	107	‡	105	‡	104	‡	103	‡
5702C	I	16	104	108	106	103	103	100	101	110	101	94	99	88	99	‡	103	‡	96	‡	93	‡
5703C			103	112	102	111	102	102	101	111	99	94	98	84	98	‡	101	‡	95	‡	91	‡
5704C			103	105	102	109	100	104	102	111	100	94	102	82	‡	‡	108	‡	111	‡	112	‡
5705C	V	51	104	115	104	109	102	112	100	123	98	102	101	91	94	‡	89	‡	84	‡	89	‡
5706C			99	122	101	115	99	111	95	121	94	102	91	93	83	‡	80	‡	83	‡	90	‡
5707C			100	118	98	114	96	107	93	117	91	101	91	90	83	‡	80	‡	75	‡	73	‡
5708C	I	13	96	127	97	100	96	110	94	116	94	98	97	88	95	‡	93	‡	92	‡	94	‡
5709C			107	120	103	122	102	111	101	118	99	100	102	92	100	‡	96	‡	98	‡	97	‡
5710C			109	117	109	122	106	108	107	116	105	105	104	92	103	‡	101	‡	102	‡	112	‡
5711C	I	11	113	115	113	121	113	109	114	111	112	107	112	91	111	‡	110	‡	127	‡	126	‡
5712C			112	116	112	109	112	108	113	109	111	104	114	95	‡	‡	127	‡	130	‡	125	‡
5713C			114	111	114	110	113	105	111	110	110	100	114	90	‡	‡	128	‡	133	‡	131	‡
5714C	II	23	119	122	119	121	119	115	121	121	119	102	122	94	130	‡	128	‡	130	‡	135	‡
5715C			112	NR	114	114	114	109	116	119	116	103	120	94	125	‡	124	‡	129	‡	127	‡
5716C			115	115	115	106	115	108	118	112	116	96	119	90	127	‡	125	‡	130	‡	129	‡
5717C	II	25†	124	115	124	113	124	115	126	122	126	106	131	96	133	‡	132	‡	137	‡	135	‡
5718C			120	128	122	109	122	116	122	120	120	109	127	99	132	‡	128	‡	130	‡	128	‡
5719C			119	125	119	104	120	111	120	112	120	107	126	95	129	‡	128	‡	128	‡	125	‡
5720C	I	19B	113	115	114	103	115	103	117	104	116	92	123	81	123	‡	123	‡	127	‡	125	‡
5721C			114	114	114	102	114	111	116	116	118	102	123	93	125	‡	123	‡	125	‡	125	‡
5722C			117	114	116	111	115	112	118	116	118	103	123	92	128	‡	126	‡	128	‡	127	‡
5723C	I	19C	118	115	121	106	120	109	120	114	120	99	125	90	125	‡	130	‡	135	‡	136	‡
5724C			114	116	114	109	115	116	115	118	114	99	114	95	124	‡	122	‡	138	‡	139	‡
5725C			116	122	116	110	117	118	117	115	115	103	119	89	119	‡	127	‡	130	‡	130	‡
5726C	I	12††	119	122	119	116	120	116	119	107	119	96	124	87	131	‡	129	‡	130	‡	131	‡
5727C			119	120	121	113	121	113	120	105	120	98	123	89	130	‡	129	‡	131	‡	129	‡
5728C			116	118	117	111	117	115	118	106	118	96	122	90	127	‡	126	‡	133	‡	133	‡
5729C	I	17	115	118	115	110	114	113	114	111	112	102	116	96	124	‡	122	‡	129	‡	128	‡
5730C			108	125	109	117	109	115	109	112	108	95	112	89	118	‡	116	‡	123	‡	128	‡
5731C			109	121	110	115	110	117	109	113	110	102	116	96	114	‡	114	‡	116	‡	115	‡
5732C	III	31††	113	126	115	117	114	114	117	109	117	‡	124	‡	133	‡	132	‡	144	‡	144	‡
5733C			113	127	114	107	112	113	117	108	117	‡	122	‡	140	‡	146	‡	159	‡	154	‡
5734C			113	118	118	92	118	113	121	113	123	‡	130	‡	138	‡	143	‡	156	‡	156	‡
5735C	I	15	106	116	110	106	111	110	111	102	112	‡	116	‡	124	‡	126	‡	126	‡	131	‡
5736C			100	118	100	107	99	110	101	112	100	‡	102	‡	108	‡	105	‡	110	‡	102	‡
5737C			102	115	101	99	101	112	103	108	103	‡	105	‡	108	‡	102	‡	110	‡	109	‡
5738C	II	22††	118	120	117	122	117	116	119	116	117	‡	124	‡	132	‡	125	‡	128	‡	116	‡
5739C			121	128	123	110	122	124	124	122	126	‡	133	‡	133	‡	136	‡	136	‡	132	‡
5740C			124	122	126	105	125	118	127	124	123	‡	135	‡	138	‡	134	‡	129	‡	136	‡

(Continued)

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* Cements 43 and 43A made at same plant.
** Cements 14, 24, and 41 made at same plant.
† Cements 25 and 33 made from same major raw materials.
†† Cements 12, 22, and 31 made at same plant.
NR Reading was not taken due to oversight.
‡ End of specimen too rough to obtain satisfactory reading.

(Revised May 1976)

Table 1-LTS (Continued)

(Installed At Treat Island in July 1955)

	Cement		1965-1974 Readings																			
Specimen No.	Type	Program No.	1237 Cycles 1965		1367 Cycles 1966		1523 Cycles 1967		1708 Cycles 1968		1862 Cycles 1969		2015 Cycles 1970		2184 Cycles 1971		2341 Cycles 1972		2481 Cycles 1973		2617 Cycles 1974	
			%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
5741C	III	33†	109	126	111	101	111	120	114	109	114	‡	120	‡	‡	‡	141	‡	146	‡	147	‡
5743C			112	106	115	106	115	117	116	116	118	‡	122	‡	123	‡	118	‡	139	‡	139	‡
5744C	I	14**	116	109	120	103	118	108	118	109	119	‡	124	‡	124	‡	119	‡	119	‡	114	‡
5745C			110	117	113	107	113	109	113	115	115	‡	120	‡	120	‡	115	‡	117	‡	117	‡
5746C			113	119	113	120	114	114	114	122	115	‡	122	‡	122	‡	113	‡	115	‡	Gone	
5747C	II	24**	115	119	116	112	116	114	116	122	115	‡	122	‡	122	‡	117	‡	122	‡	122	‡
5748C			118	118	118	120	117	112	117	122	117	‡	124	‡	126	‡	118	‡	123	‡	117	‡
5749C			114	113	115	124	116	116	114	124	116	‡	123	‡	121	‡	108	‡	121	‡	119	‡
5750C	I	19A	121	125	122	132	121	121	120	104	120	‡	126	‡	129	‡	131	‡	128	‡	129	‡
5751C			126	121	128	136	128	118	129	112	131	‡	138	‡	140	‡	133	‡	126	‡	127	‡
5752C			123	123	127	128	127	122	127	116	127	‡	132	‡	136	‡	137	‡	133	‡	131	‡
5753C	I	18	110	120	110	110	112	99	112	100	114	‡	121	‡	123	‡	118	‡	97	‡	102	‡
5754C			111	127	114	116	115	111	113	103	115	‡	122	‡	121	‡	115	‡	113	‡	113	‡
5755C			114	118	112	123	112	112	114	108	112	‡	119	‡	126	‡	118	‡	131	‡	130	‡
5756C	IV	43*	124	130	124	129	124	120	124	117	126	‡	131	‡	132	‡	131	‡	136	‡	133	‡
5757C			120	125	122	127	122	116	120	117	122	‡	127	‡	129	‡	125	‡	125	‡	123	‡
5758C			117	121	118	124	117	118	118	111	117	‡	124	‡	128	‡	123	‡	128	‡	126	‡
5759C	II	22††	119	113	119	125	119	111	118	113	117	‡	124	‡	130	‡	123	‡	114	‡	110	‡
5760C			119	121	118	125	117	112	117	113	117	‡	124	‡	125	‡	124	‡	126	‡	131	‡
5761C			129	123	133	109	132	112	132	114	133	‡	138	‡	142	‡	139	‡	139	‡	134	‡
5762C	IV	43*	121	125	123	131	123	110	122	117	123	‡	130	‡	130	‡	118	‡	130	‡	118	‡
5763C			110	122	113	110	114	115	111	111	113	‡	120	‡	120	‡	119	‡	120	‡	132	‡
5764C			122	121	123	121	123	115	123	112	124	‡	131	‡	137	‡	130	‡	130	‡	124	‡
5765C	II	25†	118	124	118	121	118	115	118	112	118	‡	127	‡	129	‡	127	‡	129	‡	128	‡
5766C			122	112	123	106	123	113	123	112	124	‡	131	‡	131	‡	129	‡	129	‡	124	‡
5767C			117	115	118	118	119	114	118	110	117	‡	123	‡	125	‡	123	‡	123	‡	122	‡
5768C	II	23	110	118	110	106	111	111	109	109	108	‡	114	‡	120	‡	116	‡	118	‡	116	‡
5769C			111	116	111	114	112	111	111	107	112	‡	116	‡	122	‡	116	‡	119	‡	116	‡
5770C			111	116	113	108	113	111	115	105	117	‡	124	‡	126	‡	126	‡	131	‡	134	‡
5771C	I	17	106	122	105	106	106	113	106	100	107	‡	109	‡	109	‡	107	‡	120	‡	111	‡
5772C			109	116	111	116	112	110	111	104	112	‡	116	‡	115	‡	111	‡	128	‡	126	‡
5773C			104	120	105	109	106	109	102	106	104	‡	100	‡	104	‡	104	‡	106	‡	108	‡
5774C	IV	43A*	127	126	127	107	127	117	126	123	127	‡	134	‡	135	‡	129	‡	129	‡	130	‡
5775C			122	118	122	117	122	120	122	114	123	‡	128	‡	125	‡	136	‡	136	‡	133	‡
5776C			135	135	132	118	131	127	135	131	135	‡	143	‡	145	‡	144	‡	145	‡	142	‡
5777C	I	16	119	126	117	107	117	102	117	102	119	‡	126	‡	126	‡	123	‡	124	‡	122	‡
5778C			110	124	113	113	114	113	114	113	115	‡	119	‡	122	‡	118	‡	124	‡	117	‡
5779C			117	NR	117	114	116	112	117	111	115	‡	117	‡	125	‡	126	‡	125	‡	130	‡
5780C	III	31††	108	128	110	98	110	‡	114	‡	115	‡	118	‡	124	‡	123	‡	137	‡	136	‡
5781C			118	126	119	94	119	‡	124	‡	124	‡	129	‡	141	‡	140	‡	152	‡	163	‡
5782C			122	122	128	100	127	‡	128	‡	127	‡	135	‡	145	‡	134	‡	155	‡	160	‡
5783C	III	33†	118	120	118	96	118	‡	119	‡	120	‡	125	‡	137	‡	133	‡	151	‡	154	‡
5784C			119	113	119	103	119	108	121	106	123	‡	130	‡	142	‡	141	‡	155	‡	155	‡
5785C			116	113	115	97	117	104	119	103	119	‡	126	‡	137	‡	138	‡	150	‡	156	‡
5786C	I	12††	99	113	99	95	100	105	97	102	99	‡	103	‡	100	‡	95	‡	97	‡	95	‡
5787C			101	105	103	100	104	100	101	97	99	‡	103	‡	109	‡	111	‡	107	‡	109	‡
5788C			105	116	106	99	107	104	104	102	106	‡	110	‡	112	‡	110	‡	114	‡	116	‡
5789C	I	19B	113	112	113	92	113	101	112	101	111	‡	115	‡	121	‡	112	‡	123	‡	128	‡
5790C			111	119	110	107	110	108	109	107	110	‡	116	‡	118	‡	126	‡	126	‡	130	‡
5791C			111	108	110	105	110	105	110	105	111	‡	115	‡	116	‡	115	‡	140	‡	118	‡
5792C	I	19C	111	106	111	85	113	95	114	97	115	‡	119	‡	126	‡	120	‡	129	‡	130	‡
5793C			113	115	115	89	114	100	117	98	117	‡	124	‡	134	‡	133	‡	123	‡	125	‡
5794C			131	116	132	90	131	105	133	103	131	‡	138	‡	148	‡	148	‡	124	‡	128	‡

(Continued)

* Cements 43 and 43A made at same plant.
** Cements 14, 24, and 41 made at same plant.
† Cements 25 and 33 made from same major raw materials.
†† Cements 12, 22, and 31 made at same plant.
NR No reading taken due to oversight.
‡ End of specimen too rough to obtain satisfactory reading.

(Revised May 1976)

Table 1-LTS (Continued)

(Installed at Treat Island in July 1955)

Specimen No.	Cement		1965-1974 Readings																			
	Type	Program No.	1237 Cycles 1965		1367 Cycles 1966		1523 Cycles 1967		1708 Cycles 1968		1862 Cycles 1969		2015 Cycles 1970		2184 Cycles 1971		2341 Cycles 1972		2481 Cycles 1973		2617 Cycles 1974	
			%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
5795C	I	14**	124	101	125	102	126	97	127	97	128	‡	133	‡	133	‡	135	‡	135	‡	135	‡
5796C			104	104	105	96	107	95	106	94	105	‡	109	‡	113	‡	111	‡	113	‡	111	‡
5797C			104	109	104	103	105	101	103	99	103	‡	109	‡	111	‡	112	‡	111	‡	107	‡
5798C	I	11	112	123	112	96	113	105	113	104	114	‡	118	‡	126	‡	126	‡	126	‡	125	‡
5799C			120	115	120	104	120	102	121	102	120	‡	122	‡	130	‡	130	‡	139	‡	138	‡
5800C			117	116	119	104	120	101	122	101	121	‡	125	‡	135	‡	135	‡	140	‡	141	‡
5801C	II	21	116	123	116	109	116	106	114	104	116	‡	120	‡	121	‡	121	‡	124	‡	124	‡
5802C			110	104	110	101	109	87	109	95	110	‡	110	‡	114	‡	113	‡	114	‡	111	‡
5803C			110	118	110	94	110	98	108	96	108	‡	112	‡	113	‡	110	‡	114	‡	115	‡
5804C	V	51	110	103	110	99	111	99	110	96	108	‡	112	‡	113	‡	114	‡	112	‡	115	‡
5805C			113	121	111	98	110	99	111	100	111	‡	118	‡	119	‡	120	‡	113	‡	115	‡
5806C			107	121	109	95	108	103	106	102	107	‡	107	‡	103	‡	105	‡	101	‡	98	‡
5807C	I	18	101	114	101	93	103	95	102	93	104	‡	108	‡	108	‡	111	‡	112	‡	111	‡
5808C			117	117	119	108	118	‡	121	‡	122	‡	129	‡	139	‡	141	‡	143	‡	142	‡
5809C			110	114	107	95	108	‡	109	‡	111	‡	115	‡	117	‡	121	‡	121	‡	120	‡
5810C	II	24**	106	117	106	92	106	94	103	94	105	‡	109	‡	107	‡	104	‡	99	‡	100	‡
5811C			105	107	105	90	107	92	103	92	102	‡	102	‡	109	‡	104	‡	96	‡	94	‡
5812C			115	111	113	95	113	106	114	104	115	‡	117	‡	121	‡	118	‡	118	‡	124	‡
5813C	I	13	107	112	108	97	109	109	107	107	109	‡	113	‡	112	‡	105	‡	122	‡	123	‡
5814C			99	126	98	90	106	100	100	99	102	‡	100	‡	89	‡	94	‡	85	‡	93	‡
5815C			101	105	101	93	102	102	100	100	101	‡	102	‡	97	‡	93	‡	101	‡	120	‡
5816C	IV	41**	120	110	120	116	120	105	120	103	118	‡	123	‡	129	‡	124	‡	122	‡	120	‡
5817C			109	109	109	119	110	101	108	100	109	‡	113	‡	114	‡	111	‡	109	‡	114	‡
5818C			112	116	111	93	112	107	111	105	113	‡	113	‡	115	‡	109	‡	122	‡	119	‡
5819C	I	19A	115	124	113	113	113	113	115	111	113	‡	115	‡	121	‡	120	‡	120	‡	119	‡
5820C			121	118	120	116	120	105	125	100	127	‡	132	‡	132	‡	131	‡	135	‡	135	‡
5821C			122	121	117	103	118	106	121	101	123	‡	128	‡	132	‡	130	‡	132	‡	130	‡
5822C	I	15	105	115	104	101	106	‡	110	‡	112	‡	114	‡	118	‡	117	‡	115	‡	116	‡
5823C			102	116	102	102	101	‡	103	‡	104	‡	106	‡	116	‡	115	‡	116	‡	119	‡
5824C			105	117	107	100	107	‡	107	‡	109	‡	111	‡	117	‡	114	‡	130	‡	130	‡
5825C	I	19C	110	116	112	108	113	‡	113	‡	113	‡	113	‡	123	‡	123	‡	124	‡	125	‡
5826C			112	110	113	102	113	‡	112	‡	112	‡	114	‡	124	‡	124	‡	129	‡	124	‡
5827C			112	115	112	97	112	‡	111	‡	113	‡	113	‡	119	‡	119	‡	140	‡	138	‡
5828C	I	11	110	112	108	96	109	‡	112	‡	111	‡	116	‡	120	‡	115	‡	112	‡	114	‡
5829C			107	106	105	87	105	‡	107	‡	107	‡	111	‡	121	‡	119	‡	130	‡	130	‡
5830C			107	115	105	95	106	‡	106	‡	107	‡	111	‡	118	‡	117	‡	123	‡	118	‡
5831C	I	19A	109	120	110	89	112	‡	109	‡	111	‡	115	‡	113	‡	108	‡	113	‡	115	‡
5832C			108	118	108	92	108	‡	107	‡	109	‡	109	‡	129	‡	122	‡	128	‡	127	‡
5833C			118	123	118	90	119	‡	119	‡	120	‡	125	‡	115	‡	109	‡	114	‡	116	‡
5834C	IV	43A*	117	127	115	114	114	‡	115	‡	116	‡	116	‡	120	‡	112	‡	115	‡	117	‡
5835C			119	125	122	105	124	‡	118	‡	120	‡	120	‡	124	‡	124	‡	124	‡	122	‡
5836C			118	100	117	102	118	‡	108	‡	106	‡	108	‡	114	‡	112	‡	110	‡	114	‡
5837C	I	18	108	108	111	84	110	‡	108	‡	109	‡	111	‡	119	‡	115	‡	122	‡	124	‡
5838C			114	112	114	100	115	‡	118	‡	120	‡	122	‡	137	‡	135	‡	150	‡	153	‡
5839C			107	116	111	99	112	‡	106	‡	107	‡	105	‡	109	‡	105	‡	111	‡	111	‡
5840C	I	15	98	105	98	85	99	‡	101	‡	102	‡	102	‡	112	‡	111	‡	123	‡	123	‡
5841C			104	97	108	79	110	‡	108	‡	108	‡	108	‡	117	‡	113	‡	124	‡	122	‡
5842C			97	103	97	80	99	‡	97	‡	99	‡	101	‡	109	‡	106	‡	110	‡	113	‡
5843C	III	33†	105	108	105	93	106	‡	107	‡	108	‡	110	‡	112	‡	108	‡	122	‡	125	‡
5844C			107	109	112	87	112	‡	111	‡	111	‡	115	‡	134	‡	133	‡	146	‡	148	‡
5845C			113	113	113	85	113	‡	117	‡	119	‡	123	‡	140	‡	135	‡	164	‡	140	‡
5846C	IV	43*	114	125	116	110	117	101	117	100	119	‡	124	‡	131	‡	129	‡	129	‡	129	‡
5847C			96	122	96	92	98	96	92	96	92	‡	96	‡	92	‡	90	‡	86	‡	88	‡
5848C			99	118	99	88	101	‡	95	‡	95	‡	95	‡	87	‡	84	‡	84	‡	89	‡

(Continued)

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* Cements 43 and 43A made at same plant.

** Cements 14, 24, and 41 made at same plant.

† Cements 25 and 33 made from same major raw materials.

‡ End of specimen too rough to obtain satisfactory reading.

(Revised May 1976)

Table 1-LTS (Continued)

(Installed at Treat Island in July 1955)

Specimen No.	Cement		1965-1974 Readings																			
	Type	Program No.	1237 Cycles 1965		1367 Cycles 1966		1523 Cycles 1967		1708 Cycles 1968		1862 Cycles 1969		2015 Cycles 1970		2184 Cycles 1971		2341 Cycles 1972		2481 Cycles 1973		2617 Cycles 1974	
			%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
5849C	I	16	106	110	110	96	110	‡	106	‡	108	‡	110	‡	113	‡	109	‡	116	‡	118	‡
5850C			115	120	117	105	117	‡	116	‡	117	‡	121	‡	123	‡	124	‡	127	‡	127	‡
5851C			107	126	107	103	107	‡	105	‡	104	‡	106	‡	112	‡	108	‡	112	‡	108	‡
5852C	I	13	109	130	107	102	108	‡	106	‡	108	‡	108	‡	112	‡	102	‡	110	‡	105	‡
5853C			109	123	109	88	108	‡	109	‡	111	‡	113	‡	116	‡	107	‡	117	‡	118	‡
5854C			108	128	108	91	107	‡	109	‡	109	‡	109	‡	118	‡	111	‡	120	‡	122	‡
5855C	III	31††	106	128	107	87	107	‡	108	‡	110	‡	112	‡	134	‡	136	‡	152	‡	155	‡
5856C			100	117	103	83	104	‡	107	‡	107	‡	109	‡	121	‡	119	‡	119	‡	121	‡
5857C			108	109	110	83	110	‡	117	‡	117	‡	122	‡	140	‡	132	‡	163	‡	163	‡
5858C	II	24**	115	111	113	90	112	95	114	94	115	‡	115	‡	121	‡	115	‡	122	‡	127	‡
5859C			113	116	113	98	113	100	111	96	113	‡	113	‡	117	‡	115	‡	117	‡	119	‡
5860C			89	111	86	90	84	101	80	97	80	‡	84	‡	77	‡	74	‡	69	‡	69	‡
5861C	I	14**	103	116	102	100	102	99	100	98	102	‡	102	‡	102	‡	90	‡	92	‡	100	‡
5862C			108	111	108	101	107	94	108	92	108	‡	108	‡	117	‡	111	‡	115	‡	116	‡
5863C			109	114	109	108	109	98	108	96	110	‡	108	‡	112	‡	110	‡	110	‡	115	‡
5864C	II	23	107	116	107	106	108	‡	105	‡	107	‡	105	‡	107	‡	99	‡	105	‡	109	‡
5865C			97	116	97	96	97	‡	93	‡	91	‡	93	‡	93	‡	85	‡	91	‡	78	‡
5866C			99	114	97	97	97	‡	95	‡	93	‡	95	‡	97	‡	89	‡	89	‡	97	‡
5867C	II	21	109	129	109	112	108	100	105	100	103	‡	103	‡	108	‡	126	‡	104	‡	106	‡
5868C			109	121	109	106	108	112	106	108	108	‡	106	‡	110	‡	106	‡	110	‡	112	‡
5869C			113	117	113	102	112	112	113	109	113	‡	109	‡	‡	‡	‡	‡	‡	‡		‡
5870C	I	19B	110	114	109	96	109	108	109	105	110	‡	107	‡	‡	‡	102	‡	112	‡	112	‡
5871C			109	111	109	90	109	‡	107	‡	109	‡	109	‡	‡	‡	101	‡	114	‡	118	‡
5872C			101	117	98	94	99	‡	96	‡	98	‡	98	‡	94	‡	90	‡	93	‡	99	‡
5873C	I	12††	90	111	88	93	88	‡	86	‡	86	‡	88	‡	84	‡	81	‡	84	‡	87	‡
5874C			100	109	100	79	100	‡	99	‡	100	‡	102	‡	110	‡	105	‡	107	‡	109	‡
5875C			112	122	113	87	112	‡	113	‡	113	‡	117	‡	122	‡	122	‡	126	‡	126	‡
5876C	V	51	109	126	119	96	119	‡	117	‡	119	‡	124	‡	124	‡	149	‡	124	‡	125	‡
5877C			102	122	101	103	99	111	95	107	93	‡	95	‡	92	‡	95	‡	85	‡	88	‡
5878C			116	131	116	112	115	112	114	109	116	‡	118	‡	122	‡	120	‡	122	‡	124	‡
5879C	IV	41**	114	122	112	109	112	113	112	109	114	‡	116	‡	117	‡	117	‡	116	‡	121	‡
5880C			112	124	114	104	113	117	111	114	113	‡	113	‡	115	‡	112	‡	111	‡	112	‡
5881C			106	116	107	100	107	109	103	105	105	‡	105	‡	107	‡	103	‡	103	‡	105	‡
5882C	I	17	106	115	108	90	106	103	106	101	104	‡	104	‡	116	‡	113	‡	112	‡	112	‡
5883C			110	114	108	91	107	‡	109	‡	110	‡	110	‡	118	‡	115	‡	123	‡	125	‡
5884C			109	114	108	92	108	‡	110	‡	112	‡	114	‡	121	‡	119	‡	122	‡	124	‡
5885C	II	25†	111	110	112	104	110	‡	108	‡	108	‡	112	‡	112	‡	109	‡	112	‡	113	‡
5886C			111	119	112	104	111	107	109	102	111	‡	113	‡	113	‡	109	‡	113	‡	113	‡
5887C			119	127	120	108	118	103	120	100	120	‡	122	‡	131	‡	125	‡	132	‡	134	‡
5888C	II	22††	118	112	118	109	117	103	117	99	119	‡	121	‡	125	‡	122	‡	130	‡	132	‡
5889C			108	123	110	112	110	109	108	104	108	‡	112	‡	112	‡	108	‡	112	‡	116	‡
5890C			126	115	125	116	123	‡	123	‡	125	‡	127	‡	131	‡	127	‡	128	‡	130	‡

** Cements 14, 24, and 41 made at same plant.

† Cements 25 and 33 made from same major raw materials.

†† Cements 12, 22, and 31 made at same plant.

‡ End of specimen too rough to obtain satisfactory reading.

(Revised August 1977)

Table 1-LTS (Continued)

(Installed at Treat Island in July 1955)

			1975- Readings			
	Cement		2729 Cycles 1975		2875 Cycles 1976	2952 Cycles 1977
Specimen No.	Type	Program No.	%E	$\%V^2$	%E	%E
5693C	IV	43A*	125	‡	137	Failed
5694C			121	‡	121	135
5695C			105	‡	123	95
5696C	II	21	102	‡	113	97
5697C			112	‡	136	112
5698C			100	‡	100	117
5699C	IV	41**	110	‡	107	108
5700C			111	‡	108	128
5701C			106	‡	107	107
5702C	I	16	97	‡	106	122
5703C			96	‡	101	102
5704C			112	‡	112	117
5705C	V	51	98	‡	121	121
5706C			95	‡	100	68
5707C			69	‡	88	88
5708C	I	13	93	‡	99	91
5709C			101	‡	102	99
5710C			114	‡	114	125
5711C	I	11	126	‡	128	139
5712C			127	‡	130	136
5713C			132	‡	132	147
5714C	II	23	135	‡	137	139
5715C			128	‡	129	136
5716C			129	‡	132	132
5717C	II	25†	136	‡	134	150
5718C			130	‡	132	143
5719C			126	‡	126	133
5720C	I	19B	125	‡	127	133
5721C			130	‡	137	138
5722C			127	‡	128	135
5723C	I	19C	136	‡	137	137
5724C			139	‡	139	140
5725C			130	‡	130	133
5726C	I	12††	132	‡	137	137
5727C			131	‡	132	130
5728C			133	‡	133	130
5729C	I	17	128	‡	128	130
5730C			130	‡	131	130
5731C			118	‡	122	Failed
5732C	III	31††	144	‡	Failed	
5733C			154	‡	154	Failed
5734C			156	‡	156	Failed
5735C	I	15	131	‡	133	Failed
5736C			106	‡	110	Failed
5737C			110	‡	125	110
5738C	II	22††	117	‡	118	129
5739C			132	‡	134	132
5740C			136	‡	136	Failed

(Continued)

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* Cements 43 and 43A made at same plant.

** Cements 14, 24, and 41 made at same plant.

† Cements 25 and 33 made from some major raw materials.

†† Cements 12, 22, and 31 made at same plant.

‡ End of specimen too rough to obtain satisfactory reading. $\%V^2$ data discontinued.

(Revised August 1977)

Table 1-LTS (Continued)

(Installed at Treat Island in July 1955)

			1975- Readings			
Specimen No.	Cement		2729 Cycles 1975		2875 Cycles 1976	2952 Cycles 1977
	Type	Program No.	%E	$\%V^2$	%E	%E
5741C	III	33†	147	‡	150	Failed
5743C			139	‡	113	140
5744C	I	14**	115	‡	114	144
5745C			119	‡	121	119
5746C			Missing			
5747C	II	24**	124	‡	123	124
5748C			118	‡	119	134
5749C			113	‡	117	117
5750C	I	19A	129	‡	130	135
5751C			127	‡	132	132
5752C			131	‡	133	133
5753C	I	18	107	‡	Failed	
5754C			115	‡	Failed	
5755C			134	‡	Failed	
5756C	IV	43*	133	‡	Failed	
5757C			123	‡	123	Failed
5758C			128	‡	128	130
5759C	II	22††	112	‡	112	127
5760C			131	‡	133	141
5761C			134	‡	139	135
5762C	IV	43*	120	‡	122	120
5763C			132	‡	133	132
5764C			125	‡	125	125
5765C	II	25†	129	‡	130	128
5766C			124	‡	126	Failed
5767C			124	‡	124	126
5768C	II	23	118	‡	120	119
5769C			119	‡	120	119
5770C			133	‡	133	122
5771C	I	17	116	‡	116	116
5772C			126	‡	124	120
5773C			110	‡	112	112
5774C	IV	43A*	130	‡	128	160
5775C			133	‡	134	137
5776C			142	‡	141	142
5777C	I	16	124	‡	132	133
5778C			119	‡	120	115
5779C			130	‡	124	123
5780C	III	31††	136	‡	Failed	
5781C			163	‡	Failed	
5782C			160	‡	Failed	
5783C	III	33†	157	‡	Failed	
5784C			155	‡	Failed	
5785C			156	‡	Failed	
5786C	I	12††	107	‡	110	110
5787C			111	‡	115	117
5788C			117	‡	117	122
5789C	I	19B	129	‡	130	112
5790C			130	‡	125	133
5791C			119	‡	119	114
5792C	I	19C	131	‡	130	126
5793C			101	‡	103	103
5794C			128	‡	132	133

(Continued)

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* Cements 43 and 43A made at same plant.

** Cements 14, 24, and 41 made at same plant.

† Cements 25 and 33 made from same major raw materials.

†† Cements 12, 22, and 31 made at same plant.

‡ End of specimen too rough to obtain satisfactory reading. $\%V^2$ data discontinued.

Table 1-LTS (Continued)

(Installed at Treat Island in July 1955)

			1975- Readings			
Specimen No.	Cement		2729 Cycles 1975		2875 Cycles 1976	2952 Cycles 1977
	Type	Program No.	%E	%V^2	%E	%E
5795C	I	14**	135	‡	130	128
5796C			112	‡	113	155
5797C			107	‡	106	107
5798C	I	11	125	‡	119	119
5799C			142	‡	142	142
5800C			141	‡	146	130
5801C	II	21	124	‡	122	124
5802C			112	‡	113	115
5803C			116	‡	116	116
5804C	V	51	116	‡	116	120
5805C			115	‡	115	Failed
5806C			99	‡	103	108
5807C	I	18	112	‡	115	116
5808C			142	‡	152	147
5809C			120	‡	123	111
5810C	II	24**	102	‡	108	107
5811C			95	‡	104	103
5812C			125	‡	126	128
5813C	I	13	123	‡	116	114
5814C			94	‡	102	102
5815C			122	‡	124	125
5816C	IV	41**	125	‡	126	127
5817C			115	‡	116	117
5818C			120	‡	117	119
5819C	I	19A	119	‡	117	118
5820C			135	‡	137	137
5821C			130	‡	129	Failed
5822C	I	15	117	‡	115	Failed
5823C			119	‡	125	97
5824C			131	‡	136	131
5825C	I	19C	130	‡	135	130
5826C			126	‡	126	129
5827C			138	‡	143	143
5828C	I	11	116	‡	114	113
5829C			130	‡	137	130
5830C			120	‡	123	124
5831C	I	19A	117	‡	121	Failed
5832C			129	‡	129	130
5833C			120	‡	139	128
5834C	IV	43A*	119	‡	122	Failed
5835C			122	‡	127	Failed
5836C			118	‡	126	Failed
5837C	I	18	124	‡	130	Failed
5838C			153	‡	166	155
5839C			115	‡	121	132
5840C	I	15	124	‡	Failed	
5841C			122	‡	Failed	
5842C			114	‡	Failed	
5843C	III	33†	125	‡	Failed	
5844C			148	‡	Failed	
5845C			141	‡	Failed	
5846C	IV	43*	131	‡	Failed	
5847C			90	‡	Failed	
5848C			91	‡	Failed	

(Continued)

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* Cements 43 and 43A made at same plant.

** Cements 14, 24, and 41 made at same plant.

† Cements 25 and 33 made from same major raw materials.

‡ End of specimen too rough to obtain satisfactory reading. %V^2 data discontinued.

(Revised August 1977)

Table 1-LTS (Continued)

(Installed at Treat Island in July 1955)

	Cement		1975- Readings			
			2729 Cycles 1975		2875 Cycles 1976	2952 Cycles 1977
Specimen No.	Type	Program No.	%E	%V^2	%E	%E
5849C	I	16	119	‡	124	118
5850C			127	‡	127	129
5851C			114	‡	115	114
5852C	I	13	106	‡	103	101
5853C			119	‡	120	120
5854C			123	‡	131	134
5855C	III	31††	155	‡	166	158
5856C			123	‡	Failed	
5857C			162	‡	178	Failed
5858C	II	24**	127	‡	132	132
5859C			121	‡	122	Failed
5860C			70	‡	62	128
5861C	I	14**	96	‡	91	97
5862C			116	‡	115	117
5863C			115	‡	118	105
5864C	II	23	114	‡	117	114
5865C			77	‡	79	77
5866C			97	‡	102	Failed
5867C	II	21	108	‡	110	112
5868C			112	‡	116	118
5869C			‡	‡	Failed	
5870C	I	19B	114	‡	117	124
5871C			120	‡	125	127
5872C			99	‡	107	109
5873C	I	12††	87	‡	92	92
5874C			109	‡	112	112
5875C			127	‡	123	124
5876C	V	51	125	‡	127	127
5877C			88	‡	95	Failed
5878C			123	‡	126	128
5879C	IV	41**	121	‡	124	125
5880C			113	‡	114	114
5881C			106	‡	115	135
5882C	I	17	114	‡	112	112
5883C			125	‡	123	123
5884C			123	‡	124	125
5885C	II	25†	114	‡	114	146
5886C			115	‡	113	119
5887C			134	‡	135	136
5888C	II	22††	132	‡	135	134
5889C			117	‡	120	152
5890C			130	‡	133	158

** Cements 14, 24, and 41 made at same plant.
† Cements 25 and 33 made from same major raw materials.
†† Cements 12, 22, and 31 made at same plant.
‡ End of specimen too rough to obtain satisfactory reading. %V^2 data discontinued.

(Revised Sept 1970)

Table 2-LTS

Record of Testing of Concrete Beams, Longtime Study, WES

St. Augustine Exposure

1955- (Installed Summer 1955)

1955-1960 Readings

Spec-imen No.	Cement		1955			1956		1958		1960		1962*		1964*		1966*		1968*		1970*			
	Type	LTS No.	%E	Pulse Veloc fps	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
5891D	IV	43A**	100	15,255	100	105	108	110	108	Lost													
5892D			100	15,575	100	106	100	108	101	121	110												
5893D			100	15,220	100	106	109	111	105	119	104												
5972D	IV	43A**	100	15,290	100	106	110	108	113	118	109												
5973D			100	15,290	100	109	98	112	111	121	108												
5974D			100	14,715	100	117	122	122	122	133	119												
6032D	IV	43A**	100	15,540	100	108	--	112	103	122	106												
6033D			100	16,105	100	100	--	97	97	106	100												
6034D			100	16,065	100	100	--	100	100	109	101												
5894D	II	21	100	15,360	100	110	109	115	109	124	110												
5895D			100	15,470	100	104	105	107	107	111	105												
5896D			100	15,910	100	102	100	105	100	105	97												
5999D	II	21	100	15,800	100	97	103	99	101	108	106												
6000D			100	15,615	100	101	106	103	101	109	104												
6001D			100	15,950	100	99	101	98	100	105	100												
6065D	II	21	100	16,220	100	99	--	104	96	114	98												
6066D			100	16,105	100	102	--	92	95	100	99												
6067D			100	15,835	100	102	--	108	97	115	101												
5897D	IV	41†	100	15,725	100	102	98	105	99	113	99												
5898D			100	15,800	100	105	99	104	99	118	100												
5899D			100	15,875	100	103	100	107	100	113	99												
6014D	IV	41†	100	15,360	100	112	--	116	106	121	102												
6015D			100	15,505	100	107	--	110	105	114	105												
6016D			100	15,650	100	103	--	100	103	106	101												
6077D	IV	41†	100	15,950	100	98	--	103	95	111	101												
6078D			100	15,725	100	104	--	108	97	118	91												
6079D			100	15,725	100	105	--	110	98	119	102												
5900D	I	16	100	15,910	100	96	98	99	101	99	102												
5901D			100	15,985	100	95	98	98	99	104	99												
5902D			100	15,910	100	96	100	98	101	102	102												
5975D	I	16	100	15,150	100	107	106	116	113	128	109												
5976D			100	15,255	100	108	108	111	109	120	107												
5977D			100	15,505	100	107	108	111	109	120	103												
6047D	I	16	100	16,460	100	100	--	97	93	103	93												
6048D			100	16,260	100	101	--	99	94	108	98												
6049D			100	15,985	100	105	--	105	99	111	101												
5903D	V	51	100	15,800	100	101	101	103	103	111	101												
5904D			100	15,800	100	102	102	105	105	111	103												
5905D			100	15,835	100	102	101	105	105	112	98												
6002D	V	51	100	15,985	100	100	102	101	97	107	103												
6003D			100	15,835	100	102	97	103	103	109	100												
6004D			100	15,615	100	104	105	106	104	113	102												
6074D	V	51	100	15,760	100	105	--	110	104	120	106												
6075D			100	15,725	100	111	--	112	105	123	107												
6076D			100	15,835	100	108	--	108	104	119	105												
5906D	I	13	100	15,950	100	100	101	103	107	110	99												
5907D			100	15,910	100	102	100	103	108	108	100												
5908D			100	15,685	100	104	102	109	109	117	105												
6011D	I	13	100	15,910	100	102	--	103	99	110	98												
6012D			100	15,760	100	104	--	104	103	111	103												
6013D			100	15,505	100	104	--	106	103	114	105												

(Continued)

-- Dashed lines in "%V^2" column in 1956 indicate that pulse velocity readings were not taken that year due to breakdown of electronic equipment.

* The information obtained at the July 1964 inspection of these specimens indicated the specimens could not be identified. The loss of identification is believed to have taken place in April 1962, consequently data developed subsequent to that date, previously reported, have been deleted.

** Cements 43 and 43A made at same plant.

† Cements 14, 24, and 41 made at same plant.

(Revised Sept 1970)

Table 2-LTS (Continued)

							1955-1960 Readings														
	Cement		1955			1956		1958		1960		1962*		1964*		1966*		1968*		1970*	
Spec-imen No.	Type	LTS No.	%E	Pulse Veloc fps	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
6050D	I	13	100	15,985	100	100	---	98	96	104	100										
6051D			100	16,065	100	99	---	96	95	105	100										
6052D			100	15,950	100	103	---	94	94	101	101										
5909D	I	11	100	15,430	100	108	105	112	108	117	107										
5910D			100	15,615	100	108	104	112	108	119	103										
5911D			100	15,290	100	106	106	111	110	120	107										
5996D	I	11	100	15,910	100	95	100	104	98	104	99										
5997D			100	16,300	100	102	98	100	97	110	95										
5998D			100	15,910	100	99	100	99	101	107	99										
6026D	I	11	100	16,260	100	102	---	97	96	104	98										
6027D			100	16,105	100	100	---	102	98	109	98										
6028D			100	16,065	100	101	---	100	96	109	99										
5912D	II	23	100	15,540	100	105	105	109	109	125	102										
5913D			100	15,360	100	107	106	110	110	110	104										
5914D			100	15,540	100	105	104	108	106	117	104										
5966D	II	23	100	16,025	100	96	105	96	106	105	102										
5967D			100	15,985	100	96	106	97	109	103	103										
5968D			100	16,105	100	94	101	95	107	102	93										
6062D	II	23	100	16,065	100	100	---	94	95	104	101										
6063D			100	16,420	100	100	---	109	90	116	97										
6064D			100	16,220	100	98	---	90	95	103	94										
5915D	II	25††	100	15,290	100	108	111	113	111	122	110										
5916D			100	15,150	100	111	107	113	110	119	109										
5917D			100	15,185	100	110	109	113	108	123	108										
5963D	II	25††	100	15,910	100	99	105	101	105	109	99										
5964D			100	15,985	100	101	103	102	106	109	100										
5965D			100	16,065	100	97	107	98	110	106	100										
6083D	II	25††	100	16,065	100	102	---	104	98	112	100										
6084D			100	16,260	100	99	---	102	98	113	97										
6085D			100	16,065	100	103	---	105	96	114	102										
5918D	I	19B	100	15,540	100	103	105	108	104	114	104										
5919D			100	15,540	100	104	105	105	105	109	102										
5920D			100	15,360	100	105	108	107	106	115	104										
5987D	I	19B	100	15,115	100	105	110	109	109	118	105										
5988D			100	15,150	100	105	108	109	108	117	108										
5989D			100	15,115	100	104	111	107	108	117	109										
6068D	I	19B	100	15,760	100	101	---	100	99	108	101										
6069D			100	15,615	100	101	---	101	98	100	102										
6070D			100	15,800	100	102	---	110	96	124	102										
5921D	I	19C	100	15,725	100	103	103	105	102	111	99										
5922D			100	15,910	100	106	101	108	100	118	103										
5923D			100	15,835	100	102	102	104	104	112	99										
5990D	I	19C	100	15,685	100	103	101	107	103	115	104										
5991D			100	15,800	100	98	101	101	99	108	101										
5992D			100	15,950	100	95	99	97	99	102	99										
6023D	I	19C	100	15,615	100	102	---	103	100	108	100										
6024D			100	15,540	100	103	---	105	101	110	99										
6025D			100	15,505	100	102	---	102	99	102	98										
5924D	I	12‡	100	15,650	100	112	107	115	107	125	106										
5925D			100	15,875	100	105	103	108	108	116	99										
5926D			100	15,540	100	109	106	112	112	120	98										
5984D	I	12‡	100	15,185	100	106	111	110	112	119	110										
5985D			100	15,685	100	105	107	109	109	118	102										
5986D			100	15,360	100	107	89	110	113	120	105										
6071D	I	12‡	100	16,105	100	102	---	107	96	117	101										
6072D			100	16,625	100	99	---	107	93	114	96										
6073D			100	16,420	100	103	---	97	93	108	99										

(Continued)

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†† Cements 25 and 33 made from same major raw materials.

‡ Cements 12, 22, and 31 made at same plant.

(Revised Sept 1970)

Table 2-LTS (Continued)

			1955-1960 Readings																		
	Cement		1955			1956		1958		1960		1962*		1964*		1966*		1968*		1970*	
Spec-imen No.	Type	LTS No.	%E	Pulse Veloc fps	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
5927D	I	17	100	15,505	100	103	104	105	107	114	105										
5928D			100	15,085	100	108	104	110	111	116	106										
5929D			100	15,185	100	108	103	109	108	108	103										
5969D	I	17	100	16,220	100	96	96	98	98	104	96										
5970D			100	16,140	100	95	99	97	103	102	97										
5971D			100	16,065	100	95	100	96	100	102	96										
6080D	I	17	100	15,985	100	102	--	103	94	113	100										
6081D			100	16,260	100	101	--	103	94	113	97										
6082D			100	16,065	100	98	--	100	97	110	100										
5930D	III	31‡	100	15,150	100	105	105	105	104	108	100										
5931D			100	15,150	100	100	105	100	105	122	100										
5932D			100	15,430	100	100	96	99	100	114	95										
5978D	III	31‡	100	15,220	100	105	105	109	106	124	104										
5979D			100	15,290	100	106	99	109	103	116	103										
5980D			100	15,185	100	102	105	104	107	109	100										
6053D	III	31‡	100	15,760	100	99	--	96	91	101	97										
6054D			100	15,760	100	101	--	104	89	102	95										
6055D			100	15,760	100	99	--	107	88	115	104										
5933D	I	15	100	15,615	100	101	99	99	99	103	99										
5934D			100	15,575	100	103	94	101	101	107	101										
5935D			100	15,835	100	101	99	99	99	107	97										
6020D	I	15	100	16,300	100	95	--	95	92	93	97										
6021D			100	16,140	100	98	--	97	96	103	95										
6022D			100	16,220	100	97	--	Broken in handling													
6038D	I	15	100	16,300	100	97	--	96	89	102	96										
6039D			100	16,340	100	95	--	94	89	101	95										
6040D			100	16,220	100	98	--	94	93	102	95										
5936D	II	22‡	100	15,430	100	104	106	104	108	109	98										
5937D			100	15,220	100	106	107	106	111	117	102										
5938D			100	15,650	100	104	103	105	108	109	97										
5957D	II	22‡	100	16,220	100	100	99	102	103	102	100										
5958D			100	15,760	100	103	102	105	106	113	104										
5959D			100	15,835	100	104	102	108	108	117	104										
6086D	II	22‡	100	15,985	100	102	--	106	96	117	104										
6087D			100	15,760	100	109	--	109	102	120	103										
6088D			100	15,835	100	106	--	110	98	119	102										
5939D	III	33††	100	15,650	100	101	101	102	111	105	97										
5940D			100	15,650	100	102	99	102	106	115	97										
5941D			100	15,615	100	101	101	101	105	112	95										
5981D	III	33††	100	15,650	100	102	99	104	99	110	100										
5982D			100	15,255	100	102	104	103	106	112	100										
5983D			100	15,185	100	103	105	105	105	112	101										
6041D	III	33††	100	15,835	100	99	--	95	97	102	97										
6042D			100	15,725	100	98	--	105	97	104	94										
6043D			100	15,950	100	100	--	100	95	108	93										
5942D	I	14†	100	16,065	100	97	101	97	101	98	102										
5943D			100	15,985	100	104	100	105	106	114	100										
5944D			100	15,650	100	106	106	108	106	119	103										
5993D	I	14†	100	16,300	100	96	97	99	101	107	96										
5994D			100	16,220	100	96	101	98	100	105	99										
5995D			100	16,260	100	96	102	98	97	107	98										
6059D	I	14†	100	16,420	100	98	--	107	88	115	94										
6060D			100	16,260	100	98	--	88	90	97	94										
6061D			100	16,180	100	101	--	107	91	112	94										
5945D	II	24†	100	15,725	100	103	103	105	106	114	98										
5946D			100	15,575	100	105	101	108	106	116	101										
5947D			100	15,360	100	110	108	112	113	119	103										

(Continued)

-- Dashed lines in "%V^2" column in 1956 indicate that pulse velocity readings were not taken that year due to breakdown of electronic equipment.

* The information obtained at the July 1964 inspection of these specimens indicated the specimens could not be identified. The loss of identification is believed to have taken place in April 1962, consequently data developed subsequent to that date, previously reported, have been deleted.

† Cements 14, 24, and 41 made at same plant.

†† Cements 25 and 33 made from same major raw materials.

‡ Cements 12, 22, and 31 made at same plant.

(Revised Sept 1970)

Table 2-LTS (Concluded)

			1955-1960 Readings																				
	Cement		1955			1956		1958		1960		1962*		1964*		1966*		1968*		1970*			
Specimen No.	Type	LTS No.	%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$		
6056D	II	24†	100	16,300	100	102	---	110	90	121	93												
6057D			100	15,950	100	102	---	96	89	106	98												
6058D			100	15,835	100	102	---	108	92	108	93												
6008D	II	24†	100	15,395	100	102	---	105	100	113	100												
6009D			100	15,505	100	103	---	106	97	113	97												
6010D			100	15,430	100	107	---	108	100	118	101												
5948D	I	19A	100	15,085	100	109	111	113	117	121	107												
5949D			100	15,115	100	107	108	109	118	117	104												
5950D			100	15,115	100	107	110	109	117	120	105												
6029D	I	19A	100	15,725	100	106	---	106	104	116	104												
6030D			100	15,650	100	105	---	107	102	Bkn in hdlg													
6031D			100	15,615	100	106	---	112	103	120	104												
6017D	I	19A	100	15,085	100	105	---	109	109	113	106												
6018D			100	14,950	100	113	---	116	112	121	108												
6019D			100	15,185	100	104	---	108	105	117	108												
5951D	I	18	100	15,950	100	100	98	101	101	106	99												
5952D			100	16,[illegible]5	100	101	98	102	100	114	97												
5953D			100	15,575	100	106	107	107	114	112	103												
6005D	I	18	100	15,800	100	103	98	106	101	113	102												
6006D			100	15,470	100	106	104	108	104	119	105												
6007D			100	15,835	100	103	100	105	101	112	100												
6035D	I	18	100	16,340	100	100	---	97	93	104	99												
6036D			100	15,985	100	100	---	99	98	107	100												
6037D			100	16,025	100	101	---	104	98	111	100												
5954D	IV	43**	100	15,360	100	106	102	109	113	118	108												
5955D			100	15,650	100	101	96	102	108	112	100												
5956D			100	15,615	100	101	103	102	105	109	99												
5960D	IV	43**	100	15,255	100	113	111	118	114	126	115												
5961D			100	15,325	100	116	114	121	115	127	113												
5962D			100	15,290	100	116	111	121	118	130	113												
6044D	IV	43**	100	15,220	100	104	---	116	100	126	104												
6045D			100	15,615	100	103	---	109	99	120	98												
6046D			100	15,875	100	100	---	99	98	97	97												

-- Dashed lines in "$\%V^2$" column in 1956 indicate that pulse velocity readings were not taken that year due to breakdown of electronic equipment.

* The information obtained at the July 1964 inspection of these specimens indicated the specimens could not be identified. The loss of identification is believed to have taken place in April 1962, consequently data developed subsequent to that date, previously reported, have been deleted.

** Cements 43 and 43A made at same plant.

† Cements 14, 24, and 41 made at same plant.

(Issued August 1977) Key to Section 18

Charles River Dam-Smelt Brook Local Protection Project
New England Division

Aggregates: Coarse "A," natural gravel, Ossipee, N. H.

Fine "A," natural sand, Ossipee, N. H.

Coarse "B," crushed quarry and natural gravel, Marshfield sand and gravel.

Fine "B," natural sand, Marshfield sand and gravel.

Admixtures: Water Reducer "A," Pozzolith 122 N, Master Builders.

Water Reducer "B," WRDA, W. R. Grace

Air-entraining "A," MBVR, Master Builders.

Air-entraining "B," DAREX, W. R. Grace.

Cement: Atlantic type II, Hudson Valley, N. Y.

Charles River Dam-Smelt Brook Local Protection Project

New England Division

In August 1976, 18 concrete beams (6 by 6 by 24 in.) were installed on the Treat Island exposure rock for the U. S. Army Engineer Division, CE, New England. These specimens represent three concrete mixes used for two construction jobs; Mixes 1 and 2 were used for the Charles River Dam, Boston, Mass., and Mix 3 was used for Smelt Brook Local Protection Project, Weymouth, Mass. Type II Portland cement was used in the three mixes. Mixes 1 and 2 contain coarse and fine aggregates "A" (1-1/2 in. maximum size), water reducer, and air-entraining admixture "A." Mix 3 contains coarse and fine aggregates "B" (3/4-in. maximum size), water reducer, and air-entraining admixtures "B." More mixture data are given in Table 1. Table 1-NED gives the exposure record of the installed beams.

(Issued August 1977)

Table 1

Charles River Dam-Smelt Brook Local Protection Project

New England Division

	Charles River Dam, Boston-Charlestown, Mass.				Smelt Brook Local Protection, Weymouth, Mass.	
Formula Number	Mix 1	Mix 1	Mix 2	Mix 2	Mix 3	Mix 3
Tag Identification Numbers*	7, 8, 9	10, 11, 12	13, 14, 15	16, 17, 18	1, 2, 3	4, 5, 6
N.E.D. nomenclature	-	-	-	-	2A, 2B, 2C	1A, 1B, 1C
Date of fabrication	10/6/75	10/7/75	10/17/75	10/22/75	9/5/75	8/14/75
Slump, in.	2.50	2.50	3.00	2.50	3.00	3.00
Air content, %	5.2	5.0	5.7	4.3	3.0	4.2
Concrete temperature, °F	62	62	75	66	78	72
Unit weight of fresh concrete, pcf	145.2	-	144.7	145.0	143.63	142.97
Compression cylinders	229-A, C, D	230-A, C, D	241-A, C, D	244-A, C, D	43-A, C, D	40-A, C, D
Compressive strength, psi						
7-day	3890	3820	3855	3960	2810	4310
28-day	4870	5095	4420	5375	3940	5440
28-day	4955	5180	4670	5375	4020	5360

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* Identification tag is attached to each specimen.

Table 1-NED

Record of Testing of Concrete Specimens from Charles River Dam, and Smelt Brook Local Protection Project (Installed August 1976)

Exposure Rack, Row 3

	1976- Readings				
	0 Cycles 1976			77 Cycles 1977	
Beam No.	%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$
1	100	16,000	100	100	98
2	100	16,130	100	106	97
3	100	16,000	100	107	98
4	100	17,240	100	113	88
5	100	17,700	100	108	89
6	100	17,240	100	115	95
7	100	16,130	100	107	91
8	100	16,260	100	106	97
9	100	15,750	100	105	105
10	100	16,130	100	116	97
11	100	16,530	100	112	91
12	100	16,000	100	111	95
13	100	15,750	100	108	97
14	100	15,875	100	105	97
15	100	15,750	100	107	98
16	100	15,875	100	105	98
17	100	16,130	100	99	95
18	100	16,260	100	107	95

Mt. Morris Dam* Cores

In October 1949, 11 concrete cores (10 in. in diameter by 18 in. long) taken from concrete placed at Mt. Morris Dam, N. Y., between May and August 1949, were installed on the Treat Island exposure rack. The purpose of this installation was to determine the durability of these cores. The aggregates used consisted of crushed limestone and manufactured limestone sand; the cement was type II-A. Five of these cores were taken from the upstream face of the structure and represent exterior concrete of approximately 4.0-bags-per-cu-yd cement factor. The remaining six cores represent interior concrete of approximately 3.1-bags-per-cu-yd cement factor.

Table 1-MM lists these cores and gives their exposure record along with other pertinent information.

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* See U. S. Army Engineer Waterways Experiment Station, CE, Aggregate Tests, Mount Morris Dam (Vicksburg, Miss., February 1948).

(Revised August 1977)

Table 1-MM

Record of Testing of Concrete Cores, Mount Morris Dam

1949- (Installed October 1949)

East Bay, Row 1 (N to S)

Specimen No.	Water Cement Ratio (by wt)	Air %	1949-1958 Readings 0 Cycles 1949	161 Cycles 1950	250 Cycles 1951	351 Cycles 1952	436 Cycles, 1953	436 Cycles, 1953	436 Cycles, 1953	547 Cycles 1954		692 Cycles 1955		859 Cycles 1956		1003 Cycles 1957		1074 Cycles 1958	
			%E	%E	%E	%E	%E	Pulse Veloc fps	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
Exterior, Nominal 4-bag-per-cu-yd Cement Factor																			
Con-1-20(1)	0.49	4.1	100	109	109	114	118	16,855	100	119	96	117	98	127	90	125	92	125	103
Con-2-21(2)	0.49	4.1	100	104	112	114	114	16,305	100	116	90	118	100	124	92	122	96	122	99
Con-3-22(1)	0.49	4.1	100	110	114	118	119	16,665	100	123	92	125	107	129	94	129	98	132	105
Con-5-24(2)	0.49	4.1	100	113	115	121	118	16,485	100	125	96	123	100	129	90	126	96	120	100
Con-6-24A	0.49	4.1	100	108	113	117	117	16,855	100	121	96	122	105	128	94	125	92	132	100
Interior, Nominal 3-bag-per-cu-yd Cement Factor																			
Con-8-3A	0.59	4.6	100	112	114	115	118	16,485	100	120	102	121	105	126	100	128	100	130	107
Con-9-3B(1)	0.59	4.7	100	113	115	113	119	16,485	100	119	107	115	112	116	105	117	103	120	108
Con-11-7	0.61	4.3	100	106	108	113	112	15,790	100	117	100	116	107	121	96	110	98	112	104
Con-12-8(2)	0.59	3.3	100	107	110	114	115	15,955	100	120	100	121	104	126	98	124	102	127	104
Con-14-9B(2)	0.59	3.3	100	104	115	118	118	16,130	100	120	94	119	100	124	92	116	94	115	100
Con-15-10	0.62	4.2	100	103	111	113	114	15,625	100	117	102	96	98	102	92	97	92	104	98

Exposure Rack, Row 4 (W to E)

Specimen No.	Water Cement Ratio (by wt)	Air %	1959-1968 Readings 1224 Cycles 1959		1295 Cycles 1960		1436 Cycles 1961		1525 Cycles 1962		1631 Cycles 1963		1766 Cycles 1964		1929 Cycles 1965		2059 Cycles 1966		2215 Cycles 1967		2400 Cycles 1968	
			%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
Exterior, Nominal 4-bag-per-cu-yd Cement Factor																						
Con-1-20(1)	0.49	4.1	132	90	125	92	123	98	111	92	117	107	113	82	107	90	107	76	97	67	93	72
Con-2-21(2)	0.49	4.1	131	91	134	97	125	104	123	90	122	102	117	94	113	100	109	94	98	85	108	85
Con-3-22(1)	0.49	4.1	137	90	133	86	125	92	120	84	121	90	109	90	119	98	106	86	99	81	94	81
Con-5-24(2)	0.49	4.1	126	90	130	92	126	90	134	77	116	98	119	92	129	100	124	77	106	72	104	78
Con-6-24A	0.49	4.1	132	84	129	89	123	94	119	98	119	92	113	88	114	88	109	81	98	75	111	82
Interior, Nominal 3-bag-per-cu-yd Cement Factor																						
Con-8-3A	0.59	4.6	127	94	129	98	122	96	118	96	116	102	110	100	101	94	101	92	92	88	93	88
Con-9-3B(1)	0.59	4.7	106	101	113	101	107	102	100	71	76	86	71	109	67	83	67	58	62	59	66	39
Con-11-7	0.61	4.3	113	94	115	96	101	88	103	92	101	102	93	94	80	90	86	72	74	77	74	71
Con-12-8(2)	0.59	3.3	122	92	125	92	112	96	111	104	115	104	106	98	105	96	100	79	83	88	91	88
Con-14-9B(2)	0.59	3.3	109	83	106	92	98	96	95	77	91	102	124	92	109	82	127	69	112	68	107	68
Con-15-10	0.62	4.2	98	89	92	89	87	89	86	79	77	92	68	89	60	78	61	--	Failed			

Specimen No.	Water Cement Ratio (by wt)	Air %	1969-1977 Readings 2554 Cycles 1969		2707 Cycles 1970		2876 Cycles 1971		3033 Cycles 1972		3173 Cycles 1973		3309 Cycles 1974		3421 Cycles 1975		3570 Cycles 1976		3647 Cycles 1977	
			%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
Exterior, Nominal 4-bag-per-cu-yd Cement Factor																				
Con-1-20(1)	0.49	4.1	92	59	93	55	91	27	NR	26	Failed									
Con-2-21(2)	0.49	4.1	108	81	105	69	105	29	Failed											
Con-3-22(1)	0.49	4.1	93	69	NR	54	93	41	Failed											
Con-5-24(2)	0.49	4.1	106	75	111	69	106	52	109	40	101	71	97	75	97	90	96	83	117	74
Con-6-24A	0.49	4.1	109	79	115	64	108	40	Failed											
Interior, Nominal 3-bag-per-cu-yd Cement Factor																				
Con-8-3A	0.59	4.6	92	81	91	70	88	52	83	63	83	49	79	48	80	90	78	81	73	70
Con-9-3B(1)	0.59	4.7	NR	--	Failed															
Con-11-7	0.61	4.3	71	NR	72	--	72	--	Failed											
Con-12-8(2)	0.59	3.3	90	82	87	68	87	27	86	57	89	NR	88	63	88	96	72	88	65	73
Con-14-9B(2)	0.59	3.3	105	58	NR	51	NR	25	Failed											

-- Dashed lines in "%V^2" column indicate that end of specimen was too rough to obtain satisfactory reading.

NR denotes that a satisfactory reading was not obtained although an attempt was made to obtain a satisfactory reading.

Air-entraining Admixture Study*

The purpose of this study is to determine the relative effect of several commercial admixtures on the durability of concrete. In November 1944, ninety (6- by 6- by 30-in.) concrete specimens containing eight admixtures were installed on the Treat Island exposure rack. The aggregates used in these specimens were natural siliceous sand and crushed traprock of 1-1/2-in. maximum size. One cement (type II) was used, and the concrete mixtures had nominal cement factors of 4.5, 5.25, and 6.0 bags per cu yd with a nominal slump of 3 in. The water-cement and sand-aggregate ratios were permitted to fluctuate as affected by the admixture. The test specimens were of one size, but of two types: columns and beams.

Table 1-CRA lists these specimens and gives their exposure record along with other pertinent information.

In November 1957, the following seven concrete beam specimens were returned to the laboratory for detailed studies.

Specimen No.	Admixture Used
AB5A	Admixture A
AB5B	Admixture A
AB4	Admixture A
PB5C	None
PB4	None
RB5A	Resin soap
RB4	Resin soap

The purpose of these studies was to determine why some specimens with no admixture and some specimens with admixture A survived 13 years exposure at Treat Island when similar concrete was found to be nonfrost-resistant by laboratory tests made in 1944. Similar tests conducted in 1958 gave the same results as the 1944 tests. The laboratory studies did not indicate conclusively the reason for the survival of these specimens, but they did indicate the following:

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* See Central Concrete Laboratory, <u>Concrete Research,</u> Second Interim Report, Part I, "Laboratory Studies of Concrete Containing Air-entraining Admixtures" (July 1945).

- a. Specimens with high relative moduli (%E) are not necessarily undamaged by exposure at Treat Island; microfractures were found in one specimen having a %E of 153.
- b. The reason for the survival of the specimens with no admixture and with admixture A was not the accidental inclusion of an air-entraining agent that produced an air-void system capable of imparting frost resistance, since no such void system is present.
- c. It is possible that the early termination of moist-curing of the specimens with admixture A increased their frost resistance by making them less readily saturable on exposure.

(Issued June 1959)

Table 1-CRA

Record of Testing of Concrete Columns and Beams, Air-entraining Admixture Study

1944- (Installed November 1944)

Center Bay, Rows 1 and 2

Spec-imen No.	Type Specimen	Cement Factor (Nominal) bags/ cu yd	Air %	1944-1953 Readings											
				0 Cycles 1944	110 Cycles 1945	215 Cycles 1946	333 Cycles 1947	464 Cycles 1948	569 Cycles 1949	730 Cycles 1950	819 Cycles 1951	920 Cycles 1952	1005 Cycles, 1953		
				%E	%E	%E	%E	%E	%E	%E	%E	%E	%E	Pulse Veloc fps	$\%V^2$
							Admixture A								
AC5A	Column*	5.25	1.9	Broken at installation											
AB5A	Beam*			100	120	127	133	132	134	136	136	139	137	15,330	100
AC5B	Column			100	119	128	129	129	130	131	131	135	138	15,430	100
AB5B	Beam			100	120	131	135	135	135	136	136	140	143	15,150	100
AC5C	Column			100	119	127	130	130	132	131	131	133	138	15,725	100
AB5C	Beam			100	120	131	136	135	138	138	138	140	144	15,530	100
AC4	Beam	4.5	2.0	100	120	136	136	138	133	138	138	141	146	14,880	100
AB4	Beam			100	119	134	139	137	140	141	140	142	148	15,060	100
AC6	Column	6.0	1.8	100	118	127	129	104	88	Failed					
AB6	Beam			100	118	127	129	128	130	129	129	131	136	16,020	100
							Paraffin Oil								
OC5A	Column	5.25	3.9	100	109	113	116	115	115	117	114	118	121	15,430	100
OB5A	Beam			100	110	117	118	118	117	119	118	121	123	15,625	100
OC5B	Column			100	106	115	116	115	114	115	113	115	119	15,150	100
OB5B	Beam			100	109	115	116	116	115	116	115	117	120	15,530	100
OC5C	Column			100	110	120	122	122	121	122	121	125	127	15,430	100
9B5C	Beam			100	108	114	115	115	115	116	115	117	120	15,245	100
OC4	Column	4.5	7.5	100	110	115	116	117	116	117	115	118	121	14,795	100
OB4	Beam			100	107	111	112	111	108	110	109	110	112	14,370	100
OC6	Column	6.0	5.6	100	111	114	115	116	113	115	113	116	119	15,430	100
OB6	Beam			100	111	116	118	118	119	119	120	120	124	15,150	100
							Admixture B								
ZC5A	Column	5.25	4.9	100	108	115	115	114	116	116	115	117	120	15,825	100
ZB5A	Beam			100	106	112	114	112	114	114	114	114	120	15,725	100
ZC5B	Column			100	106	115	117	115	113	112	111	113	120	14,705	100
ZB5B	Beam			100	101	109	112	110	110	110	110	112	115	15,530	100
ZC5C	Column			100	106	115	117	115	116	117	117	120	123	15,530	100
ZB5C	Beam			100	105	112	113	112	112	112	112	114	117	14,970	100
ZC4	Column	4.5	4.7	100	104	112	112	112	112	111	110	112	116	15,725	100
ZB4	Beam			100	102	110	112	110	109	111	110	111	113	15,430	100
ZC6	Column	6.0	6.0	100	105	111	112	111	111	112	111	114	117	15,625	100
ZB6	Beam			100	106	117	119	115	117	119	117	121	123	15,150	100
							Resin Soap + $CaCl_2$								
CC5A	Column	5.25	7.8	100	106	112	115	112	111	111	114	113	99	14,970	100
CB5A	Beam			100	104	111	112	111	108	111	108	112	115	14,705	100
CC5B	Column			100	109	118	121	119	120	121	119	123	125	15,245	100
CB5B	Beam			100	107	116	116	114	116	116	113	117	119	14,880	100
CC4	Column	4.5	5.2	100	107	114	115	114	113	113	112	114	116	15,335	100
CB4	Beam			100	107	112	113	110	110	110	109	113	114	15,060	100
CC6	Column	6.0	6.4	100	107	113	114	113	113	113	112	114	117	15,335	100
CB6	Beam			100	108	113	115	113	113	113	113	115	118	15,060	100
							Without Admixture								
PC5A	Column	5.25	1.6	100	109	113	Failed								
PB5A	Beam			100	102	Failed									
PC5B	Column			100	109	113	114	Failed							
PB5B	Beam			100	110	115	115	115	115	117	117	Failed			
PC5C	Column			100	111	118	116	111	116	118	118	Failed			
PB5C	Beam			100	110	115	115	113	112	113	111	113	116	15,335	100
PC4	Column	4.5	3.3	100	109	117	118	118	129	118	117	119	122	15,060	100
PB4	Beam			100	109	111	115	113	113	113	111	112	113	14,970	100
PC6	Column	6.0	1.7	100	106	111	112	Failed							
PB6	Beam			100	110	115	117	115	115	118	118	118	119	14,705	100

(Continued)

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* A column is cast with its long axis vertical; a beam is cast with its long axis horizontal.

Table 1-CRA (Continued)

Spec-imen No.	Type Specimen	Cement Factor (Nominal) bags/cu yd	Air %	1944-1953 Readings 0 Cycles 1944 %E	110 Cycles 1945 %E	215 Cycles 1946 %E	333 Cycles 1947 %E	464 Cycles 1948 %E	569 Cycles 1949 %E,	730 Cycles 1950 %E	819 Cycles 1951 %E	920 Cycles 1952 %E	1005 Cycles, 1953 %E	Pulse Veloc fps	%V^2
							Resin Soap								
RC5A	Column	5.25	6.5	100	112	118	120	118	118	121	118	120	123	15,150	100
RB5A	Beam			100	108	113	115	115	116	117	115	119	122	14,880	100
RC5A1	Column			100	111	115	116	115	117	118	116	118	121	15,150	100
RB5A1	Beam			100	109	113	115	115	116	117	116	118	121	15,060	100
RC5B	Column			100	111	119	120	121	121	122	118	121	126	14,970	100
RB5B	Beam			100	110	115	117	117	117	118	116	118	120	15,060	100
RC5C	Column			100	110	114	117	115	116	116	114	118	120	15,060	100
RB5C	Beam			100	108	113	115	114	114	114	114	114	117	14,880	100
RC4	Column	4.5	7.8	100	112	119	120	117	116	116	114	116	119	14,535	100
RB4	Beam			100	110	114	114	114	111	111	110	111	111	14,450	100
RC6	Column	6.0	6.5	100	110	113	114	114	113	113	111	113	116	15,335	100
RB6	Beam			100	109	120	119	122	118	119	118	119	116	15,060	100
							Tallow (Beef)								
TC5A	Column	5.25	4.0	100	111	118	119	118	115	112	100	Failed			
TB5A	Beam			100	108	110	113	113	113	113	92	Failed			
TC5B	Column			100	109	121	125	123	124	121	114	93	Failed		
TB5B	Beam			100	104	111	114	113	111	112	107	Failed			
TC5C	Column			100	109	96	Failed								
TB5C	Beam			100	108	113	115	113	114	115	113	113	116	14,970	100
TC4	Column	4.5	3.4	100	109	117	119	115	126	112	107	96	Failed		
TB4	Beam			100	104	108	109	106	111	110	109	109	110	14,880	100
TC6	Column	6.0	3.6	100	109	114	116	115	109	97	92	90	Failed		
TB6	Beam			100	111	120	123	122	121	122	121	123	124	15,530	100
							Admixture C								
DC5A	Column	5.25	6.5	100	109	114	116	115	117	117	114	117	118	15,060	100
DB5A	Beam			100	108	115	117	116	116	116	115	116	117	15,150	100
DC5B	Column			100	106	111	113	111	111	112	115	110	116	14,880	100
DB5B	Beam			100	111	115	116	115	116	117	113	116	120	14,705	100
DC5C	Column			100	111	118	120	118	118	118	117	120	118	14,795	100
DB5C	Beam			100	109	113	116	116	114	114	111	114	116	14,535	100
DC4	Column	4.5	8.1	100	109	114	116	114	111	111	107	109	108	14,450	100
DB4	Beam			100	109	114	112	109	107	107	105	106	108	14,045	100
DC6	Column	6.0	6.1	100	109	116	116	116	113	114	111	115	117	14,970	100
DB6	Beam			100	111	119	122	119	120	120	118	120	120	14,970	100
							Admixture D								
HC5A	Column	5.25	8.0	100	111	116	118	117	116	117	115	118	121	15,335	100
HB5A	Beam			100	110	118	118	117	117	118	117	119	123	15,245	100
HC5B	Column			100	109	113	116	116	117	117	114	118	118	14,880	100
HB5B	Beam			100	109	116	119	118	118	120	119	121	123	14,620	100
HC5C	Column			100	113	120	117	115	117	119	117	119	122	15,245	100
HB5C	Beam			100	110	115	116	116	115	115	114	117	120	14,795	100
HC4	Column	4.5	9.4	100	113	118	120	118	118	118	121	118	120	14,970	100
HB4	Beam			100	112	115	115	114	112	112	111	112	Failed		
HC6	Column	6.0	6.0	100	112	117	120	118	120	120	120	122	124	15,625	100
HB6	Beam			100	111	116	118	117	119	117	116	119	122	15,335	100

Exposure Rack, Row 2 (W to E)

				1954-1962 Readings 1116 Cycles 1954		1261 Cycles 1955		1428 Cycles 1956		1572 Cycles 1957		1643 Cycles 1958		1793 Cycles 1959		1864 Cycles 1960		2005 Cycles 1961		2094 Cycles 1962	
				%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
								Admixture A													
AB5A	Beam	5.25	1.9	145	101	147	105	150	99	153	Returned to laboratory November 1957										
AC5B	Column			141	104	142	105	149	98	148	93	151	97	155	90	142	92	148	99	144	113
AB5B	Beam			148	106	148	109	153	106	153	Returned to laboratory November 1957										
AC5C	Column			140	101	142	104	150	95	138	97	150	103	154	97	151	99	148	95	141	107
AB5C	Beam			147	105	147	105	150	91	144	97	151	103	155	98	149	101	149	99	142	105

(Continued)

(Revised Sept 1968)

Table 1-CRA (Continued)

Section 25
Exposure Rack, Row 2 (W to E)

Spec-imen No.	Type Specimen	Cement Factor (Nominal) bags/ cu yd	Air %	1954-1962 Readings																	
				1116 Cycles 1954		1261 Cycles 1955		1428 Cycles 1956		1572 Cycles 1957		1643 Cycles 1958		1793 Cycles 1959		1864 Cycles 1960		2005 Cycles 1961		2094 Cycles 1962	
				%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
Admixture A (Continued)																					
AC4	Column	4.5	2.0	147	104	147	108	146	100	152	98	157	105	160	99	152	101	152	102	147	108
AB4	Beam			149	106	150	108	158	101	153	Returned to laboratory November 1957										
AB6	Beam	6.0	1.8	137	100	133	98	145	**	137	90	146	91	149	87	144	88	141	95	133	99
Paraffin Oil																					
OC5A	Column	5.25	3.9	122	104	122	101	129	**	126	114	127	102	132	94	127	96	127	98	119	94
OB5A	Beam			124	104	125	101	132	96	130	100	135	104	139	98	133	101	133	100	131	104
OC5B	Column			121	108	121	106	128	99	125	104	129	108	132	102	129	103	130	99	127	85
OB5B	Beam			122	106	123	105	130	104	128	104	133	104	135	100	130	101	129	101	118	103
OC5C	Column			129	104	129	103	135	--	132	--	136	--	147	--	155	--	171	--	154	---
OB5C	Beam			122	104	122	105	127	98	126	102	128	102	131	97	125	99	124	96	114	102
OC4	Column	4.5	7.5	122	104	122	104	127	93	123	101	126	102	123	93	103	80	98	79	82	71
OB4	Beam			111	102	110	102	116	96	110	98	114	97	112	86	113	102	102	91	86	90
OC6	Column	6.0	5.6	126	103	121	103	127	87	126	100	134	103	130	98	125	98	126	98	124	101
OB6	Beam			127	105	126	108	132	93	131	103	131	104	138	98	131	100	131	101	123	110
Admixture B																					
ZC5A	Column	5.25	4.9	122	104	122	104	130	101	128	100	130	105	135	97	130	97	129	101	120	108
ZB5A	Beam			121	104	122	105	129	96	121	104	125	104	132	99	128	100	127	99	122	109
ZC5B	Column			119	-- Failed																
ZB5B	Beam			117	106	118	108	124	95	122	104	124	105	128	99	122	99	122	103	117	116
ZC5C	Column			126	101	126	99	129	102	133	97	133	105	141	96	138	95	143	88	138	--
ZB5C	Beam			116	104	116	105	123	101	115	105	120	104	122	97	117	102	117	100	112	100
ZC4	Column	4.5	4.7	116	104	116	100	117	100	117	81	118	84	126	--	161	--	153	--	125	--
ZB4	Beam			114	104	112	105	108	95	104	92	106	93	91	76	74	76	128	--	128	--
ZC6	Column	6.0	6.0	117	105	118	105	124	99	124	103	120	106	127	100	122	100	121	99	117	105
ZB6	Beam			125	109	126	110	133	99	125	107	133	110	137	93	132	93	131	105	125	105
Resin Soap + $CaCl_2$																					
CC5A	Column	5.25	7.8	99	105	99	106	102	95	101	97	102	101	102	99	100	99	98	100	94	108
CB5A	Beam			115	104	116	107	121	98	120	100	121	102	123	97	118	98	117	99	114	98
CC5B	Column			127	105	126	104	126	92	131	96	135	101	136	95	127	97	130	98	122	102
CB5B	Beam			120	101	121	100	123	95	124	96	128	102	128	94	123	99	122	95	118	99
CC4	Column	4.5	5.2	115	100	117	101	119	--	119	--	123	--	124	--	115	--	117	--	107	--
CB4	Beam			116	104	116	105	120	93	119	96	119	106	124	98	118	97	117	94	110	105
CC6	Column	6.0	6.4	118	103	119	103	118	94	123	95	126	99	130	95	122	96	123	92	116	95
CB6	Beam			121	104	122	105	125	97	121	96	126	103	130	98	121	100	124	100	119	105
Without Admixture																					
PB5C	Beam	5.25	1.6	117	104	117	105	122	94	120	Returned to laboratory November 1957										
PC4	Column	4.5	3.3	121	104	119	105	120	89	111	89	109	92	Returned to laboratory October 1958							
PB4	Beam			111	102	106	102	96	91	78	Returned to laboratory November 1957										
PB6	Beam	6.0	1.7	122	91	125	92	143	---	151	---	157	---	Returned to laboratory October 1958							
Resin Soap																					
RC5A	Column	5.25	6.5	126	104	126	102	132	98	129	99	132	101	135	97	128	106	128	101	122	105
RB5A	Beam			123	105	123	106	128	99	127	Returned to laboratory November 1957										
RC5A1	Column			123	105	124	106	127	98	126	100	130	102	131	95	126	102	126	100	120	101
RB5A1	Beam			123	104	124	102	129	101	127	101	128	103	133	96	128	97	128	98	122	100
RC5B	Column			126	106	126	105	132	99	129	103	132	104	Lost overboard in storm, Feb 1959							
RB5B	Beam			123	106	122	106	125	102	124	100	129	104	Lost overboard in storm, Feb 1959							
RC5C	Column			122	106	122	106	128	101	125	101	125	102	Lost overboard in storm, Feb 1959							
RB5C	Beam			118	104	118	108	124	99	121	99	129	105	126	99	121	101	119	101	116	106
RC4	Column	4.5	7.8	119	101	119	106	118	101	119	99	122	104	125	97	121	98	121	96	111	90
RB4	Beam			114	101	113	104	114	93	115	Returned to laboratory November 1957										
RC6	Column	6.0	6.5	117	99	117	104	121	94	120	96	124	100	125	90	119	91	117	93	112	91
RB6	Beam			125	100	126	105	131	93	128	99	132	104	135	99	130	98	127	99	112	97

(Continued)

-- Dashed lines in "$\%V^2$" column indicate that end of specimen was too rough to obtain satisfactory reading.

** These readings were inadvertently omitted in 1956.

(Revised Jan 1972)

Table 1-CRA (Continued)

Section 25

Exposure Rack, Row 2 (W to E)

Spec-imen No.	Type Specimen	Cement Factor (Nominal) bags/ cu yd	Air %	1954-1962 Readings																	
				1116 Cycles 1954		1261 Cycles 1955		1428 Cycles 1956		1572 Cycles 1957		1643 Cycles 1958		1793 Cycles 1959		1864 Cycles 1960		2005 Cycles 1961		2094 Cycles 1962	
				%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
Tallow (Beef)																					
TB5C	Beam	5.25	4.0	119	106	118	108	123	90	118	102	123	105	127	100	122	102	121	101	109	101
TB4	Beam	4.5	3.4	112	105	112	106	112	95	106	100	111	101	110	92	101	89	94	82	84	82
TB6	Beam	6.0	3.6	127	103	121	103	128	95	124	100	133	104	140	97	135	101	131	99	126	106
Admixture C																					
DC5A	Column	5.25	6.5	121	102	121	104	127	99	122	100	127	108	130	91	122	94	122	100	115	99
DB5A	Beam			120	102	120	104	126	95	124	101	134	105	129	94	123	99	122	100	115	104
DC5B	Column			116	101	115	102	121	97	118	98	121	102	124	94	118	97	118	99	113	102
DB5B	Beam			119	105	120	106	124	96	121	102	124	106	125	97	120	100	118	100	113	105
DC5C	Column			122	101	122	101	123	98	119	101	127	103	131	96	122	98	122	99	117	105
DB5C	Beam			116	104	117	105	122	97	118	100	121	101	124	95	118	96	117	97	112	105
DC4	Column	4.5	8.1	112	101	113	104	119	97	118	103	122	102	122	99	109	100	99	97	84	--
DB4	Beam			109	101	108	105	111	93	108	103	110	103	115	95	109	97	103	95	86	100
DC6	Column	6.0	6.1	119	105	120	106	125	95	124	101	125	102	128	100	123	101	123	102	118	105
DB6	Beam			121	104	126	104	130	98	129	98	132	103	136	99	129	105	128	98	124	105
Admixture D																					
HC5A	Column	5.25	8.0	123	100	117	100	122	98	120	104	129	104	132	98	126	100	126	100	120	106
HB5A	Beam			126	102	126	106	133	96	128	103	133	103	137	98	131	103	131	102	128	109
HC5B	Column			122	102	122	105	128	98	120	100	123	105	131	98	126	102	126	101	121	110
HB5B	Beam			128	106	127	107	134	104	130	104	134	104	139	99	128	103	125	101	125	109
HC5C	Column			125	106	126	108	132	101	126	102	132	106	136	100	128	102	131	99	126	106
HB5C	Beam			122	105	119	106	126	104	122	105	126	106	130	100	122	105	121	104	116	113
HC4	Column	4.5	9.4	120	106	112	106	126	86	122	98	125	103	124	95	116	97	113	98	108	108
HC6	Column	6.0	6.0	128	105	122	107	136	95	133	101	136	105	140	99	108	102	131	101	128	112
HB6	Beam			124	109	124	106	129	91	126	103	129	107	133	99	127	101	123	101	121	109

Exposure Rack, Row 2 (W to E)

Spec-imen No.	Type Specimen	Cement Factor (Nominal) bags/ cu yd	Air %	1963-1971 Readings																	
				2200 Cycles 1963		2335 Cycles 1964		2498 Cycles 1965		2628 Cycles 1966		2784 Cycles 1967		2969 Cycles 1968		3123 Cycles 1969		3276 Cycles 1970		3445 Cycles 1971	
				%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
Admixture A																					
AC5B	Column	5.25	1.9	146	107	142	60	143	107	166	100	169	102	162	96	175	91	165	87	165	--
AC5C	Column			138	104	133	87	136	100	136	--	NR††	--	F	--						
AB5C	Beam			143	108	140	100	140	103	140	96	135	103	135	93	140	92	127	87	109	--
AC4	Column	4.5	2.0	148	102	147	--	141	--	144	--	147	--	156	--	138	--	175	--	172	--
AB6	Beam	6.0	1.8	125	84	114	91	109	98	121	66	121	61	F							
Paraffin Oil																					
OC5A	Column	5.25	3.9	117	39	115	95	113	105	115	--	113	--	113	--	113	--	111	--	108	--
OB5A	Beam			125	89	129	101	126	104	124	--	124	--	126	--	128	--	130	--	124	--
OC5B	Column			124	90	132	--	143	--	199	--	NR	--	209	--	NR	--	74	--	F	--
OB5B	Beam			123	106	121	105	123	108	125	93	123	100	123	99	125	--	128	--	125	--
OC5C	Column			187	--	193	--	199	--	199	--	NR	--	254	--	NR	--	71	--	73	--
OB5C	Beam			91	108	89	--	87	--	85	--	81	--	79	--	77	--	74	--	69	--
OC4	Column	4.5	7.5	80	--	65	--	60	--	F											
OB4	Beam			76	--	119	--	F†													
OC6	Column	6.0	5.6	121	108	119	--	114	--	116	--	116	--	118	--	118	--	131	--	170	--
OB6	Beam			122	112	118	94	114	121	116	89	114	101	109	100	111	--	116	--	111	--
Admixture B																					
ZC5A	Column	5.25	4.9	124	107	122	97	118	112	116	98	116	105	118	--	123	--	123	--	123	--
ZB5A	Beam			123	105	118	100	116	117	118	91	118	99	118	94	118	--	113	--	88	--
ZB5B	Beam			115	80	113	101	118	115	118	95	118	104	118	100	120	88	115	80	95	--
ZC5C	Column			143	--	157	--	154	--	160	--	NR	--	160	--	166	--	166	--	105	--
ZB5C	Beam			112	--	112	--	110	--	110	--	106	--	108	--	108	--	106	--	NR	--

(Continued)

-- Dashed lines in "$\%V^2$" column indicate that end of specimen was too rough to obtain satisfactory reading.

† F denotes specimen has failed.

†† NR denotes that a satisfactory reading was not obtained as specimen would not respond to flexural vibration.

(Revised Jan 1973)

Table 1-CRA (Continued)

Section 25
Exposure Rack, Row 2 (W to E)

Spec-imen No.	Type Specimen	Cement Factor (Nominal) bags/ cu yd	Air %	1963-1971 Readings																	
				2200 Cycles 1963		2335 Cycles 1964		2498 Cycles 1965		2628 Cycles 1966		2784 Cycles 1967		2969 Cycles 1968		3123 Cycles 1969		3276 Cycles 1970		3445 Cycles 1971	
				%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
Admixture B (Continued)																					
ZC4	Column	4.5	4.7	143	--	173	--	F													
ZB4	Beam			F†																	
ZC6	Column	6.0	6.0	115	104	110	103	112	107	114	92	NR††	98	112	--	117	--	112	--	108	--
ZB6				125	113	122	96	122	112	153	--	150	--	112	--	112	--	112	--	110	--
Resin Soap + $CaCl_2$																					
CC5A	Column	5.25	7.8	94	104	88	99	84	102	84	--	78	--	74	--	78	--	60	--	62	--
CB5A	Beam			114	101	109	97	107	107	117	--	112	--	110	--	110	--	110	--	108	--
CC5B	Column			125	99	120	--	120	--	120	--	120	--	117	--	120	--	120	--	NR	--
CB5B	Beam			121	104	121	--	116	--	119	--	116	--	106	--	108	--	99	--	75	--
CC4	Column	4.5	5.2	101	--	91	--	116	--	200	--	NR	--	F							
CB4	Beam			110	108	104	97	101	95	140	--	NR	--	F							
CC6	Column	6.0	6.4	115	92	106	--	101	--	159	--	F									
CB6	Beam			119	95	114	98	110	108	110	--	110	--	100	--	102	--	Failed			
Resin Soap																					
RC5A	Column	5.25	6.5	122	98	119	96	119	90	122	86	119	90	114	95	119	84	114	80	114	--
RC5A1	Column			119	106	118	100	115	108	116	--	116	--	116	--	118	--	116	--	116	--
RB5A1	Beam			119	93	119	98	125	102	125	93	125	--	125	--	135	--	127	--	127	--
RB5C	Beam			112	78	108	98	108	106	108	83	108	--	108	--	113	--	108	--	104	--
RC4	Column	4.5	7.8	112	98	108	--	108	--	103	--	NR	--	111	--	127	--	127	--	F	--
RC6	Column	6.0	6.5	110	92	103	--	105	--	122	--	NR	--	143	--	149	--	149	--	F	--
RB6	Beam			114	99	112	100	110	108	108	81	101	--	86	--	86	--	74	--	F	--
Tallow (Beef)																					
TB5C	Beam	5.25	4.0	114	86	112	--	110	--	108	--	106	--	101	--	103	--	103	--	99	--
TB4	Beam	4.5	3.4	72	82	F															
TB6	Beam	6.0	3.6	129	93	124	86	121	101	124	86	119	--	109	--	111	--	106	--	95	--
Admixture C																					
DC5A	Column	5.25	6.5	116	108	112	103	114	108	124	83	117	--	110	--	110	--	108	--	110	--
DB5A	Beam			116	102	112	104	107	105	112	98	112	106	107	102	107	94	109	90	109	--
DC5B	Column			114	101	112	--	110	--	125	--	117	--	105	--	110	--	110	--	108	--
DB5B	Beam			113	106	111	104	111	112	109	98	107	98	107	94	109	--	107	--	105	--
DC5C	Column			117	104	115	97	115	105	115	--	115	--	108	--	103	--	94	--	83	--
DB5C	Beam			110	82	108	93	101	110	107	92	105	93	103	90	101	--	96	--	122	-
DC4	Column	4.5	8.1	84	--	68	--	74	--	F											
DB4	Beam			81	93	66	70	67	--	F											
DC6	Column	6.0	6.1	118	92	114	--	110	--	112	--	112	--	107	--	109	--	111	--	113	--
DB6	Beam			124	73	119	--	115	--	115	--	111	--	106	--	106	--	104	--	104	--
Admixture D																					
HC5A	Column	5.25	8.0	120	109	116	63	114	108	114	91	114	104	107	102	107	93	105	--	106	--
HB5A	Beam			124	110	120	95	118	105	120	92	115	105	120	101	120	95	120	--	118	--
HC5B	Column			121	105	121	100	118	103	121	94	121	101	117	90	118	--	123	--	123	--
HB5B	Beam			120	114	117	102	113	116	114	94	114	--	124	--	121	--	119	--	115	--
HC5C	Column			126	95	126	--	119	--	124	--	NR	--	134	--	131	--	131	--	NR	--
HB5C	Beam			116	105	109	104	109	117	109	97	109	102	104	93	109	--	109	--	83	--
HC4	Column	4.5	9.4	101	96	91	--	87	--	89	--	NR	--	F	--						
HC6	Column	6.0	6.0	128	103	190	104	98	107	100	89	100	98	98	101	100	87	98	84	98	--
HB6	Beam			121	108	119	96	117	111	117	83	117	99	110	98	110	--	105	--	102	--

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-- Dashed lines in "$\%V^2$" column indicate that end of specimen was too rough to obtain satisfactory reading.

† F denotes specimen has failed.

†† NR denotes a satisfactory reading was not obtained as specimen would not respond to flexural vibration.

Table 1-CRA (Continued)

				1972- Readings											
		Cement Factor (Nominal)		3602 Cycles 1972		3742 Cycles 1973		3878 Cycles 1974		3990 Cycles 1975		4136 Cycles 1976		4213 Cycles 1977	
Specimen No.	Type Specimen	bags/cu yd	Air %	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
						Admixture A									
AC5B	Column	5.25	1.9	159	--	244	--	172	--	179	--	163	--	166	--
AB5C	Beam			93	--	143	--	128	--	Gone					
AC4	Column	4.5	2.0	165	--	171	--	272	--	Failed					
						Paraffin Oil									
OC5A	Column	5.25	3.9	101	--	94	--	96	--	96	--	Gone			
OB5A	Beam			120	--	119	--	117	--	112	--	119	--	101	--
OC5B	Column			F[†]	--										
OB5B	Beam			120	--	147	--	186	--	Failed					
OC5C	Column			79	--	72	--	NR	--	Gone					
OB5C	Beam			62	--	58	--	52	--	51	--	Gone			
OC6	Column	6.0	5.6	164	--	155	--	NR	--	Gone					
OB6	Beam			111	--	102	--	100	--	Failed					
						Admixture B									
ZC5A	Column	5.25	4.9	121	--	121	--	119	--	114	--	Failed			
ZB5A	Beam			104	--	176	--	NR	--	Gone					
ZB5B	Beam			85	--	91	--	172	--	Failed					
ZC5C	Column			100	--	215	--	215	--	Failed					
ZB5C	Beam			184	--	102	--	209	--	Failed					
ZC6	Column	6.0	6.0	91	--	126	--	95	--	75	--	Gone			
ZB6				112	--	112	--	78	--	114	--	82	--	Failed	
						Resin Soap + $CaCl_2$									
CC5A	Column	5.25	7.8	F	--					Gone					
CB5A	Beam			85	--	62	--	NR	--	Gone					
CC5B	Column			F	--										
CB5B	Beam			F	--										
						Resin Soap									
RC5A	Column	5.25	6.5	116	--	116	--	111	--	113	--	Gone			
RC5A1	Column			114	--	119	--	NR	--	Gone					
RB5A1	Beam			122	--	120	--	120	--	122	--	Gone			
RB5C	Beam			97	--	88	--	119	--	119	--	117	--	108	--
						Tallow (Beef)									
TB5C	Beam	5.25	4.0	F	--										
TB6	Beam	6.0	3.6	83	--	NR	--	F	--						
						Admixture C									
DC5A	Column	5.25	6.5	105	--	105	--	96	--	87	--	118	--	135	--
DB5A	Beam			107	--	112	--	105	--	105	--	78	--	98	--
DC5B	Column			106	--	92	--	182	--	182	--	Gone			
DB5B	Beam			96	--	92	--	132	--	Failed					
DC5C	Column			F	--										
DB5C	Beam			72	--	F									
DC6	Column	6.0	6.1	88		122	--	153	--	Failed					
DB6	Beam			95		80	--	157	--	Gone					
						Admixture D									
HC5A	Column	5.25	8.0	105	--	94	--	103	--	99	--	95	--	130	--
HB5A	Beam			116	--	114	--	114	--	112	--	79	--	79	--
HC5B	Column			120	--	128	--	123	--	118	--	133	--	78	--
HB5B	Beam			117	--	124	--	114	--	116	--	114	--	126	--
HC5C	Column			252	--	252	--	234	--	Failed					
HB5C	Beam			79	--	68	--	NR	--	Gone					
HC6	Column	6.0	6.0	95	--	98	--	96	--	90	--	116	--	116	--
HB6	Beam			96	--	138	--	90	--	90	--	67	--	Failed	

-- Dashed lines in "$\%V^2$" column indicate that end of specimen was too rough to obtain satisfactory reading.

[†] F denotes specimen has failed.

NR Denotes no reading obtained.

Omaha District Aggregate Program

1956 installation

In December 1956, six concrete beams (6 by 6 by 30 in.) were installed on the Treat Island exposure rack to provide field durability data on concrete specimens fabricated as a part of the Omaha District, CE, Aggregate Program. This installation was made up of two series of beams, one containing the aggregate and cement combinations being used for concrete for the Oahe Dam, and the other containing a sand-gravel with a limestone addition, typical of limestone-sweetened concrete in the Lincoln-Omaha area.

Table 1-OD lists these specimens and gives their exposure record along with pertinent mixture data.

Companion specimens (3-1/2 by 4-1/2 by 16 in.) to these Treat Island exposure specimens were subjected to laboratory freezing-and-thawing tests in the Missouri River Division Laboratory, Omaha, Nebr. The results of these laboratory tests are given below:

Mixture	No. of Specimens Tested	Average %E at 300 Cycles of Freezing-and-Thawing
Oahe	9 beams	86
Sand-gravel	9 beams	53

1964 installation

In November 1964, three concrete beams (6 by 6 by 30 in.) were installed on the Treat Island exposure rack as a part of the Omaha District, CE, Aggregate Program. These beams were representative of concrete and materials used in Big Bend Dam.

Table 2-OD lists these specimens and gives their exposure record along with pertinent mixture data.

(Revised August 1977)

Table 1-OD

Record of Testing of Concrete Beams, Omaha District Aggregate Program

1956- (Installed December 1956)

Exposure Rack, Row 2 (W to E)

						1956-1962 Readings														
Beam No.	Fine Aggregate	Coarse Aggregate	Type Cement	Air %	Cement Factor bags/cu yd	0 Cycles 1956	124 Cycles, 1957			195 Cycles 1958		345 Cycles 1959		416 Cycles 1960		557 Cycles 1961		646 Cycles 1962	
						%E	%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
Oahe-1	Natural	Limestone	II,	6.1	5.32	100	116	15,245	100	117	108	123	98	121	100	121	102	115	105
Oahe-2	sand	A*	low-	6.7	5.29	100	110	14,880	100	116	109	122	101	120	105	119	108	113	112
Oahe-3			alk	6.6	5.30	100	111	15,245	100	116	106	123	98	119	102	118	108	113	113
S-G-1	Sand-	Limestone	I	7.1	5.81	100	106	15,430	100	108	107	113	103	110	103	106	105	90	104
S-G-2	gravel	B**		6.4	5.86	100	103	15,530	100	106	105	111	101	102	98	74	93	F†	--
S-G-3				6.3	5.86	100	104	15,625	100	108	105	114	101	111	102	103	101	79	--

						1963-1969 Readings													
						752 Cycles 1963		887 Cycles 1964		1050 Cycles 1965		1180 Cycles 1966		1336 Cycles 1967		1521 Cycles 1968		1675 Cycles 1969	
						%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
Oahe-1	Natural	Limestone	II,	6.1	5.32	116	100	114	105	109	111	111	103	109	105	107	98	107	92
Oahe-2	sand	A*	low-	6.7	5.29	114	118	112	110	107	112	109	102	104	109	106	100	108	95
Oahe-3			alk	6.6	5.30	113	108	108	100	105	94	106	101	104	104	102	101	104	95
S-G-1	Sand-	Limestone	I	7.1	5.81	41F	61												
S-G-3	gravel	B**		6.3	5.86	F													

						1970-1976 Readings													
						1828 Cycles 1970		1997 Cycles 1971		2154 Cycles 1972		2294 Cycles 1973		2430 Cycles 1974		2542 Cycles 1975		2688 Cycles 1976	
						%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
Oahe-1	Natural	Limestone	II,	6.1	5.32	105	90	103	74	101	82	95	94	85	94	83	113	91	96
Oahe-2	sand	A*	low-	6.7	5.29	103	94	103	78	96	82	98	87	84	95	82	114	82	86
Oahe-3			alk	6.6	5.30	100	93	100	74	96	79	98	93	82	93	82	115	80	88

						1977- Readings	
						2765 Cycles 1977	
						%E	$\%V^2$
Oahe-1	Natural	Limestone	II,	6.1	5.32	95	92
Oahe-2	sand	A*	low-	6.7	5.29	76	92
Oahe-3			alk	6.6	5.30	90	78

-- End of specimen too rough to obtain satisfactory reading.

* Maximum size aggregate = 1-1/2 in.; slump for this mix = 2-3/4 to 3 in.

** Maximum size aggregate = 1 in.; slump for this mix = 2 in.

† F denotes specimen has failed.

(Revised Jan 1972)

Table 2-OD

Record of Testing of Concrete Beams, Omaha District Aggregate Program

1964- (Installed November 1964)

Exposure Rack, Row 2 (W to E)

Beam No.	Fine Aggregate	Coarse Aggregate	Type Cement	Air %	Cement Factor bags/cu yd	0 Cycles 1964			163 Cycles 1965	
						%E	Pulse Vel fps	$\%V^2$	%E	$\%V^2$
Big Bend-1	Natural sand	Quartzite*	II, low alkali (C_3A content less than 6%)	5.9	5.48	100	15,195	100	102	99
Big Bend-2				5.8	5.48	100	15,195	100	103	101
Big Bend-3				6.2	5.46	100	15,100	100	103	101

Beam No.	Fine Aggregate	Coarse Aggregate	Type Cement	Air %	Cement Factor bags/cu yd	293 Cycles 1966		449 Cycles 1967		634 Cycles 1968	
						%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
Big Bend-1	Natural sand	Quartzite*	II, low alkali (C_3A content less than 6%)	5.9	5.48	106	104	102	110	53	66
Big Bend-2				5.8	5.48	106	103	104	107	63	58
Big Bend-3				6.2	5.46	104	103	103	108	70	87

Beam No.	Fine Aggregate	Coarse Aggregate	Type Cement	Air %	Cement Factor bags/cu yd	788 Cycles 1969		941 Cycles 1970		1110 Cycles 1971	
						%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
Big Bend-1	Natural sand	Quartzite*	II, low alkali (C_3A content less than 6%)	5.9	5.48	53	41	28F†	39	F	--
Big Bend-2				5.8	5.48	57	30	F†			--
Big Bend-3				6.2	5.46	67	41	NR	38	F	--

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* Maximum size aggregate, 1-1/2 in.; slump for this mix, 2-1/4 to 2-1/2 in.; water cement ratio, 4.93 gal/bag.

† F denotes specimen has failed.

NR A satisfactory reading was not obtained although an attempt was made to obtain one.

Kansas City District Aggregate Program

1958 installation

In January 1958, eighteen concrete beams (6 by 6 by 30 in.) were installed on the Treat Island exposure rack to provide field durability data on concrete specimens containing certain aggregate materials commercially produced in the Kansas City District, CE. This installation is a part of an aggregate program being conducted by the Kansas City District. The concrete beams represented six different combinations of fine and coarse aggregate (3 beams per combination). All concrete mixtures contained type II low-alkali cement and an air-entraining admixture, and were designed to have a water-cement ratio of 5.0 gal per bag, a slump of 2 to 3 in., an air content of 4 to 7%, and a maximum aggregate size of 1-1/2 in.

Table 1-KCD lists these specimens and gives their exposure record along with other pertinent information.

Companion specimens (3-1/2 by 4-1/2 by 16 in.) to these Treat Island exposure specimens were subjected to laboratory freezing-and-thawing tests in the Missouri River Division Laboratory, Omaha, Nebr. The results of these laboratory tests are given below:

Mixture No.	No. of Beams Tested	Average %E at 300 Cycles of Freezing-and-thawing
1	9	29
2	9	31
3	9	9
4	9	25
5	9	59
6	9	73

1959 installation

In May 1959, eighteen concrete beams (6 by 6 by 30 in.) were installed on the Treat Island exposure rack; this installation is a part of the Kansas City District aggregate program. The concrete beams represented six different aggregate combinations of fine and coarse aggregate (3 beams per combination). All concrete mixtures contained type II cement and an air-entraining admixture, and were designed to have a water-cement ratio of 5.0 gal per bag, a slump of 2 to 3 in., an air content of 4 to 7%, and a maximum aggregate size of 1-1/2 in.

Table 2-KCD lists these specimens and gives their exposure record along with other pertinent information.

Companion specimens (3-1/2 by 4-1/2 by 16 in.) to these Treat Island exposure specimens were subjected to laboratory freezing-and-thawing tests in the Missouri River Division Laboratory, Omaha, Nebr. The results of these laboratory tests are given below:

Mixture No.	No. of Beams Tested	Average %E at 300 Cycles of Freezing-and-Thawing
7	9	29
8	9	68
9	9	25
10	9	40
11	9	28
12	9	3

1962 installation

In November 1962, nine concrete beams (6 by 6 by 30 in.) were installed on the Treat Island exposure rack; this installation is a part of the Kansas City District aggregate program. The concrete beams represented three different concrete mixtures (three beams per mixture). All concrete mixtures contained type II low-alkali cement and an air-entraining admixture, and were designed to have a water-cement ratio of 5.0 gal per bag, a slump of 2 to 3 in., an air content of 4 to 7%, and a maximum aggregate size of 1-1/2 in.

Table 3-KCD lists these specimens and gives their exposure record along with other pertinent information.

Companion specimens (3-1/2 by 4-1/2 by 16 in.) to these Treat Island exposure specimens were subjected to laboratory freezing-and-thawing tests in the Missouri River Division Laboratory, Omaha, Nebr. The results of these laboratory tests are given below:

Mixture No.	No. of Beams Tested	Average %E at 300 Cycles of Freezing-and-Thawing
13*	9	69
14**	9	56
15*	9	53

* Specimens had 14 days of curing before start of test.
** Specimens had 28 days of curing before start of test.

1963 installation

In December 1963, nine concrete beams (6 by 6 x 30 in.) were installed on the Treat Island exposure rack; this installation is a part of the Kansas City District aggregate program. The concrete beams represented three concrete mixtures (three beams per mixture). All concrete mixtures contained type II cement and an air-entraining admixture and were designed to have a cement factor of approximately 6 bags per cu yd, a slump of 2 to 3 in., and an air content of approximately 4-1/2 percent. The maximum aggregate size was 1-1/2 in. in two of the mixes and 3/4 in. in the other (mixture 17). One mixture (mixture 16) contained a cement-replacement material in addition to the type II cement.

Table 4-KCD lists these specimens and gives their exposure record along with other pertinent information.

Companion specimens (3-1/2 by 4-1/2 by 16 in.) to the Treat Island exposure specimens were subjected to laboratory freezing-and-thawing tests in the Missouri River Division Laboratory, Omaha, Nebr. The results of the laboratory tests are given below:

Mixture No.	No. of Beams Tested	Avg %E at 300 Cycles of Freezing-and-Thawing
16*	9	55
17**	9	3
18**	9	55

* Specimens had 28 days curing in saturated limewater before start of test.

** Specimens had 14 days curing in saturated limewater before start of test.

1969 installation

In May 1969, three concrete beams† (6 by 6 by 30 in.) were installed on the Treat Island exposure rack; this installation is a part of the

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† These beams had 28 days curing in saturated limewater before exposure.

Kansas City District aggregate program. The concrete beams represented three concrete batches (one beam per batch) of one concrete mixture. The concrete mixture was air-entrained and contained type II low-alkali portland cement and a cement-replacement material (20% by absolute volume). The mixture was designed to have a theoretical cement factor of 5.76 bags per cu yd, a slump of 2-1/2 in., and an air content of 4.7 to 5.0 percent. The maximum aggregate size (crushed limestone) was 1-1/2 in.

Table 5-KCD lists these specimens and gives their exposure record along with other pertinent information.

Companion specimens (3-1/2 by 4-1/2 by 16 in.) to the Treat Island exposure specimens were subjected to laboratory freezing-and-thawing tests in the Missouri River Division Laboratory, Omaha, Nebr. The results of the laboratory tests are given below:

Mixture No.	Batch No.	No. of Beams Tested	Avg %E After 300 Cycles of Freezing-and-Thawing
19	1	3*	61
19	2	2*	64
19	3	3*	65

* These beams had 90 days of water curing prior to start of the laboratory freezing-and-thawing test.

1974 installation

In July 1974, six concrete beams (6 by 6 by 30 in.) were installed on the Treat Island exposure rack; this installation is a part of the Kansas City District aggregate program. The concrete beams represented two concrete mixtures (three beams per mixture). The concrete mixtures (20 and 21) contained type II cement and an air-entraining admixture and were designed to have cement factors of approximately 5.3 and 5.7 bags per cu yd, slumps of 2-1/2 and 2 in., and air contents of 5 and 4.5 percent. Maximum aggregate sizes were 1-1/2 in. Mixture 20 contained a cement-replacement material.

Tables 6- and 7-KCD list these specimens and give their exposure record along with other pertinent data.

Companion specimens (3-1/2 by 4-1/2 by 16 in.) were subjected to laboratory freezing-and-thawing tests in the Missouri River Division Laboratory, Omaha, Nebr. The results of these tests are given below:

Mixture No.	No. of Beams Tested	Avg %E at 300 Cycles of Freezing-and-Thawing
20*	9	64
21**	9	35

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* Specimens were 90 days old when freezing-and-thawing cycles started.

** Specimens were 14 days old when freezing-and-thawing cycles started.

(Revised Jan 1972)

Table 1-KCD

Mixture Data and Record of Testing of Concrete Beams, Kansas City District Aggregate Program

1957- (Installed January 1958)

Exposure Rack, Row 2 (W to E)

Beam No.	Mixture No.	Fine Aggregate	Coarse Aggregate	Cement Factor bags/ cu yd	0 Cycles 1957	43 Cycles, 1958			1957-1963 Readings									
									193 Cycles 1959		264 Cycles 1960		405 Cycles 1961		494 Cycles 1962		600 Cycles 1963	
					%E	%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
KC-1-1	1	Sand A	Limestone	5.67	100	110	15,430	100	99	90	92	90	84	83	76	80	74	78
KC-1-2			A	5.60	100	112	15,150	100	102	93	93	94	89	86	79	95	79	80
KC-1-3				5.59	100	110	15,150	100	106	95	99	96	93	87	84	88	83	76
KC-2-1	2	Sand B	Limestone	5.36	100	111	15,060	100	104	95	93	94	87	88	77	86	75	81
KC-2-2			AA	5.34	100	109	15,060	100	102	94	88	90	85	81	76	76	74	60
KC-2-3				5.34	100	108	15,060	100	104	97	95	98	90	90	78	89	78	81
KC-3-1	3	Sand B	Limestone	5.39	100	88	14,125	100	74	73	46F*							
KC-3-2			B	5.36	100	88	14,045	100	68	72	48F							
KC-3-3				5.41	100	Broken at installation												
KC-4-1	4	Sand B	Limestone	5.34	100	108	14,620	100	112	99	105	99	88	93	82	92	76	85
KC-4-2			C	5.34	100	107	14,535	100	113	98	108	104	92	96	86	96	83	93
KC-4-3				5.40	100	105	14,795	100	109	100	100	100	89	94	79	89	80	83
KC-5-1	5	Sand B	Limestone	5.16	100	112	15,430	100	114	98	108	105	104	103	101	85	99	69
KC-5-2			D	5.14	100	114	15,530	100	114	98	112	100	107	103	101	104	102	95
KC-5-3				5.15	100	111	15,530	100	113	98	110	102	108	103	100	**	102	73
KC-6-1	6	Sand C	Limestone	5.84	100	111	15,335	100	116	99	112	105	111	108	106	104	109	79
KC-6-2			D	5.83	100	111	15,335	100	117	101	113	105	111	108	106	109	109	108
KC-6-3				5.81	100	112	15,245	100	117	101	115	106	113	106	107	112	106	112

					1964-1971 Readings															
					735 Cycles 1964		898 Cycles 1965		1028 Cycles 1966		1184 Cycles 1967		1369 Cycles 1968		1523 Cycles 1969		1676 Cycles 1970		1845 Cycles 1971	
					%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
KC-1-1	1	Sand A	Limestone	5.67	64	69	59	68	54	49	F									
KC-1-2			A	5.60	69	68	62	68	59	49	56	38	F	--						
KC-1-3				5.59	76	68	71	68	59	53	54	43	34F	32						
KC-2-1	2	Sand B	Limestone	5.36	65	--	71	--	63	--	56	--	F	--						
KC-2-2			AA	5.34	69	--	62	--	60	--	F									
KC-2-3				5.34	74	70	65	32	63	51	55	54	F	--						
KC-4-1	4	Sand B	Limestone	5.34	66	77	67	82	74	64	74	68	F	--						
KC-4-2			C	5.34	72	85	62	85	F											
KC-4-3				5.40	66	83	61	82	F											
KC-5-1	5	Sand B	Limestone	5.16	97	89	108	91	110	89	103	91	94	88	92	84	96	77	96	64
KC-5-2			D	5.14	97	99	78	101	86	88	82	90	76	85	74	82	82	78	84	59
KC-5-3				5.15	98	94	94	101	94	83	94	67	92	89	90	77	94	83	95	66
KC-6-1	6	Sand C	Limestone	5.84	102	98	101	110	101	87	97	98	97	101	97	89	99	86	97	71
KC-6-2			D	5.83	101	104	99	117	97	88	97	95	93	94	91	85	91	82	95	69
KC-6-3				5.81	104	99	102	120	100	89	100	98	98	99	94	92	96	88	98	75

-- Dashed lines in "$\%V^2$" column indicate end of specimen was too rough to obtain satisfactory reading.

* F denotes specimen has failed.

** A spurious reading was obtained on this beam in 1962 and was discarded.

(Revised August 1977)

Table 1-KCD (Continued)

Exposure Rack, Row 2 (W to E)

Beam No.	Mixture No.	Fine Aggregate	Coarse Aggregate	Cement Factor bags/cu yd	1972- Readings											
					2002 Cycles 1972		2142 Cycles 1973		2278 Cycles 1974		2390 Cycles 1975		2536 Cycles 1976		2613 Cycles 1977	
					%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
KC-5-1	5	Sand B	Limestone D	5.16	96	66	98	79	94	82	88	70	92	‡	84	
KC-5-2				5.14	NR†	79	88	87	88	81	84	66	78	‡	76	
KC-5-3				5.15	74	65	93	83	93	90	93	107	85	‡	81	
KC-6-1	6	Sand C	Limestone D	5.84	95	87	101	94	93	98	97	121	89	96	89	91
KC-6-2				5.83	89	78	91	90	89	93	89	75	85	94	85	80
KC-6-3				5.81	96	79	96	98	92	93	90	77	88	85	86	92

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† NR denotes a satisfactory reading was not obtained as specimen would not respond to flexural vibration.

‡ End of specimen too rough to obtain reading. %V^2 data discontinued.

(Revised August 1977)

Table 2-KCD (Continued)

Exposure Rack, Row 2 (W to E)

					1972- Readings											
					1809 Cycles 1972		1949 Cycles 1973		2085 Cycles 1974		2197 Cycles 1975		2343 Cycles 1976		2420 Cycles 1977	
Beam No.	Mixture No.	Fine Aggregate	Coarse Aggregate	Cement Factor bags/cu yd	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
KC-8-1	8	Sand BB	Limestone F	5.44	99	79	101	104	95	91	95	117	93	87	83	72
KC-8-2				5.44	NR††	55	NR	94	Failed							
KC-8-3				5.47	NR	68	NR	79	Failed							

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†† Satisfactory reading not obtained due to deteriorated condition of specimen.

(Revised August 1977)

Table 3-KCD

Mixture Data and Record of Testing of Concrete Beams, Kansas City District Aggregate Program

1962- (Installed November 1962)

Exposure Rack, Row 2 (W to E)

						1962-1967 Readings														
						0 Cycles, 1962			106 Cycles 1963		241 Cycles 1964		404 Cycles 1965		534 Cycles 1966		690 Cycles 1967			
Beam No.	Mixture No.	Fine Aggregate	Coarse Aggregate	Cement Replacement Material	Cement Factor bags/ cu yd	%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$		
KC-13-1	13	Sand E	Limestone	None	5.47	100	15,150	100	117	101	102	100	102	110	100	101	94	104		
KC-13-2			F		5.44	100	14,795	100	103	102	103	105	104	116	100	100	100	105		
KC-13-3					5.46	100	15,150	100	103	102	103	99	101	112	99	95	93	104		
KC-14-1	14	Sand E	Limestone	Fly ash*	5.13	100	14,535	100	102	104	102	104	103	130	101	98	101	105		
KC-14-2			F		5.16	100	14,705	100	104	100	104	107	102	116	104	101	102	102		
KC-14-3					5.13	100	14,535	100	104	105	102	102	100	109	98	98	98	106		
KC-15-1	15	Sand E	Limestone	None	5.37	100	15,060	100	103	98	101	95	99	90	99	93	95	95		
KC-15-2			C		5.36	100	15,060	100	102	105	101	95	97	101	99	93	91	95		
KC-15-3					5.38	100	15,150	100	103	104	101	95	100	100	100	86	100	92		

						1968-1973 Readings											
						875 Cycles 1968		1029 Cycles 1969		1182 Cycles 1970		1351 Cycles 1971		1508 Cycles 1972		1648 Cycles 1973	
						%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
KC-13-1	13	Sand E	Limestone	None	5.47	98	100	98	94	96	90	94	75	82	87	88	101
KC-13-2			F		5.44	97	104	100	98	96	95	95	86	92	93	90	106
KC-13-3					5.46	97	100	99	94	97	90	96	75	89	75	93	87
KC-14-1	14	Sand E	Limestone	Fly ash*	5.13	101	107	99	102	97	99	97	74	101	86	101	88
KC-14-2			F		5.16	102	105	102	99	102	97	101	72	89	88	106	80
KC-14-3					5.13	100	105	98	99	98	95	106	68	100	--	122	86
KC-15-1	15	Sand E	Limestone	None	5.37	93	98	91	87	93	84	101	56	103	77	76	81
KC-15-2			C		5.36	80	85	80	76	84	75	F**					
KC-15-3					5.38	84	81	84	70	82	68	85	--	84	--	F	F

						1974- Readings							
						1784 Cycles 1974		1896 Cycles 1975		2042 Cycles 1976		2119 Cycles 1977	
						%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
KC-13-1	13	Sand E	Limestone	None	5.47	82	101	84	116	84	96	82	86
KC-13-2			F		5.44	88	104	84	122	88	98	84	90
KC-13-3					5.46	91	82	85	123	87	90	87	92
KC-14-1	14	Sand E	Limestone	Fly ash*	5.13	68	85	50	65	NR	NR	Failed	
KC-14-2			F		5.16	100	82	71	101	67	NR	Failed	
KC-14-3					5.13	113	80	Failed					
KC-15-1	15	Sand E	Limestone C	None	5.37	63	76	Failed					

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* Fly ash content, 25 percent replacement by volume.
** F denotes specimen has failed.
-- Dashed lines in "$\%V^2$" indicate that end of specimen was too rough to obtain satisfactory reading.
NR Denotes no satisfactory reading was obtained.

(Revised August 1977)

Table 4-KCD

Mixture Data and Record of Testing of Concrete Beams, Kansas City District Aggregate Program

1963- (Installed December 1963)

Exposure Rack, Row 2 (W to E)

							1963-1967 Readings										
							0 Cycles, 1963			121 Cycles 1964		284 Cycles 1965		414 Cycles 1966		570 Cycles 1967	
Beam No.	Mixture No.	Cement	Replacement Material	Fine Aggregate	Coarse Aggregate	Cement Factor bags/cu yd	%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
KC-16-1	16	A	Fly ash*	Sand E	Limestone	6.25	100	14,535	100	104	105	104	98	106	104	106	122
KC-16-2					F	6.27	100	14,705	100	104	105	105	95	103	105	103	114
KC-16-3						6.26	100	14,620	100	103	105	104	101	100	106	100	114
KC-17-1	17	B	None	Sand F	Gravel B	6.00	100	14,205	100	104	108	78	92	65	38	F	
KC-17-2						6.02	100	14,535	100	103	109	74	82	F			
KC-17-3						6.00	100	14,125	100	103	110	49F**	77				
KC-18-1	18	C	None	Sand G	Quartzite	5.73	100	14,705	100	102	107	100	100	102	111	102	117
KC-18-2						5.77	100	15,150	100	102	102	102	98	104	109	106	113
KC-18-3						5.74	100	15,060	100	102	100	104	98	104	108	104	115

							1968-1973 Readings											
							755 Cycles 1968		909 Cycles 1969		1062 Cycles 1970		1231 Cycles 1971		1388 Cycles 1972		1528 Cycles 1973	
							%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
KC-16-1	16	A	Fly ash*	Sand E	Limestone	6.25	104	114	108	107	106	104	108	87	104	95	100	99
KC-16-2					F	6.27	107	110	109	105	109	100	107	84	105	88	107	93
KC-16-3						6.26	104	111	108	105	106	101	NR†	88	108	95	104	88
KC-18-1	18	C	None	Sand G	Quartzite	5.73	102	116	106	107	106	105	104	84	100	84	98	80
KC-18-2						5.77	102	109	104	104	108	102	106	85	104	87	92	88
KC-18-3						5.74	104	109	106	99	110	108	107	81	83	90	100	76

							1974- Readings							
							1664 Cycles 1974		1776 Cycles 1975		1922 Cycles 1976		1999 Cycles 1977	
							%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
KC-16-1	16	A	Fly ash*	Sand E	Limestone	6.25	98	106	98	137	94	79	90	98
KC-16-2					F	6.27	109	65	109	130	105	100	109	100
KC-16-3						6.26	104	68	104	125	104	90	104	NR
KC-18-1	18	C	None	Sand G	Quartzite	5.73	102	106	102	82	82	93	100	NR
KC-18-2						5.77	64	65	Failed					
KC-18-3						5.74	92	68	80	72	176	NR	Failed	

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* Fly ash content, 25 percent replacement by volume.

** F denotes specimen has failed.

† NR denotes satisfactory reading was not obtained as specimen would not respond to flexural vibration.

(Revised August 1977)

Table 5-KCD

Mixture Data and Record of Testing of Concrete Beams, Kansas City District Aggregate Program

1969- (Installed May 1969)

Exposure Rack, Row 2 (W to E)

						1969-1972 Readings												
					Avg** 28-day Compressive Strength	Initial Laboratory Readings, 1969			0 Cycles 1969		153 Cycles 1970		322 Cycles 1971		479 Cycles 1972			
Beam No.	Mixture No.	Batch No.*	Aggregates	Air Content %	psi	%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$		
KC-19-1	19	1	Crushed limestone 1-1/2 in. max	4.9	3360	100	14,620	100	101	100	93	97	88	84	83	92		
KC-19-2	19	2	Crushed limestone 1-1/2 in. max	5.0	3360	100	14,620	100	100	100	90	98	87	84	83	91		
KC-19-3	19	3	Crushed limestone 1-1/2 in. max	4.7	3640	100	14,620	100	106	101	90	98	90	85	88	92		

						1973- Readings									
						619 Cycles 1973		755 Cycles 1974		867 Cycles 1975		1013 Cycles 1976		1090 Cycles 1977	
						%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
KC-19-1	19	1	Crushed limestone 1-1/2 in. max	4.9	3360	83	102	83	114	83	78	81	114	66	109
KC-19-2	19	2	Crushed limestone 1-1/2 in. max	5.0	3360	82	94	82	114	79	77	74	110	79	104
KC-19-3	19	3	Crushed limestone 1-1/2 in. max	4.7	3640	84	101	86	113	86	139	82	116	82	105

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* The water-cement ratio of all three batches was 5.39 gal/bag or 0.49 by weight.

** Average based on compressive strength of three 6- by 12-in. cylinders per batch.

(Revised August 1977)

Table 6-KCD

Mixture Data and Record of Testing of Concrete Beams, Kansas City District Aggregate Program

1975- (Installed July 1974)

Exposure Rack, Row 2 (W to E)

						Initial Laboratory Readings, 1974			1974- Readings					
									112 Cycles 1975		258 Cycles 1976		335 Cycles 1977	
Beam No.	Mixture No.	Batch No.*	Aggregates	Air Content %	Avg** 28-day Compressive Strength psi	%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
KC-20-1	20	1	Crushed limestone 1-1/2-in. max	5.0	3360	100	14,285	100	102	134	104	117	106	109
KC-20-2	20	2	Crushed limestone 1-1/2-in. max	5.4	3280	100	14,370	100	107	129	105	107	110	101
KC-20-3	20	3	Crushed limestone 1-1/2-in. max	5.3	3260	100	14,285	100	106	131	108	115	113	102

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* The water-cement ratio of all three batches was 5.34 gal/cwt or 0.445 by wt.

** Average based on compressive strength of three 6- by 12-in. cylinders per batch.

(Revised August 1977)

Table 7-KCD

Mixture Data and Record of Testing of Concrete Beams, Kansas City District Aggregate Program

1975- (Installed July 1974)

									Exposure Rack, Row 2 (W to E)					
									1974- Readings					
					Avg** 28-day Compressive Strength	Initial Laboratory Readings, 1974			112 Cycles 1975		258 Cycles 1976		335 Cycles 1977	
Beam No.	Mixture No.	Batch No.*	Aggregates	Air Content %	psi	%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
KC-21-1	21	1	Crushed limestone 1-1/2-in. max	5.0	4600	100	14,795	100	102	134	106	114	104	104
KC-20-2	21	2	Crushed limestone 1-1/2-in. max	4.9	5150	100	14,620	100	101	132	107	114	109	106
KC-21-3	21	3	Crushed limestone 1-1/2-in. max	5.1	4930	100	14,535	100	102	139	106	116	106	105

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* The water-cement ratio of all three batches was 5.28 gal/cwt or 0.44 by wt.

** Average based on compressive strength of three 6- by 12-in. cylinders per batch.

Eufaula Dam Aggregates Study

In October 1958, three concrete cubes (8 cu ft) were installed at half-tide elevation on the beach at Treat Island as part of a program being conducted by the Tulsa District, CE, to develop information about the aggregates to be used in Eufaula Dam. These aggregates were from the Tulsa District. The cubes were fabricated at the Southwestern Division Laboratory, Dallas, Tex.

The cubes were made of air-entrained concrete, admixture Z being the air-entraining admixture; type II cement was the cementing medium. The aggregates were a natural sand fine aggregate and a crush stone coarse aggregate. Two cubes contain 6-in. maximum size aggregate, the other contains 3-in. maximum size aggregate. All cubes were fabricated in August 1958.

Table 1-ED lists these specimens and gives their exposure record along with pertinent mixture data.

(Revised August 1977)

Table 1-ED

Mixture Data and Record of Testing of Concrete Cubes, Eufaula Dam Aggregate Study

1958- (Installed October 1958)

Beach Row 1 (W to E)

	Coarse Aggregate					0 Cycles, 1958		1958-1965 Readings							
Cube No.	Maximum Size in.	Description	Air %	Water-Cement Ratio gal/bag	Theo Cement Factor bags/cu yd	Pulse Veloc fps	$\%V^2$	150 Cycles 1959 $\%V^2$	220 Cycles 1960 $\%V^2$	361 Cycles 1961 $\%V^2$	451 Cycles 1962 $\%V^2$	557 Cycles 1963 $\%V^2$	692 Cycles 1964 $\%V^2$	855 Cycles 1965 $\%V^2$
1	6	Poor	5.4	4.97	4.0	14,450	100	95	101	96	100	102	110	113
2	6	Random	5.9	4.85	4.0	14,650	100	95	100	100	104	107	110	107
3	3	Random	5.7	5.30	4.0	14,075	100	95	103	99	102	108	111	112

						1966-1973 Readings							
						985 Cycles 1966 $\%V^2$	1141 Cycles 1967 $\%V^2$	1326 Cycles 1968 $\%V^2$	1480 Cycles 1969 $\%V^2$	1633 Cycles 1970 $\%V^2$	1802 Cycles 1971 $\%V^2$	1959 Cycles 1972 $\%V^2$	2099 Cycles 1973 $\%V^2$
1	6	Poor	5.4	4.97	4.0	90	112	105	96	94	85	84	*
2	6	Random	5.9	4.85	4.0	92	107	110	99	94	89	82	*
3	3	Random	5.7	5.30	4.0	97	114	109	100	96	97	95	*

						1974- Readings			
						2235 Cycles 1974 $\%V^2$	2347 Cycles 1975 $\%V^2$	2493 Cycles 1976 $\%V^2$	2570 Cycles 1977 $\%V^2$
1	6	Poor	5.4	4.97	4.0	94	88	92	97
2	6	Random	5.9	4.85	4.0	115	109	108	93
3	3	Random	5.7	5.30	4.0	109	99	96	93

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* Equipment malfunctioned in 1973.

Alkali-Aggregate Reactivity Investigation

The purpose of this investigation is to determine the effect on alkali-aggregate reactivity of varying amounts of C_3A (tricalcium aluminate) in high-alkali and low-alkali cements in concrete specimens exposed to sea water at St. Augustine, Fla.

1955 Installations

In August 1955, 72 concrete beams (6 by 6 by 30 in.) were installed on the exposure rack at St. Augustine. In September 1955, 36 concrete beams (6 by 6 by 30 in.) were installed outdoors at the Waterways Experiment Station Suboffice, Jackson, Miss. The beams installed at Jackson were controls for those installed at St. Augustine. The concrete was air-entrained, and had a water-cement ratio of 0.5 (by wt), a slump of 2-1/2 ± 1/2 in., and an air content of 5.0 + 0.5%. Cement factors were in the range of 4.5 to 5.8 bags per cu yd. Twelve concrete combinations were represented, in which two fine aggregates, three coarse aggregates (maximum size, 1-1/2 in.), two pozzolans, two high-alkali cements, and two low-alkali cements were used. Nine beams represented each of the 12 combinations (six beams at St. Augustine and three at Jackson).

Table 1-AA lists the specimens and gives their exposure record along with other pertinent information.

In November 1957, two of the specimens exposed at St. Augustine were returned to the laboratory for study (specimens 1823 and 1850). The findings were:

> Beam 1823: Showed evidence of slight alkali-aggregate reaction; no sign that this had been damaging to the concrete.
>
> Beam 1850: Showed evidence of heavy alkali-aggregate reaction and of heavy sulfate attack. The effects of this had been damaging to the concrete.

1956 Installations

In August 1956, 36 concrete beams (6 by 6 by 30 in.) were installed on the exposure rack at St. Augustine and 18 concrete beams (6 by 6 by 30 in.) were installed outdoors at the WES Suboffice, Jackson, Miss. The beams installed at Jackson were controls for those installed at St. Augustine. The concrete was air-entrained and had a water-cement ratio of 0.5 (by wt), a slump of 2-1/2 ± 1/2 in., and an air content of 5.0 ± 0.5%. Cement factors were in the range of 4.5 to 5.8 bags per cu yd. Six concrete combinations were represented, in which two cement replacement materials, one high-alkali cement, one low-alkali cement, one fine aggregate, and one coarse aggregate (maximum size, 3/4 in.) were used. These six combinations represented a repeat of two of those included in the 1955 group plus each of these with the inclusion of each of two pulverized water-quenched iron blast furnace slags used as cement replacement materials. Nine beams represented each of the six combinations (six beams at St. Augustine and three beams at Jackson).

Table 2-AA lists the specimens and gives their exposure record along with other pertinent information.

In August 1971, 15 beams (9 from 1955 installation and 6 from 1956 installation) were returned to the laboratory for study. The testing and installation of specimens at St. Augustine were discontinued after the 1970 inspection.

(Revised Aug 1964)

Table 1-AA

Record of Testing of Concrete Beams, Alkali-aggregate Reactivity Investigation

1955- (Installed August and September 1955)

Beam No.	Cement	Replacement Material* (Pozzolan)	Fine Aggregate	Coarse* Aggregate	1955-1964 Readings												
					1955			1956		1958		1960		1962		1964	
					$\%E$	Pulse Veloc fps	$\%V^2$	$\%E$	$\%V^2$	$\%E$	$\%V^2$	$\%E$	$\%V^2$	$\%E$	$\%V^2$	$\%E$	$\%V^2$
Beams Installed at St. Augustine, Fla., Aug 1955																	
1823	RC 331 high alkali low C_3A	None	Nat sand	Nat gravel + quartzite (5%)	100	14,620	100	104	117	**							
1824					100	14,970	100	103	99	115	96	64	98	Failed			
1826					100	14,620	100	102	100	126	100	††					
1827					100	14,535	100	104	104	121	102	92	92	Failed			
1829					100	14,880	100	104	99	125	90	††					
1830					100	15,060	100	103	98	131	97	106	93	56	82	Failed	
1832	RC 333 low alkali low C_3A	None	Nat sand	Nat gravel + quartzite (5%)	100	14,370	100	107	106	131	109	116	111	111	123	109	102
1833					100	14,370	100	109	109	132	109	112	111	108	120	106	106
1835					100	14,450	100	107	105	117	109	112	114	106	117	106	105
1836					100	15,060	100	107	102	120	102	115	108	109	116	107	100
1838					100	15,060	100	108	98	119	102	116	106	109	112	107	99
1839					100	14,880	100	108	101	120	102	115	108	108	113	106	101
1841	RC 333 low alkali low C_3A	None	Limestone sand	Limestone	100	14,880	100	109	112	120	115	119	121	113	122	110	112
1842					100	15,150	100	109	108	120	112	119	118	115	128	112	113
1844					100	14,975	100	112	112	124	116	117	119	105	127	103	119
1845					100	14,705	100	111	110	132	113	118	122	111	134	107	119
1847					100	14,535	100	114	111	146	114	119	122	118	125	118	116
1848					100	14,535	100	113	114	139	117	120	123	114	137	115	116
1850	RC 332 high alkali high C_3A	None	Nat sand	Nat gravel + quartzite (5%)	100	14,125	100	69	87	**							
1851					100	14,370	100	66	83	124	36	Failed					
1853					100	14,795	100	68	87	†							
1854					100	14,620	100	86	89	110	39	Failed					
1856					100	14,620	100	67	78	77	23	Failed					
1857					100	14,620	100	56	79	73	26	Failed					
1859	RC 332 high alkali high C_3A	None	Limestone sand	Limestone	100	15,060	100	105	109	126	106	110	113	105	122	122	108
1860					100	14,880	100	105	109	120	117	110	115	99	124	107	112
1862					100	15,245	100	106	105	126	110	110	112	106	121	104	105
1863					100	14,795	100	105	109	124	113	112	113	108	122	108	112
1865					100	14,620	100	105	105	123	111	108	113	104	127	108	109
1866					100	14,620	100	105	109	124	109	119	120	114	132	115	111
1868	RC 334 low alkali high C_3A	None	Limestone sand	Limestone	100	14,705	100	108	114	125	117	107	116	103	122	103	106
1869					100	14,205	100	110	115	130	118	119	120	114	129	114	117
1871					100	14,620	100	110	113	126	116	116	120	112	128	113	111
1872					100	14,880	100	110	113	128	115	117	118	111	131	117	112
1874					100	14,970	100	108	109	127	112	118	116	114	126	114	110
1875					100	14,880	100	108	109	131	112	117	115	112	125	112	110
1877	RC 331 high alkali low C_3A	None	Nat sand	Nat gravel	100	15,060	100	104	99	125	101	110	104	105	109	110	101
1878					100	14,705	100	103	89	115	101	109	109	102	114	102	101
1880					100	14,795	100	103	100	119	100	108	105	107	113	103	99
1881					100	14,795	100	104	100	121	100	110	106	105	113	108	99
1883					100	14,970	100	107	98	121	98	108	105	104	109	108	95
1884					100	14,970	100	105	99	118	100	111	105	107	106	107	96
1886	RC 332 high alkali high C_3A	None	Nat sand	Nat gravel	100	14,285	100	105	97	115	109	107	105	103	106	105	100
1887					100	14,450	100	104	98	113	97	106	104	107	107	104	98
1889					100	14,370	100	103	98	112	100	111	106	107	110	109	100
1890					100	14,535	100	104	99	117	98	111	106	108	113	108	99
1892					100	14,880	100	104	98	114	97	107	101	103	105	106	95
1893					100	14,620	100	106	98	116	99	104	102	102	109	102	94
1895	RC 331 high alkali low C_3A	Shale 30%	Nat sand	Nat gravel + quartzite (5%)	100	13,735	100	115	102	131	112	107	109	102	119	104	105
1896					100	13,810	100	114	102	131	105	125	109	119	116	123	105
1898					100	14,125	100	109	99	122	102	119	110	113	114	113	102
1899					100	14,370	100	110	98	123	101	121	107	113	111	119	93
1901					100	13,890	100	113	99	129	110	133	110	125	113	119	110
1902					100	14,125	100	110	99	127	102	121	106	115	112	122	99
1904	RC 331 high alkali low C_3A	Fly ash 20%	Nat sand	Nat gravel + quartzite (5%)	100	14,705	100	106	97	122	94	114	106	107	112	102	96
1905					100	14,705	100	107	98	122	101	115	107	108	113	106	98
1907					100	14,705	100	108	105	106	101	96	110	93	114	92	100
1908					100	14,795	100	104	102	116	102	110	107	103	114	107	99
1910					100	14,880	100	107	98	122	100	112	105	107	115	109	98
1911					100	14,880	100	108	97	120	100	113	105	109	110	106	98

(Continued)

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* Percentages given are by volume of material replaced.

** Returned to laboratory November 1957.

† Broken in handling 1958.

†† Broken in handling 1960.

(Revised Sept 1966)

Table 1-AA (Continued)

Beam No.	Cement	Replacement Material (Pozzolan)	Fine Aggregate	Coarse Aggregate	1955-1964 Readings												
					1955			1956		1958		1960		1962		1964	
					%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
					Beams Installed at St. Augustine, Fla., Aug 1955 (Continued)												
1913	RC 332	Shale 30%	Nat sand	Nat gravel	100	13,515	100	114	102	132	106	122	110	117	117	121	106
1914	high alkali			+ quartz-	100	13,515	100	111	103	130	106	124	113	115	117	119	104
1916	high C_3A			ite (5%)	100	13,890	100	110	102	126	103	119	111	113	119	115	101
1917					100	13,890	100	113	103	124	105	118	110	113	115	113	101
1919					100	14,125	100	111	102	127	106	116	106	110	111	111	99
1920					100	14,285	100	112	97	130	100	120	105	115	112	113	97
1922	RC 332	Fly ash 20%	Nat sand	Nat gravel	100	14,535	100	107	100	75	92	F*	72				
1923	high alkali			+ quartz-	100	14,450	100	106	104	100	99	F	78				
1925	high C_3A			ite (5%)	100	14,535	100	106	100	68	88	F	71				
1926					100	14,535	100	107	101	120	102	112	105	66	89	43F	58
1928					100	14,705	100	108	100	129	99	115	101	53	72	40F	46
1929					100	14,970	100	107	100	115	96	69	85	F	70		
					Beams Installed at Jackson, Miss., Sept 1955												
1825	RC 331	None	Nat sand	Nat gravel	100	14,970	100	102	104	98	102	108	98	102	101	100	99
1828	high alkali			+ quartz-	100	14,795	100	105	104	111	100	107	98	100	100	101	98
1831	low C_3A			ite (5%)	100	14,795	100	102	105	103	102	107	98	101	99	101	98
1834	RC 333	None	Nat sand	Nat gravel	100	14,205	100	104	101	107	108	109	105	103	106	103	105
1837	low alkali			+ quartz-	100	14,880	100	105	105	109	108	111	102	105	98	103	95
1840	low C_3A			ite (5%)	100	14,620	100	106	109	110	106	112	105	106	102	105	101
1843	RC 333	None	Limestone	Limestone	100	14,880	100	105	112	108	115	110	116	103	109	104	110
1846	low alkali		sand		100	14,370	100	107	114	112	118	114	117	107	117	107	115
1849	low C_3A				100	14,370	100	108	114	112	118	116	117	107	114	109	117
1852	RC 332	None	Nat sand	Nat gravel	100	14,125	100	104	106	107	105	108	100	104	102	99	99
1855	high alkali			+ quartz-	100	14,535	100	103	104	106	100	110	97	105	98	99	96
1858	high C_3A			ite (5%)	100	14,535	100	100	104	104	101	104	99	98	98	96	96
1861	RC 332	None	Limestone	Limestone	100	14,880	100	102	109	108	113	111	113	103	109	103	115
1864	high alkali		sand		100	14,450	100	102	116	106	121	111	120	104	117	103	121
1867	high C_3A				100	14,450	100	100	106	104	117	109	116	101	117	101	114
1870	RC 334	None	Limestone	Limestone	100	14,535	100	104	101	111	113	113	114	105	114	105	114
1873	low alkali		sand		100	14,450	100	105	113	112	117	114	114	106	116	106	113
1876	high C_3A				100	14,705	100	104	107	111	110	113	110	104	112	104	111
1879	RC 331	None	Nat sand	Nat gravel	100	13,965	100	103	115	106	112	111	110	103	114	103	108
1882	high alkali				100	14,705	100	102	107	104	102	108	100	102	100	102	99
1885	low C_3A				100	15,060	100	101	102	104	97	108	95	100	100	100	96
1888	RC 332	None	Nat sand	Nat gravel	100	14,125	100	103	107	107	100	110	98	101	105	101	100
1891	high alkali				100	13,890	100	104	111	109	105	111	100	104	107	102	101
1894	high C_3A				100	14,620	100	103	101	105	98	107	94	101	96	98	93
1897	RC 331	Shale 30%	Nat sand	Nat gravel	100	13,660	:00	95	102	103	98	106	94	101	102	100	99
1900	high alkali			+ quartz-	100	13,515	100	98	106	107	102	110	100	103	104	98	101
1903	low C_3A			ite (5%)	100	13,735	100	93	101	100	99	105	96	98	101	98	98
1906	RC 331	Fly ash 20%	Nat sand	Nat gravel	100	14,535	100	96	106	102	101	106	107	98	101	98	100
1909	high alkali			+ quartz-	100	14,045	100	99	112	104	107	108	108	100	108	98	107
1912	low C_3A			ite (5%)	100	14,705	100	94	102	99	100	103	100	96	100	93	99
1915	RC 332	Shale 30%	Nat sand	Nat gravel	100	13,160	100	93	103	102	103	107	104	100	105	95	102
1918	high alkali			+ quartz-	100	13,890	100	99	101	108	100	110	99	103	102	101	99
1921	high C_3A			ite (5%)	100	13,515	100	96	102	103	103	105	95	98	104	94	98
1924	RC 332	Fly ash 20%	Nat sand	Nat gravel	100	14,205	100	97	101	103	105	107	102	99	106	97	105
1927	high alkali			+ quartz-	100	14,795	100	101	107	106	99	104	100	98	101	99	100
1930	high C_3A			ite (5%)	100	14,705	100	96	104	104	99	115	98	100	100	96	99

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* F denotes specimen has failed.

(Revised Sept 1970)

Table 1-AA (Continued)

Beam No.	Cement	Replacement Material (Pozzolan)	Fine Aggregate	Coarse Aggregate	1966-1970 Readings 1966 %E	1966 %V^2	1968 %E	1968 %V^2	1970 %E	1970 %V^2
Beams Installed at St. Augustine, Fla., Aug 1955										
1832	RC 333 low alkali low C_3A	None	Nat sand	Nat gravel + quartzite (5%)	109	121	109	110	109	109
1833					108	123	110	111	110	105
1835					107	125	108	111	108	107
1836					107	119	113	104	113	108
1838					107	120	103	103	103	101
1839					108	119	112	105	112	106
1841	RC 333 low alkali low C_3A	None	Limestone sand	Limestone	101	133	99	114	99	120
1842					114	126	113	117	113	115
1844					101	132	105	111	105	116
1845					111	134	115	116	117	119
1847					115	134	116	119	116	119
1848					113	137	112	119	112	116
1859	RC 332 high alkali high C_3A	None	Limestone sand	Limestone	103	138	105	109	103	105
1860					103	126	101	113	101	109
1862					103	123	108	108	106	105
1863					106	122	108	112	108	110
1865					104	127	102	109	104	112
1866					114	131	119	122	119	117
1868	RC 334 low alkali high C_3A	None	Limestone sand	Limestone	99	119	103	112	99	105
1869					116	134	114	118	114	117
1871					113	133	111	117	111	114
1872					111	129	111	115	111	118
1874					114	125	121	113	121	113
1875					112	127	117	111	117	116
1877	RC 331 high alkali low C_3A	None	Nat sand	Nat gravel	106	113	110	101	112	105
1878					103	116	99	107	99	108
1880					105	116	105	106	105	107
1881					105	105	104	108	104	107
1883					105	111	110	101	108	92
1884					107	107	106	102	110	95
1886	RC 332 high alkali high C_3A	None	Nat sand	Nat gravel	105	111	103	106	105	100
1887					108	110	115	103	117	99
1889					105	113	109	105	111	99
1890					106	114	108	108	108	103
1892					104	111	102	99	102	101
1893					101	112	102	101	102	105
1895	RC 331 high alkali low C_3A	Shale 30%	Nat sand	Nat gravel + quartzite (5%)	104	119	104	110	104	110
1896					124	118	126	109	126	106
1898					114	115	115	107	113	103
1899					110	118	112	102	110	98
1901					134	120	133	113	130	108
1902					118	114	123	106	118	99
1904	RC 331 high alkali low C_3A	Fly ash 20%	Nat sand	Nat gravel + quartzite (5%)	112	112	108	104	108	100
1905					109	118	106	104	106	101
1907					94	113	90	107	87	100
1908					107	112	104	104	106	98
1910					111	113	111	104	111	100
1911					110	111	105	103	105	99
1913	RC 332 high alkali high C_3A	Shale 30%	Nat sand	Nat gravel + quartzite (5%)	121	120	126	110	129	108
1914					118	116	119	110	119	109
1916					115	117	114	109	114	107
1917					113	115	115	106	115	106
1919					113	114	115	103	111	97
1920					113	110	120	103	120	100

(Continued)

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Table 1-AA (Concluded)

Beam No.	Cement	Replacement Material (Pozzolan)	Fine Aggregate	Coarse Aggregate	1966-1970 Readings					
					1966		1968		1970	
					%E	%V^2	%E	%V^2	%E	%V^2
Beams Installed at Jackson, Miss., Sept 1955										
1825	RC 331	None	Nat sand	Nat gravel	102	99	102	97	104	95
1828	high alkali			+ quartz-	100	95	102	95	103	94
1831	low C_3A			ite (5%)	101	94	102	98	101	97
1834	RC 333	None	Nat sand	Nat gravel	103	92	104	105	107	101
1837	low alkali			+ quartz-	103	106	105	100	105	101
1840	low C_3A			ite (5%)	105	100	106	101	107	100
1843	RC 333	None	Limestone	Limestone	104	101	104	109	107	109
1846	low alkali		sand		107	101	109	109	115	113
1849	low C_3A				109	105	111	115	114	114
1852	RC 332	None	Nat sand	Nat gravel	104	89	104	97	108	97
1855	high alkali			+ quartz-	98	88	100	94	102	91
1858	high C_3A			ite (5%)	95	85	98	97	100	91
1861	RC 332	None	Limestone	Limestone	105	113	107	117	108	112
1864	high alkali		sand		104	108	106	118	111	118
1867	high C_3A				102	109	104	114	111	113
1870	RC 334	None	Limestone	Limestone	106	101	107	116	111	111
1873	low alkali		sand		107	110	108	114	111	114
1876	high C_3A				104	106	105	106	112	104
1879	RC 331	None	Nat sand	Nat gravel	103	103	104	107	106	100
1882	high alkali				102	100	104	98	105	99
1885	low C_3A				100	93	102	93	104	94
1888	RC 332	None	Nat sand	Nat gravel	101	96	103	99	105	97
1891	high alkali				102	100	102	99	106	99
1894	high C_3A				98	92	100	93	102	90
1897	RC 331	Shale 30%	Nat sand	Nat gravel	94	85	98	89	108	89
1900	high alkali			+ quartz-	97	96	103	98	112	98
1903	low C_3A			ite (5%)	94	83	98	95	105	93
1906	RC 331	Fly ash 20%	Nat sand	Nat gravel	98	90	100	100	101	98
1909	high alkali			+ quartz-	100	87	100	106	103	102
1912	low C_3A			ite (5%)	97	98	96	98	98	93
1915	RC 332	Shale 30%	Nat sand	Nat gravel	96	94	99	102	104	100
1918	high alkali			+ quartz-	101	94	104	99	107	98
1921	high C_3A			ite (5%)	93	93	96	97	103	94
1924	RC 332	Fly ash 20%	Nat sand	Nat gravel	99	106	100	102	103	102
1927	high alkali			+ quartz-	100	102	101	99	104	99
1930	high C_3A			ite (5%)	98	98	98	97	102	97

(Revised Sept 1970)

Table 2-AA

Record of Testing of Concrete Beams, Alkali-Aggregate Reactivity Investigation

1956- (Installed August 1956)

Fine aggregate, limestone sand
Coarse aggregate, limestone (3/4-in. maximum size)

			1956-1970 Readings																	
			1956			1958		1960		1962		1964		1966		1968		1970		
Beam No.	Cement	Replacement Material*	%E	Pulse Veloc fps	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$	
Beams Installed at St. Augustine, Fla.																				
2535	RC 332	None	100	15,245	100	113	109	115	115	109	116	107	106	105	112	107	109	108	103	
2536	high alkali		100	15,060	100	116	112	121	115	114	121	113	106	111	113	112	112	112	109	
2538	high C_3A		100	14,795	100	111	106	117	114	110	117	106	105	104	110	115	106	117	108	
2539			100	14,795	100	112	109	117	112	162	120	146	103	143	114	134	107	128	98	
2541			100	14,970	100	111	109	113	115	104	126	104	110	102	111	106	111	107	107	
2542			100	15,060	100	111	104	111	113	105	121	107	102	103	121	101	106	101	107	
2544	RC 334	None	100	15,430	100	122	109	122	110	111	118	111	103	109	127	111	109	111	111	
2545	low alkali		100	15,335	100	115	112	121	110	114	118	114	105	113	81	112	112	114	111	
2547	high C_3A		100	14,620	100	114	113	115	119	109	123	107	107	103	120	101	115	103	107	
2548			100	14,705	100	128	99	115	129	106	122	106	107	106	123	110	109	110	108	
2550			100	15,060	100	115	115	123	116	108	122	108	99	108	147	110	111	112	109	
2551			100	15,060	100	114	116	122	116	107	122	112	109	110	135	112	111	112	103	
2553	RC 332	RC 198	100	15,925	100	111	108	122	108	109	119	114	106	112	143	112	108	112	103	
2554	high alkali	blast-furnace	100	15,925	100	113	107	130	111	115	121	111	106	111	145	118	107	118	104	
2556	high C_3A	slag 40%	100	15,530	100	115	109	128	111	109	120	114	106	113	144	114	105	116	101	
2557			100	15,625	100	111	108	124	111	111	117	109	105	109	144	109	107	109	100	
2559			100	15,430	100	113	108	127	111	109	120	111	106	110	131	111	107	109	103	
2560			100	15,430	100	140	101	113	109	113	121	113	103	111	124	111	106	109	102	
2562	RC 332	RC 216	100	15,335	100	150	105	123	100	114	120	118	104	114	123	114	108	114	111	
2563	high alkali	blast-furnace	100	15,335	100	147	105	114	103	114	121	110	104	114	123	112	108	112	110	
2565	high C_3A	slag 40%	100	15,335	100	113	109	130	105	112	117	108	106	109	119	108	107	106	104	
2566			100	15,430	100	123	105	126	111	117	117	110	108	110	117	112	107	110	103	
2568			100	15,060	100	114	108	127	113	109	118	109	107	111	125	113	111	111	108	
2569			100	14,970	100	119	108	128	115	112	122	112	109	113	121	116	111	114	109	
2571	RC 334	RC 198	100	15,530	100	127	103	132	111	117	115	114	103	114	114	112	106	110	104	
2572	low alkali	blast-furnace	100	15,625	100	127	104	133	111	114	118	118	106	119	132	118	106	116	103	
2574	high C_3A	slag 40%	100	15,150	100	128	105	117	110	111	119	111	103	117	123	123	110	121	105	
2575			100	15,150	100	124	105	125	110	120	121	120	103	114	122	116	109	114	105	
2577			100	15,245	100	128	105	122	110	117	119	117	102	117	119	124	107	122	102	
2578			100	15,245	100	123	104	121	109	116	123	118	101	118	121	120	109	118	104	
2580	RC 334	RC 216	100	15,245	100	127	104	121	110	115	124	131	105	112	119	116	110	116	105	
2581	low alkali	blast-furnace	100	15,150	100	130	106	118	113	113	121	139	102	112	116	115	109	115	106	
2583	high C_3A	slag 40%	100	15,150	100	130	106	123	110	114	119	112	106	117	121	115	109	113	102	
2584			100	15,060	100	123	105	122	112	108	119	102	106	107	119	106	109	102	102	
2586			100	15,150	100	130	105	116	113	110	113	110	103	114	142	113	110	109	98	
2587			100	15,060	100	129	106	119	113	113	116	113	107	116	120	117	109	115	106	
Beams Installed at Jackson, Miss.																				
2537	RC 332	None	100	14,970	100	106	109	113	104	104	112	104	110	105	116	107	108	109	109	
2540	high alkali		100	14,970	100	103	106	107	108	101	109	99	105	102	110	103	102	107	105	
2543	high C_3A		100	15,150	100	104	105	110	105	103	106	101	105	104	107	105	102	107	102	
2546	RC 334	None	100	15,245	100	111	109	115	109	107	110	107	108	109	132	110	106	112	108	
2549	low alkali		100	14,705	100	110	106	114	106	105	109	105	106	106	106	107	102	109	105	
2552	high C_3A		100	14,970	100	109	108	113	109	106	112	106	110	108	113	109	105	112	109	
2555	RC 332	RC 198	100	15,725	100	103	107	107	107	100	111	97	109	97	109	99	107	103	111	
2558	high alkali	blast-furnace	100	15,725	100	102	103	106	102	98	105	96	104	96	117	98	100	98	104	
2561	high C_3A	slag 40%	100	15,430	100	100	108	106	108	97	108	96	106	97	117	98	106	100	108	
2564	RC 332	RC 216	100	15,335	100	104	109	108	108	99	112	98	109	98	127	100	104	102	106	
2567	high alkali	blast-furnace	100	15,150	100	104	109	104	108	96	109	98	108	100	123	100	105	102	108	
2570	high C_3A	slag 40%	100	15,150	100	101	106	107	106	97	109	96	105	98	117	99	101	103	104	
2573	RC 334	RC 198	100	15,245	100	104	112	110	110	101	110	100	108	102	119	104	106	108	109	
2576	low alkali	blast-furnace	100	15,335	100	107	104	113	105	104	105	102	104	104	120	106	101	108	105	
2579	high C_3A	slag 40%	100	14,880	100	104	115	110	112	100	113	100	110	100	126	103	109	107	110	
2582	RC 334	RC 216	100	15,430	100	107	107	113	104	102	105	102	100	102	116	104	99	106	104	
2585	low alkali	blast-furnace	100	15,060	100	106	110	113	109	102	110	102	105	103	118	104	102	106	106	
2588	high C_3A	slag 40%	100	14,795	100	107	116	114	112	104	114	103	112	105	122	106	109	107	110	

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* Percentages given are by volume of material replaced.

Nonmetallic Waterstop Investigation

The purpose of this investigation is to evaluate the durability of nonmetallic waterstops of a variety of compositions, when exposed under different stress conditions, to different types and severity of exposure conditions.

The test specimens are rectangular pieces of nonmetallic waterstop material 1/16 to 3/8 in. thick. Pieces are either 6 by 6 in. or 3 by 6 in. in size. The specimens are exposed at four locations: Treat Island, Maine; St. Augustine, Fla.; Jackson, Miss. (indoors); and Jackson, Miss. (outdoors). Three stress conditions are represented:

a. Unstressed; bolted on lumber stringer.

b. Bent; bolted around lumber stringer (approximately 180°).

c. Embedded; embedded across joint plane between two 6-in. concrete cubes and stressed to open up 1-in. gap in the joint plane. Wood blocks are inserted to maintain the waterstop in a stretched condition.

Treat Island Installations

In 1957 and 1958, 129 nonmetallic waterstop specimens were installed on the exposure rack at Treat Island as follows:

Date	No. and Types of Specimens Installed
May 1957	81 (27 embedded, 27 bent, and 27 unstressed)
Nov 1957	45 (15 embedded, 15 bent, and 15 unstressed)
Aug 1958	3 (1 embedded, 1 bent, and 1 unstressed)

Table 1-WS lists these specimens, identifies them as to type, manufacturer, and stress condition, and gives their exposure record. It should be noted that bent and unstressed specimens of the same material have the same specimen numbers. All remaining specimens were sent back to the concrete laboratory in 1973. Exposure was discontinued at that time.

St. Augustine Installations

In 1957 and 1958, 111 nonmetallic waterstops were installed on the

(Revised Sept 1969)

Table 1-WS

Record of Observations of Unstressed, Bent, and Embedded Specimens, Nonmetallic Waterstop Investigation

Treat Island Exposure

1957- (Installed 1957 and 1958)

Exposure Rack, North Wall

Specimen No.	Description	Manufacturer	Date Installed	Condition of Unstressed Specimens, 1957-1965								
				0 Cycles 1957	71 Cycles 1958	221 Cycles 1959	292 Cycles 1960	433 Cycles 1961	522 Cycles 1962	628 Cycles 1963	763 Cycles 1964	926 Cycles 1965
NR-1-1	Natural rubber	A	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NR-1-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NR-1-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NR-2-1	Natural rubber (3500-lb tensile strength)	B	Nov '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NR-2-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NR 2-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-1-1	General service rubber	A	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-1-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-1-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-2-1	General service rubber (2000-lb tensile strength)	B	Nov '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-2-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-2-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-3-1	General service rubber (3000-lb tensile strength)	B	Nov '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-3-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-3-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-1-1	Neoprene rubber	A	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-1-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-1-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-2-1	Neoprene rubber	B	Nov '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-2-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-2-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
BUTYL-1-1	Butyl rubber	B	Nov '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
BUTYL-1-2				Sound	Sound	Sound	Lost*	Lost*				
BUTYL-1-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2-1	Type IV standard polyvinyl chloride	C	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2A-1	Type IV arctic polyvinyl chloride	C	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2A-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2A-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3-1	Type V standard polyvinyl chloride	C	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3A-1	Type V arctic polyvinyl chloride	C	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3A-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3A-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-4-1	Polyvinyl chloride	A	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-4-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-4-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-5-1	Polyvinyl chloride	D	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-5-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-5-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
					0 Cycles 1958	150 Cycles 1959	221 Cycles 1960	362 Cycles 1961	451 Cycles 1962	557 Cycles 1963	692 Cycles 1964	855 Cycles 1965
PVC-9A(2)	Polyvinyl chloride	E	Aug '58	---	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound

(Continued)

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* This specimen presumably lost overboard in Sept 1959.

AD-A075 359 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS F/G 11/2
INVESTIGATION OF PERFORMANCE OF CONCRETE AND CONCRETING MATERIA--ETC(U)
AUG 77
UNCLASSIFIED WES-TR-6-553-VOL-1-REV NL

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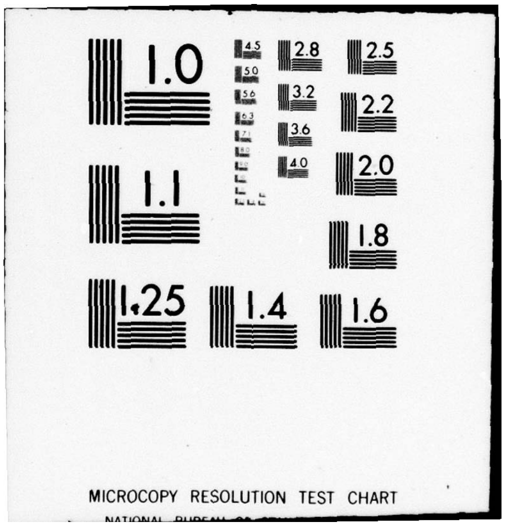
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MICROCOPY RESOLUTION TEST CHART

(Revised Jan 1972)

Table 1-WS (Continued)

Exposure Rack, North Wall

Specimen No.	Description	Manu-facturer	Date In-stalled	Condition of Unstressed Specimens, 1966-					
				1056 Cycles 1966	1212 Cycles 1967	1397 Cycles 1968	1551 Cycles 1969	1704 Cycles 1970	1873 Cycles 1971
NR-1-1	Natural rubber	A	May '57	†					
NR-1-2				†					
NR-1-3				Sound	Sound	Crazing	Crazing	†	
NR-2-1	Natural rubber (3500-lb tensile strength)	B	Nov '57	†					
NR-2-2				†					
NR-2-3				Sound	Sound	Crazing	Crazing	Crazing	Crazing
SR-1-1	General service rubber	A	May '57	†					
SR-1-2				†					
SR-1-3				Sound	Sound	Crazing	Crazing	Crazing	Crazing
SR-2-1	General service rubber (2000-lb tensile strength)	B	Nov '57	†					
SR-2-2				†					
SR-2-3				Sound	Sound	Crazing	Crazing	Crazing	Crazing
SR-3-1	General service rubber (3000-lb tensile strength)	B	Nov '57	†					
SR-3-2				†					
SR-3-3				Sound	Sound	Crazing	Crazing	Crazing	Crazing
NEOR-1-1	Neoprene rubber	A	May '57	†					
NEOR-1-2				†					
NEOR-1-3				Sound	Sound	Sound	Crazing	Crazing	Crazing
NEOR-2-1	Neoprene rubber	B	Nov '57	†					
NEOR-2-2				†					
NEOR-2-3				Sound	Sound	Sound	Sound	Sound	Sound
BUTYL-1-1	Butyl rubber	B	Nov '57	†					
BUTYL-1-3				Sound	Sound	Sound	Sound	Sound	Sound
PVC-2-1	Type IV standard polyvinyl chloride	C	May '57	†					
PVC-2-2				†					
PVC-2-3				Sound	Sound††	Sound††	Sound††	Sound††	Sound
PVC-2A-1	Type IV arctic polyvinyl chloride	C	May '57	†					
PVC-2A-2				†					
PVC-2A-3				Sound	Sound	Sound	Sound	Sound	Sound
PVC-3-1	Type V standard polyvinyl chloride	C	May '57	†					
PVC-3-2				†					
PVC-3-3				Sound	Sound	Sound	Sound	Sound	Sound
PVC-3A-1	Type V arctic polyvinyl chloride	C	May '57	†					
PVC-3A-2				†					
PVC-3A-3				Sound	Sound	Sound	Sound	†	
PVC-4-1	Polyvinyl chloride	A	May '57	†					
PVC-4-2				†					
PVC-4-3				Sound	Sound	Sound	Sound	Sound	Sound
PVC-5-1	Polyvinyl chloride	D	May '57	†					
PVC-5-2				†					
PVC-5-3				Sound	Sound	Sound	Sound	Sound	Sound
				985 Cycles 1966	1141 Cycles 1967	1326 Cycles 1968	1480 Cycles 1969	1633 Cycles 1970	1802 Cycles 1971
PVC-9A(2)	Polyvinyl chloride	E	Aug '58	Sound	Sound	Sound	Sound	Sound	Sound

(Continued)

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† Returned to laboratory for tests.

†† This specimen has curled.

Table 1-WS (Continued)

Exposure Rack, North Wall

				Condition of Bent Specimens, 1957-1963						
Specimen No.	Description	Manu-facturer	Date In-stalled	0 Cycles 1957	71 Cycles 1958	221 Cycles 1959	292 Cycles 1960	433 Cycles 1961	522 Cycles 1962	628 Cycles 1963
NR-1-1	Natural rubber	A	May '57	Sound	Crazing	Crazing	Crazing	Crazing	Crazing	Crazing
NR-1-2				Sound	Crazing	Crazing	Crazing	Crazing	Crazing	Crazing
NR-1-3				Sound	Crazing	Crazing	Crazing	Crazing	Crazing	Crazing
NR-2-1	Natural rubber	B	Nov '57	Sound	Crazing	Crazing	Crazing	Crazing	Crazing	Crazing
NR-2-2	(3500-lb tensile			Sound	Sound	Crazing	Crazing	Crazing	Crazing	Crazing
NR-2-3	strength)			Sound	Crazing	Crazing	Crazing	Crazing	Crazing	Crazing
SR-1-1	General service	A	May '57	Sound	Crazing	Cracked	Cracked	Cracked	Badly cracked	Badly cracked
SR-1-2	rubber			Sound	Crazing	Cracked	Cracked	Cracked	Badly cracked	Badly cracked
SR-1-3				Sound	Crazing	Cracked	Cracked	Cracked	Badly cracked	Badly cracked
SR-2-1	General service	B	Nov '57	Sound	Cracked	Cracked	Cracked	Cracked	Badly cracked	Badly cracked
SR-2-2	rubber (2000-lb			Sound	Cracked	Cracked	Cracked	Cracked	Badly cracked	Badly cracked
SR-2-3	tensile strength)			Sound	Cracked	Cracked	Cracked	Cracked	Badly cracked	Badly cracked
SR-3-1	General service	B	Nov '57	Sound	Sound	Cracked	Cracked	Cracked	Badly cracked	Badly cracked
SR-3-2	rubber (3000-lb			Sound	Sound	Cracked	Cracked	Cracked	Badly cracked	Badly cracked
SR-3-3	tensile strength)			Sound	Sound	Cracked	Cracked	Cracked	Badly cracked	Badly cracked
NEOR-1-1	Neoprene rubber	A	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-1-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-1-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-2-1	Neoprene rubber	B	Nov '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-2-2				Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-2-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound
BUTYL-1-1	Butyl rubber	B	Nov '57	Sound	Sound	Sound	Sound	Sound	Sound	Crazing
BUTYL-1-2				Sound	Sound	Sound	Sound	Sound	Sound	Crazing
BUTYL-1-3				Sound	Sound	Sound	Sound	Sound	Sound	Crazing
PVC-2-1	Type IV standard	C	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2-2	polyvinyl			Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2-3	chloride			Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2A-1	Type IV arctic	C	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2A-2	polyvinyl			Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2A-3	chloride			Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3-1	Type V standard	C	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3-2	polyvinyl			Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3-3	chloride			Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3A-1	Type V arctic	C	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3A-2	polyvinyl			Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3A-3	chloride			Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-4-1	Polyvinyl	A	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-4-2	chloride			Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-4-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-5-1	Polyvinyl	D	May '57	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-5-2	chloride			Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-5-3				Sound	Sound	Sound	Sound	Sound	Sound	Sound

					0 Cycles 1958	150 Cycles 1959	221 Cycles 1960	362 Cycles 1961	451 Cycles 1962	557 Cycles 1963
PVC-9A(2)	Polyvinyl chloride	E	Aug '58	---	Sound	Sound	Sound	Sound	Sound	Sound

(Continued)

(Revised Sept 1969)

Table 1-WS (Continued)

Exposure Rack, North Wall

Specimen No.	Description	Manu-facturer	Date In-stalled	Condition of Bent Specimens, 1964-1968 763 Cycles 1964	926 Cycles 1965	1056 Cycles 1966	1212 Cycles 1967	1397 Cycles 1968
NR-1-1	Natural rubber	A	May '57	Crazing	Crazing	Crazing	Crazing	Cracked
NR-1-2				Crazing	Crazing	†		
NR-1-3				Crazing	Crazing	†		
NR-2-1	Natural rubber (3500-lb tensile strength)	B	Nov '57	Crazing	Crazing	Crazing	Crazing	Cracked
NR-2-2				Crazing	Crazing	†		
NR-2-3				Crazing	Crazing	†		
SR-1-1	General service rubber	A	May '57	Badly cracked	Badly cracked	Badly cracked	Badly cracked	Badly cracked
SR-1-2				Badly cracked	Badly cracked	†		
SR-1-3				Badly cracked	Badly cracked	†		
SR-2-1	General service rubber (2000-lb tensile strength)	B	Nov '57	Badly cracked	Badly cracked	Badly cracked	Badly cracked	Badly cracked, torn
SR-2-2				Badly cracked	Badly cracked	†		
SR-2-3				Badly cracked	Badly cracked	†		
SR-3-1	General service rubber (3000-lb tensile strength)	B	Nov '57	Badly cracked	Badly cracked	Badly cracked	Badly cracked	Badly cracked, torn
SR-3-2				Badly cracked	Badly cracked	†		
SR-3-3				Badly cracked	Badly cracked	†		
NEOR-1-1	Neoprene rubber	A	May '57	Sound	Sound	Sound	Sound	Sound
NEOR-1-2				Sound	Sound	†		
NEOR-1-3				Sound	Sound	†		
NEOR-2-1	Neoprene rubber	B	Nov '57	Sound	Sound	Sound	Sound	Sound
NEOR-2-2				Sound	Sound	†		
NEOR-2-3				Sound	Sound	†		
BUTYL-1-1	Butyl rubber	B	Nov '57	Crazing	Crazing	Crazing	Crazing	Crazing
BUTYL-1-2				Crazing	Crazing	†		
BUTYL-1-3				Crazing	Crazing	†		
PVC-2-1	Type IV standard polyvinyl chloride	C	May '57	Sound	Sound	Sound	Sound	Crazing
PVC-2-2				Sound	Sound	†		
PVC-2-3				Sound	Sound	†		
PVC-2A-1	Type IV arctic polyvinyl chloride	C	May '57	Sound	Sound	Sound	Sound	Sound
PVC-2A-2				Sound	Sound	†		
PVC-2A-3				Sound	Sound	†		
PVC-3-1	Type V standard polyvinyl chloride	C	May '57	Sound	Sound	Sound	Sound	Sound
PVC-3-2				Sound	Sound	†		
PVC-3-3				Sound	Sound	†		
PVC-3A-1	Type V arctic polyvinyl chloride	C	May '57	Sound	Sound	Sound	Sound	Sound
PVC-3A-2				Sound	Sound	†		
PVC-3A-3				Sound	Sound	†		
PVC-4-1	Polyvinyl chloride	A	May '57	Sound	Sound	Sound	Sound	Sound
PVC-4-2				Sound	Sound	†		
PVC-4-3				Sound	Sound	†		
PVC-5-1	Polyvinyl chloride	D	May '57	Sound	Sound	Sound	Sound	Sound
PVC-5-2				Sound	Sound	†		
PVC-5-3				Sound	Sound	†		
				692 Cycles 1964	855 Cycles 1965	985 Cycles 1966	1141 Cycles 1967	1326 Cycles 1968
PVC-9A(2)	Polyvinyl chloride	E	Aug '58	Sound	Sound	Sound	Sound	Sound

(Continued)

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† Returned to laboratory in May 1966 for tests.

(Revised Jan 1972)

Table 1-WS (Continued)

Section 30

Exposure Rack, North Wall

Specimen No.	Description	Manufacturer	Installed	Condition of Bent Specimens 1969-		
				1551 Cycles 1969	1704 Cycles 1970	1873 Cycles 1971
NR-1-1	Natural rubber	A	May '57	Cracked	Cracked	Cracked
NR-2-1	Natural rubber (3500-lb tensile strength)	B	Nov '57	Cracked	Cracked	Cracked
SR-1-1	General service rubber	A	May '57	Badly cracked	Badly cracked	Badly cracked
SR-2-1	General service rubber (2000-lb tensile strength)	B	Nov '57	Badly cracked, torn	Torn	Torn
SR-3-1	General service rubber (3000-lb tensile strength)	B	Nov '57	Badly cracked, torn	Torn	Torn
NEOR-1-1	Neoprene rubber	A	May '57	Sound	Sound	Sound
NEOR-2-1	Neoprene rubber	B	Nov '57	Sound	Sound	Sound
BUTYL-1-1	Butyl rubber	B	Nov '57	Crazing	†	
PVC-2-1	Type IV standard polyvinyl chloride	C	May '57	Crazing	Crazing	Crazing
PVC-2A-1	Type IV arctic polyvinyl chloride	C	May '57	Sound	Sound	Sound
PVC-3-1	Type V standard polyvinyl chloride	C	May '57	Sound	Sound	Sound
PVC-3A-1	Type V arctic polyvinyl chloride	C	May '57	Sound	Sound	Sound
PVC-4-1	Polyvinyl chloride	A	May '57	Sound	Sound	Sound
PVC-5-1	Polyvinyl chloride	D	May '57	Sound	Sound	Sound
				1480 Cycles 1969	1633 Cycles 1970	1802 Cycles 1971
PVC-9A(2)	Polyvinyl chloride	E	Aug '58	Sound	Sound	Sound

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† Returned to laboratory for tests.

(Revised Sept 1969)

Table 1-WS (Continued)

Exposure Rack, Row 2 (W to E)

				Condition of Embedded Specimens, 1957-1961				
Specimen No.	Description	Manufacturer	Date Installed	0 Cycles 1957	71 Cycles 1958	221 Cycles 1959	292 Cycles 1960	433 Cycles 1961
NEOR-1-15	Neoprene rubber	A	May '57	Sound	Sound	Sound	Sound	Sound
NEOR-1-14				Sound	Sound	Sound	Sound	Sound
NEOR-1-13				Sound	Sound	Sound	Sound	Sound
PVC-4-7	Polyvinyl chloride	A	May '57	Sound	Sound	Sound	Sound	Sound
PVC-4-6				Sound	Sound	Sound	Sound	Sound
PVC-4-5				Sound	Sound	Sound	Sound	Sound
NR-1-11	Natural rubber	A	May '57	Sound	Sound	Sound	Crazing	Crazing
NR-1-12				Sound	Sound	Sound	Sound	Sound
NR-1-10				Sound	Sound	Sound	Crazing	Crazing
PVC-3A-25	Type V arctic polyvinyl chloride	C	May '57	Sound	Sound	Sound	Sound	Sound
PVC-3A-26				Sound	Sound	Sound	Sound	Sound
PVC-3A-27				Sound	Sound	Sound	Sound	Sound
PVC-2A-24	Type IV arctic polyvinyl chloride	C	May '57	Sound	Badly torn	Completely torn	Completely torn	Completely torn
PVC-2A-23				Sound	Sound	Sound	Completely torn	Completely torn
PVC-2A-22				Sound	Sound	Sound	Completely torn	Completely torn
PVC-2-3	Type IV standard polyvinyl chloride	C	May '57	Sound	Sound	Sound	Sound	Sound
PVC-2-2				Sound	Sound	Sound	Sound	Sound
PVC-2-1				Sound	Sound	Sound	Sound	Sound
PVC-3-6	Type V standard polyvinyl chloride	C	May '57	Sound	Sound	Concrete cracked	Concrete cracked	Sound
PVC-3-5				Sound	Sound	Sound	Sound	Sound
PVC-3-4				Sound	Sound	Sound	Sound	Sound
SR-1-18	General service rubber	A	May '57	Sound	Sound	Sound	Crazing	Crazing
SR-1-17				Sound	Sound	Sound	Crazing	Crazing
SR-1-16				Sound	Sound	Sound	Sound	Sound
PVC-5-21	Polyvinyl chloride	D	May '57	Sound	Sound	Sound	Sound	Sound
PVC-5-20				Sound	Sound	Sound	Sound	Sound
PVC-5-19				Sound	Sound	Sound	Sound	Sound
SR-3-105	General service rubber (3000-lb tensile strength)	B	Nov '57	Sound	Sound	Sound	Crazing	Crazing
SR-3-104				Sound	Sound	Sound	Crazing	Crazing
SR-3-103				Sound	Sound	Sound	Crazing	Crazing
SR-2-102	General service rubber (2000-lb tensile strength)	B	Nov '57	Sound	Sound	Sound	Crazing	Crazing
SR-2-101				Sound	Sound	Sound	Crazing	Crazing
SR-2-100				Sound	Sound	Sound	Crazing	Crazing
NR-2-99	Natural rubber (3500-lb tensile strength)	B	Nov '57	Sound	Sound	Sound	Crazing	Crazing
NR-2-98				Sound	Sound	Sound	Sound	Sound
NR-2-97				Sound	Sound	Sound	Sound	Sound
NEOR-2-96	Neoprene rubber	B	Nov '57	Sound	Sound	Sound	Sound	Sound
NEOR-2-95				Sound	Sound	Sound	Sound	Sound
NEOR-2-94				Sound	Sound	Sound	Sound	Sound
BUTYL-1-93	Butyl rubber	B	Nov '57	Sound	Sound	Sound	Sound	Sound
BUTYL-1-92				Sound	Sound	Sound	Sound	Sound
BUTYL-1-91				Sound	Sound	Sound	Sound	Sound

				Cycles 1957	0 Cycles 1958	150 Cycles 1959	221 Cycles 1960	362 Cycles 1961
PVC-9A(2)	Polyvinyl chloride	E	Aug '58	---	Sound	Sound	Sound	Sound

(Continued)

(Revised Sept 1969)

Table 1-WS (Concluded)

Exposure Rack, Row 2 (W to E)

Specimen No.	Description	Manufacturer	Date Installed	Condition of Embedded Specimens, 1962-1964		
				522 Cycles, 1962	628 Cycles, 1963	763 Cycles, 1964
NEOR-1-15	Neoprene rubber	A	May '57	Sound (concrete cracked)	Sound (concrete cracked)	Disintegrated
NEOR-1-14				Sound (concrete cracked)	Sound (concrete cracked)	Disintegrated
NEOR-1-13				Sound (concrete cracked)	Sound (concrete cracked)	Disintegrated
PVC-4-7	Polyvinyl chloride	A	May '57	Sound	Sound (concrete cracked)	Disintegrated
PVC-4-6				Sound	Sound	Disintegrated
PVC-4-5				Sound	Sound	Disintegrated
NR-1-11	Natural rubber	A	May '57	Crazing	Crazing	Disintegrated
NR-1-12				Sound	Sound (concrete cracked)	Disintegrated
NR-1-10				Crazing	Crazing	Disintegrated
PVC-3A-25	Type V arctic polyvinyl chloride	C	May '57	Sound	Sound (concrete cracked)	Disintegrated
PVC-3A-26				Sound	Sound	Disintegrated
PVC-3A-27				Sound	Sound	Disintegrated
PVC-2A-24	Type IV arctic polyvinyl chloride	C	May '57	Completely torn	Completely torn	Disintegrated
PVC-2A-23				Completely torn	Completely torn	Disintegrated
PVC-2A-22				Completely torn	Completely torn	Disintegrated
PVC-2-3	Type IV standard polyvinyl chloride	C	May '57	Sound	Sound (concrete cracked)	Disintegrated
PVC-2-2				Sound	Sound	Disintegrated
PVC-2-1				Sound (concrete cracked)	Sound (concrete cracked)	Disintegrated
PVC-3-6	Type V standard polyvinyl chloride	C	May '57	Sound (concrete cracked)	Sound (concrete cracked)	Disintegrated
PVC-3-5				Sound (concrete cracked)	Sound (concrete cracked)	Disintegrated
PVC-3-4				Sound (concrete cracked)	Sound (concrete cracked)	Disintegrated
SR-1-18	General service rubber	A	May '57	Crazing (concrete cracked)	Crazing	Disintegrated
SR-1-17				Crazing	Crazing	Disintegrated
SR-1-16				Sound	Sound (concrete cracked)	Disintegrated
PVC-5-21	Polyvinyl chloride	D	May '57	Sound	Sound (concrete cracked)	Disintegrated
PVC-5-20				Sound (concrete cracked)	Sound (concrete cracked)	Disintegrated
PVC-5-19				Sound	Sound (concrete cracked)	Disintegrated
SR-3-105	General service rubber (3000-lb tensile strength)	B	Nov '57	Crazing (concrete cracked)	Crazing	Disintegrated
SR-3-104				Crazing (concrete cracked)	Crazing	Disintegrated
SR-3-103				Crazing	Crazing	Disintegrated
SR-2-102	General service rubber (2000-lb tensile strength)	B	Nov '57	Crazing	Crazing	Disintegrated
SR-2-101				Crazing	Crazing	Disintegrated
SR-2-100				Crazing	Crazing	Disintegrated
NR-2-99	Natural rubber (3500-lb tensile strength)	B	Nov '57	Crazing	Crazing	Disintegrated
NR-2-98				Sound	Sound	Disintegrated
NR-2-97				Sound	Sound	Disintegrated
NEOR-2-96	Neoprene rubber	B	Nov '57	Sound	Sound	Disintegrated
NEOR-2-95				Sound	Sound	Disintegrated
NEOR-2-94				Sound	Sound	Disintegrated
BUTYL-1-93	Butyl rubber	B	Nov '57	Sound	Sound	Disintegrated
BUTYL-1-92				Sound	Sound	Disintegrated
BUTYL-1-91				Sound	Sound	Disintegrated
				451 Cycles, 1962	557 Cycles, 1963	692 Cycles, 1964
PVC-9A(2)	Polyvinyl chloride	E	Aug '58	Sound	Sound	Disintegrated

(Revised Sept 1969)

Table 2-WS

Record of Observation of Unstressed, Bent, and Embedded Specimens, Nonmetallic Waterstop Investigation

St. Augustine Exposure

1957-   (Installed November 1957 Except Where Otherwise Indicated)

Specimen No.	Description	Manufacturer	Condition of Unstressed Specimens, 1957-1960			Condition of Bent Specimens, 1957-1960			Condition of Embedded Specimens, 1957-1960		
			1957	1958	1960	1957	1958	1960	1957	1958	1960
NR-1-1 & 64	Natural rubber	A	Sound	Sound	Lost*	Sound	Sound	Lost	Sound	Sound	Sound
NR-1-2 & 65			Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
NR-1-3 & 66			Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
NR-2-1 & 82	Natural rubber (3500-lb tensile strength)	B	Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
NR-2-2 & 83			Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Crazing
NR-2-3 & 84			Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
SR-1-1 & 70	General service rubber	A	Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
SR-1-2 & 71			Sound	Sound	Lost	Sound	Sound	Lost	Sound	Sound	Sound
SR-1-3 & 72			Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
SR-2-1 & 85	General service rubber (2000-lb tensile strength)	B	Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
SR-2-2 & 86			Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Crazing
SR-2-3 & 87			Sound	Sound	Sound	Sound	Sound	Cracked	Sound	Sound	Crazing
SR-3-1 & 88	General service rubber (3000-lb tensile strength)	B	Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
SR-3-2 & 89			Sound	Sound	Sound	Sound	Sound	Cracked	Sound	Sound	Sound
SR-3-3 & 90			Sound	Sound	Lost	Sound	Sound	Cracked	Sound	Sound	Sound
NEOR-1-1 & 67	Neoprene rubber	A	Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
NEOR-1-2 & 68			Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
NEOR-1-3 & 69			Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
NEOR-2-1 & 79	Neoprene rubber	B	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-2-2 & 80			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-2-3 & 81			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
BUTYL-1-1 & 76	Butyl rubber	B	Sound	Sound	Lost	Sound	Sound	Lost	Sound	Sound	Sound
BUTYL-1-2 & 77			Sound	Sound	Lost	Sound	Sound	Lost	Sound	Sound	Sound
BUTYL-1-3 & 78			Sound	Sound	Lost	Sound	Sound	Lost	Sound	Sound	Sound
PVC-2-1 & 55	Type IV standard polyvinyl chloride	C	Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
PVC-2-2 & 56			Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
PVC-2-3 & 57			Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	†
PVC-3-1 & 58	Type V standard polyvinyl chloride	C	Sound	Sound	Lost	Sound	Sound	Lost	Sound	Sound	Sound
PVC-3-2 & 59			Sound	Sound	Lost	Sound	Sound	Lost	Sound	Sound	Sound
PVC-3-3 & 60			Sound	Sound	Lost	Sound	Sound	Lost	Sound	Sound	Sound
PVC-4-1 & 61	Polyvinyl chloride	A	Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
PVC-4-2 & 62			Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
PVC-4-3 & 63			Sound	Sound	Lost	Sound	Sound	Lost	Sound	Sound	Sound
PVC-5-1 & 73	Polyvinyl chloride	D	Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
PVC-5-2 & 74			Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
PVC-5-3 & 75			Sound	Sound	Sound	Sound	Sound	Lost	Sound	Sound	Sound
PVC-9A(2) & 91	Polyvinyl chloride	E	**	Sound	Lost	**	Sound	Lost	**	Sound	Sound

			Condition of Unstressed Specimens, 1962-1964		Condition of Bent Specimens, 1962-1964		Condition of Embedded Specimens, 1962-1964	
			1962	1964	1962	1964	1962	1964
NR-1-1 & 64	Natural rubber	A					Crazing	Crazing
NR-1-2 & 65			Crazing	Crazing			Crazing	Crazing
NR-1-3 & 66			Crazing	Crazing			Crazing	Crazing
NR-2-1 & 82	Natural rubber (3500-lb tensile strength)	B	Crazing	Crazing			Crazing	Crazing
NR-2-2 & 83			Crazing	Crazing			Crazing	Crazing
NR-2-3 & 84			Crazing	Crazing			Crazing	Crazing
SR-1-1 & 70	General service rubber	A	Crazing	Crazing			Crazing	Crazing
SR-1-2 & 71							Crazing	Crazing
SR-1-3 & 72			Crazing	Crazing			Crazing	Crazing

(Continued)

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* Specimens marked "Lost" have disappeared from the exposure rack.
** Installed Aug 1958.
† Specimen completely torn.

(Revised Sept 1970)

Table 2-WS (Continued)

Specimen No.	Description	Manufacturer	Condition of Unstressed Specimens, 1962-1964		Condition of Bent Specimens, 1962-1964		Condition of Embedded Specimens, 1962-1964	
			1962	1964	1962	1964	1962	1964
SR-2-1 & 85	General service	B	Cracked	Cracked			Crazing	Crazing
SR-2-2 & 86	rubber (2000-lb		Crazing	Crazing			Crazing	Crazing
SR-2-3 & 87	tensile strength)		Crazing	Cracked	Cracked	Lost	Crazing	Crazing
SR-3-1 & 88	General service	B	Cracked	Cracked			Sound	Sound
SR-3-2 & 89	rubber (3000-lb		Crazing	Cracked	Cracked	Cracked	Sound	Sound
SR-3-3 & 90	tensile strength)				Cracked	Cracked	Sound	Sound
NEOR-1-1 & 67	Neoprene rubber	A	Sound	Sound			Crazing	Crazing
NEOR-1-2 & 68			Sound	Sound			Crazing	Crazing
NEOR-1-3 & 69			Sound	Sound			Crazing	Crazing
NEOR-2-1 & 79	Neoprene rubber	B	Sound	Sound	Sound	Sound	Crazing	Crazing
NEOR-2-2 & 80			Sound	Sound	Sound	Sound	Crazing	Crazing
NEOR-2-3 & 81			Sound	Sound	Cracked	Cracked	Crazing	Crazing
BUTYL-1-1 & 76	Butyl rubber	B					Crazing	Crazing
BUTYL-1-2 & 77							Crazing	Crazing
BUTYL-1-3 & 78							Crazing	Crazing
PVC-2-1 & 55	Type IV standard	C	Sound	Lost			Crazing	Crazing
PVC-2-2 & 56	polyvinyl		Sound	Lost			Crazing	Crazing
PVC-2-3 & 57	chloride		Sound	Lost			Crazing	Crazing
PVC-3-1 & 58	Type V standard	C					Crazing	Crazing
PVC-3-2 & 59	polyvinyl						Crazing	Crazing
PVC-3-3 & 60	chloride						Crazing	Crazing
PVC-4-1 & 61	Polyvinyl chloride	A	Sound	Sound			Crazing	Crazing
PVC-4-2 & 62			Sound	Sound			Crazing	Crazing
PVC-4-3 & 63							Crazing	Crazing
PVC-5-1 & 73	Polyvinyl chloride	D	Sound	Sound			Crazing	Crazing
PVC-5-2 & 74			Sound	Sound			Crazing	Crazing
PVC-5-3 & 75			Sound	Sound			Crazing	Crazing
PVC-9A(2) & 91	Polyvinyl chloride	E					Crazing	Crazing

Specimen No.	Description	Manufacturer	Condition of Unstressed Specimens	Condition of Bent Specimens	Condition of Embedded Specimens, 1966-1970	
			1966	1966	1966	1968 and 1970
NR-1-1 & 64	Natural rubber	A			††	
NR-1-2 & 65			††		††	
NR-1-3 & 66			††		Crazing	Crazing‡
NR-2-1 & 82	Natural rubber	B	††		††	
NR-2-2 & 83	(3500-lb tensile		††		††	
NR-2-3 & 84	strength)		††		Crazing	Crazing‡
SR-1-1 & 70	General service	A	††		††	
SR-1-2 & 71	rubber		††		††	
SR-1-3 & 72			††		Crazing	Crazing‡
SR-2-1 & 85	General service	B	††		††	
SR-2-2 & 86	rubber (2000-lb		††		††	
SR-2-3 & 87	tensile strength)		††		Crazing	Crazing‡
SR-3-1 & 88	General service	B	††		††	
SR-3-2 & 89	rubber (3000-lb		††	Lost	††	
SR-3-3 & 90	tensile strength)		††	Lost	Sound	Crazing‡
NEOR-1-1 & 67	Neoprene rubber	A	††		††	
NEOR-1-2 & 68			††		††	
NEOR-1-3 & 69			††		Crazing	Crazing‡

(Continued)

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†† Returned to laboratory in June 1966 for tests.
‡ Exposure discontinued in 1970.

(Revised Sept 1970)

Table 2-WS (Concluded)

			Condition of Unstressed Specimens	Condition of Bent Specimens	Condition of Embedded Specimens, 1966-1970	
Specimen No.	Description	Manufacturer	1966	1966	1966	1968 and 1970
NEOR-2-1 & 79	Neoprene rubber	B	††	Lost	††	
NEOR-2-2 & 80			††	Lost	††	
NEOR-2-3 & 81			††	Lost	Crazing	Crazing‡
BUTYL-1-1 & 76	Butyl rubber	B			††	
BUTYL-1-2 & 77					††	
BUTYL-1-3 & 78					Crazing	Crazing‡
PVC-2-1 & 55	Type IV standard polyvinyl chloride	C			††	
PVC-2-2 & 56					††	
PVC-2-3 & 57					Crazing	Completely torn‡
PVC-3-1 & 58	Type V standard polyvinyl chloride	C			††	
PVC-3-2 & 59					††	
PVC-3-3 & 60					Crazing	Crazing‡
PVC-4-1 & 61	Polyvinyl chloride	A	††		††	
PVC-4-2 & 62			††		††	
PVC-4-3 & 63					Crazing	Crazing‡
PVC-5-1 & 73	Polyvinyl chloride	D	††		††	
PVC-5-2 & 74			††		††	
PVC-5-3 & 75			††		Crazing	Crazing‡
PVC-9A(2) & 91	Polyvinyl chloride	E			††	

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†† Returned to laboratory in June 1966 for tests.

‡ Exposure discontinued in 1970.

(Revised Jan 1972)

Table 3-WS

Record of Observations of Unstressed and Bent Specimens, Nonmetallic Waterstop Investigation

Jackson Indoor Exposure

1957- (Installed 1957)

WES Specimen No.	Description	Manufacturer	Condition of Unstressed Specimens, 1957-									
			1957	1958	1959	1960	1962	1963	1964	1965	1966	1970**
NR-1-1	Natural rubber	A	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NR-1-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
NR-1-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
NR-2-1	Natural rubber (3500-lb tensile strength)	B	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NR-2-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
NR-2-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
SR-1-1	General service rubber	A	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-1-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
SR-1-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
SR-2-1	General service rubber (2000-lb tensile strength)	B	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-2-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
SR-2-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
SR-3-1	General service rubber (3000-lb tensile strength)	B	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-3-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
SR-3-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
NEOR-1-1	Neoprene rubber	A	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-1-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
NEOR-1-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
NEOR-2-1	Neoprene rubber	B	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-2-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
NEOR-2-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
BUTYL-1-1	Butyl rubber	B	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
BUTYL-1-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
BUTYL-1-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
PVC-2-1	Type IV standard polyvinyl chloride	C	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
PVC-2-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
PVC-2A-1	Type IV arctic polyvinyl chloride	C	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2A-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
PVC-2A-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
PVC-3-1	Type V standard polyvinyl chloride	C	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
PVC-3-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
PVC-3A-1	Type V arctic polyvinyl chloride	C	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3A-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
PVC-3A-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
PVC-4-1	Polyvinyl chloride	A	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-4-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
PVC-4-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
PVC-5-1	Polyvinyl chloride	D	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-5-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	
PVC-5-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*	

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* Removed from exposure in June 1966 for tests.

** The condition of all of these specimens was the same in 1967, 1968, 1969, and 1970.

(Sheet 1)

(Revised Jan 1972)

Table 3-WS (Concluded)

WES Specimen No.	Description	Manufacturer	Condition of Bent Specimens, 1957-										
			1957	1958	1959	1960	1962	1963	1964	1965	1966	1970**	1971
NR-1-1	Natural rubber	A	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NR-1-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
NR-1-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
NR-2-1	Natural rubber (3500-lb tensile strength)	B	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NR-2-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
NR-2-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
SR-1-1	General service rubber	A	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-1-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
SR-1-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
SR-2-1	General service rubber (2000-lb tensile strength)	B	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-2-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
SR-2-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
SR-3-1	General service rubber (3000-lb tensile strength)	B	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
SR-3-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
SR-3-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
NEOR-1-1	Neoprene rubber	A	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-1-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
NEOR-1-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
NEOR-2-1	Neoprene rubber	B	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
NEOR-2-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
NEOR-2-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
BUTYL-1-1	Butyl rubber	B	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
BUTYL-1-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
BUTYL-1-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
PVC-2-1	Type IV standard polyvinyl chloride	C	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
PVC-2-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
PVC-2A-1	Type IV arctic polyvinyl chloride	C	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-2A-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
PVC-2A-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
PVC-3-1	Type V standard polyvinyl chloride	C	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
PVC-3-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
PVC-3A-1	Type V arctic polyvinyl chloride	C	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-3A-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
PVC-3A-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
PVC-4-1	Polyvinyl chloride	A	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-4-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
PVC-4-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
PVC-5-1	Polyvinyl chloride	D	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound
PVC-5-2			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		
PVC-5-3			Sound	Sound	Sound	Sound	Sound	Sound	Sound	Sound	*		

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* Removed from exposure in June 1966 for tests.

** The condition of all of these specimens was the same in 1967, 1968, 1969, and 1970.

(Sheet 2)

(Revised Jan 1972)

Table 4-WS

Record of Observations of Unstressed, Bent, and Embedded Specimens, Nonmetallic Waterstop Investigation

Jackson Outdoor Exposure

1957- (Installed 1957)

Specimen No.	Description	Manufacturer	Condition* of Unstressed Specimens, 1957-												
			1957	1958	1959	1960	1962	1963	1964	1965	1966	1967	1968	1969	1970
NR-1-1	Natural rubber	A	Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz
NR-1-2			Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	**				
NR-1-3			Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	**				
NR-2-1	Natural rubber (3500-lb tensile strength)	B	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd
NR-2-2			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**				
NR-2-3			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**				
SR-1-1	General service rubber	A	Sd	Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz
SR-1-2			Sd	Sd	Sd	Sd	Crz	Crz	Crz	Crz	**				
SR-1-3			Sd	Sd	Sd	Sd	Crz	Crz	Crz	Crz	**				
SR-2-1	General service rubber (2000-lb tensile strength)	B	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd
SR-2-2			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**				
SR-2-3			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**				
SR-3-1	General service rubber (3000-lb tensile strength)	B	Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz
SR-3-2			Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	**				
SR-3-3			Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	**				
NEOR-1-1	Neoprene rubber	A	Sd	Sd	Sd	Sd	Crz	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd
NEOR-1-2			Sd	Sd	Sd	Sd	Crz	Sd	Sd	Sd	**				
NEOR-1-3			Sd	Sd	Sd	Sd	Crz	Sd	Sd	Sd	**				
NEOR-2-1	Neoprene rubber	B	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd
NEOR-2-2			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**				
NEOR-2-3			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**				
BUTYL-1-1	Butyl rubber	B	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd
BUTYL-1-2			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**				
BUTYL-1-3			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**				
PVC-2-1	Type IV standard polyvinyl chloride	C	Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz
PVC-2-2			Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	**				
PVC-2-3			Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	**				
PVC-2A-1	Type IV arctic polyvinyl chloride	C	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd
PVC-2A-2			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**				
PVC-2A-3			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**				
PVC-3-1	Type V standard polyvinyl chloride	C	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz
PVC-3-2			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**				
PVC-3-3			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**				
PVC-3A-1	Type V arctic polyvinyl chloride	C	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd
PVC-3A-2			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**				
PVC-3A-3			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**				
PVC-4-1	Polyvinyl chloride	A	Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz
PVC-4-2			Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	**				
PVC-4-3			Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	**				
PVC-5-1	Polyvinyl chloride	A	Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz
PVC-5-2			Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	**				
PVC-5-3			Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	**				

(Continued)

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* Conditions are described as sound (SD), crazing (Crz).

** Removed from exposure in June 1966 for tests.

(Revised Jan 1972)

Table 4-WS (Continued)

Specimen No.	Description	Manu-facturer	Condition* of Bent Specimens, 1957-1971													
			1957	1958	1959	1960	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
NR-1-1	Natural rubber	A	Sd	Crz	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd
NR-1-2			Sd	Crz	Cd	Cd	Cd	Cd	Cd	Cd	**					
NR-1-3			Sd	Crz	Cd	Cd	Cd	Cd	Cd	Cd	**					
NR-2-1	Natural rubber	B	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz
NR-2-2	(3500-lb tensile		Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	**					
NR-2-3	strength)		Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	**					
SR-1-1	General service	A	Sd	Cd	B cd	B cd	B cd	B cd	B cd	B cd	B cd	B cd	B cd	B cd	B cd	B cd
SR-1-2	rubber		Sd	Cd	B cd	B cd	B cd	B cd	B cd	B cd	**					
SR-1-3			Sd	Cd	B cd	B cd	B cd	B cd	B cd	B cd	**					
SR-2-1	General serivce	B	Sd	Sd	Crz	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd
SR-2-2	rubber (2000-lb		Sd	Crz	Crz	Cd	Cd	Cd	Cd	Cd	**					
SR-2-3	tensile strength)		Sd	Sd	Crz	Cd	Cd	Cd	Cd	Cd	**					
SR-3-1	General service	B	Sd	Cd	B cd	B cd	B cd	B cd	B cd	B cd	B cd	B cd	B cd	B cd	B cd	B cd
SR-3-2	rubber (3000-lb		Sd	Cd	B cd	B cd	B cd	B cd	B cd	B cd	**					
SR-3-3	tensile strength)		Sd	Cd	B cd	B cd	B cd	B cd	B cd	B cd	**					
NEOR-1-1	Neoprene rubber	A	Sd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd
NEOR-1-2			Sd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	**					
NEOR-1-3			Sd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	**					
NEOR-2-1	Neoprene rubber	B	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd
NEOR-2-2			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
NEOR-2-3			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
BUTYL-1-1	Butyl rubber	B	Sd	Crz	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd
BUTYL-1-2			Sd	Crz	Cd	Cd	Cd	Cd	Cd	Cd	**					
BUTYL-1-3			Sd	Crz	Cd	Cd	Cd	Cd	Cd	Cd	**					
PVC-2-1	Type IV standard	C	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz
PVC-2-2	polyvinyl		Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	**					
PVC-2-3	chloride		Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	**					
PVC-2A-1	Type IV arctic	C	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd
PVC-2A-2	polyvinyl		Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
PVC-2A-3	chloride		Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
PVC-3-1	Type V standard	C	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz
PVC-3-2	polyvinyl		Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	**					
PVC-3-3	chloride		Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	**					
PVC-3A-1	Type V arctic	C	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	Crz
PVC-3A-2	polyvinyl		Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
PVC-3A-3	chloride		Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
PVC-4-1	Polyvinyl chloride	A	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz
PVC-4-2			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	**					
PVC-4-3			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	**					
PVC-5-1	Polyvinyl chloride	A	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz
PVC-5-2			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	**					
PVC-5-3			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	**					

(Continued)

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* Conditions are described as sound (SD), crazing (Crz), cracked (Cd), and badly cracked (B cd).

** Removed from exposure in June 1966 for tests.

Table 4-WS (Concluded)

Specimen No.	Description	Manufacturer	Condition* of Embedded Specimens, 1957-1971													
			1957	1958	1959	1960	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
NR-1-37	Natural rubber	A	Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz
NR-1-38			Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	**					
NR-1-39			Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	**					
NR-2-112	Natural rubber	B	Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz
NR-2-113	(3500-lb tensile		Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	**					
NR-2-114	strength)		Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	**					
SR-1-43	General service	A	Sd	Cd	B cd	B cd	B cd	B cd	B cd	C tn	**					
SR-1-44	rubber		Sd	Cd	B cd	B cd	B cd	B cd	B cd	C tn	**					
SR-1-45			Sd	Cd	B cd	B cd	B cd	B cd	B cd	C tn	**					
SR-2-115	General service	B	Sd	Tn	C tn											
SR-2-116	rubber (2000-lb		Sd	Tn	C tn											
SR-2-117	tensile strength)		Sd	Tn	C tn											
SR-3-118	General service	B	Sd	Cd	B cd	B cd	B cd	Tn	Tn	C tn	**					
SR-3-119	rubber (3000-lb		Sd	Cd	B cd	B cd	B cd	Tn	Tn	C tn	**					
SR-3-120	tensile strength)		Sd	Cd	B cd	B cd	B cd	Tn	Tn	C tn	**					
NEOR-1-40	Neoprene rubber	A	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd
NEOR-1-41			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
NEOR-1-42			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
NEOR-2-109	Neoprene rubber	B	Sd	Sd	Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz
NEOR-2-110			Sd	Sd	Sd	Sd	Sd	Crz	Crz	Crz	**					
NEOR-2-111			Sd	Sd	Sd	Sd	Sd	Crz	Crz	Crz	**					
BUTYL-1-106	Butyl rubber	B	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd
BUTYL-1-107			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
BUTYL-1-108			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
PVC-2-28	Type IV standard	C	Sd	Sd	Sd	Sd	Sd	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz	Crz
PVC-2-29	polyvinyl		Sd	Sd	Sd	Sd	Sd	Crz	Crz	Crz	**					
PVC-2-30	chloride		Sd	Sd	Sd	Sd	Sd	Crz	Crz	Crz	**					
PVC-2A-49	Type IV arctic	C	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	Crz
PVC-2A-50	polyvinyl		Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
PVC-2A-51	chloride		Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
PVC-3-31	Type V standard	C	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	Crz
PVC-3-32	polyvinyl		Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
PVC-3-33	chloride		Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
PVC-3A-52	Type V arctic	C	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd
PVC-3A-53	polyvinyl		Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
PVC-3A-54	chloride		Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
PVC-4-34	Polyvinyl chloride	A	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	Crz
PVC-4-35			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
PVC-4-36			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
PVC-5-46	Polyvinyl chloride	D	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	Crz	Crz
PVC-5-47			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					
PVC-5-48			Sd	Sd	Sd	Sd	Sd	Sd	Sd	Sd	**					

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* Conditions are described as sound (Sd), cracked (Cd), torn (Tn), badly cracked (B cd), completely torn (C tn), and crazing (Crz).

** Removed from exposure in June 1966 for tests.

Woven Plastic Test Program

The purpose of this investigation is to evaluate the durability of two types of woven plastic filter material under three exposure conditions.

The test specimens are 13-in.-square pieces of woven plastic and are exposed at two locations: Treat Island, Maine, and Jackson, Mississippi (indoors).

1963 Treat Island installation

In November 1963, 160 woven plastic pieces were installed at the Treat Island exposure station. Eighty pieces were installed in thin redwood frames (two pieces per frame) with a nominal 1-in. space between them for circulation of air. The redwood frames were contained in one long redwood box, slatted to permit circulation of air and seawater; the top of the box had an overhang, and baffles were provided to shade the plastic pieces from the sun at all times. The remaining 80 pieces were installed flat in two redwood boxes with a 2-in. layer of pea gravel top and bottom.

1963 Jackson installation

In November 1963, 80 woven plastic pieces were installed indoors at the WES Jackson installation. These specimens were installed in thin redwood frames contained in a long redwood box as were one set of the companion specimens at Treat Island.

Loss of test specimens

In July 1966, 60 specimens in redwood frames were lost overboard (two plastic pieces per frame). At that time, 20 of the frame specimens had already been returned to the laboratory for testing.

1967 Treat Island installation

In April 1967, 80 woven plastic pieces were installed at the Treat Island exposure station. All of these were installed in thin redwood frames (two pieces per frame) with a nominal 1-in. space between them for circulation of air. As in the 1963 installation, the redwood frames were contained in one long redwood box, slatted to permit circulation of air and seawater. Baffles were provided to shade the plastic pieces from the sun at all times. This installation replaced the specimens lost overboard in July 1966.

Schedule of testing (from May 1967)

Every 6 months until November 1969, 12 specimens were removed from their exposure (four from Jackson, eight from Treat Island) and tested in the laboratory (see table 1-WPF).

In January 1970, this phase of the investigation was terminated. At that time only 64 specimens remained under test: 32 were in the pea gravel boxes at Treat Island and 32 were in frames (indoors) at the laboratory.

1970 installation

In March 1970, 22 plastic pieces were installed at Treat Island in redwood frames. This installation represented four additional types of plastic, three of which were woven plastics (see table 1-WPF). The schedule for laboratory testing of these samples has not yet been established.

Table 1-WPF

Woven Plastic Test Program Summary

No. of Specimens	Exposure Conditions	Woven Plastic	No. of Specimens to be Removed from Exposure and Tested Every 6 months
	Exposed at Treat Island, Maine (Installed November 1963)		
40*	Wooden frames, vertical	Type F	0
40*	Wooden frames, vertical	Type P	0
40	Horizontal, pea gravel, Box F	Type F	2
40	Horizontal, pea gravel, Box P	Type P	2
	Exposed at Jackson, Miss. (Indoors) (Installed November 1963)		
40	Wooden frames, vertical	Type F	2
40	Wooden frames, vertical	Type P	2
	Exposed at Treat Island, Maine (Installed April 1967)		
40†	Wooden frames, vertical	Type F	2**
40†	Wooden frames, vertical	Type P	2**
	Exposed at Treat Island, Maine (Installed March 1970)		
1	Wooden frames, vertical	Type F	
1	Wooden frames, vertical	Type P	
10	Wooden frames, vertical	Type L	
4	Wooden frames, vertical	Type PM (not a woven plastic)	
2	Wooden frames, vertical	Type PGB	
4	Wooden frames, vertical	Type Z	

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* Thirty of these specimens were lost overboard in July 1966. Ten of these specimens had been sent back to the laboratory for testing prior to July 1966.

** Return of these specimens began in May 1967. No frame specimens were returned from Treat Island in November 1966.

† Thirty of these specimens were lost overboard in a storm in November 1969. Ten specimens have been tested in the laboratory after exposure.

National Bureau of Standards Supersulfate Cement Program

In November 1957, 27 concrete beams (3 by 4 by 16 in.) were installed on the exposure rack at St. Augustine as part of a program being conducted by the National Bureau of Standards to investigate the properties of concrete containing supersulfate cements.

The 27 beams represented nine cements (3 beams per cement); other concrete characteristics were: slump, 5 ± 1 in.; nominal cement factor, 5.5 bags per cu yd; aggregates, natural sand and natural gravel of 1-in. maximum size.

Table 1-SS lists these specimens and gives their exposure record, along with their cements.

Data collection on these specimens was discontinued after the 1970 inspection.

(Revised Sept 1966)

Table 1-SS Section 32

Record of Testing of Concrete Beams, Supersulfate Cement Program

1957- (Installed November 1957)

	Cementitious Material		1957-1964 Readings				
Beam No.	Type	Serial No.	1957 %E	1958 %E	1960 %E	1962 %E	1964 %E
1SS1	Supersulfate cement	1	100	113	103	99	102
1SS2			100	115	104	102	104
1SS3			100	114	100	99	102
2SS1	Supersulfate cement	2	100	109	109	103	105
2SS2			100	110	112	107	106
2SS3			100	109	110	105	109
3SS1	Supersulfate cement	3	100	119	113	106	107
3SS2			100	119	111	104	105
3SS3			100	121	111	105	106
4SS1	Supersulfate cement	4	100	116	102	99	101
4SS2			100	118	110	106	109
4SS3			100	117	110	106	108
5SS1	Supersulfate cement	5	100	109	109	100	105
5SS2			100	109	110	104	106
5SS3			100	109	109	105	106
6SS1	Portland, blast-furnace slag	6	100	113	109	94	84
6SS2			100	113	109	93	Failed
6SS3			100	112	107	96	95
7SS1	Type V	7	100	113	102	97	100
7SS2			100	112	101	99	99
7SS3			100	111	102	99	101
8SS1	Portland-pozzolan blend	8	100	112	110	99	105
8SS2			100	113	106	102	107
8SS3			100	112	108	*	
9SS1	High-alumina cement	9	100	112	105	101	108
9SS2			100	112	102	101	107
9SS3			100	114	105	105	110

(Continued)

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* Broken in handling.

(Revised Sept 1970)

Table 1-SS (Concluded)

Beam No.	Cementitious Material		1966-Readings		
	Type	Serial No.	1966 %E	1968 %E	1970 %E
1SS1	Supersulfate cement	1	101	97	96
1SS2			103	104	102
1SS3			100	104	102
2SS1	Supersulfate cement	2	105	104	104
2SS2			107	101	100
2SS3			108	109	108
3SS1	Supersulfate cement	3	107	105	105
3SS2			104	106	106
3SS3			106	101	101
4SS1	Supersulfate cement	4	100	105	104
4SS2			109	112	110
4SS3			107	114	112
5SS1	Supersulfate cement	5	104	105	104
5SS2			108	107	107
5SS3			106	111	Failed
6SS1	Portland, blast-furnace slag	6	Failed		
6SS3			94	86	85
7SS1	Type V	7	100	99	98
7SS2			99	101	99
7SS3			100	102	101
8SS1	Portland-pozzolan blend	8	111	109	108
8SS2			*		
8SS3					
9SS1	High-alumina cement	9	109	114	Lost
9SS2			107	104	Lost
9SS3			111	104	Lost

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* Broken in handling.

Membrane Curing Program

On 12 June 1946, 14 box specimens were installed on top of the wharf at Treat Island, Maine. Exposure of these specimens is a phase of the investigation of the effect of method of curing on the durability of vertical concrete surfaces. Each of the specimens is a hollow, monolithic, concrete box with exterior vertical surfaces 24 in. wide and 20 in. high and with hollow, tapered, prismoidal centers 18 in. square at the top and 14 in. square at the bottom.

The specimens were made during the winter of 1942-43 and were formed out-of-doors, on the ground, at the moderate weathering exposure installation at Mount Vernon, N. Y. Each pair of adjacent exterior vertical surfaces represented a given test condition and the edge between each pair of similar surfaces was oriented in an east or west direction. The hollow centers were filled with earth.

After two and one-half winters of moderate weathering exposure (approximately 250 cycles of freezing-and-thawing), the specimens were emptied of earth and transferred to Treat Island, installed on top of the wharf with the same orientation as previously employed, and the centers were refilled with earth.

Table 1-MCP lists these specimens and gives their present condition along with other pertinent information.

(Revised August 1977)

Table 1-MCP

Record of Testing of Box Specimens, Membrane Curing Program

1959- (Installed June 1946)

									Condition of Specimens, 1959-1961					
						Curing			13 Winters		14 Winters		15 Winters	
Box	East	West	Admixture			Material		Form	1959		1960		1961	
No.	Corner	Corner	East	West	Cement	East	West	Lining	East	West	East	West	East	West
1	GVRW	GW	Resin	None	A	Water	Water	T-and-G*	Excel**	Excel	Excel	Excel	Excel	Excel
2	GVRCCW	GVRAHW	Resin + CC	Resin + AH	A	Water	Water	T-and-G	Excel	Excel	Excel	Excel	Excel	Excel
3	GCCJW	GCCW	Resin soap + CC	CC	A	Water	Water	T-and-G	Excel	Excel	Excel	Excel	Excel	Excel
4	GJW		Resin soap	Resin soap	A	Water	Water	T-and-G	Excel	Excel	Excel	Excel	Excel	Excel
5	AC		None	None	B	Air	Air	T-and-G	Excel	Excel	Excel	Excel	Excel	Excel
6	CAC	CWC	None	None	B	Air	Water	Lining A	Excel	Excel	Excel	Excel	Excel	Excel
7	RAC	RWC	None	None	B	Air	Water	Lining B	Excel	Excel	Excel	Excel	Excel	Excel
8	AHAC		AH	AH	B	Air	Air	T-and-G	Sl ck†	Excel	Sl ck	Excel	Excel	Excel
9	B-3	B-1	None	None	B	HPB	RG	T-and-G	Excel	Excel	Excel	Excel	Excel	Excel
10	B-8	B-2	None	None	B	KC70	HPC	T-and-G	Excel	Excel	Excel	Excel	Excel	Excel
11	B-25	B-23	None	None	B	SF45W	CS45	T-and-G	Excel	Excel	Excel	Excel	Excel	Excel
12	B-24	B-29	None	None	B	SF45	DSA	T-and-G	Excel	Excel	Excel	Excel	Excel	Excel
13	B-17	B-28	None	None	B	AFMST	PENC	T-and-G	Excel	Excel	Excel	Excel	Excel	Excel
14	B-18	B-30	None	None	B	A1C	TFX199	T-and-G	Excel	Excel	Excel	Excel	Excel	Excel

	Condition of Specimens, 1962-1972															
	16 Winters		17 Winters		18 Winters		19 Winters		20 Winters		24 Winters		25 Winters		26 Winters	
	1962		1963		1964		1965		1966		1970††		1971		1972	
	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West
1	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
2	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
3	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
4	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
5	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
6	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
7	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
8	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
9	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
10	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
11	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
12	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
13	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
14	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel

	Condition of Specimens, 1973-									
	27 Winters		28 Winters		29 Winters		30 Winters		31 Winters	
	1973		1974		1975		1976		1977	
	East	West	East	West	East	West	East	West	East	West
1	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
2	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
3	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
4	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
5	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
6	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
7	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
8	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
9	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
10	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
11	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
12	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
13	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel
14	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel	Excel

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* Tongue-and-groove lumber.

** Excel denotes excellent.

† Sl ck denotes slight crack.

†† Condition of the specimens did not change from 1967 to 1971.

Quality Aggregate Investigation

The purpose of this investigation is to develop satisfactory test methods for evaluating the quality of aggregate larger than the 1-1/2-in. size.

During the period 1959-1962, 16 mass concrete cubes (8 cu ft) were fabricated for field exposure tests from 16 different concrete mixtures (one cube per mixture). All cubes were made of air-entrained concrete using type II portland cement, a 6-in. maximum size coarse aggregate, and a manufactured limestone sand as the fine aggregate. The test variables were water-cement ratio and kind of coarse aggregate; eight coarse aggregates and two water-cement ratios were used. Each cube was allowed to reach a minimum age of 1 year before installation at Treat Island.

1962 Installation

In November 1962, ten of these concrete cubes were installed at half-tide elevation on the beach at Treat Island for field exposure tests. Table 1-QA lists these specimens and gives their exposure record along with pertinent mixture data.

1963 Installation

In December 1963, the remaining six of these concrete cubes were installed at half-tide elevation on the beach at Treat Island. Table 2-QA lists these specimens and gives their exposure record.

(Revised August 1977)

Table 1-QA

Record of Testing of Cubes Made for Quality Aggregate Investigation

1962 Installation (Installed November 1962)

Beach Row 2 (W to E)

						1962-1968 Readings								
Cube No.	Date Made	Coarse Aggregate	Water-Cement Ratio (by Wt)	Air Content* %	Slump* in.	0 Cycles 1962		106 Cycles 1963 %V^2	241 Cycles 1964 %V^2	404 Cycles 1965 %V^2	534 Cycles 1966 %V^2	690 Cycles 1967 %V^2	875 Cycles 1968 %V^2
						Pulse Veloc fps	%V^2						
Q-1	Mar 1959	Limestone C	0.5	5.3	1	17,315	100	104	97	103	96	88	79
Q-2	July 1959	Limestone C	0.8	5.0	1-3/4	16,065	100	65	72	41	Failed		
Q-3	June 1959	Graywacke	0.5	5.5	1-3/4	13,515	100	108	112	126	112	110	NR**
Q-4	June 1959	Graywacke	0.8	5.4	2	12,780	100	99	102	91	46	66	Failed
Q-5	Oct 1959	Natural gravel A	0.5	5.2	1-1/2	15,150	100	97	100	106	97	100	100
Q-6	Oct 1959	Natural gravel A	0.8	5.3	2	14,035	100	97	89	75	51	Failed	
Q-7	Feb 1960	Limestone B	0.5	5.0	1-3/4	16,000	100	102	102	108	97	90	82
Q-8	Feb 1960	Limestone B	0.8	4.9	1-1/4	15,150	100	77	57	NR**	33†	Failed	
Q-9	Mar 1960	Limestone A	0.5	4.8	1-1/4	16,600	100	94	97	101	86	82	93
Q-10	Mar 1960	Limestone A	0.8	5.2	1-3/4	16,065	100	96	98	81	75	79	60

						1969-1977 Readings							
						1029 Cycles 1969 %V^2	1182 Cycles 1970 %V^2	1351 Cycles 1971 %V^2	1508 Cycles 1972 %V^2	1648 Cycles 1973 %V^2	1784 Cycles 1974 %V^2	1896 Cycles 1975 %V^2	2042 Cycles 1976 %V^2
Q-1	Mar 1959	Limestone C	0.5	5.3	1	Failed							
Q-3	June 1959	Graywacke	0.5	5.5	1-3/4	NR**	NR**	Failed					
Q-5	Oct 1959	Natural gravel A	0.5	5.2	1-1/2	73	67	58	58	††	27	Failed	
Q-7	Feb 1960	Limestone B	0.5	5.0	1-3/4	56	54	29	43	††	17	41	Failed
Q-9	Mar 1960	Limestone A	0.5	4.8	1-1/4	66	64	53	65	††	58	56	Failed
Q-10	Mar 1960	Limestone A	0.8	5.2	1-3/4	42	NR**	Failed					

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* Air content and slump of that portion of the concrete containing aggregate smaller than 1-1/2 in. in size.

** NR = no satisfactory reading was obtained due to condition of specimen; however, specimen cannot as yet be adjudged as "failed."

† This reading is doubtful because of deteriorated condition of specimen.

†† Equipment malfunctioned in 1973.

(Revised August 1977)

Table 2-QA

Record of Testing of Cubes Made for Quality Aggregate Investigation

1963 Installation (Installed December 1963)

Beach Row A-1 (W to E)

						0 Cycles 1963		1963-1969 Readings					
Cube No.	Date Made	Coarse Aggregate	Water-Cement Ratio (by Wt)	Air Content* %	Slump* in.	Pulse Veloc fps	%V^2	121 Cycles 1964 %V^2	284 Cycles 1965 %V^2	414 Cycles 1966 %V^2	570 Cycles 1967 %V^2	755 Cycles 1968 %V^2	909 Cycles 1969 %V^2
Q-11	Aug 1962	Dolomite	0.5	4.8	1-1/2	15,565	100	102	119	117	88	89	73
Q-12	Aug 1962	Dolomite	0.8	4.9	1-1/2	14,870	100	112	110	122	51	Failed	
Q-13	July 1962	Natural gravel B	0.5	5.0	1-1/2	15,875	100	114	122	112	107	105	91
Q-14	Aug 1962	Natural gravel B	0.8	4.9	1-1/2	15,505	100	103	118	118	102	84	66
Q-15	Aug 1962	Gneiss	0.5	4.8	1-1/2	14,335	100	124	140	135	131	121	107
Q-16	Aug 1962	Gneiss	0.8	4.8	1-1/2	13,890	100	122	112	139	76	Failed	

						1970-1976 Readings						
						1062 Cycles 1970 %V^2	1231 Cycles 1971 %V^2	1388 Cycles 1972 %V^2	1528 Cycles 1973 %V^2	1664 Cycles 1974 %V^2	1776 Cycles 1975 %V^2	1922 Cycles 1976 %V^2
Q-11	Aug 1962	Dolomite	0.5	4.8	1-1/2	Failed						
Q-13	July 1962	Natural gravel B	0.5	5.0	1-1/2	81	80	90	††	118	105	94
Q-14	Aug 1962	Natural gravel B	0.8	4.9	1-1/2	†	Failed					
Q-15	Aug 1962	Gneiss	0.5	4.8	1-1/2	99	104	115	††	120	123	116

						1977- Readings
						1999 Cycles 1977 %V^2
Q-11	Aug 1962	Dolomite	0.5	4.8	1-1/2	
Q-13	July 1962	Natural gravel B	0.5	5.0	1-1/2	94
Q-14	Aug 1962	Natural gravel B	0.8	4.9	1-1/2	
Q-15	Aug 1962	Gneiss	0.5	4.8	1-1/2	109

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* Air content and slump of that portion of the concrete containing aggregate smaller than 1-1/2 in. in size.

† A satisfactory reading could not be taken because of the condition of the specimen.

†† Equipment malfunctioned in 1973.

Cement-Replacement Materials Investigation, Phase G*

In November 1962, two concrete prisms (18 by 18 by 36 in.) were installed at half-tide elevation on the beach at Treat Island as a part of Phase G (field phase) of the cement-replacement materials investigation.* Phase G (field phase) involved the proportioning, outdoor mixing, and placing of lean mass concrete containing pozzolans. The purpose of this installation is to develop information about the durability of these lean mass concretes.

The prisms were made from two different concrete mixtures (one prism per mixture); the coarse and fine aggregates used in both mixtures were crushed limestone. Each concrete mixture was air-entrained and each contained type II portland cement and one replacement material. The mixture data are tabulated below. Table 1-CRMI-PG lists these concrete prisms and gives their exposure record.

Specimen and Mix No.	Date Cast 1962	Portland Cement %, by Wt	Replacement Material		Max Size Coarse Aggr	Nominal Cementitious Material Factor bags/cu yd	Water-cement Ratio by Wt	Nominal Slump in.	Air** %
			Type	% by Wt Used					
1	9-12	48.5	Fly ash	51.5	6	2.1	0.62	1-3/4	5.0-6.6
6	6-21	57.3	Shale	42.7	6	1.7	0.85	1-3/4	5.0-6.0

** Air content of that portion of the concrete containing aggregate smaller than 1-1/2-in. size.

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* See: (1) U. S. Army Engineer Waterways Experiment Station, CE, Investigation of Cement-Replacement Materials; Use of Large Amounts of Pozzolans in Lean Mass Concrete, by W. O. Tynes, Miscellaneous Paper No. 6-123, Report 10 (Vicksburg, Miss., August 1962).

(2) U. S. Army Engineer Waterways Experiment Station, CE, Investigation of Cement-Replacement Materials; Use of Large Amounts of of Pozzolans in Lean Mass Concrete (Second Phase), by W. O. Tynes, Miscellaneous Paper No. 6-123, Report 14 (Vicksburg, Miss., October 1966).

Record of Testing of Prisms Made for Cement-Replacement Materials Investigation

Phase G, 1962- (Installed November 1962)

Beach Row 2 (E to W)

Specimen and Mix No.	Portland Cement %	Replacement Material* %	Maximum Aggregate Size in.	1962-1964 Readings				1965-1968 Readings				1969- Readings		
				0 Cycles 1962		106 Cycles 1963	241 Cycles 1964	404 Cycles 1965	534 Cycles 1966	690 Cycles 1967	875 Cycles 1968	1029 Cycles 1969	1182 Cycles 1970	1351 Cycles 1971
				Pulse Veloc fps	%V^2	%V^2	%V^2	%V^2	%V^2	%V^2	%V^2	%V^2	%V^2	%V^2
1	48.5**	51.5**	6	16,665	100	102	95	94	76	79	66	†	†	Failed
6	57.3**	42.7**	6	15,305	100	94	92	119	85	†	†	†	Failed	

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* Replacement material in mix 1 was fly ash; replacement material in mix 6 was shale.

** Percent by weight of total cementitious material (cement plus pozzolan).

† Faces of prism too rough to obtain satisfactory reading.

Maximum Size of Coarse Aggregate Program

In December 1963, 18 mass concrete prisms (18 by 18 by 36 in.) were installed at half-tide elevation on the beach at Treat Island.

The objective of this program was to determine if the maximum size of coarse aggregate used in mass concrete could be reduced from 6 to 3 in. without loss in quality of concrete.

The prisms were made from 18 different concrete mixtures (one prism per mixture); the coarse and fine aggregate used in all mixtures was a crushed limestone. Each concrete mixture was air-entrained (5 ± 1 percent) with a slump of 2 ± 1/2 in., and each contained type II portland cement. Cement factors varied from 2 to 3 bags per cu yd; 12 mixtures contained a cement-replacement material. The maximum size of aggregate in all mixtures was either 3 or 6 in.

Table 1-CAP lists these concrete prisms and gives their exposure record along with other pertinent information.

(Revised Sept 1966)

Table 1-CAP

Record of Testing of Prisms Made for Maximum Size of Coarse Aggregate Program

1963- (Installed December 1963)

Beach Row 2 (W to E)

Specimen and Mix No.	Date Made	Nominal Cement Factor bags/cu yd	Replacement Material*	Actual Sand: Aggregate Ratio %	Max Size Coarse Aggregate in.	0 Cycles 1963		121 Cycles 1964	284 Cycles 1965
						Pulse Velocity fps	$\%V^2$	$\%V^2$	$\%V^2$
1	Sept 1963	2.0	None	30	3	14,285	100	129	121
2	Sept 1963	2.0	None	24	6	15,545	100	109	114
3	Sept 1963	2.0	Fly ash	30	3	14,150	100	93	**
4	Sept 1963	2.0	Fly ash	24	6	15,385	100	115	115
5	Sept 1963	2.0	Shale	30	3	14,780	100	107	119
6	Sept 1963	2.0	Shale	24	6	16,395	100	107	109
7	Sept 1963	2.5	None	30	3	14,850	100	117	119
8	Sept 1963	2.5	None	23	6	16,215	100	110	113
9	Sept 1963	2.5	Fly ash	30	3	15,465	100	104	115
10	Sept 1963	2.5	Fly ash	23	6	16,130	100	107	114
11	Oct 1963	2.5	Shale	30	3	15,305	100	104	116
12	Oct 1963	2.5	Shale	23	6	15,955	100	106	113
13	Oct 1963	3.0	None	29	3	14,925	100	113	126
14	Oct 1963	3.0	None	22	6	16,130	100	104	113
15	Oct 1963	3.0	Fly ash	29	3	14,705	100	113	136
16	Oct 1963	3.0	Fly ash	22	6	15,875	100	107	109
17	Oct 1963	3.0	Shale	29	3	15,385	100	111	123
18	Oct 1963	3.0	Shale	22	6	15,955	100	108	118

(Continued)

Note: The following specimens were made on the same day: 1 and 2, 3 and 4, 5 and 6, 7 and 8, 9 and 10, 11 and 12, 13 and 14, 15 and 16, 17 and 18; in other words, the specimens were made on 9 different days (2 per day).

* 30% replacement by solid volume.

** Condition of this prism precluded pulse velocity testing.

(Revised Sept 1970)

Table 1-CAP (Continued) Section 37

Beach Row 2 (W to E)

Specimen and Mix No.	Date Made	Nominal Cement Factor bags/cu yd	Replacement Material	Actual Sand: Aggregate Ratio %	Max Size Coarse Aggregate in.	414 Cycles 1966 $\%V^2$	570 Cycles 1967 $\%V^2$	755 Cycles 1968 $\%V^2$	909 Cycles 1969 $\%V^2$
1	Sept 1963	2.0	None	30	3	106	†	Failed	
2	Sept 1963	2.0	None	24	6	103	88	102	†
3	Sept 1963	2.0	Fly ash	30	3	Failed			
4	Sept 1963	2.0	Fly ash	24	6	108	104	103	97
5	Sept 1963	2.0	Shale	30	3	108	107	100	†
6	Sept 1963	2.0	Shale	24	6	97	94	92	88
7	Sept 1963	2.5	None	30	3	111	113	110	106
8	Sept 1963	2.5	None	23	6	106	103	106	91
9	Sept 1963	2.5	Fly ash	30	3	100	91	93	85
10	Sept 1963	2.5	Fly ash	23	6	101	94	95	85
11	Oct 1963	2.5	Shale	30	3	108	99	101	95
12	Oct 1963	2.5	Shale	23	6	101	101	100	88
13	Oct 1963	3.0	None	29	3	112	117	112	103
14	Oct 1963	3.0	None	22	6	100	100	99	92
15	Oct 1963	3.0	Fly ash	29	3	115	114	114	110
16	Oct 1963	3.0	Fly ash	22	6	108	100	103	96
17	Oct 1963	3.0	Shale	29	3	111	110	106	97
18	Oct 1963	3.0	Shale	22	6	108	101	103	94

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† End of prism too rough to obtain satisfactory reading.

(Sheet 2)

Table 1-CAP (Continued)

Beach Row 2 (W to E)

Speci-men and Mix No.	Date Made	Nominal Cement Factor bags/cu yd	Replace-ment Material	Actual Sand: Aggre-gate Ratio %	Max Size Coarse Aggre-gate in.	1970-1975 Readings					
						1062 Cycles 1970 $\%V^2$	1231 Cycles 1971 $\%V^2$	1388 Cycles 1972 $\%V^2$	1528 Cycles 1973 $\%V^2$	1664 Cycles 1974 $\%V^2$	1776 Cycles 1975 $\%V^2$
2	Sept 1963	2.0	None	24	6	†	Failed				
4	Sept 1963	2.0	Fly ash	24	6	86	†	Failed			
5	Sept 1963	2.0	Shale	30	3	†	Failed				
6	Sept 1963	2.0	Shale	24	6	84	†	Failed			
7	Sept 1963	2.5	None	30	3	104	76	104	††	84	106
8	Sept 1963	2.5	None	23	6	87	NR	86	††	104	94
9	Sept 1963	2.5	Fly ash	30	3	Failed					
10	Sept 1963	2.5	Fly ash	23	6	80	NR	86	††	38	Failed
11	Oct 1963	2.5	Shale	30	3	88	NR	88	††	Failed	
12	Oct 1963	2.5	Shale	23	6	83	20	84	††	96	92
13	Oct 1963	3.0	None	29	3	100	NR	100	††	116	113
14	Oct 1963	3.0	None	22	6	89	34	91	††	84	71
15	Oct 1963	3.0	Fly ash	29	3	91	90	109	††	122	118
16	Oct 1963	3.0	Fly ash	22	6	89	74	94	††	107	106
17	Oct 1963	3.0	Shale	29	3	95	72	99	††	112	114
18	Oct 1963	3.0	Shale	22	6	91	80	102	††	108	108

						1976- Readings	
						1922 Cycles 1976 $\%V^2$	1999 Cycles 1977 $\%V^2$
2	Sept 1963	2.0	None	24	6		
4	Sept 1963	2.0	Fly ash	24	6		
5	Sept 1963	2.0	Shale	30	3		
6	Sept 1963	2.0	Shale	24	6		
7	Sept 1963	2.5	None	30	3	Failed	
8	Sept 1963	2.5	None	23	6	83	Failed
9	Sept 1963	2.5	Fly ash	30	3		
10	Sept 1963	2.5	Fly ash	23	6		
11	Oct 1963	2.5	Shale	30	3		
12	Oct 1963	2.5	Shale	23	6	67	Failed
13	Oct 1963	3.0	None	29	3	101	95
14	Oct 1963	3.0	None	22	6	71	81
15	Oct 1963	3.0	Fly ash	29	3	115	103
16	Oct 1963	3.0	Fly ash	22	6	89	65
17	Oct 1963	3.0	Shale	29	3	86	47
18	Oct 1963	3.0	Shale	22	6	77	59

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† End of prism too rough to obtain satisfactory reading.

†† Equipment malfunctioned in 1973.

NR Unable to obtain satisfactory reading, although an attempt was made to do so.

Maximum Allowable Water-cement Ratio Investigation

In December 1964, 24 concrete prisms (18 by 18 by 36 in.) were installed on the beach at Treat Island. The objective of this installation was to observe the durability of mass concrete mixtures in which the water-cement ratios varied from 0.6 to 1.1 by weight.

The prisms were made from 12 concrete mixtures (two prisms per mixture); the coarse and fine aggregate used in all mixtures was a crushed limestone. The maximum size of the aggregate was 6 in. Each concrete mixture was air-entrained (5 ± 1%) with a slump of 2 ± 1/2 in., and each contained type II portland cement. Cement factors varied from 1.59 to 2.93 bags per cu yd; 6 mixtures contained a cement-replacement material (30% by solid volume).

Table 1-MAWC lists these concrete prisms and gives their exposure record along with other pertinent information.

(Revised Sept 1968)

Table 1-MAWC

Record of Testing of Prisms Made for Maximum Allowable Water-Cement Ratio Investigation

1964- (Installed December 1964)

Prism No.	Date Made	Type Cement	Replacement Material*	Water-Cement Ratio gals/bag	Water-Cement Ratio by weight	Cement Factor bags/cu yd	0 Cycles 1964 Pulse Velocity fps	0 Cycles 1964 $\%V^2$	Beach, Row A-1 152 Cycles 1965 $\%V^2$
Mix 1, Rd 1	Feb 1964	II	None	6.8	0.6	2.93	16,395	100	106
Rd 2	Aug 1964	II	None	6.8	0.6	2.93	16,130	100	114
Mix 2, Rd 1	May 1964	II	None	7.9	0.7	2.51	16,215	100	116
Rd 2	July 1964	II	None	7.9	0.7	2.51	16,665	100	108
Mix 3, Rd 1	June 1964	II	None	9.0	0.8	2.20	16,485	100	109
Rd 2	July 1964	II	None	9.0	0.8	2.20	16,395	100	111
Mix 4, Rd 1	June 1964	II	None	10.2	0.9	1.95	16,215	100	108
Rd 2	Aug 1964	II	None	10.2	0.9	1.95	16,045	100	107
Mix 5, Rd 1	Apr 1964	II	None	11.3	1.0	1.76	15,705	100	100
Rd 2	Aug 1964	II	None	11.3	1.0	1.76	15,875	100	104
Mix 6, Rd 1	Apr 1964	II	None	12.4	1.1	1.59	15,230	100	106
Rd 2	Aug 1964	II	None	12.4	1.1	1.59	15,150	100	111
Mix 7, Rd 1	Mar 1964	II	Fly ash	6.4	0.6	2.93	17,240	100	95
Rd 2	Aug 1964	II	Fly ash	6.4	0.6	2.93	16,575	100	103
Mix 8, Rd 1	June 1964	II	Fly ash	7.4	0.7	2.51	16,305	100	113
Rd 2	June 1964	II	Fly ash	7.4	0.7	2.51	16,760	100	102
Mix 9, Rd 1	Mar 1964	II	Fly ash	8.4	0.8	2.20	16,215	100	106
Rd 2	Aug 1964	II	Fly ash	8.4	0.8	2.20	16,215	100	108
Mix 10, Rd 1	June 1964	II	Fly ash	9.6	0.9	1.95	16,215	100	106
Rd 2	Aug 1964	II	Fly ash	9.6	0.9	1.95	15,385	100	111
Mix 11, Rd 1	June 1964	II	Fly ash	10.6	1.0	1.76	16,395	100	101
Rd 2	Aug 1964	II	Fly ash	10.6	1.0	1.76	16,130	100	110
Mix 12, Rd 1	June 1964	II	Fly ash	11.6	1.1	1.59	15,955	100	102
Rd 2	Aug 1964	II	Fly ash	11.6	1.1	1.59	16,130	100	89

Prism No.	Date Made	Type Cement	Replacement Material*	Water-Cement Ratio gals/bag	Water-Cement Ratio by weight	Cement Factor bags/cu yd	282 Cycles 1966 $\%V^2$	438 Cycles 1967 $\%V^2$
Mix 1, Rd 1	Feb 1964	II	None	6.8	0.6	2.93	103	112
Rd 2	Aug 1964	II	None	6.8	0.6	2.93	107	117
Mix 2, Rd 1	May 1964	II	None	7.9	0.7	2.51	106	116
Rd 2	July 1964	II	None	7.9	0.7	2.51	100	113
Mix 3, Rd 1	June 1964	II	None	9.0	0.8	2.20	102	109
Rd 2	July 1964	II	None	9.0	0.8	2.20	103	111
Mix 4, Rd 1	June 1964	II	None	10.2	0.9	1.95	106	109
Rd 2	Aug 1964	II	None	10.2	0.9	1.95	107	116
Mix 5, Rd 1	Apr 1964	II	None	11.3	1.0	1.76	111	103
Rd 2	Aug 1964	II	None	11.3	1.0	1.76	110	108
Mix 6, Rd 1	Apr 1964	II	None	12.4	1.1	1.59	70	99
Rd 2	Aug 1964	II	None	12.4	1.1	1.59	93	82
Mix 7, Rd 1	Mar 1964	II	Fly ash	6.4	0.6	2.93	93	101
Rd 2	Aug 1964	II	Fly ash	6.4	0.6	2.93	101	113
Mix 8, Rd 1	June 1964	II	Fly ash	7.4	0.7	2.51	103	111
Rd 2	June 1964	II	Fly ash	7.4	0.7	2.51	99	110
Mix 9, Rd 1	Mar 1964	II	Fly ash	8.4	0.8	2.20	106	113
Rd 2	Aug 1964	II	Fly ash	8.4	0.8	2.20	104	117
Mix 10, Rd 1	June 1964	II	Fly ash	9.6	0.9	1.95	90	106
Rd 2	Aug 1964	II	Fly ash	9.6	0.9	1.95	105	115
Mix 11, Rd 1	June 1964	II	Fly ash	10.6	1.0	1.76	93	101
Rd 2	Aug 1964	II	Fly ash	10.6	1.0	1.76	106	114
Mix 12, Rd 1	June 1964	II	Fly ash	11.6	1.1	1.59	98	103
Rd 2	Aug 1964	II	Fly ash	11.6	1.1	1.59	96	99

(Continued)

* 30% replacement by solid volume.

(Revised August 1977)

Table 1-MAWC (Continued)

Section 38

Beach Row A-1

Prism No.	Date Made	Type Cement	Replacement Material*	Water-Cement gals/bag	Ratio by weight	Cement Factor bags/cu yd	623 Cycles 1968 f^2	777 Cycles 1969 f^2	930 Cycles 1970 f^2	1099 Cycles 1971 f^2	1256 Cycles 1972 f^2
Mix 1, Rd 1	Feb 1964	II	None	6.8	0.6	2.93	111	115	109	102	88
Rd 2	Aug 1964	II	None	6.8	0.6	2.93	117	102	NR	106	91
Mix 2, Rd 1	May 1964	II	None	7.9	0.7	2.51	108	100	102	87	75
Rd 2	July 1964	II	None	7.9	0.7	2.51	108	101	121	115	66
Mix 3, Rd 1	June 1964	II	None	9.0	0.8	2.20	105	97	98	75	65
Rd 2	July 1964	II	None	9.0	0.8	2.20	110	99	88	82	78
Mix 4, Rd 1	June 1964	II	None	10.2	0.9	1.95	106	NR**	NR	NR	NR
Rd 2	Aug 1964	II	None	10.2	0.9	1.95	112	101	91	80	35
Mix 5, Rd 1	Apr 1964	II	None	11.3	1.0	1.76	100	77	NR	NR	Failed
Rd 2	Aug 1964	II	None	11.3	1.0	1.76	105	82	NR	NR	Failed
Mix 6, Rd 1	Apr 1964	II	None	12.4	1.1	1.59	57	†	Failed		
Rd 2	Aug 1964	II	None	12.4	1.1	1.59	78	NR	Failed		
Mix 7, Rd 1	Mar 1964	II	Fly ash	6.4	0.6	2.93	93	88	102	88	84
Rd 2	Aug 1964	II	Fly ash	6.4	0.6	2.93	109	101	97	99	93
Mix 8, Rd 1	June 1964	II	Fly ash	7.4	0.7	2.51	103	100	107	90	NR
Rd 2	June 1964	II	Fly ash	7.4	0.7	2.51	105	96	100	85	NR
Mix 9, Rd 1	Mar 1964	II	Fly ash	8.4	0.8	2.20	110	95	74	86	NR
Rd 2	Aug 1964	II	Fly ash	8.4	0.8	2.20	113	97	95	NR	NR
Mix 10, Rd 1	June 1964	II	Fly ash	9.6	0.9	1.95	110	NR	NR	NR	NR
Rd 2	Aug 1964	II	Fly ash	9.6	0.9	1.95	115	NR	NR	NR	NR
Mix 11, Rd 1	June 1964	II	Fly ash	10.6	1.0	1.76	102	61	NR	NR	NR
Rd 2	Aug 1964	II	Fly ash	10.6	1.0	1.76	110	98	97	90	NR
Mix 12, Rd 1	June 1964	II	Fly ash	11.6	1.1	1.59	106	87	76	NR	NR
Rd 2	Aug 1964	II	Fly ash	11.6	1.1	1.59	71	NR	NR	NR	NR

Prism No.	Date Made	Type Cement	Replacement Material*	Water-Cement gals/bag	Ratio by weight	Cement Factor bags/cu yd	1396 Cycles 1973 f^2	1532 Cycles 1974 f^2	1644 Cycles 1975 f^2	1790 Cycles 1976 f^2	1889 Cycles 1977 f^2
Mix 1, Rd 1	Feb 1964	II	None	6.8	0.6	2.93	††	109	103	69	96
Rd 2	Aug 1964	II	None	6.8	0.6	2.93	††	107	112	107	98
Mix 2, Rd 1	May 1964	II	None	7.9	0.7	2.51	††	94	109	86	77
Rd 2	July 1964	II	None	7.9	0.7	2.51	††	105	118	112	51
Mix 3, Rd 1	June 1964	II	None	9.0	0.8	2.20	††	Failed			
Rd 2	July 1964	II	None	9.0	0.8	2.20	††	89	102	Failed	
Mix 4, Rd 1	June 1964	II	None	10.2	0.9	1.95	††	Failed			
Rd 2	Aug 1964	II	None	10.2	0.9	1.95	††	88	84	Failed	
Mix 5, Rd 1	Apr 1964	II	None	11.3	1.0	1.76					
Rd 2	Aug 1964	II	None	11.3	1.0	1.76					
Mix 6, Rd 1	Apr 1964	II	None	12.4	1.1	1.59					
Rd 2	Aug 1964	II	None	12.4	1.1	1.59					
Mix 7, Rd 1	Mar 1964	II	Fly ash	6.4	0.6	2.93	††	93	NR	59	88
Rd 2	Aug 1964	II	Fly ash	6.4	0.6	2.93	††	99	102	96	38
Mix 8, Rd 1	June 1964	II	Fly ash	7.4	0.7	2.51	††	104	109	105	Failed
Rd 2	June 1964	II	Fly ash	7.4	0.7	2.51	††	99	114	Failed	
Mix 9, Rd 1	Mar 1964	II	Fly ash	8.4	0.8	2.20	††	103	108	Failed	
Rd 2	Aug 1964	II	Fly ash	8.4	0.8	2.20	††	Failed			
Mix 10, Rd 1	June 1964	II	Fly ash	9.6	0.9	1.95	††	Failed			
Rd 2	Aug 1964	II	Fly ash	9.6	0.9	1.95	††	Failed			
Mix 11, Rd 1	June 1964	II	Fly ash	10.6	1.0	1.76	††	Failed			
Rd 2	Aug 1964	II	Fly ash	10.6	1.0	1.76	††	103	93	Failed	
Mix 12, Rd 1	June 1964	II	Fly ash	11.6	1.1	1.59	††	Failed			
Rd 2	Aug 1964	II	Fly ash	11.6	1.1	1.59	††	Failed			

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* 30% replacement by solid volume.

** NR denotes that a satisfactory reading was not obtained although an attempt was made.

† A pulse velocity reading could not be taken through the path previously used because of the poor condition of the specimen.

†† Equipment malfunctioned in 1973.

Curing Investigation

In June 1968, 56 mass concrete prisms (18- by 18- by 36-in.) were installed on the Treat Island exposure rack.

The purpose of this installation is to develop information about the durability of mass concrete mixtures that contain special cements or pozzolans.

The prisms were made from seven concrete mixtures (eight prisms per mixture); the coarse and fine aggregate used in all mixtures was a crushed limestone, maximum size 6-in. Each concrete mixture was air-entrained (5.5 ± 1 percent) with a slump of 1-1/2 ± 1/2 in. and a cement factor of 2.5 bags per cu yd. One portland blast-furnace slag cement, two type II portland cements, one blend of type II portland cement and natural cement, and three blends of type II portland cement with a replacement material (fly ash or calcined shale) were used. Four curing conditions were utilized (14 prisms per curing condition):

Curing Condition No.	Days of Fog Room Curing	Subsequent Curing
1	14	Laboratory air
2	21	Laboratory air
3	2	Membrane curing compound
4	2	Laboratory air

Table 1-CT lists these concrete prisms and gives their exposure record along with other pertinent information.

(Revised Jan 1972)

Table 1-CT

Record of Testing of Prisms Made for Curing Investigation

1968- (Installed June 1968 at Treat Island, Me.)

Exposure Rack, Row 1

Prism No.	Position on Rack*	Curing Condition**	Type II Portland Cement %†	Other Cement %	Other Replacement Material %	0 Cycles, 1968			154 Cycles 1969		307 Cycles 1970		476 Cycles 1971	
						%E	Pulse Veloc fps	$\%V^2$	%E††	$\%V^2$	%E	$\%V^2$	%E	$\%V^2$
30021	10	1	100 (cement A)	None	None	100	16,305	100		104	106	102	105	82
30022	49					100	16,485	100		100	103	97	102	83
40021	14	2				100	16,575	100		103	103	99	99	74
40022	44					100	16,215	100		103	108	100	108	78
50021	8	3				100	16,045	100		108	114	95	114	92
50022	31					100	15,705	100		104	113	104	112	87
60021	23	4				100	15,955	100		110	106	108	100	74
60022	30					100	15,705	100		105	112	104	112	84
30421	40	1	100 (cement B)	None	None	100	17,145	100		99	105	100	106	76
30422	20					100	17,045	100		98	106	98	103	76
40421	15	2				100	17,045	100		98	106	95	105	80
40422	26					100	16,665	100		102	107	102	104	83
50421	28	3				100	16,215	100		103	112	99	108	71
50422	6					100	15,955	100		109	114	107	103	89
60421	35	4				100	16,395	100		99	113	98	109	70
60422	11					100	15,790	100		107	115	105	112	82
325S1	18	1	75 (cement A)	None	25 (calcined shale)	100	16,395	100		96	115	95	115	77
325S2	1					100	15,790	100		98	111	94	117	87
425S1	42	2				100	16,130	100		97	117	84	113	78
425S2	38					100	16,215	100		95	108	95	108	78
525S1	51	3			25 (shale)	100	15,705	100		99	131	96	127	70
525S2	12					100	15,465	100		100	116	99	113	85
625S1	27	4				100	16,130	100		102	112	100	109	86
625S2	13					100	15,875	100		100	119	99	116	82
335N1	3	1	65 (cement A)	35 (nat cement)	None	100	15,955	100		101	108	98	102	83
335N2	24					100	16,305	100		100	107	98	104	79
435N1	50	2				100	16,575	100		98	89	96	85	78
435N2	9					100	15,790	100		104	110	103	110	88
535N1	55	3				100	16,395	100		96	110	93	109	64
535N2	39					100	15,875	100		101	113	99	113	77
635N1	4	4				100	15,790	100		103	107	100	104	31
635N2	7					100	16,215	100		95	116	107	116	75
325F1	53	1	75 (cement A)	None	25 (fly ash)	100	17,750	100		83	108	79	107	80
325F2	45					100	16,130	100		94	109	91	110	77
425F1	56	2				100	16,855	100		96	104	93	103	80
425F2	25					100	16,305	100		95	110	95	107	80
525F1	17	3				100	16,305	100		97	115	95	113	76
525F2	29					100	16,485	100		100	115	100	116	77
625F1	33	4				100	16,305	100		102	127	100	124	87
625F2	36					100	15,790	100		101	116	99	115	80
3BFS1	41	1	None	100 (portland blast-furnace slag cement)	None	100	16,855	100		94	102	89	101	74
3BFS2	19					100	16,665	100		94	107	93	106	78
4BFS1	52	2				100	16,665	100		92	101	86	100	75
4BFS2	21					100	16,485	100		96	108	93	105	75
5BFS1	16	3				100	16,575	100		97	108	92	108	72
5BFS2	2					100	16,760	100		95	108	92	‡	86
6BFS1	5	4				100	16,855	100		95	108	89	97	80
6BFS2	37					100	16,215	100		102	107	100	104	73
335F1	22	1	65 (cement A)	None	35 (fly ash)	100	16,855	100		94	111	93	108	75
335F2	54					100	16,855	100		87	105	82	105	59
435F1	46	2				100	16,855	100		90	106	88	103	83
435F2	48					100	16,760	100		90	111	84	107	72
535F1	47	3				100	16,395	100		95	94	93	90	75
535F2	34					100	16,045	100		101	120	96	120	86
635F1	32	4				100	16,485	100		98	114	97	110	80
635F2	43					100	15,705	100		101	121	99	118	80

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* Position in row 1 of exposure rack starting from western end. For example: Prism 30021 is the 10th prism from the western end of row 1.

** See text of Section 39 for outline of curing conditions.

† All percentages are by solid volume of total cementitious material.

†† Satisfactory flexural frequency readings were not obtained on any of these prisms in 1969 due to malfunction of testing equipment.

‡ A satisfactory reading was not obtained.

Table 1-CT (Continued)

Exposure Rack, Row 1

Prism No.	Position on Rack	Curing Condition	Type II Portland Cement %	Other Cement %	Other Replacement Material %	633 Cycles 1972		773 Cycles 1973		909 Cycles 1974		1021 Cycles 1975	
						%E	%V^2	%E	%V^2	%E	%V^2	%E	%V^2
30021	10	1	100 (cement A)	None	None	91	92	99	100	100	100	103	129
30022	49					103	99	103	99	104	99	104	125
40021	14	2				93	94	90	97	87	97	83	115
40022	44					107	97	107	110	100	110	100	123
50021	8	3				108	99	92	110	108	110	105	140
50022	31					111	101	109	109	109	109	109	128
60021	23	4				83	82	83	85	82	85	NR	89
60022	30					109	107	109	110	109	110	108	137
30421	40	1	100 (cement B)	None	None	95	88	90	89	90	89	85	67
30422	20					104	95	103	82	103	82	100	117
40421	15	2				98	93	100	99	97	99	87	111
40422	26					104	96	104	107	104	107	104	36
50421	28	3				98	87	94	79	91	79	84	129
50422	6					100	99	78	102	101	102	101	125
60421	35	4				86	59	85	64	84	64	83	120
60422	11					109	94	108	86	107	86	116	129
325S1	18	1	75 (cement A)	None	25 (calcined shale)	105	98	107	105	105	105	105	107
325S2	1					117	95	92	113	117	113	117	131
425S1	42	2				108	86	106	93	103	93	103	87
425S2	38					101	81	102	106	100	106	101	38
525S1	51	3			25 (shale)	122	85	95	103	101	103	101	92
525S2	12					107	100	113	112	113	112	118	133
625S1	27	4				108	85	97	79	90	79	83	108
625S2	13					116	99	116	108	116	108	111	127
335N1	3	1	65 (cement A)	35 (nat cement)	None	98	93	99	95	96	95	93	102
335N2	24					103	89	100	88	97	88	74	103
435N1	50	2				100	90	106	97	98	97	NR	102
435N2	9					104	92	90	113	111	113	112	125
535N1	55	3				102	33	99	61	98	61	NR	58
535N2	39					99	83	96	82	100	82	97	127
635N1	4	4				98	59	81	47	77	47	70	33
635N2	7					108	99	106	81	104	81	101	113
325F1	53	1	75 (cement A)	None	25 (fly ash)	101	75	95	82	95	82	95	100
325F2	45					107	93	108	93	105	91	110	126
425F1	56	2				108	95	93	95	90	95	NR	107
425F2	25					97	86	108	98	111	98	110	134
525F1	17	3				107	100	110	100	108	100	117	132
525F2	29					111	101	113	105	112	105	113	120
625F1	33	4				106	100	104	107	104	107	100	99
625F2	36					115	92	115	100	118	100	115	43
3BFS1	41	1	None	100 (portland blast-furnace slag cement)	None	92	77	87	75	92	75	87	32
3BFS2	19					106	95	106	102	105	102	104	124
4BFS1	52	2				98	44	90	78	90	78	90	91
4BFS2	21					101	99	101	98	104	98	104	112
5BFS1	16	3				102	80	99	79	99	79	107	102
5BFS2	2					96	94	83	94	97	94	NR	105
6BFS1	5	4				94	84	88	84	87	84	77	103
6BFS2	37					100	78	93	100	94	100	91	126
335F1	22	1	65 (cement A)	None	35 (fly ash)	105	96	102	92	102	92	103	118
335F2	54					106	49	105	91	105	91	NR	116
435F1	46	2				103	84	100	93	106	93	109	115
435F2	48					104	91	101	91	104	91	104	91
535F1	47	3				103	99	85	99	84	99	84	122
535F2	34					117	89	122	79	122	79	127	58
635F1	32	4				108	97	106	100	110	100	115	126
635F2	43					120	91	120	103	102	103	107	141

Table 1-CT (Continued)

Exposure Rack, Row 1

Prism No.	Position on Rack	Curing Condition	Type II Portland Cement %	Other Cement %	Other Replacement Material %	1167 Cycles 1976		1244 Cycles 1977	
						%E	$\%V^2$	%E	$\%V^2$
30021	10	1	100 (cement A)	None	None	99	99	99	98
30022	49					104	98	101	92
40021	14	2				109	91	105	70
40022	44					93	98	101	68
50021	8	3				102	100	101	96
50022	31					108	102	110	109
60021	23	4				NR*	66	61	78
60022	30					102	105	102	109
30421	40	1	100 (cement B)	None	None	86	85	101	24
30422	20					91	93	95	99
40421	15	2				96	96	88	92
40422	26					95	109	98	84
50421	28	3				84	86	83	Broken
50422	6					98	98	95	102
60421	35	4				71	44	62	Broken
60422	11					113	66	100	89
325S1	18	1	75 (cement A)	None	25 (calcined shale	97	75	96	75
325S2	1					108	104	106	83
425S1	42	2				119	26	NR	NR
425S2	38					100	89	100	Broken
525S1	51	3			25 (shale)	Broken	61	NR	Broken
525S2	12					116	96	110	108
625S1	27	4				75	NR	88	109
625S2	13					101	96	113	98
335N1	3	1	65 (cement A)	35 (nat cement)	None	110	82	84	72
335N2	24					97	94	90	86
435N1	50	2				108	98	94	79
435N2	9					100	101	102	94
535N1	55	3				128	50	120	Broken
535N2	39					124	NR	118	101
635N1	4	4				Broken		Broken	
635N2	7					109		98	
325F1	53	1	75 (cement A)	None	25 (fly ash)	101	81	90	81
325F2	45					106	97	105	100
425F1	56	2				84	96	80	95
425F2	25					116	99	112	96
525F1	17	3				112	103	104	105
525F2	29					107	100	104	80
625F1	33	4				100	95	97	87
625F2	36					124	107	110	60
3BFS1	41	1	None	100 (portland blast-furnace slag cement)	None	95	NR	69	84
3BFS2	19					96	94	96	93
4BFS1	52	2				110	68	107	59
4BFS2	21					110	92	99	90
5BFS1	16	3				99	72	84	68
5BFS2	2					86	74	78	Broken
6BFS1	5	4				97	41	71	Broken
6BFS2	37					110	73	109	97
335F1	22	1	65 (cement A)	None	35 (fly ash)	102	97	101	104
335F2	54					109	85	102	69
435F1	46	2				92	97	93	93
435F2	48					105	83	94	89
535F1	47	3				79	88	79	94
535F2	34					125	NR	123	97
635F1	32	4				107	91	101	92
635F2	43					110	89	112	69

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* NR means no reading was obtained.

Investigation of Plastic Based Mortar Coatings

In July 1969, eight concrete panels (nominal size 10 by 10 by 3 in.) were installed on the exposure rack at Treat Island. These panels are part of an investigation to determine the field durability of certain plastic based coatings.

The panels were made of air-entrained concrete containing 3/4-in. maximum size natural coarse aggregate, natural sand fine aggregate, and type II portland cement. The concrete in four of the panels had a 28-day compressive strength of 3000 psi, while the concrete in the other four had a 28-day compressive strength of 5000 psi. Each panel (10 by 10 by 3 in.) was formed against a plywood mold, moist-cured for 28 days, and then stored at a relative humidity of 50 percent for seven days (at laboratory temperature). After this 35-day curing period each panel was coated with a 1/8- to 1/4-in.-thick plastic based mortar coating in accordance with the coating manufacturer's specifications. The coated panels were then stored at 50 percent relative humidity (at laboratory temperature) for 28 days and then shipped to Treat Island.

The eight panels installed in July 1969 were coated with a plastic based mortar coating designated PMC-1. Table 1-MBC lists these panels and gives their exposure record along with other pertinent information.

In early November 1969, eight additional concrete panels of the same size were installed on the Treat Island exposure rack. These panels were identical in every respect to the first eight panels except that a different plastic based mortar coating, designated PMC-2, was used. The exposure record and other information about these panels are given in table 2-MBC.

Panels representing two additional plastic based mortar coatings were installed at Treat Island in December 1971. The mortar coatings, designated PMC-3 and PMC-4, represent two new materials. The panels are identical with previous ones exposed. The exposure record and other information are given in Tables 3-MBC and 4-MBC.

Table 1-MBC

Investigation of Plastic Based Mortar Coatings

Record of Testing of Concrete Panels

1969- (Installed July 1969)

			Exposure Rack, Row 5 (W to E)		
			1969-1971 Conditions		
Panel No.	28-day Compressive Strength of Mixture, psi	Mortar Coating	0 Cycles 1969	153 Cycles 1970	322 Cycles 1971
I-A-1	3000	PMC-1	Sound	Light spalling	Heavy spalling
I-A-2	3000	PMC-1	Sound	Moderate spalling	Heavy spalling
I-A-3	3000	PMC-1	Sound	Moderate spalling	Heavy spalling
I-A-4	3000	PMC-1	Sound	Moderate spalling	Heavy spalling
I-B-1	5000	PMC-1	Sound	Heavy spalling	Heavy spalling
I-B-2	5000	PMC-1	Sound	Heavy spalling	Heavy spalling
I-B-3	5000	PMC-1	Sound	Heavy spalling	Heavy spalling
I-B-4	5000	PMC-1	Sound	Heavy spalling	Heavy spalling
			479 Cycles, 1972*		
I-A-1	3000	PMC-1	Mortar coating completely deteriorated		
I-A-2	3000	PMC-1	Mortar coating completely deteriorated		
I-A-3	3000	PMC-1	Mortar coating completely deteriorated		
I-A-4	3000	PMC-1	Mortar coating completely deteriorated		
I-B-1	5000	PMC-1	Mortar coating completely deteriorated		
I-B-2	5000	PMC-1	Mortar coating completely deteriorated		
I-B-3	5000	PMC-1	Mortar coating completely deteriorated		
I-B-4	5000	PMC-1	Mortar coating completely deteriorated		

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* Monitoring discontinued after 1972 inspection.

Table 2-MBC

Investigation of Plastic Based Mortar Coatings

Record of Testing of Concrete Panels

1969- (Installed November 1969)

Exposure Rack, Row 5 (W to E)

			1969-1971 Conditions		
Panel No.	28-day Compressive Strength of Mixture, psi	Mortar Coating	0 Cycles 1969	153 Cycles 1970	322 Cycles 1971
II-A-1	3000	PMC-2	Sound	Light spalling	Heavy spalling
II-A-2	3000	PMC-2	Sound	Light spalling	Heavy spalling
II-A-3	3000	PMC-2	Sound	Light spalling	Heavy spalling
II-A-4	3000	PMC-2	Sound	Sound	Heavy spalling
II-B-1	5000	PMC-2	Sound	Sound	Heavy spalling
II-B-2	5000	PMC-2	Sound	Sound	Heavy spalling
II-B-3	5000	PMC-2	Sound	Light cracking	Heavy spalling
II-B-4	5000	PMC-2	Sound	Sound	Moderate spalling
			479 Cycles, 1972		
II-A-1	3000	PMC-2	Mortar coating completely deteriorated		
II-A-2	3000	PMC-2	Mortar coating completely deteriorated		
II-A-3	3000	PMC-2	Heavy spalling		
II-A-4	3000	PMC-2	Heavy spalling		
II-B-1	5000	PMC-2	Heavy spalling		
II-B-2	5000	PMC-2	Heavy spalling		
II-B-3	5000	PMC-2	Heavy spalling		
II-B-4	5000	PMC-2	Moderate spalling		
			619 Cycles, 1973*		
II-A-1	3000	PMC-2	Mortar coating completely deteriorated		
II-A-2	3000	PMC-2	Mortar coating completely deteriorated		
II-A-3	3000	PMC-2	Mortar coating completely deteriorated		
II-A-4	3000	PMC-2	Mortar coating completely deteriorated		
II-B-1	5000	PMC-2	Mortar coating completely deteriorated		
II-B-2	5000	PMC-2	Mortar coating completely deteriorated		
II-B-3	5000	PMC-2	Mortar coating completely deteriorated		
II-B-4	5000	PMC-2	Mortar coating completely deteriorated		

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* Monitoring discontinued after 1973 inspection.

Table 3-MBC

Investigation of Plastic Based Mortar Coatings

Record of Testing of Concrete Panels

1970- (Installed Dec 1970)

			Exposure Rack, Row 5 (W to E)		
			1970-1972 Conditions		
Panel No.	28-day Compressive Strength of Mixture, psi	Mortar Coating	0 Cycles 1970	156 Cycles 1971	313 Cycles 1972
III-A-1	3000	PMC-3	Sound	Light spalling	Light spalling
III-A-2	3000	PMC-3	Sound	Light spalling	Light spalling
III-A-3	3000	PMC-3	Sound	Light spalling	Light spalling
III-A-4	3000	PMC-3	Sound	Light spalling	Light spalling
III-B-I	5000	PMC-3	Sound	Light spalling	Light spalling
III-B-2	5000	PMC-3	Sound	Light spalling	Light spalling
III-B-3	5000	PMC-3	Sound	Light spalling	Light spalling
III-B-4	5000	PMC-3	Sound	Light spalling	Light spalling
			453 Cycles, 1973*		
III-A-1	3000	PMC-3	Mortar coating completely deteriorated		
III-A-2	3000	PMC-3	Mortar coating completely deteriorated		
III-A-3	3000	PMC-3	Mortar coating completely deteriorated		
III-A-4	3000	PMC-3	Mortar coating completely deteriorated		
III-B-1	5000	PMC-3	Mortar coating completely deteriorated		
III-B-2	5000	PMC-3	Mortar coating completely deteriorated		
III-B-3	5000	PMC-3	Mortar coating completely deteriorated		
III-B-4	5000	PMC-3	Mortar coating completely deteriorated		

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* Monitoring discontinued after 1973 inspection.

Table 4-MBC

Investigation of Plastic Based Mortar Coatings

Record of Testing of Concrete Panels

1970- (Installed Dec 1970)

Exposure Rack, Row 5 (W to E)

			1970-1972 Conditions		
Panel No.	28-day Compressive Strength of Mixture, psi	Mortar Coating	0 Cycles 1970	156 Cycles 1971	313 Cycles 1972
IV-A-1	3000	PMC-4	Sound	Light spalling	Light spalling
IV-A-2	3000	PMC-4	Sound	Sound	Light spalling
IV-A-3	3000	PMC-4	Sound	Light spalling	Light spalling
IV-A-4	3000	PMC-4	Sound	Light spalling	Light spalling
IV-B-1	5000	PMC-4	Sound	Sound	Sound
IV-B-2	5000	PMC-4	Sound	Sound	Sound
IV-B-3	5000	PMC-4	Sound	Light spalling	Light spalling
IV-B-4	5000	PMC-4	Sound	Light spalling	Light spalling

			453 Cycles, 1973*
IV-A-1	3000	PMC-4	Mortar coating completely deteriorated
IV-A-2	3000	PMC-4	Mortar coating completely deteriorated
IV-A-3	3000	PMC-4	Mortar coating completely deteriorated
IV-A-4	3000	PMC-4	Mortar coating completely deteriorated
IV-B-1	5000	PMC-4	Mortar coating completely deteriorated
IV-B-2	5000	PMC-4	Mortar coating completely deteriorated
IV-B-3	5000	PMC-4	Mortar coating completely deteriorated
IV-B-4	5000	PMC-4	Mortar coating completely deteriorated

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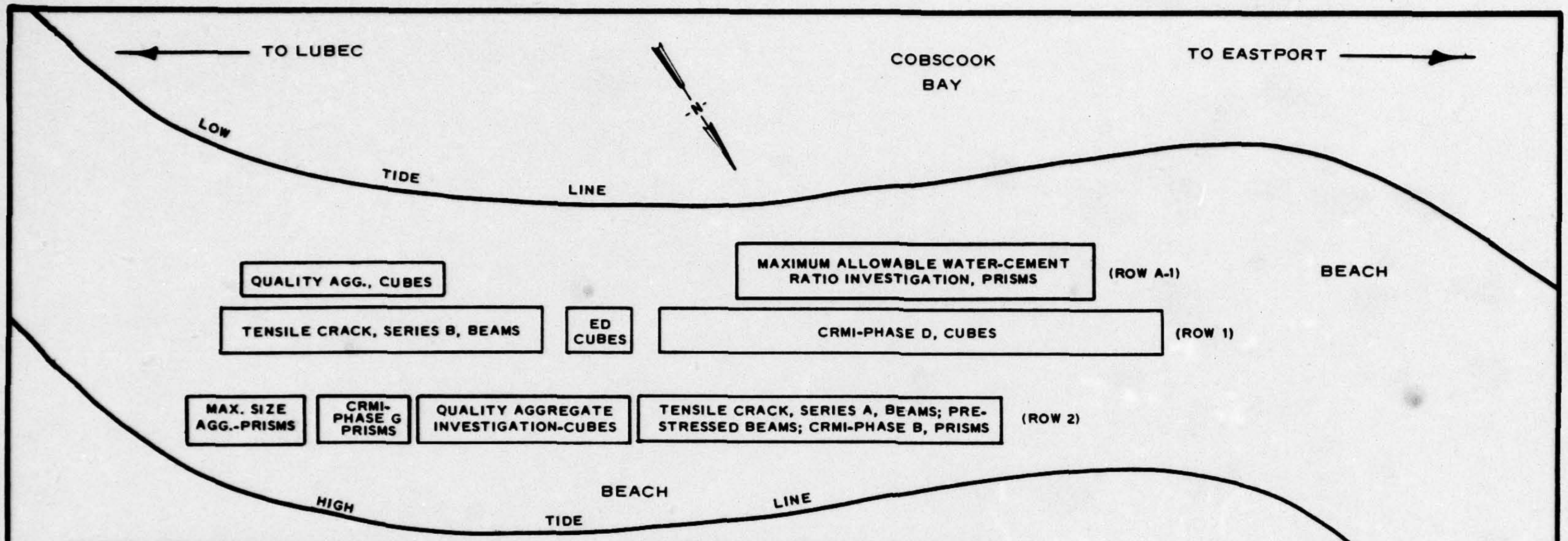
* Monitoring discontinued after 1973 inspection.



SUMMARY OF SPECIMENS ON BEACH

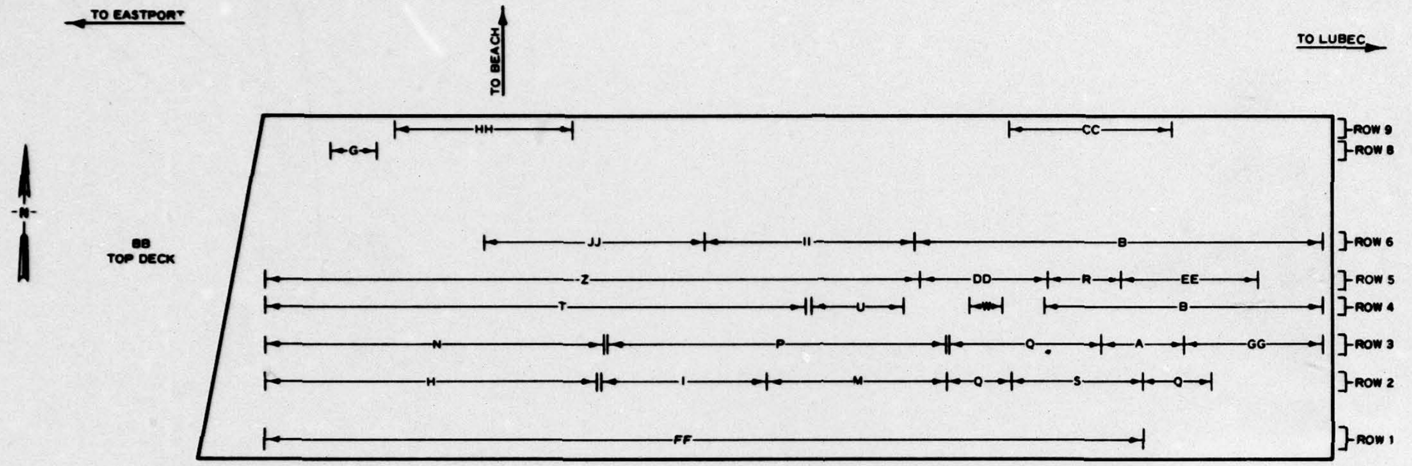
SECTION NO.	ROW	SERIES	SPECIMENS			DATE INSTALLED
			SIZE	INSTALLED	LEFT	
2	1	TENSILE CRACK, SERIES B, BEAMS	7 FT 9 IN. LONG	76	75	NOV. 1954
28	1	EUFAULA DAM, CUBES	2 FT	3	3	OCT. 1958
8	1	CRMI-PHASE D, CUBES	2 FT	20	7	OCT. 1958
1	2	TENSILE CRACK, SERIES A, BEAMS	7 FT 9 IN. LONG	82	17	NOV. 1951
4	2	CRMI-PHASE B, PRISMS	18 × 18 × 36 IN.	21	6	DEC. 1953
6	2	PRESTRESSED BEAMS (PRETENSIONED)	81 IN. LONG	16	5	OCT. 1958
6	2	PRESTRESSED BEAMS (POST-TENSIONED)	10 × 16 × 96 IN.	20	20	JUNE 1961
36	2	CRMI-PHASE G, PRISMS	18 × 18 × 36 IN.	2	0	NOV. 1962
37	2	MAXIMUM SIZE AGGREGATE, PRISMS	18 × 18 × 36 IN.	18	13	DEC. 1963
35	2	QUALITY AGGREGATE CUBES	2 FT	10	3	NOV. 1962
35	A-1	QUALITY AGGREGATE CUBES	2 FT	6	2	DEC. 1963
38	A-1	MAX. ALLOWABLE W/C RATIO, PRISMS	18 × 18 × 36 IN.	24	22	DEC. 1964

ARRANGEMENT OF TEST SPECIMENS ON BEACH

SEVERE-WEATHERING
EXPOSURE STATION
TREAT ISLAND, MAINE

JAN 1973

PLATE 1



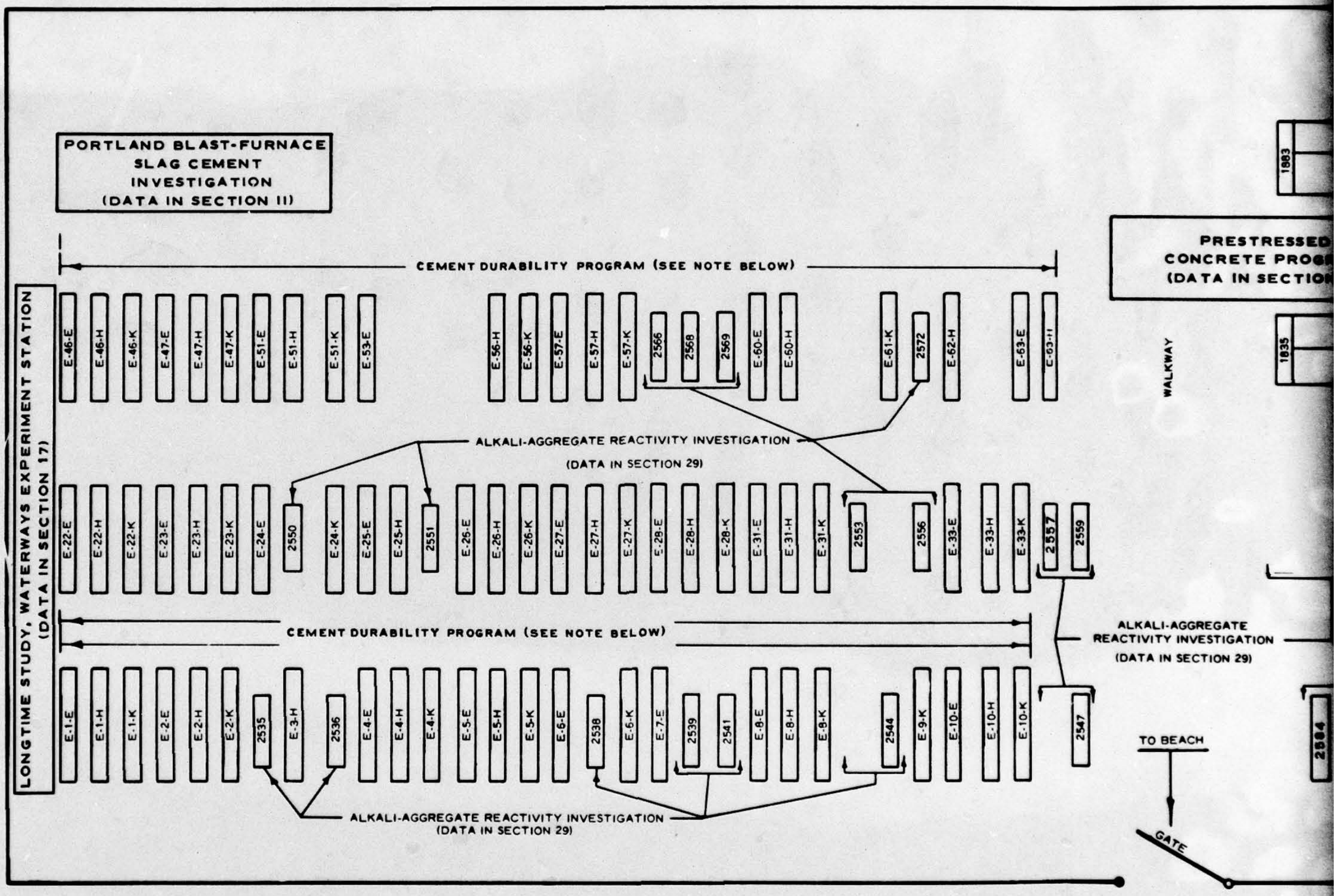
LEGEND

A	CERL FIBROUS CONCRETE (SECTION 5)
B	WES FIBROUS CONCRETE (SECTION 7)
G	PASSAMAQUODDY PROJECT (SECTION 9)
H	AIR-ENTRAINING ADMIXTURE STUDY (SECTION 25)
I	KANSAS CITY AGGREGATE PROGRAM (SECTION 27)
M	OMAHA DISTRICT AGGREGATE PROGRAM (SECTION 26)
N	LONG-TIME STUDY, WES (SECTION 17)
P	PRESTRESS (PRETENSIONED) PROGRAM (SECTION 6)
T	CRMI-PHASE D (CORES) (SECTION 8)
U	MT. MORRIS DAM CORES (SECTION 22)
W	PINE FLAT DAM CORES (SECTION 5)
Z	PORTLAND BLAST-FURNACE SLAG CEMENT (SECTION 11)
BB	MEMBRANE CURING PROGRAM (SECTION 34)
CC	STEWART FIELD SPHERES (SECTION 3)
DD	MISSOURI RIVER DIVISION PROGRAM (SECTION 10)
EE	WOVEN PLASTIC TEST PROGRAM (SECTION 31)
FF	CURING INVESTIGATION (SECTION 39)
Q	SPECIMEN SIZE-FROST EFFECTS INVESTIGATION (SECTION 12)
R	INVESTIGATION OF PLASTIC BASED MORTAR COATINGS (SECTION 40)
S	INVESTIGATION OF 4-1/2-IN. AGGREGATE CONCRETE (SECTION 14)
GG	TRUMBULL POND DAM PRISMS (SECTION 13)
HH	SULFUR-INFILTRATED CONCRETE
II	ROLLER COMPACTED CONCRETE
JJ	CHARLES RIVER-SMELT BROOK (SECTION 18)

ARRANGEMENT OF TEST SPECIMENS ON RACK

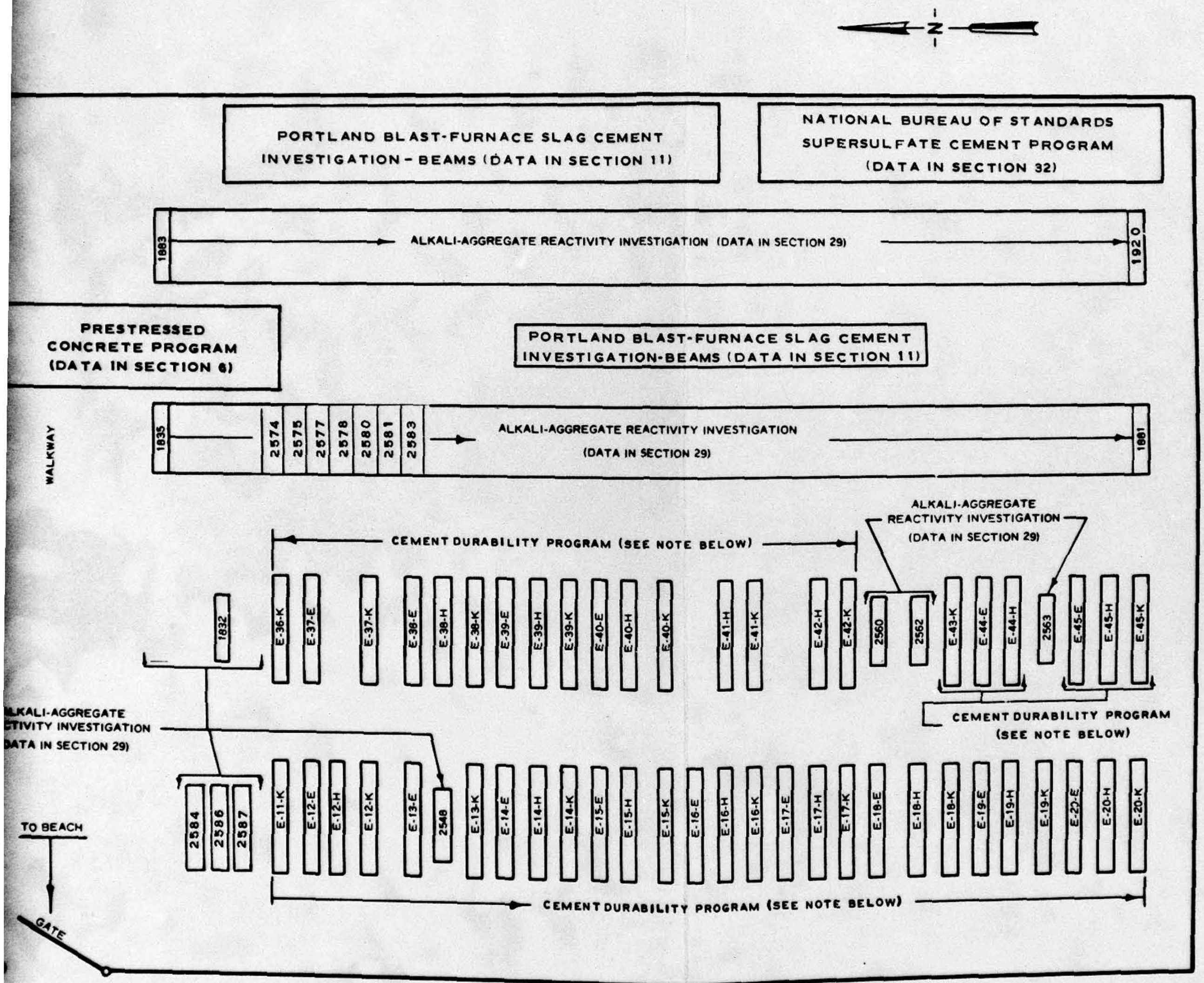
SEVERE-WEATHERING
EXPOSURE STATION
TREAT ISLAND, MAINE
AUGUST 1977

PLATE 2



NOTE: THE EXPOSURE OF THESE CEMENT DURABILITY PROGRAM SPECIMENS HAS NOW BEEN TERMINATED. THE TEST SPECIMENS REMAIN ON THE EXPOSURE RACK, HOWEVER. SEE VOL II, COMPLETED INVESTIGATIONS, PROGRAM 21.

THE TESTING AND INSTALLATION OF SPECIMENS AT ST. AUGUSTINE WAS DISCONTINUED AFTER THE 1970 INSPECTION. IN AUGUST 1971, 15 SPECIMENS FROM THE ALKALI-AGGREGATE REACTIVITY INVESTIGATION WERE RETURNED TO THE LABORATORY.



ARRANGEMENT OF TEST SPECIMENS
MILD-WEATHERING EXPOSURE STATION
ST AUGUSTINE, FLORIDA

(SEE TABLE 2)

JAN. 1972

NOT TO SCALE