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DIVISION OF STRUCTURAL ENGINEERING
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UNIVERSITY OF CALIFORNIA

UC SESM 72-3

STRUCTURES AND MATERIALS RESEARCH
DEPARTMENT OF CIVIL ENGINEERING

STUDIES OF CONCRETE FOR MILLSTONE UNIT No. 2 NUCLEAR CONTAINMENT VESSEL

FINAL REPORT

by

DAVID PIRTZ

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FEBRUARY 1972

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DIVISION OF STRUCTURAL ENGINEERING
AND STRUCTURAL MECHANICS

BERKELEY, CALIFORNIA 94720

February 9, 1972

Bechtel Corporation
Post Office Box 607
15740 Shady Grove Road
Gaitersburg, Maryland 20760

Attention: Mr. J. L. Turdera

Gentlemen:

RE: Concrete Properties of Millstone Unit No. 2 Nuclear Containment Vessel, FINAL REPORT.

Transmitted herewith is the final report entitled, "Studies of Concrete for Millstone Unit No. 2 Nuclear Containment Vessel - Coarse Aggregate: Wallingford Basalt."

This report contains compressive strength; splitting tensile strength, elastic properties, diffusivity, thermal coefficient of expansion, and creep for concrete loaded at ages of 28, 212 and 365 days.

Sincerely yours,

David Pirtz
Professor of Civil Engineering

DP:ib
Enclosure
cc: D. Graham

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Final Report

STUDIES OF CONCRETE FOR MILLSTONE UNIT NO. 2
NUCLEAR CONTAINMENT VESSEL
COARSE AGGREGATE: WALLINGFORD BASALT

TEST PROGRAM

The purpose of the testing program is to establish some of the mechanical and thermal properties of the concrete using 1 1/2-in. maximum size aggregate to be used in the construction of the Millstone Unit No. 2 Nuclear Power Plant's containment structure.

The test program comprises of the evaluation of the properties of the concrete:

a. Compressive Strength to be determined on sealed concrete specimens stored at 73°F at ages of 7, 28, 180 and 365 days on three each of 6-in. x 12-in. cylinders.

b. Modulus of Elasticity and Poisson's Ratio to be determined on sealed concrete specimens stored at 73°F at ages of 28, 180 and 365 days.

c. Diffusivity to be determined on sealed concrete specimens at age of 28 days for two each of 8 1/2-in. x 17-in. cylinders.

d. Coefficient of Thermal Expansion to be determined on sealed concrete specimens stored at 73°F at ages of 28, 180 and 365 days on two cylinders of 6-in. x 18-in.

e. Tensile Strength to be determined on sealed concrete specimens stored at 73°F at age of 28 days by the splitting tension method.

f. Creep characteristic of sealed concrete specimens to be determined at a sustained load of 1530 psi initially applied at 28, 180 and 365 days.

Observations for Autogeneous Strain change shall be determined for 1 year on creep specimens that are to be loaded at age of 1 year. The creep tests shall be carried out on three frames containing 2 each 6-in. x 16-in. cylinders per frame at 73°F.

CONCRETE MIX

The mix design and data for the concrete mixes used in casting the specimens are shown in Table A and B. In Table B the weight of cement, water, sand, 3/4-in. and 1 1/2-in. aggregate per cu. yd. of concrete was computed using the measured unit weight of the concrete and the batch weight of each material.

The aggregates used in casting the specimens were shipped to Davis Hall on the University of California campus at Berkeley. The aggregates were placed in steel drums and soaked for 24 hours then air dried and blended to about saturated surface dry conditions (sand + 1.65%, 3/4-in. agg. + 0.46%, and 1 1/2-in. agg. + 0.16%.) Bulk specific gravities and absorption capacities of the aggregates as determined at Berkeley are shown in Table C.

The concrete was mixed in a 2 cu. ft. capacity pan-type mixer with each batch making approximately 1.70 cu. ft. of concrete.

Hand-held internal vibrators were used in the casting to insure proper compaction of the concrete.

MANUFACTURE OF SPECIMENS

Creep and thermal expansion specimens were cast in 6-in. x 16-in. machined split cast iron molds. A 10-in. Carlson Strain Meter was centered on the axis of the cast iron mold with its lead wire being brought out through a hole in the center of the 2-inch thick base plate which has an "O" ring seal for the lead wire. A 1/8-in. x 8-in. metal rod was placed

diametrically across the top of this mold to serve as support for a wire which held the meter in an axial position during casting. After casting, the wire was cut off and the rod removed.

The creep and thermal expansion specimens were allowed about 5 hours time for the bleeding water to rise to the surface, and then a conical-shaped layer of mortar made from the original mix was formed on the top of each cylinder. The 2-in. thick steel top-plates were then worked back and forth into position until the mortar appeared to be spread uniformly between the plate and the specimen. A square was used to assure that each top-plate was perpendicular to the axis of the specimen. The creep and thermal expansion specimens were then moved to the 73°F constant temperature room.

Split cast iron molds were stripped from the creep and thermal expansion specimens at the age of one day. Within 3 minutes after removal of the cast iron mold a 1/16-in. thick butyl rubber sheet was wrapped and bonded to the top and bottom steel plate with rubber cement. A 4-in. wide butt-splice was used to join the butyl rubber sheet. Large hose clamps were placed over the butyl rubber and the end steel plates to assure that the specimens would be internally sealed.

Compressive strength specimens were cast in 6-in. by 12-in. metal cans provided with lids to internally seal the specimen. All compressive strength specimens remained in mold cans in the fog room until just prior to testing, at which time they were stripped, capped, and covered with saran wrapping to ensure water retention through the test period.

Splitting tension specimens were cast in 6-in. by 12-in. metal cans provided with lids to internally seal the specimens. All splitting tension specimens remained in metal cans in the fog room until just prior to testing.

Specimens for thermal diffusivity tests were cast in 8 1/2-in. by 17-in. 0.020 in. thick copper cans. They were cast solid except for a 3/8-in. diameter by 8 1/2-in. deep thermometer well centered on the axis of the specimen. The external metal container was left on the cylinders throughout the duration of the test.

TEST PROCEDURES AND RESULTS

Compressive Strength and Elastic Properties

Compressive strength was determined at the ages of 7, 28, 212 and 365 days. Each strength determination represents the average obtained for three 6-in. by 12-in. cylinders. The same three 6-in. by 12-in. concrete cylinders were used in the determination of compressive strength, modulus or elasticity (E), and Poisson's ratio (μ) for the 28, 212 and 365-day-old concrete. The modulus of elasticity and Poisson's ratio were determined by use of an XYY' recorder employing differential transformers. This arrangement produces a continuous plot of both longitudinal stress vs. longitudinal strain and longitudinal strain vs. lateral strain from which both the modulus of elasticity and Poisson's ratio were computed. The loading rate used was 60,000 lbs. per minute which is equivalent to 36 psi/sec., for the 6-in. diameter specimens.

Compressive strengths, modulus of elasticity, and Poisson's ratio for sealed concrete specimens stored at $73^{\circ}F$ are shown in Table D.

Splitting tensile strength was determined on three 6-in. x 12-in. concrete cylinders at age of 28 days by A.S.T.M. C496-66 method. Data for splitting tension is shown in Table D.

Thermal Diffusivity

The 28-day thermal diffusivity, as determined on two 8 1/2-in. diameter by 17-in. long concrete cylinders, was 0.029 ft^2/hr. The hot water bath and

the cold water bath were approximately 120°F and 40°F, respectively, for the thermal diffusivity tests.

Thermal diffusivity determined by cooling test as described on pages 66 through 86 and pages 133 through 143 in "Thermal Properties of Concrete," Bulletin 1, United States Bureau of Reclamation, Boulder Canyon Project, Final Report, 1940.

Thermal Coefficient of Expansion

The two 6-in. by 16-in. thermal coefficient of expansion specimens were cycled several times from 40°F to 90°F. Specimens were left for at least 24 hours at each temperature before strain readings were taken. At the end of the cycling period the specimens were stored at 73°F. The average linear thermal expansion for the two specimens at age of 28, 215 and 365 days was 5.1, 5.0, and 5.2 micro-strain per 1°F temperature change, respectively.

Creep Tests

Creep characteristics for the concrete were determined on sealed 6-in. by 16-in. cylinders with centrally embedded Carlson Strain Meters. Two specimens each were initially loaded at the ages of 28, 212 and 365 days all at a temperature of 73°F. Two specimens which were loaded at 365 days were used to determine the autogenous strain for the 28 and 212-day loaded creep specimens. Autogenous strain change after the age of 365 days were very small and assumed to be zero.

A stress level of 1530 psi was applied to all loaded creep specimens by a hydraulic system with an automatic controller which was used to maintain a constant stress level.

Sustained modulus of elasticity, creep characteristics, and autogenous strains for sealed concrete specimens stored at 73°F are shown in Table E

for concrete loaded at age of 28 days, in Table F for concrete loaded at age of 212 days, and in Table G for concrete loaded at age of 365 days. The total load was applied within 30 seconds and the first strain reading taken within another 30 seconds or 1 minute after the load was started to be applied. Specimens loaded at 28 days were under stress for 338 days and then unloaded to zero stress and those loaded at 212 days were under stress for 154 days and then unloaded to zero stress. Specimens loaded at age of 365 days have been under stress for 100 days. Sustained modulus of elasticity was computed by dividing the applied stress of 1530 psi by the sum of the elastic, creep, and autogenous strains at 1 minute after the load was started to be applied and at various other times. Creep plus autogenous strains and creep strains only starting from one minute and 10 minutes after load was applied are shown. Autogenous strains shown are those starting from the time the load was applied were taken as zero. Creep plus autogenous strains and creep strains per psi of stress starting from 10 minutes after load was applied were taken as zero are shown.

Elastic, creep, plus autogenous strains; creep plus autogenous strains from 10 minutes after load was applied; and creep strains from 10 minutes after load was applied are all shown plotted vs log of time for the average of two sealed concrete specimens stored at 73°F in Figure 1 for specimens loaded at age of 28 days, in Figure 2 for specimens loaded at age of 212 days, and in Figure 3 for specimens loaded at age of 365 days.

Elastic, creep, plus autogenous strains for specimens loaded at age of 28 and 212 days up to 365 days and for specimens loaded at age 365 days for 100 days are shown plotted vs time in days for the average of two sealed concrete specimens stored at 73°F in Figure 4. Strains for the 28 days and 212 days loaded specimens which were unloaded at age of 365 days are also shown for 100 days.

The complete computer calculations for determining the strains due to loading and unloading the sealed concrete specimens are shown in Tables H and I for specimens initially loaded at age of 28 days and Tables J and K for specimens initially loaded at age of 212 days. Tables L and M show the complete calculations for determining the autogenous strains up to age of 365 days and then the strain due to loading the sealed concrete specimens at age of 365 days.

TABLES

TABLE A

MIX DESIGN FOR MILLSTONE UNIT NO. 2 CONCRETE

Material		Source
Cement:	ASTM C150 Type II	Lehigh Portland Cement Company
Pozzolan:		Northeast Utilities Company
Sand:		Wauregan Alluvial Glacial
3/4-in. Gravel:		Wallingford basalt
1 1/2-in. Gravel:		" "
WRA Admixture:	MBHC	Master Builders
AEA Admixture:	Vinsol Resin Air Entraining Agent	Master Builders

Specifications:

f'c (at 28 days) 5,000 psi

Slump: 2 to 3 inches

Air: 4 percent

One Cubic Yard Batch, SSD Weights as given by Mr. D. E. Graham, Bechtel Corporation (San Francisco office)

	Wallingford Basalt
Cement, lbs	559
Pozzolan, lbs	99
Sand, lbs	1130
3/4-in. Gravel, lbs	1035
1 1/2-in. Gravel, lbs	966
Water, lbs	283
WRA, oz.	8.93
AEA, oz.	5.95

TABLE B

CASTING DATA

WALLINGFORD BASALT

Date	October 27, 1970				
Specimens Cast	6 - 6x16-in. creep specimens 2 - 6x16-in. thermal expansion cylinders 15 - 6x12-in. compressive strength, Young's Modulus and Poisson's ratio cylinders 3 - 6x12-in. splitting tension cylinders 1 - 8 1/2x17-in. diffusivity cylinders				
Batch No.[a]	1[b]	2	3	4	Avg.
Cement, pcy	570	565	565	560	565
Fly Ash, pcy	101	100	100	99	100
Water, pcy	263	253	257	255	257
Sand, pcy S.S.D.	1172	1161	1162	1152	1162
3/4-in. aggregate, pcy S.S.D.	1061	1051	1052	1043	1054
1 1/2-in. aggregate, pcy S.S.D.	987	978	979	970	979
Unit wt., pcf	153.9	152.2	152.5	151.1	152.4
Slump, inches	3	2 1/2	3	3 1/4	3
Air, % by Vol.	3.0	3.5	4.0	4.5	4.0
AEA, oz. pcy	6.07	7.16	7.72	7.72	7.16
W.R.A. oz. pcy	9.10	9.03	9.03	8.96	9.03
Temp. ^{o}F [c]	63	63	63	65	63

(a) Each batch approximately 1.70 cu. ft.

(b) Used in the bottom quarter of all specimens.

(c) Water, cement, and fly ash stored at 38^{o}F.

TABLE C

MILLSTONE NUCLEAR CONTAINMENT VESSEL CONCRETE

BULK SPECIFIC GRAVITY AND ABSORPTION CAPACITY

Aggregate	BULK SPECIFIC GRAVITY - Saturated Surface Dry	ADSORPTION CAPACITY, percent
Wauregan alluvial glacial sand	2.70	1.21
3/4-in. Wallingford basalt	2.90	1.46
1 1/2-in. " "	2.90	1.16

TABLE D

MECHANICAL AND THERMAL PROPERTIES

Age, Days	7	28	212	365
Compressive strength,[(a)] psi	3950	5810	8050	7680
Poisson's ratio[(a)]	-	0.21	0.22	0.23
Modulus of Elasticity,[(a)] psi x 10^6	-	4.7	5.5	5.6
" " " ,[(b)] psi x 10^6	-	4.5	5.0	5.2
Splitting tensile strength[(a)], psi	-	535	-	
Diffusivity, ft^2/hr	-	0.029	-	
Linear thermal expansion Micro-strain per ^oF	-	5.1	5.0	5.2

(a) Average of three 6 x 12-in. cylinders.

(b) Average of two creep specimens.

TABLE E

MILLSTONE NUCLEAR CONTAINMENT VESSEL -

ELASTIC, CREEP, AND AUTOGENOUS STRAINS -

COARSE AGGREGATE: WALLINGFORD BASALT

Maximum size of aggregate: 1 1/2-in.
Specimen size: 6-in. by 16-in. (Sealed)
Temperature: 73 ± 3°F
Age of loading: 28 days
Applied stress: 1530 psi
Compressive strength: 5810 psi at age 28 days
8050 psi at age 212 days
7680 psi at age 365 days

Time under stress, Days	Sustained Modulus of Elasticity, psi x 10^6 (a)	Elastic, Creep plus Autog-enous	Micro-strain						
			Creep plus Autogenous			Autog-enous	Creep		
			Time after load applied				Time after load applied		
			1 min.	10 min.			1 min.	10 min.	
					per psi (b)				per psi (b)
0	-	0							
0.0007	4.46	-343	0			0	-0		
0.0035	4.32	-354	-11			0	-11		
0.0069	4.27	-358	-15	0	0	0	-15	0	0
0.115	3.96	-386	-43	-28	-0.0183	0	-43	-28	-0.0183
0.694	3.71	-412	-69	-54	-0.0353	0	-69	-54	-0.0353
1	3.62	-423	-80	-65	-0.0425	0	-80	-65	-0.0425
2	3.52	-435	-92	-77	-0.0503	0	-92	-77	-0.0503
3	3.41	-449	-106	-91	-0.0595	0	-106	-91	-0.0595
4	3.36	-455	-112	-97	-0.0634	-1	-111	-96	-0.0627
5	3.30	-464	-121	-106	-0.0692	-1	-120	-105	-0.0686
7	3.22	-475	-132	-117	-0.0765	-2	-130	-115	-0.0751
15	2.97	-516	-173	-158	-0.103	-3	-170	-155	-0.101
29	2.78	-551	-208	-193	-0.126	-5	-203	-188	-0.123
39	2.70	-566	-223	-208	-0.136	-6	-217	-202	-0.132
55	2.62	-584	-241	-226	-0.147	-7	-241	-219	-0.143
77	2.53	-605	-262	-247	-0.161	-8	-254	-239	-0.156
93	2.49	-614	-271	-256	-0.167	-9	-262	-247	-0.161
105	2.46	-621	-278	-263	-0.172	-10	-270	-253	-0.165
119	2.43	-630	-287	-272	-0.178	-13	-274	-259	-0.169
133	2.41	-634	-291	-276	-0.180	-10	-281	-266	-0.174
154	2.39	-641	-298	-283	-0.185	-8	-290	-275	-0.180
168	2.37	-646	-303	-288	-0.188	-8	-295	-280	-0.183
182	2.35	-652	-309	-294	-0.192	-9	-300	-285	-0.185
196	2.33	-657	-314	-299	-0.195	-9	-305	-290	-0.189

(a) Sustained Modulus of Elasticity computed as follows: 1530 psi divided by sum of elastic, creep, and autogenous strains.

(b) Micro-strain ÷ 1530 psi.

TABLE E (Contd.)

MILLSTONE NUCLEAR CONTAINMENT VESSEL -

ELASTIC, CREEP, AND AUTOGENOUS STRAINS -

COARSE AGGREGATE: WALLINGFORD BASALT

Maximum size of aggregate: 1 1/2-in.
Specimen size: 6-in. by 16-in. (Sealed)
Temperature: 73 ± 3°F
Age of loading: 28 days
Applied stress: 1530 psi
Compressive strength: 5810 psi at age 28 days
8050 psi at age 212 days
7680 psi at age 365 days

Time under stress, Days	Sustained Modulus of Elasticity, psi x 10^6 (a)	Elastic, Creep plus Autogenous	Micro-strain						
			Creep plus Autogenous			Autogenous	Creep		
			Time after load applied				Time after load applied		
			1 min.	10 min.	per psi (b)		1 min.	10 min.	per psi (b)
210	2.31	-662	-319	-304	-0.199	-9	-310	-295	-0.193
224	2.30	-665	-322	-307	-0.201	-11	-311	-296	-0.193
238	2.29	-667	-324	-309	-0.202	-11	-313	-298	-0.195
252	2.27	-672	-329	-314	-0.205	-12	-317	-302	-0.197
266	2.26	-676	-333	-318	-0.208	-13	-320	-305	-0.199
280	2.25	-678	-335	-320	-0.209	-15	-320	-305	-0.199
295	2.24	-684	-341	-326	-0.213	-16	-325	-310	-0.203
309	2.23	-685	-342	-327	-0.214	-17	-325	-310	-0.203
325	2.23	-687	-344	-329	-0.215	-17	-327	-312	-0.204
338	2.22	-689	-346	-331	-0.216	-17	-329	-314	-0.205

(a) Sustained Modulus of Elasticity computed as follows: 1530 psi divided by sum of elastic, creep, and autogenous strains.

(b) Micro-strain ÷ 1530 psi.

TABLE F

MILLSTONE NUCLEAR CONTAINMENT VESSEL -

ELASTIC, CREEP, AND AUTOGENOUS STRAINS -

COARSE AGGREGATE: WALLINGFORD BASALT

Maximum size of aggregate: 1 1/2-in.
Specimen size: 6-in. by 16-in. (Sealed)
Temperature: 73 ± 3°F
Age of loading: 212 days
Applied stress: 1530 psi
Compressive strength: 5810 psi at age 28 days
8050 psi at age 212 days
7680 psi at age 365 days

Time under stress, Days	Sustained Modulus of Elasticity, psi x 10^6 (a)	Elastic, Creep plus Autog-enous	Micro-strain						
			Creep plus Autogenous			Autog-enous	Creep		
			Time after load applied				Time after load applied		
			1 min.	10 min.			1 min.	10 min.	
					per psi (b)				per psi (b)
0	-	0				0			
0.0007	4.97	-302	0			0	0		
0.0035	4.93	-309	-7			0	-7		
0.0069	4.91	-311	-9	0	0	0	-9	0	0
0.0208	4.81	-318	-16	-7	-0.0045	0	-16	-7	-0.0045
0.0416	4.75	-322	-20	-11	-0.0071	0	-20	-11	-0.0071
0.1298	4.65	-329	-27	-18	-0.0117	0	-27	-18	-0.0117
1	4.49	-341	-39	-30	-0.0196	0	-37	-30	-0.0196
2	4.41	-349	-47	-38	-0.0248	0	-47	-38	-0.0148
3	4.35	-352	-50	-41	-0.0267	0	-50	-41	-0.0267
4	4.30	-356	-54	-45	-0.0294	-1	-53	-44	-0.0287
5	4.26	-359	-57	-48	-0.0313	-1	-56	-47	-0.0307
7	4.27	-363	-61	-52	-0.0339	-1	-60	-51	-0.0333
12	4.12	-371	-69	-60	-0.0392	-1	-68	-59	-0.0385
26	3.95	-387	-85	-76	-0.0496	-2	-83	-74	-0.0483
40	3.84	-398	-96	-87	-0.0568	-2	-94	-85	-0.0555
54	3.81	-402	-100	-91	-0.0594	-2	-98	-89	-0.0581
68	3.70	-413	-111	-102	-0.0666	-4	-107	-98	-0.0640
82	3.64	-420	-118	-109	-0.0712	-6	-112	-103	-0.0673
111	3.55	-431	-129	-120	-0.0784	-7	-122	-113	-0.0738
125	3.52	-435	-133	-124	-0.0810	-8	-125	-118	-0.0771
141	3.48	-440	-138	-129	-0.0843	-8	-130	-123	-0.0803
154	3.45	-444	-142	-133	-0.0869	-8	-134	-187	-0.0830

(a) Sustained Modulus of Elasticity computed as follows: 1530 psi divided by sum of elastic, creep, and autogenous strains.

(b) Micro-strain ÷ 1530 psi.

TABLE G

MILLSTONE NUCLEAR CONTAINMENT VESSEL -

ELASTIC, CREEP, AND AUTOGENOUS STRAINS -

COARSE AGGREGATE: WALLINGFORD BASALT

Maximum size of aggregate: 1 1/2-in.
Specimen size: 6-in. by 16-in. (Sealed)
Temperature: 73 ± 3°F
Age of loading: 365 days
Applied stress: 1530 psi
Compressive strength: 5810 psi at age 28 days
8050 psi at age 212 days
7680 psi at age 365 days

Time under stress, Days	Sustained Modulus of Elasticity, psi x 10^6 (a)	Elastic, Creep plus Autog-enous	Micro-strain						
			Creep plus Autogenous			Autog-enous	Creep		
			Time after load applied				Time after load applied		
			1 min.	10 min.			1 min.	10 min.	
					per psi (b)				per psi (b)
0	-	0				0			
0.0007	5.20	-294	0			0	0		
0.0035	5.10	-300	-6			0	-6		
0.0069	5.05	-303	-9	0	0	0	-9	0	0
0.031	4.97	-308	-14	-5	-0.0032	0	-14	-5	-0.0032
0.069	4.89	-313	-19	-10	-0.0065	0	-19	-10	-0.0065
0.273	4.83	-317	-23	-14	-0.0091	0	-23	-14	-0.0091
1	4.71	-325	-31	-22	-0.0143	0	-31	-22	-0.0143
2	4.65	-329	-35	-26	-0.0169	0	-35	-26	-0.0169
3	4.61	-332	-38	-29	-0.0189	0	-38	-29	-0.0189
5	4.54	-337	-43	-34	-0.0222	0	-43	-34	-0.0222
8	4.46	-343	-49	-40	-0.0261	0	-49	-40	-0.0261
10	4.42	-346	-52	-43	-0.0281	0	-52	-43	-0.0281
12	4.35	-352	-58	-49	-0.0320	0	-58	-49	-0.0320
19	4.29	-357	-63	-54	-0.0352	0	-63	-54	-0.0352
35	4.20	-364	-70	-61	-0.0450	0	-70	-69	-0.0450
68	4.07	-376	-82	-73	-0.0477	0	-82	-73	-0.0477
100	3.97	-385	-91	-82	-0.0535	0	-91	-82	-0.0535

(a) Sustained Modulus of Elasticity computed as follows: 1530 psi divided by sum of elastic, creep, and autogenous strains.

(b) Micro-strain ÷ psi.

STRAIN METER NO. X 1

PROJECT MILLSTONE 8 Y65901 LOADED TO 1530PSI AT AGE 28 DAYS
LOCATION DAVIS HALL ROOM 360A 73F DATE CAST 10-27-70

CALIBRATIONS

METER RESISTANCE AT 0.0 DEGREES F.	46.92	OHMS
CHANGE IN TEMP. PER OHM CHANGE IN RESIS.	11.88	DEGREES F.
USEFUL RANGE	96.9-102.2	RATIO IN PERCENT
ORIGINAL CALIBRATION CONSTANT	3.33	MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
CALIBRATION CONSTANT CORR. FOR LEAD	3.33	MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
TEMPERATURE CORRECTION	5.1	MICROSTRAIN PER DEGREE F.
CONCRETE EXPANSION	7.5	MICROSTRAIN PER DEGREE F.

DATE	TIME	METER RESIST. OHMS	TEMP. F.	RESIST. RATIO PERCENT	CHANGE IN RATIO PERCENT	TOTAL MICRO-STRAIN	MICROSTRAIN TEMPERATURE CORRECTED TIME AFTER LOADING FROM DAY CAST	0	1 MIN. @1530 PSI	1 MIN. @ 1 PSI	10 MIN. @1530 PSI	10 MIN. @ 1 PSI
11 -3-70	1330	53.04	72.7	100.815		0.	0.					
11 -6-70	815	53.02	72.5	100.800	-.015	-6.	-4.					
11-11-70	915	53.03	72.6	100.789	-.026	-9.	-8.					
11-24-70	1700	53.03	72.6	100.754	-.061	-21.	-20.	0.				
11-24-70	1701	53.03	72.6	99.660	-1.155	-385.	-384.	-364.	0.	0.		
11-24-70	1705	53.03	72.6	99.634	-1.181	-394.	-393.	-373.	-9.	-.0057		
11-24-70	1710	53.03	72.6	99.618	-1.197	-399.	-398.	-378.	-14.	-.0091	0.	0.
11-24-70	1945	53.03	72.6	99.531	-1.284	-428.	-427.	-407.	-43.	-.0281	-29.	-.0189
11-25-70	925	53.02	72.5	99.445	-1.370	-457.	-456.	-436.	-71.	-.0466	-57.	-.0375
11-25-70	1735	53.01	72.3	99.414	-1.401	-468.	-466.	-446.	-81.	-.0532	-67.	-.0440
11-26-70	1720	53.00	72.2	99.367	-1.448	-485.	-481.	-461.	-97.	-.0632	-83.	-.0541
11-27-70	1600	53.01	72.3	99.327	-1.488	-497.	-495.	-475.	-110.	-.0721	-96.	-.0630
11-28-70	1700	52.95	71.6	99.306	-1.509	-508.	-500.	-480.	-116.	-.0756	-102.	-.0664
11-29-70	1640	52.98	72.0	99.277	-1.538	-516.	-510.	-490.	-126.	-.0824	-112.	-.0733
12 -1-70	1200	52.97	71.9	99.240	-1.575	-529.	-522.	-502.	-138.	-.0903	-124.	-.0812
12 -9-70	1550	53.01	72.3	99.123	-1.692	-565.	-563.	-543.	-178.	-.1165	-164.	-.1074
12-23-70	1430	52.98	72.0	99.026	-1.789	-599.	-594.	-574.	-210.	-.1371	-196.	-.1279
1 -2-71	955	52.98	72.0	98.964	-1.851	-620.	-615.	-595.	-230.	-.1506	-216.	-.1414
1-18-71	1005	52.96	71.8	98.910	-1.905	-639.	-632.	-612.	-248.	-.1619	-234.	-.1528
2 -9-71	1330	53.01	72.3	98.851	-1.964	-656.	-653.	-633.	-269.	-.1757	-255.	-.1666
2-25-71	1055	53.02	72.5	98.822	-1.993	-665.	-663.	-643.	-279.	-.1822	-265.	-.1731
3 -9-71	1445	53.01	72.3	98.801	-2.014	-672.	-670.	-650.	-285.	-.1866	-271.	-.1774
3-23-71	1540	53.05	72.8	98.777	-2.038	-678.	-679.	-659.	-295.	-.1926	-281.	-.1834
4 -6-71	1000	53.05	72.8	98.763	-2.052	-683.	-684.	-664.	-299.	-.1956	-285.	-.1865
4-27-71	1200	53.03	72.6	98.741	-2.074	-691.	-690.	-670.	-306.	-.2000	-292.	-.1909
5-11-71	1430	53.02	72.5	98.726	-2.089	-697.	-695.	-675.	-311.	-.2031	-297.	-.1940
5-25-71	1200	53.03	72.6	98.708	-2.107	-702.	-701.	-681.	-317.	-.2072	-303.	-.1981
6 -8-71	915	53.04	72.7	98.693	-2.122	-707.	-707.	-687.	-322.	-.2107	-308.	-.2015
6-22-71	1200	53.06	72.9	98.678	-2.137	-710.	-712.	-692.	-328.	-.2143	-314.	-.2051
7 -6-71	1330	53.03	72.6	98.667	-2.148	-716.	-715.	-695.	-331.	-.2161	-317.	-.2070
7-20-71	1000	53.06	72.9	98.663	-2.152	-715.	-717.	-697.	-333.	-.2176	-319.	-.2084
8 -3-71	1400	53.07	73.1	98.645	-2.170	-721.	-723.	-703.	-339.	-.2217	-325.	-.2125
8-17-71	840	53.08	73.2	98.634	-2.181	-724.	-727.	-707.	-343.	-.2242	-329.	-.2151
8-31-71	1345	53.07	73.1	98.623	-2.187	-725.	-729.	-709.	-345.	-.2254	-331.	-.2162
9-15-71	1600	53.11	73.5	98.615	-2.200	-728.	-735.	-715.	-350.	-.2289	-336.	-.2198
9-29-71	1410	53.04	72.7	98.612	-2.203	-734.	-734.	-714.	-349.	-.2283	-335.	-.2191
10-14-71	1400	53.07	73.1	98.602	-2.213	-735.	-738.	-718.	-353.	-.2310	-339.	-.2219
10-27-71	1408	53.05	72.8	98.597	-2.218	-738.	-739.	-719.	-355.	-.2317	-341.	-.2226
10-27-71	1409	53.05	72.8	99.421	-1.394	-464.	-464.	-444.	-80.	-.0524	-66.	-.0432
10-27-71	1413	53.05	72.8	99.436	-1.379	-459.	-459.	-439.	-75.	-.0491	-61.	-.0400
10-27-71	1420	53.01	72.3	99.493	-1.322	-442.	-439.	-419.	-55.	-.0360	-41.	-.0268
10-27-71	2125	53.02	72.5	99.478	-1.337	-446.	-445.	-425.	-60.	-.0394	-46.	-.0303
10-28-71	1445	53.01	72.3	99.497	-1.318	-441.	-438.	-418.	-54.	-.0351	-40.	-.0260
10-29-71	1445	53.00	72.2	99.507	-1.308	-438.	-434.	-414.	-50.	-.0327	-36.	-.0236
10-30-71	1575	53.01	72.3	99.516	-1.299	-434.	-432.	-412.	-47.	-.0310	-33.	-.0218
11 -1-71	1350	53.01	72.3	99.526	-1.289	-431.	-428.	-408.	-44.	-.0288	-30.	-.0197
11 -4-71	1350	53.03	72.6	99.535	-1.280	-427.	-426.	-406.	-42.	-.0272	-28.	-.0181
11 -6-71	1330	53.03	72.6	99.539	-1.276	-426.	-425.	-405.	-40.	-.0263	-26.	-.0172
11-11-71	1400	53.01	72.3	99.551	-1.264	-423.	-420.	-400.	-36.	-.0234	-22.	-.0142
11-18-71	1640	53.02	72.5	99.566	-1.249	-417.	-415.	-395.	-31.	-.0203	-17.	-.0111
12 -1-71	1550	53.01	72.3	99.578	-1.237	-414.	-411.	-391.	-27.	-.0175	-13.	-.0083
1 -3-72	1450	52.98	72.0	99.614	-1.201	-404.	-398.	-378.	-14.	-.0091	0.	.0001
2 -4-72	1445	52.96	71.8	99.626	-1.189	-401.	-394.	-374.	-9.	-.0061	5.	.0030

TABLE H

STRAIN METER NO. X 2

PROJECT MILLSTONE B Y65901 LOADED TO 1530PSI AT AGE 28 DAYS
LOCATION DAVIS HALL ROOM 360A 73F DATE CAST 10-27-70

CALIBRATIONS
METER RESISTANCE AT 0.0 DEGREES F. 46.59 OHMS
CHANGE IN TEMP. PER OHM CHANGE IN RESIS. 12.01 DEGREES F.
USEFUL RANGE 97.0-102.1 RATIO IN PERCENT
ORIGINAL CALIBRATION CONSTANT 3.31 MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
CALIBRATION CONSTANT CORR. FOR LEAD 3.31 MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
TEMPERATURE CORRECTION 5.1 MICROSTRAIN PER DEGREE F.
CONCRETE EXPANSION 7.5 MICROSTRAIN PER DEGREE F.

DATE	TIME	METER RESIST. OHMS	TEMP. F.	RESIST. RATIO PERCENT	CHANGE IN RATIO PERCENT	TOTAL MICRO-STRAIN	MICROSTRAIN TEMPERATURE CORRECTED TIME AFTER LOADING					
							FROM DAY CAST	0	1 MIN. 1530 PSI	1 MIN. 1 PSI	10 MIN. 1530 PSI	10 MIN. 1 PSI
11 -3-70	1330	52.64	72.7	101.000		0.	0.					
11 -4-70	815	52.62	72.4	100.989	-.011	-5.	-3.					
11-11-70	915	52.63	72.5	100.979	-.021	-8.	-7.					
11-24-70	1700	52.65	72.8	100.945	-.055	-18.	-18.	0.				
11-24-70	1701	52.65	72.8	99.972	-1.028	-340.	-341.	-322.	0.	0.		
11-24-70	1705	52.65	72.8	99.937	-1.063	-351.	-352.	-334.	-12.	-.0076		
11-24-70	1710	52.65	72.8	99.923	-1.077	-356.	-357.	-338.	-16.	-.0106	0.	0.
11-24-70	1945	52.65	72.8	99.842	-1.158	-383.	-384.	-365.	-43.	-.0281	-27.	-.0175
11-25-70	925	52.65	72.8	99.772	-1.228	-406.	-407.	-388.	-66.	-.0433	-50.	-.0327
11-25-70	1735	52.64	72.7	99.740	-1.260	-417.	-417.	-399.	-77.	-.0500	-60.	-.0394
11-26-70	1720	52.64	72.7	99.707	-1.293	-428.	-428.	-409.	-87.	-.0571	-71.	-.0465
11-27-70	1690	52.64	72.7	99.667	-1.333	-441.	-441.	-423.	-101.	-.0658	-84.	-.0552
11-28-70	1700	52.60	72.2	99.645	-1.355	-451.	-447.	-429.	-107.	-.0698	-91.	-.0592
11-29-70	1640	52.63	72.5	99.621	-1.379	-457.	-456.	-438.	-116.	-.0756	-99.	-.0650
12 -1-70	1200	52.62	72.4	99.585	-1.415	-470.	-468.	-449.	-127.	-.0832	-111.	-.0726
12 -9-70	1550	52.67	73.0	99.468	-1.532	-505.	-508.	-489.	-167.	-.1094	-151.	-.0988
12-23-70	1430	52.64	72.7	99.347	-1.653	-547.	-547.	-529.	-207.	-.1350	-190.	-.1244
1 -2-71	955	52.63	72.5	99.316	-1.684	-558.	-557.	-539.	-217.	-.1415	-200.	-.1309
1-19-71	1005	52.63	72.5	99.265	-1.735	-575.	-574.	-556.	-233.	-.1526	-217.	-.1420
2 -9-71	1330	52.66	72.9	99.204	-1.796	-593.	-595.	-577.	-254.	-.1663	-238.	-.1557
2-25-71	1055	52.67	73.0	99.177	-1.823	-602.	-604.	-586.	-264.	-.1724	-248.	-.1618
3 -9-71	1445	52.67	73.0	99.156	-1.844	-609.	-611.	-593.	-271.	-.1769	-254.	-.1663
3-23-71	1540	52.68	73.1	99.133	-1.867	-616.	-619.	-601.	-279.	-.1821	-262.	-.1715
4 -6-71	1000	52.68	73.1	99.120	-1.880	-620.	-623.	-605.	-283.	-.1849	-267.	-.1743
4-27-71	1200	52.68	73.1	99.098	-1.902	-627.	-631.	-612.	-290.	-.1896	-274.	-.1790
5-11-71	1430	52.66	72.9	99.083	-1.917	-633.	-635.	-617.	-295.	-.1925	-278.	-.1819
5-25-71	1200	52.66	72.9	99.065	-1.935	-639.	-641.	-623.	-301.	-.1964	-284.	-.1858
6 -8-71	915	52.67	73.0	99.051	-1.949	-643.	-646.	-627.	-305.	-.1996	-289.	-.1890
6-22-71	1200	52.68	73.1	99.039	-1.961	-647.	-650.	-632.	-310.	-.2024	-293.	-.1918
7 -6-71	1330	52.68	73.1	99.029	-1.971	-650.	-654.	-635.	-313.	-.2046	-297.	-.1940
7-20-71	1000	52.70	73.4	99.022	-1.978	-651.	-656.	-638.	-316.	-.2065	-300.	-.1959
8 -3-71	1400	52.69	73.3	99.008	-1.992	-656.	-661.	-642.	-320.	-.2093	-304.	-.1987
8-17-71	840	52.70	73.4	98.997	-2.003	-659.	-665.	-646.	-324.	-.2119	-308.	-.2013
8-31-71	1345	52.69	73.3	98.990	-2.010	-662.	-667.	-648.	-326.	-.2132	-310.	-.2026
9-15-71	1600	52.72	73.6	98.978	-2.022	-664.	-672.	-653.	-331.	-.2164	-315.	-.2058
9-29-71	1410	52.67	73.0	98.975	-2.025	-668.	-671.	-653.	-331.	-.2161	-314.	-.2055
10-14-71	1400	52.70	73.4	98.966	-2.034	-670.	-675.	-655.	-334.	-.2186	-318.	-.2080
10-27-71	1400	52.69	73.3	98.961	-2.039	-672.	-676.	-658.	-336.	-.2195	-320.	-.2089
10-27-71	1401	52.69	73.3	99.716	-1.284	-422.	-426.	-408.	-86.	-.0561	-70.	-.0455
10-27-71	1413	52.69	73.3	99.826	-1.174	-386.	-390.	-372.	-49.	-.0323	-33.	-.0217
10-27-71	1420	52.65	72.8	99.825	-1.175	-388.	-389.	-371.	-49.	-.0318	-32.	-.0212
10-27-71	2125	52.63	72.5	99.857	-1.143	-379.	-378.	-360.	-37.	-.0245	-21.	-.0139
10-28-71	1445	52.62	72.4	99.876	-1.124	-373.	-371.	-353.	-31.	-.0202	-15.	-.0096
10-29-71	1445	52.61	72.3	99.887	-1.113	-370.	-368.	-349.	-27.	-.0176	-11.	-.0070
10-30-71	1575	52.62	72.4	99.895	-1.105	-367.	-365.	-347.	-25.	-.0161	-8.	-.0055
11 -1-71	1350	52.62	72.4	99.904	-1.096	-364.	-362.	-344.	-22.	-.0141	-5.	-.0035
11 -4-71	1350	52.63	72.5	99.914	-1.086	-360.	-359.	-341.	-19.	-.0122	-2.	-.0016
11 -6-71	1330	52.64	72.7	99.918	-1.082	-358.	-358.	-340.	-18.	-.0115	-1.	-.0009
11-11-71	1400	52.61	72.3	99.929	-1.071	-356.	-354.	-335.	-13.	-.0085	3.	.0021
11-18-71	1640	52.62	72.4	99.942	-1.058	-351.	-350.	-331.	-9.	-.0059	7.	.0047
12 -1-71	1550	52.62	72.4	99.954	-1.046	-347.	-346.	-327.	-5.	-.0033	11.	.0073
1 -3-72	1450	52.58	71.9	99.989	-1.011	-338.	-333.	-314.	8.	.0050	24.	.0156
2 -4-72	1445	52.58	71.9	100.000	-1.000	-335.	-329.	-311.	11.	.0074	28.	.0180

TABLE I

STRAIN METER NO. X 4

PROJECT MILLSTONE B Y65901 LOADED TO 1530PSI AT AGE 212 DAYS
LOCATION DAVIS HALL ROOM 360A 73F DATE CAST 10-27-70

CALIBRATIONS

METER RESISTANCE AT 0.0 DEGREES F.	46.74	OHMS
CHANGE IN TEMP. PER OHM CHANGE IN RESIS.	12.04	DEGREES F.
USEFUL RANGE	97.2-102.8	RATIO IN PERCENT
ORIGINAL CALIBRATION CONSTANT	3.33	MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
CALIBRATION CONSTANT CORR. FOR LEAD	3.33	MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
TEMPERATURE CORRECTION	5.1	MICROSTRAIN PER DEGREE F.
CONCRETE EXPANSION	7.5	MICROSTRAIN PER DEGREE F.

DATE	TIME	METER RESIST. OHMS	TEMP. F.	RESIST. RATIO PERCENT	CHANGE IN RATIO PERCENT	TOTAL MICRO-STRAIN	MICROSTRAIN TEMPERATURE CORRECTED FROM DAY CAST	TIME AFTER LOADING 0	1 MIN. 1530 PSI	1 MIN. 1 PSI	10 MIN. 1530 PSI	10 MIN. 1 PSI
11 -3-70	1330	52.80	73.0	100.485		0.	0.					
11 -6-70	815	52.78	72.7	100.471	-.014	-6.	-4.					
11-11-70	915	52.79	72.8	100.460	-.025	-9.	-8.					
11-25-70	1735	52.74	72.2	100.431	-.054	-22.	-16.					
12 -1-70	1200	52.70	71.8	100.428	-.057	-25.	-16.					
12 -9-70	1550	52.74	72.2	100.420	-.065	-25.	-20.					
12-23-70	1430	52.71	71.9	100.417	-.068	-28.	-20.					
1 -2-71	955	52.70	71.8	100.413	-.072	-30.	-21.					
1-18-70	1005	52.70	71.8	100.410	-.075	-31.	-22.					
2 -9-71	1330	52.73	72.1	100.408	-.077	-30.	-24.					
2-25-71	1055	52.75	72.4	100.405	-.080	-30.	-25.					
3 -9-71	1445	52.74	72.2	100.407	-.078	-30.	-24.					
3-23-71	1540	52.79	72.8	100.402	-.083	-28.	-27.					
4 -6-71	1000	52.76	72.5	100.405	-.080	-29.	-25.					
4-27-71	1200	52.73	72.1	100.410	-.075	-29.	-23.					
5-11-71	1430	52.72	72.0	100.409	-.076	-30.	-23.					
5-25-71	1200	52.73	72.1	100.404	-.081	-31.	-25.					
5-27-71	1338	52.72	72.0	100.404	-.081	-32.	-25.	0.				
5-27-71	1339	52.72	72.0	99.526	-.959	-324.	-317.	-292.	0.	0.		
5-27-71	1343	52.72	72.0	99.505	-.980	-331.	-324.	-299.	-7.	-.0046		
5-27-71	1348	52.72	72.0	99.499	-.986	-333.	-326.	-301.	-9.	-.0059	0.	0.
5-27-71	1408	52.67	71.4	99.473	-1.012	-345.	-333.	-309.	-16.	-.0106	-7.	-.0047
5-27-71	1433	52.76	72.5	99.465	-1.020	-342.	-339.	-314.	-21.	-.0140	-12.	-.0082
5-27-71	1645	52.76	72.5	99.444	-1.041	-349.	-345.	-321.	-28.	-.0186	-19.	-.0127
5-28-71	1350	52.74	72.2	99.399	-1.086	-365.	-360.	-335.	-43.	-.0280	-34.	-.0221
5-29-71	1330	52.74	72.2	99.381	-1.104	-371.	-366.	-341.	-49.	-.0319	-40.	-.0261
5-30-71	1330	52.76	72.5	99.367	-1.118	-375.	-371.	-346.	-54.	-.0354	-45.	-.0295
5-31-71	1330	52.77	72.6	99.355	-1.130	-378.	-375.	-351.	-58.	-.0382	-49.	-.0323
6 -1-71	1330	52.77	72.6	99.347	-1.138	-381.	-378.	-353.	-61.	-.0399	-52.	-.0340
6 -3-71	1330	52.76	72.5	99.333	-1.152	-386.	-382.	-358.	-65.	-.0428	-56.	-.0369
6 -8-71	915	52.76	72.5	99.309	-1.176	-394.	-390.	-366.	-73.	-.0480	-64.	-.0421
6-22-71	1200	52.77	72.6	99.262	-1.223	-409.	-406.	-382.	-89.	-.0584	-80.	-.0525
7 -6-71	1330	52.78	72.7	99.228	-1.257	-420.	-418.	-393.	-101.	-.0660	-92.	-.0601
7-20-71	1000	52.76	72.5	99.216	-1.269	-426.	-421.	-396.	-104.	-.0678	-95.	-.0620
8 -3-71	1403	52.78	72.7	99.184	-1.301	-434.	-433.	-408.	-116.	-.0756	-107.	-.0697
8-17-71	840	52.79	72.8	99.164	-1.321	-441.	-440.	-415.	-123.	-.0801	-114.	-.0742
8-31-71	1345	52.78	72.7	99.150	-1.335	-446.	-444.	-419.	-127.	-.0830	-118.	-.0771
9-15-71	1600	52.78	72.7	99.131	-1.354	-452.	-450.	-426.	-133.	-.0871	-124.	-.0812
9-29-71	1410	52.77	72.6	99.120	-1.365	-456.	-454.	-429.	-137.	-.0893	-128.	-.0834
10-14-71	1400	52.78	72.7	99.107	-1.378	-460.	-458.	-434.	-141.	-.0923	-132.	-.0865
10-27-71	1427	52.77	72.6	99.094	-1.391	-465.	-462.	-438.	-145.	-.0950	-136.	-.0891
10-27-71	1428	52.77	72.6	99.919	-.566	-190.	-188.	-163.	129.	.0846	138.	.0905
10-27-71	1432	52.91	74.3	99.913	-.572	-184.	-194.	-169.	123.	.0806	132.	.0865
10-27-71	1437	52.74	72.2	99.935	-.550	-187.	-181.	-157.	136.	.0886	145.	.0945
10-28-71	1445	52.75	72.4	99.990	-.495	-168.	-163.	-139.	154.	.1004	163.	.1063
10-29-71	1445	52.74	72.2	99.999	-.486	-166.	-160.	-135.	157.	.1026	166.	.1084
10-30-71	1575	52.75	72.4	100.006	-.479	-163.	-158.	-133.	159.	.1039	168.	.1098
11 -1-71	1350	52.75	72.4	100.015	-.470	-160.	-155.	-130.	162.	.1059	171.	.1117
11 -4-71	1550	52.77	72.6	100.023	-.462	-156.	-153.	-128.	164.	.1072	173.	.1131
11 -6-71	1330	52.77	72.6	100.026	-.459	-155.	-152.	-127.	165.	.1079	174.	.1138
11-11-71	1400	52.75	72.4	100.038	-.447	-152.	-147.	-123.	170.	.1109	179.	.1167
11-18-71	1640	52.76	72.5	100.048	-.437	-148.	-144.	-120.	173.	.1129	182.	.1187
12 -1-71	1550	52.76	72.5	100.059	-.426	-144.	-141.	-116.	176.	.1153	185.	.1211
1 -3-72	1450	52.71	71.9	100.094	-.391	-136.	-128.	-103.	189.	.1238	198.	.1297
2 -4-72	1445	52.71	71.9	100.097	-.388	-135.	-127.	-102.	190.	.1245	199.	.1303

TABLE J

STRAIN METER NO. X 3

PROJECT MILLSTONE B Y65901 LOADED TO 1530PSI AT AGE 212 DAYS
LOCATION DAVIS HALL ROOM 360A 73F DATE CAST 10-27-70

CALIBRATIONS

METER RESISTANCE AT 0.0 DEGREES F.	46.82	OHMS
CHANGE IN TEMP. PER OHM CHANGE IN RESIS.	11.99	DEGREES F.
USEFUL RANGE	96.7-102.1	RATIO IN PERCENT
ORIGINAL CALIBRATION CONSTANT	3.28	MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
CALIBRATION CONSTANT CORR. FOR LEAD	3.28	MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
TEMPERATURE CORRECTION	5.1	MICROSTRAIN PER DEGREE F.
CONCRETE EXPANSION	7.5	MICROSTRAIN PER DEGREE F.

DATE	TIME	METER RESIST. OHMS	TEMP. F.	RESIST. RATIO PERCENT	CHANGE IN RATIO PERCENT	TOTAL MICRO-STRAIN	FROM DAY CAST	MICROSTRAIN TEMPERATURE CORRECTED TIME AFTER LOADING 0	1 MIN. 1530 PSI	1 MIN. 1 PSI	10 MIN. 1530 PSI	10 MIN. 1 PSI
11 -3-70	1330	52.91	73.0	101.009		0.	0.					
11 -6-70	915	52.89	72.8	100.994	-.015	-6.	-4.					
11-11-70	915	52.89	72.8	100.982	-.027	-10.	-8.					
11-25-70	1735	52.84	72.2	100.949	-.060	-24.	-18.					
12 -1-70	1200	52.80	71.7	100.945	-.064	-28.	-18.					
12 -9-70	1550	52.84	72.2	100.937	-.072	-28.	-22.					
12-23-70	1430	52.81	71.8	100.934	-.075	-31.	-22.					
1 -2-71	955	52.80	71.7	100.930	-.079	-33.	-23.					
1-18-71	1005	52.79	71.6	100.926	-.083	-35.	-24.					
2 -9-71	1330	52.84	72.2	100.923	-.086	-32.	-26.					
2-25-71	1055	52.85	72.3	100.921	-.088	-33.	-27.					
3 -9-71	1445	52.85	72.3	100.922	-.087	-32.	-27.					
3-23-71	1540	52.89	72.8	100.915	-.094	-32.	-30.					
4 -6-71	1000	52.87	72.5	100.917	-.092	-33.	-29.					
4-27-71	1200	52.84	72.2	100.922	-.087	-33.	-27.					
5-11-71	1430	52.83	72.1	100.920	-.089	-34.	-27.					
5-25-71	1200	52.84	72.2	100.916	-.093	-35.	-28.					
5-27-71	1330	52.85	72.3	100.913	-.096	-35.	-30.	0.				
5-27-71	1339	52.85	72.3	99.961	-1.048	-347.	-342.	-312.	0.	0.		
5-27-71	1343	52.85	72.3	99.943	-1.066	-353.	-348.	-318.	-6.	-.0039		
5-27-71	1348	52.85	72.3	99.938	-1.071	-355.	-350.	-320.	-8.	-.0049	0.	0.
5-27-71	1403	52.89	72.8	99.916	-1.093	-360.	-358.	-328.	-16.	-.0104	-8.	-.0055
5-27-71	1438	52.89	72.8	99.909	-1.100	-362.	-360.	-330.	-18.	-.0119	-11.	-.0070
5-27-71	1645	52.89	72.8	99.889	-1.120	-369.	-367.	-337.	-25.	-.0162	-17.	-.0113
5-29-71	1350	52.87	72.5	99.855	-1.154	-381.	-377.	-348.	-35.	-.0231	-28.	-.0182
5-29-71	1330	52.87	72.5	99.838	-1.171	-387.	-383.	-353.	-41.	-.0267	-33.	-.0218
5-30-71	1330	52.89	72.8	99.825	-1.184	-390.	-388.	-358.	-46.	-.0299	-38.	-.0250
5-31-71	1330	52.90	72.9	99.816	-1.193	-392.	-391.	-361.	-49.	-.0320	-41.	-.0271
6 -1-71	1330	52.92	73.1	99.807	-1.202	-394.	-395.	-365.	-53.	-.0343	-45.	-.0294
6 -3-71	1330	52.89	72.8	99.792	-1.217	-400.	-399.	-369.	-57.	-.0370	-49.	-.0321
6 -6-71	915	52.90	72.9	99.768	-1.241	-408.	-407.	-377.	-65.	-.0423	-57.	-.0374
6-22-71	1200	52.90	72.9	99.722	-1.287	-423.	-422.	-392.	-80.	-.0522	-72.	-.0472
7 -6-71	1330	52.91	73.0	99.689	-1.320	-433.	-433.	-403.	-91.	-.0594	-83.	-.0545
7-20-71	1000	52.89	72.8	99.673	-1.336	-439.	-438.	-408.	-96.	-.0625	-88.	-.0576
8 -3-71	1400	52.91	73.0	99.643	-1.366	-448.	-448.	-418.	-106.	-.0693	-98.	-.0644
8-17-71	840	52.92	73.1	99.621	-1.388	-455.	-456.	-426.	-114.	-.0742	-106.	-.0693
8-15-71	1600	52.92	73.1	99.586	-1.423	-466.	-467.	-437.	-125.	-.0817	-117.	-.0768
8-24-71	1410	52.91	73.0	99.573	-1.436	-471.	-471.	-441.	-129.	-.0843	-121.	-.0794
10-14-71	1400	52.91	73.0	99.562	-1.447	-475.	-475.	-445.	-133.	-.0867	-125.	-.0817
10-27-71	1427	52.91	73.0	99.546	-1.463	-480.	-480.	-450.	-138.	-.0901	-130.	-.0852
10-27-71	1428	52.91	73.0	100.429	-.580	-190.	-190.	-160.	152.	.0992	159.	.1041
10-27-71	1437	52.88	72.7	100.434	-.575	-190.	-188.	-158.	154.	.1008	162.	.1058
10-27-71	2125	52.86	72.4	100.474	-.535	-179.	-174.	-144.	168.	.1098	176.	.1147
10-28-71	1445	52.85	72.3	100.496	-.513	-172.	-167.	-137.	175.	.1147	183.	.1196
10-29-71	1445	52.84	72.2	100.506	-.503	-169.	-163.	-133.	179.	.1170	187.	.1220
10-30-71	1575	52.85	72.3	100.516	-.493	-165.	-160.	-130.	182.	.1190	190.	.1239
11 -1-71	1350	52.85	72.3	100.526	-.483	-162.	-157.	-127.	185.	.1211	193.	.1261
11 -4-71	1350	52.87	72.5	100.533	-.476	-159.	-155.	-125.	187.	.1222	195.	.1272
11 -6-71	1330	52.87	72.5	100.538	-.471	-157.	-153.	-124.	189.	.1233	196.	.1283
11-11-71	1400	52.85	72.3	100.548	-.461	-155.	-149.	-120.	193.	.1258	200.	.1308
11-13-71	1640	52.86	72.4	100.562	-.447	-150.	-145.	-115.	197.	.1287	204.	.1336
12 -1-71	1550	52.85	72.3	100.572	-.437	-147.	-142.	-112.	200.	.1310	208.	.1359
1 -3-72	1450	52.80	71.7	100.602	-.407	-140.	-130.	-101.	212.	.1384	219.	.1433
1 -4-72	1445	52.80	71.7	100.600	-.409	-141.	-131.	-101.	211.	.1379	219.	.1429

TABLE K

STRAIN METER NO. X 5

PROJECT MILLSTONE B Y65901
LOCATION DAVIS HALL ROOM 360A 73F DATE CAST 10-27-70

CALIBRATIONS
METER RESISTANCE AT 0.0 DEGREES F. 46.76 OHMS
CHANGE IN TEMP. PER OHM CHANGE IN RESIS. 11.93 DEGREES F.
USEFUL RANGE 97.3-102.4 RATIO IN PERCENT
ORIGINAL CALIBRATION CONSTANT 3.30 MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
CALIBRATION CONSTANT CORR. FOR LEAD 3.30 MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
TEMPERATURE CORRECTION 5.1 MICROSTRAIN PER DEGREE F.
CONCRETE EXPANSION 7.5 MICROSTRAIN PER DEGREE F.

DATE	TIME	METER RESIST. OHMS	TEMP. F.	RESIST. RATIO PERCENT	CHANGE IN RATIO PERCENT	TOTAL MICRO-STRAIN	MICROSTRAIN TEMPERATURE CORRECTED TIME AFTER LOADING: FROM DAY CAST	0	1 MIN. 1530 PSI	1 MIN. 1 PSI	10 MIN. 1530 PSI	10 MIN. 1 PSI
11-3-70	1330	52.83	73.0	101.215		0.	0.					
11-6-70	915	52.87	72.9	101.203	-.012	-5.	-4.					
11-11-70	915	52.97	72.9	101.191	-.024	-9.	-8.					
11-24-70	1735	52.84	72.5	101.160	-.055	-21.	-17.					
12-1-70	1200	52.79	71.9	101.155	-.060	-25.	-17.					
12-5-70	1550	52.93	72.3	101.147	-.068	-26.	-21.					
12-23-70	1430	52.89	72.1	101.140	-.075	-30.	-22.					
1-2-71	955	52.79	71.9	101.137	-.078	-31.	-23.					
1-18-70	1005	52.78	71.8	101.136	-.079	-32.	-23.					
2-5-71	1230	52.82	72.2	101.133	-.082	-31.	-25.					
2-25-71	1355	52.83	72.4	101.132	-.083	-30.	-26.					
3-4-71	1445	52.83	72.4	101.132	-.083	-30.	-26.					
3-23-71	1540	52.87	72.9	101.120	-.095	-32.	-31.					
4-6-71	1320	52.84	72.5	101.129	-.086	-31.	-27.					
4-22-71	1200	52.82	72.3	101.134	-.081	-30.	-25.					
5-11-71	1430	52.81	72.2	101.135	-.080	-31.	-24.					
5-25-71	1200	52.82	72.3	101.129	-.086	-32.	-27.					
5-28-71	1300	52.81	72.2	101.130	-.085	-32.	-26.					
6-7-71	1320	52.81	72.2	101.130	-.085	-32.	-26.					
6-10-71	1330	52.82	72.3	101.131	-.084	-31.	-26.					
6-21-71	1330	52.84	72.5	101.129	-.086	-31.	-27.					
7-1-71	1330	52.84	72.5	101.129	-.086	-31.	-27.					
7-3-71	1330	52.81	72.2	101.130	-.085	-32.	-26.					
7-12-71	915	52.80	72.1	101.129	-.086	-33.	-26.					
7-22-71	1200	52.82	72.3	101.126	-.089	-33.	-28.					
7-26-71	1330	52.82	72.3	101.124	-.091	-34.	-28.					
8-3-71	1400	52.82	72.3	101.125	-.090	-33.	-28.					
8-17-71	940	52.83	72.4	101.121	-.094	-34.	-30.					
8-31-71	1145	52.82	72.3	101.119	-.096	-35.	-30.					
9-15-71	1600	52.84	72.5	101.113	-.097	-34.	-31.					
9-29-71	1410	52.80	72.1	101.119	-.096	-37.	-29.					
10-14-71	1400	52.81	72.2	101.117	-.098	-37.	-30.					
10-27-71	1445	52.82	72.3	101.117	-.098	-36.	-31.	0.				
10-27-71	1446	52.74	71.3	100.219	-.996	-337.	-325.	-294.	0.	0.		
10-27-71	1450	52.74	71.3	100.203	-1.012	-342.	-330.	-299.	-5.	-.0035		
10-27-71	1455	52.75	72.7	100.197	-1.018	-338.	-335.	-304.	-10.	-.0068	0.	0.
10-27-71	1530	52.85	72.7	100.179	-1.036	-344.	-341.	-310.	-16.	-.0107	-6.	-.0039
10-27-71	1735	52.86	72.8	100.160	-1.055	-349.	-348.	-317.	-23.	-.0150	-12.	-.0082
10-27-71	2100	52.86	72.8	100.149	-1.066	-353.	-351.	-321.	-27.	-.0173	-16.	-.0105
10-28-71	1445	52.86	72.8	100.126	-1.089	-361.	-359.	-328.	-34.	-.0223	-24.	-.0155
10-30-71	1445	52.86	72.8	100.110	-1.105	-366.	-364.	-333.	-39.	-.0258	-29.	-.0190
10-30-71	1575	52.86	72.8	100.101	-1.114	-369.	-367.	-336.	-42.	-.0277	-32.	-.0209
11-1-71	1430	52.86	72.8	100.083	-1.132	-375.	-373.	-342.	-48.	-.0316	-38.	-.0248
11-4-71	1150	52.88	73.0	100.068	-1.147	-379.	-379.	-348.	-54.	-.0352	-43.	-.0284
11-6-71	1330	52.88	73.0	100.062	-1.153	-380.	-380.	-350.	-56.	-.0365	-45.	-.0297
11-11-71	1400	52.94	72.5	100.040	-1.175	-390.	-387.	-356.	-62.	-.0405	-52.	-.0337
11-13-71	1440	52.97	72.9	100.024	-1.191	-394.	-393.	-362.	-68.	-.0445	-58.	-.0377
12-1-71	1555	52.96	72.8	100.000	-1.215	-402.	-400.	-370.	-76.	-.0495	-65.	-.0427
1-3-72	1445	52.92	72.3	99.959	-1.256	-418.	-412.	-382.	-88.	-.0574	-77.	-.0506
1-4-72	1446	52.91	72.2	99.928	-1.287	-429.	-423.	-392.	-98.	-.0641	-88.	-.0573

TABLE I

STRAIN METER NO. X 6

PROJECT MILLSTONE 3 Y65901
LOCATION DAVIS HALL ROOM 3604 73F DATE CAST 10-27-70

CALIBRATIONS
METER RESISTANCE AT 0.0 DEGREES F. 46.74 OHMS
CHANGE IN TEMP. PER OHM CHANGE IN RESIS. 12.04 DEGREES F.
USEFUL RANGE 97.3-102.7 RATIO IN PERCENT
ORIGINAL CALIBRATION CONSTANT 3.27 MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
CALIBRATION CONSTANT CORR. FOR LEAD 3.27 MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
TEMPERATURE CORRECTION 5.1 MICROSTRAIN PER DEGREE F.
CONCRETE EXPANSION 7.5 MICROSTRAIN PER DEGREE F.

DATE	TIME	METER RESIST. OHMS	TEMP. F.	RESIST. RATIO PERCENT	CHANGE IN RATIO PERCENT	TOTAL MICRO-STRAIN	MICROSTRAIN TEMPERATURE CORRECTED FROM DAY CAST	0	TIME AFTER LOADING 1 MIN. 1530 PSI	1 MIN. 1 PSI	10 MIN. 1530 PSI	10 MIN. 1 PSI
11 -3-70	1330	52.80	73.0	100.983		0.	0.					
11 -5-70	815	52.80	73.0	100.969	-.014	-5.	-5.					
11-11-70	915	52.80	73.0	100.957	-.026	-9.	-9.					
11-25-70	1735	52.75	72.4	100.925	-.058	-22.	-18.					
12 -1-70	1200	52.72	72.0	100.922	-.061	-25.	-18.					
12 -9-70	1550	52.75	72.4	100.913	-.070	-26.	-21.					
12-23-70	1430	52.73	72.1	100.908	-.075	-29.	-23.					
1 -2-71	955	52.72	72.0	100.904	-.079	-31.	-24.					
1-18-70	1005	52.72	72.0	100.901	-.082	-32.	-25.					
2 -9-71	1330	52.75	72.4	100.897	-.086	-31.	-27.					
2-25-71	1055	52.76	72.5	100.896	-.087	-31.	-27.					
3 -9-71	1445	52.76	72.5	100.892	-.091	-32.	-29.					
3-23-71	1540	52.81	73.1	100.890	-.093	-30.	-31.					
4 -6-71	1000	52.77	72.6	100.892	-.091	-32.	-29.					
4-27-71	1200	52.74	72.2	100.897	-.086	-32.	-26.					
5-11-71	1430	52.73	72.1	100.897	-.086	-32.	-26.					
5-25-71	1200	52.74	72.2	100.891	-.092	-34.	-28.					
5-28-71	1350	52.73	72.1	100.892	-.091	-34.	-29.					
5-29-71	1330	52.74	72.2	100.893	-.090	-33.	-28.					
5-30-71	1330	52.74	72.2	100.893	-.090	-33.	-28.					
5-31-71	1330	52.76	72.5	100.891	-.092	-33.	-29.					
6 -1-71	1330	52.76	72.5	100.889	-.094	-33.	-30.					
6 -3-71	1330	52.73	72.1	100.892	-.091	-34.	-28.					
6 -8-71	915	52.73	72.1	100.891	-.092	-34.	-28.					
6-22-71	1200	52.74	72.2	100.886	-.097	-35.	-30.					
7 -6-71	1330	52.74	72.2	100.886	-.097	-35.	-30.					
7-20-71	1000	52.70	71.8	100.895	-.088	-35.	-26.					
8 -3-71	1400	52.74	72.2	100.885	-.098	-36.	-30.					
8-17-71	840	52.75	72.4	100.881	-.102	-36.	-32.					
8-31-71	1345	52.75	72.4	100.880	-.103	-37.	-32.					
9-15-71	1600	52.76	72.5	100.878	-.105	-37.	-33.					
9-29-71	1410	52.73	72.1	100.880	-.103	-38.	-32.					
10-14-71	1400	52.74	72.2	100.878	-.105	-38.	-33.					
10-27-71	1445	52.74	72.2	100.875	-.108	-39.	-34.	0.				
10-27-71	1446	52.74	72.2	99.976	-1.007	-333.	-328.	-294.	0.	0.		
10-27-71	1450	52.82	73.2	99.962	-1.021	-333.	-334.	-301.	-7.	-.0045		
10-27-71	1455	52.77	72.6	99.954	-1.029	-338.	-336.	-302.	-8.	-.0053	0.	0.
10-27-71	1530	52.77	72.6	99.941	-1.042	-343.	-340.	-306.	-12.	-.0080	-4.	-.0028
10-27-71	1735	52.77	72.6	99.925	-1.058	-348.	-345.	-312.	-18.	-.0115	-9.	-.0062
10-27-71	2120	52.76	72.5	99.914	-1.069	-352.	-348.	-315.	-21.	-.0136	-13.	-.0084
10-28-71	1445	52.76	72.5	99.891	-1.092	-360.	-356.	-328.	-29.	-.0185	-20.	-.0133
10-29-71	1445	52.75	72.4	99.878	-1.105	-364.	-360.	-326.	-32.	-.0211	-24.	-.0159
10-30-71	1575	52.75	72.4	99.872	-1.111	-366.	-362.	-328.	-34.	-.0224	-26.	-.0171
11 -1-71	1350	52.75	72.4	99.856	-1.127	-372.	-367.	-334.	-40.	-.0258	-31.	-.0206
11 -4-71	1350	52.78	72.7	99.838	-1.145	-376.	-374.	-340.	-46.	-.0302	-38.	-.0250
11 -6-71	1330	52.78	72.7	99.830	-1.153	-378.	-376.	-343.	-49.	-.0320	-41.	-.0267
11-11-71	1400	52.74	72.2	99.811	-1.172	-387.	-382.	-348.	-54.	-.0353	-46.	-.0300
11-18-71	1640	52.76	72.5	99.797	-1.186	-390.	-387.	-353.	-59.	-.0386	-51.	-.0334
12 -1-71	1550	52.74	72.2	99.773	-1.210	-399.	-394.	-360.	-66.	-.0434	-58.	-.0381
1 -3-72	1450	52.70	71.8	99.740	-1.243	-413.	-404.	-370.	-76.	-.0497	-68.	-.0444
2 -4-72	1445	52.68	71.5	99.710	-1.273	-424.	-413.	-379.	-85.	-.0557	-77.	-.0504

TABLE M

FIGURES

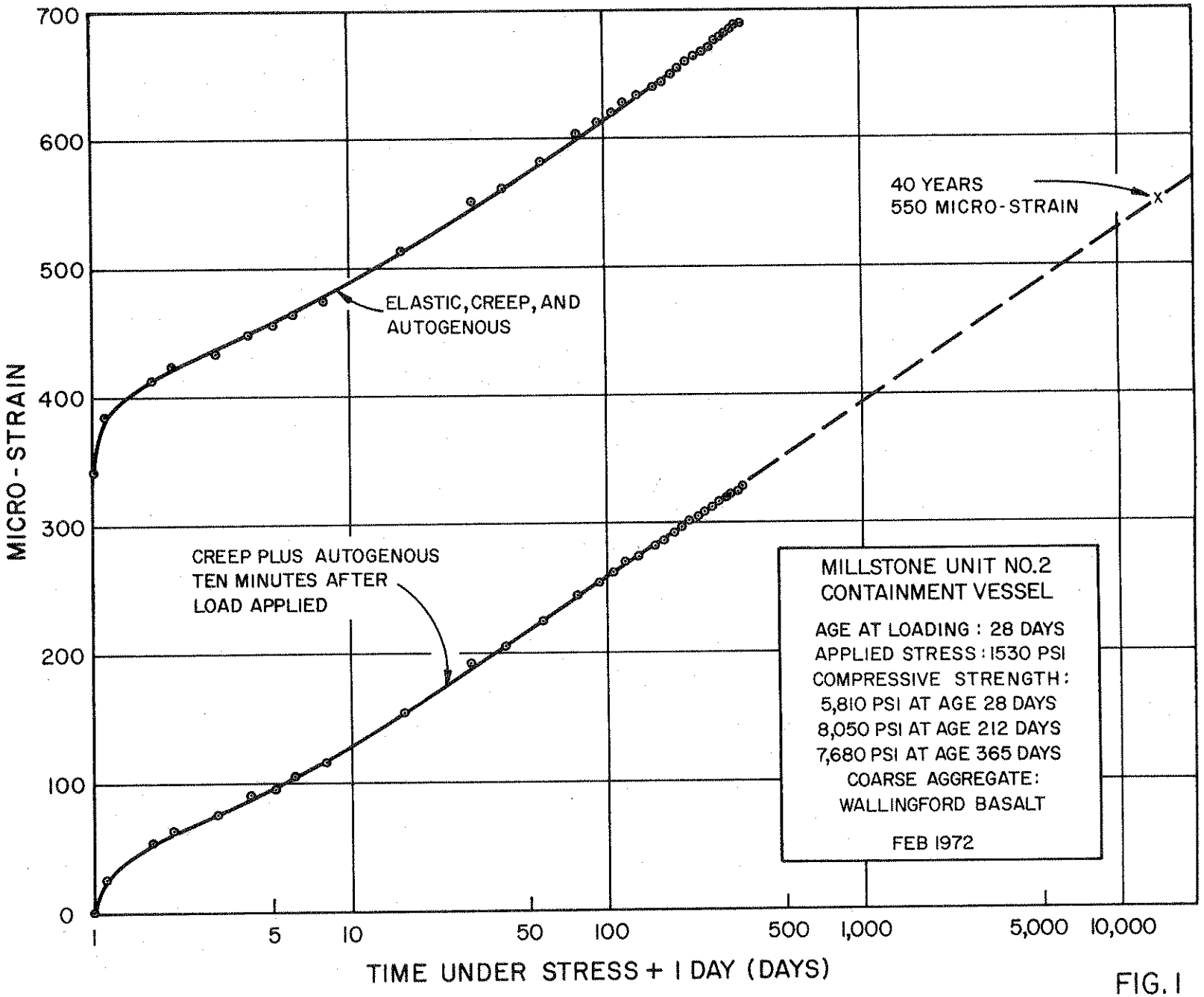
700
600
500
400
300
200
100
0
MICRO-STRAIN
1
5
10
50
100
500
1,000
5,000
10,000
TIME UNDER STRESS + 1 DAY (DAYS)
40 YEARS
550 MICRO-STRAIN
ELASTIC, CREEP, AND
AUTOGENOUS
CREEP PLUS AUTOGENOUS
TEN MINUTES AFTER
LOAD APPLIED
MILLSTONE UNIT NO.2
CONTAINMENT VESSEL
AGE AT LOADING : 28 DAYS
APPLIED STRESS : 1530 PSI
COMPRESSIVE STRENGTH:
5,810 PSI AT AGE 28 DAYS
8,050 PSI AT AGE 212 DAYS
7,680 PSI AT AGE 365 DAYS
COARSE AGGREGATE:
WALLINGFORD BASALT
FEB 1972

FIG. 1

FIG. 1

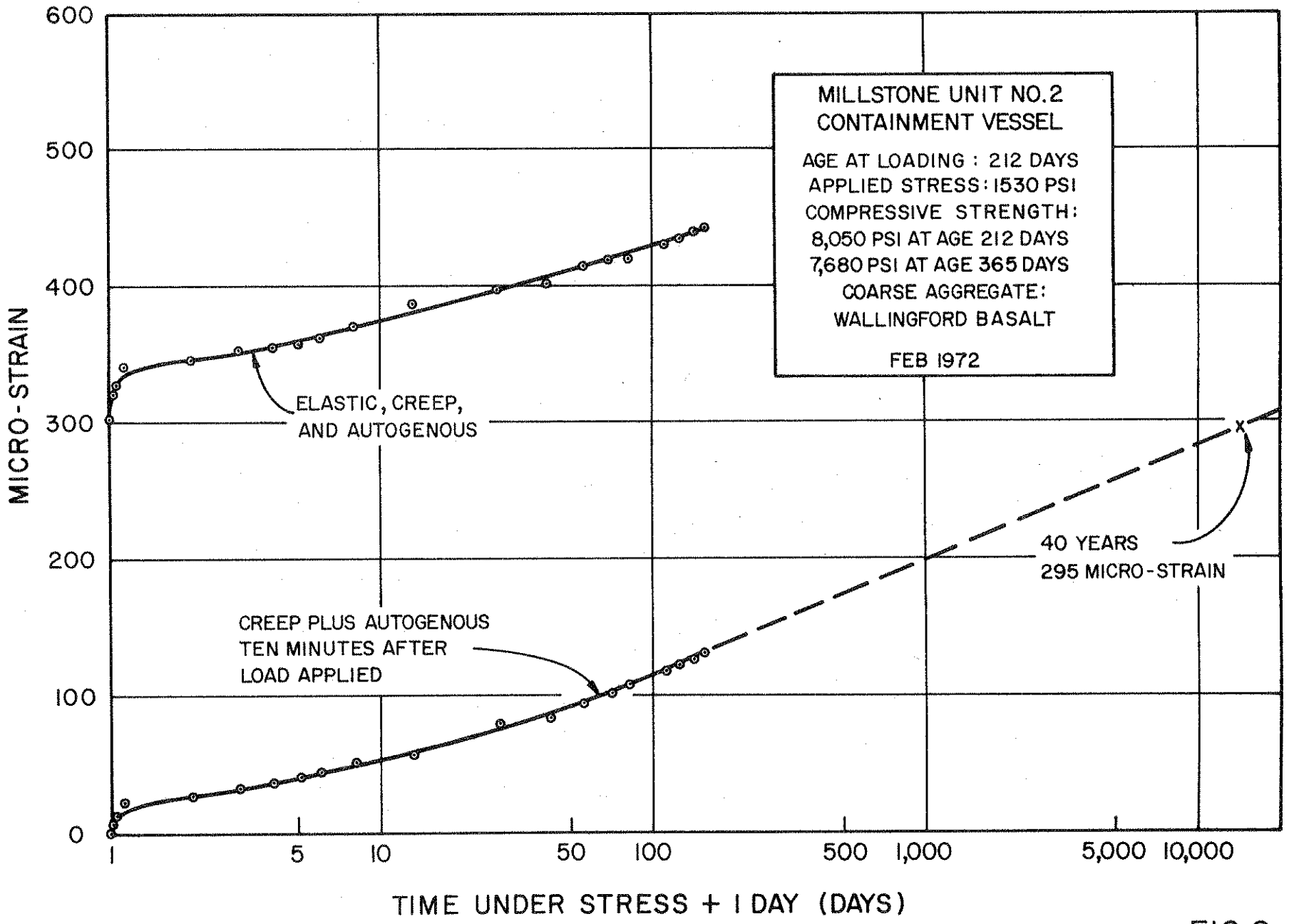
MILLSTONE UNIT NO.2
CONTAINMENT VESSEL
AGE AT LOADING : 212 DAYS
APPLIED STRESS: 1530 PSI
COMPRESSIVE STRENGTH:
8,050 PSI AT AGE 212 DAYS
7,680 PSI AT AGE 365 DAYS
COARSE AGGREGATE:
WALLINGFORD BASALT
FEB 1972
ELASTIC, CREEP,
AND AUTOGENOUS
CREEP PLUS AUTOGENOUS
TEN MINUTES AFTER
LOAD APPLIED
40 YEARS
295 MICRO-STRAIN
MICRO-STRAIN
TIME UNDER STRESS + 1 DAY (DAYS)
0
100
200
300
400
500
600
1
5
10
50
100
500
1,000
5,000
10,000

FIG. 2

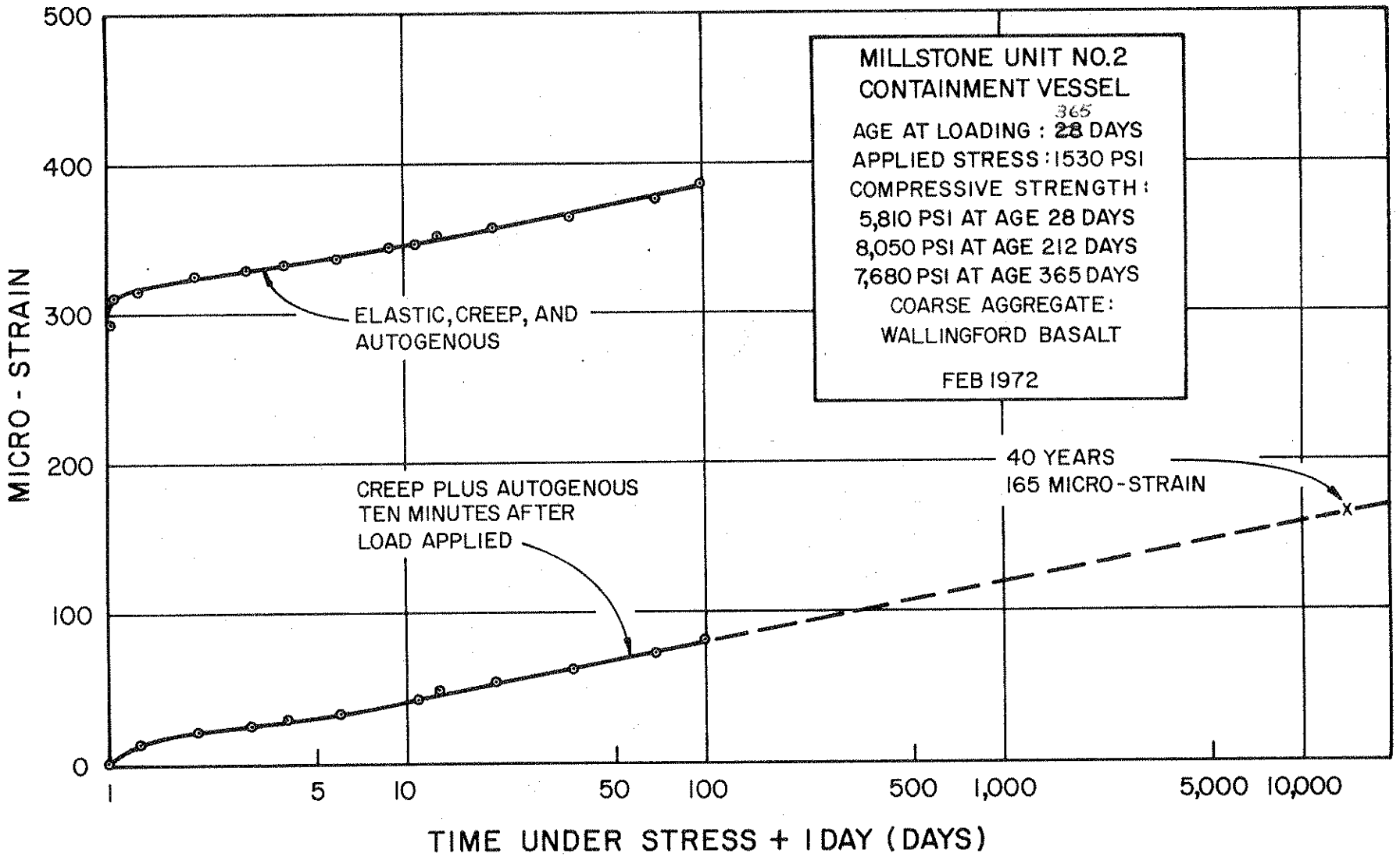
MILLSTONE UNIT NO.2
CONTAINMENT VESSEL
AGE AT LOADING : 28 365 DAYS
APPLIED STRESS : 1530 PSI
COMPRESSIVE STRENGTH :
5,810 PSI AT AGE 28 DAYS
8,050 PSI AT AGE 212 DAYS
7,680 PSI AT AGE 365 DAYS
COARSE AGGREGATE:
WALLINGFORD BASALT
FEB 1972
ELASTIC, CREEP, AND AUTOGENOUS
CREEP PLUS AUTOGENOUS TEN MINUTES AFTER LOAD APPLIED
40 YEARS
165 MICRO-STRAIN
MICRO - STRAIN
TIME UNDER STRESS + 1 DAY (DAYS)
0
100
200
300
400
500
1
5
10
50
100
500
1,000
5,000
10,000

FIG.3

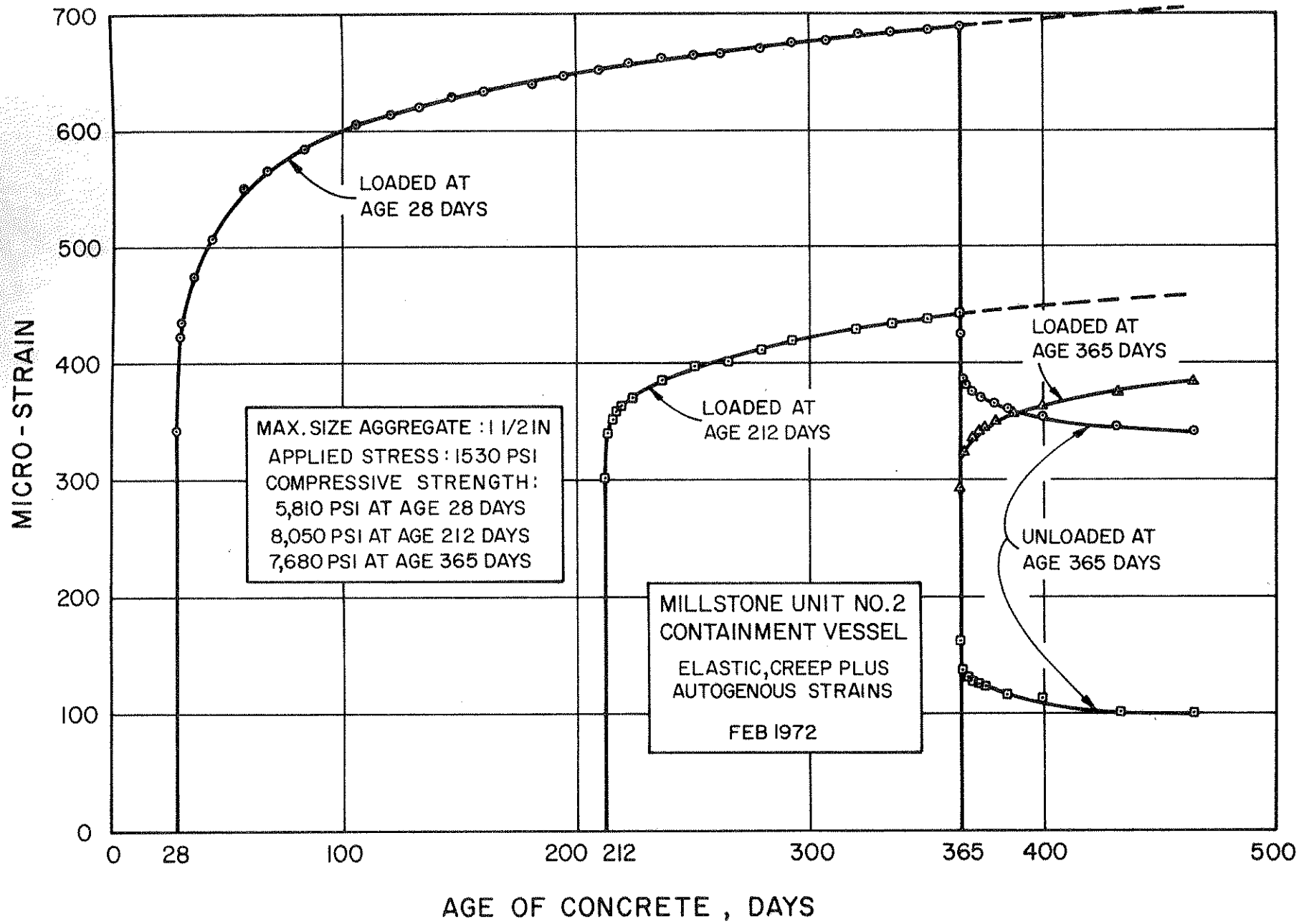
700
600
500
400
300
200
100
0
MICRO-STRAIN
0
28
100
200
212
300
365
400
500
AGE OF CONCRETE , DAYS
LOADED AT
AGE 28 DAYS
LOADED AT
AGE 212 DAYS
LOADED AT
AGE 365 DAYS
UNLOADED AT
AGE 365 DAYS
MAX. SIZE AGGREGATE : 1 1/2 IN
APPLIED STRESS : 1530 PSI
COMPRESSIVE STRENGTH:
5,810 PSI AT AGE 28 DAYS
8,050 PSI AT AGE 212 DAYS
7,680 PSI AT AGE 365 DAYS
MILLSTONE UNIT NO. 2
CONTAINMENT VESSEL
ELASTIC, CREEP PLUS
AUTOGENOUS STRAINS
FEB 1972

FIG. 4

FIG 4