UNIVERSITY OF CALIFORNIA, BERKELEY

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SANTA BARBARA • SANTA CRUZ

COLLEGE OF ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING
DIVISION OF STRUCTURAL ENGINEERING
AND STRUCTURAL MECHANICS

BERKELEY, CALIFORNIA 94720

February 22, 1972

Bechtel Corporation
190 Shady Grove Road
P.O. Box 607
Gaithersburg, Maryland 20760

Attention: Mr. N. K. Bhatia

Gentlemen:

RE: Creep of Concrete for Turkey Point Containment Vessel - 1972

Transmitted herewith is the final report entitled, "Creep of Concrete for Turkey Point Containment Vessel - 1972," which gives results from creep studies on concrete cast at Berkeley and at the job site. Concrete specimens were under load for approximately one year.

Sincerely yours,

David Pirtz
Professor of Civil Engineering

DP:ib
Enclosure

Final Report

STUDIES OF CONCRETE FOR TURKEY POINT NUCLEAR CONTAINMENT VESSEL

TEST PROGRAM

The purpose of the testing program is to establish some of the mechanical and thermal properties of the concrete using 3/4-in. maximun size aggregate to be used in the construction of the Turkey Point 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 3, 7, and 28 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 age of 28 days on three each of 6-in. x 12-in. cylinders.

c. Creep characteristic of sealed concrete specimens to be determined at a sustained load of 1530 psi initially applied at 28 days. The creep tests shall be run on specimens cast at Berkeley and specimens that were cast on the job site and shipped to Berkeley. The creep tests shall be carried out on two frames containing 2 each 6-in. x 18-in. cylinders per frame at 73°F.

CONCRETE MIX

The mix design for both the Berkeley and job site specimens are shown in Table A. The casting data for specimens made in Berkeley are shown in

Table B. In Table B the weight of cement, water, sand, and 3/4-in. aggregate per cu. yd. of concrete was computed using the measured unit weight of the concrete and the batch weights of each material. The concrete at the job site had a slump of 2 1/2 inches and a temperature at time of casting of 63°F.

The aggregates used in the casting of the Turkey Point 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 +5.02%, 3/4-in. agg. -0.90%). Bulk specific gravities and absorption capacities of the aggregates as determined at Berkeley are shown in Table C.

The concrete was mixed at Berkeley 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 specimens were cast in 6-in. diameter by 20-in. long 16-gage sheet metal molds which were lined inside with a 1/16-in. thick seamless butyl rubber sleeve. The butyl rubber sleeve was bonded to a 2-in. thick steel base plate and then the 16-gage sheet metal mold was slipped over the rubber sleeve and banded with a large hose clamp to the base plate. The purpose of the outer steel mold is to assure that the outer surface of the creep specimen will be kept uniform during casting. A 10-in. Carlson Strain Meter was centered on the axis of the mold with its lead wire being brought out through a hole in the center of the base plate which has a "O" ring seal for the lead wire. A 1/8-in. by 8-in. metal rod was placed diametrically across the top of the 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 specimens cast at Berkeley were allowed about five 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 normal to the axis of the specimen. The creep specimens were then moved to the 73°F. constant temperature room. Sheet metal molds were stripped from the creep specimens at the age of one day, and the top two inches of the butyl rubber sleeve was then bonded and banded with a large hose clamp to the top plate to assure that the specimens would be internally sealed.

Molds for the creep specimen to be cast at the job site were prepared at Berkeley and shipped to the job site. Creep specimens were cast on the job site with concrete taken from the truck after two-thirds of the load had been discharged. The concrete was allowed about two hours time for the bleeding water to rise to the surface, the bleeding water was removed and a thin layer of mortar applied to provide a smooth surface for the top plate. The top two inches of butyl rubber sleeve was bonded and banded with a large hose clamp to the top plate to assure that the specimens would be internally sealed. Specimens were allowed to stand overnight and then moved to the civil office where the temperature remains about 70°F.

Compressive strength specimens cast at Berkeley were cast in 6-in. by 12-in. metal cans provided with lids to internally seal the specimen. Compressive strength specimens remained 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. Compressive strength specimens cast on the job site were cured at 70°F in water tanks until tested.

TEST PROCEDURES AND RESULTS

Compressive Strength and Elastic Properties

Compressive strength at Berkeley was determined at the ages of 3, 7 and 28 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-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 stress 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°F in Berkeley are shown in Table D. Compressive strengths for concrete cast at the job site ~~and~~ are shown in Table D.

Splitting tensile strengths were determined on three 6-in. x 12-in. concrete cylinders by A.S.T.M. C496-66 method.

Creep Tests

Creep characteristics for the concrete were determined on sealed 6-in. by 18-in. cylinders with centrally embedded Carlson Strain Meters. Two

specimens each were initially loaded at the ages of 28 days for specimens cast at Berkeley and 31 days for specimens cast at the job site all at a temperature of 73°F.

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 cast at Berkeley and in Table F for concrete cast at the job site. 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 cast at Berkeley have been under stress for 418 days and those cast at the job site have been under stress for 282 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 starting from one minute and minutes after load was applied are shown. Creep plus autogenous strains per psi of stress starting from 10 minutes after load was applied are shown.

Elastic, creep, plus autogenous strains and creep plus autogenous 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 cast at Berkeley and at the job site.

The complete computer calculations for determining the strains due to loading the sealed concrete specimens are shown in Tables G and H for specimens cast at Berkeley and Tables I and J for specimens cast at the job site.

TABLES

TABLE A

MIX DESIGN FOR TURKEY POINT CONCRETE

PENNSUCO AGGREGATES - 1970

Material	Source
Cement: Type II	Florida Portland Cement
Sand:	Pennsuco, Oolite, Florida Rock and Sand
3/4-in. Gravel:	Pennsuco, Oolite, Florida Rock and Sand
WRA Admixture:	Retardwell - Union Carbide
AEA Admixture:	Airecon - Union Carbide

Specifications	
f'c (at 28 days)	5000 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).

Mix No.	2P6
Cement, lbs.	635
Sand, lbs.	1254
3/4-in. Aggregate, lbs.	1630
Water, lbs.	260
WRA, oz.	27
AEA, oz.	1.6

TABLE B

CASTING DATA

PENNSUCO AGGREGATES

Date	November 20, 1970	
Specimens Cast	2 - 6x18-in. creep specimens 6 - 6x12-in. compressive strength cylinders 3 - 6x12-in. compressive strength, Young's Modulus, and Poisson's ratio cylinders 3 - 6x12-in. splitting tension cylinders	
Batch No.(a)	1	2
Cement, pcy	639	638
Water, pcy	279	277
Sand, pcy S.S.D.	1263	1257
3/4-in. aggregate, pcy S.S.D.	1636	1636
Unit wt., pcf	141.6	141.0
Slump, inches	2 1/2	2 3/4
Air, % by Vol.	3.8	3.8
AEA, oz. pcy	1.6	1.6
WRA, oz. pcy	27.2	27.1
Temp. ^{o}F	69	69

(a) Each batch approximately 1.70 cu. ft.

TABLE C

TURKEY POINT NUCLEAR CONTAINMENT VESSEL CONCRETE

BULK SPECIFIC GRAVITY AND ABSORPTION CAPACITY

Aggregate	BULK SPECIFIC GRAVITY - Saturated surface dry	ABSORPTION CAPACITY percent
Pennsuco sand	2.50	2.49
Pennsuco 3/4-in. aggregate	2.40	5.10

TABLE D

MECHANICAL PROPERTIES

Age, Days		Specimens Cast at	
		Berkeley	Job Site
3	Compressive strength,[(a)] psi	6,590	-
7	" " "	7,330	5,340
28	" " "	8,470	6,690
90	" " "	-	7,120
28	Poisson's Ratio	0.24	-
28	Modulus of elasticity,[(a)] psi x 10^6	4.4	-
28	" " "[(b)] "	4.7	-
28	Splitting tensile strength,[(a)] psi	570	-

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

(b) Average of two creep specimens.

TABLE E

TURKEY POINT NUCLEAR CONTAINMENT VESSEL CONCRETE

PENNSUCO AGGREGATE - 1972

ELASTIC, CREEP, AND AUTOGENOUS STRAINS

Specimen cast: At Berkeley, California
Maximum size of aggregate: 3/4-in.
Specimen size: 6-in. by 18-in. (Sealed)
Temperature: 73 $\pm$ 3°F
Age at loading: 28 days
Applied stress: 1530 psi
Compressive strength: 8470 psi at age 28 days
Fine aggregate: Pennsuco
Coarse aggregate: Pennsuco 3/4-in.

Time under Stress, days	Sustained Modulus of Elasticity psi x 10^6 (a)	Micro-strain			
		Elastic Creep plus Autogenous Strains	Creep plus Autogenous Strains		
			One minute after load applied	Ten minutes after load applied	
					per psi
0	-	0			
0.0007	4.71	-325	0		
0.0035	4.61	-333	-8		
0.0069	4.55	-336	-11	0	0
0.021	4.44	-345	-20	-9	-0.0058
1.04	3.85	-398	-73	-62	-0.0406
2	3.69	-415	-90	-79	-0.0516
3	3.60	-425	-100	-89	-0.0584
4	3.53	-434	-109	-98	-0.0640
10	3.24	-465	-140	-129	-0.0843
15	3.12	-489	-165	-153	-0.100
18	3.09	-496	-170	-160	-0.104
25	2.99	-512	-178	-176	-0.115
31	2.94	-520	-195	-184	-0.121
37	2.87	-533	-208	-197	-0.128
53	2.71	-555	-230	-219	-0.143
69	2.68	-571	-246	-235	-0.153
81	2.65	-578	-253	-242	-0.158
92	2.59	-590	-265	-254	-0.166
109	2.57	-595	-270	-259	-0.169
130	2.53	-605	-280	-269	-0.176
144	2.50	-613	-288	-277	-0.181
158	2.47	-619	-294	-283	-0.185
172	2.44	-628	-303	-292	-0.191
186	2.42	-633	-308	-297	-0.194
200	2.40	-637	-312	-301	-0.197
214	2.40	-638	-313	-302	-0.197

TABLE E, Continued

TURKEY POINT NUCLEAR CONTAINMENT VESSEL CONCRETE

PENNSUCO AGGREGATE - 1972

ELASTIC, CREEP, AND AUTOGENOUS STRAINS

Specimen cast: At Berkeley, California
Maximum size of aggregate: 3/4-in.
Specimen size: 6-in. by 18-in. (Sealed)
Temperature: 73 ± 3°F
Age at loading: 28 days
Applied stress: 1530 psi
Compressive strength: 8470 psi at age 28 days
Fine aggregate: Pennsuco
Coarse aggregate: Pennsuco 3/4-in.

Time under Stress, days	Sustained Modulus of Elasticity psi x 10^6 (a)	Micro-strain			
		Elastic Creep plus Autogenous Strains	Creep plus Autogenous Strains		
			One minute after load applied	Ten minutes after load applied	
					per psi
228	2.37	-645	-320	-309	-0.202
242	2.35	-650	-325	-314	-0.205
256	2.34	-653	-328	-317	-0.207
271	2.32	-658	-333	-322	-0.210
284	2.32	-660	-335	-324	-0.212
301	2.31	-663	-338	-327	-0.214
311	2.30	-666	-341	-330	-0.216
328	2.29	-669	-344	-333	-0.218
350	2.27	-673	-348	-337	-0.220
380	2.27	-674	-349	-338	-0.220
418	2.24	-682	-357	-346	-0.226

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

TABLE F

TURKEY POINT NUCLEAR CONTAINMENT VESSEL CONCRETE

PENNSUCO AGGREGATE - 1972

ELASTIC, CREEP, AND AUTOGENOUS STRAINS

Specimen cast: At Berkeley, California
Maximum size of aggregate: 3/4-in.
Specimen size: 6-in. by 18-in. (Sealed)
Temperature: 73 ± 3°F
Age at loading: 31 days
Applied stress: 1530 psi
Fine aggregate: Pennsuco
Coarse aggregate: Pennsuco 3/4-in.

Time under Stress, days	Sustained Modulus of Elasticity psi x 10^6 (a)	Micro-strain			
		Elastic Creep plus Autogenous Strains	Creep plus Autogenous Strains		
			One minute after load applied	Ten minutes after load applied	
					per psi
0	-	0			
0.0007	4.16	-368	0		
0.0035	4.05	-378	-10		
0.0069	3.97	-385	-17	0	0
0.014	3.87	-375	-27	-10	-0.0065
0.035	3.79	-404	-36	-19	-0.0124
0.333	3.53	-433	-65	-48	-0.0313
0.472	3.40	-450	-82	-65	-0.0424
0.881	3.35	-457	-89	-72	-0.0476
1	3.33	-460	-92	-75	-0.0490
7	2.85	-536	-168	-151	-0.0986
14	2.66	-575	-206	-189	-0.124
22	2.57	-595	-227	-210	-0.137
36	2.44	-627	-259	-242	-0.158
50	2.34	-655	-287	-270	-0.176
64	2.28	-671	-303	-286	-0.187
78	2.23	-685	-317	-300	-0.196
92	2.19	-698	-330	-313	-0.204
106	2.15	-711	-343	-326	-0.213
120	2.13	-720	-352	-335	-0.220
135	2.09	-732	-364	-347	-0.227
148	2.08	-736	-368	-351	-0.229
165	2.05	-745	-377	-360	-0.235
175	2.04	-751	-383	-366	-0.239
192	2.02	-757	-389	-372	-0.243
214	2.00	-764	-396	-379	-0.248
244	1.98	-772	-404	-387	-0.253
282	1.95	-784	-416	-399	-0.261

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

STRAIN METER NO. L290

PROJECT TURKEY POINT
LOCATION DAVIS HALL ROOM 360A CAST 11-20-70

CALIBRATIONS
METER RESISTANCE AT 0.0 DEGREES F. 53.38 OHMS
CHANGE IN TEMP. PER OHM CHANGE IN RESIS. 9.68 DEGREES F.
USEFUL RANGE 96.8-101.9 RATIO IN PERCENT
ORIGINAL CALIBRATION CONSTANT 3.15 MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE

CALIBRATION CONSTANT CORR. FOR LEAD 3.15 MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE

TEMPERATURE CORRECTION 5.5 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
11-12-70	915	61.43	77.9	99.865		0.	0.					
11-25-70	1740	60.96	73.4	99.882	.017	-20.	14.					
12 -9-70	1625	60.94	73.2	99.865	0.	-26.	9.					
12-18-70	1530	60.90	72.8	99.861	-.004	-29.	9.	0.				
12-18-70	1531	60.90	72.8	98.846	-1.019	-349.	-311.	-320.	0.	0.		
12-18-70	1535	60.90	72.8	98.824	-1.041	-356.	-318.	-327.	-7.	-.0045		
12-18-70	1540	60.94	73.2	98.819	-1.046	-356.	-320.	-329.	-9.	-.0061	0.	0.
12-18-70	1600	60.95	73.3	98.791	-1.074	-364.	-329.	-338.	-18.	-.0120	-9.	-.0059
12-19-70	1630	60.93	73.1	98.626	-1.239	-417.	-381.	-390.	-70.	-.0457	-61.	-.0396
12-20-70	1605	60.93	73.1	98.570	-1.295	-435.	-398.	-407.	-88.	-.0572	-78.	-.0511
12-21-70	1615	60.91	72.9	98.537	-1.328	-446.	-408.	-417.	-98.	-.0637	-88.	-.0577
12-22-70	1620	60.92	73.0	98.511	-1.354	-454.	-417.	-426.	-106.	-.0692	-97.	-.0632
12-28-70	940	60.90	72.8	98.409	-1.456	-487.	-448.	-457.	-138.	-.0900	-128.	-.0839
1 -2-71	945	60.94	73.2	98.332	-1.533	-509.	-473.	-482.	-163.	-.1063	-153.	-.1003
1 -5-71	1715	60.93	73.1	98.316	-1.549	-515.	-478.	-487.	-168.	-.1095	-158.	-.1034
1-12-71	1530	60.95	73.3	98.262	-1.603	-531.	-496.	-505.	-185.	-.1209	-176.	-.1148
1-18-71	955	60.93	73.1	98.233	-1.632	-541.	-504.	-513.	-194.	-.1266	-184.	-.1205
1-24-71	1410	60.96	73.4	98.192	-1.673	-552.	-518.	-527.	-207.	-.1354	-198.	-.1293
2 -9-71	1210	60.98	73.6	98.125	-1.740	-572.	-539.	-548.	-229.	-.1495	-219.	-.1434
2-25-71	1030	60.98	73.6	98.079	-1.786	-587.	-554.	-563.	-243.	-.1589	-234.	-.1529
3 -9-71	1410	60.98	73.6	98.053	-1.812	-595.	-562.	-571.	-251.	-.1643	-242.	-.1582
3-23-71	1440	61.01	73.9	98.021	-1.844	-603.	-573.	-582.	-262.	-.1712	-253.	-.1652
4 -6-71	930	60.99	73.7	98.002	-1.863	-610.	-578.	-587.	-268.	-.1749	-258.	-.1688
4-27-71	1000	60.98	73.6	97.974	-1.891	-620.	-587.	-596.	-276.	-.1805	-267.	-.1745
5-11-71	1350	60.96	73.4	97.941	-1.924	-631.	-597.	-606.	-286.	-.1871	-277.	-.1810
5-25-71	1500	60.98	73.6	97.927	-1.938	-634.	-602.	-611.	-291.	-.1902	-282.	-.1842
6 -8-71	920	61.02	74.0	97.897	-1.968	-642.	-612.	-621.	-301.	-.1969	-292.	-.1908
6-22-71	1410	61.00	73.8	97.884	-1.981	-647.	-616.	-625.	-305.	-.1993	-296.	-.1933
7 -6-71	1340	61.01	73.9	97.870	-1.995	-651.	-620.	-629.	-310.	-.2023	-300.	-.1963
7-20-71	1015	61.00	73.8	97.864	-2.001	-653.	-622.	-631.	-311.	-.2034	-302.	-.1974
8 -3-71	1510	61.01	73.9	97.848	-2.017	-658.	-627.	-636.	-316.	-.2069	-307.	-.2008
8-17-71	850	61.03	74.1	97.834	-2.031	-661.	-632.	-641.	-321.	-.2100	-312.	-.2039
8-31-71	1410	61.02	74.0	97.823	-2.042	-665.	-635.	-644.	-325.	-.2121	-315.	-.2061
9-15-71	1610	61.04	74.1	97.807	-2.058	-669.	-641.	-650.	-330.	-.2157	-321.	-.2096
9-27-71	1415	61.03	74.1	97.799	-2.066	-672.	-643.	-652.	-332.	-.2172	-323.	-.2111
10-14-71	1400	61.01	73.9	97.792	-2.073	-675.	-645.	-654.	-334.	-.2184	-325.	-.2123
10-24-71	1440	61.00	73.8	97.780	-2.085	-680.	-648.	-657.	-338.	-.2207	-328.	-.2147
11-11-71	1400	60.98	73.6	97.772	-2.093	-683.	-651.	-660.	-340.	-.2221	-331.	-.2161
12 -1-71	1410	60.99	73.7	97.759	-2.106	-687.	-655.	-664.	-344.	-.2249	-335.	-.2189
1 -3-71	1420	60.96	73.4	97.753	-2.112	-690.	-656.	-665.	-345.	-.2258	-336.	-.2197
2-10-72	1420	60.97	73.5	97.727	-2.138	-698.	-665.	-674.	-354.	-.2313	-345.	-.2252

TABLE G

STRAIN METER NO. L291

PROJECT TURKEY POINT
LOCATION DAVIS HALL ROOM 360A CAST 11-20-70

CALIBRATIONS
METER RESISTANCE AT 0.0 DEGREES F. 53.51 OHMS
CHANGE IN TEMP. PER OHM CHANGE IN RESIS. 9.65 DEGREES F.
USEFUL RANGE 96.8-101.9 RATIO IN PERCENT
ORIGINAL CALIBRATION CONSTANT 3.16 MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
CALIBRATION CONSTANT CORR. FOR LEAD 3.16 MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
TEMPERATURE CORRECTION 5.5 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
11-12-70	915	61.52	77.3	99.852		0.	0.					
11-25-70	1740	61.14	73.6	99.862	.010	-17.	10.					
12 -9-70	1625	61.12	73.4	99.848	-.004	-22.	6.					
12-18-70	1530	61.10	73.2	99.842	-.010	-25.	5.	0.				
12-18-70	1531	61.10	73.2	98.794	-1.058	-357.	-326.	-331.	0.	0.		
12-18-70	1535	61.10	73.2	98.770	-1.082	-364.	-334.	-339.	-8.	-.0050		
12-18-70	1540	61.14	73.6	98.758	-1.094	-366.	-338.	-343.	-12.	-.0079	0.	0.
12-18-70	1600	61.14	73.6	98.730	-1.122	-375.	-347.	-352.	-21.	-.0137	-9.	-.0058
12-19-70	1630	61.08	73.1	98.553	-1.299	-434.	-402.	-407.	-76.	-.0495	-64.	-.0416
12-20-70	1605	61.06	72.9	98.501	-1.351	-451.	-418.	-423.	-92.	-.0600	-80.	-.0521
12-21-70	1615	61.06	72.9	98.467	-1.385	-462.	-429.	-434.	-103.	-.0670	-90.	-.0591
12-22-70	1620	61.08	73.1	98.441	-1.411	-469.	-437.	-442.	-111.	-.0727	-99.	-.0647
12-28-70	940	61.04	72.7	98.342	-1.510	-503.	-468.	-473.	-142.	-.0926	-130.	-.0847
1 -2-71	945	61.09	73.1	98.270	-1.582	-523.	-492.	-497.	-165.	-.1081	-153.	-.1002
1 -6-71	1715	61.08	73.1	98.245	-1.607	-531.	-499.	-504.	-173.	-.1131	-161.	-.1052
1-12-71	1530	61.10	73.2	98.195	-1.657	-546.	-516.	-520.	-189.	-.1237	-177.	-.1158
1-18-71	955	61.04	72.7	98.166	-1.686	-558.	-524.	-528.	-197.	-.1289	-185.	-.1210
1-24-71	1410	61.08	73.1	98.131	-1.721	-567.	-535.	-540.	-209.	-.1367	-197.	-.1287
2 -9-71	1210	61.13	73.5	98.061	-1.791	-587.	-558.	-563.	-232.	-.1518	-220.	-.1438
2-25-71	1030	61.13	73.5	98.012	-1.840	-602.	-574.	-579.	-248.	-.1619	-236.	-.1539
3 -9-71	1410	61.12	73.4	97.987	-1.865	-611.	-582.	-587.	-255.	-.1669	-243.	-.1590
3-23-71	1440	61.16	73.8	97.952	-1.900	-620.	-593.	-598.	-267.	-.1747	-255.	-.1667
4 -6-71	930	61.05	72.8	97.931	-1.921	-632.	-598.	-603.	-272.	-.1776	-260.	-.1697
4-27-71	1000	61.13	73.5	97.899	-1.953	-638.	-610.	-615.	-283.	-.1852	-271.	-.1773
5-11-71	1350	61.12	73.4	97.878	-1.974	-645.	-616.	-621.	-290.	-.1894	-278.	-.1815
5-25-71	1500	61.14	73.6	97.859	-1.993	-650.	-622.	-627.	-296.	-.1936	-284.	-.1857
6 -8-71	920	61.15	73.7	97.834	-2.018	-657.	-631.	-635.	-304.	-.1989	-292.	-.1910
6-22-71	1410	61.16	73.8	97.816	-2.036	-662.	-636.	-641.	-310.	-.2027	-298.	-.1948
7 -6-71	1340	61.17	73.9	97.801	-2.051	-667.	-641.	-646.	-315.	-.2060	-303.	-.1980
7-20-71	1015	61.12	73.4	97.797	-2.055	-671.	-642.	-647.	-315.	-.2062	-303.	-.1982
8 -3-71	1510	61.17	73.9	97.776	-2.076	-675.	-649.	-654.	-323.	-.2111	-311.	-.2032
8-17-71	850	61.18	74.0	97.761	-2.091	-679.	-654.	-659.	-328.	-.2144	-316.	-.2064
8-31-71	1410	61.17	73.9	97.751	-2.101	-682.	-657.	-662.	-331.	-.2163	-319.	-.2084
9-15-71	1610	61.13	74.0	97.735	-2.117	-687.	-662.	-667.	-336.	-.2197	-324.	-.2118
9-27-71	1415	61.15	73.7	97.727	-2.125	-691.	-664.	-669.	-338.	-.2210	-326.	-.2131
10-14-71	1400	61.16	73.8	97.717	-2.135	-694.	-668.	-673.	-341.	-.2232	-329.	-.2153
10-24-71	1440	61.16	73.8	97.707	-2.145	-697.	-671.	-676.	-345.	-.2253	-333.	-.2173
11-11-71	1400	61.14	73.6	97.697	-2.155	-701.	-674.	-679.	-347.	-.2271	-335.	-.2191
12 -1-71	1410	61.14	73.6	97.685	-2.167	-705.	-677.	-682.	-351.	-.2296	-339.	-.2216
1 -3-71	1420	61.09	73.1	97.680	-2.172	-709.	-678.	-683.	-352.	-.2300	-340.	-.2220
2-10-72	1420	61.10	73.2	97.659	-2.193	-715.	-685.	-690.	-359.	-.2344	-347.	-.2265

TABLE H

STRAIN METER NO. L286

PROJECT TURKEY POINT FS 7151 CAST ON JOB
LOCATION ROOM 360A DAVIS HALL LOADED TO 1530 PSI

CALIBRATIONS

METER RESISTANCE AT 0.0 DEGREES F.	53.56	OHMS
CHANGE IN TEMP. PER OHM CHANGE IN RESIS.	9.65	DEGREES F.
USEFUL RANGE	96.6-101.7	RATIO IN PERCENT
ORIGINAL CALIBRATION CONSTANT	3.14	MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
CALIBRATION CONSTANT CORR. FOR LEAD	3.14	MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
TEMPERATURE CORRECTION	5.2	MICROSTRAIN PER DEGREE F.
CONCRETE EXPANSION	5.7	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
4-22-71	1425	59.70	59.3	99.716		0.	0.					
5 -3-71	1538	60.94	71.2	99.580	-.136	20.	-49.	0.				
5 -3-71	1539	60.94	71.2	98.361	-1.355	-363.	-431.	-383.	0.	0.		
5 -3-71	1541	60.94	71.2	98.339	-1.377	-370.	-438.	-390.	-7.	-.0045		
5 -3-71	1543	60.94	71.2	98.325	-1.391	-375.	-443.	-394.	-11.	-.0074		
5 -3-71	1548	60.99	71.7	98.302	-1.414	-379.	-450.	-402.	-19.	-.0123	0.	0.
5 -3-71	1608	60.99	71.7	98.268	-1.448	-390.	-461.	-412.	-29.	-.0192	-11.	-.0070
5 -3-71	1638	60.99	71.7	98.238	-1.478	-399.	-470.	-422.	-39.	-.0254	-20.	-.0131
5 -3-71	2207	60.98	71.6	98.139	-1.577	-431.	-501.	-453.	-70.	-.0457	-51.	-.0334
5 -4-71	755	60.98	71.6	98.086	-1.630	-448.	-518.	-469.	-87.	-.0566	-68.	-.0443
5 -4-71	1255	60.98	71.6	98.062	-1.654	-455.	-526.	-477.	-94.	-.0615	-75.	-.0492
5 -4-71	1538	60.98	71.6	98.054	-1.662	-458.	-528.	-479.	-97.	-.0631	-78.	-.0509
5-11-71	1350	61.02	72.0	97.811	-1.905	-532.	-605.	-556.	-173.	-.1131	-154.	-.1009
5-17-71	1630	61.07	72.5	97.697	-2.019	-565.	-641.	-592.	-209.	-.1367	-190.	-.1244
5-25-71	1500	61.03	72.1	97.621	-2.095	-591.	-664.	-616.	-233.	-.1522	-214.	-.1399
5 -8-71	920	61.05	72.3	97.515	-2.201	-623.	-698.	-649.	-266.	-.1740	-247.	-.1617
6-22-71	1410	61.10	72.8	97.433	-2.283	-647.	-724.	-675.	-292.	-.1910	-273.	-.1787
7 -6-71	1340	61.10	72.8	97.375	-2.341	-665.	-742.	-693.	-310.	-.2029	-292.	-.1906
7-20-71	1015	61.10	72.8	97.331	-2.385	-679.	-756.	-707.	-324.	-.2119	-305.	-.1996
8 -3-71	1510	61.10	72.8	97.285	-2.431	-693.	-770.	-721.	-339.	-.2213	-320.	-.2091
8-17-71	850	61.12	73.0	97.245	-2.471	-705.	-783.	-734.	-351.	-.2296	-333.	-.2173
8-31-71	1410	61.12	73.0	97.214	-2.502	-714.	-792.	-744.	-361.	-.2360	-342.	-.2237
9-15-71	1610	61.22	73.9	97.173	-2.543	-722.	-806.	-757.	-374.	-.2447	-356.	-.2324
9-27-71	1415	61.07	72.5	97.160	-2.556	-734.	-809.	-761.	-378.	-.2469	-359.	-.2346
10-14-71	1400	61.11	72.9	97.132	-2.584	-741.	-818.	-769.	-387.	-.2528	-368.	-.2405
10-24-71	1440	61.06	72.4	97.111	-2.605	-750.	-825.	-776.	-393.	-.2569	-374.	-.2446
11-11-71	1400	61.04	72.2	97.092	-2.624	-757.	-830.	-782.	-399.	-.2608	-380.	-.2485
12 -1-71	1410	61.02	72.0	97.072	-2.644	-764.	-837.	-788.	-405.	-.2648	-386.	-.2525
1 -3-71	1420	60.98	71.6	97.043	-2.673	-775.	-845.	-797.	-414.	-.2706	-395.	-.2584
2-10-72	1420	61.01	71.9	97.006	-2.710	-785.	-857.	-809.	-426.	-.2783	-407.	-.2660

TABLE I

STRAIN METER NO. L287

PROJECT TURKEY POINT ES 7151 CAST ON JOB
LOCATION ROOM 360A DAVIS HALL LOADED TO 1530 PSI

CALIBRATIONS

METER RESISTANCE AT 0.0 DEGREES F.	52.95	OHMS
CHANGE IN TEMP. PER OHM CHANGE IN RESIS.	9.75	DEGREES F.
USEFUL RANGE	96.7-101.9	RATIO IN PERCENT
ORIGINAL CALIBRATION CONSTANT	3.17	MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
CALIBRATION CONSTANT CORR. FOR LEAD	3.17	MICROSTRAIN PER 0.01 PERCENT RATIO CHANGE
TEMPERATURE CORRECTION	5.2	MICROSTRAIN PER DEGREE F.
CONCRETE EXPANSION	5.7	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
4-22-71	1425	59.07	59.7	99.826		0.	0.					
5 -3-71	1538	60.36	72.2	99.682	-.144	20.	-52.	0.				
5 -3-71	1539	60.36	72.2	98.565	-1.261	-334.	-406.	-354.	0.	0.		
5 -3-71	1541	60.36	72.2	98.550	-1.276	-339.	-411.	-359.	-5.	-.0031		
5 -3-71	1543	60.36	72.2	98.539	-1.287	-343.	-414.	-362.	-8.	-.0054		
5 -3-71	1548	60.41	72.7	98.519	-1.307	-346.	-421.	-369.	-15.	-.0097	0.	0.
5 -3-71	1608	60.41	72.7	98.487	-1.339	-357.	-431.	-379.	-25.	-.0163	-10.	-.0066
5 -3-71	1638	60.41	72.7	98.463	-1.363	-364.	-439.	-387.	-33.	-.0213	-18.	-.0116
5 -3-71	2207	60.40	72.6	98.373	-1.453	-393.	-467.	-415.	-61.	-.0399	-46.	-.0302
5 -4-71	755	60.40	72.6	98.320	-1.506	-410.	-484.	-432.	-78.	-.0509	-63.	-.0412
5 -4-71	1255	60.40	72.6	98.297	-1.529	-417.	-491.	-439.	-85.	-.0557	-70.	-.0460
5 -4-71	1538	60.40	72.6	98.288	-1.538	-420.	-494.	-442.	-88.	-.0575	-73.	-.0478
5-11-71	1350	60.43	72.9	98.048	-1.778	-495.	-570.	-518.	-164.	-.1073	-149.	-.0976
5-17-71	1630	60.46	73.2	97.926	-1.900	-532.	-609.	-557.	-203.	-.1327	-188.	-.1230
5-25-71	1500	60.43	72.9	97.867	-1.959	-552.	-628.	-576.	-222.	-.1448	-207.	-.1352
6 -8-71	920	60.45	73.1	97.765	-2.061	-583.	-660.	-608.	-254.	-.1660	-239.	-.1563
6-22-71	1410	61.48	83.2	97.693	-2.133	-554.	-688.	-636.	-282.	-.1842	-267.	-.1745
7 -6-71	1340	60.48	73.4	97.635	-2.191	-623.	-701.	-649.	-295.	-.1931	-281.	-.1834
7-20-71	1015	60.51	73.7	97.591	-2.235	-635.	-716.	-664.	-309.	-.2023	-295.	-.1926
8 -3-71	1510	60.49	73.5	97.552	-2.274	-649.	-728.	-676.	-322.	-.2103	-307.	-.2006
8-17-71	850	60.51	73.7	97.515	-2.311	-660.	-740.	-688.	-334.	-.2180	-319.	-.2083
8-31-71	1410	60.51	73.7	97.484	-2.342	-669.	-749.	-697.	-343.	-.2244	-329.	-.2148
9-15-71	1510	60.58	74.4	97.451	-2.375	-676.	-760.	-708.	-354.	-.2315	-339.	-.2218
9-27-71	1415	60.47	73.3	97.434	-2.392	-687.	-765.	-713.	-359.	-.2347	-344.	-.2250
10-14-71	1400	60.50	73.6	97.410	-2.416	-693.	-773.	-721.	-367.	-.2398	-352.	-.2301
10-24-71	1440	60.46	73.2	97.390	-2.436	-702.	-779.	-727.	-373.	-.2438	-358.	-.2341
11-11-71	1400	60.45	73.1	97.371	-2.455	-708.	-785.	-733.	-379.	-.2477	-364.	-.2380
12 -1-71	1410	60.44	73.0	97.347	-2.479	-716.	-793.	-741.	-386.	-.2526	-372.	-.2429
1 -3-71	1420	60.41	72.7	97.322	-2.504	-726.	-800.	-748.	-394.	-.2577	-379.	-.2480
2-10-72	1420	60.43	72.9	97.288	-2.538	-736.	-811.	-759.	-405.	-.2648	-390.	-.2551

TABLE J

FIGURE

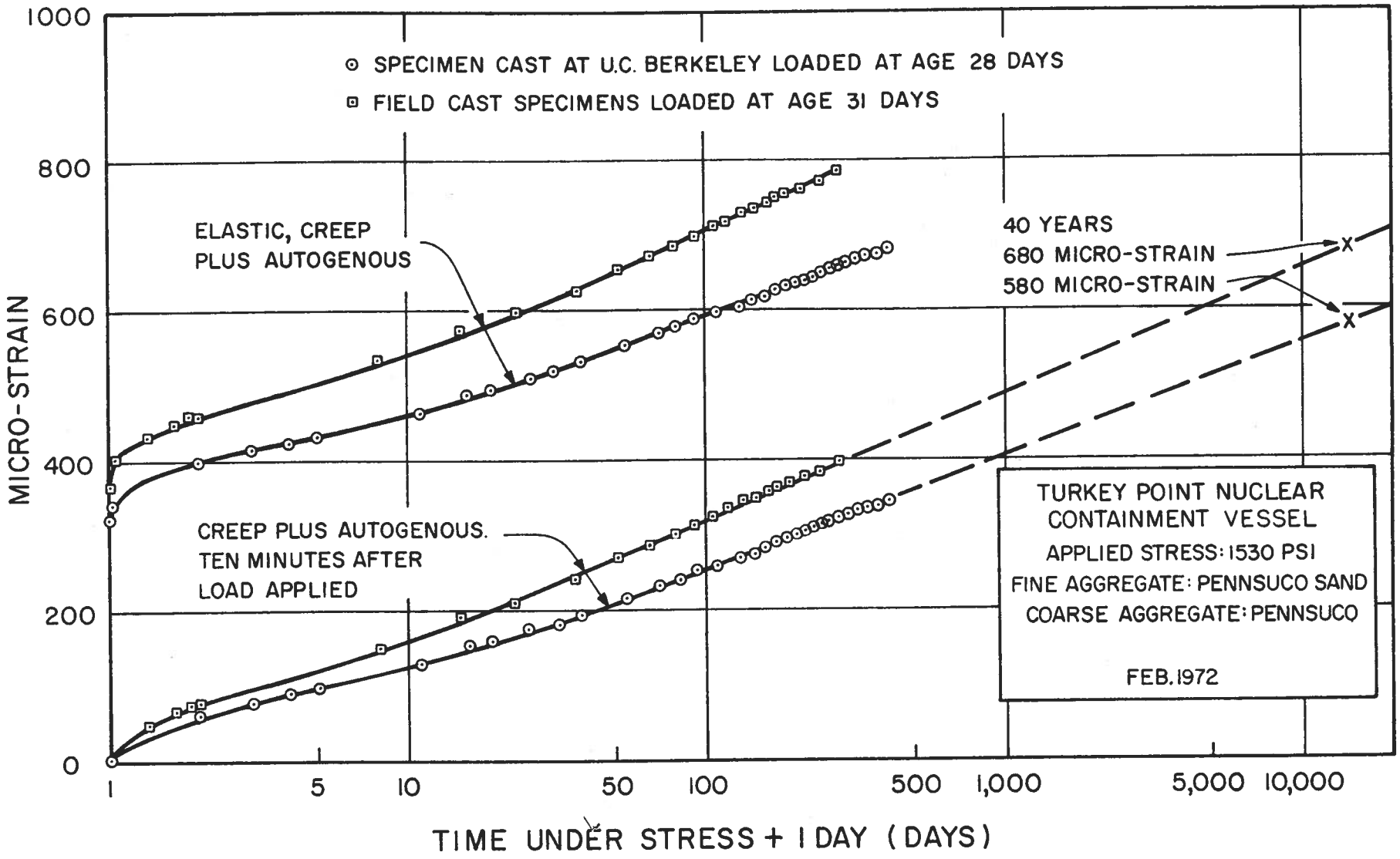
1000
800
600
400
200
0
MICRO-STRAIN
SPECIMEN CAST AT U.C. BERKELEY LOADED AT AGE 28 DAYS
FIELD CAST SPECIMENS LOADED AT AGE 31 DAYS
ELASTIC, CREEP
PLUS AUTOGENOUS
CREEP PLUS AUTOGENOUS.
TEN MINUTES AFTER
LOAD APPLIED
40 YEARS
680 MICRO-STRAIN
580 MICRO-STRAIN
X
X
TURKEY POINT NUCLEAR
CONTAINMENT VESSEL
APPLIED STRESS: 1530 PSI
FINE AGGREGATE: PENNSUCO SAND
COARSE AGGREGATE: PENNSUCO
FEB. 1972
1
5
10
50
100
500
1,000
5,000
10,000
TIME UNDER STRESS + 1 DAY (DAYS)

FIG. 1

FIG. 1