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20. ABSTRACT (Continued).

(73° and 150°F), and four types of loading (uniaxial, hydrostatic, biaxial, and triaxial).

This effort was intended primarily as a data report; therefore, the experimental procedures and results are presented in detail. A comprehensive evaluation of the effects of various parameters and their interactions on the behavior of concrete was not included in this report. However, a number of general comparisons were made concerning the effect of the various test conditions on concrete behavior. Based on this limited evaluation of the data, general conclusions and recommendations for additional work were formulated.

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PREFACE

The study reported herein was conducted by personnel of the Concrete Laboratory (CL), U. S. Army Engineer Waterways Experiment Station (WES), under the sponsorship of the Energy Research and Development Administration.

The investigation was conducted during the period 1966 to 1971 under the general supervision of Mr. B. Mather, Chief, CL, and Mr. J. M. Polatty, Chief, Engineering Mechanics Division, CL. The study was initiated by Dr. J. C. Chakrabarti under the direct supervision of Dr. H. G. Geymayer, former Chief, Structures Branch, CL. The investigation was completed by Mr. J. E. McDonald, Chief, Structures Branch, CL, who also prepared this report. The author acknowledges the cooperation of Mr. G. D. Whitman, Coordinator, Pressure Vessel Technology Program, and Mr. J. P. Callahan, Manager, Prestressed Concrete Reactor Vessel Program Office, Oak Ridge National Laboratory, whose active support allowed this investigation to be successfully completed and reported.

Directors of WES during this investigation and the preparation of this report were COL J. R. Oswalt, Jr., CE; COL L. A. Brown, CE; BG E. D. Peixotto, CE; and COL G. H. Hilt, CE. Technical Directors were Messrs. J. B. Tiffany and F. R. Brown.

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

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
inches	25.4	millimetres
pounds (mass)	0.4535924	kilograms
pounds (force) per square inch	0.006894757	megapascals
cubic feet	0.02831685	cubic metres
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following equation: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

TIME-DEPENDENT DEFORMATION OF CONCRETE
UNDER MULTIAXIAL STRESS CONDITIONS

PART I: INTRODUCTION

Background

1. One of the most important aspects in the design and safety evaluation of a prestressed concrete reactor vessel (PCRv) is the time-dependent deformation behavior of concrete in the presence of varying temperatures, moisture, and loading conditions. Creep and shrinkage in the concrete can have serious consequences because they produce (a) a loss of initial prestress, (b) large deformations of the vessel, which could result in misalignment of the control rod passages, and (c) residual stresses that may be introduced as the loading conditions change. In the latter case, the residual stresses could conceivably be tensile stresses, resulting in serious damage to the vessel. Consequently, a basic research program formulated and directed by the Oak Ridge National Laboratory to develop and improve the technology of PCRv's in the United States included a sizeable investigation of the time-dependent conditions existing in a PCRv. This program was intended to provide basic information that could be used, first, as a basis for developing analytical techniques for examining the time-dependent behavior of a PCRv, and, second, as the data necessary when using these techniques for design and safety evaluations. One of the projects included in this effort was a multiaxial creep program performed at the U. S. Army Engineer Waterways Experiment Station (WES); this project is reported herein.

Purpose and Scope

2. The WES investigation was part of an overall investigation to provide information on the time-dependent deformation of concrete

that could be used in predictions of vessel behavior for the many regimes of loading experienced under design and hypothetical accident conditions. This particular investigation encompassed one strength (6000 psi* at 28 days), three aggregate types (chert, limestone, and graywacke), one cement (type II), two types of specimens (as-cast and air-dried), two levels of temperature during test (73° and 150° F), and four types of loading (uniaxial, hydrostatic, biaxial, and triaxial).

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 4.

PART II: EXPERIMENTAL PROGRAM

Test Conditions

3. Although numerous factors affect the time-dependent deformation behavior of concrete, this study concerned only four of the more important variables, i.e., modulus of elasticity of the aggregate, curing history prior to loading, temperature during loading, and state of stress during loading. Sixty-six test conditions involving loaded specimens were investigated. In addition, twelve test conditions involving unloaded or control specimens were investigated. The seventy-eight test conditions are summarized in Table 1.

Aggregate

4. Concrete made with Tennessee limestone aggregate (3/4-in. maximum size) was chosen as the main mixture since it was representative of mixtures that might be used in a PCRV in most sections of the United States. Two other mixtures containing Alabama graywacke and chert, aggregates with elastic moduli lower and higher, respectively, than that of limestone, were used to provide information for comparison. Pertinent physical characteristics of the aggregates are given in Plates 1-3 and in Appendix A. Average aggregate moduli are compared in Figure 1.

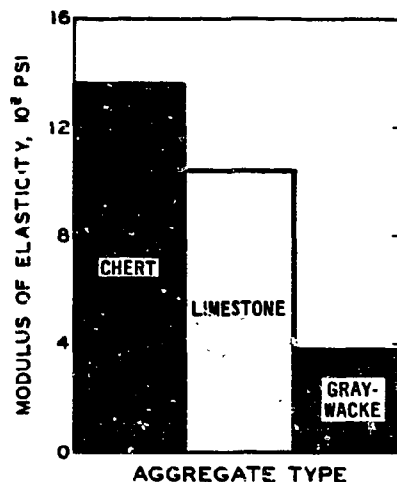


Figure 1. Comparison of aggregate modulus

Curing history

5. The two curing histories selected for this study were designated "as-cast" (AC) and "air-dried" (AD). The AC specimens were sealed shortly after casting and remained so throughout the test to prevent evaporation losses. The resultant saturated concrete was representative of the interior of a mass of concrete such as a PCRV. After seven days of wet curing, the AD specimens were allowed to dry in air at 73°F and 50 percent relative humidity for the remainder of the 90-day period preceding testing. These specimens exhibited considerable moisture loss and were representative of concrete near the exterior of a PCRV.

Temperature

6. The temperature levels during loading were selected as representative of the limits of the range of concrete temperatures experienced in a nuclear reactor containment vessel during normal operation, 73°F and 150°F corresponding to temperatures expected at the outer and inner surfaces, respectively.

Load

7. Until recently, the majority of creep work has concerned uniaxial loading only; however, the reinforcement of a PCRV is such that other states of stress exist. As a result, test specimens were loaded in uniaxial, biaxial, hydrostatic, and triaxial states of stress with both axial stress and radial confining stress ranging from 0 to 2400 psi.

Mixture Proportions

8. Three concrete mixtures were proportioned with type II portland cement and 3/4-in. maximum size aggregates, the moduli of elasticity of which ranged from 3.8 to 13.65×10^6 psi, to have compressive strengths of 6000 psi at 28 days. Proportions of the resultant concrete mixtures, designated high, main, and low modulus according to aggregate moduli, are shown in Appendix A and summarized as follows:

<u>Material</u>	<u>Saturated Surface Dry Weight, lb</u>	<u>Solid Volume, cu ft</u>
<u>High Modulus (Chert Aggregate)</u>		
Portland cement	784.90	4.000
Fine aggregate	1234.40	7.534
Coarse aggregate	1774.40	11.302
Water	259.43	4.164
Total	4053.13	27.000
<u>Main Modulus (Limestone Aggregate)</u>		
Portland cement	681.50	3.473
Fine aggregate	1381.50	8.305
Coarse aggregate	1784.40	10.569
Water	289.86	4.653
Total	4137.26	27.000
<u>Low Modulus (Graywacke Aggregate)</u>		
Portland cement	775.50	3.952
Fine aggregate	1224.10	7.586
Coarse aggregate	1622.90	10.057
Water	336.76	5.405
Total	3959.26	27.000

Specimens

9. Three basic types of specimens were utilized in this investigation: creep, control, and strength. All creep and control specimens were 6 in. in diameter by 16 in. in length and were attached to 1-in.-thick steel end plates (Figure 2). The creep specimens, the primary test specimens, were used to determine total concrete strains under the various test conditions. The experimental design required 66 such specimens. Four control specimens were cast from each batch of concrete to determine volume changes of unloaded specimens subjected to environmental conditions identical with those used for companion loaded specimens.

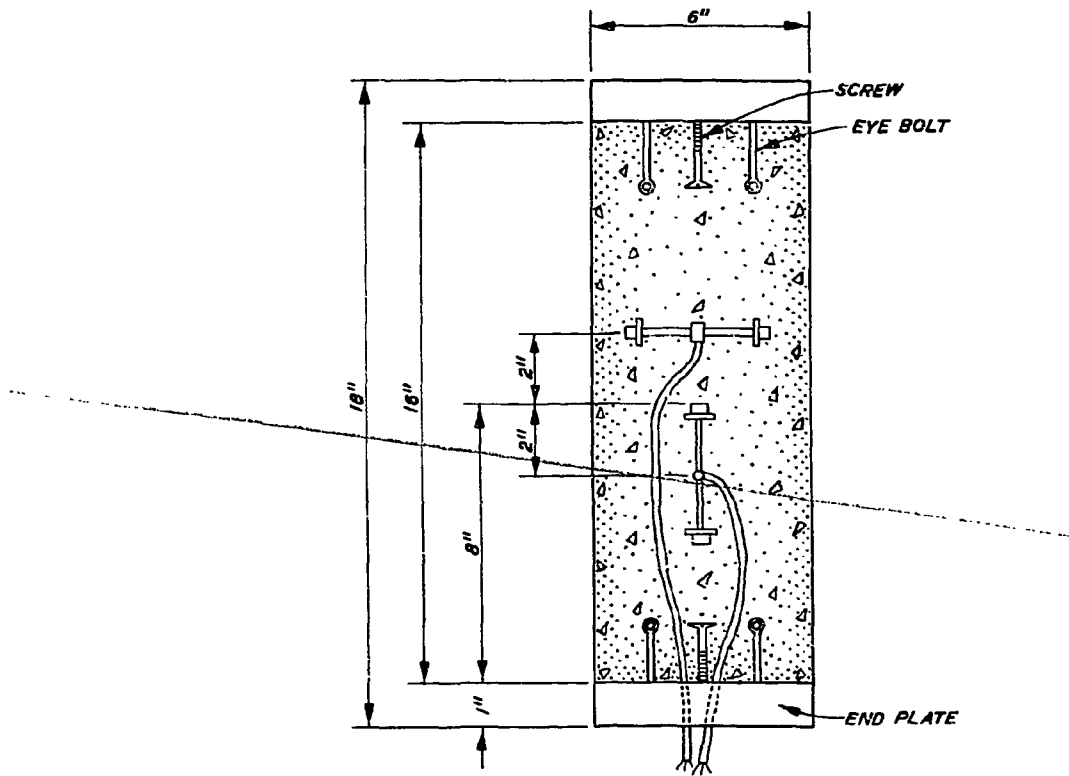


Figure 2. Test specimen and gage locations

10. In addition to the creep and control specimens, 6- by 12-in. cylindrical, concrete strength specimens were cast. These specimens were cast from all eight batches and consisted of AC, AD, and standard cured specimens. These specimens were used to determine compressive strengths of the concrete for the various conditions throughout the test period.

Specimen Preparation

Molds

11. All creep and control specimens were cast in specially designed steel molds (Figure 3). Since it was essential for the creep tests that the end plates of each specimen be both parallel to each other and

perpendicular to the longitudinal axis of the specimen, jigs were designed and fabricated for preliminary adjustment and positioning of the end plates in the creep mold (Figure 4) and for checking the parallelism of the end plates (Figure 5) after specimen fabrication. Using this equipment, test specimens were found to differ by not more than 0.003 in. in parallelism of their end plates. The compressive strength specimens were cast in standard 6- by 12-in. molds.

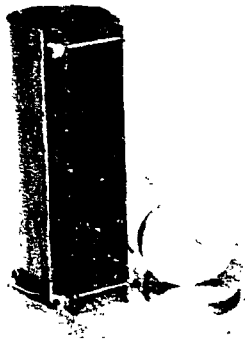


Figure 3. Creep and shrinkage specimen mold with end plates

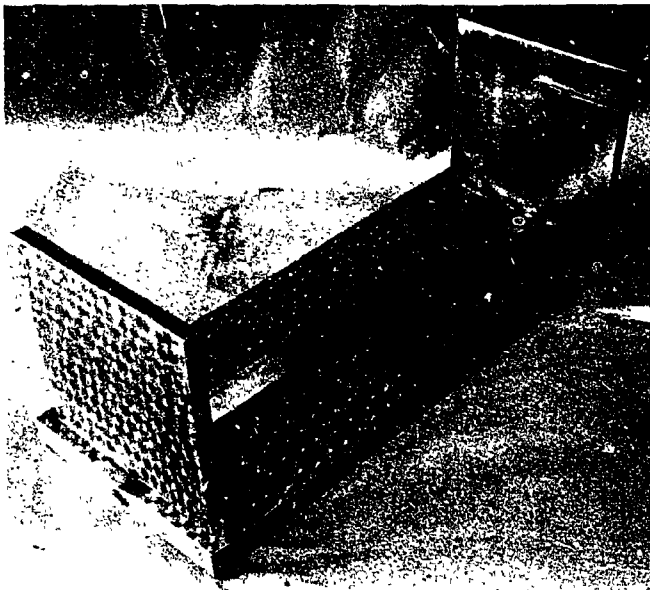


Figure 4. Apparatus for positioning end plates in creep molds

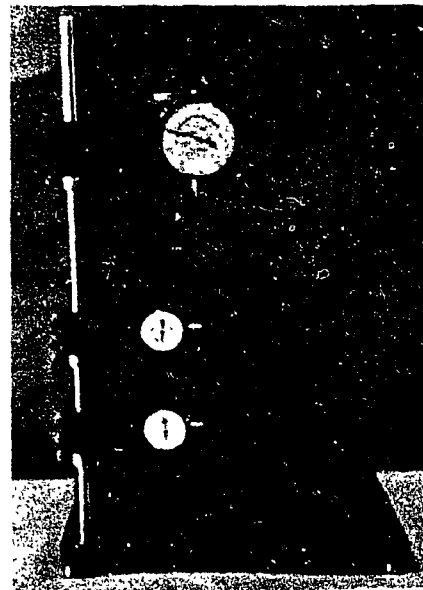


Figure 5. Apparatus to check parallelism and perpendicularity of end plates

Strain gages

12. To further protect the gages against moisture penetration, a waterproofing adhesive was applied to the ends of the gages and around the leads prior to embedment. Two vibrating-wire strain gages (Figure 6) were placed in each 6- by 16-in. specimen to measure axial and radial strains. Thirty-pound test monofilament nylon line was used to position and secure both the axial and radial strain gages. The line passed through the two diametrically opposite holes on each flange of the vibrating wire gage end disks and was fastened with two anchor bolts placed diametrically opposite on each of the specimen end plates (Figure 7).

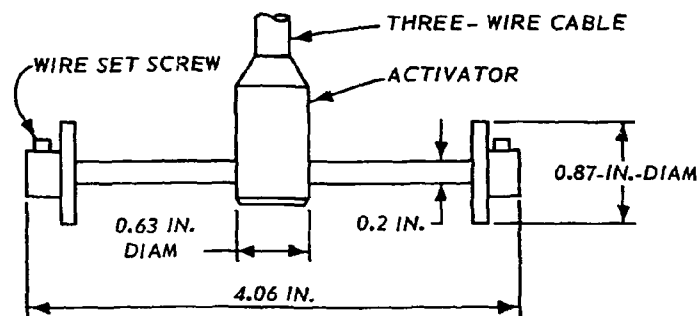


Figure 6. Vibrating-wire strain gage

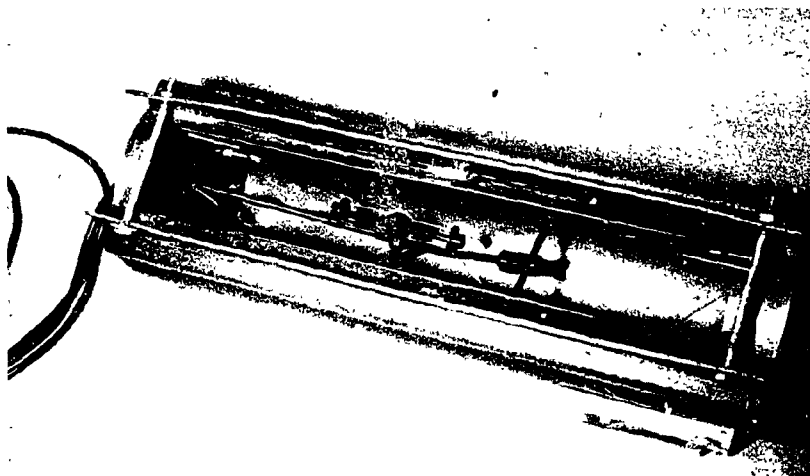


Figure 7. Mold for creep and control specimens with vibrating-wire strain gages in place

Batches and specimens

13. A total of 347 specimens were cast from eight batches of concrete. There were 98 6- by 16-in. cylinders and 249 6- by 12-in. cylinders. The casting dates and number of specimens cast from each batch are shown in Table 2. The creep and control specimens cast from individual batches of concrete are shown in Table 3.

Casting and consolidation

14. The 6- by 16-in. cylindrical creep and control specimens were cast horizontally in a steel mold that maintained parallelism of the 1-in. end plates holding the vibrating-wire strain gages in place (Figure 6). Prior to casting, the strain gages were read and recorded. After casting and consolidation on a vibrating table, the specimens were troweled to complete the circular cross section (Figure 8), the strain gages were read, and the specimens were then placed in a 100-percent-humidity (fog) room. The 6- by 12-in. strength specimens were cast in standard molds, except that molds used for the AC specimens contained 0.008-in.-thick copper inserts (Figure 9) for sealing.

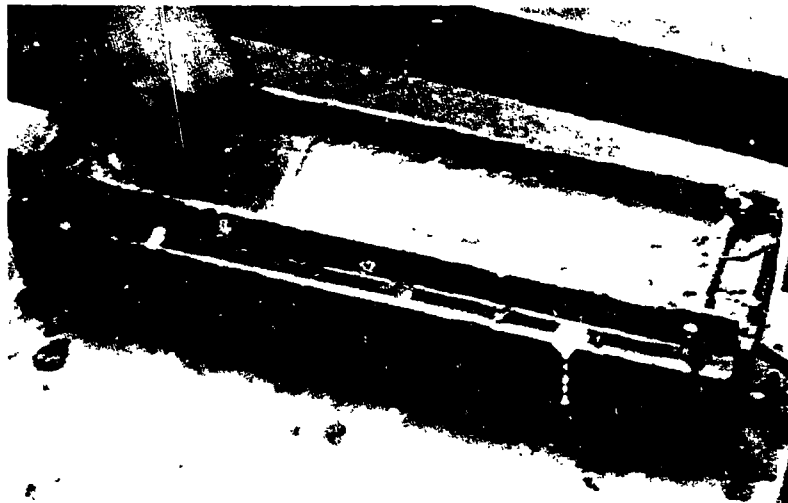


Figure 8. Troweling a 6- by 16-in. specimen to complete circular cross section



Figure 9. Copper inserts for AC concrete strength specimens

Curing and sealing

15. After 24 hr in the fog room, all specimens were demolded and those requiring copper and epoxy coating (AC specimens) were brushed with a wire brush and lightly tapped with a special rounded-tip hammer to reveal surface irregularities (Figure 10). All surface voids were then filled with neat cement (Figure 11), after which the specimens were coated with epoxy and returned to the fog room. All gages were read and AC specimens were weighed following epoxy coating. The remaining cylinders were placed in lime-saturated water (limewater). After 24 hr, AC specimens received another coat of epoxy (Figure 12) and were sealed in copper (Figure 13); the specimens remained in this condition until 83 days age. At this time, the specimens were coated with epoxy, sealed in neoprene, and placed in the test units at the proper temperature for an additional 7 days.

16. After 6 days of limewater curing, the AD creep and control specimens were removed from the limewater and stored at 50-percent relative humidity and $73 \pm 3^{\circ}\text{F}$. Specimens were exposed to this environment for 75 days at which time they were coated with epoxy and sealed in copper. After 24 hr, a coat of epoxy was applied to the copper seal, the specimens

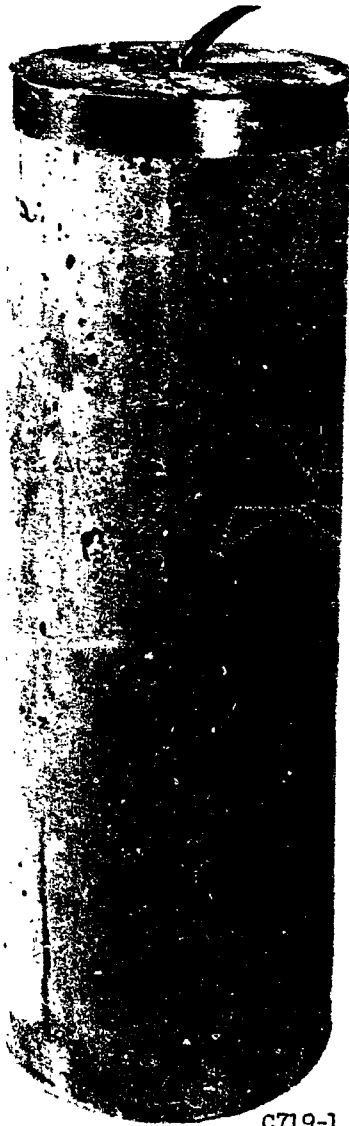


Figure 10. Specimen with surface irregularities exposed



Figure 11. Specimen after surface voids were filled with neat cement



Figure 13. Copper-sealed specimen

Figure 12. Specimen after application of epoxy coating



were sealed in neoprene, and were then placed in the testing units. The testing units containing the specimens were then placed in the proper testing temperature environment for an additional 7 days (90 days total curing).

17. The strength specimens were placed in the fog room for 24 hr after casting. All specimens were then demolded and the AC specimens were completely sealed in copper (Figure 14) and stored at $73 \pm 3^{\circ}\text{F}$. Approximately 24 hr prior to testing, the copper seals were stripped from the specimens. In most cases, this resulted in some chipping of the top and bottom surfaces. As a result, the ends of the specimens were ground. No fluid was used in the grinding process. AC specimens selected from Batches I-III were tested at ages greater than 90 days to determine the effect of elevated temperature on compressive strength. These specimens were placed in the 150°F environment at 83 days age and remained therein until 24 hr prior to testing.



Figure 14. Sealed AC strength specimen

18. Upon removal from the fog room, the AD and standard strength specimens were submerged in limewater. The standard specimens remained in the limewater until testing. At 7 days age, the AD specimens were removed from the limewater and stored at 50 percent relative humidity at $73 \pm 3^{\circ}\text{F}$. AD specimens to be tested at ages greater than 90 days were coated with epoxy and sealed in polyethylene plastic bags at 83 days and stored in the appropriate temperature environment until 24 hr prior to testing. The top surfaces of both the standard and AD specimens were ground (no fluid) immediately prior to testing.

Loading System

19. Creep specimens were loaded hydraulically using a system designed and installed by WES personnel. The loading system (Figure 15) consisted essentially of two hydraulic trunk lines pressurized to 600 and 2400 psi.



Figure 15. Hydraulic loading system for
multiaxial creep test units

One end of each line was connected to a pressurized-gas cylinder by an accumulator and a regulator; the other end branched out and connected to individual creep cells. Cylinders of nitrogen gas at 1500 and 6000 psi were used for maintaining 600- and 2400-psi pressures in the lines, respectively. Provision was made to connect or disconnect any creep cell at any time without disturbing the pressures in the trunk lines or in any other cell. The pressure lines remained open to maintain a constant test pressure in the individual cells; however, a needle valve was provided in each line to restrict the flow so that an unexpected major leak in an individual creep cell would not appreciably affect the system as a whole. A precision hydraulic dial gage placed in each line immediately behind the accumulator indicated line pressure; additional gages in the individual cells indicated loading pressures.

Uniaxial test units

20. Eleven creep rigs were designed and fabricated (Figures 16 and 17) for uniaxial testing. The only problem experienced with this system was

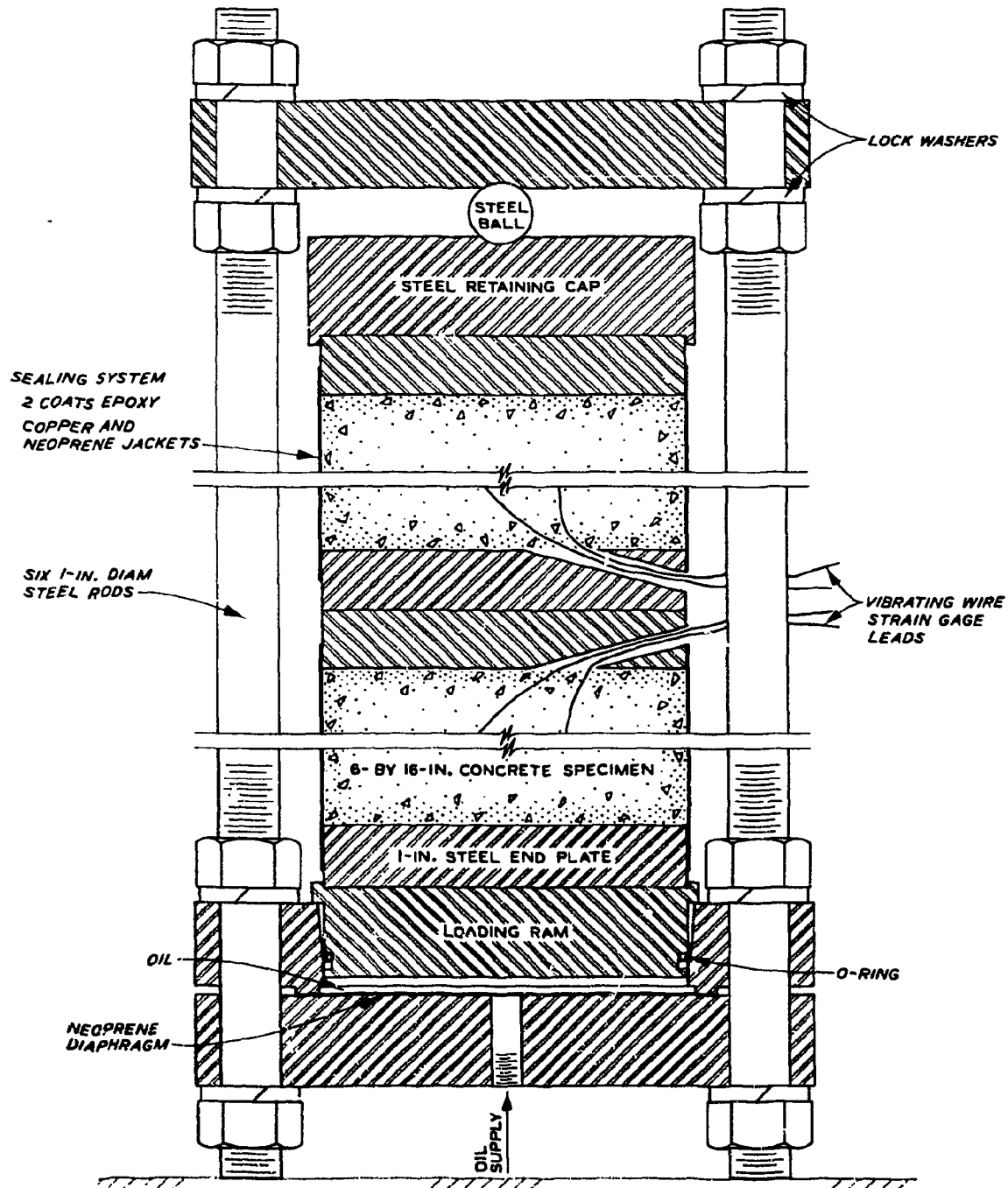


Figure 16. Schematic of uniaxial test unit

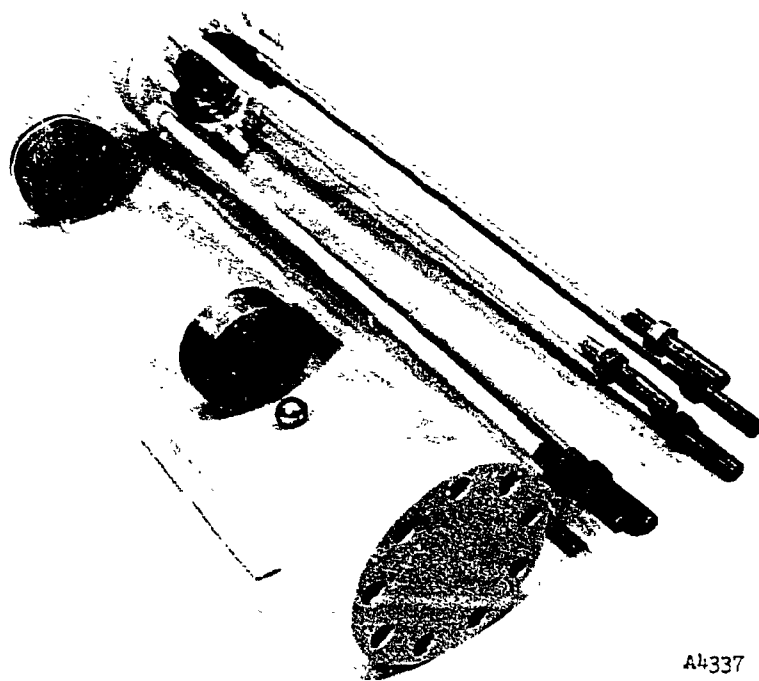


Figure 17. Uniaxial test unit, disassembled

that, in two instances, specimens experienced sufficient creep to unseat the O-ring seal on the pressure piston, thereby releasing the load on the cylinders. This was easily corrected by reseating the piston in the load cylinder and reloading the rig.

Hydrostatic test units

21. Eight hydrostatic creep test vessels were designed and fabricated (Figures 18 and 19). Considerable difficulty was encountered in developing an oiltight seal around the leads of the hydrostatic test vessels. An epoxy seal was placed inside the pipe nipple during casting, and when the specimens were placed in the test vessels, epoxy was poured around the leads for sealing. However, oil leaks developed in each hydrostatic test vessel as evidenced by oil around the leads. The specimens were removed from the test vessel and the loading heads removed from the concrete cylinders. Unfortunately, due to the hardened epoxy, all the lead wires to the gages were broken by shearing when the heads were

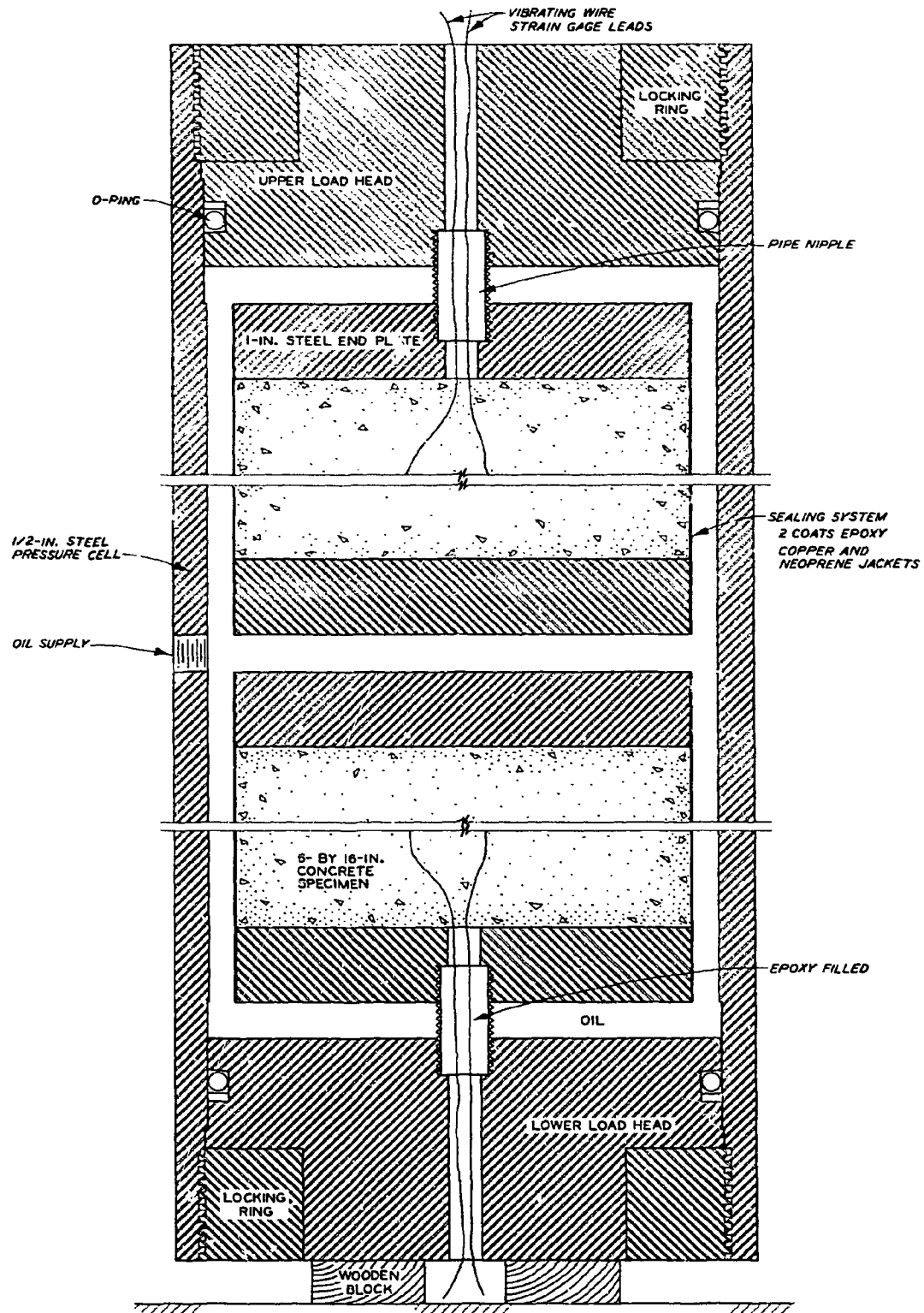
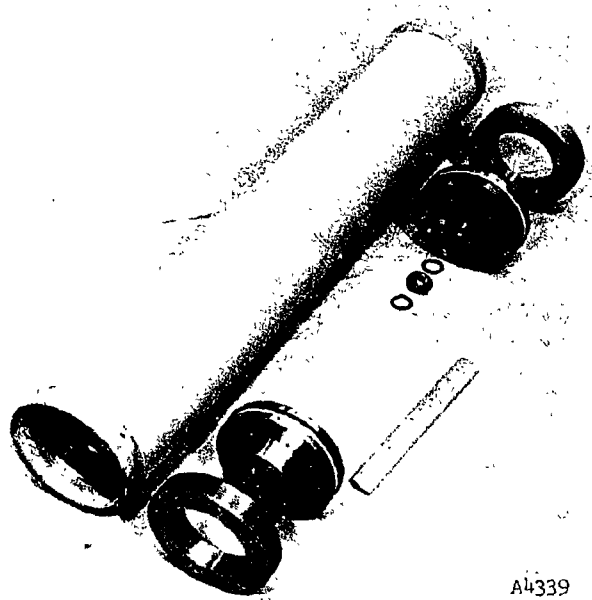


Figure 18. Schematic of hydrostatic test cell



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Figure 19. Hydrostatic test cell,
disassembled

turned. When one of the 150°F hydrostatic vessels was disassembled, it was observed that oil had bypassed the pipe nipple, penetrated the epoxy and wire casing, and destroyed the gages. The specimens could not be repaired.

22. The remaining hydrostatic specimens were partially repaired by splicing the lead wires and using an O-ring adaptor as a seal (Figure 20). This procedure was very effective except in cases in which rough surfaces on the steel end plates caused very slow leaks. However, these leaks apparently did not affect the gages, since the gages with spliced leads appeared to give accurate readings. Ten of the hydrostatic specimen gage leads broken by the removal of the load heads could not be spliced.

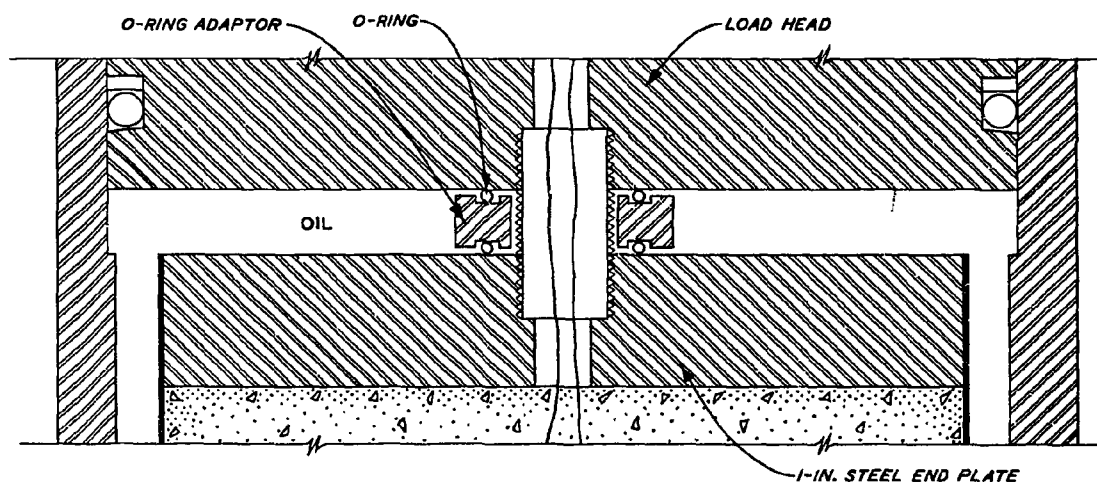


Figure 20. Schematic of revised sealing technique, hydrostatic test cell

Triaxial and biaxial test units

23. Fourteen creep test vessels were fabricated (Figures 21 and 22) for triaxial and biaxial testing. The only problem encountered with these vessels was an isolated instance in which the upper O-ring seal failed allowing a biaxial loading to become triaxial. This was remedied by unloading the vessel, replacing the seal, and reloading the vessel.

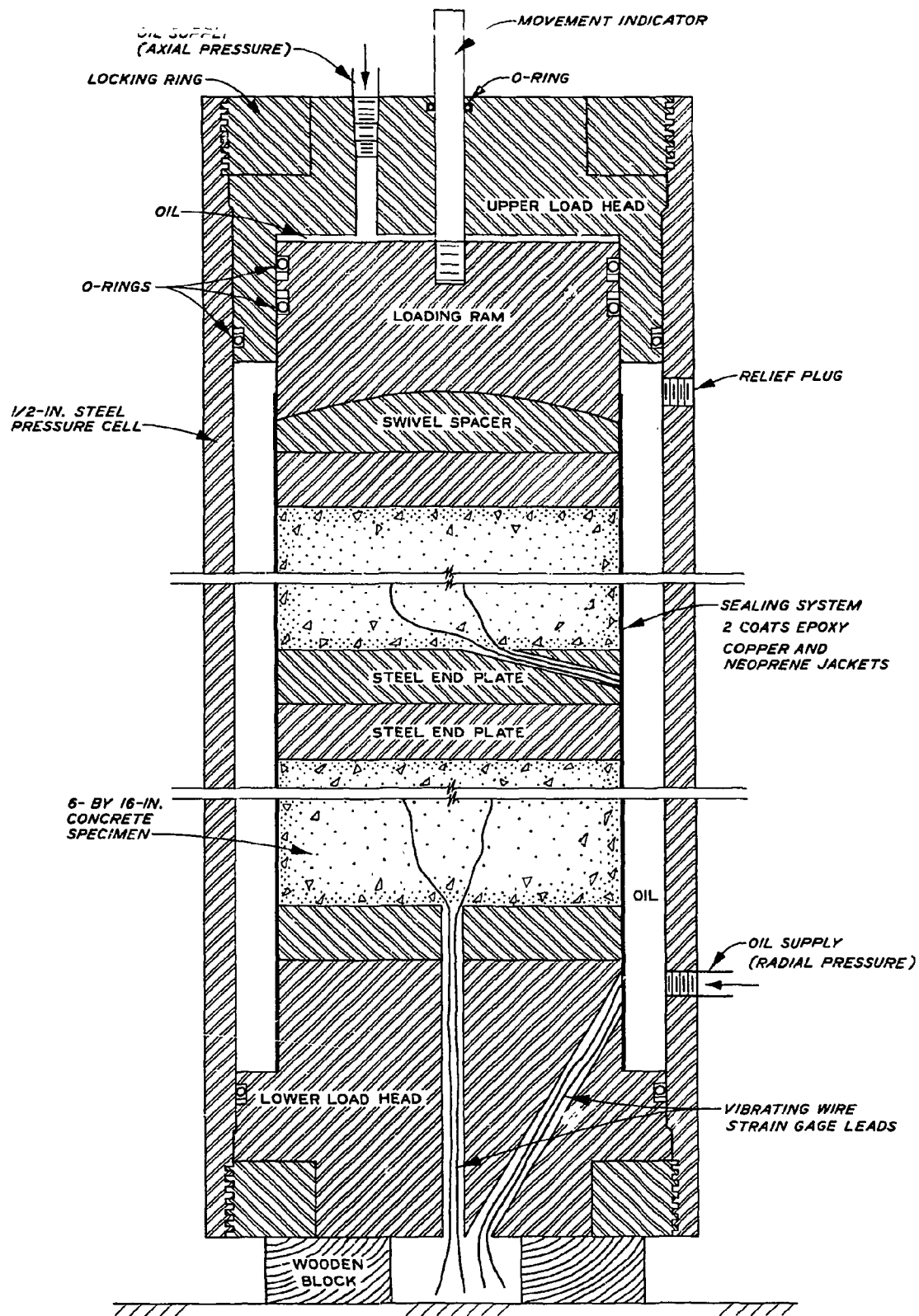
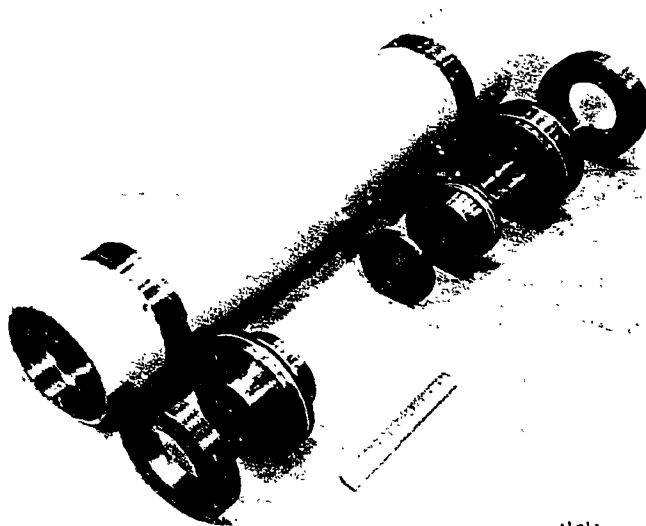


Figure 21. Schematic of biaxial and triaxial test cells



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Figure 22. Biaxial and triaxial test
cells, disassembled

Pressure losses

24. Two each of the uniaxial creep rigs and triaxial cells were loaded to 4000 psi to determine the input pressure loss due to O-ring friction. The friction loss in the uniaxial rig was less than that in the triaxial cell piston, and the maximum error in the applied stress in any case was not more than about 3.8 percent in the first run for instantaneous loading. The error was less in the second run. An important point in these tests was the absence of a serious hysteresis in any case. Based on these results, it was estimated that potential errors in the applied stress were within acceptable limits.

Loading Procedures

25. In general, the test specimens were cured for 83 days as previously described, then placed in test rigs located in the proper environmental condition (73° or 150°F) for 7 days prior to loading. All loads were applied manually with a hydraulic hand pump. When the desired maximum load was attained, the vessel was switched to the loading system which maintained a constant load using an oil reservoir under regulated high-pressure gas.

Uniaxial tests

26. The bottom creep specimen was placed in the test frame first. Care was taken to ensure that the bottom end plate of this specimen was in proper contact with the ram. The top creep specimen was seated directly on top of the bottom specimen and a steel retaining cap was placed over the top end plate of this specimen. A steel ball was placed on top of the retaining cap prior to inserting the retaining head over the retaining rods. Once proper alignment was accomplished, the retaining head was locked into position (Figure 16). Axial loads were applied in 100- and 200-psi increments for maximum loads of 600 and 2400 psi, respectively. The rate of loading was approximately 35 psi/min.

Hydrostatic tests

27. The test cells were initially placed upright in an inverted position and the bottom specimen, which had been previously attached to

the lower load head, was inserted into the cell and secured with the lower locking ring. The test cell was then placed in its proper upright position and partially filled with hydraulic oil. The top specimen was then inserted, and after filling the cell with hydraulic oil, secured in the same manner as that described for the bottom specimen. Hydrostatic loads were applied in 100- and 200-psi increments for maximum loads of 600 and 2400 psi.

Biaxial and triaxial tests

28. A primary concern in preparing specimens for biaxial and triaxial testing was to maintain the cylinders in a vertical position at all times and ensure parallel contact between the upper and lower cylinders. Initially, the lower specimen was placed on the lower load head with the strain gage leads going directly through the center of the head. The upper specimen was then placed directly on top of the lower specimen (Figure 23). The swivel spacer and loading ram were then positioned directly on top of the upper cylinder. Copper sleeves were placed at each joint in the specimen stack to protect the neoprene membrane from the sharp edges of the cylinder seal. Tape was used to cushion the edges of the sleeves and to hold them in position (Figure 24). After the membrane was pressure-tested for leaks, it was placed over the specimens and clamped at each end. Liquid neoprene was used between the end plates and the membrane under each hose clamp. The pressure cell was then lowered around the specimen stack (Figure 25). The upper load head was then inserted into the cell and both heads were secured with locking rings.

29. In the biaxial tests, an axial load of approximately 50 psi was applied to the loading ram to seat the ball assembly. Then the confining pressure was increased in 100- and 200-psi increments to attain the desired maximums of 600 and 2400 psi, respectively. Load increments of 200-psi axial and 50-psi radial were applied simultaneously in triaxial tests.



Figure 23. Creep specimens in initial stage of preparation for loading

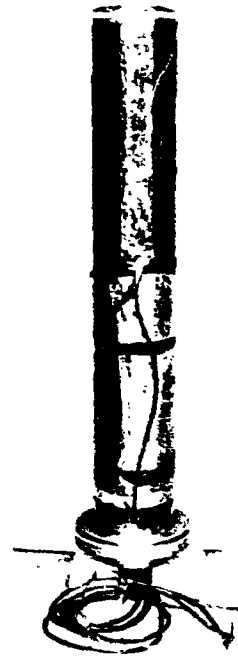
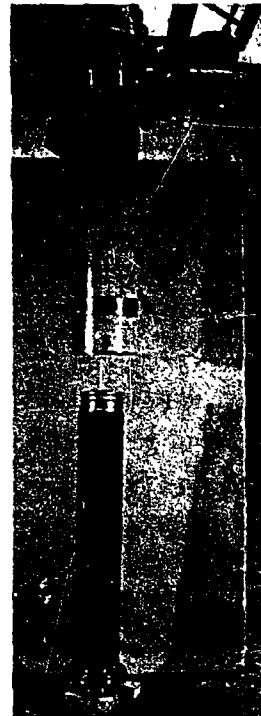


Figure 24. Specimen stack immediately prior to placing neoprene membrane

Figure 25. Lowering pressure cell around the completed specimen stack



Strain Measurements

30. Strain gages embedded in the creep and control specimens were read immediately after casting and intermittently during the 90-day curing period. Once the creep specimens were placed in the test units and located in the proper testing temperature, the leads from strain gages and companion control specimens were independently connected to switchboards (Figure 26). This allowed strain or temperature measurements in any one of the 196 gages (98 specimens) from a central location using a single comparator.

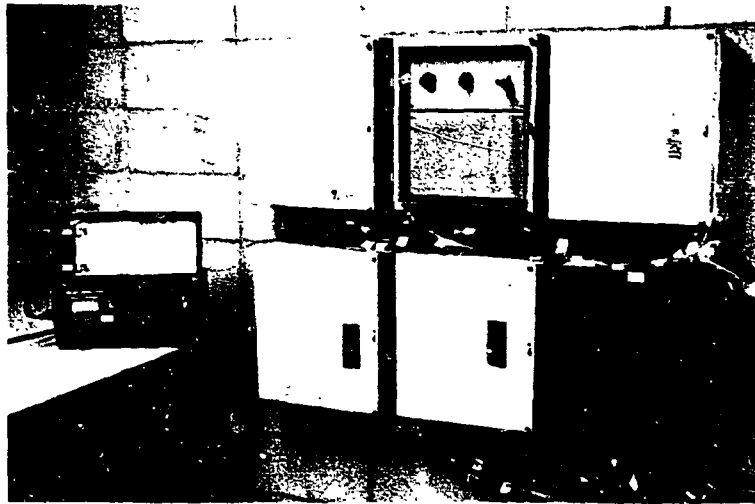


Figure 26. Switchboards and comparator used for strain gage readings

31. Strain and temperature measurements were obtained on the creep and control specimens throughout the 90-day curing period, immediately prior to loading, upon attaining full load, and throughout the test period. In addition, strain readings were obtained on the creep specimens at each load increment. After applying the full test loads, gages were generally read every 15 to 30 min for the first 2 to 3 hr or until the readings began to stabilize and then daily for one week after loading; as the readings tended to further stabilize with increased time under load, the time between readings was increased.

PART III: EXPERIMENTAL RESULTS

Compressive Strength

32. The unconfined compressive strength of each concrete batch was determined at 28 and 90 days. In addition, specimens from Batches I-III were tested at advanced ages ranging up to 455 days. The average compressive strengths are shown in Table 4 for the various curing conditions and testing ages.

33. Even though the concrete mixtures contained aggregates with a wide range of moduli, they did have similar compressive strengths (Figure 27). The compressive strength of AC specimens from each of

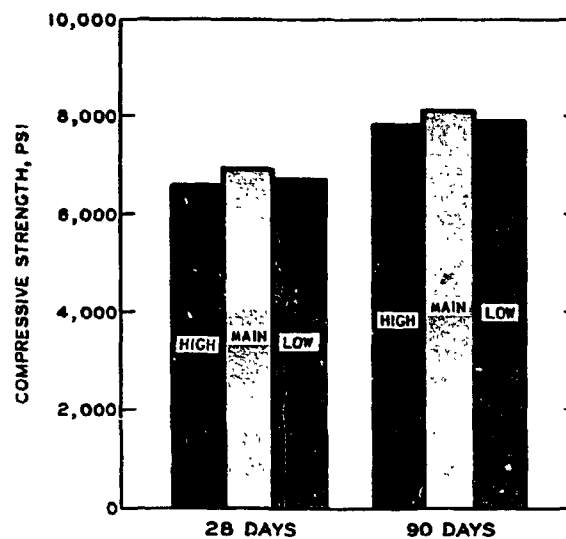


Figure 27. Overall average compressive strengths (Batches I-VIII)

the three concrete mixtures was lower than that of AD specimens at both 28 and 90 days. However, after 90 days curing, both curing procedures resulted in concretes which exhibited lower strengths than concrete cured in limewater (standard specimens) until tested (Figure 28).

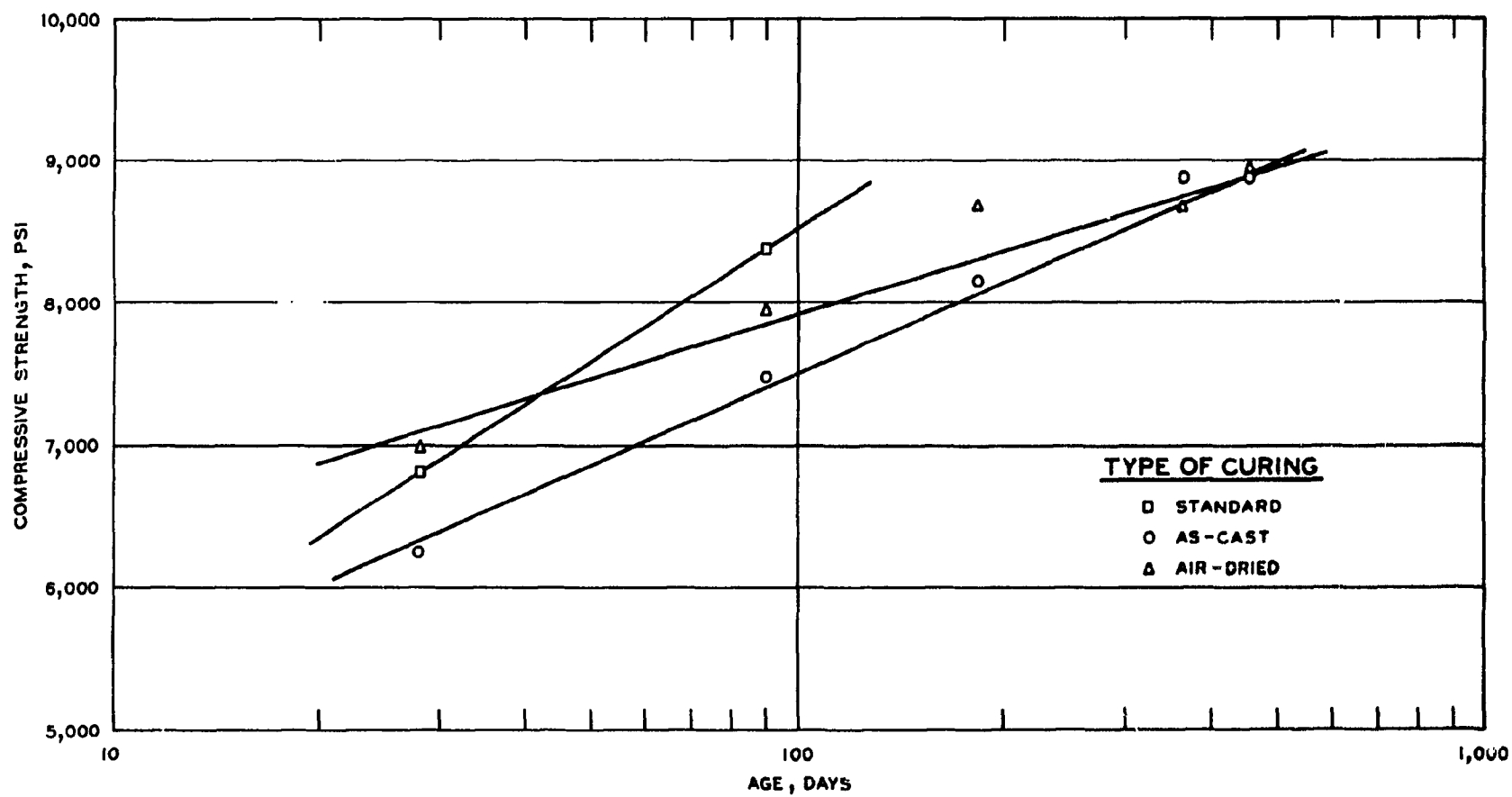


Figure 28. Overall average compressive strength of specimens stored at 73°F

Beyond 90 days both AC and AD specimens were sealed in copper and, after approximately 1 year of additional curing at 73°F, the compressive strengths of AC and AD concrete were essentially equal. In comparison, in specimens sealed and stored at 150°F from 83 days until time of testing, the compressive strength of AC concrete was higher than that of AD concrete (Figure 29). AC specimens sealed and stored at 150°F 83 days after casting had slightly higher strengths than those stored at 73°F (Figure 30), whereas AD specimens stored at 150°F had slightly lower strengths than those stored at 73°F (Figure 31).

Modulus of Elasticity and Poisson's Ratio

34. Elastic strains were determined by taking the difference in strain measurements on the creep specimens immediately before and after loading. These elastic strains were used to compute Poisson's ratio and the modulus of elasticity as follows:

$$\mu = \frac{\sigma_a \epsilon_r - \sigma_r \epsilon_a}{2\sigma_r \epsilon_r - \epsilon_a (\sigma_r + \sigma_a)}$$

$$E = \frac{\sigma_a - 2\mu\sigma_r}{\epsilon_a}$$

Where

- μ = Poisson's ratio
- σ_a = axial stress, psi
- ϵ_r = elastic radial strain
- σ_r = radial stress, psi
- ϵ_a = elastic axial strain
- E = modulus of elasticity, psi

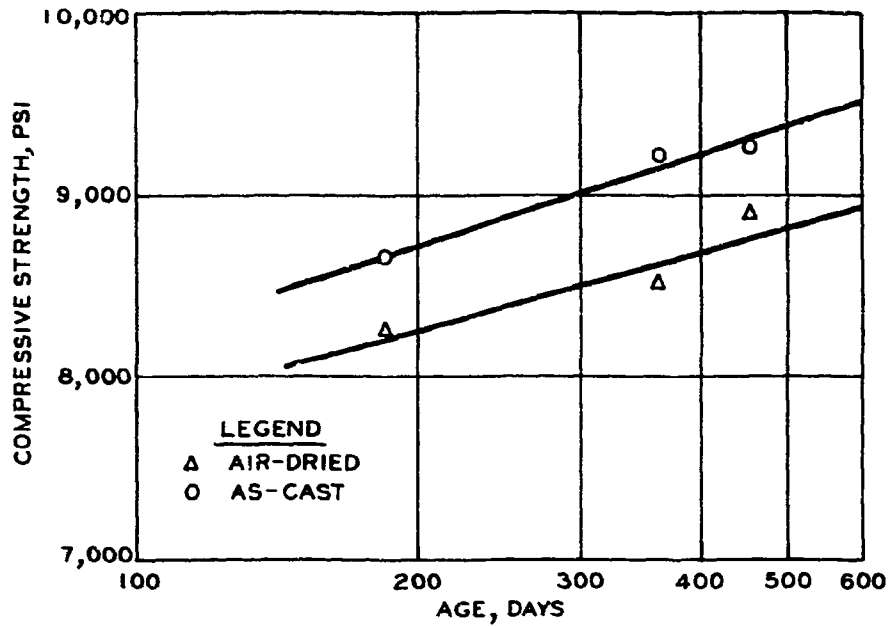


Figure 29. Overall average compressive strength of specimens stored at 150°F

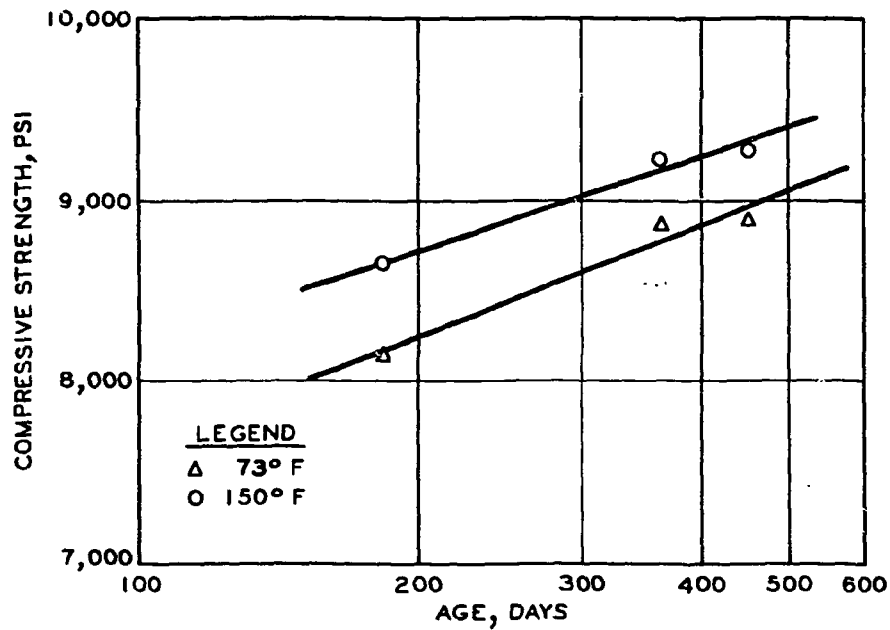


Figure 30. Overall average compressive strength of as-cast specimens stored at 73°F and 150°F

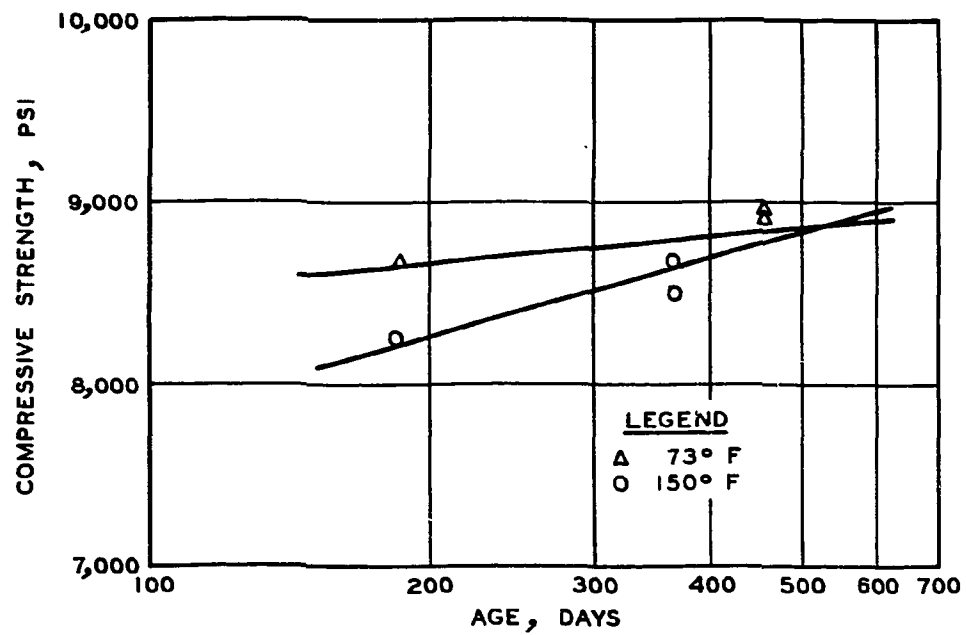


Figure 31. Overall average compressive strength of air-dried specimens sealed and stored at 73° and 150°F

Poisson's ratios and the secant moduli of elasticity for all creep specimens successfully loaded are given in Table 5. As expected, the expressions used in these calculations resulted in values of 0.5 and 0.0 for Poisson's ratio and modulus of elasticity, respectively, for hydrostatic loading. Omitting the hydrostatic conditions, results are summarized below for the various test conditions.

<u>Modulus</u>	<u>Temperature °F</u>	<u>Curing</u>	<u>Poisson's Ratio</u>	<u>Modulus of Elasticity, 10⁶ psi</u>
High	73	AC	0.159	7.16
		AD	0.163	6.30
	150	AC	0.161	6.82
		AD	<u>0.144</u>	<u>6.51</u>
		Avg	0.157	6.70
Main	73	AC	0.232	5.88
		AD	0.236	5.52
	150	AC	0.200	6.02
		AD	<u>0.228</u>	<u>5.84</u>
		Avg	0.224	5.82
Low	73	AC	0.136	3.14
		AD	0.124	2.88
	150	AC	0.115	3.08
		AD	<u>0.110</u>	<u>2.97</u>
		Avg	0.121	3.02

35. These average values indicate the modulus of elasticity of concrete is proportional to the modulus of elasticity of the aggregate (Figure 32). A similar relation would appear to exist for Poisson's ratio with the exception of the high-modulus mixture where Poisson's ratio for the concrete was higher than that for the chert aggregate (Figure 33). The secant modulus of elasticity for AC concrete was slightly greater than that for AD concrete (Figure 34). While the secant modulus of elasticity of the main-modulus concrete was slightly higher at 150°F than 73°F (Figure 34), the higher temperature had no

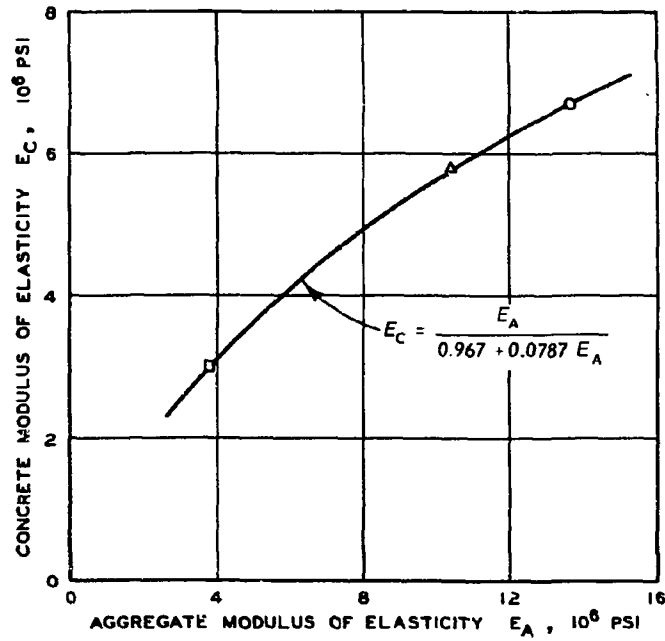


Figure 32. Relationship of moduli of elasticity of aggregate and concrete

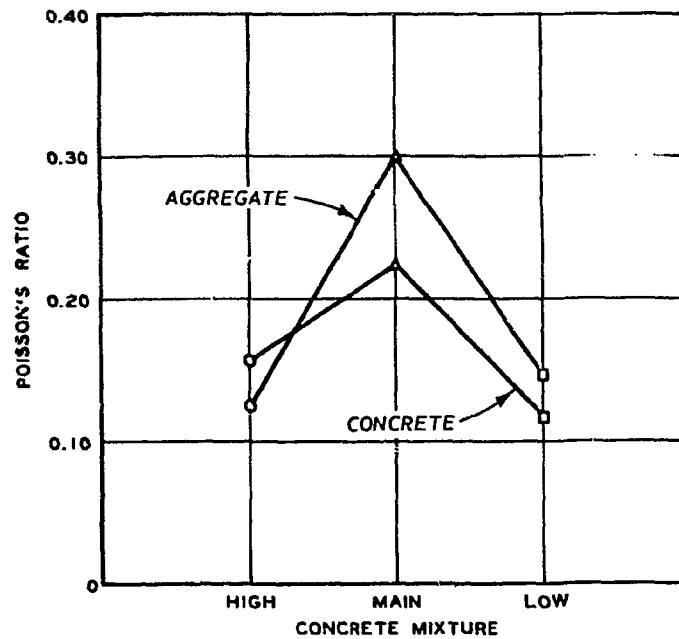


Figure 33. Relationship of Poisson's ratio of aggregate and concrete

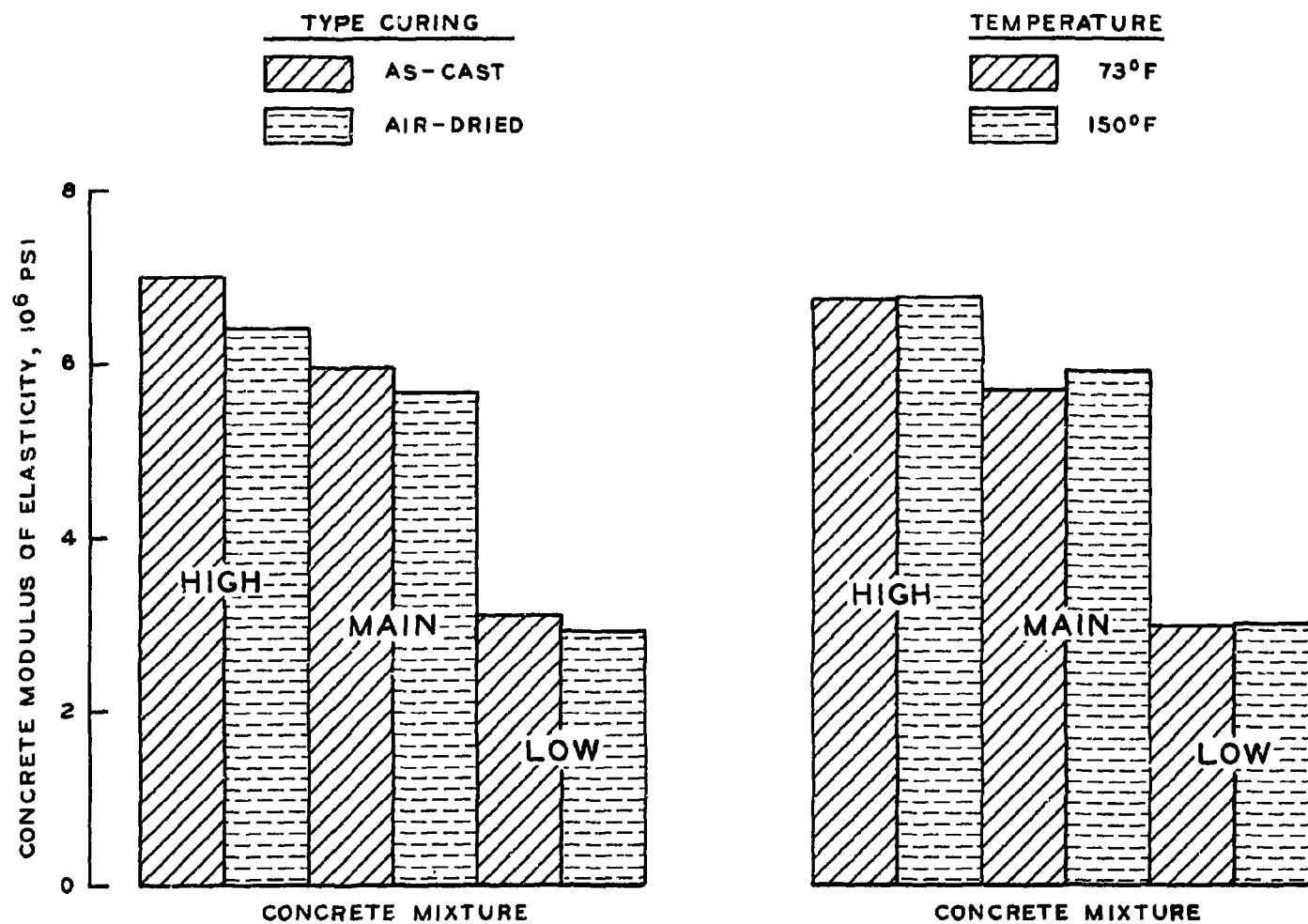


Figure 34. Effect of curing and temperature on modulus of elasticity

significant effect on the two remaining mixtures. With the exception of the main-modulus concrete, Poisson's ratio was slightly higher for AC concrete than for AD and, in all cases, it was higher at 73°F than at 150°F (Figure 35).

Strains in Control Specimens

36. Strains were monitored intermittently during the curing period to determine concrete deformations (shrinkage and expansion) due to any chemical or physical cause other than applied load and temperature change. The reference reading for calculating these strains was the 7-day reading because this was the earliest time at which the various environmental test conditions could be considered comparable and stable. Results of individual strain measurements on the control cylinders are presented in Appendix B for the period prior to loading of the creep specimens. Average volume-change strains for each concrete mixture are shown in Figures 36-38.

37. Axial and radial strains for the AC control specimens were similar in magnitude and remained essentially constant during the curing period. Each of the three concrete mixtures exhibited small shrinkage strains at the end of the curing period. These average strains, determined from specimens sealed shortly after casting to prevent moisture loss, ranged from 4 to 26 millionths with an overall average of 13 millionths.

38. The AD specimens were allowed to air-dry at 50 percent relative humidity and $73 \pm 3^\circ\text{F}$ from 7 to 90 days age. The resultant moisture loss caused significant shrinkage strains in all AD control specimens. At the end of the curing period, average axial and radial strains were 127, 178, and 552 millionths shrinkage for the high-, main-, and low-modulus concrete mixtures, respectively. This would indicate that shrinkage strains are inversely proportional to the elastic moduli of both aggregate and concrete (Figure 39). The shape of the relation between the shrinkage of AD concrete and the modulus of elasticity of aggregate is similar to that previously reported by Rüsçh et al.¹

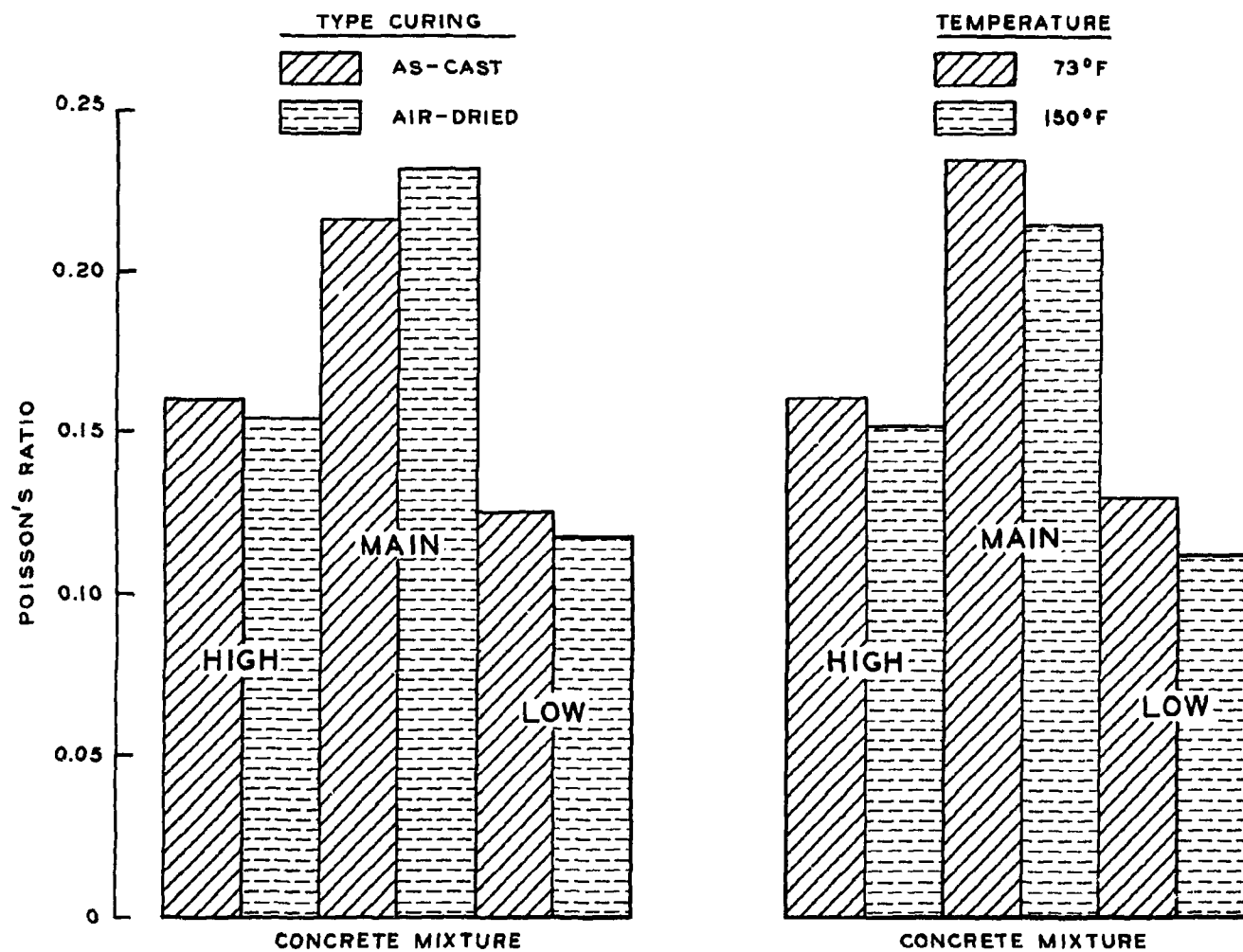


Figure 35. Effect of curing and temperature on Poisson's ratio

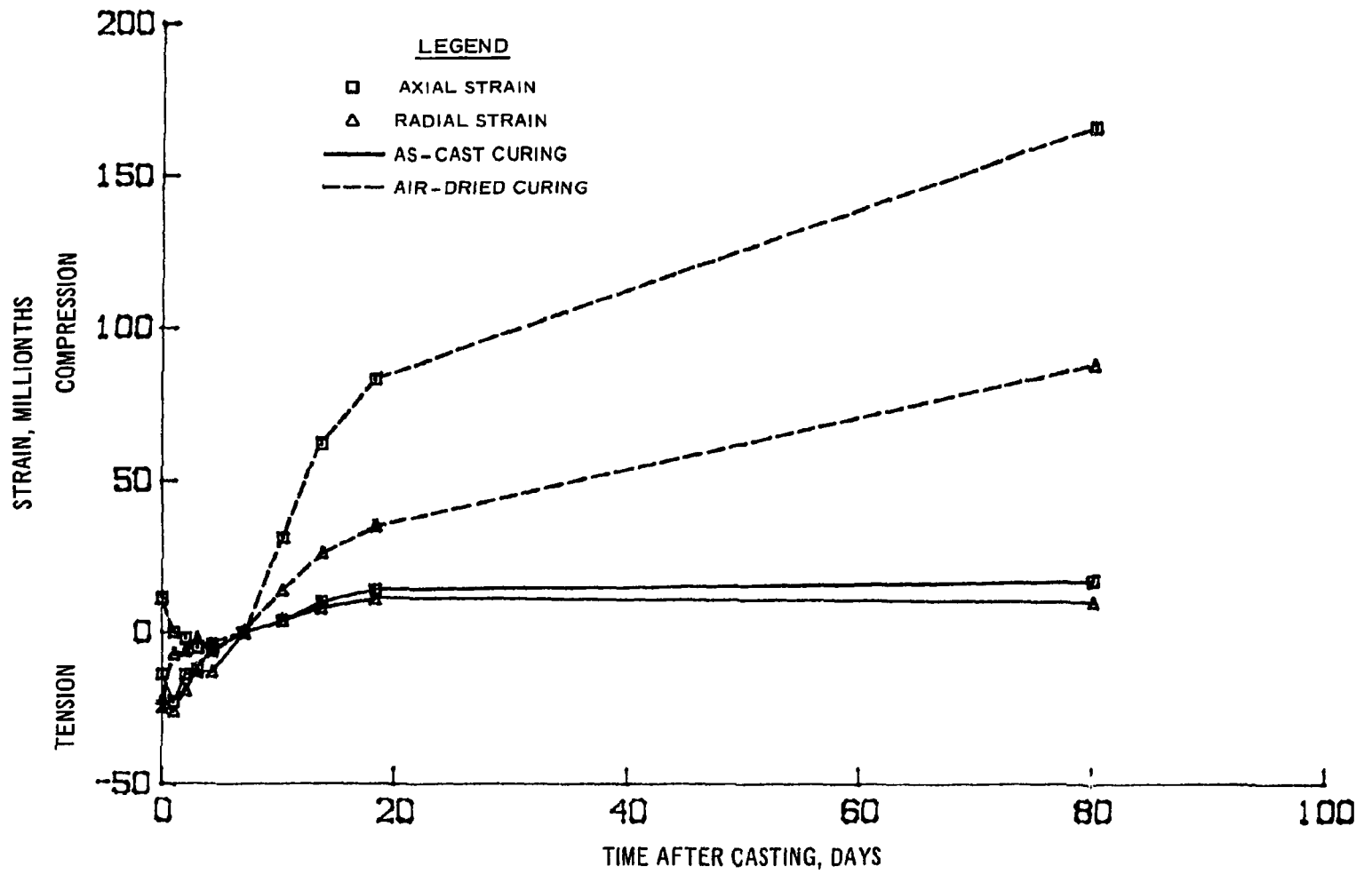


Figure 36. Average strains from high-modulus concrete control specimens

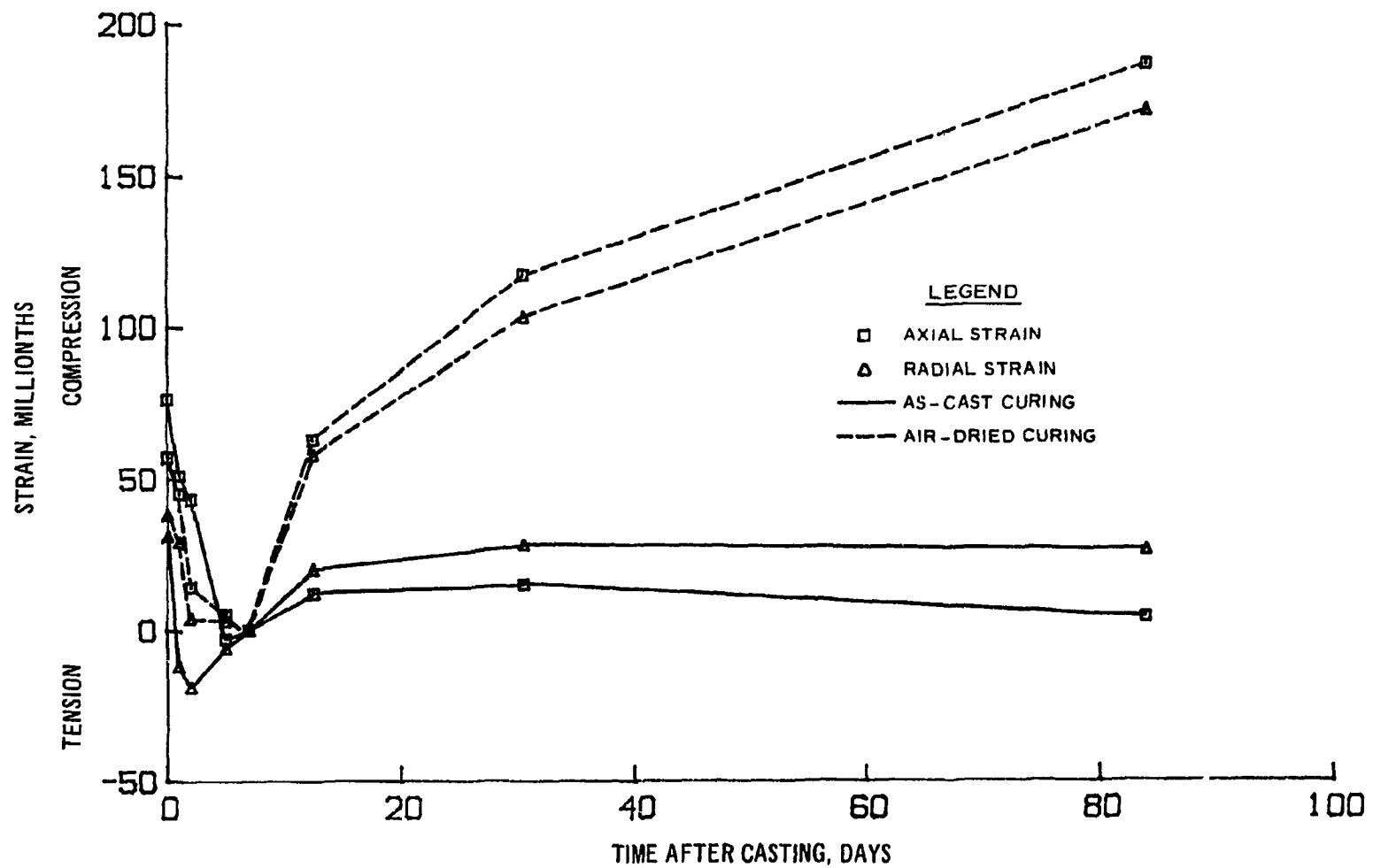


Figure 37. Average strains from main-modulus concrete control specimens

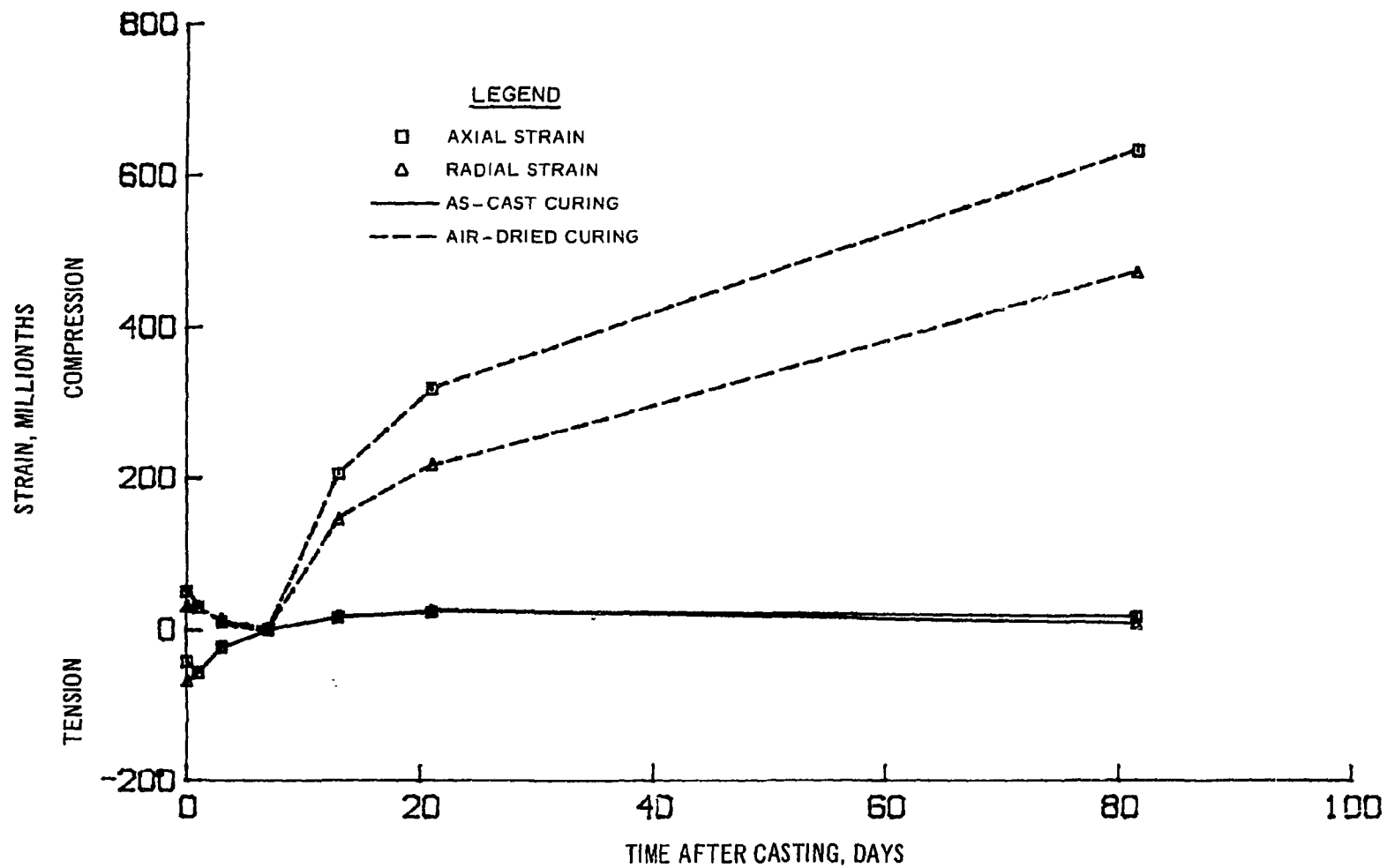


Figure 38. Average strains from low-modulus concrete control specimens

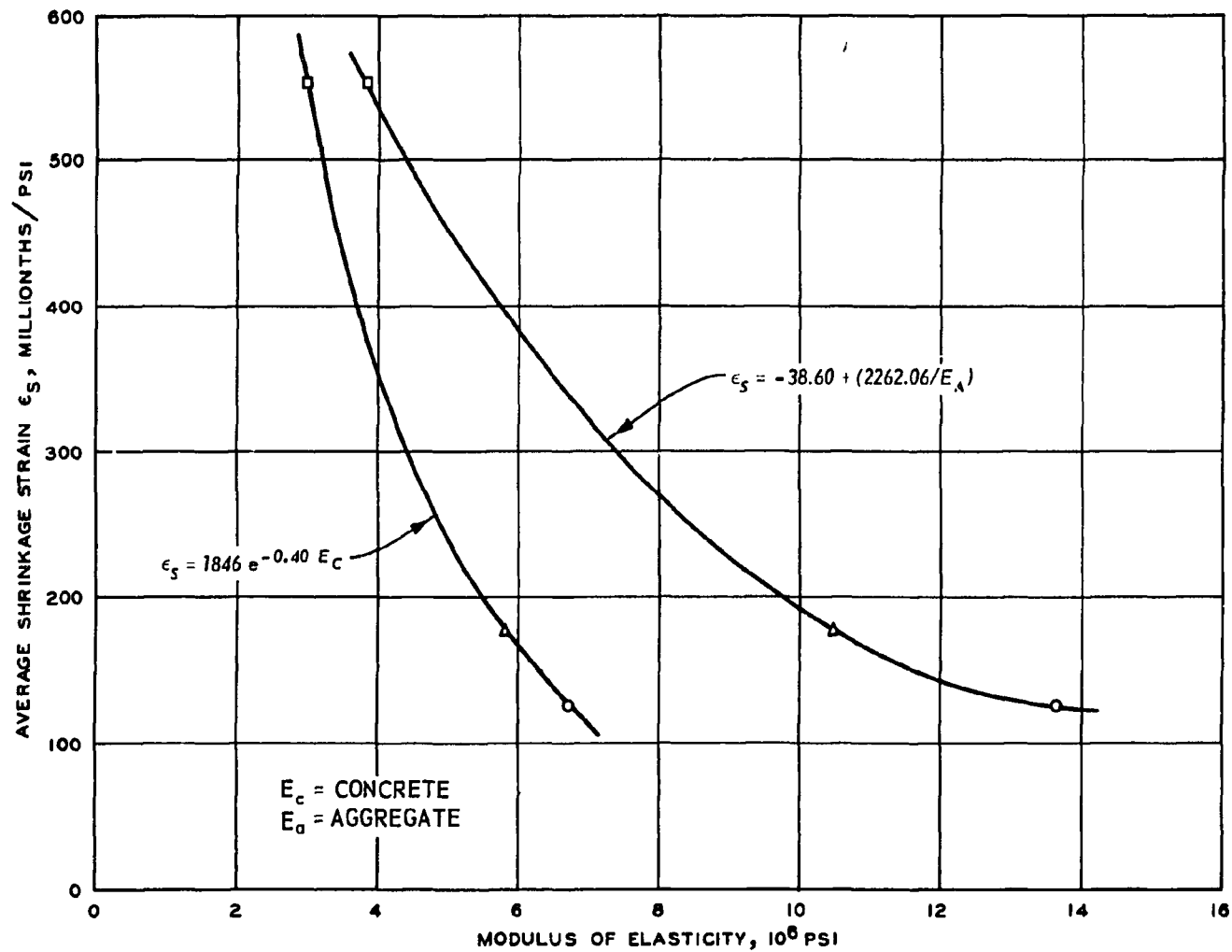


Figure 39. Relationship of shrinkage strain of air-dried concrete and modulus of elasticity of air-dried concrete

It should be noted that the average shrinkage strain in the axial direction was higher than in the radial direction. The ratios of axial to radial strains ranged from 1.1 for the main-modulus concrete to 1.9 for the high-modulus concrete, with an average ratio of 1.4. According to Jain and Kesler,² the reverse should have been true, because the average internal humidity around the radial gage should have been less than that around the axial gage since the radial gage was nearest the drying surface. However, similar tests on the main-modulus concrete mixture conducted at the University of Texas³ as a part of the overall PCRV program indicated the shrinkage strain in the axial direction was approximately 60 millionths more than in the radial direction.

39. Control specimens were subjected to the same environmental conditions as the creep specimens throughout the creep loading and unloading period. Results of individual strain measurements are presented in Appendix B. The 90-day reading was the reference reading for calculating these strains. Average strain-time relationships for each concrete mixture are shown in Figures 40-42.

40. As in the curing period, axial and radial strains for the AC control specimens at 73°F were similar in magnitude and remained essentially constant throughout the testing period. The main- and low-modulus concrete specimens indicated small shrinkage strains, both axial and radial, at the end of the test period as compared with the small expansion strains in the high-modulus specimens. The shrinkage strains were almost identical with those of the curing period ranging from 3 to 26 millionths with an average of 14 millionths. Expansion strains in the high-modulus concrete were 2 and 8 millionths axially and radially, respectively. At 150°F, AC specimens exhibited increasing expansion strains for approximately 100 days after loading of the creep specimens. Generally, at this point, expansion strains began to decrease, possibly as a result of either moisture loss or thermal incompatibility between strain gage and concrete³ and a number of specimens later indicated shrinkage strains, particularly those experiencing strain-gage failure during the test period. At approximately 100 days after loading the creep specimens, expansion strains in the AC control specimens stored

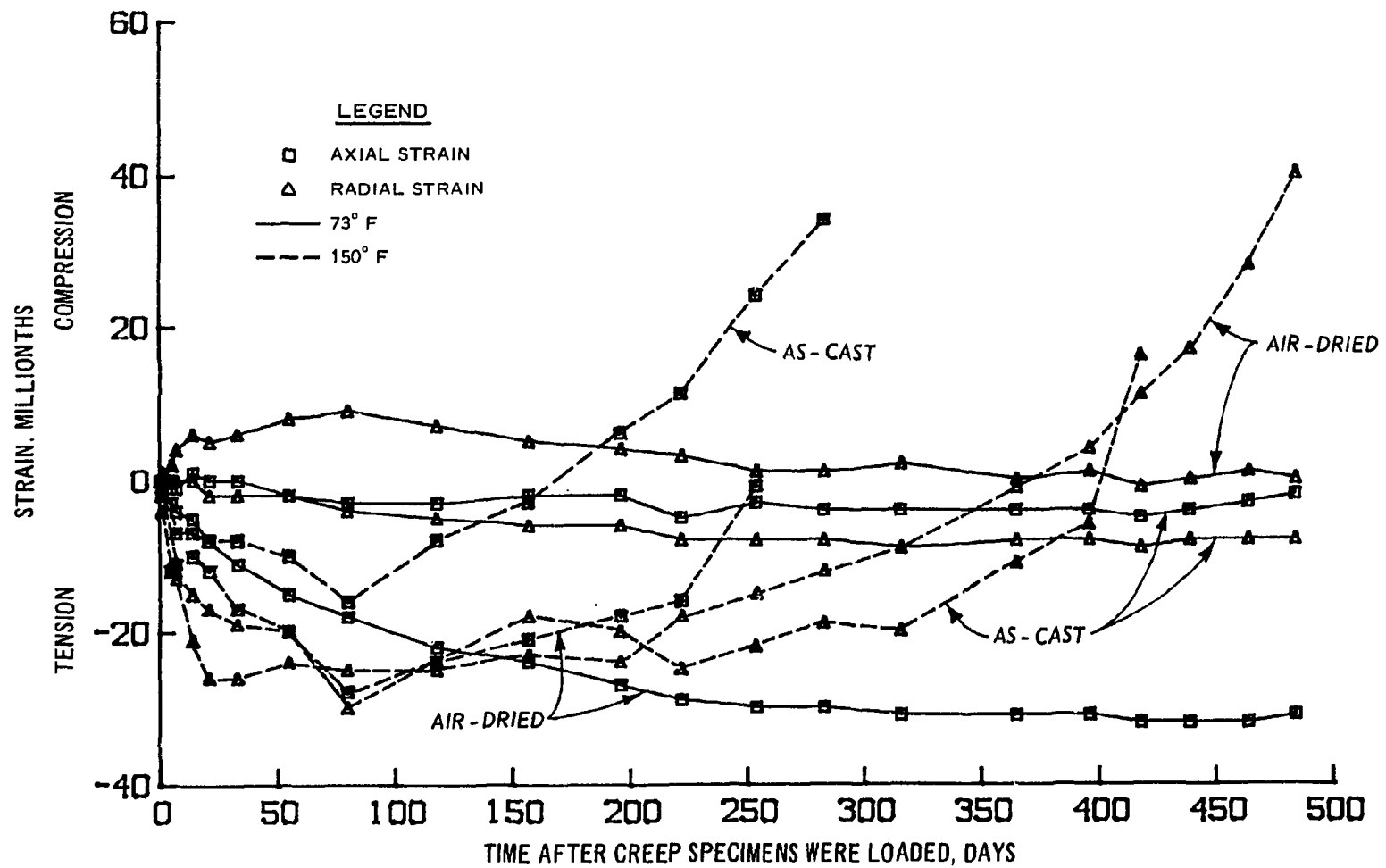


Figure 40. Average strains from high-modulus concrete control specimens

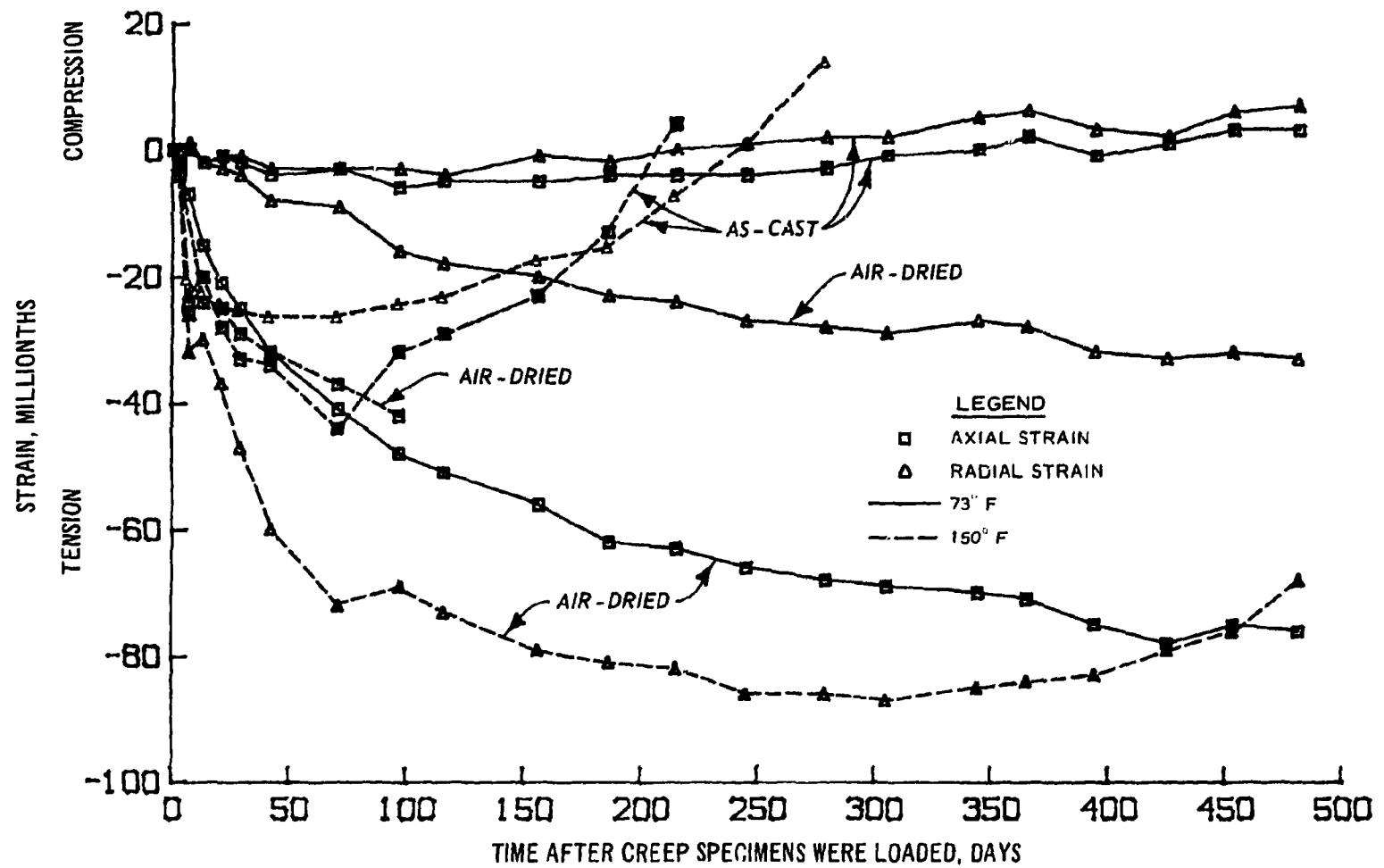


Figure 41. Average strains from main-modulus concrete control specimens

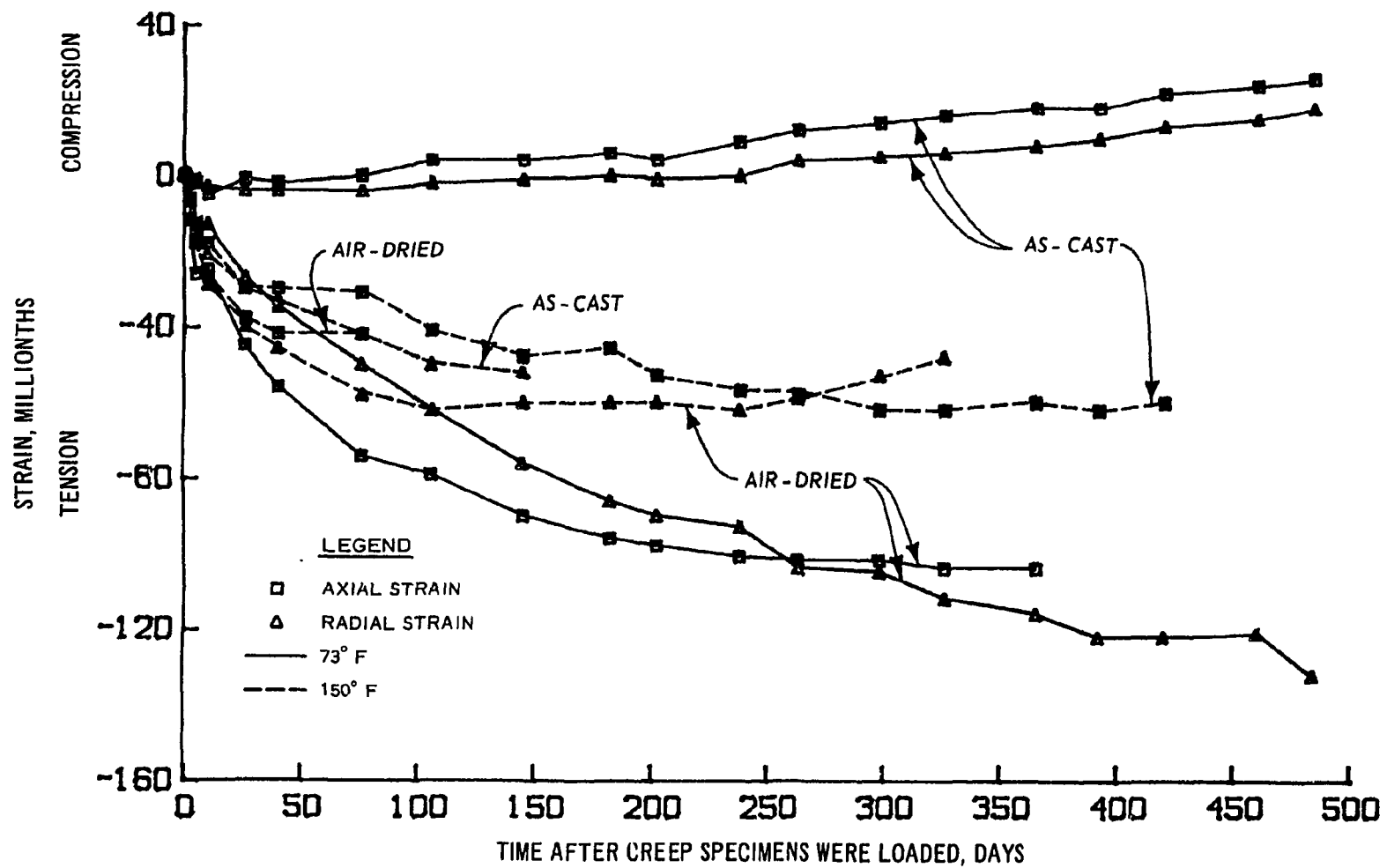


Figure 42. . Average strains from low-modulus concrete control specimens

at 150°F averaged 20, 28, and 46 millionths for the high-, main-, and low-modulus concrete mixtures, respectively.

41. For the 73°F AD condition, the main- and low-modulus concrete specimens expanded in both axial and radial directions at a decreasing rate during the testing period. It should be noted that AD specimens were sealed similar to the AC specimens during this period. In main-modulus specimens, average axial strains were more than twice the radial strains with the average axial strain approaching 80 millionths near the end of the testing period. Average axial strains in the low-modulus specimens were larger than the radial strains until approximately 250 days after sealing. The high-modulus concrete expanded in the axial direction and shrank slightly in the radial direction. Average axial strains increased uniformly to 30 millionths expansion at approximately 250 days after sealing and remained essentially constant during the remainder of the testing period. Average radial strains increased uniformly to 9 millionths shrinkage 80 days after sealing, then decreased to zero at 365 days after sealing, stabilizing at this point for the remainder of the testing period.

42. For the 150°F AD test condition, all three concretes expanded in both axial and radial directions at a decreasing rate until the average strains either essentially stabilized or began decreasing, in some cases eventually showing shrinkage. Generally, average radial strains were higher than axial strains, particularly for the main-modulus concrete where the radial strain tended to stabilize around 85 millionths, approximately 25 millionths higher than the comparable value for the low-modulus concrete.

Strains in Creep Specimens

43. As previously described, 66 creep specimens were fabricated for loading at 90 days age under a variety of test conditions. Unfortunately, a number of specimens, particularly those for hydrostatic test conditions, were not successfully loaded until some time after 90 days.

This delay was primarily caused by the problem of sealing around gage leads. While there were appreciable delays in the loading of some specimens (Table 6), significant deviations in strain measurements would not be expected for those specimens loaded at ages slightly greater than 90 days.

44. The strain data obtained from the loaded creep specimens during the course of the testing period represented total strains, i.e., those which included the elastic deformation upon application of load, and the time-dependent deformations due to load and chemical or physical volume changes within the specimen (Figure 43). Results of individual measurements of both axial and radial total strains for each creep specimen are given in Appendix C. In addition, total strain-time relationships for each creep specimen are presented in Plates 4-66.

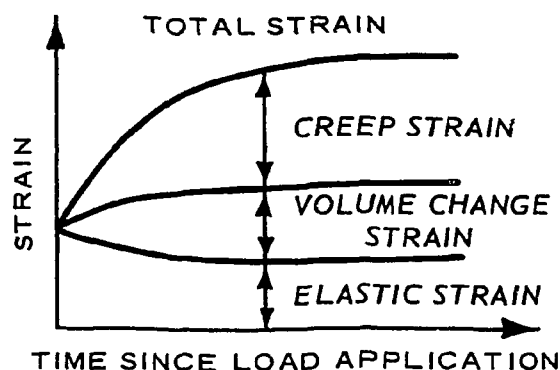


Figure 43. Typical time-dependent strains in concrete subjected to a sustained load

45. A linear relationship between stress and creep strain was reported as early as 1940.⁴ This led to the concept of specific creep,⁵ which is creep strain per unit applied stress. It is generally accepted that the stress-creep strain relationship is linear up to stress-strength ratios of approximately 35 percent. While the majority of creep studies in the past dealt with uniaxial stresses at conventional temperatures, Gopalakrishnan,⁶ et al, showed that the linear stress-creep strain relationship was also valid for multiaxial states of stress. In addition, tests conducted by Hannant⁷ showed that creep strain was proportional to stress at temperatures up to 163°F.

46. At conventional stress levels, the rate of creep decreases with time under load; however, it is not known whether there is a finite limit to creep after infinite time. Therefore, the literature contains several functions for describing the chronological development of creep deformation in concrete.⁸ Both expressions which tend to a limiting value (exponential and hyperbolic) and those which increase indefinitely (power and logarithmic) have been used for the prediction of creep.

47. A logarithmic creep expression based on the assumption that the specific creep rate is inversely proportional to time has been used successfully for a number of years by both the U. S. Bureau of Reclamation and WES.⁹ The general expression, including the elastic deformation, is as follows:

$$\epsilon = 1/E + F(k) \text{ LN } (t + 1)$$

where t is the time after loading, and $1/E$ and $F(k)$ are parameters obtained experimentally for each type of concrete and age at loading. In this investigation, specific creep is being considered separate from elastic deformation; therefore, the creep expression alone becomes:

$$\epsilon = F(k) \text{ LN}(t)$$

Thus, specific creep plots as a linear function of the logarithm of time under load.

48. Specific creep strains for a given time were determined by subtracting the elastic strain from the total strain, correcting this value for the appropriate volume-change (control) strain, and dividing it by the applied load. Results obtained in this manner are shown for each creep specimen in Appendix C. In addition, specific creep strain-time relationships are presented in Plates 67-80.

49. To form a numerical basis of comparison for the various test conditions, curves of best fit based on a least squares analysis were computed for the creep strain-time relationships shown in Plates 67-80. These equations were then used to compute specific axial and radial creep strains at 1 year after loading as shown in Tables 7-9. Axial creep strains are summarized as follows:

		Axial Creep Strains, millionths/psi					
		High-Modulus		Main-Modulus		Low-Modulus	
		73°F	150°F	73°F	150°F	73°F	150°F
U 600/0	AC	0.0580	0.1093	0.1114	0.0837	--	0.4297
"	AD	0.0454	0.1588	0.1335	--	--	0.2179
U 2400/0	AC	0.0545	0.1453	0.1026	0.1755	0.2239	0.4014
"	AD	0.0553	0.1666	0.1258	--	--	0.2623
H 600/600	AC	--	--	--	--	--	--
"	AD	0.0427	--	--	--	--	--
H 2400/2400	AC	--	--	0.0442	0.0625	--	--
"	AD	0.0524	--	--	0.0753	0.0738	--
B 0/600	AC	--	-0.0488	-0.0338	-0.0352	--	-0.0784
"	AD	--	-0.0202	-0.0409	-0.0321	--	-0.0561
B 0/2400	AC	--	-0.0301	-0.0325	--	--	-0.1003
"	AD	--	-0.0302	-0.0183	-0.0415	--	-0.0931
T 2400/600	AC	0.0473	0.0917	0.0890	0.1105	0.2040	--
"	AD	0.0779	0.0996	--	0.1308	0.2019	0.2982

50. There are 15 cases in which the effect of temperature of storage can be compared directly. In all cases except one biaxial and one uniaxial creep case, there is a greater specific axial creep strain associated with the higher temperature of storage. It should be noted that, in the biaxial case, the specific creep strain associated with the lower temperature was based on 20 observations throughout the 1-year test period, whereas the gage at 150°F failed after only eight observations spanning 42 days. A similar situation occurred in the uniaxial case, except the gage at elevated temperature failed after 13 observations spanning 93 days. Overall for the 15 cases, the specific axial creep strain after 1 year under load at 150°F was 1.67 times that at 73°F. Twelve of these cases involved compressive creep where the increases at the higher temperature ranged from -33 to 250 percent with an average of 88 percent. In comparison, the three cases involving tensile creep exhibited increases ranging from -27 to 127 percent with an average of 35 percent.

51. There are 20 cases in which the comparison can be made directly between AC and AD specimens. Overall, the greater specific axial creep strain is associated with AD specimens in 11 cases as compared with nine cases for the AC specimens. It is interesting to note that the AC specimens exhibited higher creep in only 4 of 15 cases for the high- and main-moduli concrete, whereas in the low-modulus concrete, AC specimens exhibited higher creep strain in all 5 cases. Overall for the 20 cases, AC specimens indicated an average of 12 percent more axial creep than the AD specimens. This overall average was significantly affected by the low-modulus concrete where, for five cases AC specimens averaged 46 percent higher creep than AD specimens. In comparison, AD specimens of high- and main-modulus concrete averaged 12 and 14 percent larger strains, respectively, than AC specimens.

52. There were eight cases where loading, moisture, and temperature conditions allowed direct comparisons between concretes of different moduli. For these cases, average compressive creep strains in the axial direction were 0.091, 0.116, and 0.311 millionths/psi for the high-, main-, and low-moduli concrete, respectively. These strains were in the proportion 1.0:1.3:3.4, somewhat higher than comparable tensile creep strains in the axial direction (1.0:1.1:2.3).

53. There were 17 cases in which the effect of stress level could be compared directly. In 10 of these cases, the higher specific creep strain in the axial direction was associated with the higher stress level. For the 17 cases, the average increase in strain with increased stress level was 11 percent.

54. Specific radial creep strains at 1 year after loading were computed by the same procedure as the axial strains. The results, shown in Tables 7-9, are summarized as follows.

		Radial Creep Strains, millionths/psi					
		High-Modulus		Main-Modulus		Low-Modulus	
		73°F	150°F	73°F	150°F	73°F	150°F
U 600/0	AC	-0.0264	-0.0036	-0.0188	-0.0052	--	-0.0402
"	AD	-0.0063	0.0251	0.0144	--	--	-0.1211
U 2400/0	AC	-0.0098	-0.0128	--	--	-0.0160	-0.0664
"	AD	-0.0046	-0.0124	-0.0010	-0.0008	--	-0.0629
H 600/600	AC	--	--	0.0426	--	--	--
"	AD	0.0392	--	--	--	--	--
H 2400/2400	AC	0.0184	--	0.0383	0.0696	--	--
"	AD	0.0362	--	0.0380	0.0823	--	0.1964
B 0/600	AC	--	0.0919	0.0640	0.0987	--	0.2645
"	AD	--	0.1494	0.0811	0.1838	--	0.1916
B 0/2400	AC	--	0.0762	0.0858	--	--	0.3063
"	AD	--	0.1016	--	0.0706	--	0.2795
T 2400/600	AC	0.0526	0.0431	0.0639	0.0885	0.1140	--
"	AD	0.0421	--	0.0961	--	0.1817	0.1505

The index of determination, a measure of how well the data fit the creep expression (a value of 1.0 being perfect correlation), was generally lower for the radial creep data than for those of the axial creep. Except for the cases where only two points were available, the overall average indices of determination were 0.928 and 0.838 for the axial and radial specific creep, respectively. In addition, there were two cases of uniaxial loading where the radial gages indicated compressive instead of tensile creep as should have been the case; these two cases were omitted from further analysis.

55. There were 13 cases in which the effect of testing temperature on radial specific creep could be compared directly. In 8 of the 13 cases, the larger strain was associated with the higher temperature. There were considerable variations in individual comparisons; however, for the 13 cases, specific radial creep strains after 1 year under load at 150°F averaged 1.37 times those at 73°F.

56. There were 17 cases in which a comparison could be made directly between AC and AD specimens. The greater radial strain was associated with the AD specimens in 9 of the 17 cases, essentially the same ratio as that given for the axial strains. Again, there were rather large variations in individual cases, but for the 17 cases, radial creep strain averaged 18 percent higher for the AD specimens when compared with the AC specimens.

57. There were seven cases in which loading, moisture, and temperature conditions allowed direct comparisons between concretes of different moduli. Average compressive creep strains in the radial direction (five cases) were 0.088, 0.103, and 0.206 millionths/psi for the high-, main-, and low-moduli concrete, respectively. These strains are in the proportions 1.0:1.2:2.3, somewhat lower than the same proportions for compressive creep strains in the axial direction. In comparison, average tensile creep strains in the radial direction (two cases) were 0.008, 0.003, and 0.052 millionths/psi, radically different from tensile creep strains in the axial direction.

58. There were 13 cases in which the effect of stress level could be compared directly. In eight of these cases, the higher specific creep strain in the radial direction was associated with the lower stress level. For the 13 cases, the average increase in strain with decreased stress level was 6 percent.

59. In general, the creep strains could be classified compressive or tensile as follows:

Type of Loading	Strain	
	Axial	Radial
Uniaxial	Compressive	Tensile
Hydrostatic	Compressive	Compressive
Triaxial	Compressive	Compressive
Biaxial	Tensile	Compressive

60. Since both strains are compressive for two types of loading, it is logical to compare the two strains in each instance. In the hydrostatically loaded specimens, the axial strain is greater than the radial

strain in three of the five cases where a direct comparison is possible. However, the overall average for the five cases indicates the axial strain is only 4 percent greater than the radial strain. In the tri-axially loaded specimens, the greater strain is in the axial direction in seven of the eight cases where a direct comparison is allowed. Overall, the axial strain was 52 percent greater than comparable radial strains. Therefore, for further analysis, the axial strains will be considered the major strains for hydrostatic and triaxial test conditions. On this basis, tensile and compressive strains were determined for the various loading conditions as follows:

Type of Loading	Strain	
	Compressive	Tensile
Uniaxial	Axial	Radial
Hydrostatic	Axial	--
Triaxial	Axial	--
Biaxial	Radial	Axial

61. In addition, it was arbitrarily decided to eliminate from further consideration those test conditions that: (a) involved less than five observations, (b) spanned less than 20 days, (c) had an index of determination less than 0.6, or (d) were loaded at an age beyond 125 days. On this basis, five values for specific creep strain in the axial direction were eliminated, with four of the five being the result of less than five observations. In comparison, nine values for radial creep strain were eliminated, the majority as a result of the index of determination being less than 0.6. The remaining values for specific compressive and tensile creep strain are summarized as follows:

		Compressive Creep Strains, millionths/psi					
		High-Modulus		Main-Modulus		Low-Modulus	
		73°F	150°F	73°F	150°F	73°F	150°F
U 600/0	AC	0.0580	0.1093	0.1114	0.0837	--	0.4297
	AD	0.0454	0.1588	0.1335	--	--	0.2179
U 2400/0	AC	0.0545	0.1453	0.1026	0.1755	0.2239	--
	AD	0.0553	0.1666	0.1258	--	--	0.2623

(Continued)

		Compressive Creep Strains, millionths/psi					
		High-Modulus		Main-Modulus		Low-Modulus	
		73°F	150°F	73°F	150°F	73°F	150°F
H 600/600	AC	--	--	--	--	--	--
"	AD	0.0427	--	--	--	--	--
H 2400/2400	AC	--	--	0.0442	0.0625	--	--
"	AD	0.0524	--	--	0.0753	--	--
B 0/600	AC	--	--	0.0640	0.0987	--	0.2645
"	AD	--	0.1494	0.0811	0.1838	--	0.1916
B 0/2400	AC	--	0.0762	0.0858	--	--	0.3063
"	AD	--	0.1016	--	--	--	0.2795
T 2400/600	AC	0.0473	0.0917	0.0890	0.1105	0.2040	--
"	AD	0.0779	0.0996	--	0.1308	--	0.2982

		Tensile Creep Strains, millionths/psi					
		High-Modulus		Main-Modulus		Low-Modulus	
		73°F	150°F	73°F	150°F	73°F	150°F
U 600/0	AC	-0.0264	--	-0.0188	--	--	-0.0402
"	AD	--	--	--	--	--	-0.1211
U 2400/0	AC	-0.0098	-0.0128	--	--	-0.0160	-0.0664
"	AD	-0.0046	-0.0124	--	--	--	-0.0629
B 0/600	AC	--	--	-0.0338	-0.0352	--	-0.0784
"	AD	--	-0.0202	-0.0409	-0.0321	--	-0.0561
B 0/2400	AC	--	-0.0301	-0.0325	--	--	-0.1003
"	AD	--	-0.0302	-0.0183	--	--	-0.0931

62. Based on the results of a review of the literature, Geymayer¹⁹ concluded that elevated temperatures (at least up to 50°C) would increase creep, creep at 50°C being approximately two to three times as great as creep at room temperature. Nasser and Neville^{20,21} concluded from their tests that creep was not a monotonic function of temperature but passed a maximum in the vicinity of 160°F. This was confirmed by Marechal's²² tests which showed that creep increased with temperatures up to 122°F, was less at 158°F, reached a minimum at 221°F, and then increased again up to 752°F.

63. In this investigation, major compressive and tensile creep strains were also compared as groups in a manner similar to that used for the individual axial and radial values previously discussed. On this basis, there were 5 and 12 cases where the effect of testing temperature could be compared directly for tensile and compressive creep, respectively. At 150°F, the tensile creep was larger in four of five cases as compared with 11 of 12 cases for the compressive creep. In these cases, the increase in creep at the higher temperature was slightly higher for the compressive mode, averaging 79 and 51 percent for the compressive and tensile creep, respectively. AD concrete at 150°F exhibited a greater increase in compressive creep than did the AC concrete whereas the opposite was true for tensile creep.

64. Specimens tested by Nasser and Neville²⁰ were stored continuously in a water bath at the desired testing temperature from 24 hr after casting until they were loaded at 14 days. Results of specimens loaded (underwater) to a stress-strength ratio of 0.35 indicated the uniaxial compressive creep after 15 months under load at 160°F was 1.75 times that of specimens at 70°F. In comparison, AC specimens loaded uniaxially to an average stress-strength ratio of 0.31 at 90 days indicated the compressive creep after 12 months under load at 150°F was 2.0 times that at 73°F. Overall for the 17 cases where effect of temperature could be compared directly for tensile and compressive creep, the absolute average creep at 150°F was 1.76 times that at 73°F.

65. It is generally concluded that creep depends on the loss of water under load and the amount of water present at the time of application of load, with the latter possibly having the larger effect. Thus, the environment for specimens during the curing period prior to application of load and the environment during the sustained loading period are important. AD specimens would be expected to have a lower moisture content upon loading than AC specimens and, therefore, might be expected to exhibit less creep. However, in 12 of 16 cases where a direct comparison between AC and AD specimens was possible, the higher compressive creep was associated with the AD concrete. AD specimens of the high- and

main-modulus concretes averaged 27 percent greater compressive creep strain than comparable AC specimens. Three of the four cases where creep was greater for AC concrete occur in the low-modulus concrete. The AC specimens of low-modulus concrete averaged 45 percent greater compressive creep strain than comparable AC specimens. It should be noted that shrinkage strains in AD control specimens averaged 127, 178, and 552 millionths at the time of loading for high-, main-, and low-modulus concrete mixtures, respectively. If the significantly larger compressive strains in the low-modulus concrete are indicative of a greater moisture loss compared with the remaining mixtures, then this might explain why the compressive creep behavior of low-modulus specimens was opposite the other two mixtures. During the loading period, AD control specimens generally exhibited tensile (expansion) strains, the magnitudes of which were essentially proportional to the concrete modulus of elasticity ranging up to approximately 130 millionths. This would indicate moisture movement within the AD specimens, and since the direction of the moisture movement is immaterial as far as its effect on creep is concerned,²³ drying creep in the loaded AD specimens would tend to increase the ultimate creep.

66. In general, tensile creep strains behaved in a manner opposite that of compressive creep. AC specimens of the high- and main-modulus concretes averaged 11 percent greater tensile creep strain than comparable AD specimens, whereas AD specimens of the low-modulus concrete averaged 17 percent greater tensile strain than comparable AC specimens. However, it should be noted that in three of the four low-modulus cases, AC strains averaged 16 percent greater than AD, and it was the remaining case in which the AD strain was 201 percent greater than AC that caused the overall average to be reversed. In comparison, York et al,³ in similar tests on the main-modulus mixture, found that compressive and tensile creep strains were generally larger for AD concrete than for AC concrete except in the case of low tensile creep, where the reverse was true.

67. Except for some unusual aggregates, the magnitude of creep in the aggregate at stresses to which aggregate particles are subjected in

concrete is very small, particularly in comparison with the creep of concrete. The most probable explanation of the influence of aggregate type on creep involves the modulus of elasticity of aggregate; the higher the modulus, the greater the restraint offered by the aggregate to the potential creep of the cement paste.⁸ This restraining effect of aggregate on the deformation of concrete is largely independent of the cause of the deformation (i.e., shrinkage or creep). According to comparisons of results reported by Kordina²⁴ and Rüschi, et al.,¹ these comparisons show the shape of the curve relating shrinkage of concrete and the modulus of elasticity of aggregate as similar to that of the curve relating creep and modulus of elasticity of aggregate. Based on these results and those reported by others,²⁵⁻²⁷ it is generally concluded, for a given matrix and a given volume concentration of aggregate, that elastic, creep, and creep-recovery strains of concrete increase as the modulus of elasticity of the aggregate decreases.

68. In this investigation, there were five cases in which loading, moisture, and temperature conditions allowed a direct comparison of compressive creep strains concerning the effect of concrete modulus. The average strains for these cases were 0.092, 0.118, and 0.270 millionths/psi for high-, main-, and low-modulus concrete, respectively. These strain values correlate generally with the inverse of the modulus of elasticity of the concrete and hence the inverse of the modulus of elasticity of the aggregate (Figure 44). The shapes of the curves relating compressive creep and the elastic modulus of concrete and aggregate are similar to those previously reported^{24,1} for longitudinal and lateral creep. There was only one case in which a direct comparison could be made concerning the effect of concrete modulus on tensile creep. In this case, strains were 0.0202, 0.0321, and 0.0561 millionths/psi for high-, main-, and low-modulus concrete, respectively (Figure 45). In comparison, an overall average gave values for tensile creep of 0.0183, 0.0302, and 0.0705 millionths/psi for the three concretes. Obviously, with only one direct comparison, the data are limited and the averages are slightly biased; however, the data do offer a general indication that tensile creep also increases as the elastic modulus of the aggregate and concrete decreases.

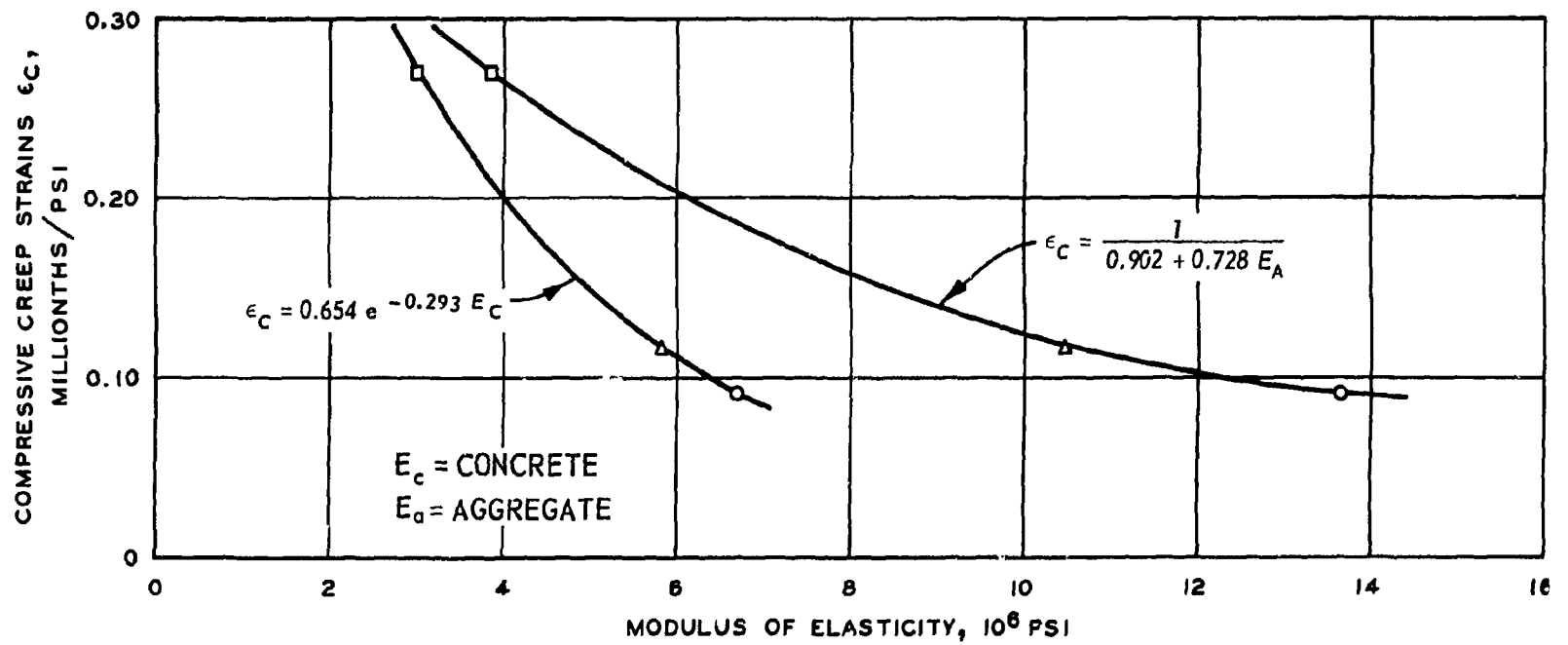


Figure 44. Relation of compressive creep and elastic modulus of concrete and aggregate

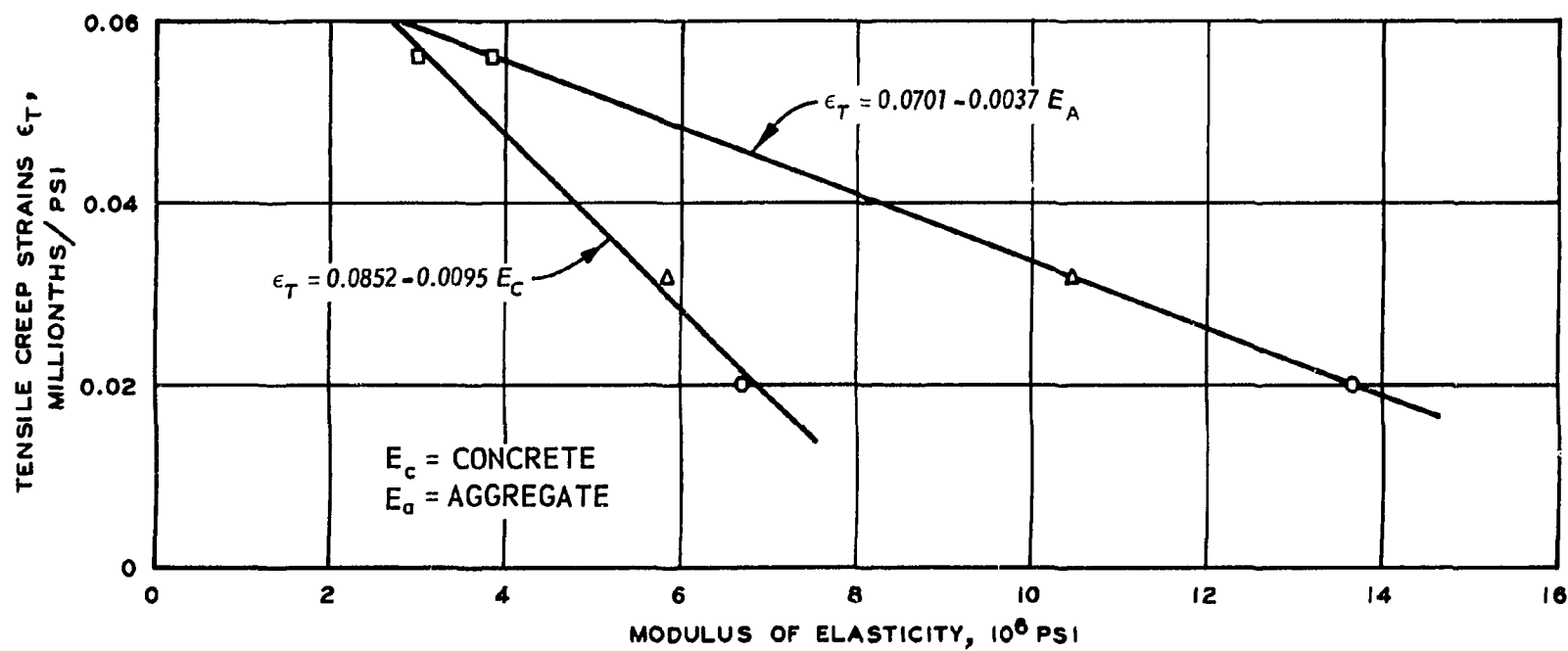


Figure 45. Relation of tensile creep and elastic modulus of concrete and aggregate

69. While the majority of creep work in the past has been concerned with uniaxial stress, interest in creep of concrete under multiaxial stress has increased in recent years, largely because of the advent of the prestressed concrete reactor vessels. Hannant¹⁶ tested concrete specimens sealed against moisture loss under multiaxial compressive stress and concluded that stresses at right angles to a uniaxial stress field reduce creep in the direction of the original stress field. This reduction in creep was approximately proportional to the magnitude of the orthogonal stress. It was also concluded that considerable creep occurred under a hydrostatic state of stress. Gopalakrishnan, et al,⁶ reported creep strains in all three principal directions for concrete specimens under different states of stress, each stress component being independently controlled. It was found that creep was less under multiaxial compression than under a uniaxial compression of the same magnitude in the given direction, thus substantiating Hannant's results. Also, creep under multiaxial stress could not be simply predicted from uniaxial creep measurements.

70. In the current investigation, there were only two cases in which moisture and temperature conditions allowed a direct comparison concerning the effect of loading mode on compressive creep; both of these cases involved main-modulus concrete. Average values of compressive creep for these two cases differed by a factor of 1.00:0.45:0.69:0.84 for uniaxial, hydrostatic, biaxial, and triaxial loading, respectively (Figure 46). In comparison, the overall averages for all values of compressive creep in the main-modulus concrete differed by a factor of 1.00:0.50:0.84:0.90 for the same states of stress, which is in fairly good agreement with the direct comparison, particularly considering the slight bias in the overall average resulting from differences in moisture and temperature conditions for the various states of stress. On the same basis, overall average values for the high- and low-modulus concrete differed by factors of 1.00:0.48:1.10:0.80 and 1.00:---:0.92:0.89 for the various states of stress. No measurements were available for hydrostatically loaded low-modulus concrete. Multiaxial stress resulted

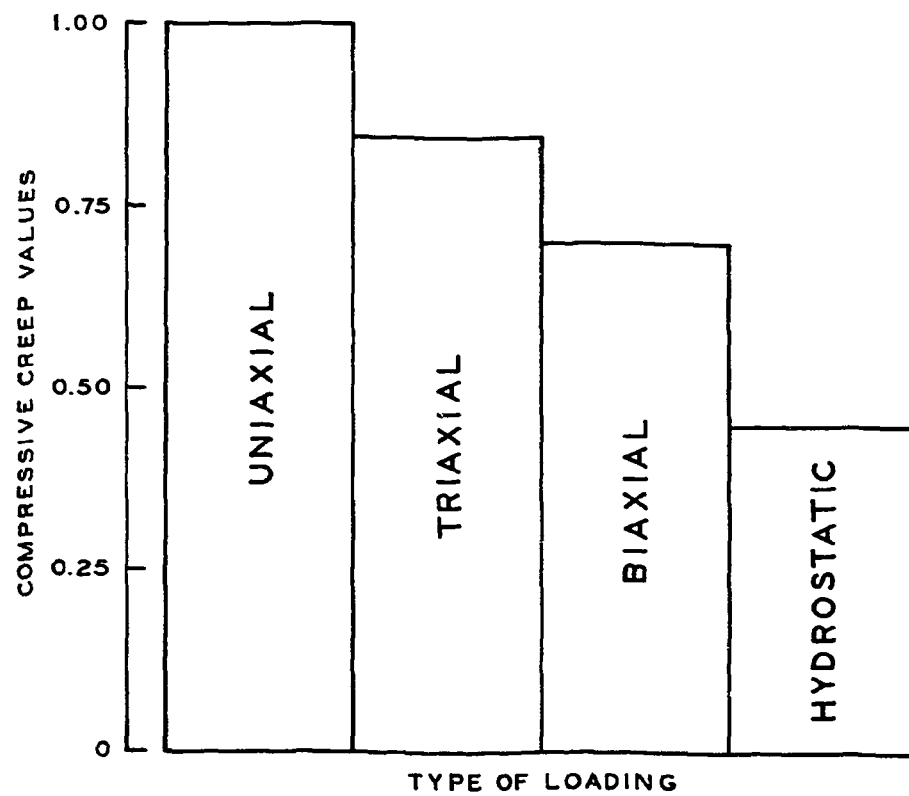


Figure 46. Effect of type of loading on compressive creep

in compressive creep strains apparently higher than those associated with the uniaxial stress only when biaxially loaded high-modulus specimens were used. It should be noted that this result was particularly biased by temperature difference, i.e., all available biaxial results were for the 150°F environment, whereas at least half of the measurements for each of the remaining states of stress were for 73°F where strains were generally lower.

71. There were 13 cases in which a direct comparison could be made concerning the effect of increased stress level on compressive creep for a given state of stress. In 9 of the 13 cases, the higher compressive creep strain was associated with the higher stress level. For the uniaxial, hydrostatic, and biaxial loadings, the specific creep strain at the 2400-psi stress level averaged 1.17 times that at the 600-psi stress level. This increase in strain was essentially the same for all three states of stress, ranging from 1.15 for biaxial loading to 1.23 for the hydrostatic case. The higher stress level resulted in an average stress-strength ratio upon loading of 0.31, which is, as the data would indicate, approaching the generally accepted limit for creep-stress proportionality. The application of a 600-psi radial stress reduced an average of 14 percent the compressive creep strains in the direction of the axial load relative to compressive creep strains in comparable uniaxially loaded specimens.

72. The effect of uniaxial and biaxial loadings on tensile creep could be compared directly in seven cases; in six of these cases, the higher tensile creep strain was associated with the biaxial stress condition. For these seven cases, the tensile creep strains for biaxially loaded specimens averaged 1.26 times that obtained for comparable specimens uniaxially loaded. There were eight cases in which a direct comparison could be made concerning the effect of increased stress level on tensile creep for the uniaxial and biaxial stress states. In these eight cases, the higher tensile creep strain was equally divided between the two stress levels. Averaging the two states of stress, there was less than 1 percent difference in tensile creep strain for the two stress levels. However, the tensile creep strain at 600 psi was 1:35 times

that at 2400 psi for the uniaxial stress state, whereas the tensile creep at 2400 psi was 1.20 times that at 600 psi for the biaxial state of stress.

Creep Poisson's Ratio

73. As shown by Neville,⁸ there is no agreement on the magnitude of creep Poisson's ratio (CPR) in uniaxial compression. Some investigators have reported it to be zero or approximately so,^{10,11} others^{12,13} reported a value of approximately 0.05, while others¹⁴⁻¹⁷ claimed that creep Poisson's ratio was equal to the elastic Poisson's ratio (EPR). Part of this discrepancy was probably due to differences in test conditions and methods of strain measurement. The methods used by most investigators to determine the magnitude of CPR under uniaxial stresses have been essentially the same. However, different methods have been used to compute the magnitude of CPR under multiaxial stresses, depending on the investigator's definition of CPR.

74. Hannant¹⁶ reported that CPR under multiaxial states of stress remained virtually constant throughout a 2-year test period with an average value of 0.18 which was similar in magnitude to EPR. Similarly, Illston and Jordaan¹⁸ reported that creep of concrete under variable multiaxial states of stress can be satisfactorily predicted using a rate-of-flow method on the assumption of a constant Poisson's ratio equal to the static elastic value. Others⁶ report the effective CPR under multiaxial stress is lower (0.09 to 0.17) than uniaxial CPR (0.17 to 0.20) which was approximately the same as EPR. Considering the variation in methods used to calculate CPR magnitudes, it is difficult to evaluate the results of different researchers. In this report, values of CPR were calculated by the same equation used to calculate EPR by substituting the appropriate creep strains for elastic strains, a method previously used by York, et al.³

75. Excluding hydrostatic specimens and those which had gage failures, CPR values at various times during the loading period are

presented in Table 10. Average CPR values for the various environmental test conditions over the entire test period are shown therein and also summarized below. Obviously, these averages are somewhat biased due to differences in loading conditions. Also, the limited data and scatter of the data would make definite conclusions questionable; however, the averages should offer general indications as to the effect of the various test conditions on values of CPR.

<u>Modulus</u>	<u>Temperature °F</u>	<u>Curing</u>	<u>Creep Poisson's Ratio</u>	<u>Percentage of Elastic Poisson's Ratio</u>
High	73	AC	0.160	101
		AD	0.067	41
	150	AC	0.096	60
		AD	0.098	68
		Average	0.105	68
Main	73	AC	0.133	57
		AD	0.233	99
	150	AC	0.104	52
		AD	0.122	54
		Average	0.148	66
Low	73	AC	0.082	60
		AD	--	--
	150	AC	0.112	97
		AD	0.132	120
		Average	0.109	92

76. Overall, CPR's averaged approximately 0.10, 0.15, and 0.11 for high-, main-, and low-modulus concrete, respectively. CPR was generally smaller than EPR, averaging 66 to 92 percent of the elastic values. York,³ et al, reported an average CPR of 0.16 which was approximately 65 percent of the average EPR for main-modulus concrete. This finding is almost identical to the results of this investigation on the same concrete mixture.

77. To form a basis for comparison of CPR values, the average CPR over the entire test period was computed for each test condition where data were available. Results are as follows:

Creep Poisson's Ratio

		<u>High-Modulus</u>		<u>Main-Modulus</u>		<u>Low-Modulus</u>	
		<u>73°F</u>	<u>150°F</u>	<u>73°F</u>	<u>150°F</u>	<u>73°F</u>	<u>150°F</u>
U 600/0	AC	--	--	0.142	--	--	0.097
	AD	--	--	--	--	--	--
U 2400/0	AC	0.160	0.101	--	--	0.074	--
	AD	0.062	0.087	--	--	--	0.150
B 0/600	AC	--	--	0.195	0.165	--	0.141
	AD	--	0.130	0.233	0.122	--	0.148
B 0/2400	AC	--	--	0.148	--	--	0.120
	AD	--	--	--	--	--	0.127
T 2400/600	AC	--	0.090	0.046	0.043	0.089	--
	AD	0.076	--	--	--	--	0.108

78. There were six cases, two each for each of the concrete mixtures, in which the average CPR over the test period could be compared directly concerning the effect of curing conditions. In three of the four cases involving high- and main-modulus concrete, the larger CPR was associated with the AC specimens. It was shown previously that tensile creep strains for AD specimens were smaller than those of comparable AC specimens of the high- and main-modulus concretes. Therefore, it would be expected that CPR would be less for AD concrete; for the limited data available, the CPR for AC specimens averaged 23 percent more than for comparable AD specimens. Similarly, it was previously shown that average tensile creep strains for AD specimens were slightly higher than for comparable AC specimens of low-modulus concrete, and in the two cases in which a direct comparison was possible, the CPR for AD specimens averaged approximately 5 percent higher than for comparable AC specimens.

79. In four of five cases in which a direct comparison was possible concerning the effect of temperature, the higher CPR was associated with the lower testing temperature. The limited data available indicate CPR at 73°F averaged approximately 34 percent higher than at 150°F. This apparent trend agrees with results reported by others.^{3,7,16}

80. The state of stress also appeared to influence the magnitude of CPR. For each concrete mixture, the higher overall average CPR was associated with the biaxial loading and the lower CPR with the triaxial loading. Values for uniaxial loading ranged between these two bounds. The overall average CPR's for all three concrete mixtures were in the proportion 1.00:0.80:0.54 for biaxial, uniaxial, and triaxial loading, respectively.

81. The effect of time on CPR is shown in Figure 47. While the CPR of low-modulus concrete appears to remain essentially constant throughout the test period, CPR for the two remaining mixtures would appear to be increasing slightly with time. In all three cases, CPR after 1 year under sustained load is still slightly lower than EPR. The data, particularly for the high- and low-modulus concretes in the later part of the sustained load period, are limited; however, it would appear, particularly for the main-modulus concrete, that CPR increases somewhat with time under load. In similar tests, York,³ et al, did not draw definite conclusions due to lack of sufficient data; however, they believe that time does not significantly affect CPR.

Elastic Recovery Strains

82. The elastic recovery strains which occurred immediately after the creep specimens were unloaded are shown in Table 11. In addition, Table 11 contains modulus of elasticity and Poisson's ratio values for elastic recovery which were calculated in a manner similar to that used for calculating the elastic values. Elastic recovery values are also compared with elastic values in Table 11.

83. Overall elastic recovery strains in the axial direction ranged from 77 to 121 percent of elastic strains upon loading with an average of 99 percent. While the range of recovery strains in the radial direction was much greater (61 to 257 percent), the overall average (101 percent) was again essentially the same as for the elastic strains.

84. Overall elastic recovery strains for the main-modulus concrete averaged 8 percent larger than elastic strains at loading. This

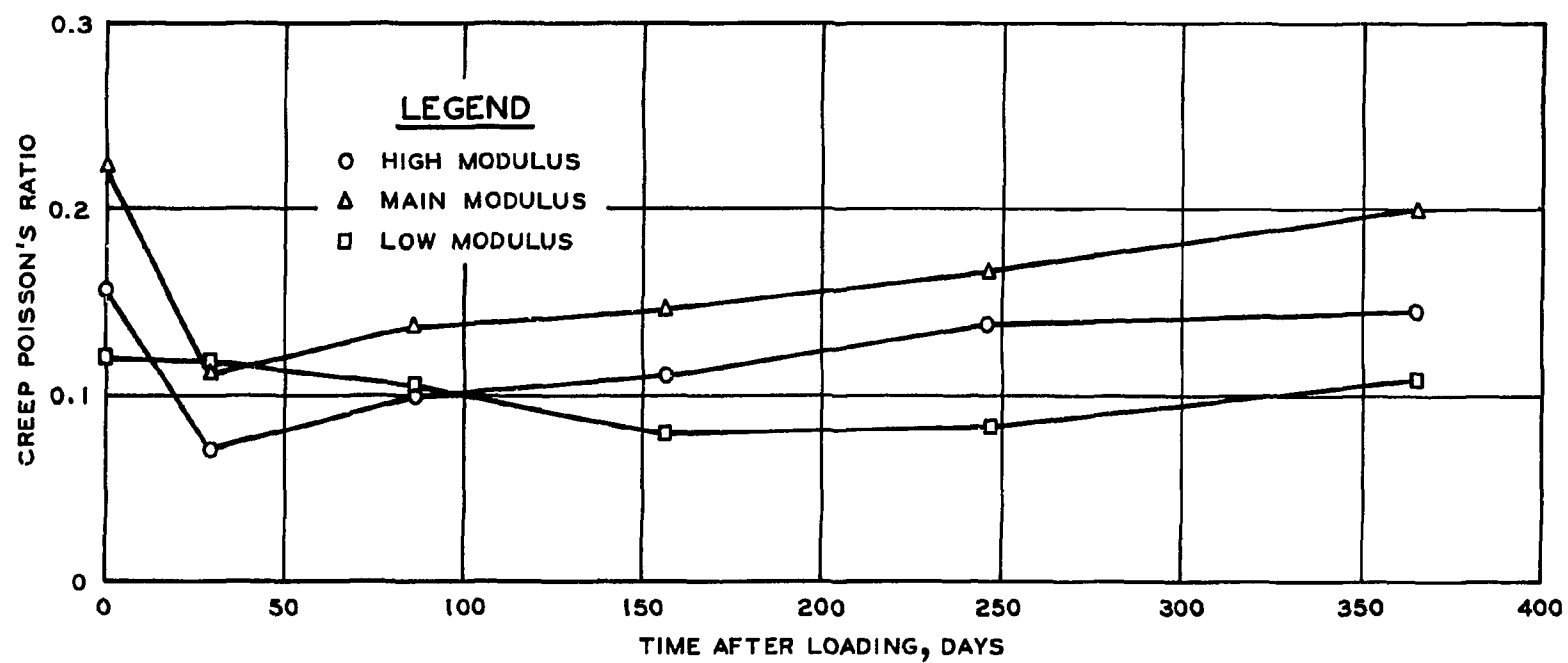


Figure 47. Effect of time after loading on CPR

finding agrees with the results of similar tests on the same concrete mixture at the University of Texas.³ In comparison, average elastic recovery strains for the high- and low-moduli concretes were 2 and 13 percent less than elastic strains, respectively. Gopalakrishnan⁶ found that, for concrete cubes subjected to multiaxial stresses, the elastic recovery strains were less than the elastic strains upon loading in all cases.

85. Elastic recovery strains for three of the four temperature and curing conditions shown in Table 11 were essentially the same, averaging approximately 3 percent higher than elastic strains upon loading. The exception was AD specimens loaded at 150°F in which elastic recovery strains averaged 12 percent less than elastic strains upon loading.

86. Average values of moduli of elasticity and Poisson's ratios during recovery are compared with similar values obtained upon loading below.

<u>Modulus</u>	<u>Poisson's Ratio</u>		<u>Modulus of Elasticity</u> <u>10⁶ psi</u>	
	<u>Elastic</u>	<u>Elastic Recovery</u>	<u>Elastic</u>	<u>Elastic Recovery</u>
High	0.157	0.150	6.70	7.14
Main	0.224	0.235	5.82	5.61
Low	0.121	0.146	3.02	3.86

The elastic recovery modulus of elasticity for low-modulus concrete was significantly larger than the moduli upon loading; however, it should be noted that the latter value is the average of only four specimens. Generally, other values of moduli of elasticity and Poisson's ratios were only slightly different upon loading and during recovery.

Creep Recovery

89. After unloading, strains in the creep and control specimens were monitored intermittently for a period of approximately 4 months to determine creep recovery. Results of creep recovery measurements are shown in Appendix C and summarized in Table 12.

88. From 4 to 60 percent of the creep strain at time of unloading, an average of 31 percent, was recovered 117 days after the loads were released. This recovery, still continuing at the time comparisons were made, was in the direction opposite that of creep strains with the exception of three cases in which there were small strain recoveries in the same direction as the creep strain.

89. Overall, creep recovery for AC and AD specimens was essentially the same, averaging 29 and 32 percent of the creep strains at time of unloading, respectively. Results reported by Gopalakrishnan¹⁷ indicated that, for uniaxially loaded specimens, the percentage of axial creep strain recovered was slightly higher for wet-stored than dry-stored cylindrical specimens. Under comparable test conditions in this investigation, results indicate that the percentage of axial creep recovered for the AC specimens was 4 percent greater than that for AD specimens.

90. Although only limited test results were available for the 150°F test condition, the data indicate no significant difference in the percentage of creep recovered at the two test temperatures. Average creep recovery at 73°F and 150°F was 31 and 30 percent, respectively.

91. Creep recovery of main- and low-modulus concrete specimens was essentially the same, averaging 27 and 28 percent, respectively, of the creep strain at the time of unloading. In comparison, creep recovery of high-modulus concrete specimens averaged 35 percent of the creep at the time of unloading.

92. The percentage of creep recovered was essentially the same for both stress levels, averaging 33 and 35 percent of the creep at the time of unloading for the 2400- and 600-psi stress levels, respectively. The type of stress applied also appeared to have only a small effect on the percentage of creep recovered, with multiaxial states of stress averaging 5 percent more creep recovery than uniaxial states. In comparison, York,³ et al, in similar tests on the main-modulus concrete mixture, reported no significant effect of type stress applied, whereas Gopalakrishnan⁶ found that the percentage of creep strain recovered was approximately 20 percent higher for multiaxial than uniaxial states of

stress. It should be noted that in the latter tests the age at loading was 8 days and the duration of load ranged from 22 to 98 days, with the majority of the tests being 28 days duration.

PART IV: CONCLUSIONS AND RECOMMENDATIONS

93. This report presents the results of tests conducted to determine the elastic and time-dependent deformation behavior of concrete subjected to a variety of test conditions. This was intended primarily as a data report; therefore, a comprehensive evaluation of the effects and interactions of aggregate moduli, moisture condition, testing temperature, and loading conditions on the behavior of concrete was not conducted. However, a number of general comparisons were made concerning the effect of the various test conditions on the behavior of concrete. Based on this limited data evaluation, some general conclusions and recommendations for additional work were formulated as discussed in the following paragraphs.

Conclusions

94. For the concretes used and the actual test conditions investigated, it appears that the following conclusions can be drawn.

a. Strength and elastic deformation

- (1) It is possible to proportion concrete mixtures containing widely varying aggregate moduli with subsequent variations in concrete moduli to obtain similar compressive strengths.
- (2) After 90 days curing at 73°F, the unconfined compressive strength of AD concrete was slightly higher than that of AC concrete. However, both of these curing procedures resulted in concretes which exhibited lower strengths than concrete cured in limewater until tested.
- (3) Beyond 90 days, both AC and AD specimens were sealed against moisture loss, and after approximately 1 year of additional curing at 73°F, the compressive strengths of both types of concrete specimens were essentially equal.
- (4) Curing of AC specimens at 150°F beyond 83 days resulted in compressive strengths higher than those of both sealed AD specimens under similar curing conditions and AC specimens with additional curing at 73°F.

- (5) Additional curing of sealed AD specimens at 150°F resulted in compressive strengths lower than those of similar specimens cured at 73°F.
- (6) The secant modulus of elasticity of concrete was proportional to the modulus of elasticity of the aggregate.
- (7) The secant modulus of elasticity for AC concrete was slightly higher than that for AD concrete.
- (8) The secant modulus of elasticity did not appear to be significantly affected by an increase in temperature at time of loading.
- (9) Except for main-modulus concrete, Poisson's ratio was slightly higher for AC concrete than for AD, and in all cases, it was slightly higher at 73°F than at 150°F.

b. Time-dependent deformation

- (1) Axial and radial shrinkage strains for AC control specimens were similar in magnitude and remained essentially constant during the curing period. Average strains ranged from 4 to 26 millionths with an overall average of 13 millionths.
- (2) Average axial and radial shrinkage strains for AD specimens at the end of the curing period were inversely proportional to the concrete and aggregate moduli, ranging from 127 to 552 millionths for the high- and low-modulus concretes, respectively. Axial shrinkage strains averaged 1.4 times greater than comparable radial strains.
- (3) During the test period, axial and radial strains for AC control specimens at 73°F were similar in magnitude. Strains ranged from 8 millionths expansion to 26 millionths shrinkage at the end of the test period.
- (4) Generally, AD specimens at 73°F indicated expansion in both axial and radial directions at a decreasing rate during the test period. These strains were generally inversely proportional to concrete and aggregate moduli, ranging up to approximately 130 millionths for the low-modulus specimens at the end of the test period.
- (5) At 150°F AC and AD control specimens expanded in both axial and radial directions at a decreasing rate until the average strains either essentially stabilized at 100-150 days after loading of the

creep specimens or began to decrease, in some cases eventually indicating shrinkage, particularly those experiencing strain gage failures during the test period.

- (6) Specific creep strains were larger for the 150°F condition during loading, averaging 1.79 and 1.51 times that at 73°F for the compressive and tensile creep, respectively. AD concrete exhibited a greater increase in compressive creep than AC concrete at 150°F, whereas the reverse was true for tensile creep. Overall, the absolute average creep at 150°F was 1.76 times that at 73°F.
- (7) AD specimens of the high- and main-modulus concrete averaged 27 percent greater compressive creep strain than comparable AC specimens, whereas AC specimens of the low-modulus concrete averaged 45 percent greater compressive creep strain than comparable AD specimens. The reverse was true for tensile creep; AC specimens of the high- and main-modulus concretes averaged 11 percent greater tensile creep strain than comparable AD specimens, whereas AD specimens of the low-modulus concrete averaged 17 percent greater strain than comparable AC specimens.
- (8) Compressive and tensile creep strains are generally proportional to the inverse of the elastic modulus of both concrete and aggregate.
- (9) In the two cases in which moisture and temperature conditions allowed a direct comparison concerning the effect of loading mode, values of compressive creep for main-modulus concrete differed by a factor of 1.00(uniaxial):0.45(hydrostatic):0.69(biaxial):0.84(triaxial). Overall averages for the three concrete mixtures, although somewhat biased as a result of differences in moisture and temperature conditions for the various states of stress, differed by a factor of 1.00:0.49:0.95:0.86. This indicates that compressive creep under multiaxial stress is less than that under uniaxial stress.
- (10) The increase in compressive specific-creep strain at the 2400-psi level was essentially the same for the uniaxial, hydrostatic, and biaxial states of stress, averaging 1.17 times that at the 600-psi level.
- (11) The application of a 600-psi radial stress reduced compressive creep strains in the direction of the axial load relative to similar strains in comparable uniaxially loaded specimens an average of 14 percent.

- (12) Tensile specific-creep strains for biaxially loaded specimens averaged 1.26 times that for comparable uniaxially loaded specimens.
- (13) Tensile specific-creep strains at the 600-psi level averaged 1.35 times that at the 2400-psi level for the uniaxial stress state, whereas the similar strains at 2400-psi stress averaged 1.20 times that at the 600-psi level for the biaxial state of stress.

c. Creep Poisson's ratio (CPR)

- (1) CPR was generally smaller than elastic Poisson's ratio, averaging 68, 66, and 92 percent of the elastic values for high-, main-, and low-modulus concretes, respectively.
- (2) CPR for AC high- and main-modulus concrete averaged 23 percent higher than that of comparable AD specimens. The reverse was true for the low-modulus concrete; CPR averaged approximately 5 percent higher for AD specimens than for comparable AC specimens.
- (3) The limited data available indicate CPR at 73°F averaged approximately 34 percent higher than at 150°F.
- (4) The state of stress also appeared to influence the magnitude of CPR. The overall average CPR's for all concrete mixtures were in the proportion 1.00:0.80:0.54 for biaxial, uniaxial, and triaxial states of stress, respectively.
- (5) While the CPR of low-modulus concrete appeared to remain essentially constant throughout the test period, CPR for the two remaining mixtures appeared to increase slightly with time. In all three cases, CPR after 1 year under sustained load was still slightly lower than EPR.

d. Elastic recovery strains

- (1) Overall, average elastic recovery strains for the three concrete mixtures were slightly less than elastic strains except for the main-modulus concrete, where the reverse was true.
- (2) For the temperature and curing conditions investigated, elastic recovery strains were essentially the same as elastic strains, except for AD specimens loaded at 150°F.
- (3) The modulus of elasticity and Poisson's ratio for elastic recovery were essentially the same as those at the time of loading, except for those for low-modulus concrete which were somewhat higher than at the time of loading.

e. Creep recovery

- (1) From 4 to 60 percent of the creep strain at time of unloading, an average of 31 percent, was recovered 117 days after the loads were released. This recovery, still continuing at the time comparisons were made, was in the direction opposite of the direction of creep strains, except for three cases in which there were small strain recoveries in the same direction as the creep strain.
- (2) The percentage of creep recovered was essentially the same for variations in curing, temperature, concrete modulus, and stress level investigated, ranging from 27 to 35 percent of the creep at the time of unloading.
- (3) The state of stress applied appeared to have a small effect on the percentage of creep recovered, with multiaxial states of stress averaging 5 percent more creep recovery than uniaxial states.

Recommendations

95. Creep of concrete under multiaxial stress is a very complex phenomenon involving many interaction effects. The data developed in this investigation should be analyzed statistically to determine what factors and interactions of factors significantly affect the creep of concrete. Also, it is considered desirable to use the experimental data reported herein to develop equations for predicting long-term multiaxial creep behavior from relatively short-term uniaxial creep tests and evaluate the accuracy of such predictive equations.

96. Results of this investigation illustrate the significant effect of elevated temperature on creep of concrete. The data developed, although for the single temperature of 150°F, should prove useful in analyses to predict the time-dependent behavior of vessels during reactor operation. However, additional creep tests at higher temperatures are necessary to allow accurate predictions of time-dependent vessel behavior for the range of operating temperatures.

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Table 1

Summary of Experimental Test Conditions

Modulus of Elasticity		<u>High</u>				Main				Low			
Testing Temperature, °F		72		150		73		150		73		150	
Curing History		AC	AD	AC	AD	AC	AD	AC	AD	AC	AD	AC	AD
Stress, psi													
Axial	Radial												
2400	2400	*	*	*	*	*	*	*	*	*	*	*	*
	600	*	*	*	*	*	*	*	*	*	*	*	*
	0	*	*	*	*	*	*	*	*	*	*	*	*
600	600	*	*	--	--	*	*	--	--	--	--	--	--
	0	*	*	*	*	*	*	*	*	--	--	*	*
0	2400	--	--	*	*	*	*	*	*	--	--	*	*
	600	--	--	*	*	*	*	*	*	--	--	*	*
	0	*	*	*	*	*	*	*	*	*	*	*	*

* Test conditions investigated.

Table 2

Test Specimen Data

<u>Batch</u>	<u>Modulus</u>	<u>Date of Casting 1969</u>	<u>Number of Specimens Cast</u>		
			<u>Creep*</u>	<u>Control*</u>	<u>Strength</u>
I	High	Apr 21	8	4	42
II	Main	May 7	8	4	42
III	Low	May 14	8	4	42
IV	High	May 21	6	4	27
V	Main	Jun 4	10	4	24
VI	Main	Jul 30	8	4	24
VII	High	Nov 3	8	4	24
VIII	Low	Nov 18	10	4	24

* Equally divided between AC and AD.

Table 3

Summary of Creep and Control Specimens Cast According to Concrete Batch Number

Modulus of Elasticity		High				Main				Low			
Testing Temperature, °F		73		150		73		150		73		150	
Curing History		AC	AD	AC	AD	AC	AD	AC	AD	AC	AD	AC	AD
Stress, psi													
Axial	Radial												
2400	2400	IV	IV	IV	IV	V	V	V	V	III	III	III	III
	600	VII	VII	VII	VII	VI	VI	VI	VI	VIII	VIII	VIII	VIII
	0	I	I	I	I	II	II	II	II	III	III	III	III
600	600	IV	IV	--	--	V	V	--	--	--	--	--	--
	0	I	I	I	I	II	II	II	II	--	--	VIII	VIII
0	2400	--	--	VII	VII	VI	VI	VI	VI	--	--	VIII	VIII
	600	--	--	VII	VII	V	V	V	V	--	--	VIII	VIII
	0	I	I	I	I	II	II	II	II	III	III	III	III
		IV	IV	IV	IV	V	V	V	V	VIII	VIII	VIII	VIII
		VII	VII	VII	VII	VI	VI	VI	VI	--	--	--	--

Table 4

Average Compressive Strengths

<u>Modulus</u>	<u>Batch</u>	<u>Curing Condition</u>	<u>Average Strengths (psi) at Following Ages (days) and Temperatures (°F)</u>							
			<u>28</u>	<u>90</u>	<u>183</u>		<u>365</u>		<u>455</u>	
			<u>73</u>	<u>73</u>	<u>73</u>	<u>150</u>	<u>73</u>	<u>150</u>	<u>73</u>	<u>150</u>
High	I	Standard	6840	8400	--	--	--	--	--	--
	IV	"	6290	7610	--	--	--	--	--	--
	VII	"	6950	8490	--	--	--	--	--	--
		Average	6690	8170	--	--	--	--	--	--
Main	II	Standard	7420	8840	--	--	--	--	--	--
	V	"	--	8140	--	--	--	--	--	--
	VI	"	7650*	9060	--	--	--	--	--	--
		Average	7420**	8680						
Low	III	Standard	6370	7940	--	--	--	--	--	--
	VIII	"	7010	8630	--	--	--	--	--	--
		Average	6690	8280						
High	I	AC	6690	7890	7480†	8660†	8160	10,010	8160	9860
	IV	"	5670	--	--	--	--	--	--	--
	VII	"	6190	7470	--	--	--	--	--	--
Main	II	AC	6600	7480	8590	8560	9110	9430	9140	8690
	V	"	6010	7250	--	--	--	--	--	--
	VI	"	6080*	7490	--	--	--	--	--	--
		Average	6300**	7410						

(Continued)

Table 4 (Concluded)

Modulus	Batch	Curing Condition	Average Strengths (psi) at Following Ages (days) and Temperatures (°F)							
			28	90	183		365		455	
			73	73	73	150	73	150	73	150
Low	III VIII	AC	6320	7160	8370	8690	9350	8200	9350	9250
		"	6330	8150	--	--	--	--	--	--
		Average	6320	7660						
High	I IV VII	AD	6970	8010	9250†	8880†	8840	8410	9480	9030
		"	6540	7430	--	--	--	--	--	--
		"	7080	8250	--	--	--	--	--	--
		Average	6860	7900						
Main	II V VI	AD	7320	8110	8590	7890	8660	8380	8980	8380
		"	6800	7870	--	--	--	--	--	--
		"	7350*	8250	--	--	--	--	--	--
		Average	7060**	8080						
Low	III VIII	AD	6700	7570	8220	7990	8530	8710	8340	9300
		"	7500	8050	--	--	--	--	--	--
		Average	7100	7810						

* Tested at 35 days.

** Excludes Batch VI.

† Tested at 189 days.

Table 5

Modulus of Elasticity and Poisson's Ratio

Curing Conditions	Specimen	Stress, psi		Strain, millionths		Poisson's Ratio	Modulus of Elasticity, 10 ⁶ psi
		Axial	Radial	Axial	Radial		
High-Modulus Concrete							
73°F, AC	I-1	600	0	85	-15	0.176	7.06
	I-3	2400	0	363	-64	0.176	6.61
	IV-1	600	600	51	54	0.500	0.0
	VII-5	2400	600	288	29	0.124	7.81
73°F, AD	I-2	600	0	89	-16	0.180	6.74
	I-4	2400	0	389	-67	0.172	6.17
	IV-2	600	600	57	73	0.500	0.0
	IV-4	2400	2400	247	245	0.500	0.0
	VII-6	2400	600	367	16	0.168	5.99
150°F, AC	I-5	600	0	84	-14	0.167	7.14
	I-7	2400	0	362	-57	0.157	6.63
	VII-1	0	600	-23	69	0.143	7.45
	VII-3	0	2400	-199	337	0.228	5.50
	VII-7	2400	600	308	37	0.109	7.37
150°F, AD	I-6	600	0	91	-14	0.154	6.59
	I-8	2400	0	367	-58	0.158	6.54
	IV-6	2400	2400	258	293	0.500	0.0
	VII-2	0	600	-22	75	0.128	6.98
	VII-4	0	2400	-116	342	0.145	6.00
	VII-8	2400	600	349	31	0.134	6.42
Main-Modulus Concrete							
73°F, AC	II-1	600	0	95	-23	0.242	6.32
	V-1	600	600	39	38	0.500	0.0
	V-3	2400	2400	195	169	0.500	0.0
	V-7	0	600	-53	78	0.254	5.74
	VI-1	0	2400	-202	359	0.220	5.22
	VI-5	2400	600	342	-7	0.215	6.26
73°F, AD	II-2	600	0	102	-24	0.235	5.88
	II-4	2400	0	436	-107	0.245	5.50
	V-2	600	600	41	44	0.500	0.0
	V-4	2400	2400	185	240	0.500	0.0
	V-8	0	600	-53	89	0.229	5.19

(Continued)

Table 5 (Concluded)

Curing Conditions	Specimen	Stress, psi		Strain, millionths		Poisson's Ratio	Modulus of Elasticity, 10 ⁶ psi
		Axial	Radial	Axial	Radial		
Main-Modulus Concrete (Continued)							
150°F, AC	II-5	600	0	106	-19	0.179	5.66
	V-5	2400	2400	184	218	0.500	0.0
	V-9	0	600	-47	71	0.249	6.35
	VI-3	0	2400	-197	369	0.211	5.13
	VI-7	2400	600	318	19	0.160	6.96
150°F, AD	V-6	2400	2400	203	220	0.500	0.0
	V-10	0	600	-45	74	0.233	6.22
	VI-4	0	2400	-216	354	0.234	5.19
	VI-8	2400	600	350	-8	0.216	6.12
Low-Modulus Concrete							
73°F, AC	III-1	2400	0	775	-96	0.124	3.10
	VIII-7	2400	600	700	49	0.148	3.17
73°F, AD	III-6	2400	2400	510	595	0.500	0.0
	VIII-8	2400	600	782	79	0.124	2.88
150°F, AC	III-3	2400	0	924	-115	0.124	2.60
	III-7	2400	2400	551	613	0.500	0.0
	VIII-1	600	0	179	-21	0.117	3.35
	VIII-3	0	600	-29	155	0.086	3.54
	VIII-5	0	2400	-229	739	0.134	2.81
150°F, AD	III-4	2400	0	875	-109	0.125	2.74
	VIII-2	600	0	197	-25	0.127	3.05
	VIII-4	0	600	-27	174	0.072	3.20
	VIII-6	0	2400	-225	822	0.120	2.57
	VIII-10	2400	600	695	87	0.105	3.27

Table 6

Summary of Creep Specimen Loading Conditions

<u>Modulus</u>	<u>Specimen</u>	<u>Age at Loading, days</u>	<u>Temperature, °F</u>	<u>Load, psi</u>	
				<u>Axial</u>	<u>Radial</u>
High	I-1, 2	93	73	600	0
	I-3, 4	93	73	2400	0
	I-5, 6	93	150	600	0
	I-7, 8	93	150	2400	0
Main	II-1, 2	90	73	600	0
	II-3, 4	90	73	2400	0
	II-5, 6	90	150	600	0
	II-7, 8	90	150	2400	0
Low	III-1, 2	90	73	2400	0
	III-3, 4	90	150	2400	0
	III-5, 6	142	73	2400	2400
	III-7, 8	97	150	2400	2400
High	IV-1, 2	92	73	600	600
	IV-3, 4	112	73	2400	2400
	IV-5, 6	91	150	2400	2400
Main	V-1, 2	121	73	600	600
	V-3, 4	105	73	2400	2400
	V-5, 6	105	150	2400	2400
	V-7, 8	91	73	0	600
	V-9, 10	91	150	0	600
Main	VI-1, 2	97	73	0	2400
	VI-3, 4	100	150	0	2400
	VI-5, 6	92	73	2400	600
	VI-7, 8	105	150	2400	600
High	VII-1, 2	91	150	0	600
	VII-3, 4	91	150	0	2400
	VII-5, 6	92	73	2400	600
	VII-7, 8	92	150	2400	600
Low	VIII-1, 2	90	150	600	0
	VIII-3, 4	90	150	0	600
	VIII-5, 6	91	150	0	2400
	VIII-7, 8	90	73	2400	600
	VIII-9, 10	90	150	2400	600

Table 7

Creep Strains, High-Modulus Concrete

Specimen	Loading	Curing	Temp, °F	Axial Strains						Radial Strains					
				Observa- tions		Index of Determi- nation	Equation Coefficients		Calcu- lated Strain, 365 days	Observa- tions		Index of Determi- nation	Equation Coefficients		Calcu- lated Strain, 365 days
				No.	Span, days		A	B		No.	Span, days		A	B	
I-1	U 600/0	AC	73	30	366	0.884	-0.00426	0.01056	0.0580	30	366	0.857	0.01081	-0.00630	-0.0264
I-2	U 600/0	AD	73	30	366	0.916	-0.00049	0.00778	0.0454	30	366	0.509	0.00982	-0.00274	-0.0063
I-3	U 2400/0	AC	73	29	366	0.948	-0.00782	0.01056	0.0545	29	366	0.869	0.00520	-0.00254	-0.0098
I-4	U 2400/0	AD	73	29	366	0.964	-0.00367	0.00999	0.0553	29	366	0.755	0.00411	-0.00148	-0.0046
I-5	U 600/0	AC	150	22	225	0.972	0.02572	0.01417	0.1093	21	120	0.293	0.00919	-0.00216	-0.0036
I-6	U 600/0	AD	150	20	106	0.910	-0.00729	0.02815	0.1588	19	120	0.906	0.00369	0.00363	0.0251
I-7	U 2400/0	AC	150	20	120	0.972	0.02239	0.02083	0.1453	20	120	0.902	-0.00532	-0.00127	-0.0128
I-8	U 2400/0	AD	150	24	285	0.951	0.01011	0.02652	0.1666	21	120	0.766	-0.00060	-0.00200	-0.0124
IV-2	H 600/600	AD	73	22	365	0.798	0.00392	0.00657	0.0427	20	365	0.876	-0.00097	0.00681	0.0392
IV-3	H 2400/2400	AC	73							6	4	0.704	0.00511	0.00226	0.0184
IV-4	H 2400/2400	AD	73	21	365	0.968	-0.01456	0.01135	0.0524	21	365	0.928	-0.00830	0.00754	0.0362
VII-1	B 0/600	AC	150	7	16	0.967	-0.00787	-0.00693	-0.0488	7	16	0.939	0.02191	0.01186	0.0919
VII-2	B 0/600	AD	150	8	28	0.668	-0.00596	-0.00241	-0.0202	11	52	0.965	0.02121	0.02172	0.1494
VII-3	B 0/2400	AC	150	8	24	0.811	-0.00166	-0.00482	-0.0301	8	24	0.953	0.01099	0.01106	0.0762
VII-4	B 0/2400	AD	150	9	35	0.820	0.00141	-0.00535	-0.0302	12	63	0.974	0.01478	0.01472	0.1016
VII-5	T 2400/600	AC	73	26	366	0.930	-0.00847	0.00945	0.0473	27	366	0.906	0.00990	0.00723	0.0526
VII-6	T 2400/600	AD	73	28	366	0.953	-0.00233	0.01360	0.0779	15	196	0.895	0.00926	0.00557	0.0421
VII-7	T 2400/600	AC	150	17	251	0.938	0.00252	0.01511	0.0917	13	120	0.925	0.00676	0.00616	0.0431
VII-8	T 2400/600	AD	150	32	366	0.981	0.00890	0.01537	0.0996						

Table 8

Creep Strains, Main-Modulus Concrete

Specimen	Loading	Curing	Temp, OF	Axial Strains					Radial Strains						
				Observa- tions		Index of Determi- nation	Equation Coefficients		Calcu- lated Strain, 365 days	Observa- tions		Index of Determi- nation	Equation Coefficients		Calcu- lated Strain, 365 days
				No.	Span, days		A	B		No.	Span, days		A	B	
II-1	U 600/0	AC	73	23	365	0.900	0.01764	0.01590	0.1114	23	365	0.601	0.01010	-0.00499	-0.0188
II-2	U 600/0	AD	73	24	365	0.913	0.00957	0.02100	0.1335	23	365	0.836	-0.00828	0.00389	0.0144
II-3	U 2400/0	AC	73	20	365	0.971	0.00936	0.01580	0.1026						
II-4	U 2400/0	AD	73	21	365	0.977	0.00883	0.01983	0.1258	21	365	0.104	-0.00233	0.00023	-0.0010
II-5	U 600/0	AC	150	13	93	0.966	0.01051	0.01240	0.0837	10	31	0.007	-0.00279	-0.00041	-0.0052
II-7	U 2400/0	AC	150	14	122	0.952	0.01412	0.02736	0.1755						
II-8	U 2400/0	AD	150							12	71	0.571	-0.00509	0.00073	-0.0008
V-1	H 600/600	AC	73							18	367	0.807	0.00733	0.00597	0.0426
V-3	H 2400/2400	AC	73	20	366	0.934	-0.00429	0.00822	0.0442	18	366	0.929	-0.00284	0.00697	0.0383
V-4	H 2400/2400	AD	73							20	366	0.926	0.00149	0.00618	0.0380
V-5	H 2400/2400	AC	150	20	366	0.949	0.01161	0.00862	0.0625	20	366	0.990	0.01643	0.00902	0.0696
V-6	H 2400/2400	AD	150	19	366	0.873	-0.01065	0.01457	0.0753	20	366	0.887	-0.00512	0.01481	0.0823
V-7	B 0/600	AC	73	20	365	0.808	0.00322	-0.00628	-0.0338	20	365	0.829	0.00988	0.00918	0.0640
V-8	B 0/600	AD	73	20	365	0.905	-0.00348	-0.00753	-0.0409	20	365	0.847	0.00489	0.01291	0.0811
VI-1	B 0/2400	AC	73	23	365	0.893	0.00395	-0.00618	-0.0325	23	365	0.962	-0.00502	0.01540	0.0858
VI-2	B 0/2400	AD	73	23	365	0.775	0.00144	-0.00335	-0.0183						
V-9	B 0/600	AC	150	7	21	0.970	-0.00516	-0.00510	-0.0352	9	64	0.982	0.01346	0.01444	0.0987
V-10	B 0/600	AD	150	8	42	0.951	-0.00982	-0.00378	-0.0321	21	365	0.932	-0.00770	0.03246	0.1838
VI-4	B 0/2400	AD	150	2	8	1.000	0.00100	-0.00721	-0.0415	2	8	1.000	0.01100	0.01010	0.0706
VI-5	T 2400/600	AC	73	25	365	0.949	-0.00715	0.01629	0.0890	24	365	0.901	0.00193	0.01051	0.0639
VI-6	T 2400/600	AD	73							7	39	0.939	0.00728	0.01506	0.0961
VI-7	T 2400/600	AC	150	9	84	0.956	0.01611	0.01600	0.1105	5	26	0.937	0.01093	0.01314	0.0865
VI-8	T 2400/600	AD	150	21	365	0.952	-0.00289	0.02266	0.1308						

Table 9
Creep Strains, Low-Modulus Concrete

Specimen	Loading	Curing	Temp, OF	Axial Strains						Radial Strains					
				Observa- tions		Index of Determi- nation	Equation Coefficients		Calcu- lated Strain, 365 days	Observa- tions		Index of Determi- nation	Equation Coefficients		Calcu- lated Strain, 365 days
				No.	Span, days		A	B		No.	Span, days		A	B	
III-1	U 2400/0	AC	73	20	365	0.967	0.03030	0.03282	0.2239	21	365	0.915	-0.00381	-0.00207	-0.0160
VIII-1	U 600/0	AC	150	28	350	0.987	-0.00250	0.07326	0.4297	30	358	0.868	-0.00339	-0.00624	-0.0402
VIII-2	U 600/0	AD	150	19	273	0.965	0.05519	0.02757	0.2179	14	183	0.970	-0.01380	-0.01819	-0.1211
III-3	U 2400/0	AC	150	2	2	1.000	0.07900	0.05465	0.4014	14	149	0.916	-0.00560	-0.01030	-0.0664
III-4	U 2400/0	AD	150	8	26	0.980	0.07608	0.03157	0.2623	22	365	0.888	0.00238	-0.01107	-0.0629
III-6	H 2400/2400	AD	73	3	3	0.990	0.00228	0.01212	0.0738						
III-8	H 2400/2400	AD	150							3	7	0.991	0.03026	0.02816	0.1964
VIII-3	B 0/600	AC	150	10	77	0.962	-0.00975	-0.01164	-0.0784	13	183	0.960	0.01278	0.04266	0.2645
VIII-4	B 0/600	AD	150	11	217	0.904	-0.02431	-0.00538	-0.0561	6	20	0.979	0.03315	0.02685	0.1916
VIII-5	B 0/2400	AC	150	18	328	0.947	-0.00577	-0.01603	-0.1003	10	77	0.945	0.03874	0.04535	0.3063
VIII-6	B 0/2400	AD	150	11	106	0.980	-0.01278	-0.01362	-0.0931	7	28	0.972	0.06186	0.03689	0.2795
VIII-7	T 2400/600	AC	73	31	365	0.956	0.00159	0.03431	0.2040	23	350	0.985	-0.00363	0.01993	0.1140
VIII-8	T 2400/600	AD	73	4	10	0.998	0.05168	0.02546	0.2019	6	18	0.993	-0.00011	0.03082	0.1817
VIII-10	T 2400/600	AD	150	11	108	0.986	0.04247	0.04334	0.2982	8	29	0.955	0.01349	0.02322	0.1505

Table 10
Creep Poisson's Ratio

Curing Conditions	Specimen*	Stress, psi		Creep Poisson's Ratio at Times (Days) After Loading					Average**
		Axial	Radial	29	86	156	246	365	
<u>High Modulus</u>									
73°F, AC	I-1	600	0	0.267	0.429	0.500	0.457	0.450	0.160
	I-3	2400	0	0.074	0.167	0.185	0.188	0.186	
	VII-5	2400	600	-0.305	-0.031	-0.060	-0.022	-0.004	
<u>Main Modulus</u>									
	II-1	600	0	0.057	0.061	0.119	0.174	0.301	0.133
	V-7	0	600	0.143	0.161	0.185	0.227	0.258	
	VI-1	0	2400	0.125	0.152	0.153	0.153	0.158	
	VI-5	2400	600	-0.022	0.076	0.053	0.057	0.068	
<u>Low Modulus</u>									
	III-1	2400	0	0.086	0.068	0.075	0.069	0.073	0.082
	VIII-7	2400	600	0.088	0.070	0.083	0.088	0.118	
<u>High Modulus</u>									
73°F, AD	I-4	2400	0	-0.016	0.061	0.071	0.089	0.106	0.067
	VII-6	2400	600	0.055	0.085	0.088	--	--	
<u>Main Modulus</u>									
	V-8	0	600	0.269	0.242	0.223	0.217	0.215	0.233

(Continued)

Table 10 (Continued)

<u>Curing Conditions</u>	<u>Specimen*</u>	<u>Stress, 'psi</u>		<u>Creep Poisson's Ratio at Times (Days) After Loading</u>					<u>Average**</u>
		<u>Axial</u>	<u>Radial</u>	<u>29</u>	<u>86</u>	<u>156</u>	<u>246</u>	<u>365</u>	
150 ^o F, AC				<u>High Modulus</u>					
	I-7	2400	0	0.106	0.096	--	--	--	0.096
	VII-7	2400	600	0.077	0.103	--	--	--	
				<u>Main Modulus</u>					
	V-9	0	600	0.165	--	--	--	--	0.104
	VI-7	2400	600	0.043	--	--	--	--	
				<u>Low Modulus</u>					
	VIII-1	600	0	0.093	0.075	0.081	0.096	0.139	0.112
	VIII-3	0	600	0.139	0.143	--	--	--	
	VIII-5	0	2400	0.122	0.117	--	--	--	
150 ^o F, AD				<u>High Modulus</u>					
	I-8	2400	0	0.072	0.090	0.099	--	--	0.098
	VII-4	0	600	0.130	--	--	--	--	
				<u>Main Modulus</u>					
	V-10	0	600	0.122	--	--	--	--	0.122

(Continued)

Table 10 (Concluded)

<u>Curing Conditions</u>	<u>Specimen*</u>	<u>Stress, psi</u>		<u>Creep Poisson's Ratio at Times (Days) After Loading</u>					<u>Average**</u>
		<u>Axial</u>	<u>Radial</u>	<u>29</u>	<u>86</u>	<u>156</u>	<u>246</u>	<u>365</u>	
				<u>Low Modulus</u>					
150°F, AD	III-4	2400	0	0.150	--	--	--	--	0.132
	VIII-2	600	0	0.489	0.491	0.484	--	--	
	VIII-4	0	600	0.150	0.146	--	--	--	
	VIII-6	0	2400	0.127	--	--	--	--	
	VIII-10	2400	600	0.100	0.117	--	--	--	

* Readings from hydrostatic specimens and those gages which failed are excluded from this table.

** Average over entire test period for those gages which appeared to be functioning properly.

Table 11
Elastic Recovery Strains

Curing Conditions	Specimen*	Released Stress, psi		Strain, millionths		Poisson's Ratio	Modulus of Elasticity, 10 ⁶ psi	Percent of Elastic Loading Strain	
		Axial	Radial	Axial	Radial			Axial	Radial
High Modulus									
73°F, AC	I-1	600	0	87	-10	0.115	6.90	102	67
	I-3	2400	0	351	-60	0.171	6.84	97	94
	VII-5	2400	600	259	27	0.122	8.70	90	93
Main Modulus									
	II-1	600	0	94	-27	0.287	6.38	99	117
	V-1	600	600	47	--	--	--	121	--
	V-3	2400	2400	181	--	--	--	93	--
	V-7	0	600	-60	75	0.286	5.71	113	96
	VI-1	0	2400	-188	357	0.208	5.32	93	99
	VI-5	2400	600	334	-18	0.238	6.33	98	257
Low Modulus									
	III-1	2400	0	634	-84	0.132	3.79	82	88
	VIII-7	2400	600	540	40	0.145	4.12	77	82
High Modulus									
73°F, AD	I-2	600	0	85	-15	0.176	7.06	96	94
	I-4	2400	0	384	-61	0.159	6.25	99	91
	IV-2	600	600	67	75	0.500	0.0	118	103
	IV-4	2400	2400	246	234	0.500	0.0	100	96
	VII-6	2400	600	343	28	0.139	6.51	93	175

(Continued)

(Sheet 1 of 3)

Table 11 (Continued)

Curing Conditions	Specimen*	Released Stress, psi		Strain, millionths		Poisson's Ratio	Modulus of Elasticity, 10 ⁶ psi	Percent of Elastic Loading Strain	
		Axial	Radial	Axial	Radial			Axial	Radial
73°F, AD				<u>Main Modulus</u>					
	II-2	600	0	118	-27	0.229	5.08	116	112
	II-4	2400	0	457	-102	0.223	5.25	105	95
	V-2	600	600	38	43	0.500	0.0	93	98
	V-4	2400	2400	--	231	--	--	--	96
	V-8	0	600	-64	76	0.296	5.56	121	85
				<u>Low Modulus</u>					
	VIII-8	2400	600	--	65	--	--	--	82
				<u>High Modulus</u>					
	I-5	600	0	78	-13	0.167	7.69	93	93
150°F, AC				<u>Main Modulus</u>					
	II-5	600	0	115	-13	0.113	5.22	108	68
	V-5	2400	2400	222	247	0.500	0.0	121	113
	V-9	0	600	-55	--	--	--	117	--
				<u>Low Modulus</u>					
	III-3	2400	0	-99	--	--	--	86	--
	VIII-1	600	0	169	-31	0.183	3.55	94	148

(Continued)

Table 11 (Concluded)

<u>Curing Conditions</u>	<u>Specimen*</u>	<u>Released Stress, psi</u>		<u>Strain, millionths</u>		<u>Poisson's Ratio</u>	<u>Modulus of Elasticity, 10⁶ psi</u>	<u>Percent of Elastic Loading Strain</u>	
		<u>Axial</u>	<u>Radial</u>	<u>Axial</u>	<u>Radial</u>			<u>Axial</u>	<u>Radial</u>
<u>High Modulus</u>									
150°F, AD	I-6	600	0	87	--	--	--	96	--
	I-8	2400	0	--	-45	--	--	--	78
	VII-8	2400	600	347	--	--	--	99	--
<u>Main Modulus</u>									
	V-6	2400	2400	185	207	0.500	0.0	91	94
	V-10	0	600	--	82	--	--	--	111
	VI-8	2400	600	339	--	--	--	97	--
<u>Low Modulus</u>									
	III-4	2400	0	--	-86	--	--	--	79
	VIII-2	600	0	151	-19	0.126	3.97	77	76
	VIII-4	0	600	-26	--	--	--	96	--
	VIII-6	0	2400	-192	--	--	--	85	--
	VIII-10	2400	600	--	53	--	--	--	61

* Only specimens in which at least one gage was functioning properly after unloading are included in this table.

Table 12

Summary of Creep Recovery Results

<u>Curing Conditions</u>	<u>Specimen*</u>	<u>Stress, psi</u>		<u>Creep After 1-yr Loading, millionths</u>		<u>Creep Strains Recovered,** millionths</u>		<u>Percent of Creep Strain Recovered**</u>	
		<u>Axial</u>	<u>Radial</u>	<u>Axial</u>	<u>Radial</u>	<u>Axial</u>	<u>Radial</u>	<u>Axial</u>	<u>Radial</u>
<u>High Modulus</u>									
73°F, AC	I-1	600	0	40	-18	9	-8	22	44
	I-3	2400	0	145	-27	48	-4	33	15
	VII-5	2400	600	122	31	43	9	35	29
<u>Main Modulus</u>									
	II-1	600	0	73	-22	9	-4	12	18
	V-3	2400	2400	117	98	55	--	47	--
	V-7	0	600	-25	36	1	19	--	53
	VI-1	0	2400	-81	216	-25	72	31	33
	VI-5	2400	600	228	39	67	-5	29	--
<u>Low Modulus</u>									
	III-1	2400	0	565	-41	180	-20	32	49
	VIII-7	2400	600	513	56	137	9	27	16
<u>High Modulus</u>									
73°F, AD	I-2	600	0	29	-7	8	-3	28	43
	I-4	2400	0	142	-15	46	-9	32	60
	IV-2	600	600	27	23	-1	10	--	43
	IV-4	2400	2400	130	90	40	43	31	48
	VII-6	2400	600	193	--	48	--	25	--

(Continued)

Table 12 (Concluded)

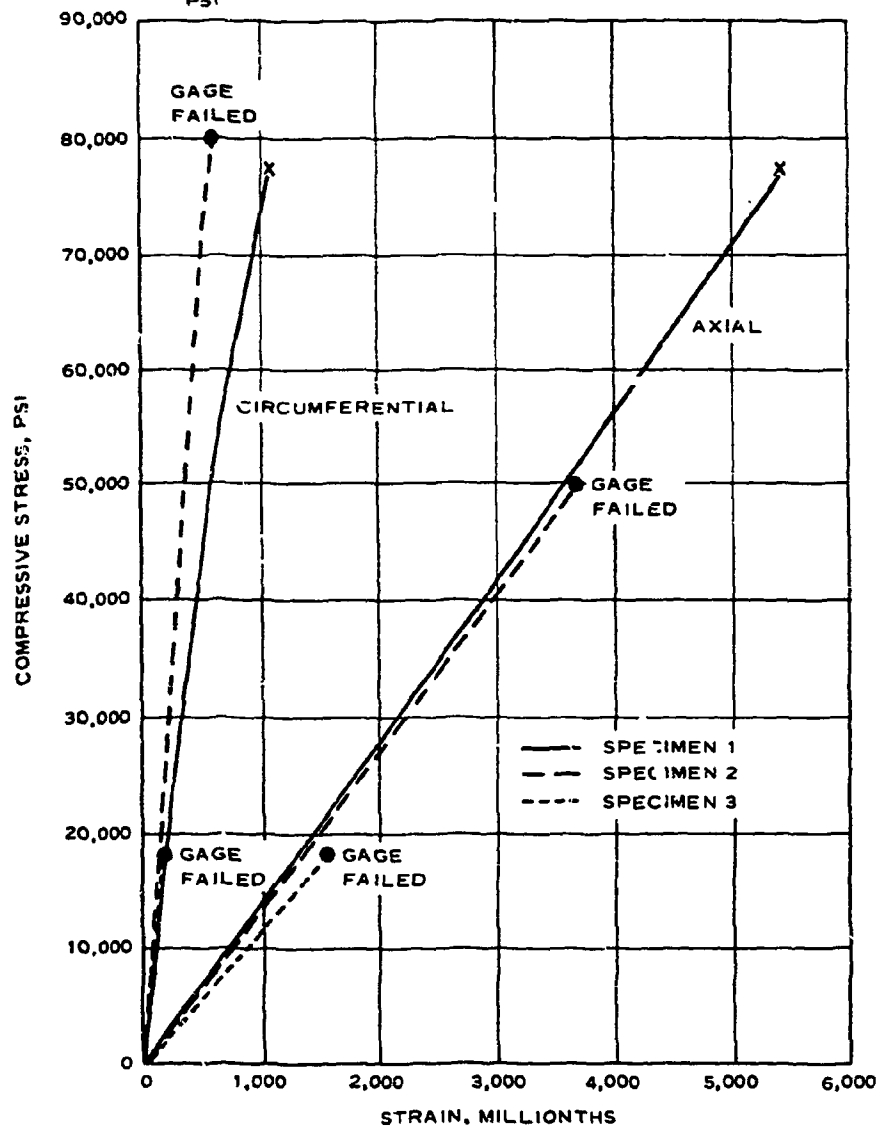
Curing Conditions	Specimen*	Stress, psi		Creep After 1-yr Loading, millionths		Creep Strains Recovered,** millionths		Percent of Creep Strain Recovered**	
		Axial	Radial	Axial	Radial	Axial	Radial	Axial	Radial
<u>Main Modulus</u>									
73°F, AD	II-2	600	0	93	--	12	--	13	--
	II-4	2400	0	320	--	36	--	11	--
	V-4	2400	2400	--	99	--	24	--	24
	V-8	0	600	-29	53	0	2	--	4
<u>Main Modulus</u>									
150°F, AC	V-5	2400	2400	166	169	36	--	22	--
<u>Low Modulus</u>									
	VIII-1	600	0	251	-35	30	-10	12	29
<u>Main Modulus</u>									
150°F, AD	V-6	2400	2400	--	214	--	125	--	58

* Excludes specimens in which both gages had failed or were not functioning properly.

** 117 days after unloading.

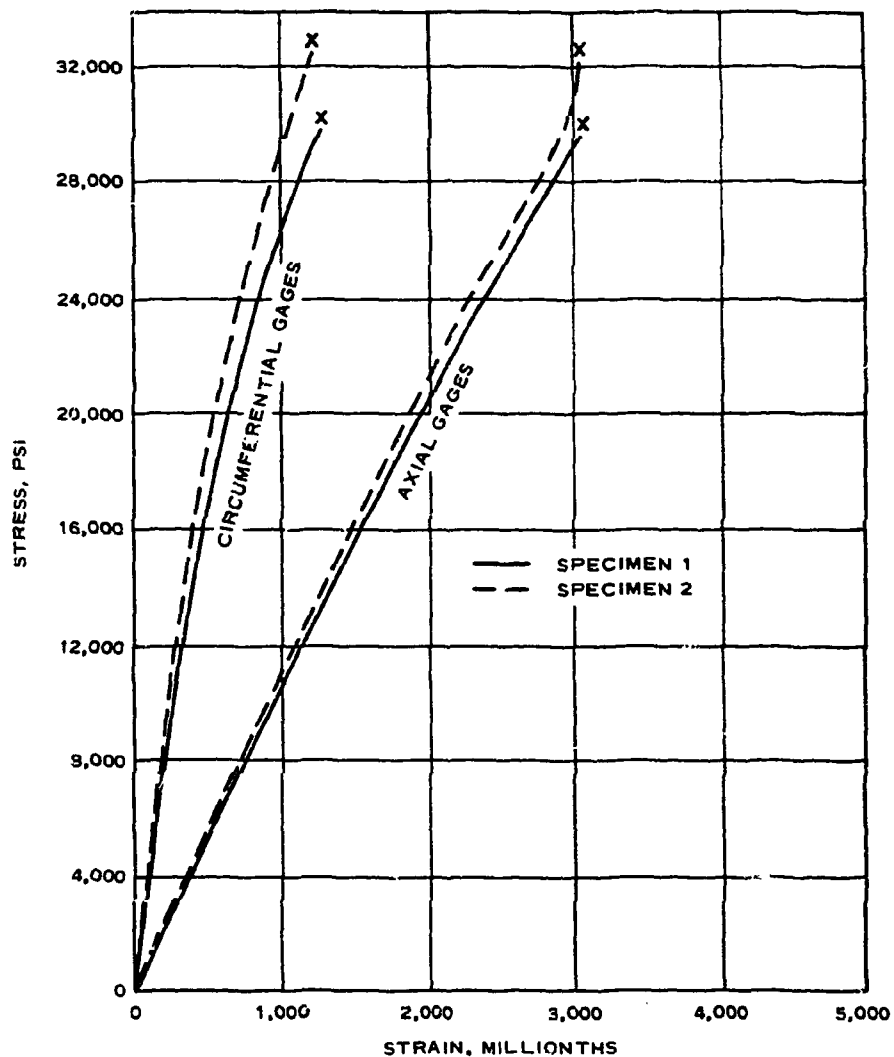
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	SPECIMEN			AVERAGE
	1	2	3	
ELASTIC MODULUS, PSI (SECANT, 40,000 PSI)	13.8×10^6	13.5×10^6		13.65×10^6
POISSON'S RATIO (AT 40,000 PSI)	0.15	0.10		0.125
COMPRESSIVE STRENGTH, PSI	77,000	106,810	50,360	78,060



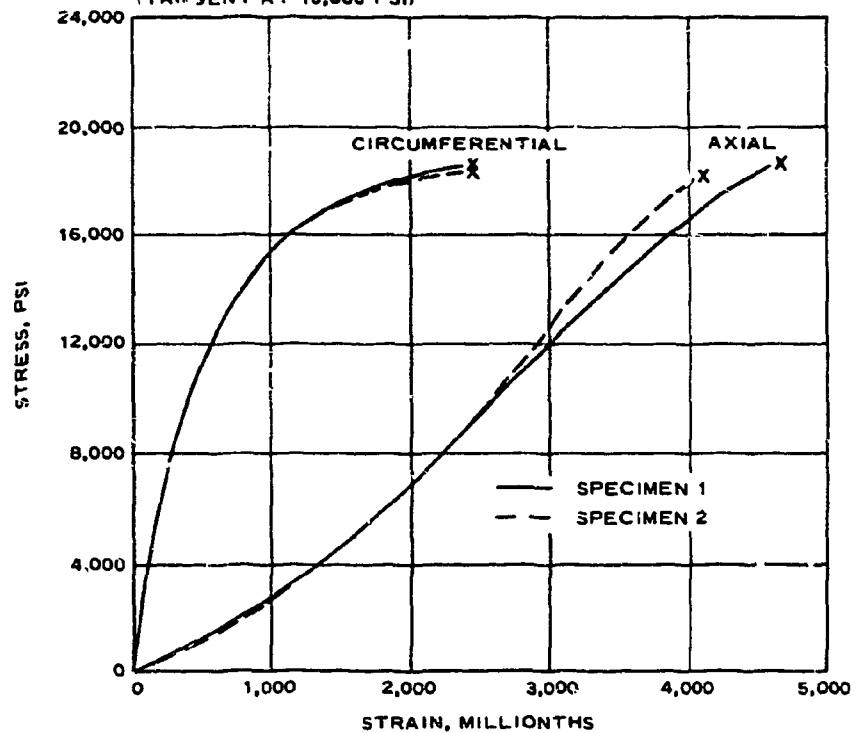
STRESS VERSUS STRAIN FOR
1- BY 2-IN. CHERT CORES

	SPECIMEN		AVERAGE
	1	2	
ELASTIC MODULUS, PSI (SECANT, 16,000 PSI)	10.2×10^6	10.7×10^6	10.45×10^6
POISSON'S RATIO (AT 16,000 PSI)	0.31	0.29	0.30
COMPRESSIVE STRENGTH, PSI	30,000	32,400	31,200

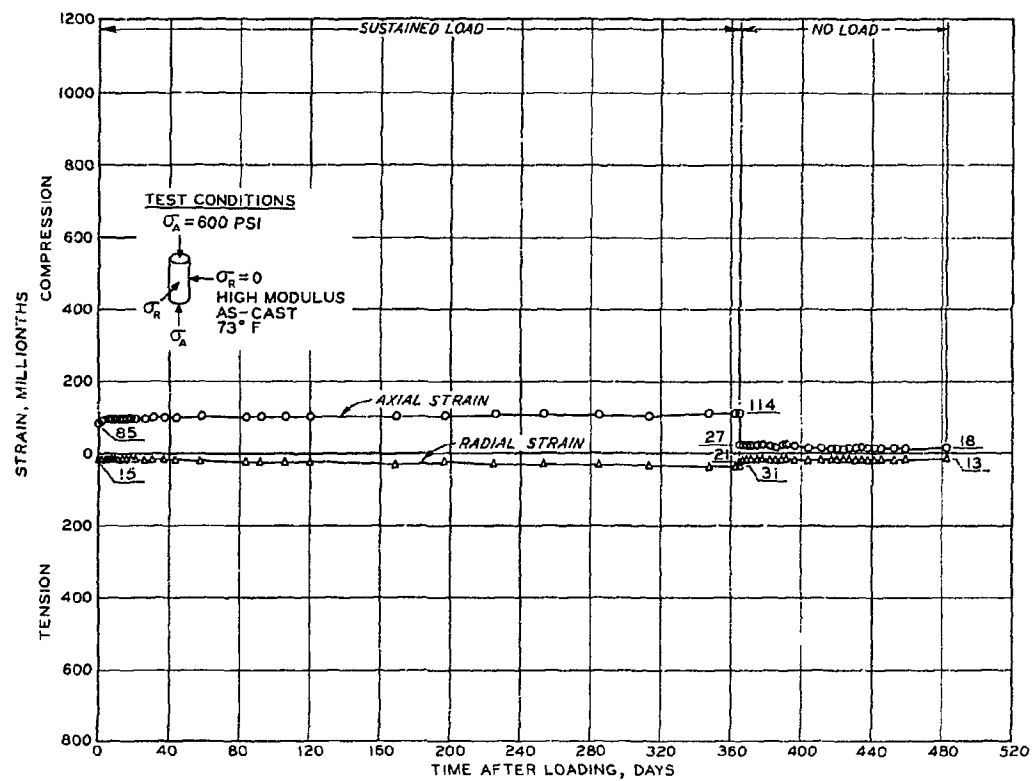


STRESS VERSUS STRAIN FOR
2-BY 4-IN. LIMESTONE CORES

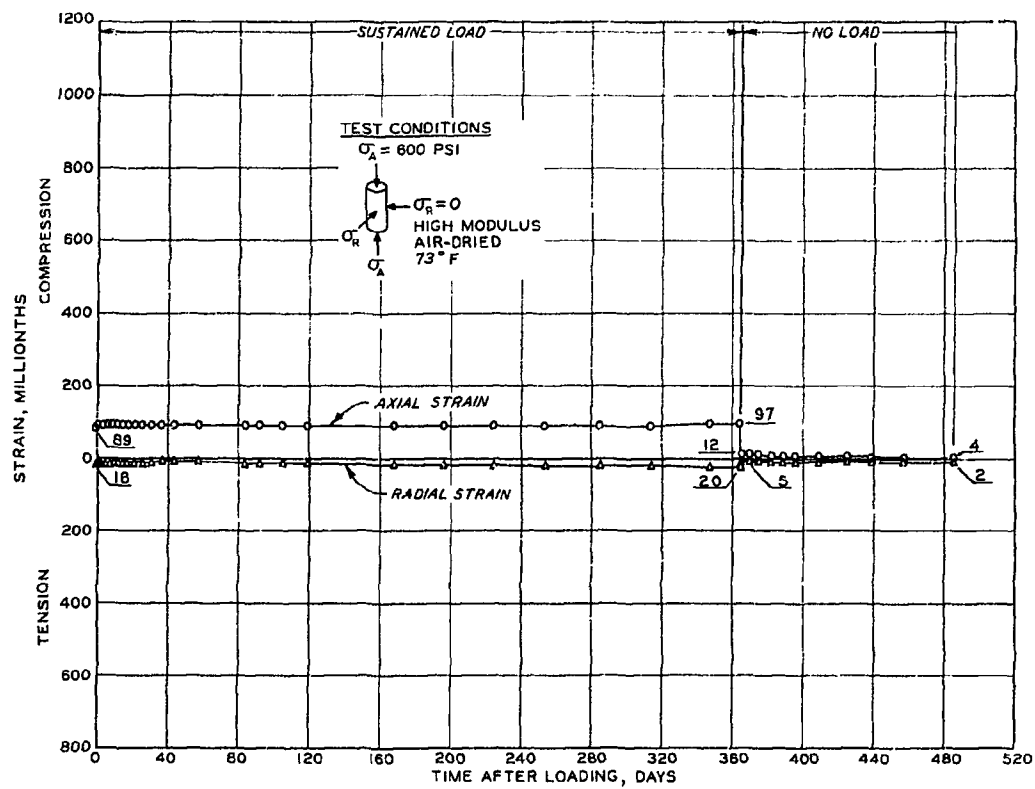
	SPECIMEN		AVERAGE
	1	2	
ELASTIC MODULUS, PSI (SECANT, 0 TO 10,000 PSI)	3.02×10^6	3.85×10^6	3.83×10^6
POISSON'S RATIO (AT 10,000 PSI)	0.146	0.149	0.147
COMPRESSIVE STRENGTH, PSI	18,450	18,200	18,325
ELASTIC MODULUS, PSI (TANGENT AT 10,000 PSI)	4.85×10^6	5.65×10^6	5.25×10^6



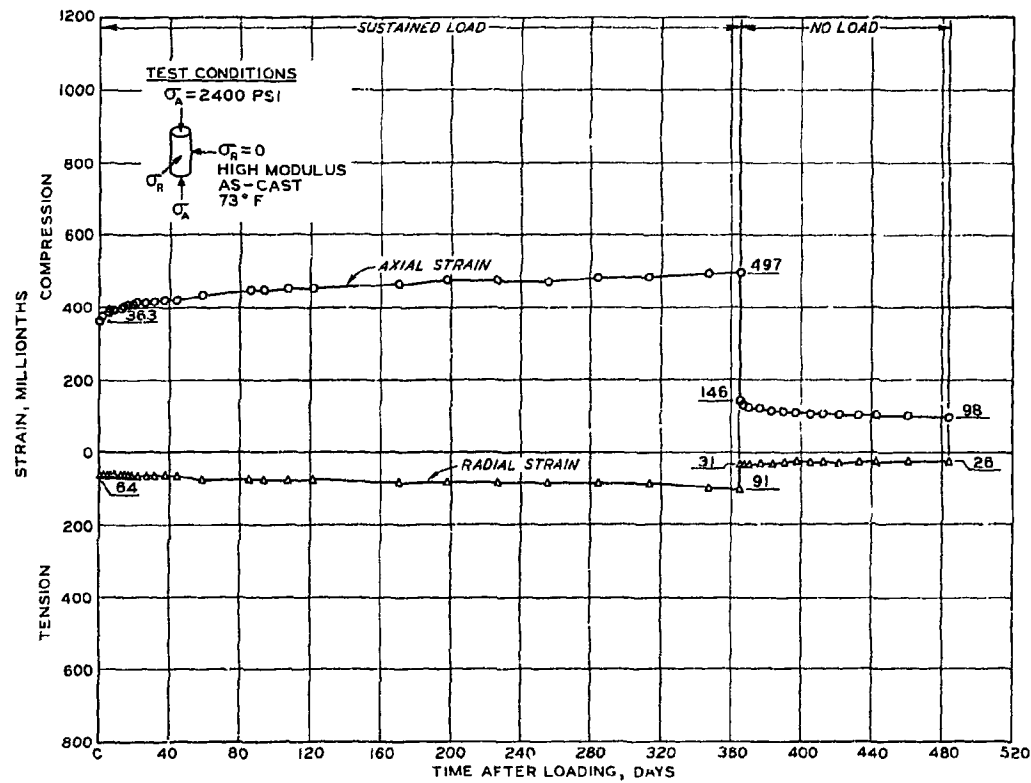
STRESS VERSUS STRAIN FOR
2-BY 4-IN. GRAYWACKE CORES



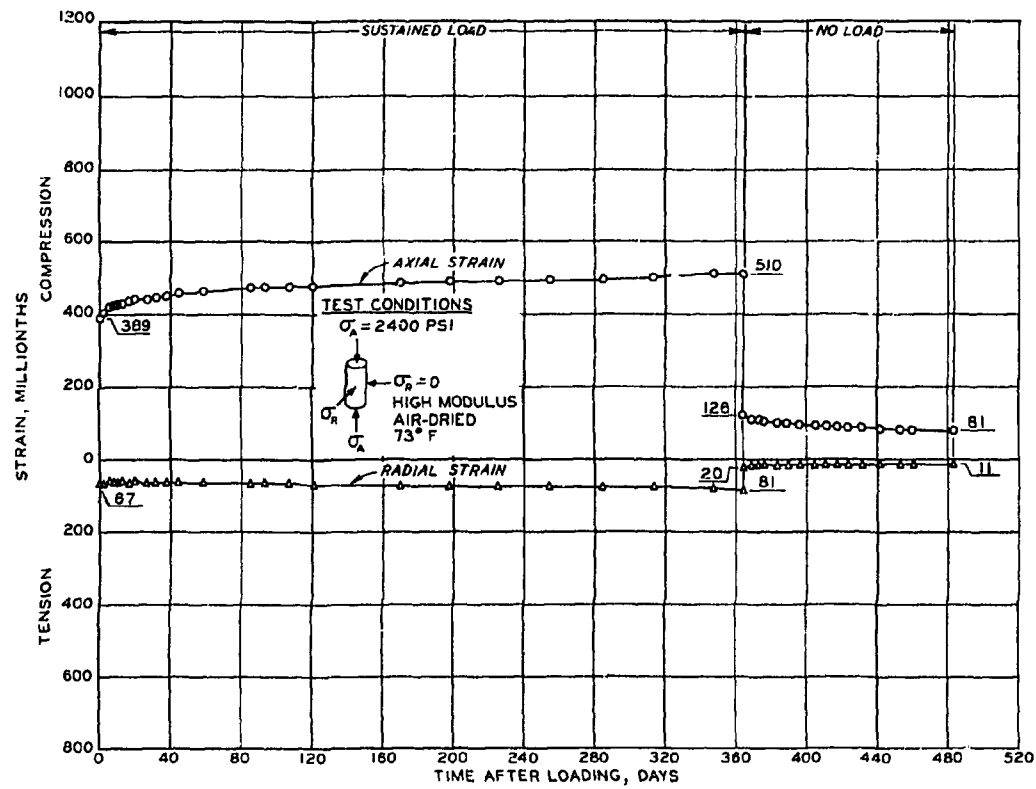
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN I-1



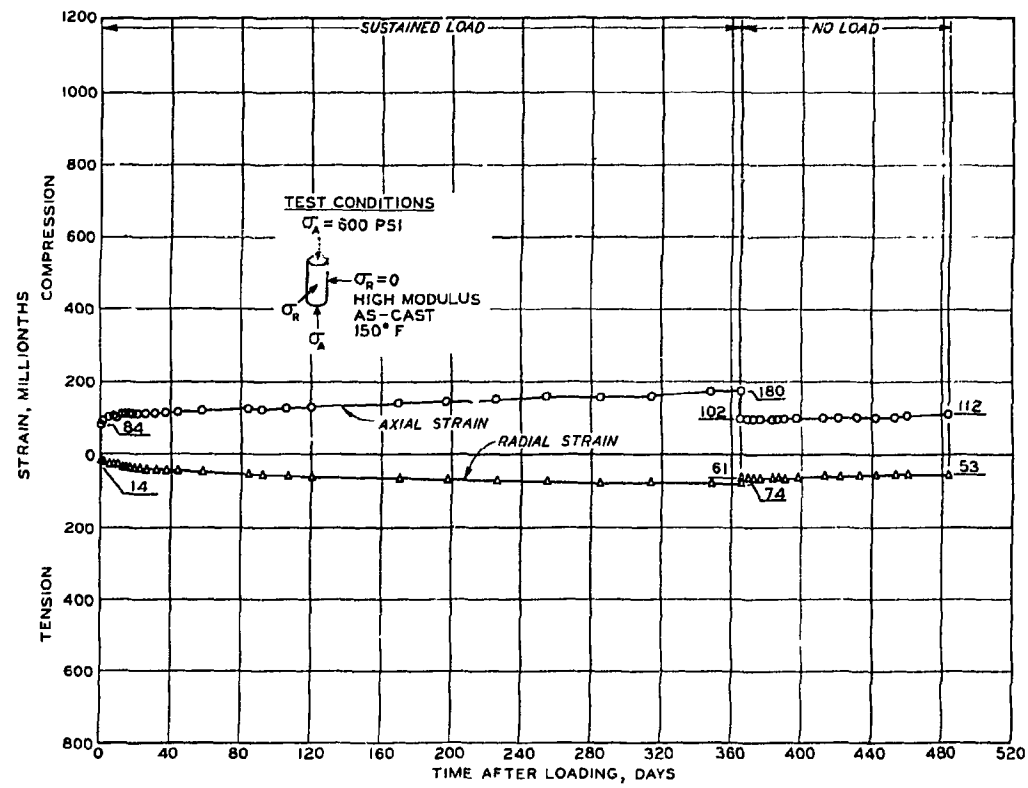
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN I-2



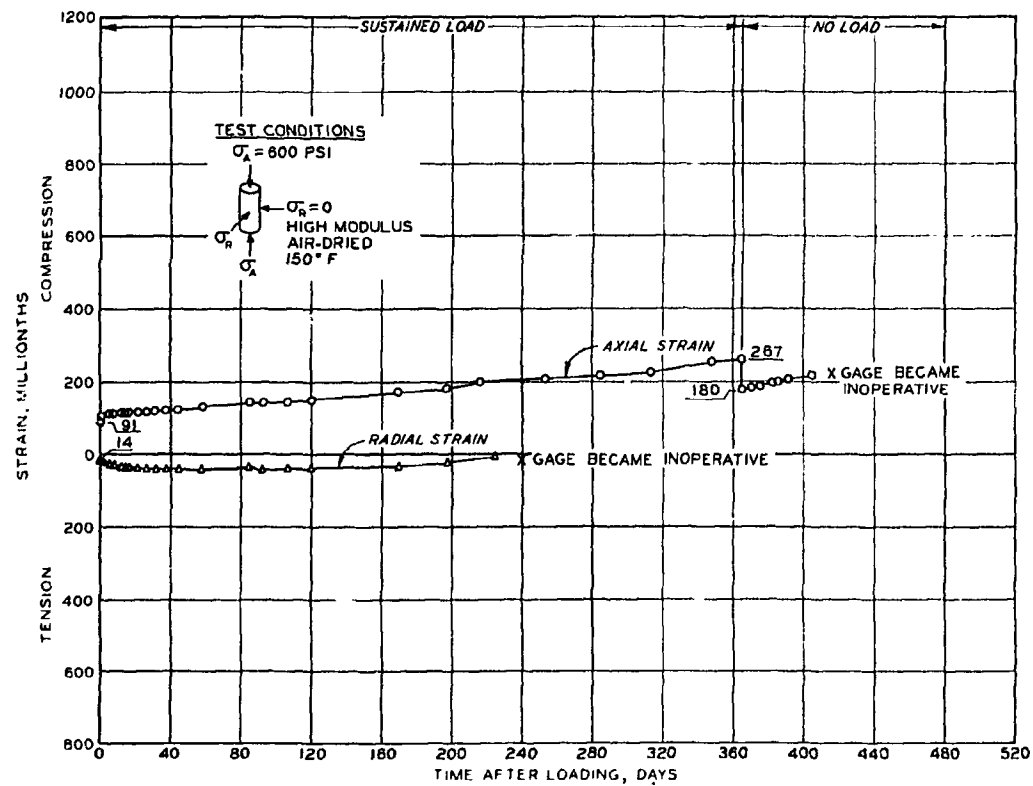
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN I-3



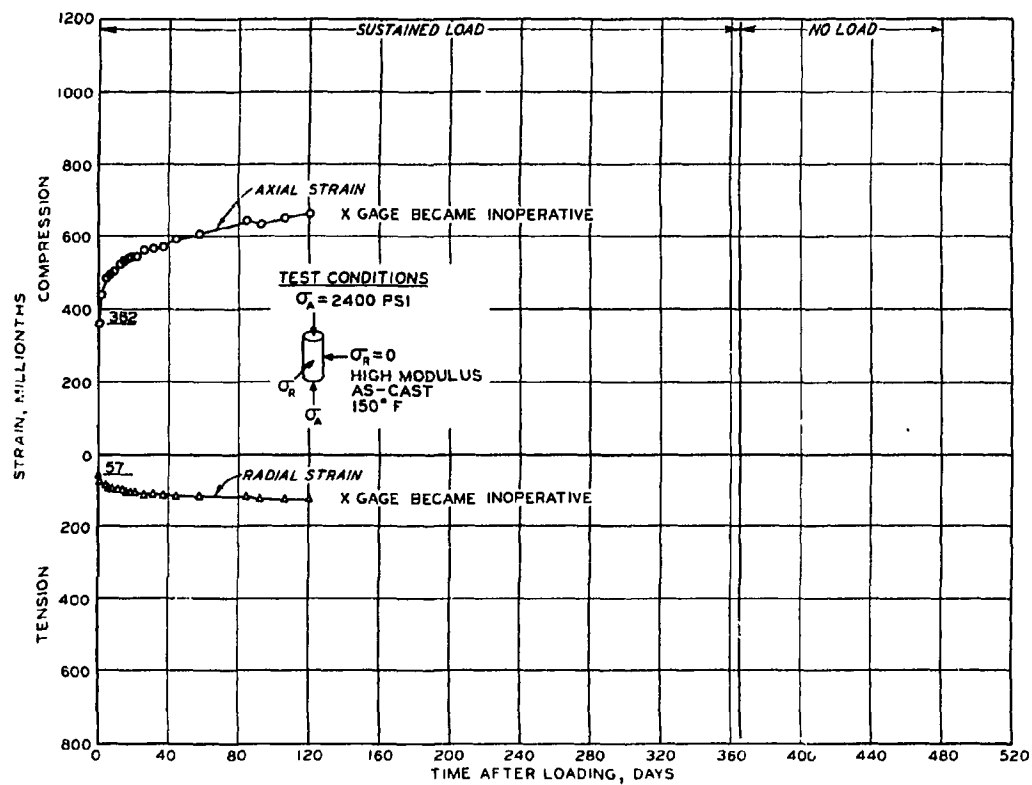
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN I-4



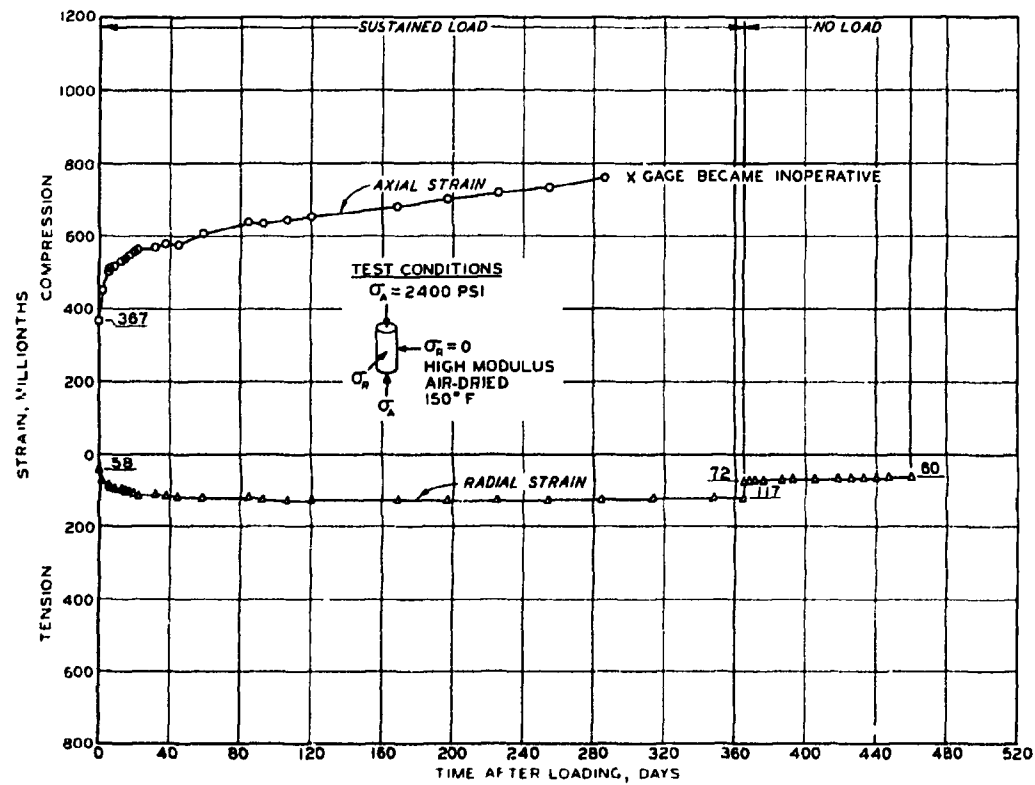
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN I-5



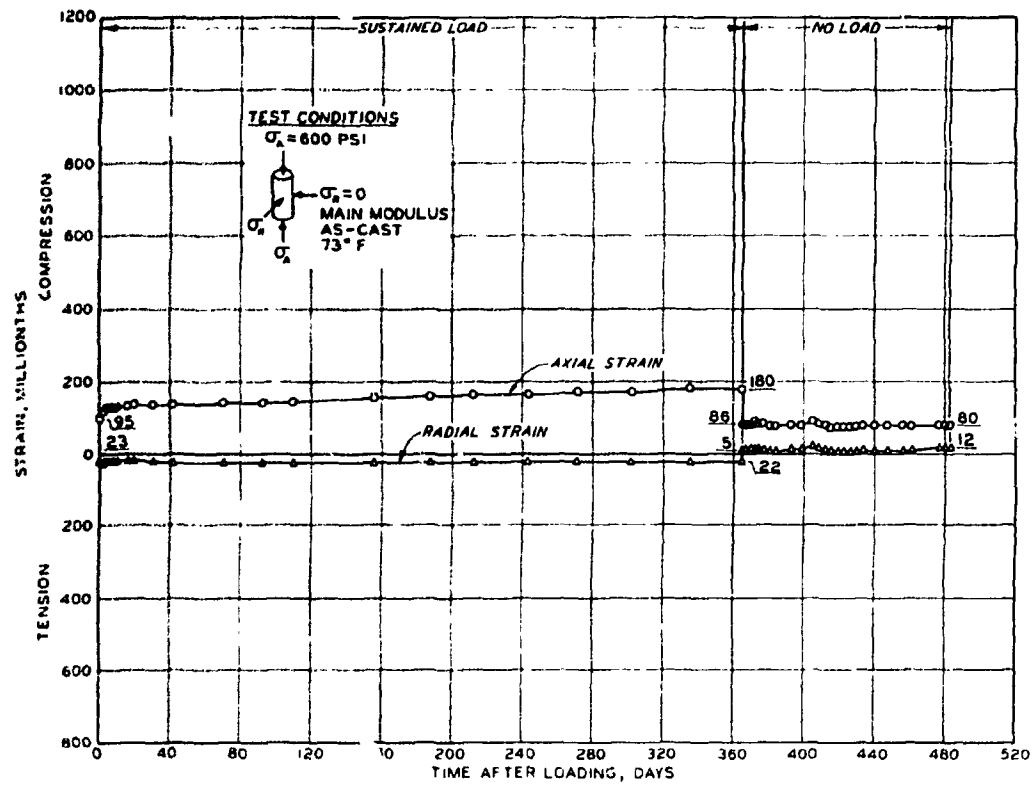
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN I-6



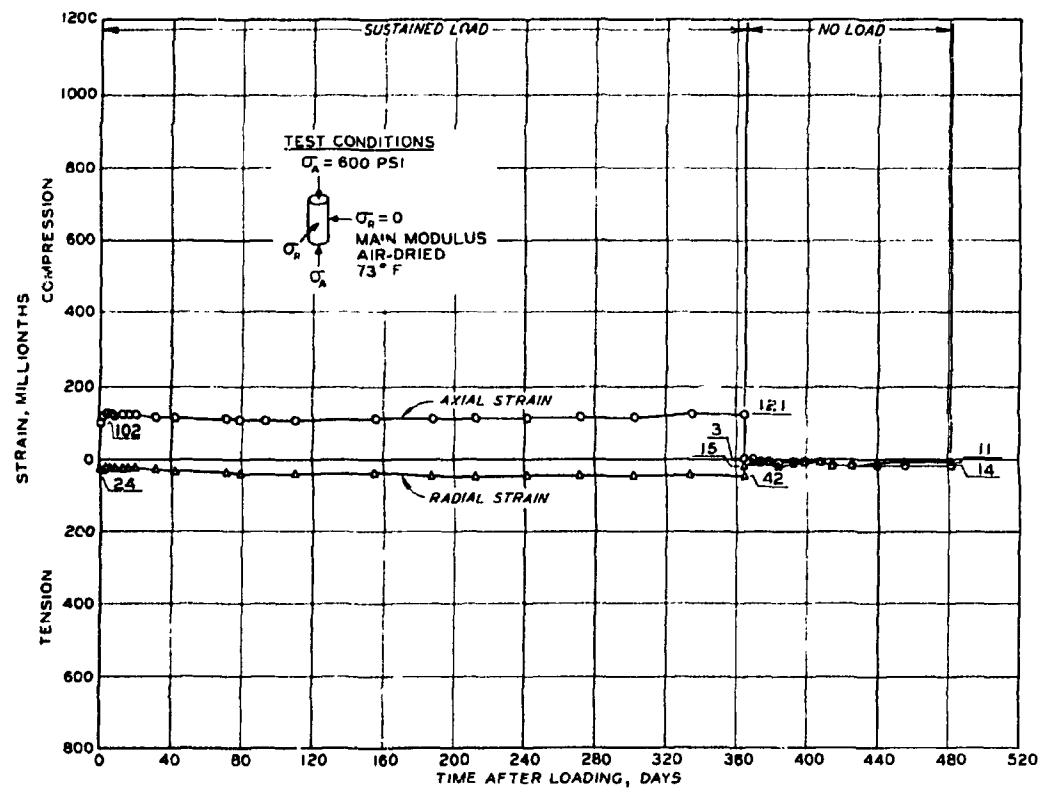
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN I-7



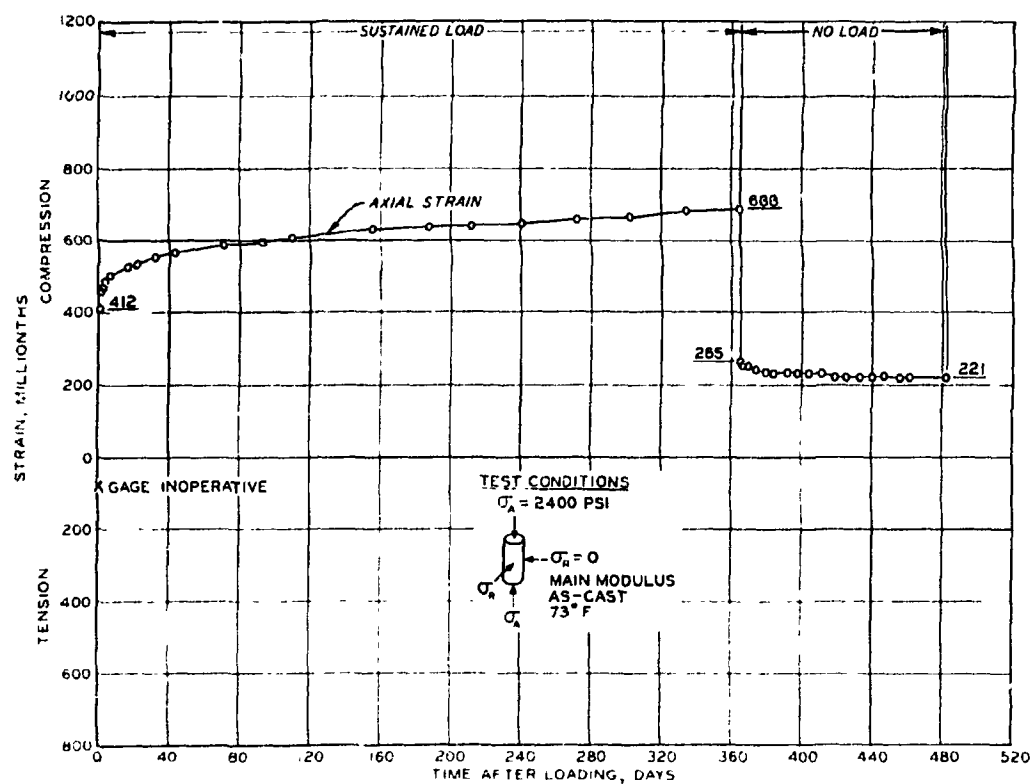
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN I-8



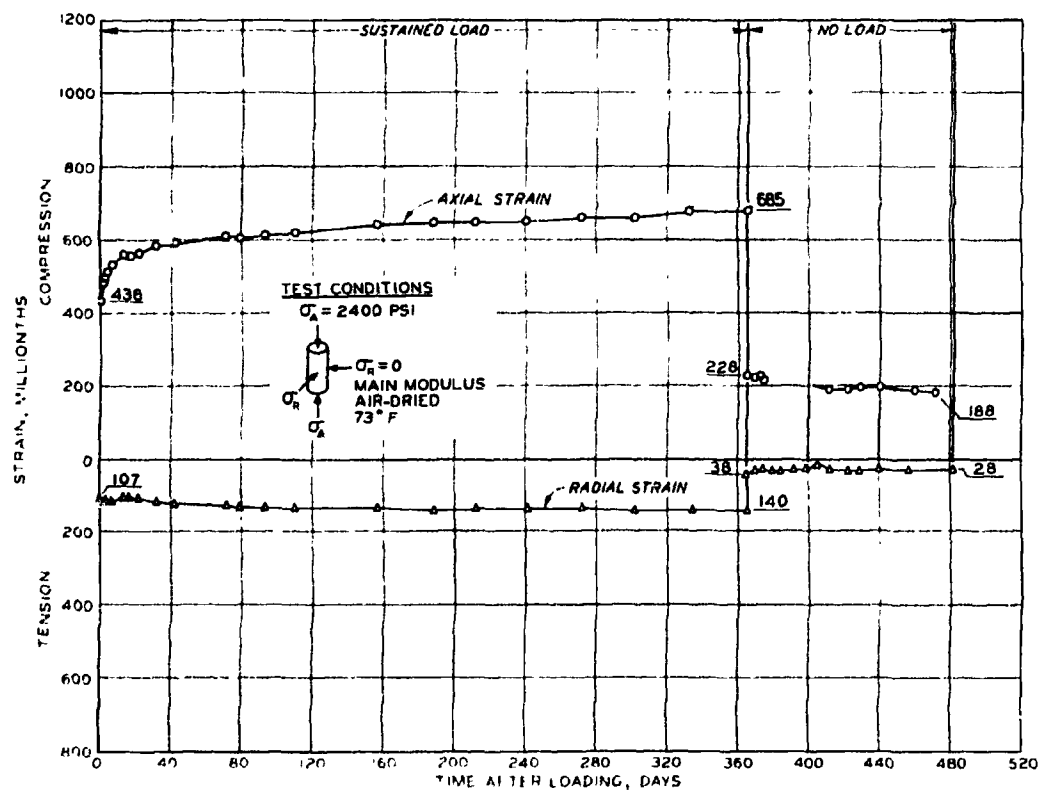
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN II-1



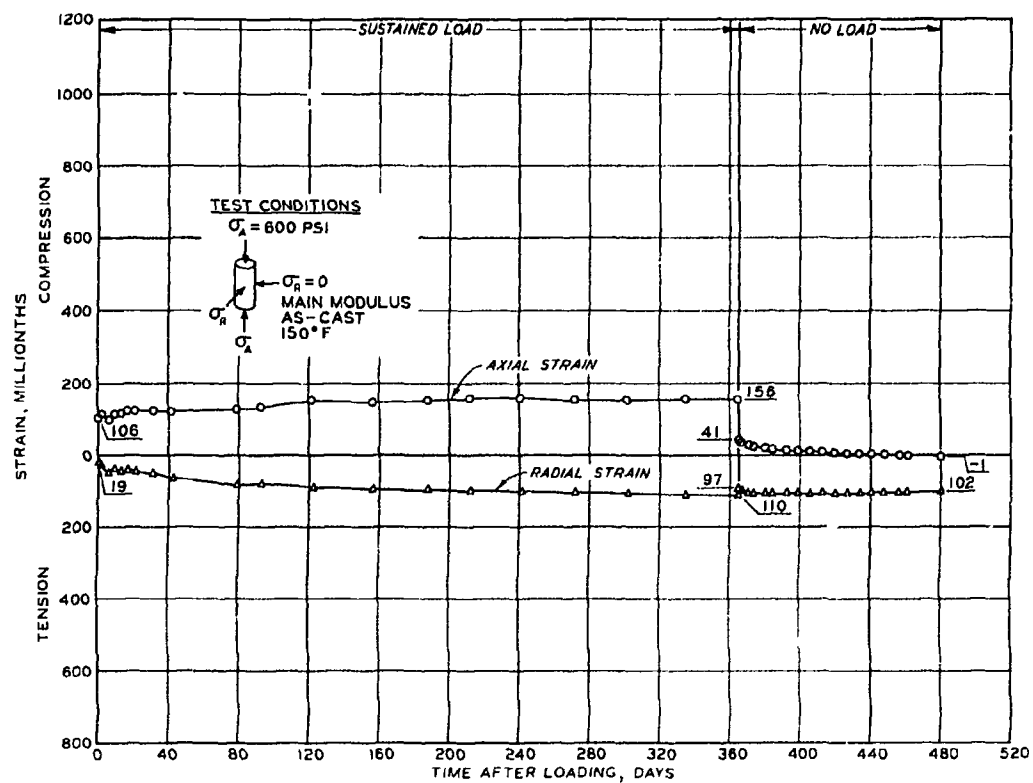
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN II-2



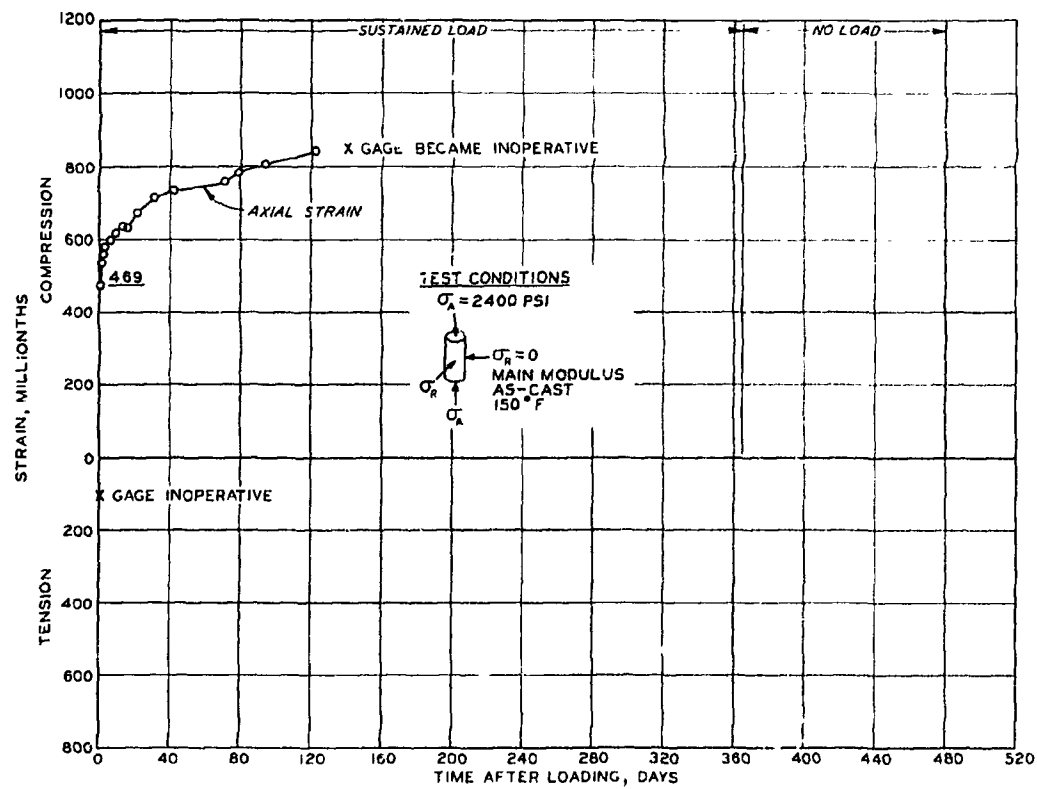
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN II-3



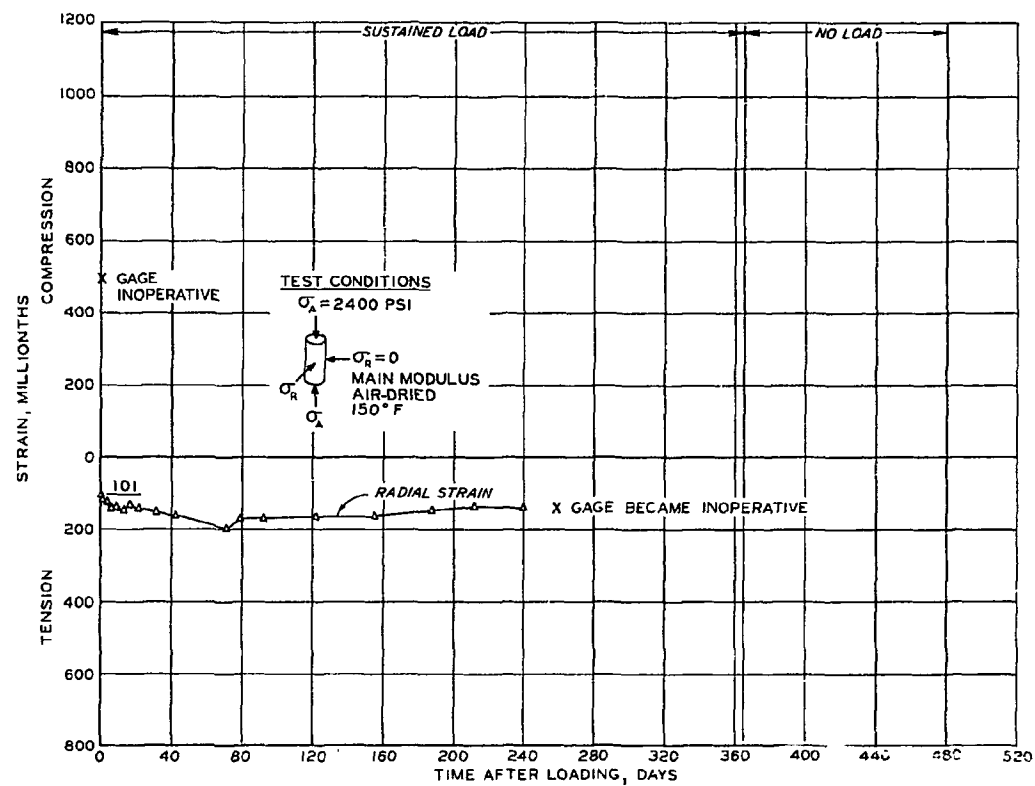
TOTAL AXIAL AND
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SPECIMEN II-4



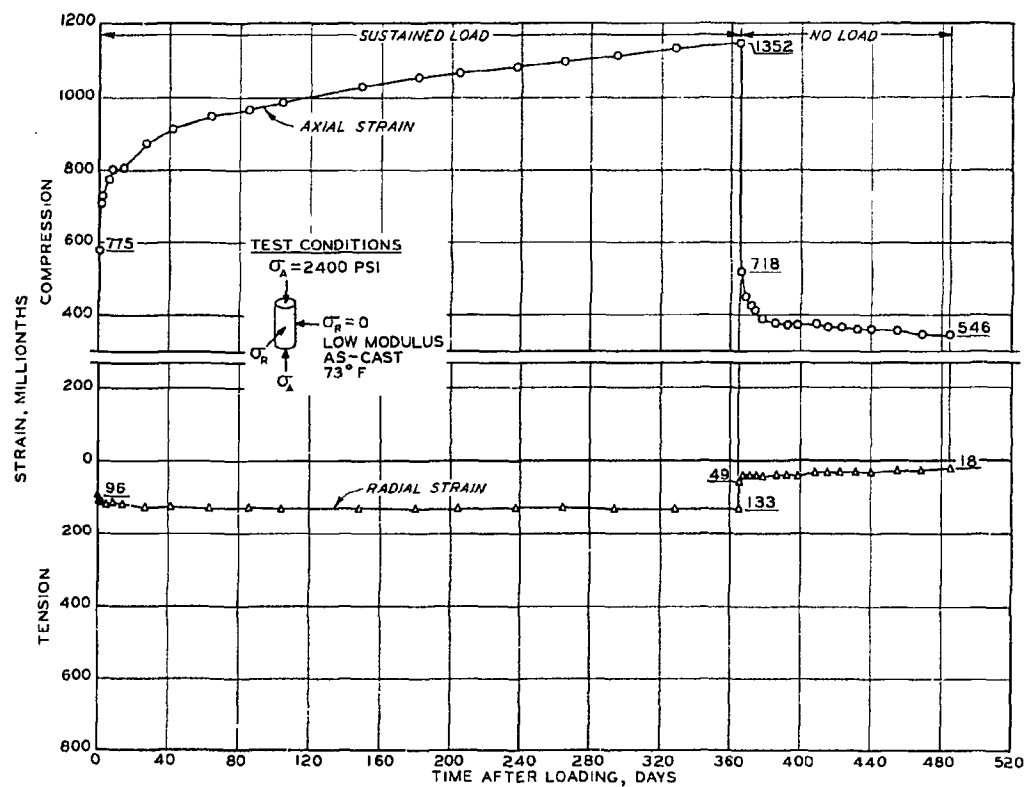
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN II-5



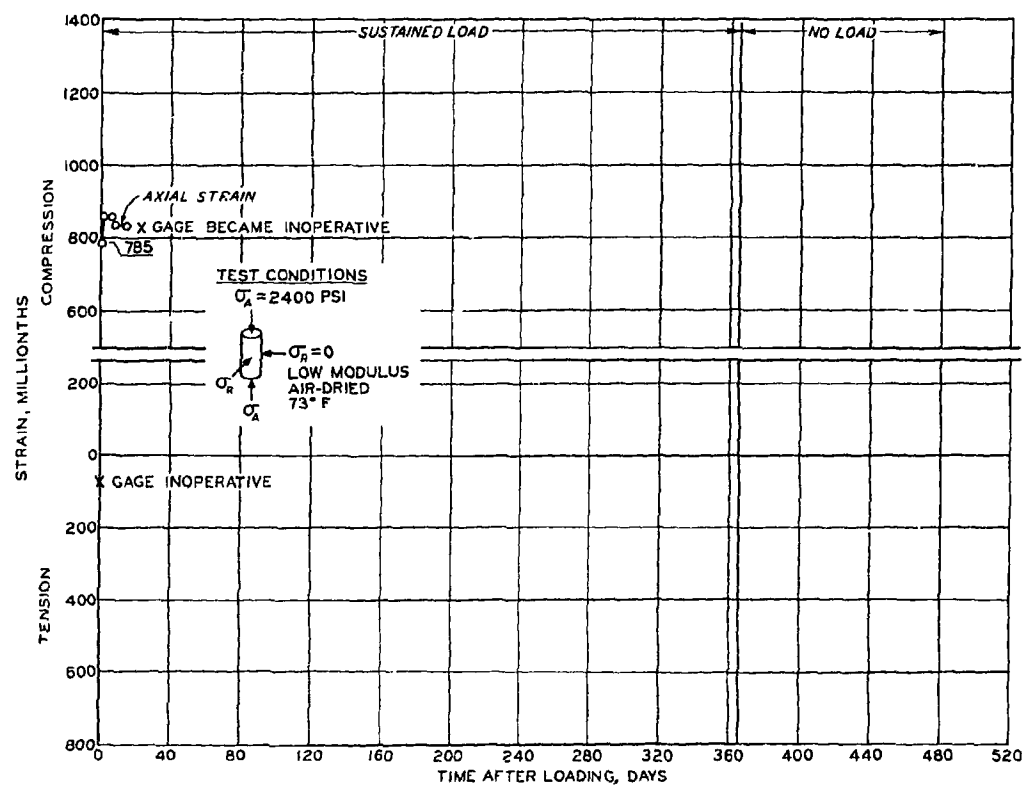
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN II-7



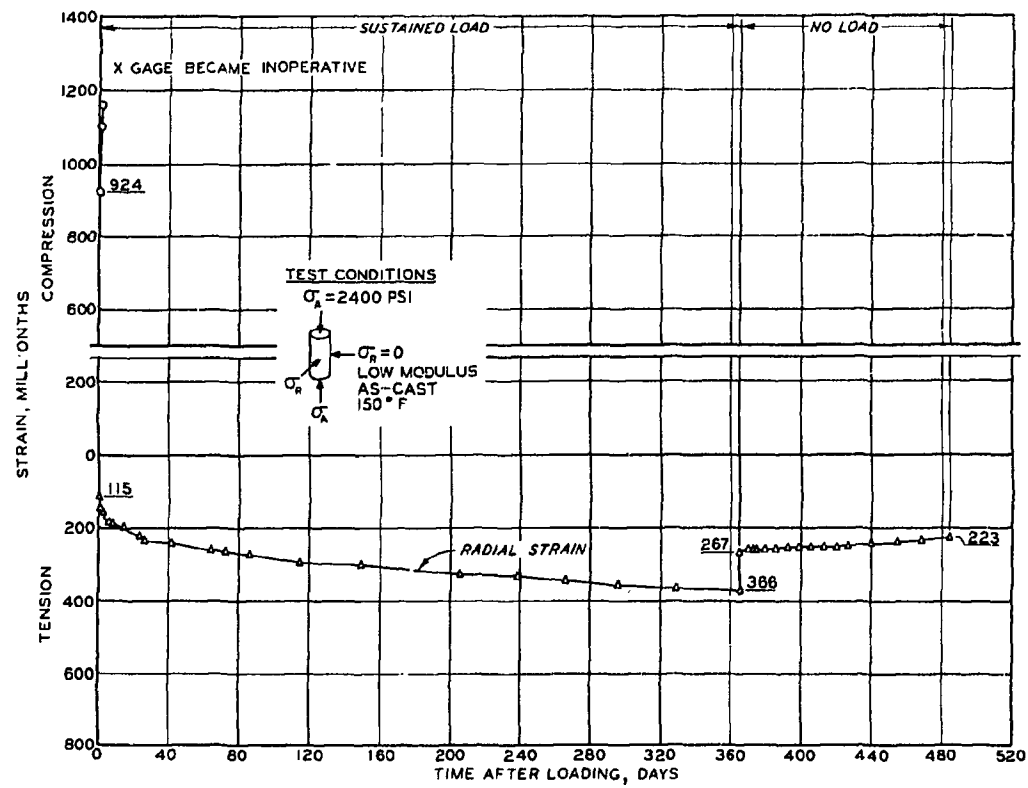
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN II-8



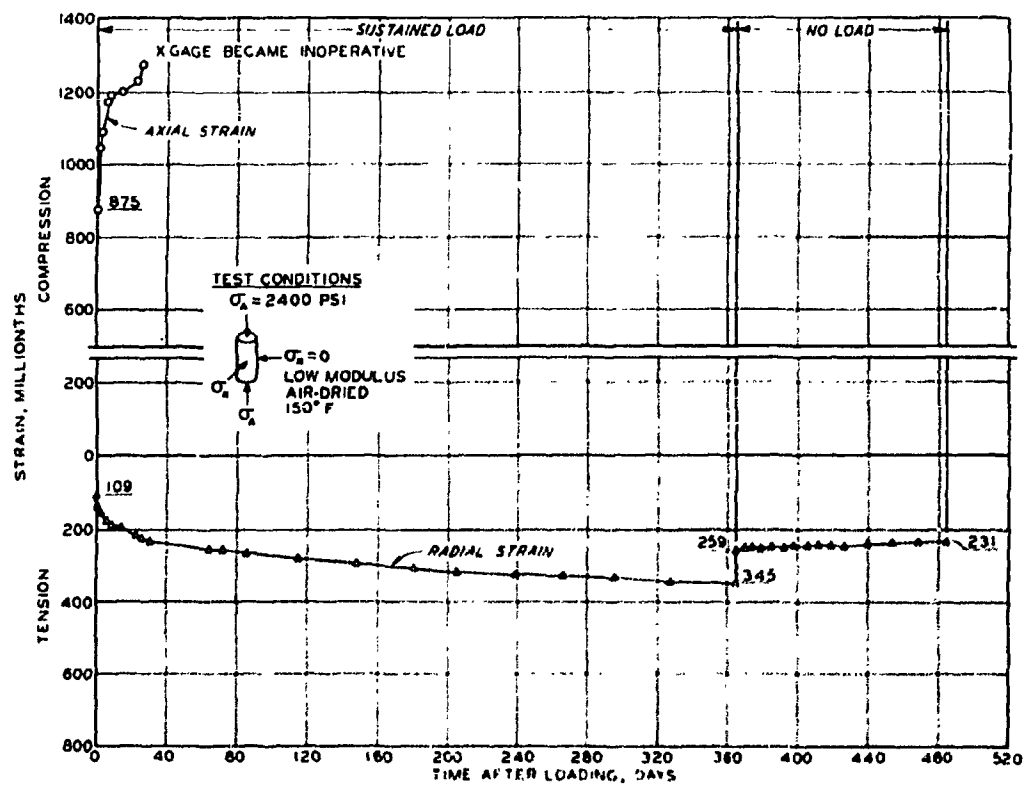
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN III-1



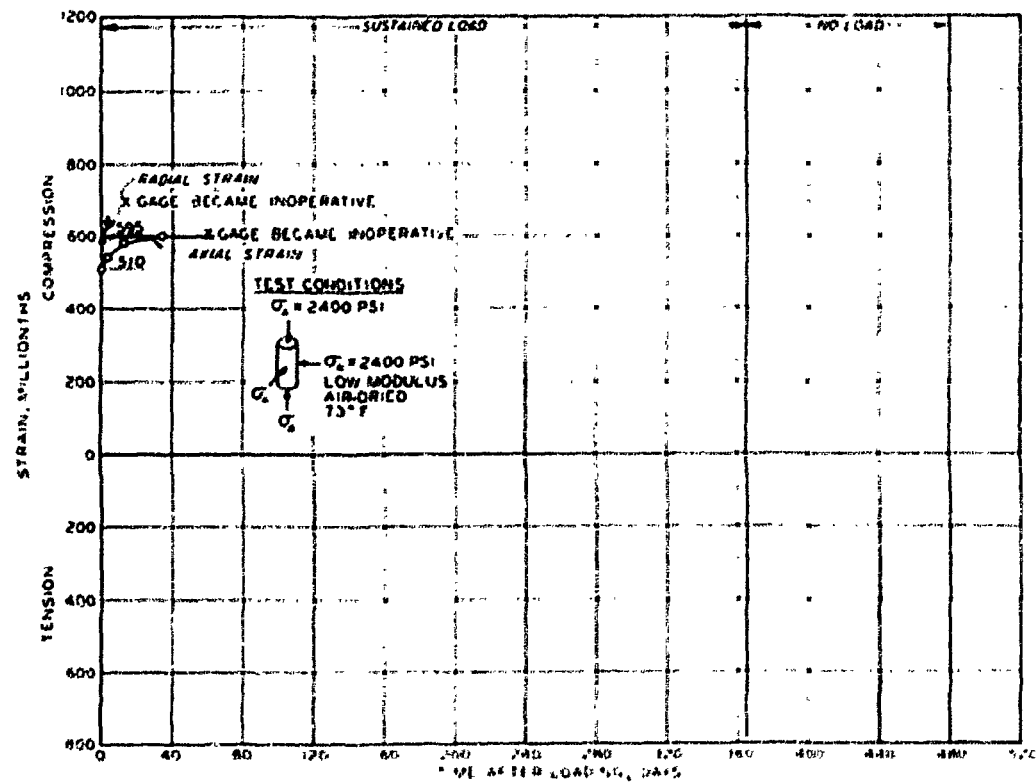
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN III-2



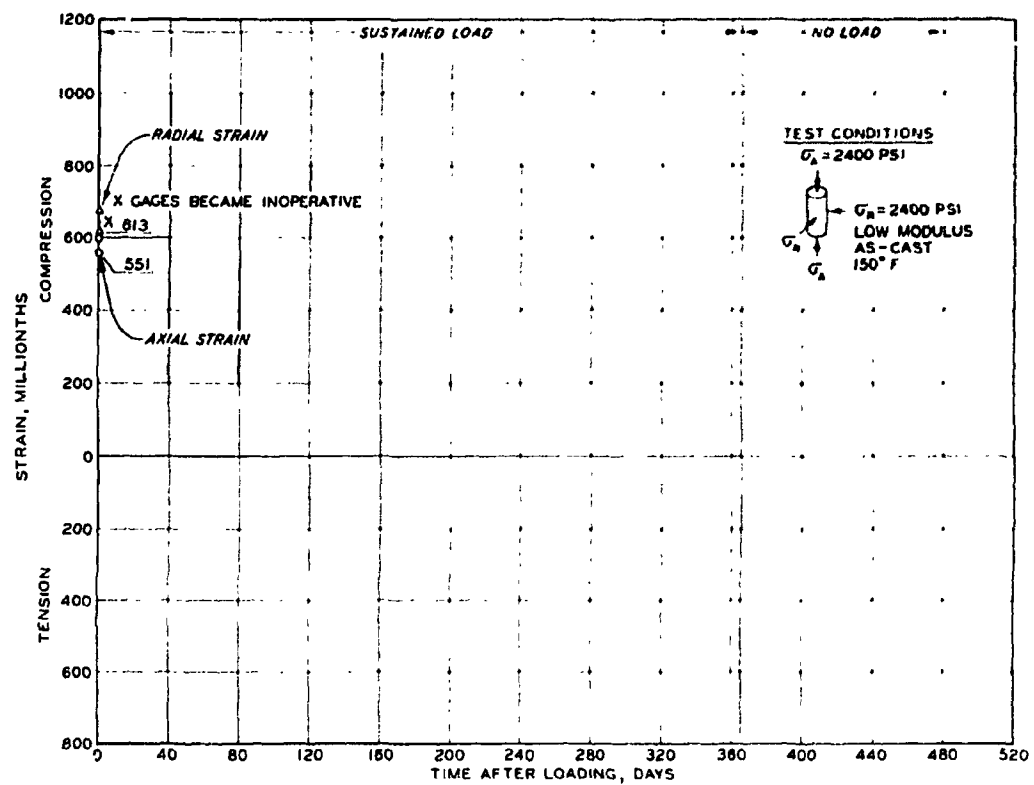
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN III-3



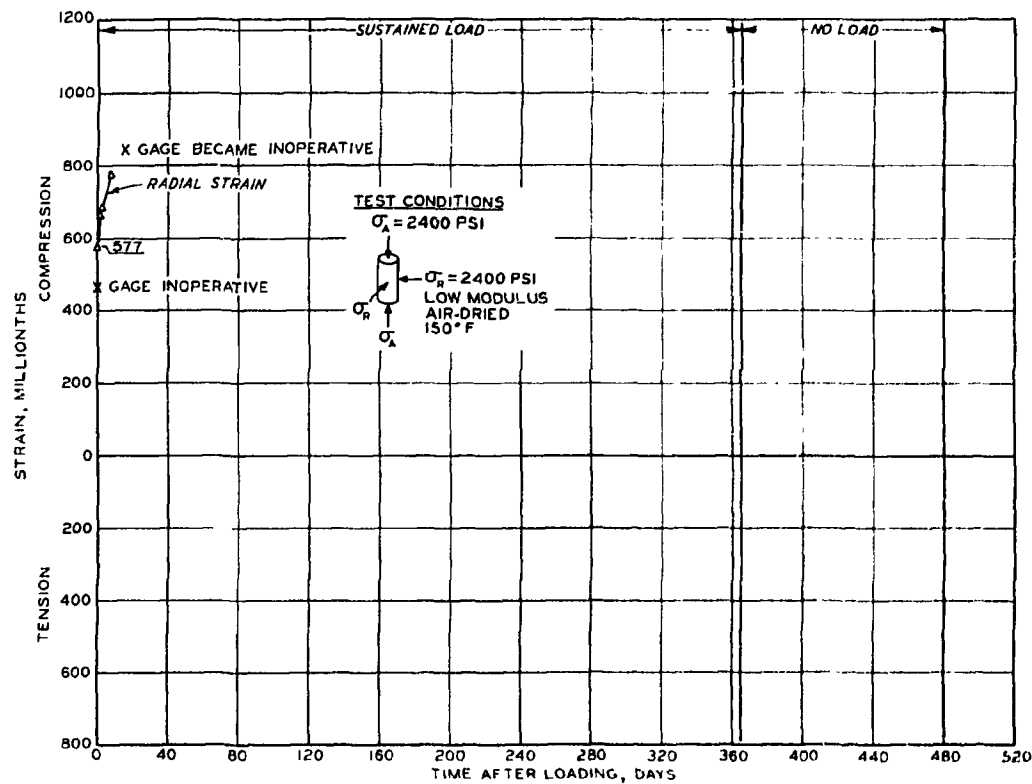
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN III-4



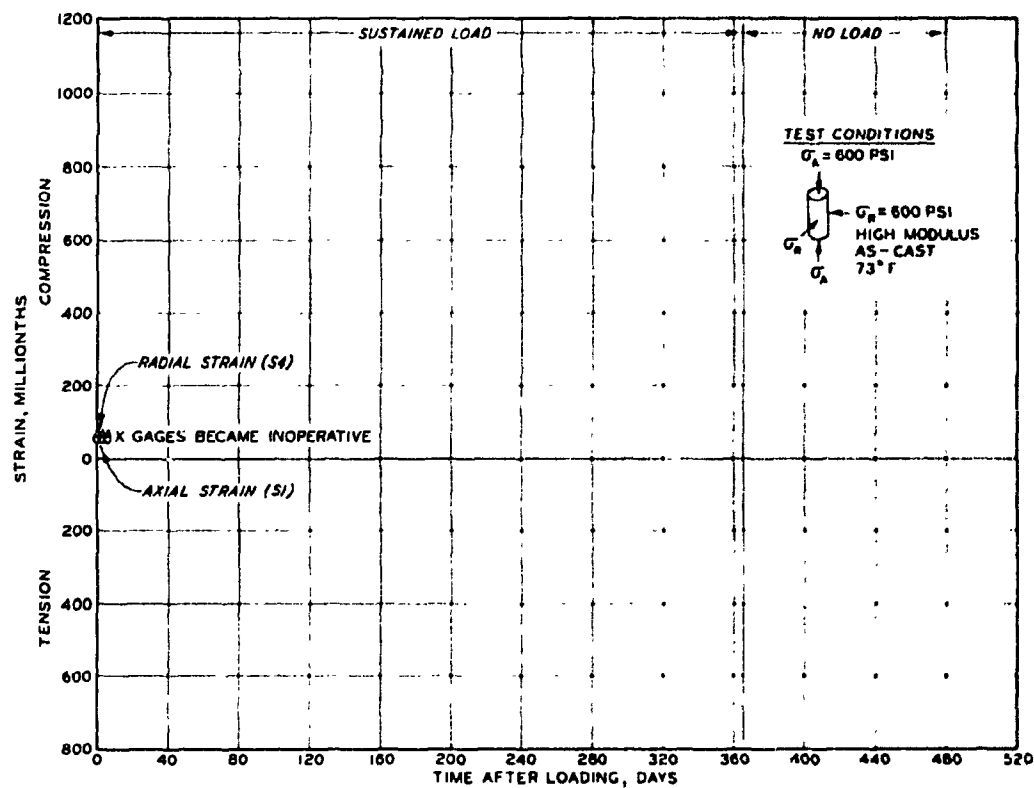
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN III-6



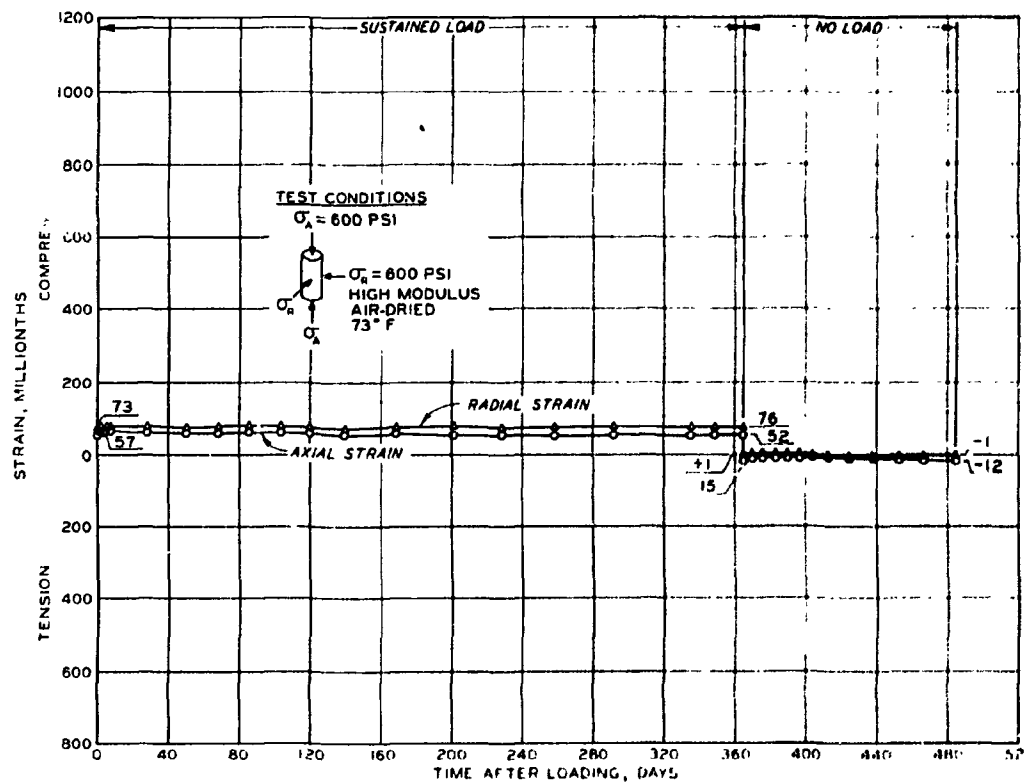
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN III-7



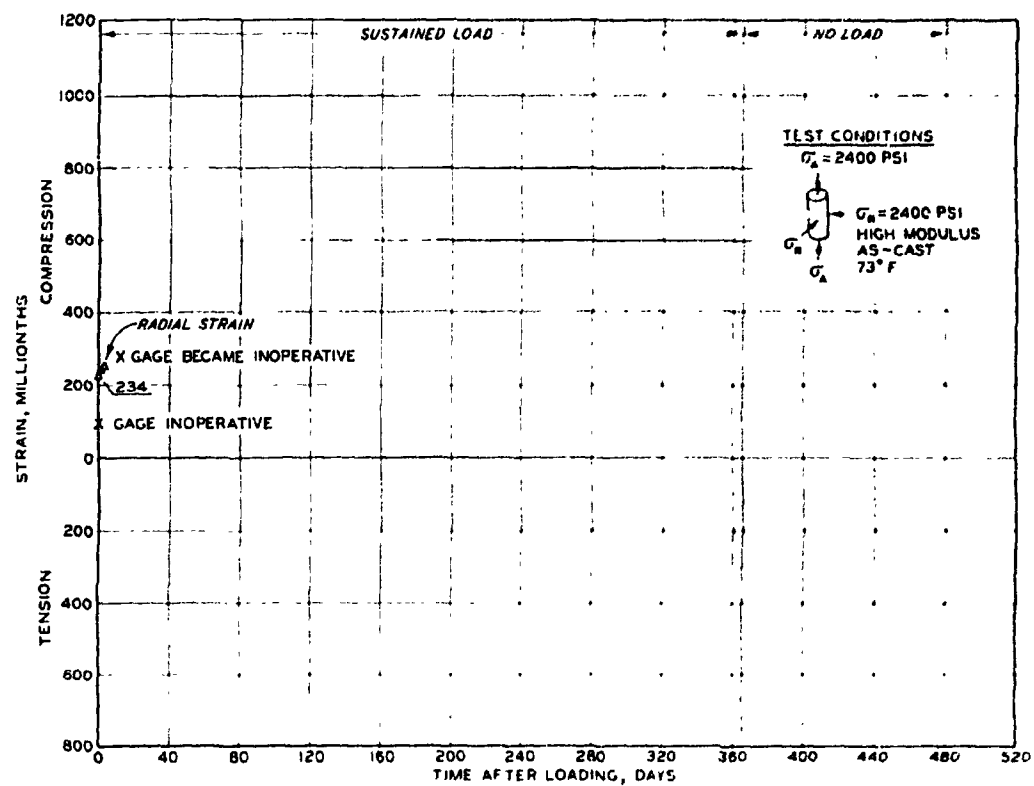
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN III-8



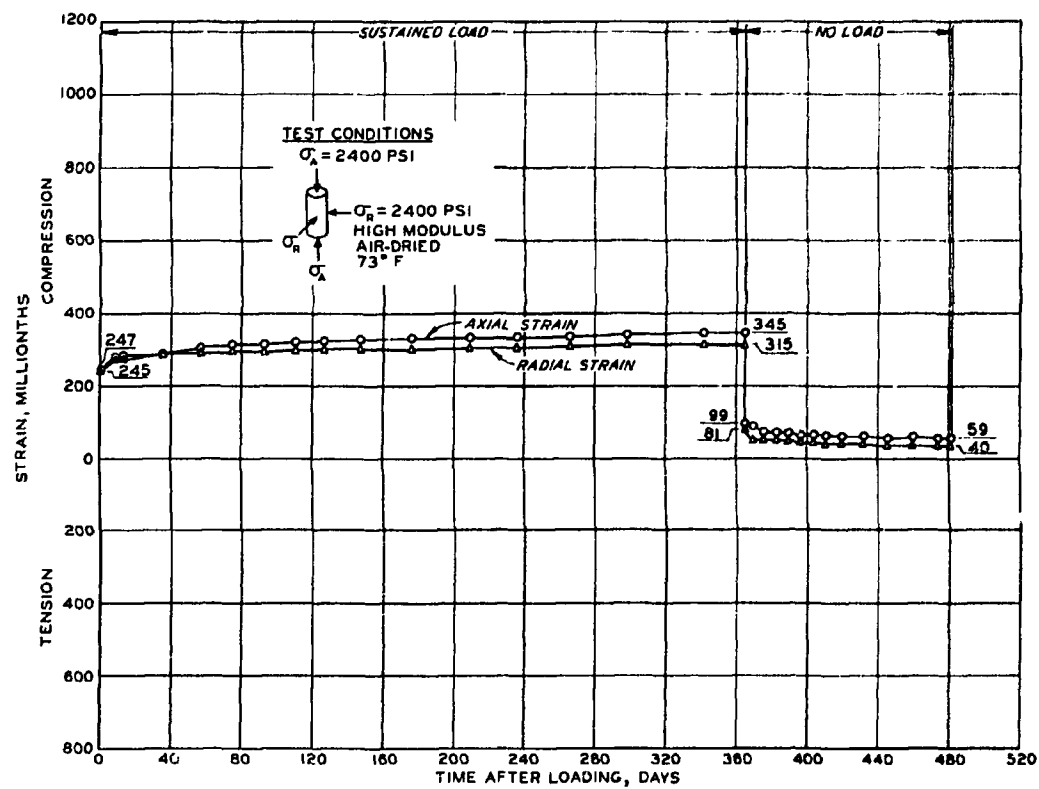
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN IV-1



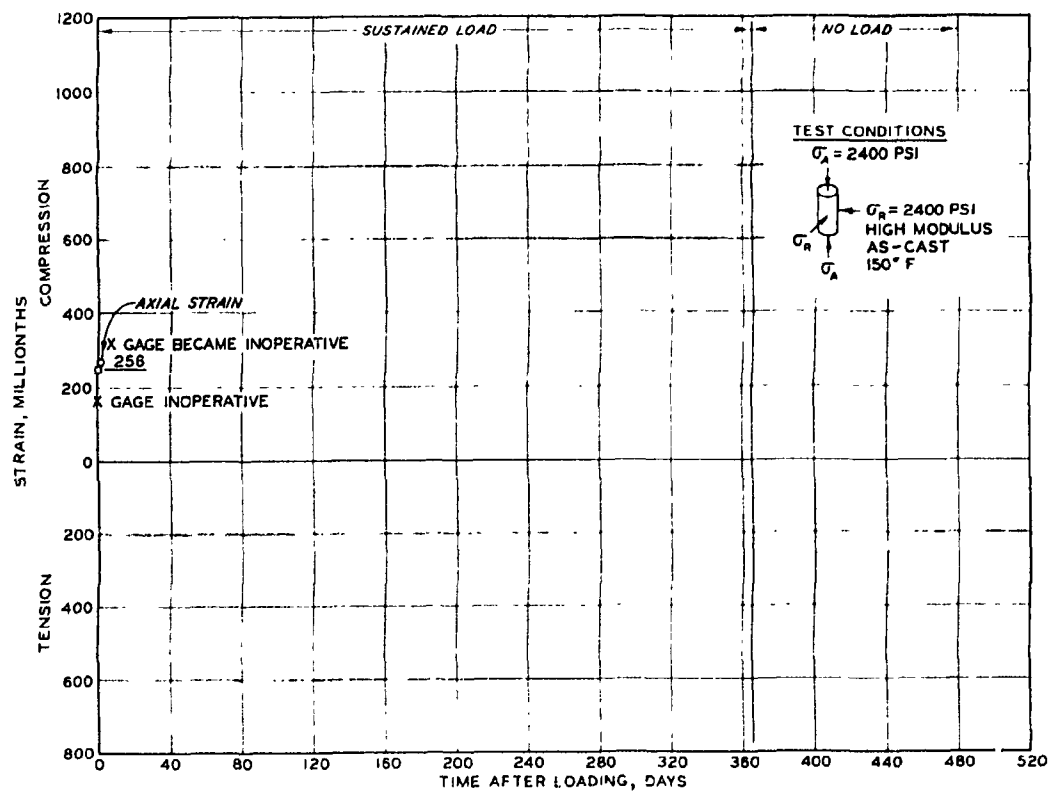
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN IV-2



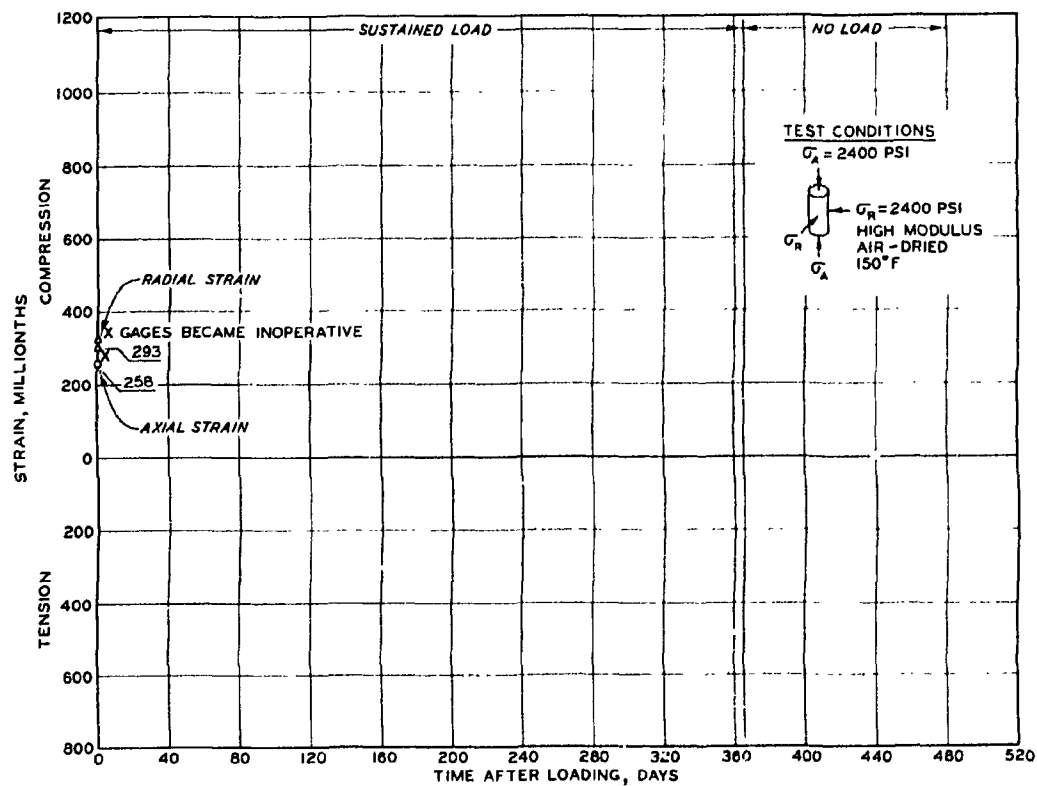
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN IV-3



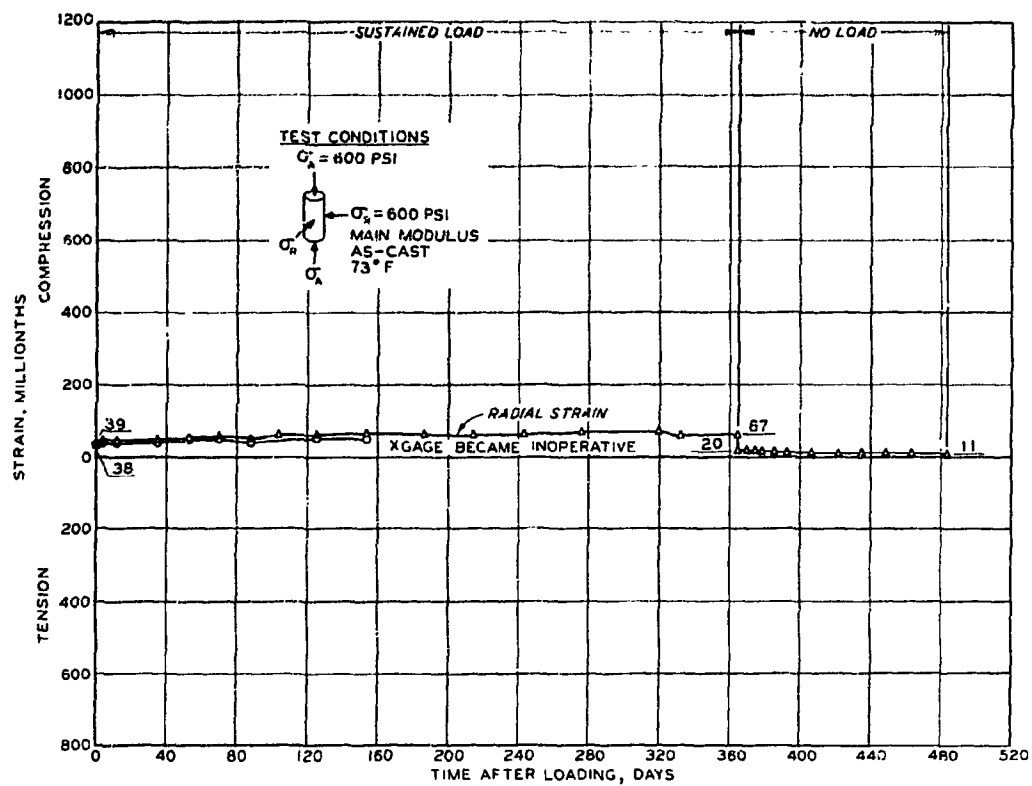
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN IV-4



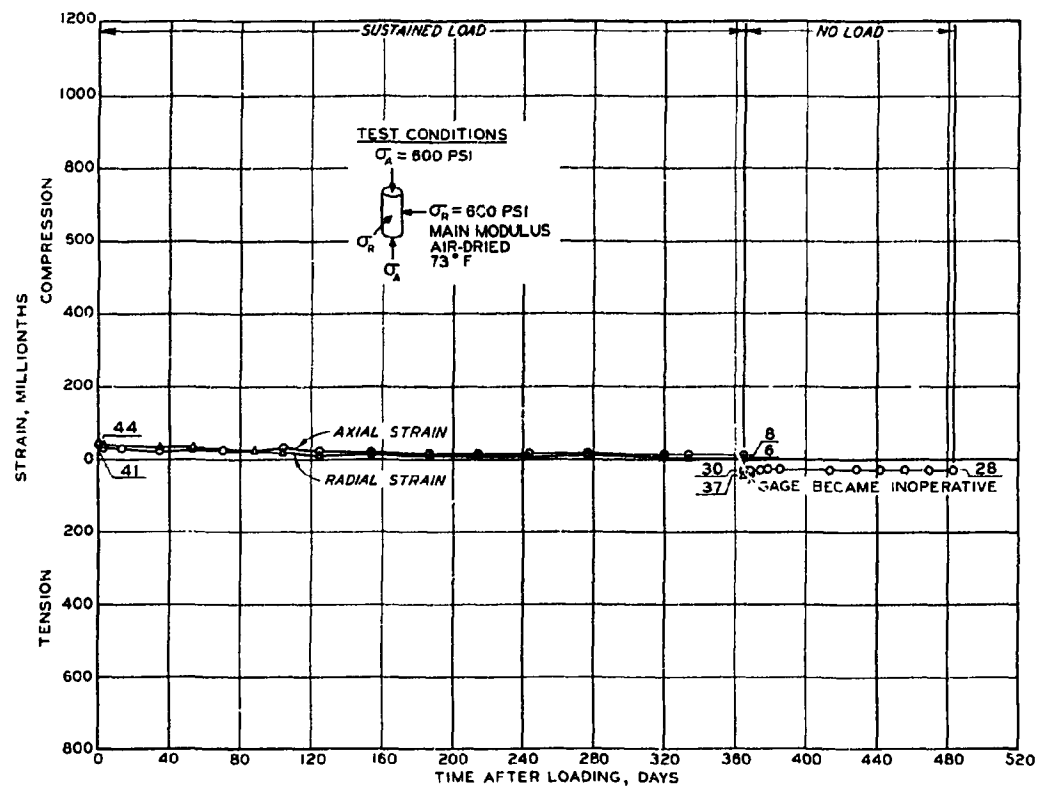
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN IV-5



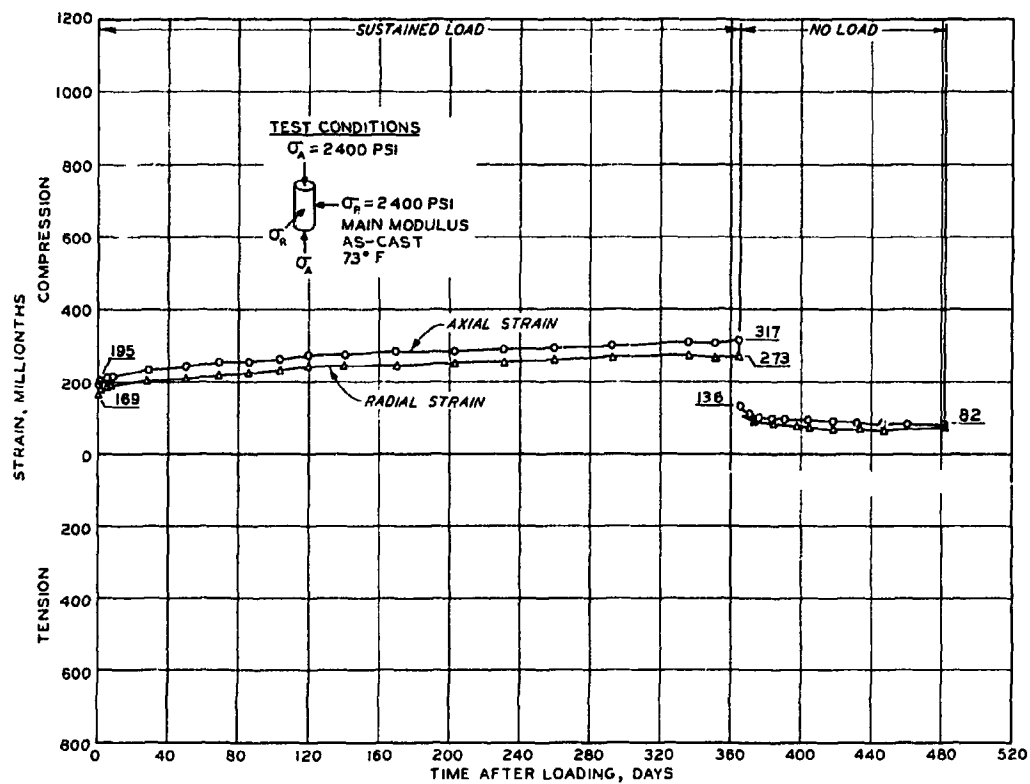
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN IV-6



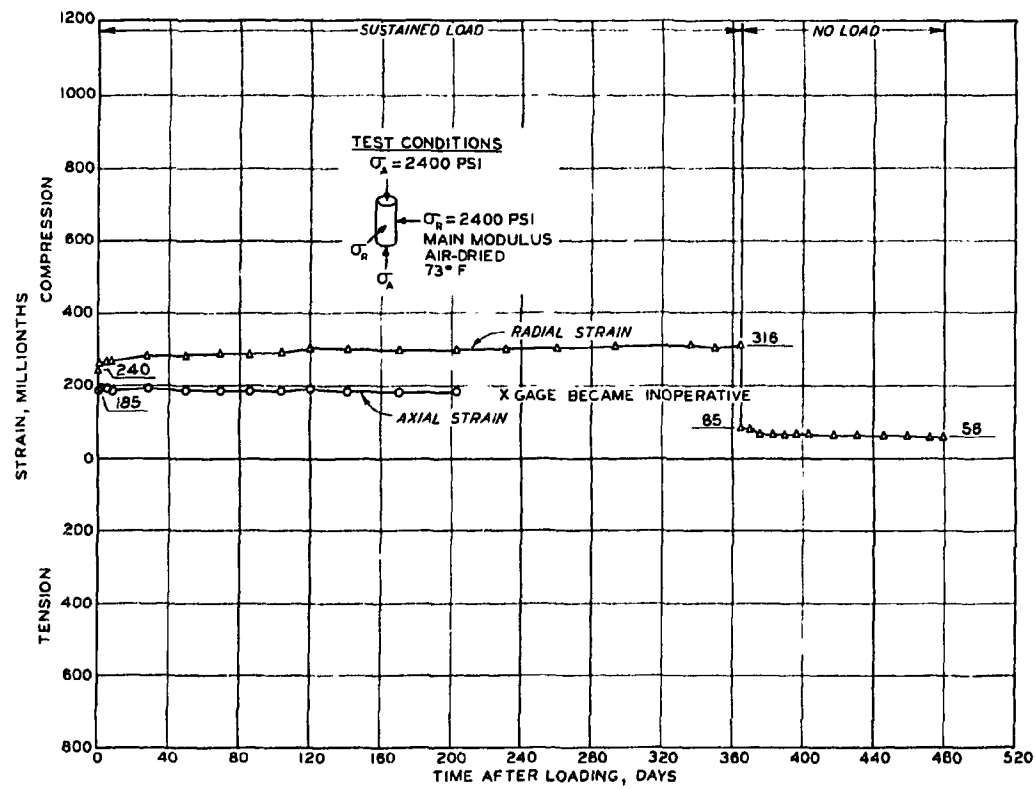
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN V-1



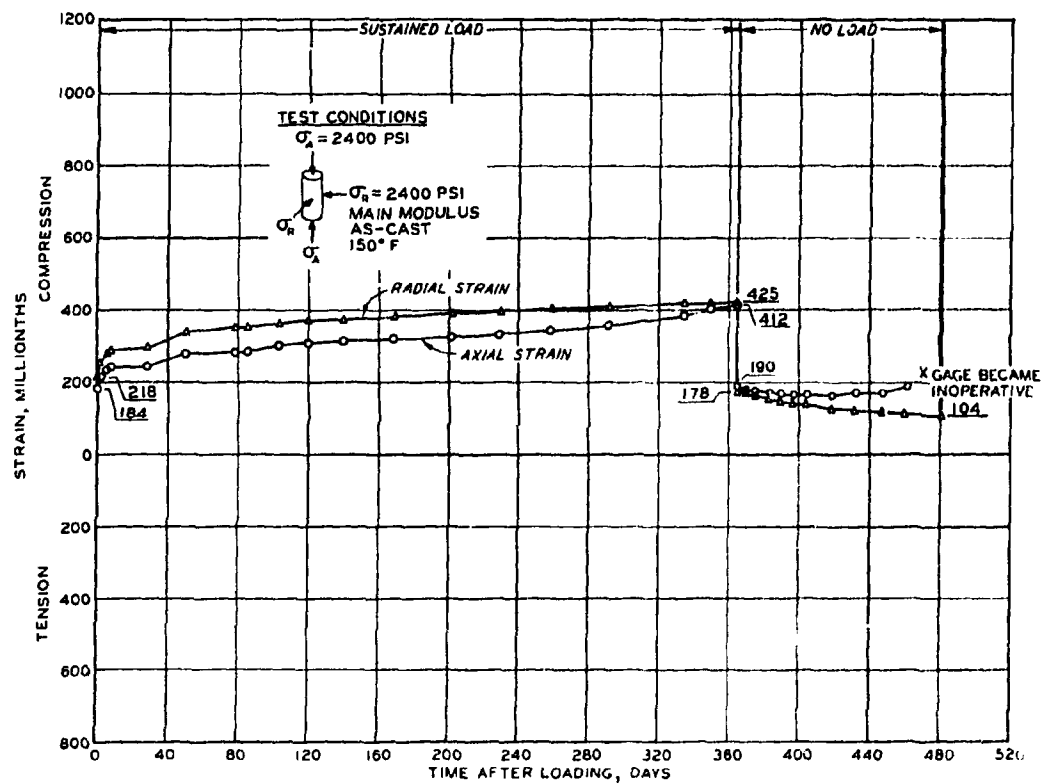
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN V-2



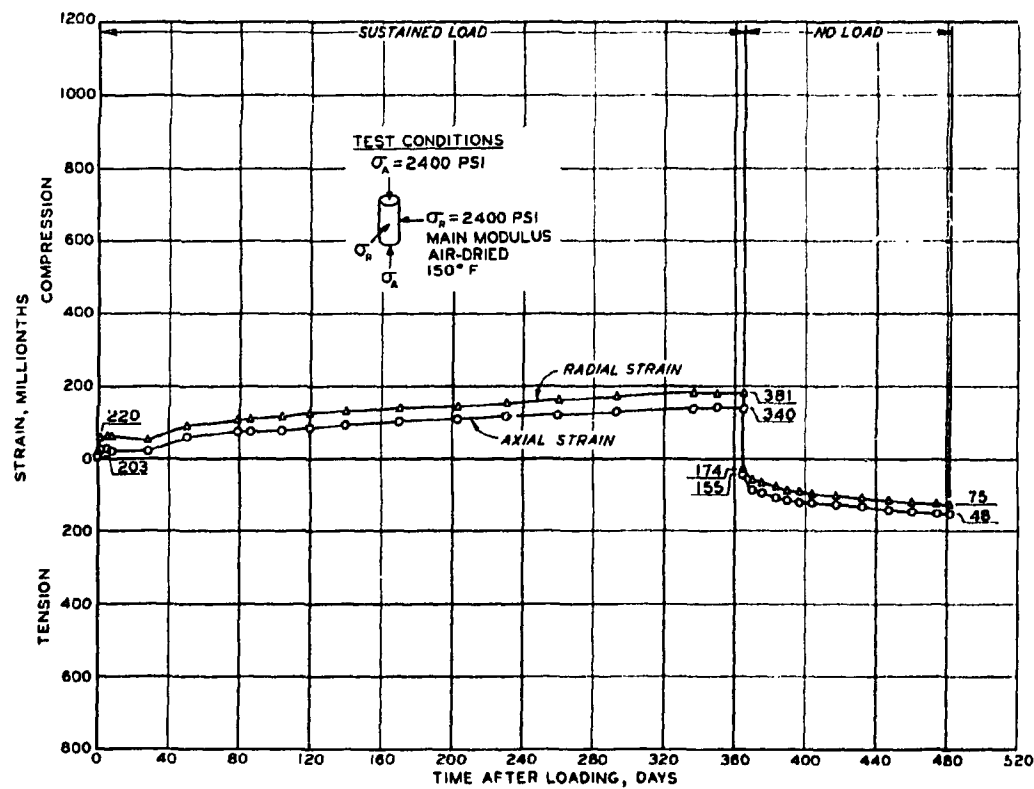
TOTAL AXIAL AND
 RADIAL STRAIN CURVE FOR
 SPECIMEN V-3



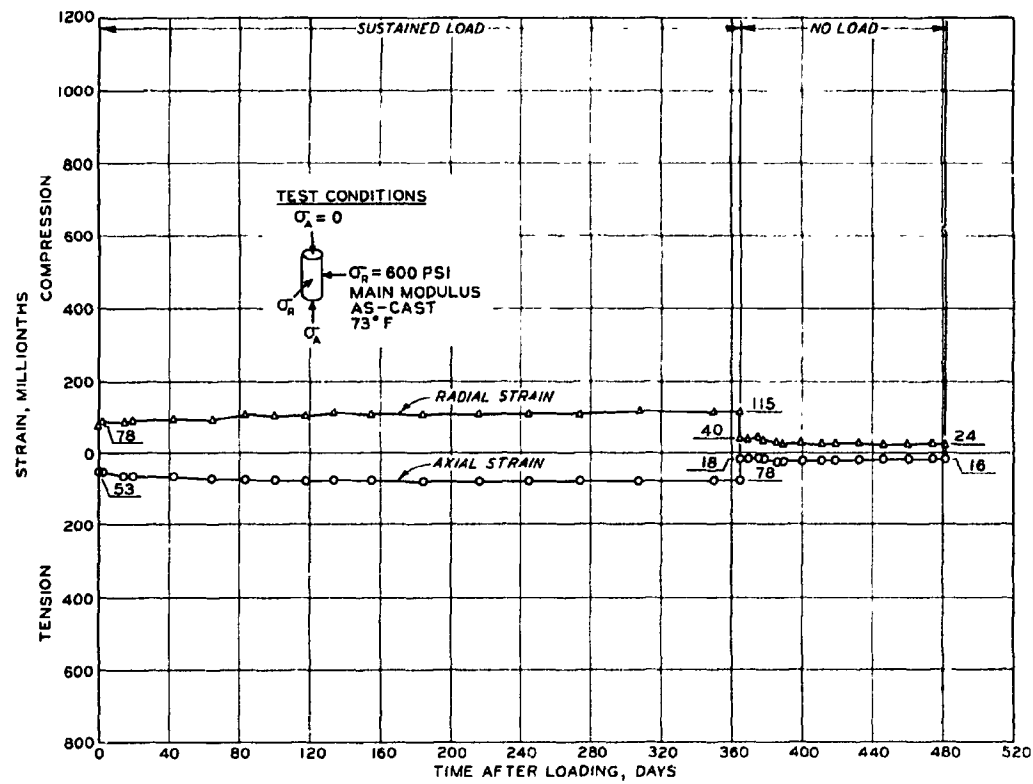
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN V-4



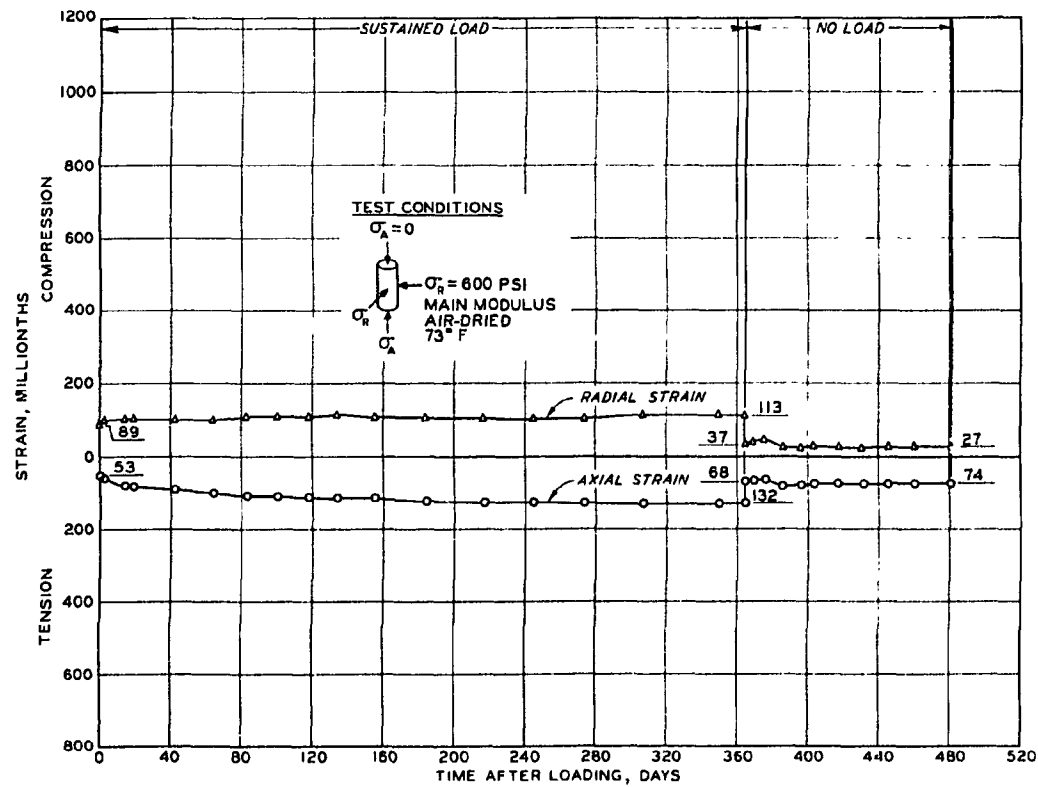
TOTAL AXIAL AND
 RADIAL STRAIN CURVE FOR
 SPECIMEN V-5



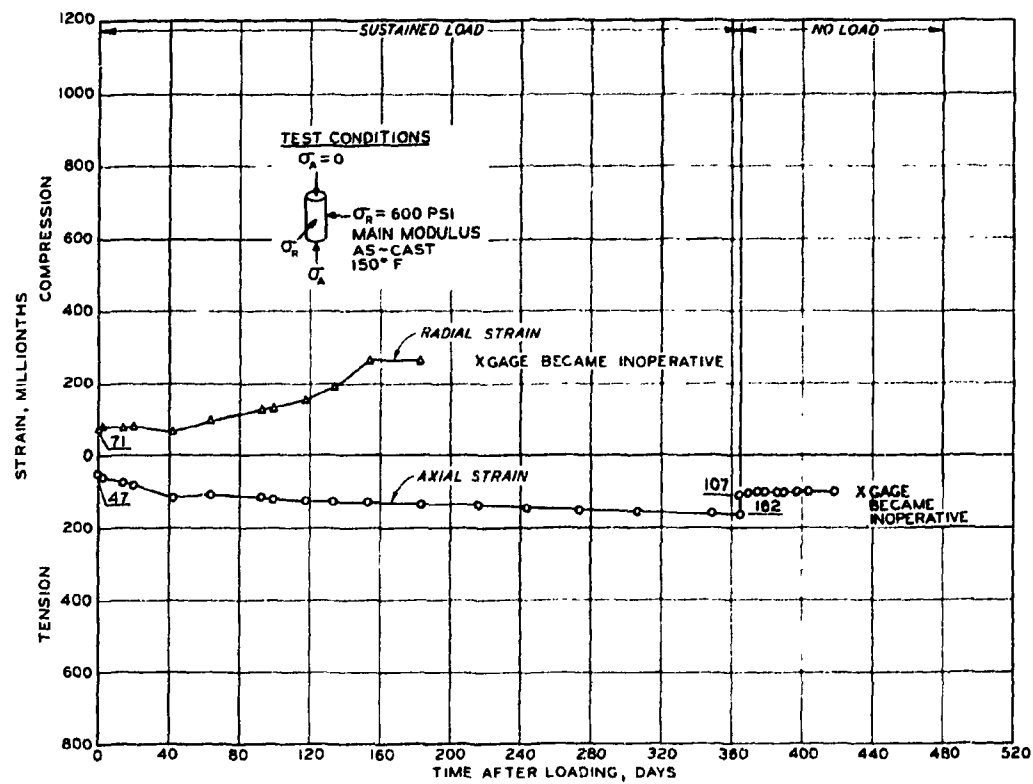
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN X-6



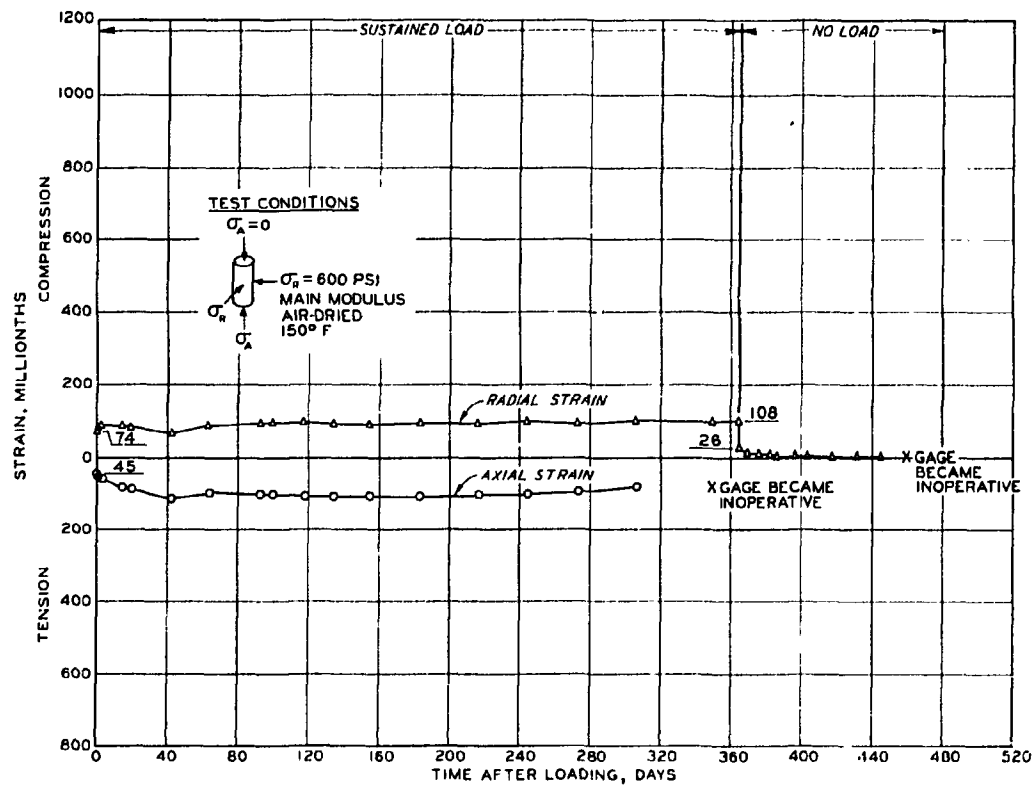
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN V-7



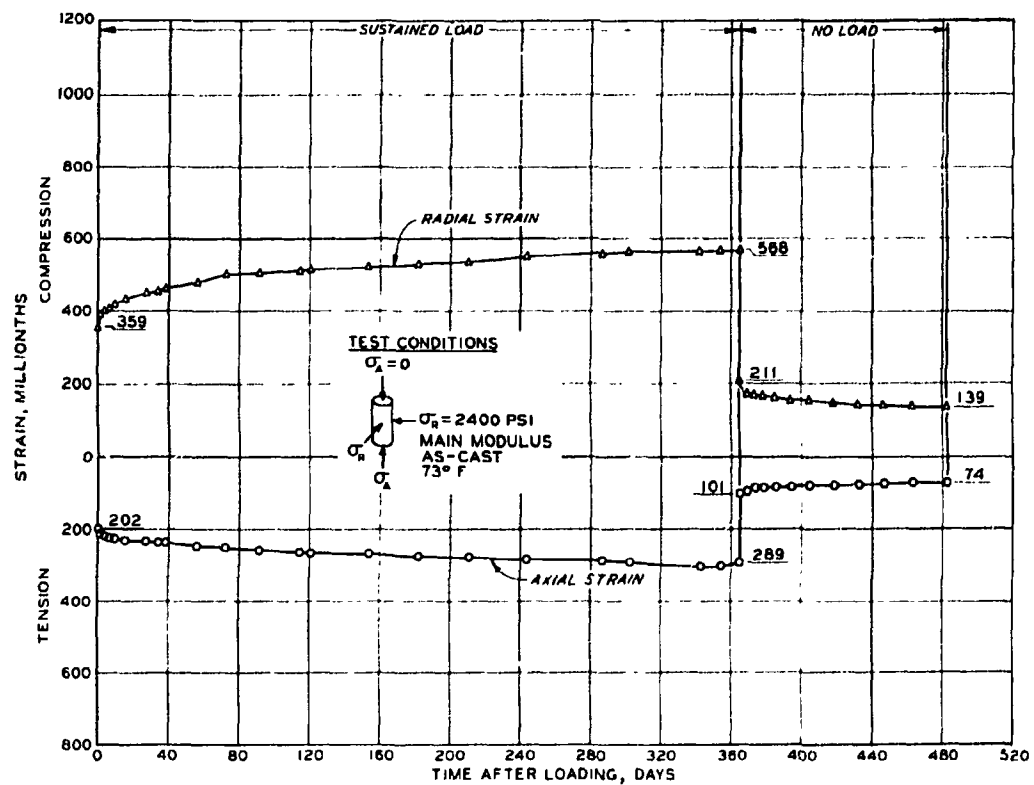
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN V-8



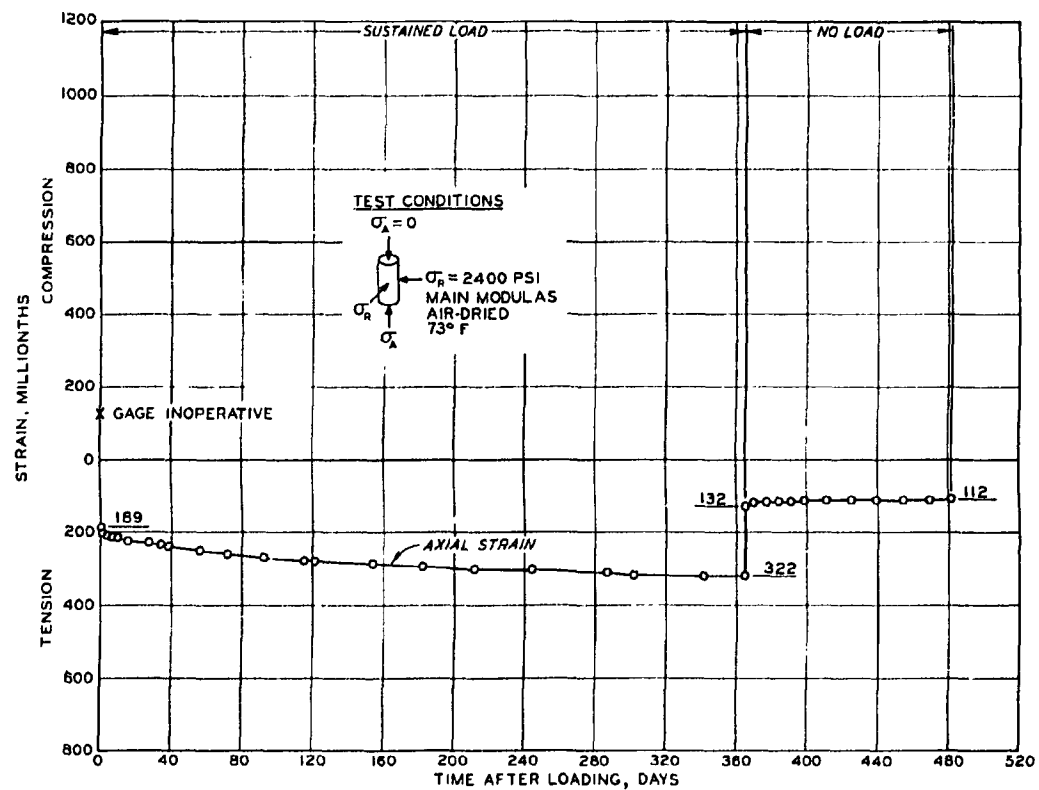
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN V-9



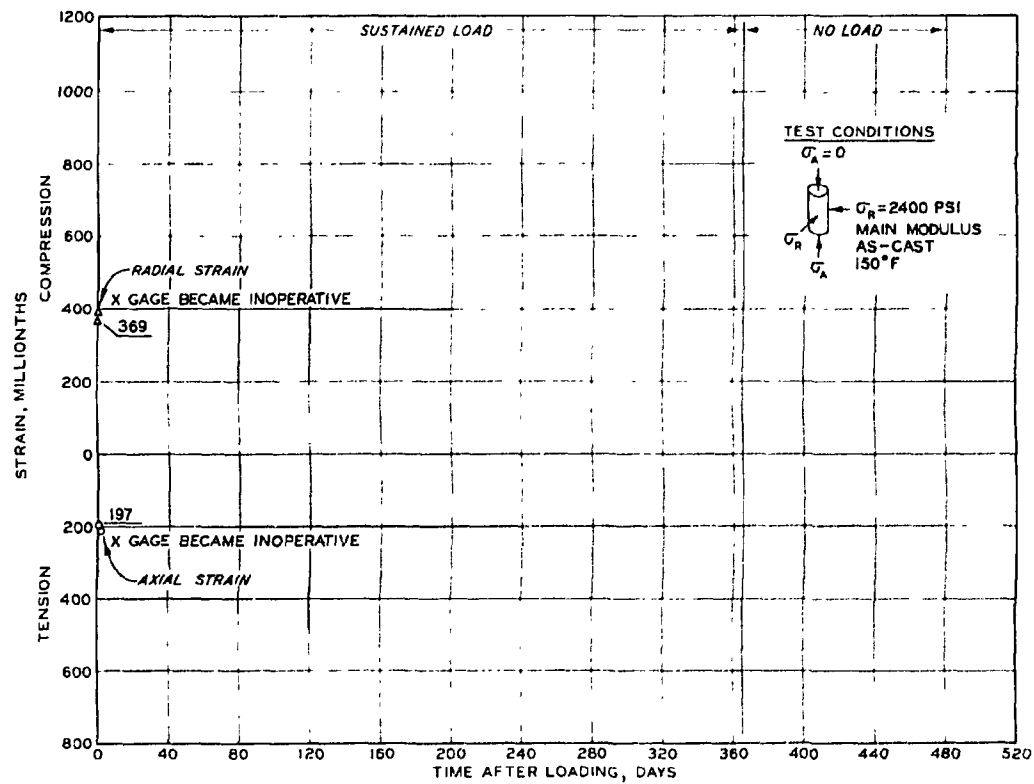
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN V-10



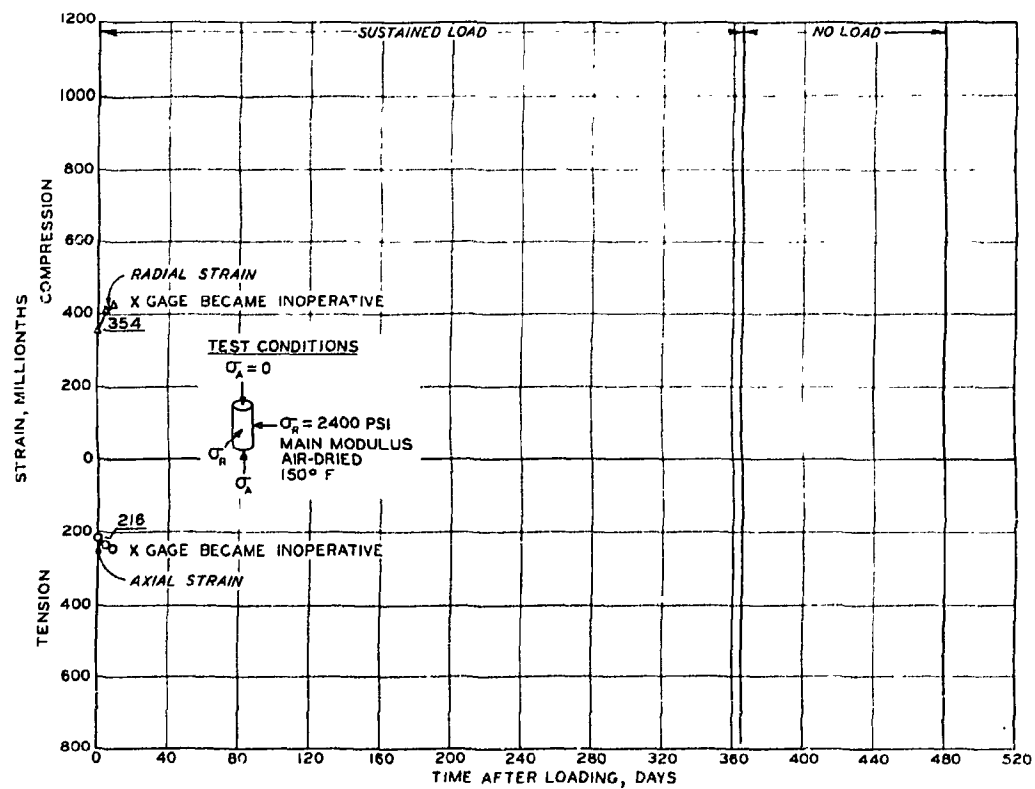
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN VI-1



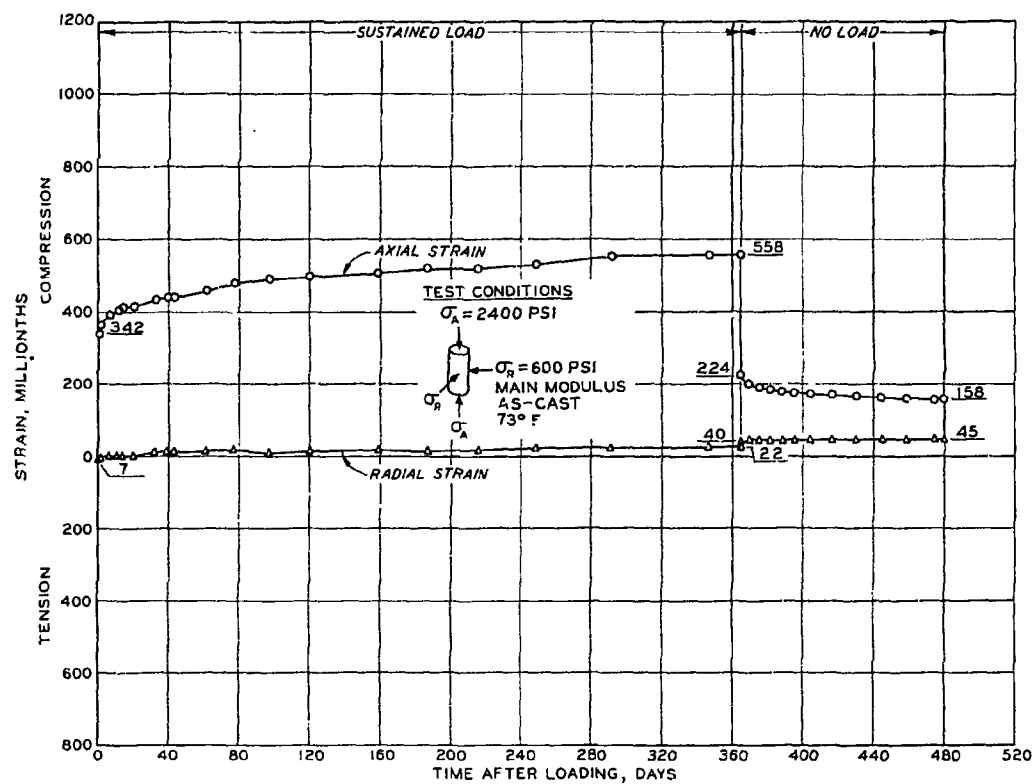
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN VI-2



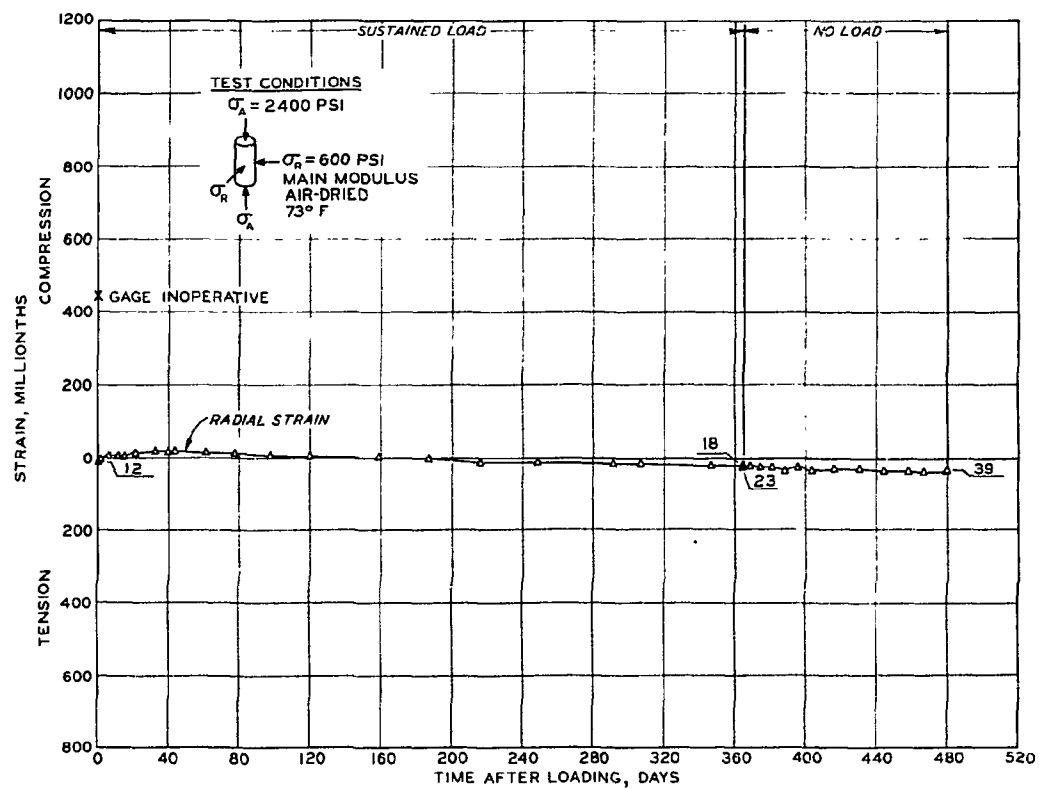
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN VI-3



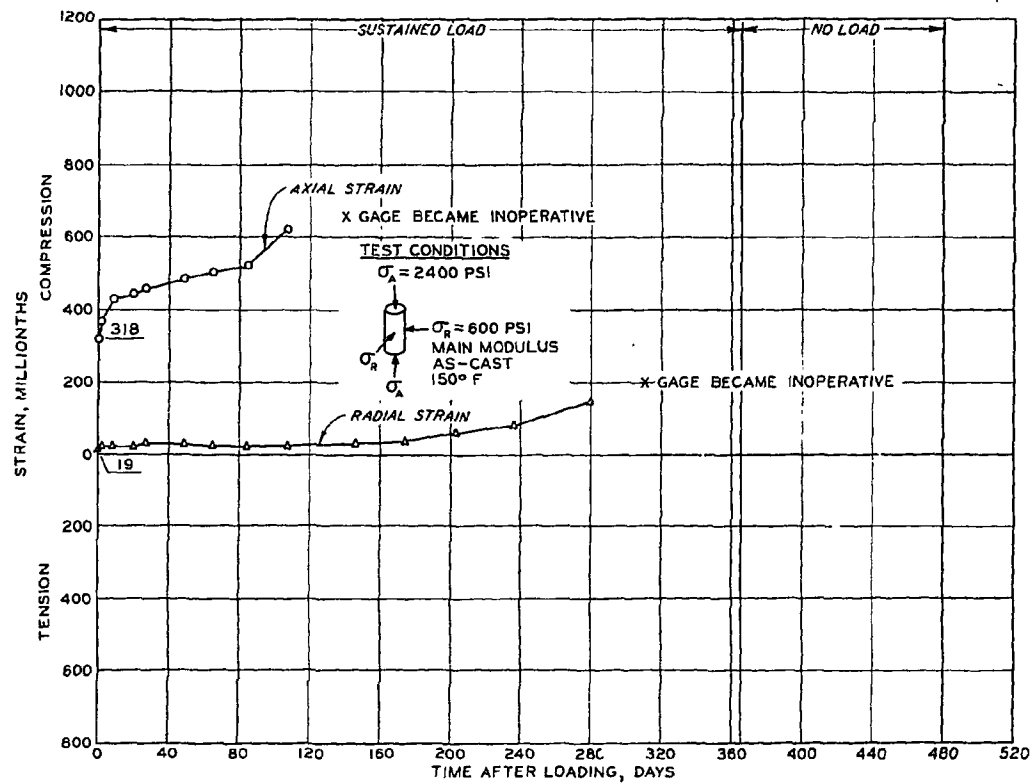
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN VI-4



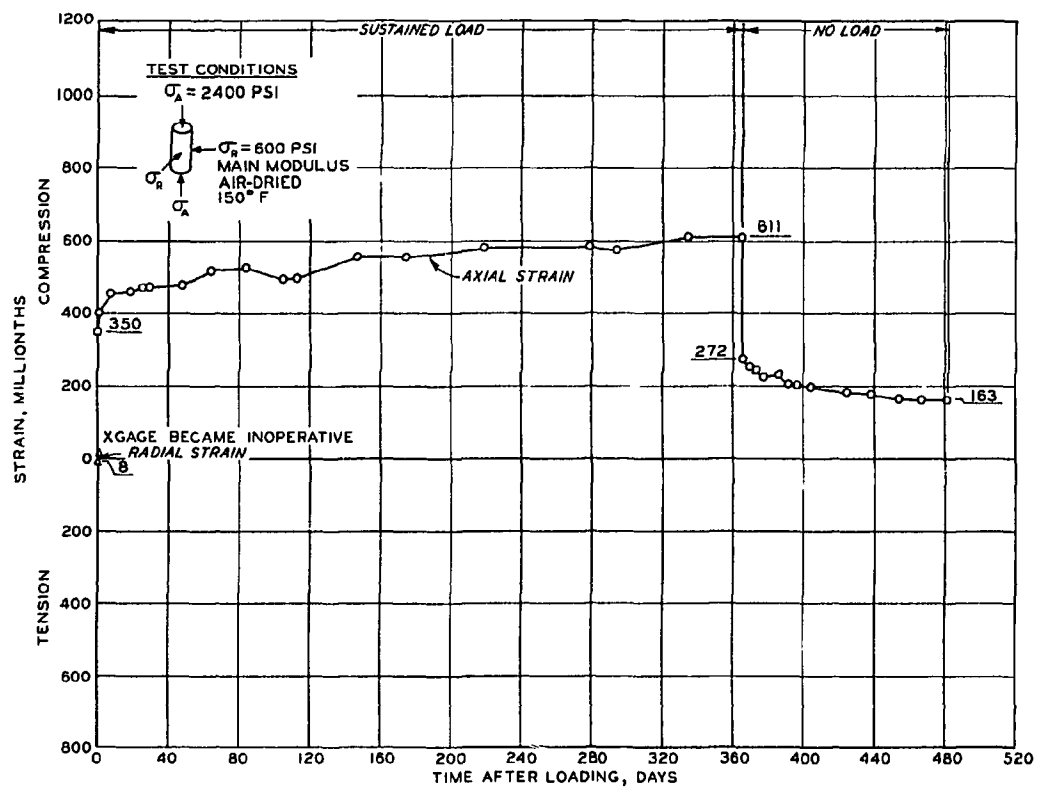
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN VI-5



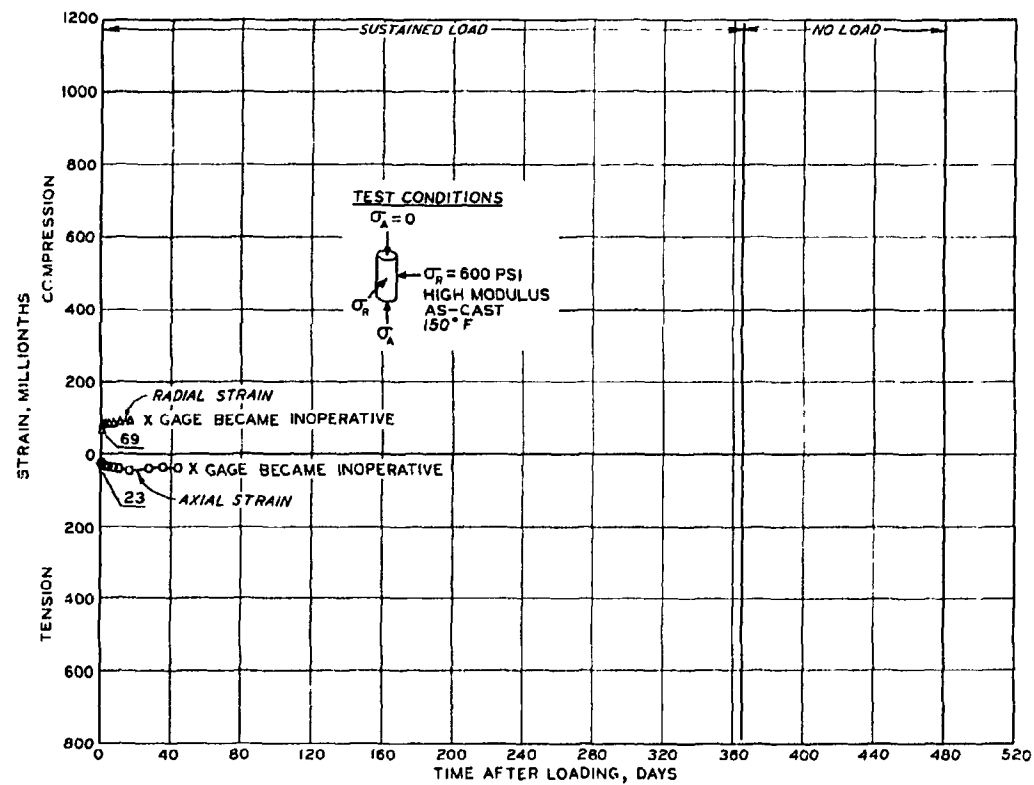
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN VI-6



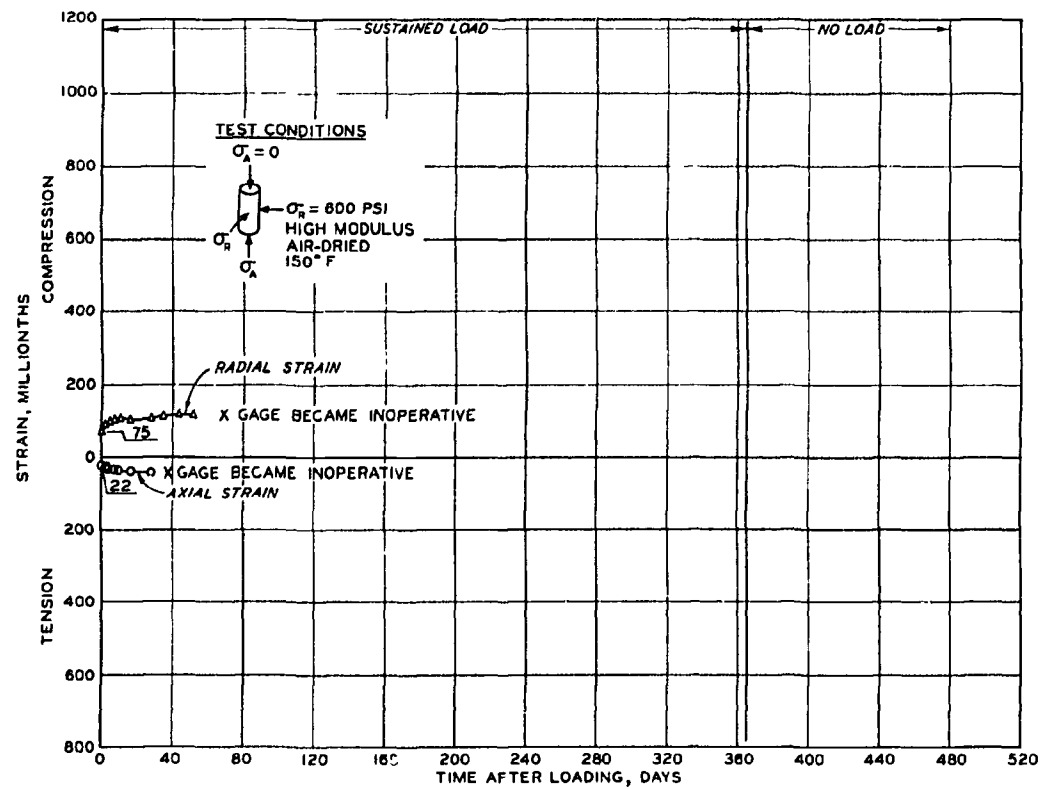
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN VI-7



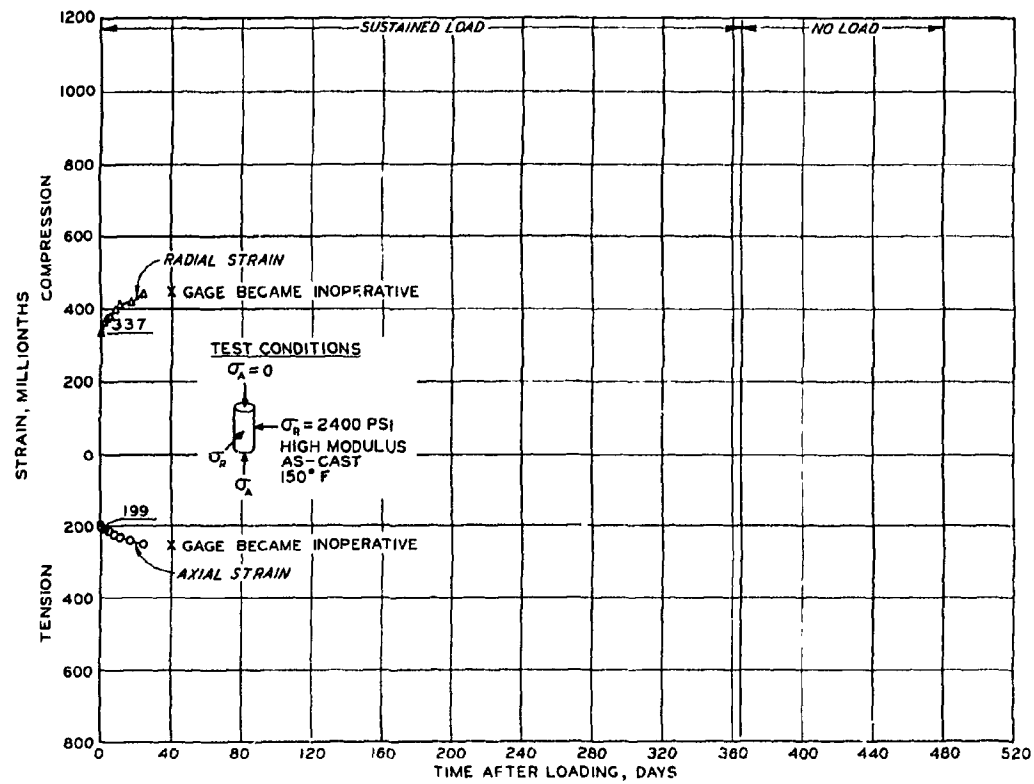
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN VI-8



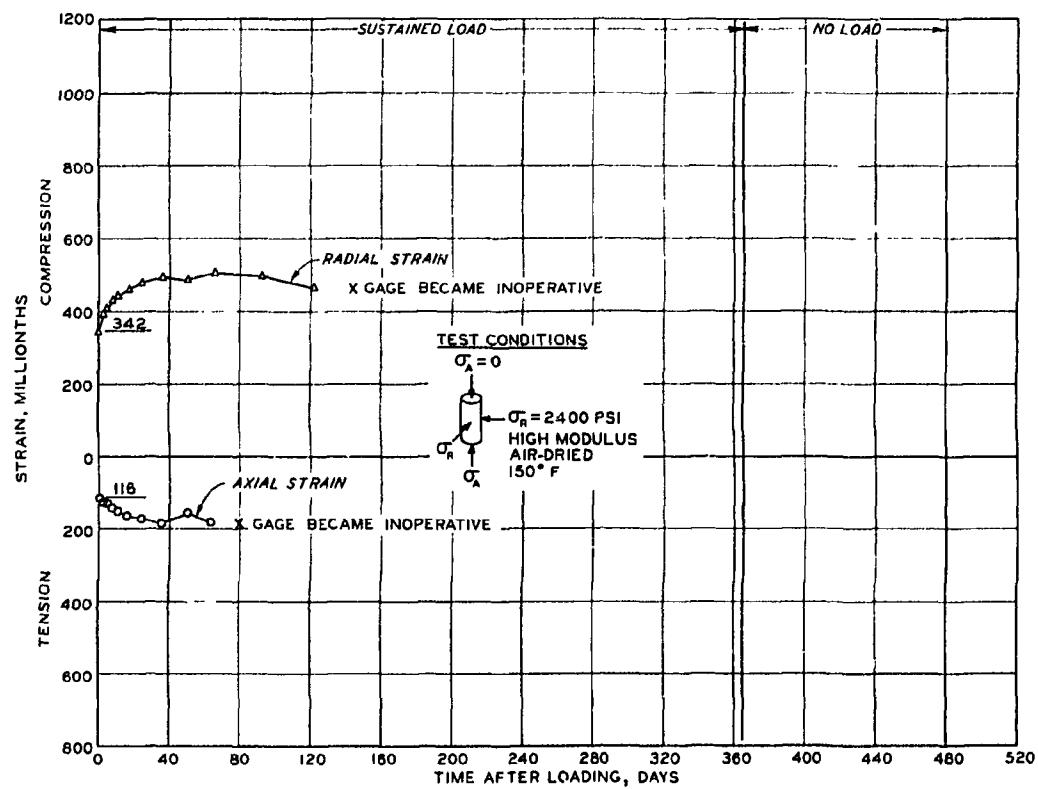
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN VII-1



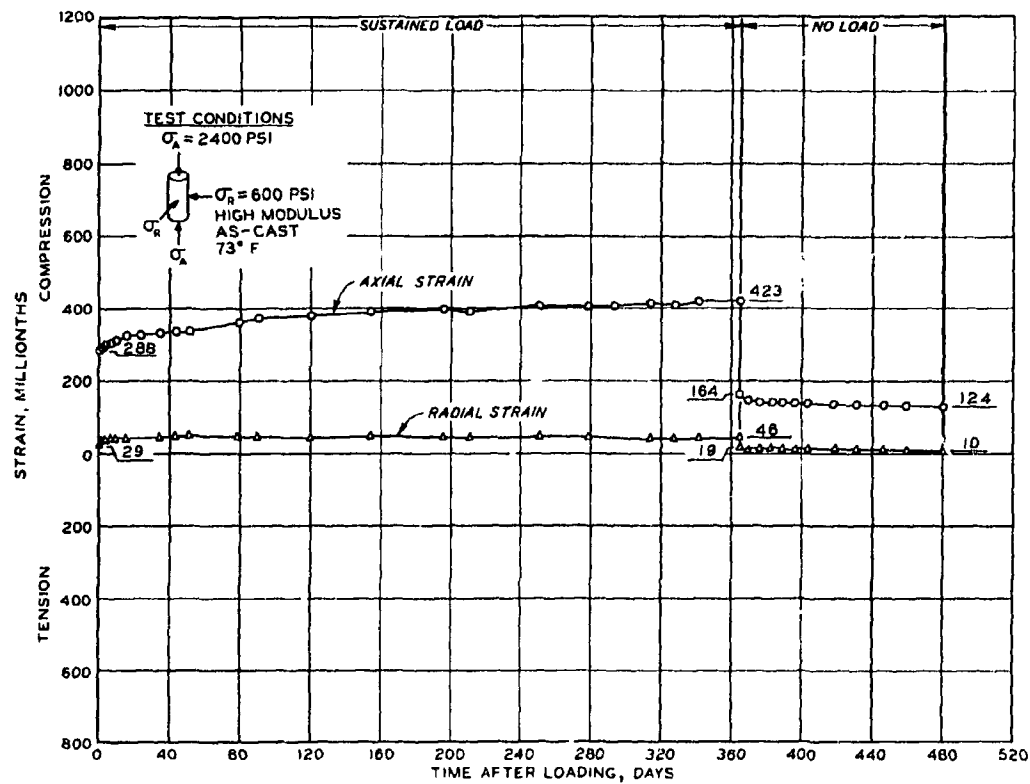
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN VII-2



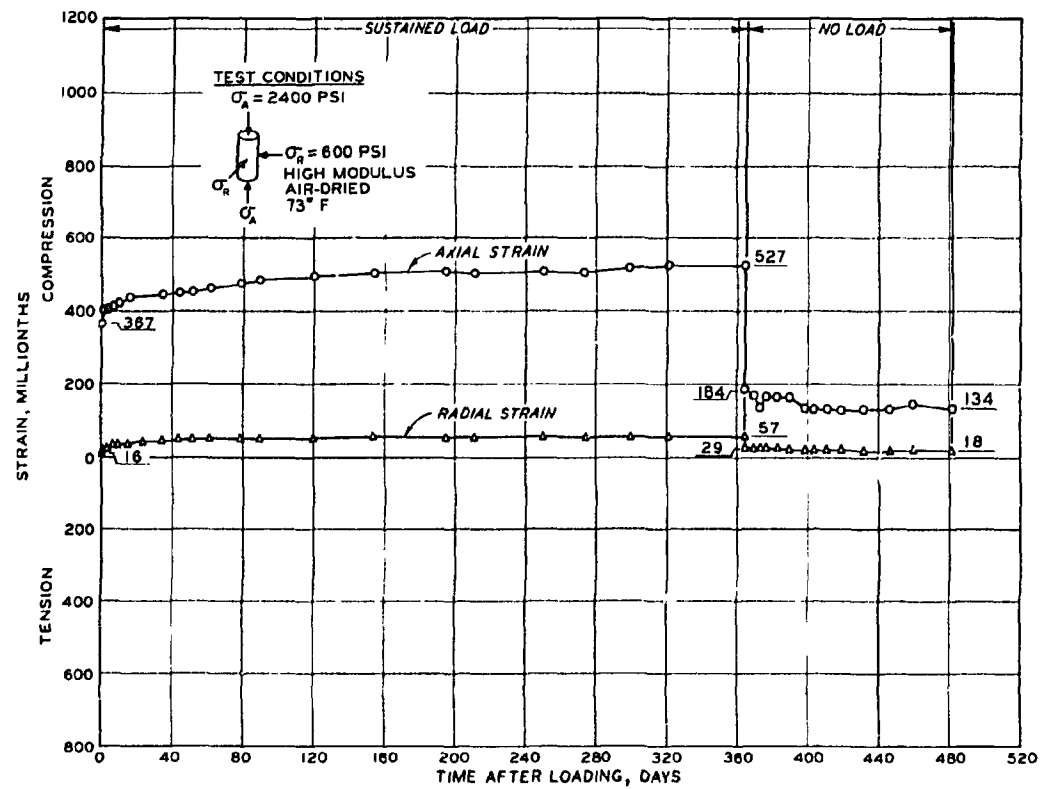
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN VII-3



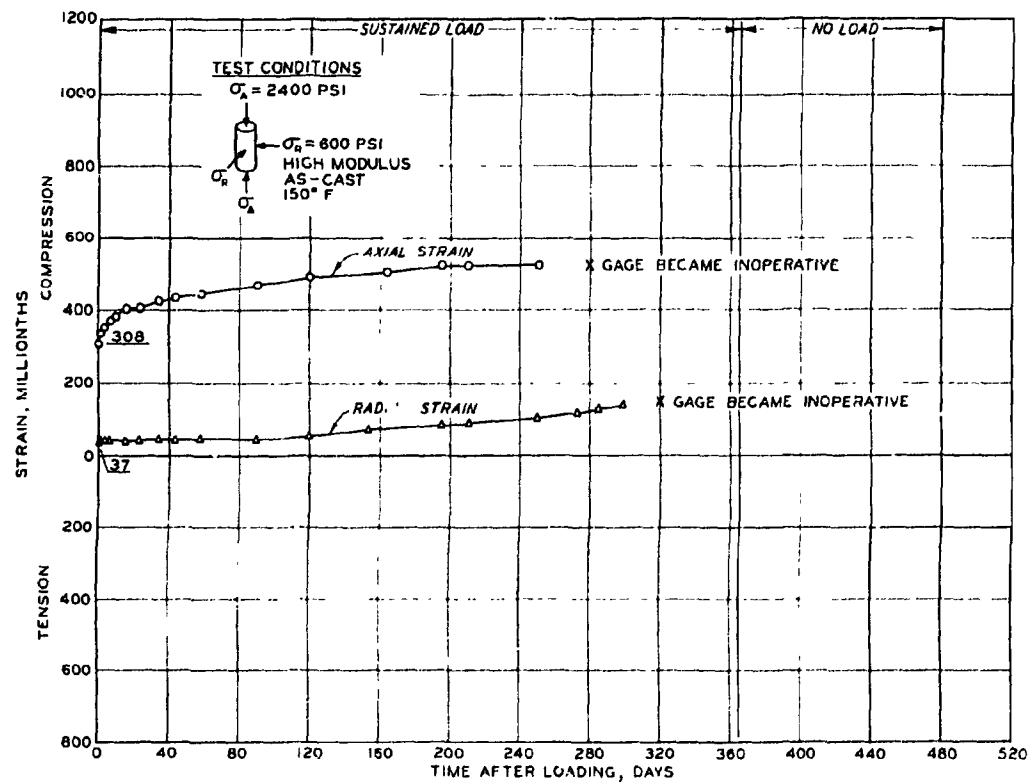
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN VII-4



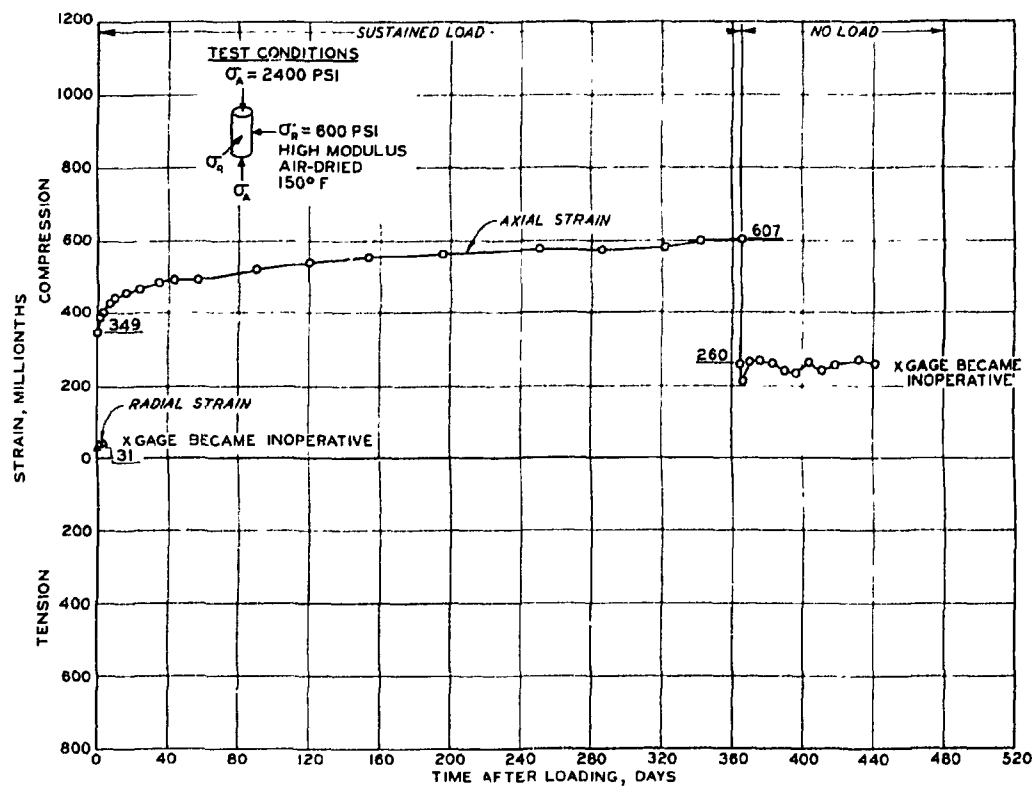
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN VII-5



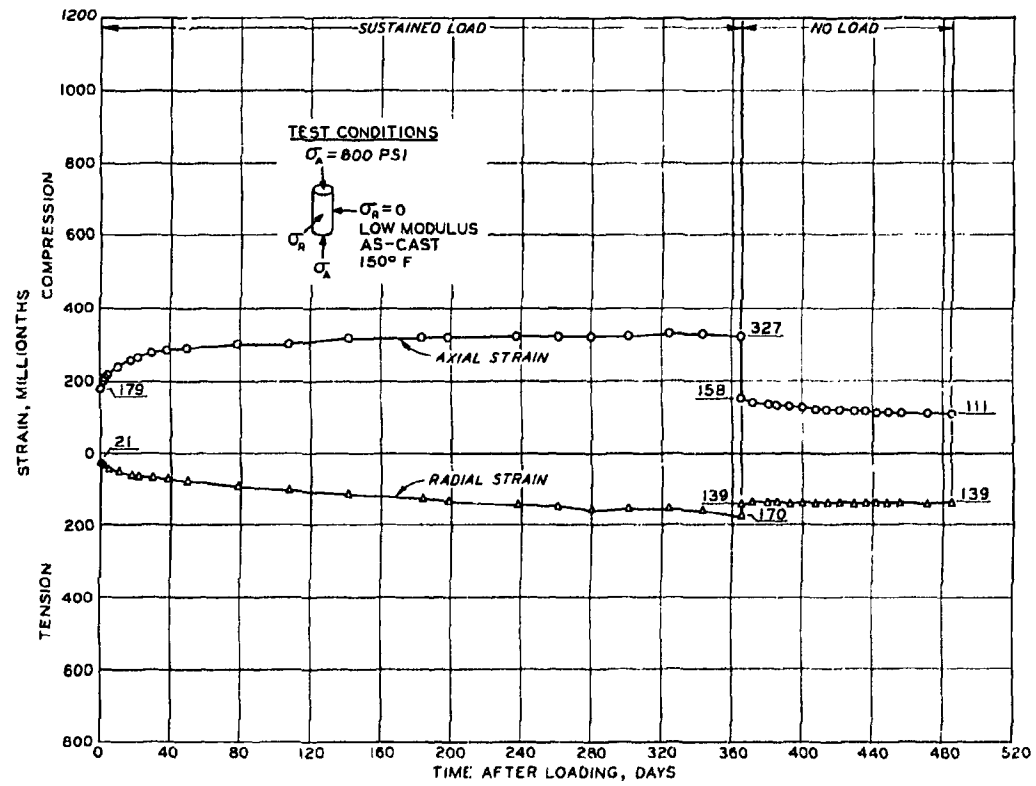
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN VII-6



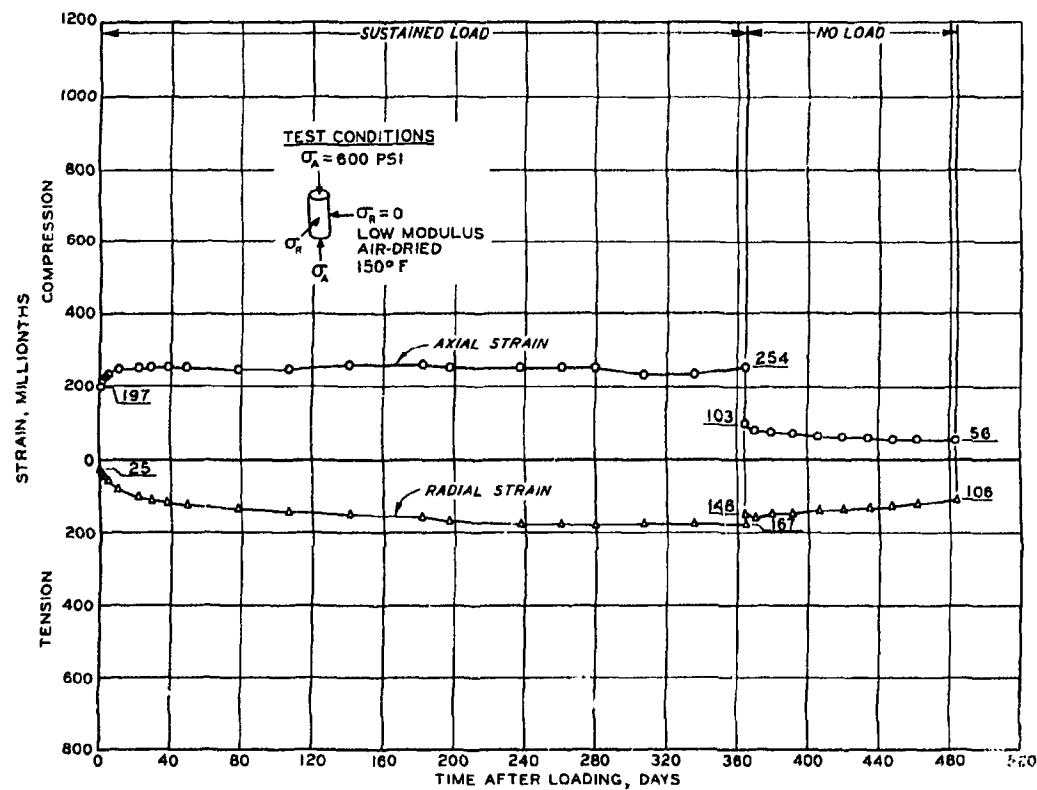
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN VII-7



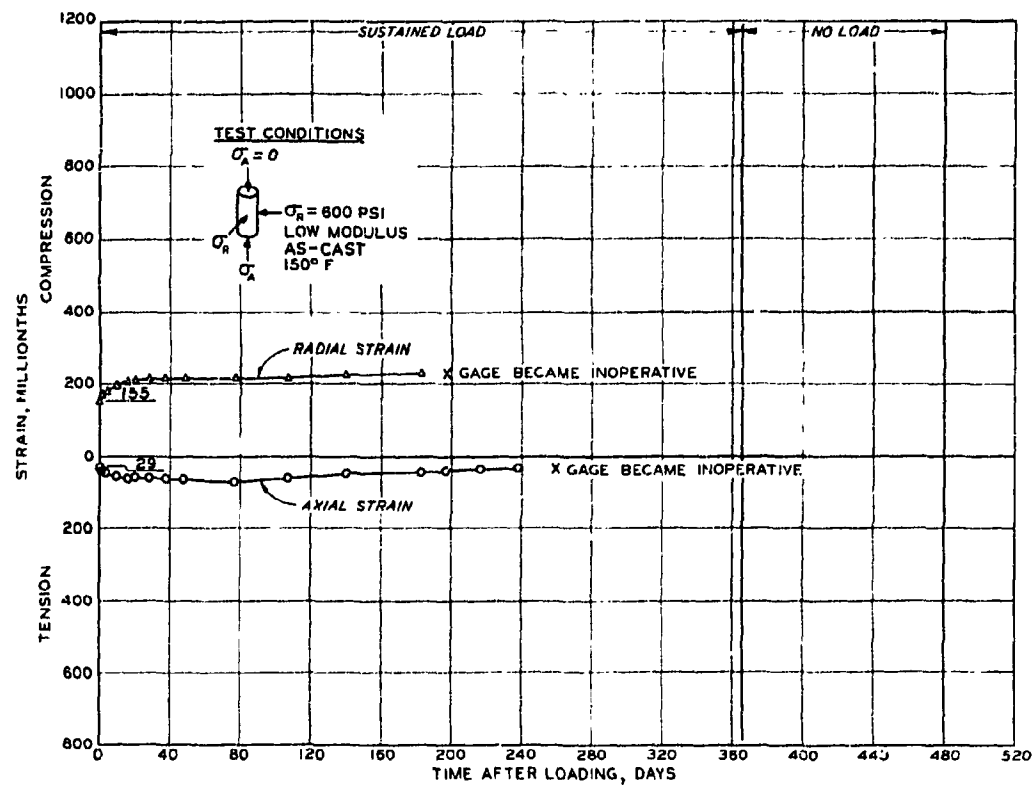
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN VII-8



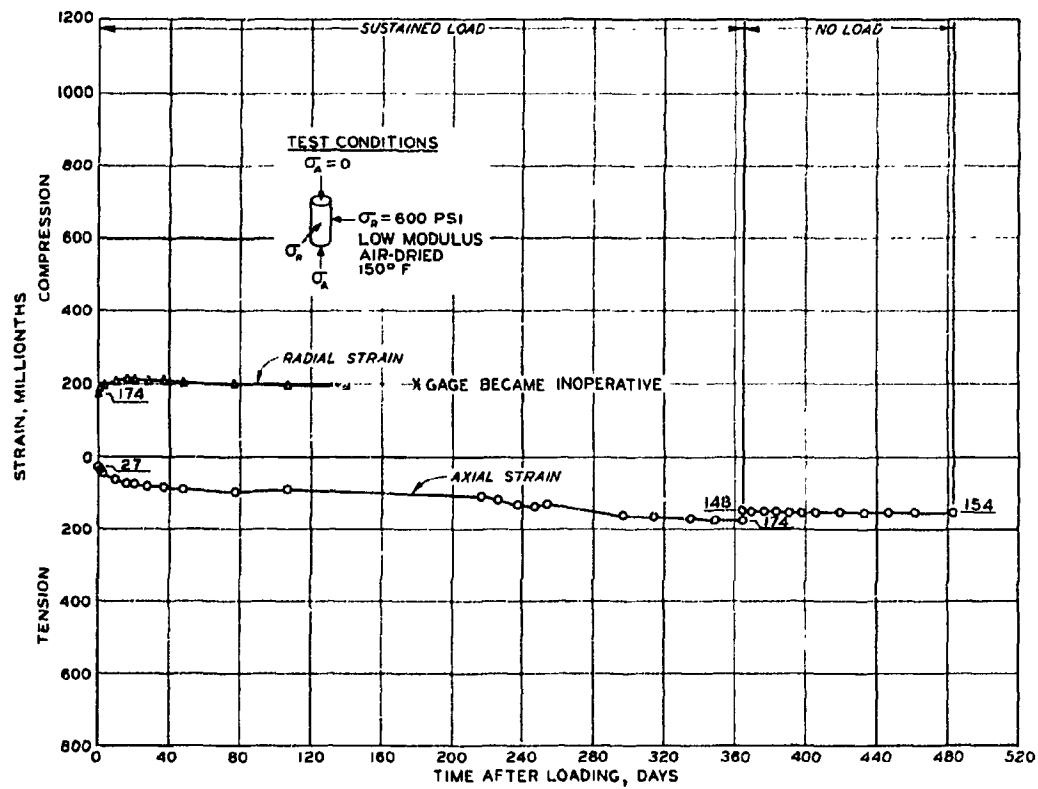
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN VIII-1



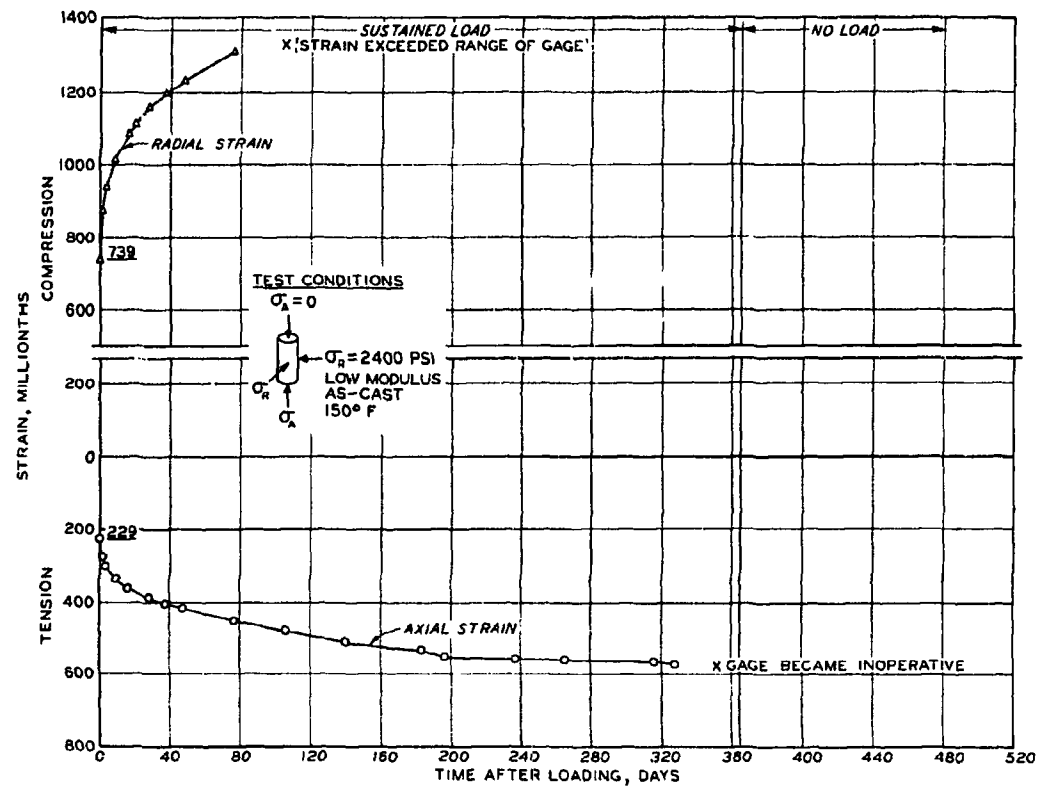
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN VIII-2



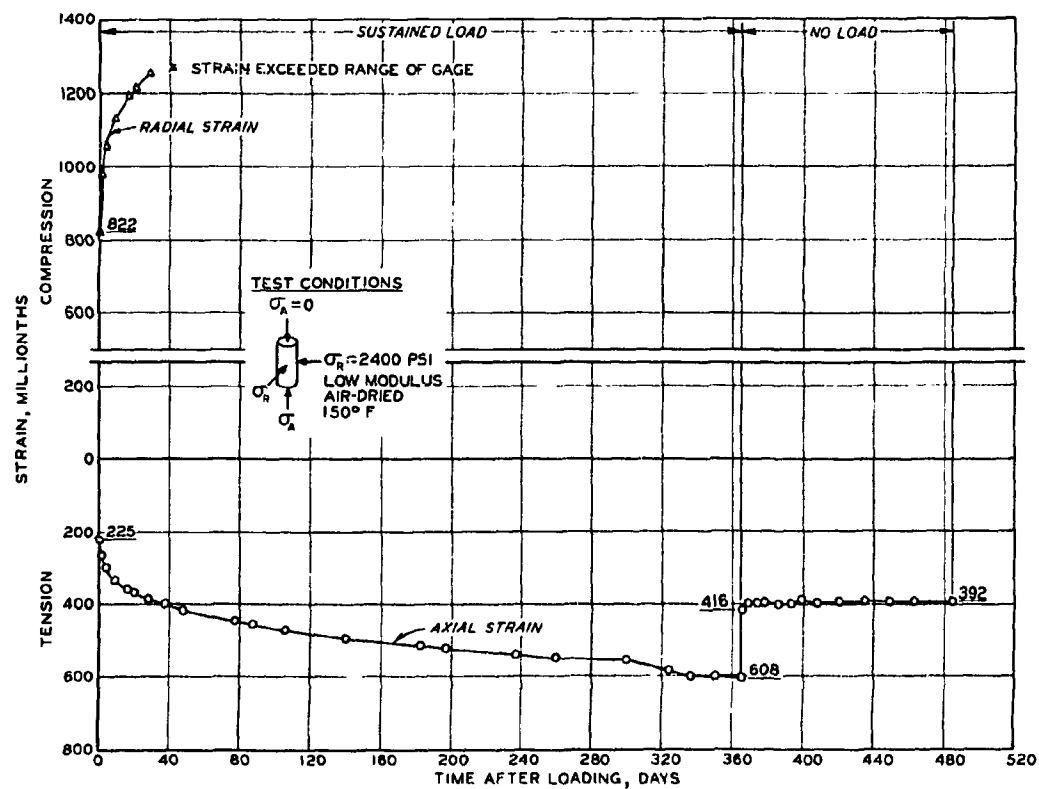
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN VII-3



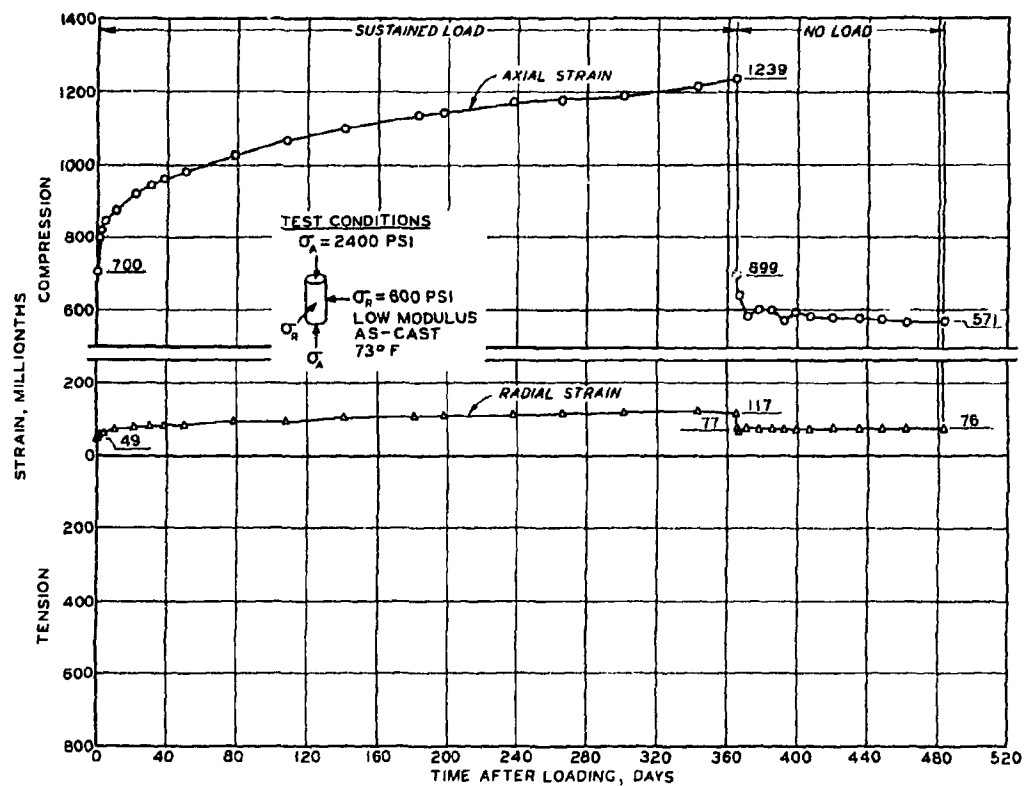
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN VIII-4



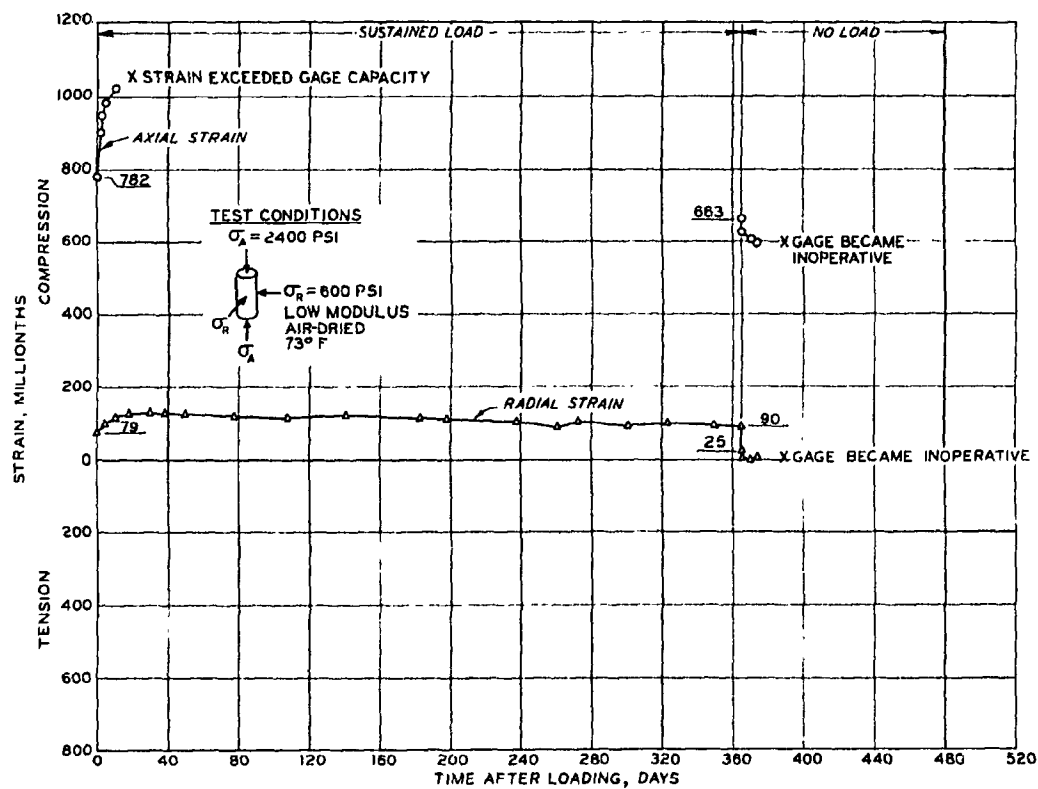
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN VIII-5



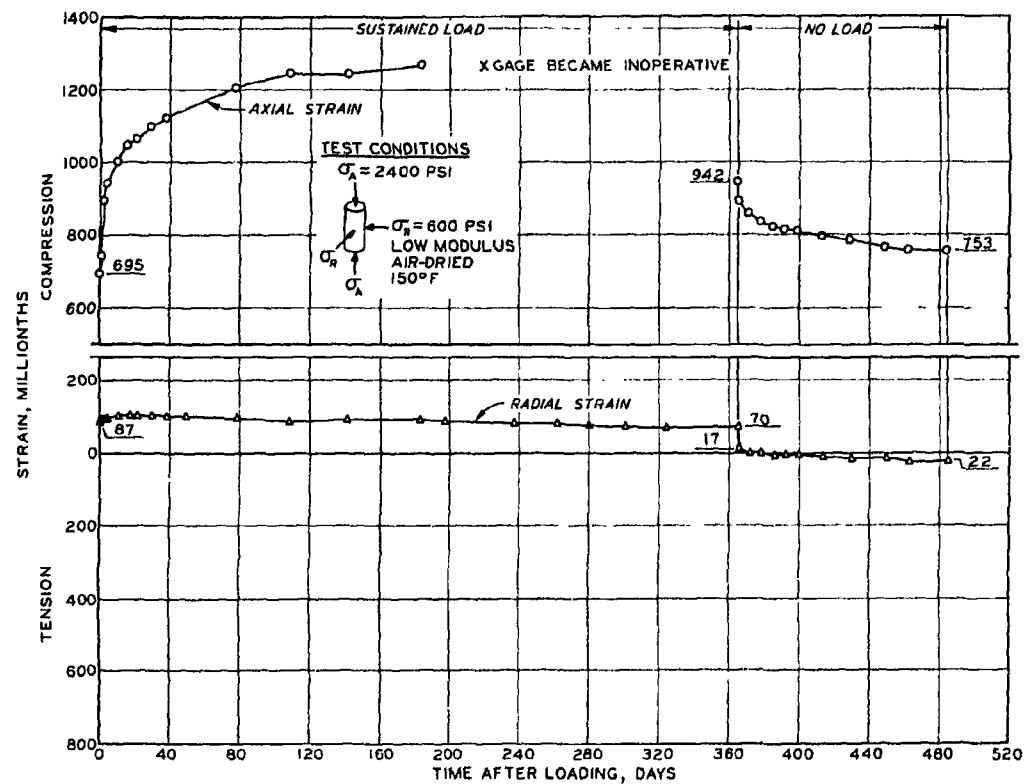
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN VIII-6



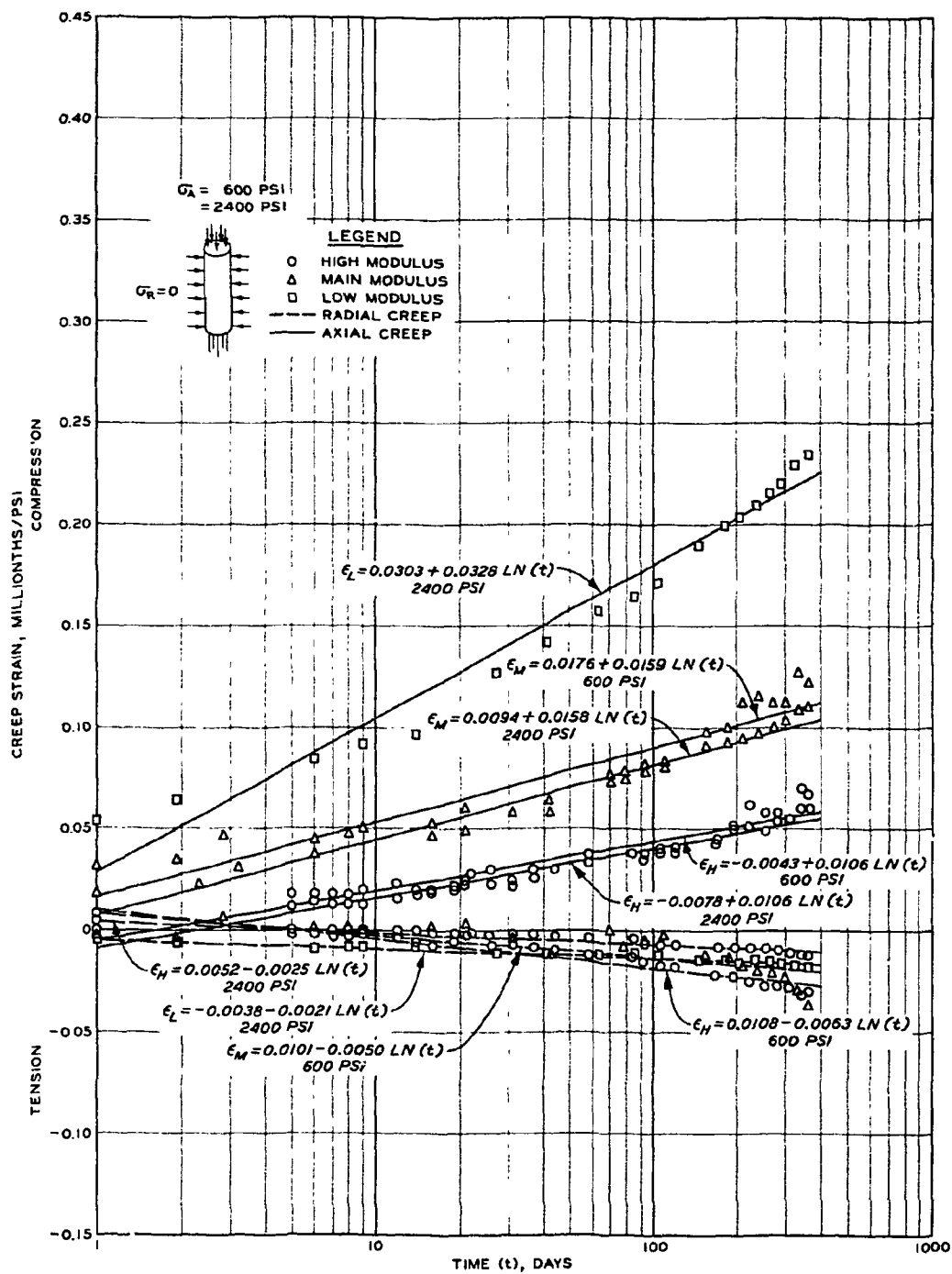
TOTAL AXIAL AND
 RADIAL STRAIN CURVES FOR
 SPECIMEN VIII-7



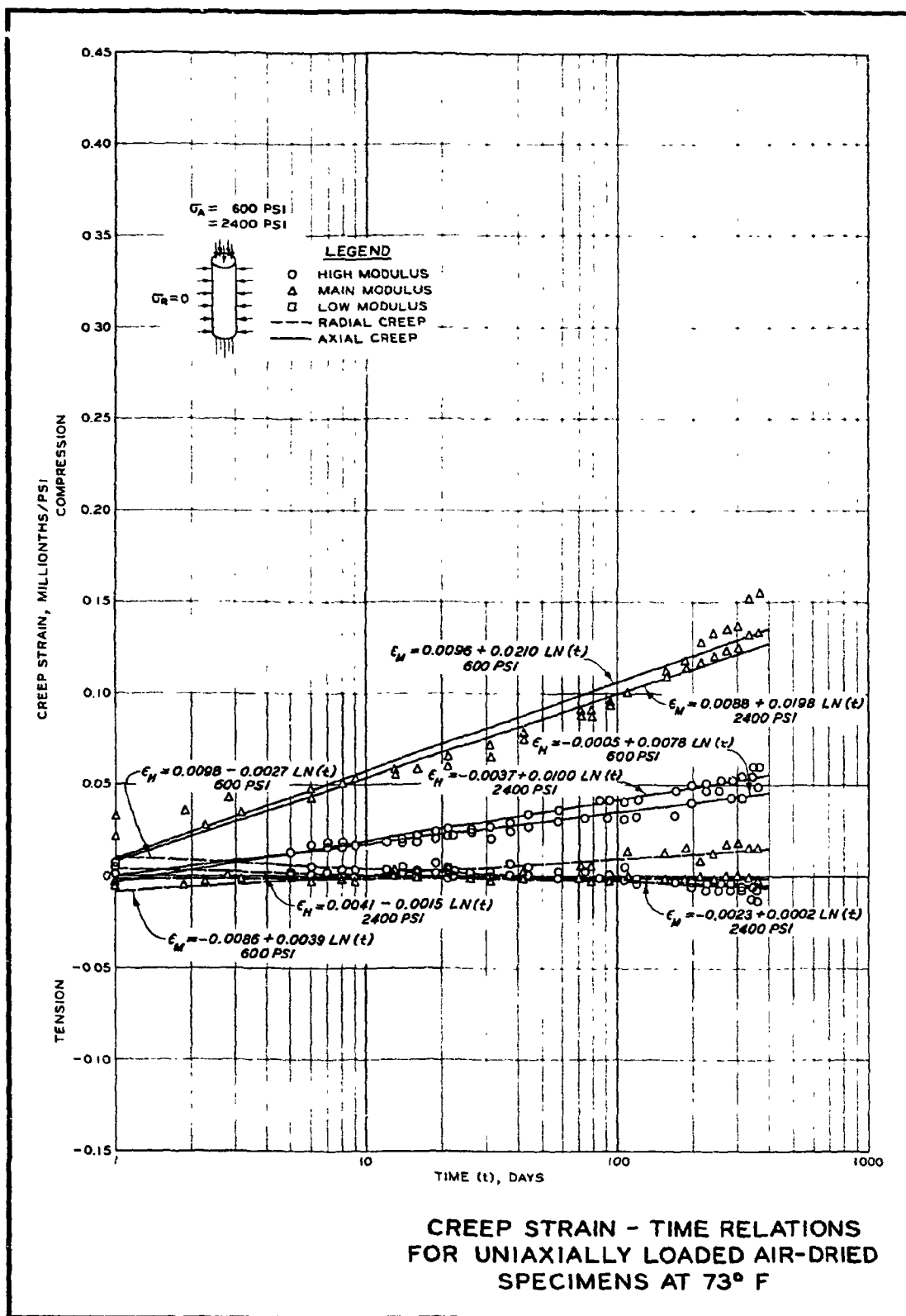
TOTAL AXIAL AND
RADIAL STRAIN CURVES FOR
SPECIMEN VIII-8

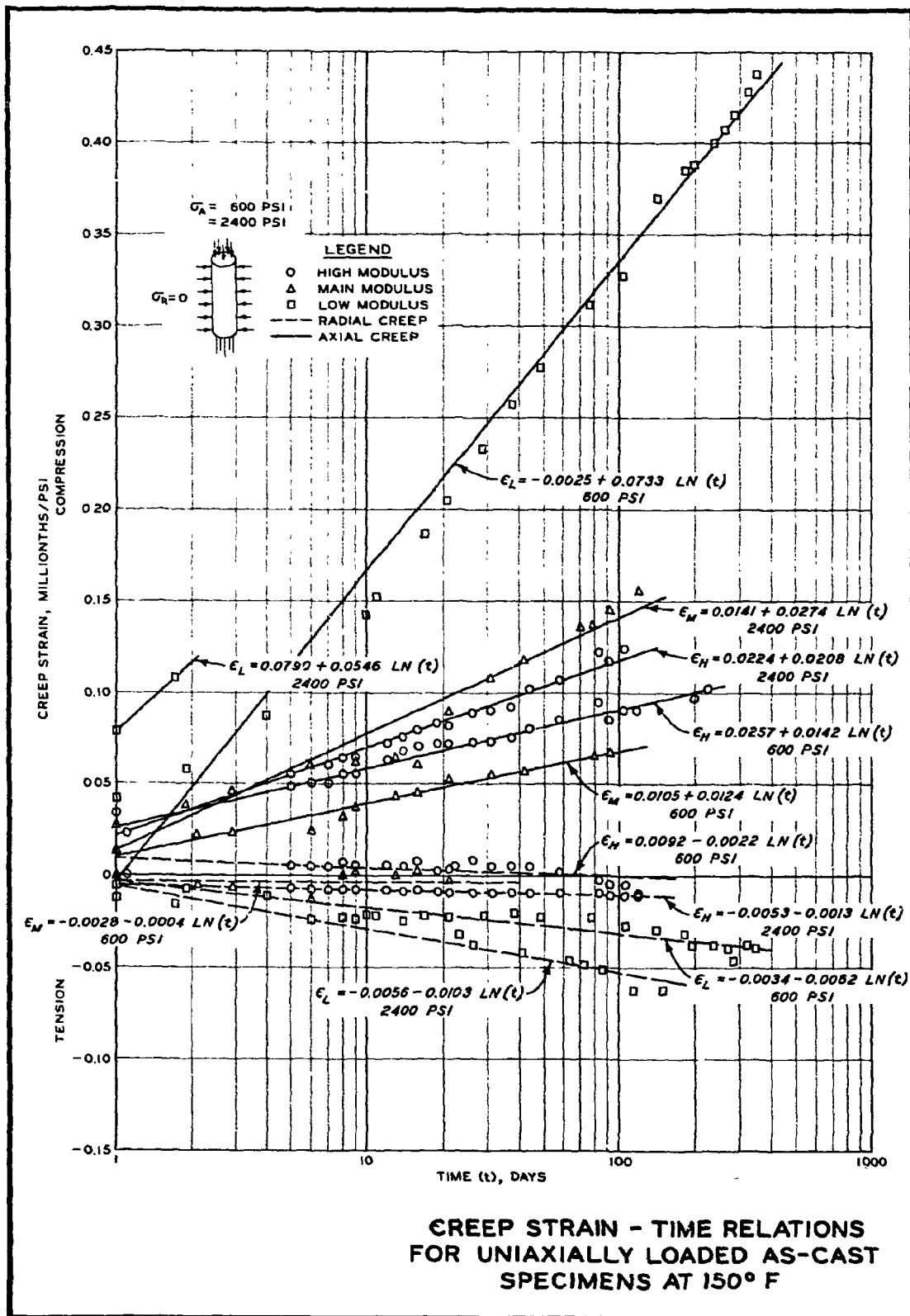


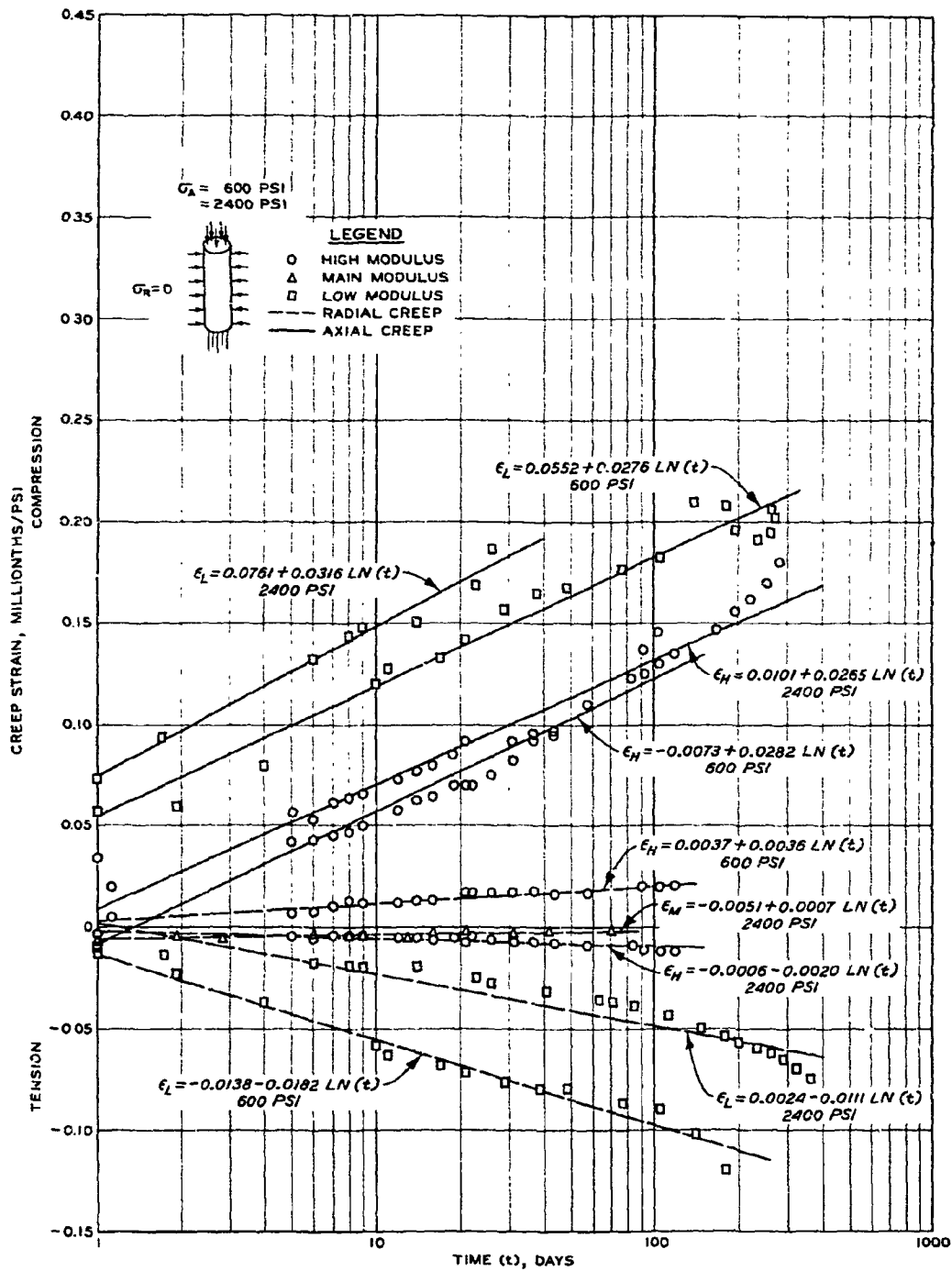
TOTAL AXIAL AND
RADIAL STRAIN CURVE FOR
SPECIMEN VIII-10



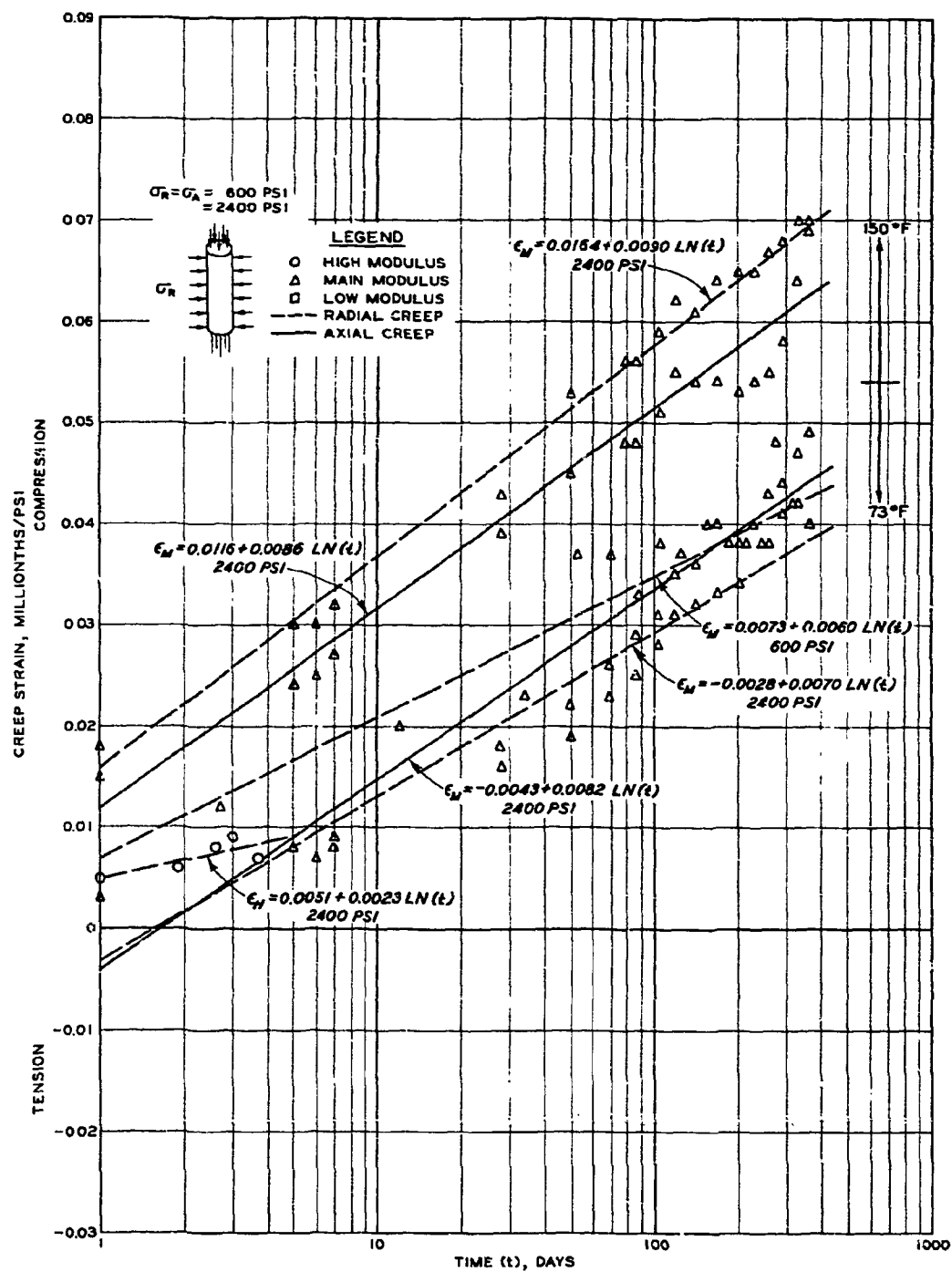
CREEP STRAIN - TIME RELATIONS
FOR UNIAXIALLY LOADED AS-CAST
SPECIMENS AT 73° F



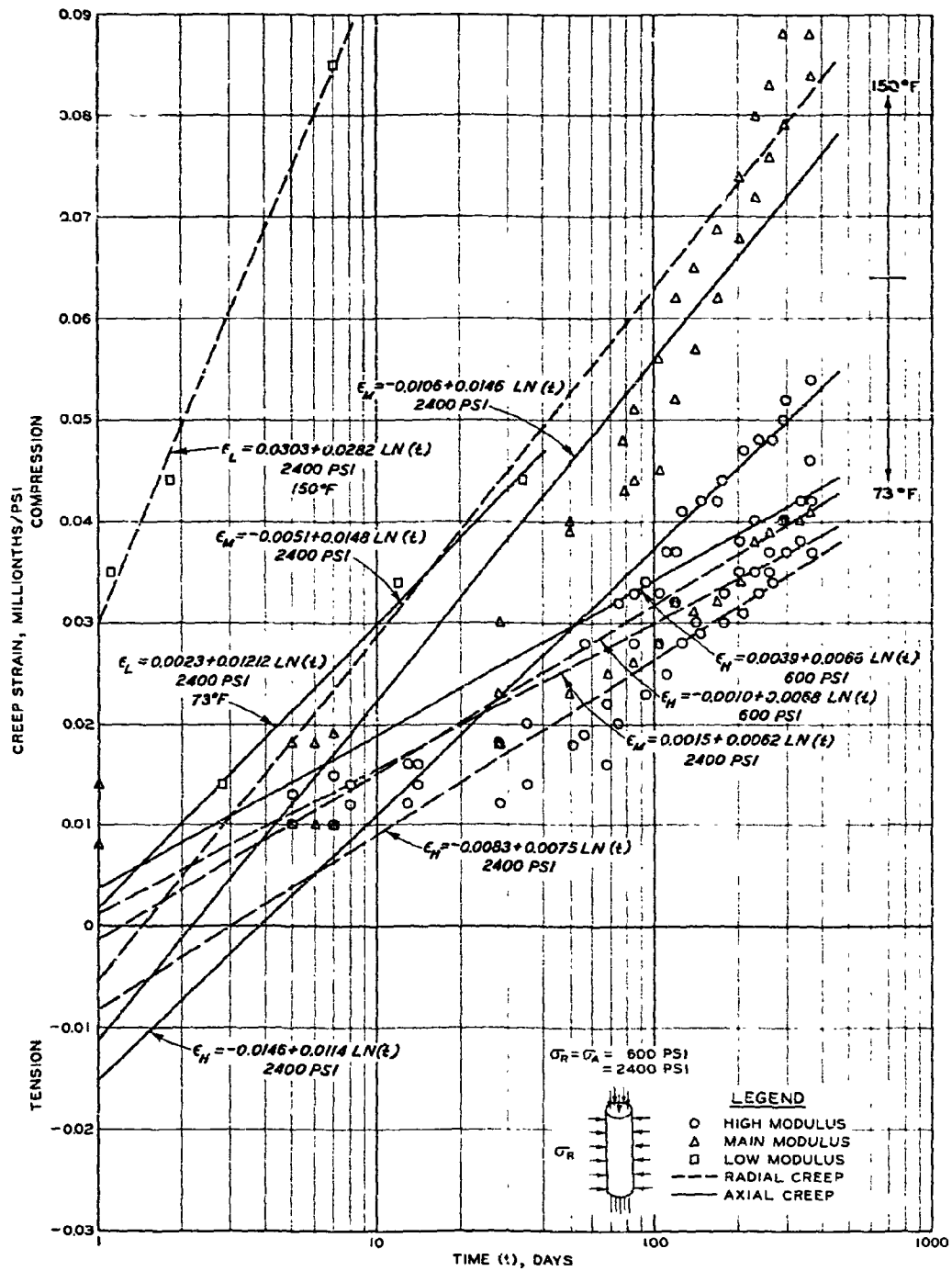




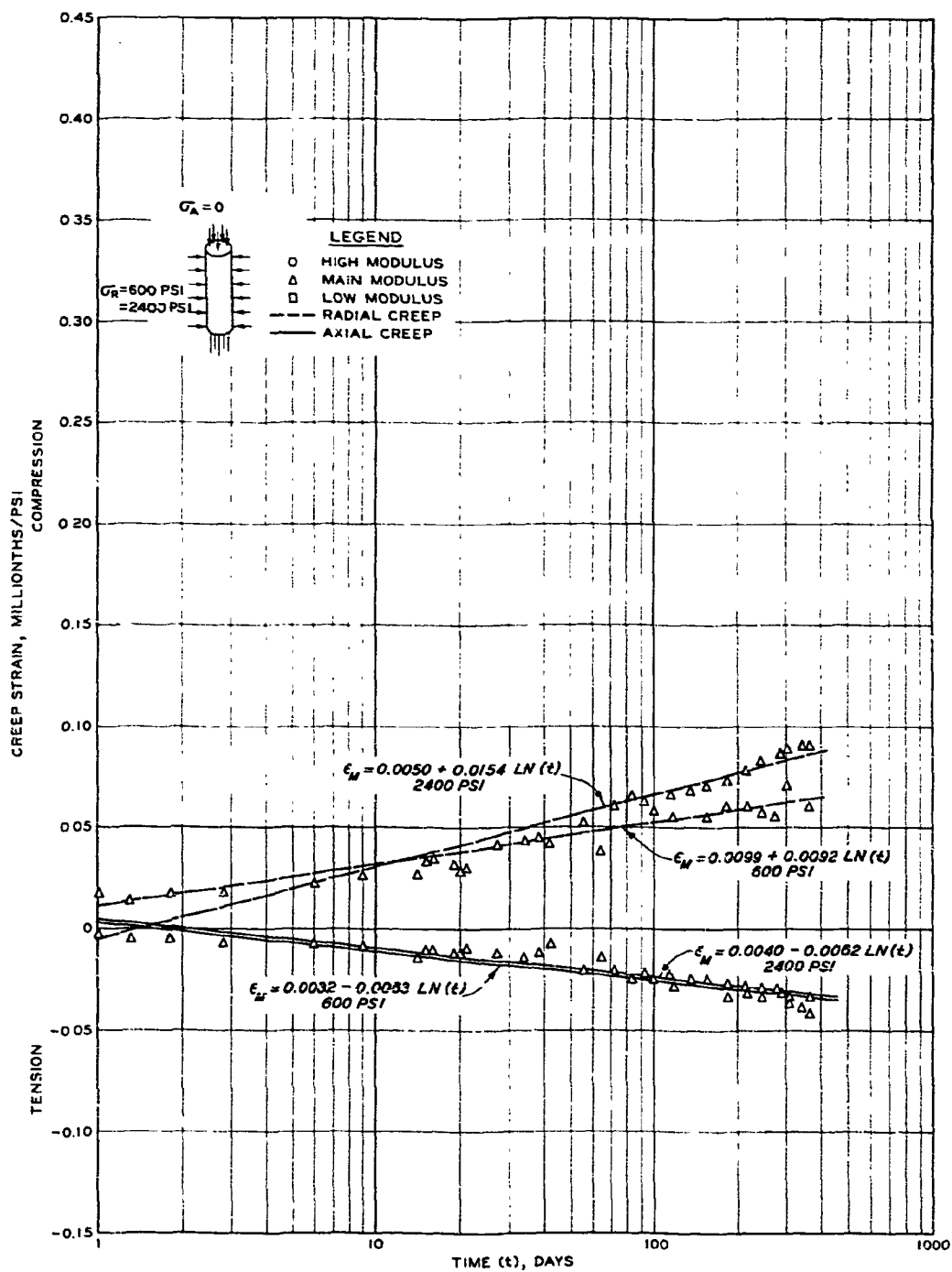
**CREEP STRAIN - TIME RELATIONS
FOR UNIAXIALY LOADED AIR-DRIED
SPECIMENS AT 150° F**



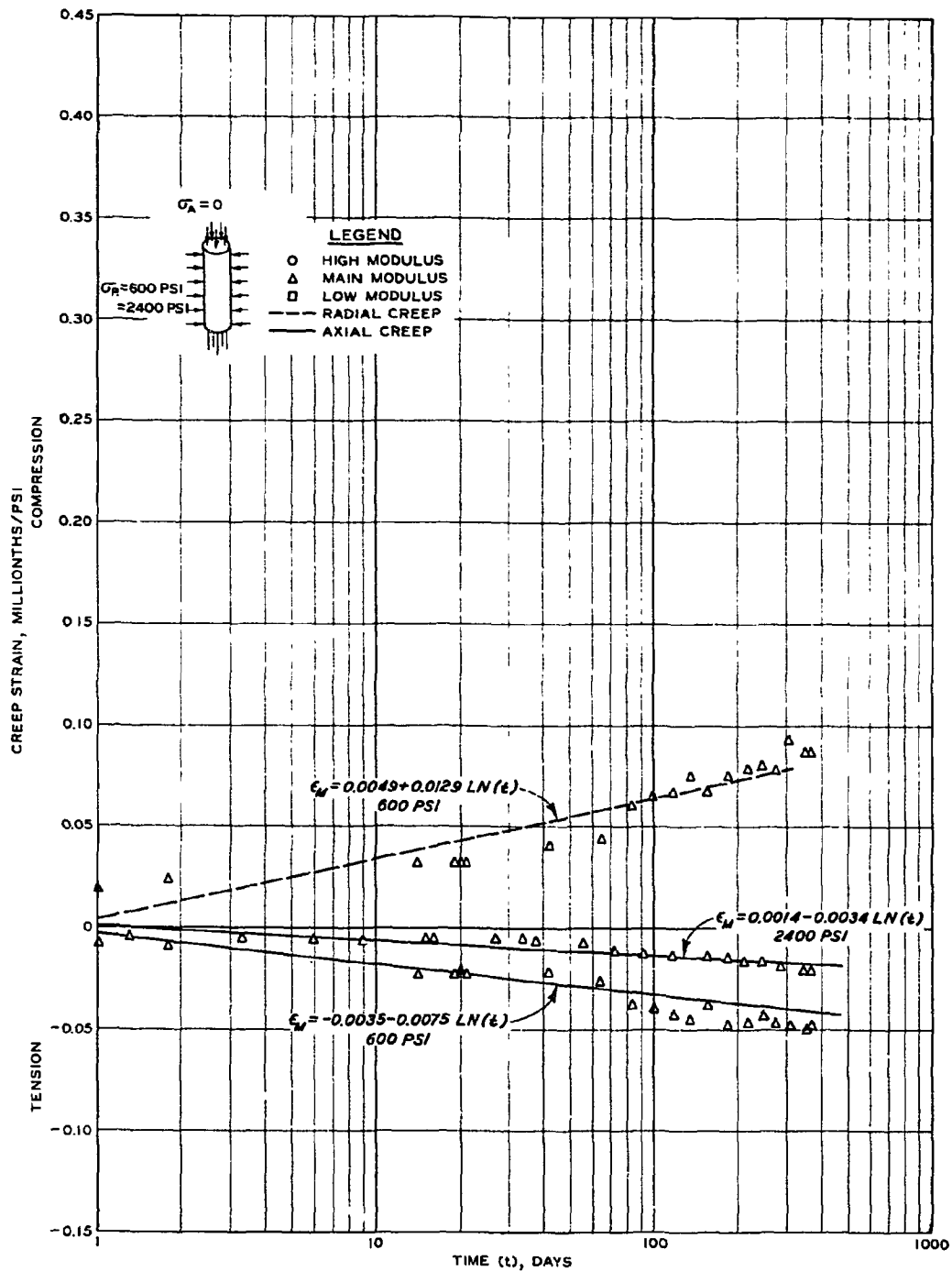
**CREEP STRAIN - TIME RELATIONS
 FOR HYDROSTATICALLY LOADED AS-CAST
 SPECIMENS AT 73° AND 150° F**



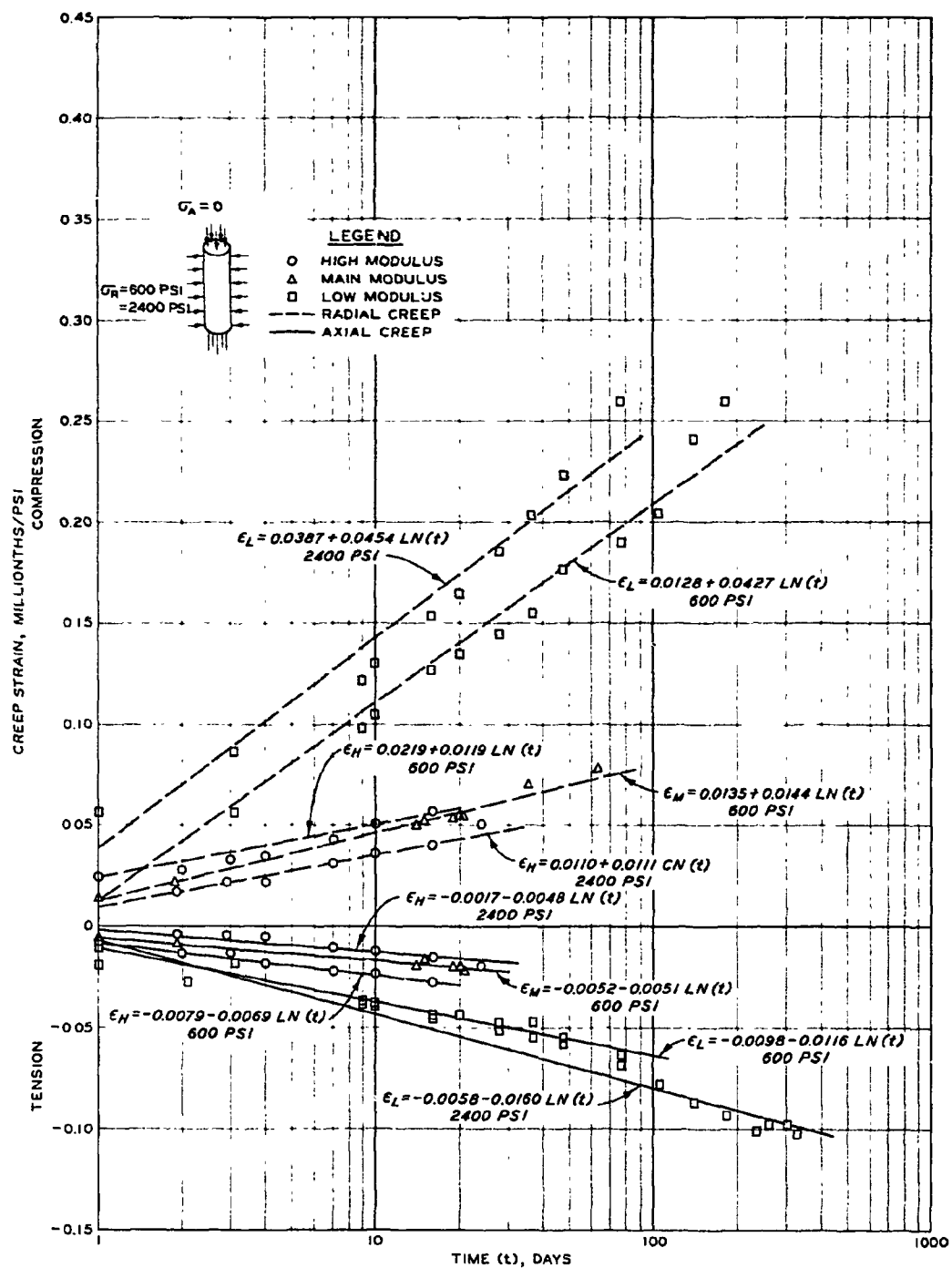
**CREEP STRAIN - TIME RELATIONS
 FOR HYDROSTATICALLY LOADED AIR-DRIED
 SPECIMENS AT 73° AND 150° F**



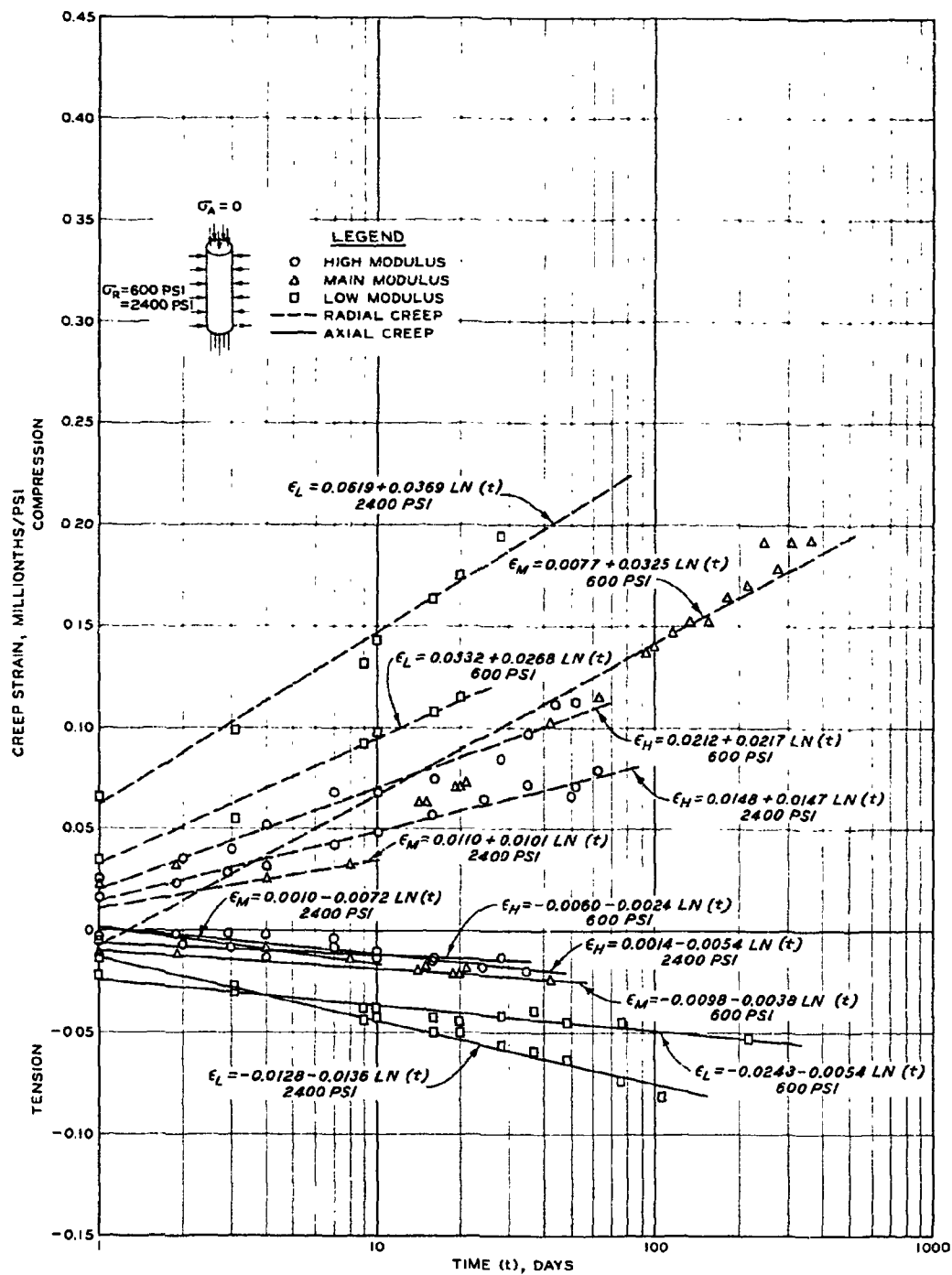
**CREEP STRAIN - TIME RELATIONS
FOR BIAXIALLY LOADED AS-CAST
SPECIMENS AT 73° F**



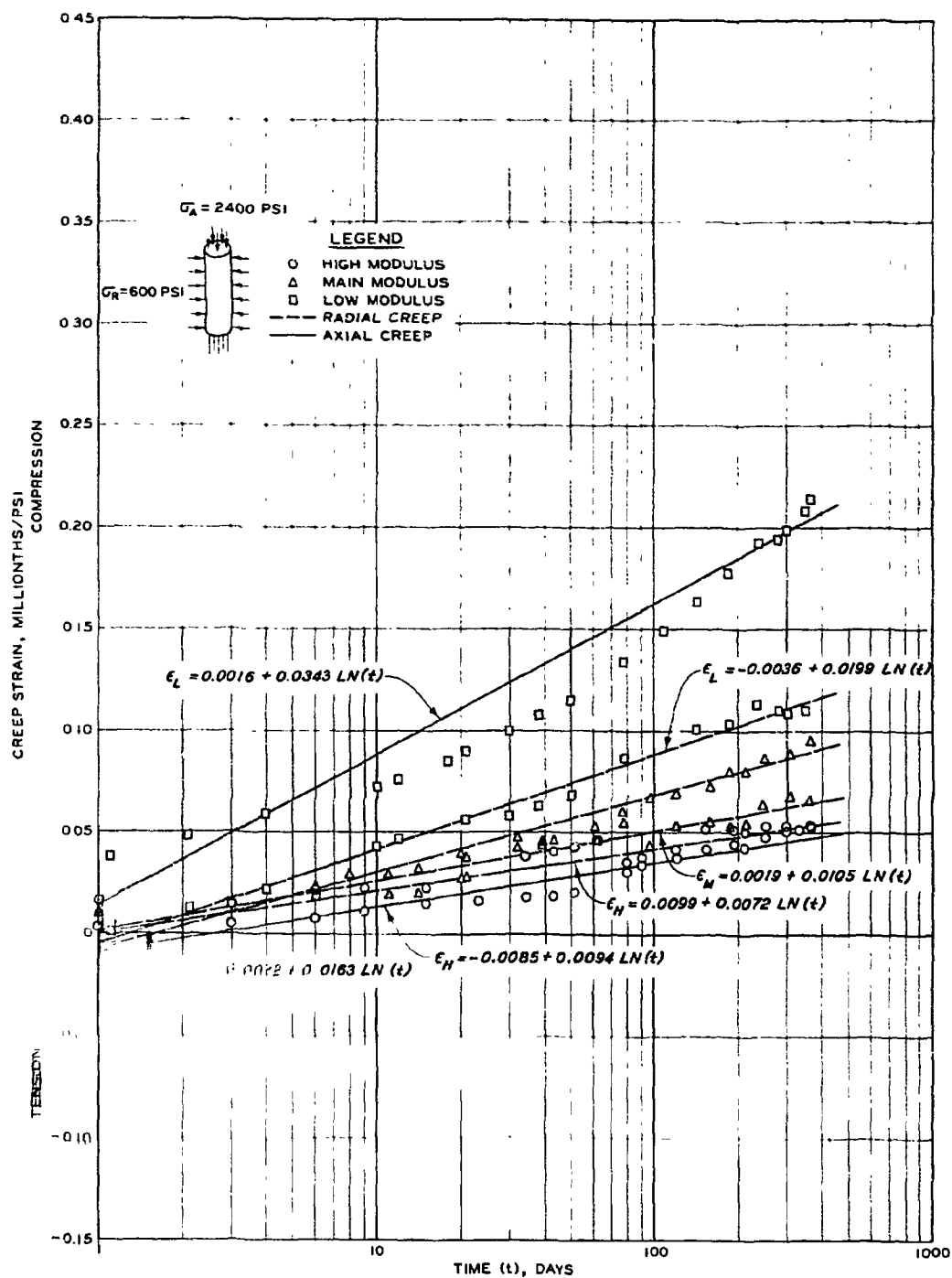
CREEP STRAIN - TIME RELATIONS
FOR BIAXIALLY LOADED AIR-DRIED
SPECIMENS AT 73° F



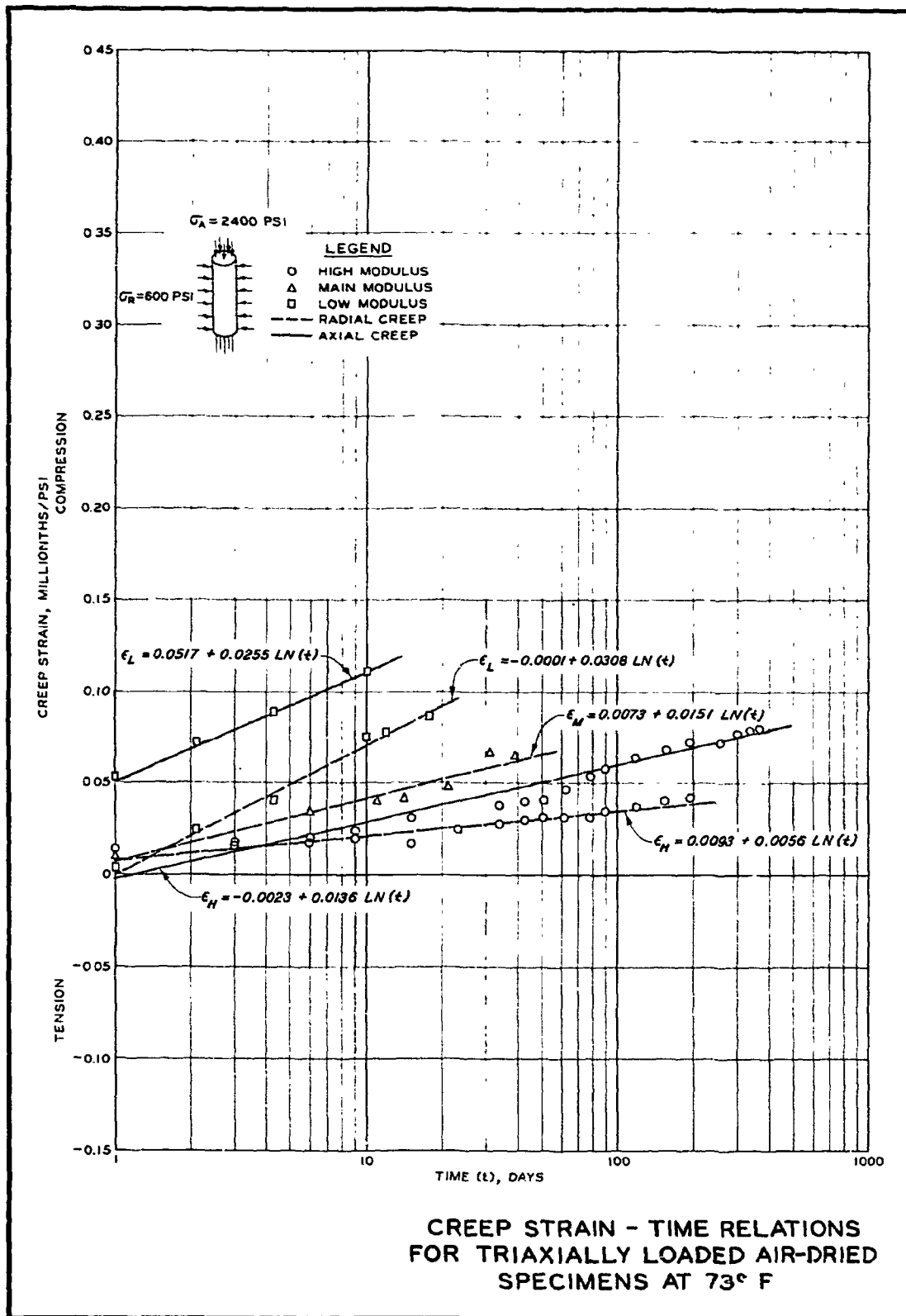
CREEP STRAIN - TIME RELATIONS
FOR BIAXIALLY LOADED AS-CAST
SPECIMENS AT 150° F

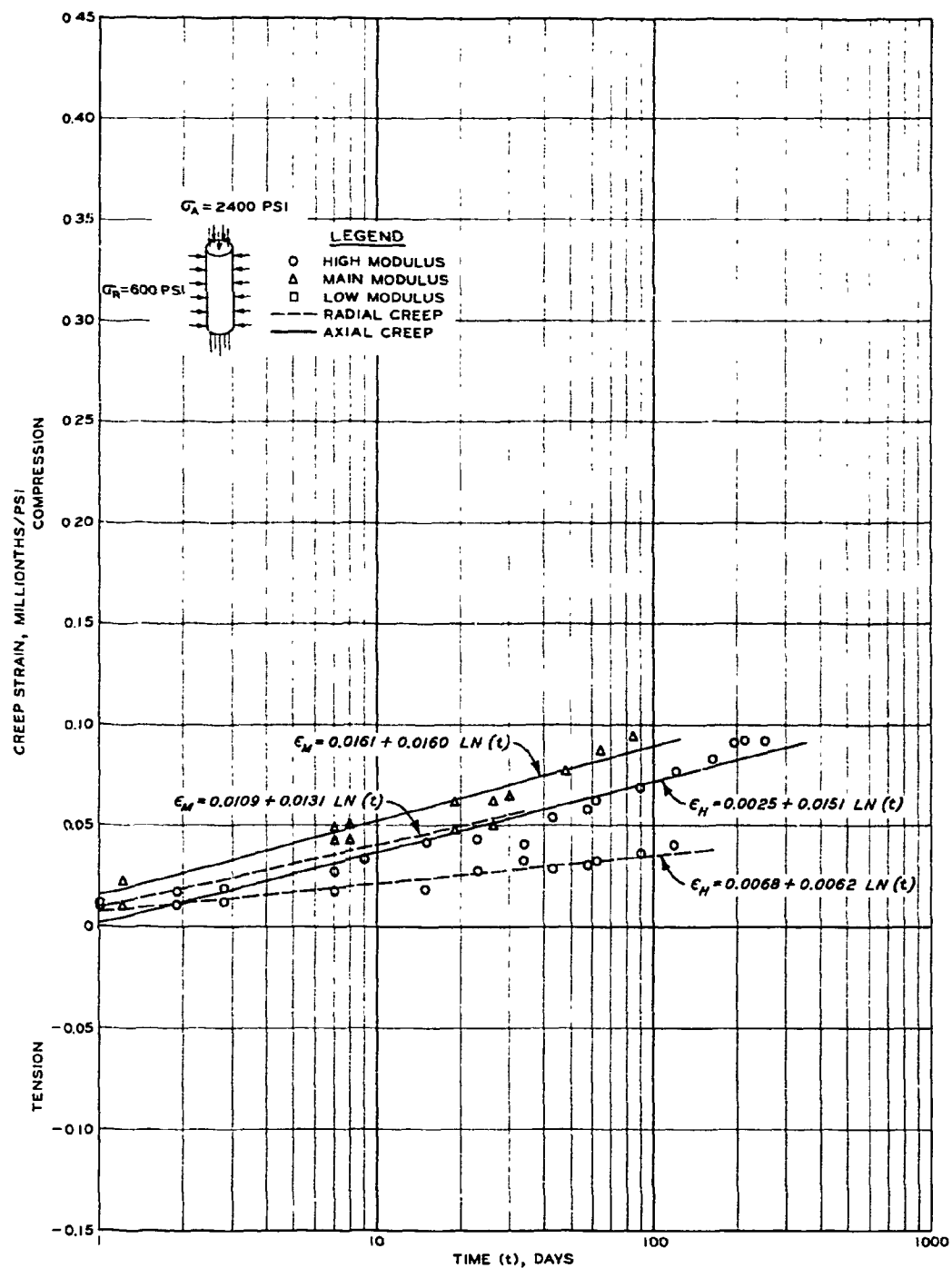


**CREEP STRAIN - TIME RELATIONS
FOR BIAXIALLY LOADED AIR-DRIED
SPECIMENS AT 150° F**

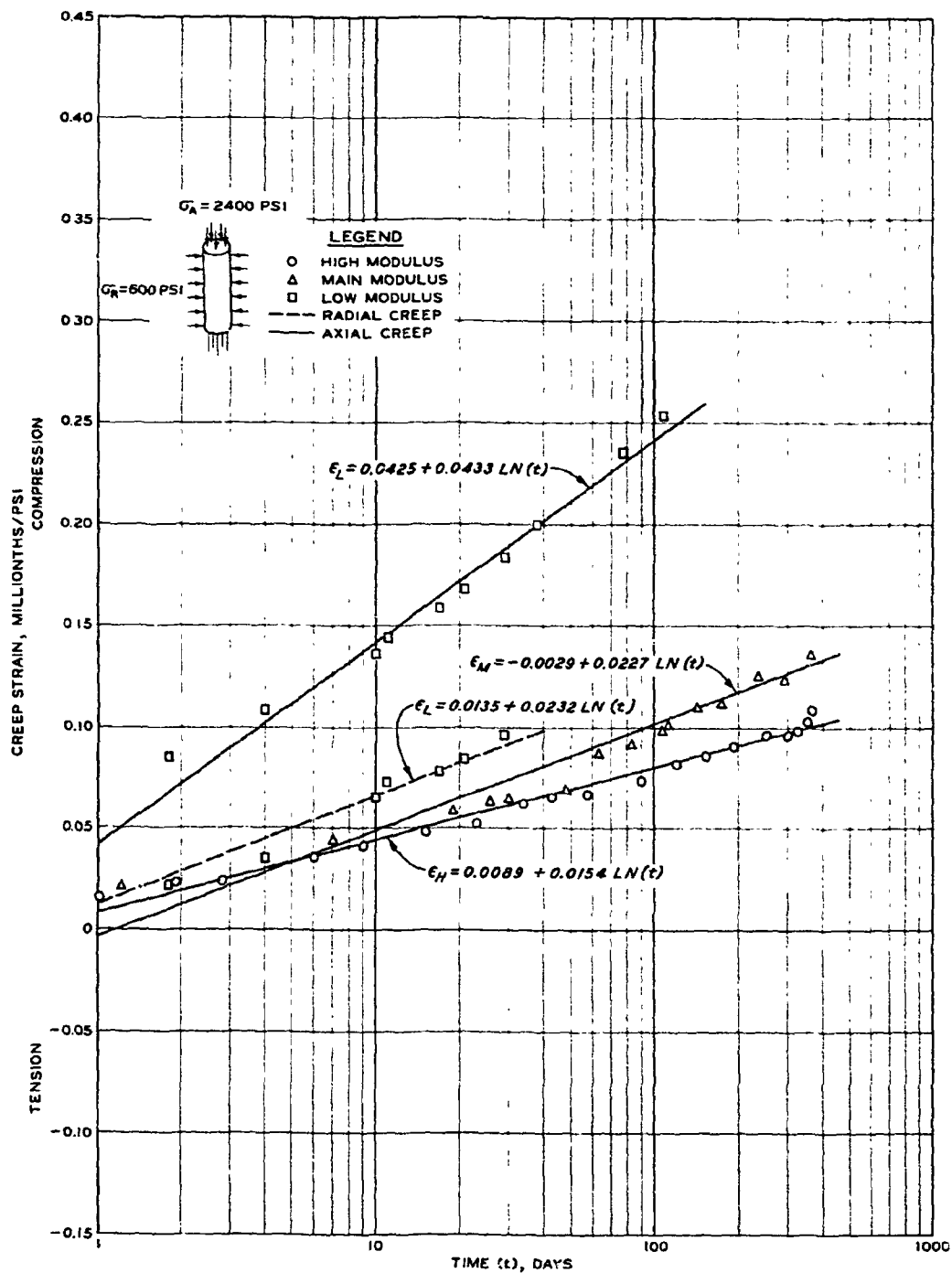


CREEP STRAIN - TIME RELATIONS
 FOR TRIAXIALLY LOADED AS-CAST
 SPECIMENS AT 73° F





**CREEP STRAIN - TIME RELATIONS
FOR TRIAXIALLY LOADED AS-CAST
SPECIMENS AT 150° F**



CREEP STRAIN - TIME RELATIONS
FOR TRIAXIALLY LOADED AIR-DRIED
SPECIMENS AT 150° F

APPENDIX A
CONCRETE MATERIALS AND
MIXTURE PROPORTIONS

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STATE Miss		INDEX NO.		AGGREGATE DATA SHEET		TESTED BY. USAEWED	
LAT. 31		LONG 90		DATE 16 November 1967			
LAB SYMBOL NO. WES-1 G-5(16)				TYPE OF MATERIAL Natural gravel			
LOCATION. Bayou Pierre Creek, Carpenter, Miss.							
PRODUCER Traxler Gravel Company, Utica, Miss.							
SAMPLED BY.							
TESTED FOR							
USED AT:							
PROCESSING BEFORE TESTING.							
GEOLOGICAL FORMATION AND AGE. Chert							

GRADING (CRD-C 103) (CUM. % PASSING)						TEST RESULTS																									
SIEVE	3-6"	1 1/2"-3	3/4"-1 1/2"	#4-3/8"	FINE AGG.	3-6"	1 1/2"-3	3/4"-1 1/2"	#4-3/8"	FINE AGG.																					
						BULK SP GR, S.S.D. (CRD-C 107, 108)					2.52																				
6 IN.						ABSORPTION, % (CRD-C 107, 108)					2.6																				
5 IN.						ORGANIC IMPURITIES, FIG. NO. (CRD-C 121)																									
4 IN.						SOFT PARTICLES, % (CRD-C 130)																									
3 IN.						% LIGHTER THAN SP GR (CRD-C 122)																									
2 1/2 IN.						% FLAT AND ELONGATED (CRD-C 119, 120)																									
2 IN.						WT AV % LOSS, 5 CYC M ₂ SO ₄ (CRD-C 115)																									
1 1/2 IN.						L.A. ABRASION LOSS, % (CRD-C 117, 145) GRADING																									
1 IN.						UNIT WT, LB/CU FT (CRD-C 106)																									
3/4 IN.					100	FRIABLE PARTICLES, % (CRD-C 142)																									
3/8 IN.					73	SPEC HEAT, BTU/LB DEG F. (CRD-C 124)																									
3/16 IN.					39	REACTIVITY WITH NaOH					SE, MM/L																				
NO. 4					0	(CRD-C 128)					RE, MM/L																				
NO. 8																															
NO. 16						MORTAR-MAKING PROPERTIES (CRD-C 116)																									
NO. 30						TYPE CEMENT, RATIO: DAYS: DAYS:																									
NO. 50						LINEAR THERMAL EXPANSION, MILLIONTHS DEG F (CRD-C 125, 126)																									
NO. 100						<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <th>ROCK TYPE</th> <th>PARALLEL</th> <th>ACROSS</th> <th>ON</th> <th>AVERAGE</th> </tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </table>					ROCK TYPE	PARALLEL	ACROSS	ON	AVERAGE																
ROCK TYPE	PARALLEL	ACROSS	ON	AVERAGE																											
NO. 200																															
-200 (a)																															
F.W. (b)																															

(a) CRD-C 106		(b) CRD-C 104		MORTAR							
MORTAR-BAR EXPANSION AT 100F, % (CRD-C 123):				FINE AGGREGATE				COARSE AGGREGATE			
				2 MO.	6 MO.	9 MO.	12 MO.	3 MO.	6 MO.	9 MO.	12 MO.
LOW-ALK. CEMENT. % Na ₂ O EQUIVALENT											
HIGH-ALK. CEMENT. % Na ₂ O EQUIVALENT:											
SOUNDNESS IN CONCRETE (CRD-C 40, 114).								F&T	HW-CD	HD-CW	
FINE AGG.				COARSE AGG.				DFE ₃₀₀			
FINE AGG.				COARSE AGG.				DFE ₃₀₀			
PETROGRAPHIC DATA (CRD-C 127):											
REMARKS:											

STATE Miss		INDEX NO.		AGGREGATE DATA SHEET		TESTED BY: USAEWES	
LAT 31N		LONG 89W		DATE: 16 November 1967			
LAB SYMBOL NO WES-1 S-4(47)				TYPE OF MATERIAL Natural sand			
LOCATION Sec 13, T4N, R13W, Forrest County, NE of Hattiesburg, Miss.							
PRODUCER American Sand and Gravel Company, Hattiesburg, Miss.							
SAMPLED BY USAEWES							
TESTED FOR:							
USED AT:							
PROCESSING BEFORE TESTING							
GEOLOGICAL FORMATION AND AGE							

GRADING (CRD-C 103) (CUM. % PASSING):						TEST RESULTS																													
SIEVE	3/6"	1 1/2"	3/4"	20-40"	FINE AGG.	3-0"	1 1/2-3"	3/4-1 1/2"	20-40"	FINE AGG.																									
						BULK SP. GR. S.S.D. (CRD-C 107, 108)				2.63																									
5 IN.						ABSORPTION, % (CRD-C 107, 108)				0.5																									
5 IN.						ORGANIC IMPURITIES, FIG. NO. (CRD-C 121)																													
4 IN.						SOFT PARTICLES, % (CRD-C 130)																													
3 IN.						% LIGHTER THAN SP. GR. (CRD-C 122)																													
2 1/2 IN.						% FLAT AND ELONGATED (CRD-C 119, 120)																													
2 IN.						WT. AV. % LOSS, 5 CYC N ₂ O ₅ (CRD-C 115)																													
1 1/2 IN.						L.A. ABRASION LOSS, % (CRD-C 117, 145) GRADING																													
1 IN.						UNIT WT. LB./CU. FT. (CRD-C 106)																													
3/4 IN.						FRIABLE PARTICLES, % (CRD-C 142)																													
3/8 IN.						SPEC. HEAT, BTU/LB./DEG. F. (CRD-C 124)																													
3/16 IN.					100	REACTIVITY WITH NaOH				SC, MM/L:																									
NO. 4					98	CRD-C 128:				RC, MM/L:																									
NO. 6					85																														
NO. 16					66	MORTAR-MAKING PROPERTIES (CRD-C 116)																													
NO. 30					45	TYPE _____ CEMENT, RATIO: _____ DAYS, _____ %, _____ DAYS, _____ %																													
NO. 50					20	LINEAR THERMAL EXPANSION, MILLIONTHS/DEG. F. (CRD-C 125, 126):																													
NO. 100					6	<table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th>ROCK TYPE</th> <th>PARALLEL</th> <th>ACROSS</th> <th>ON</th> <th>AVERAGE</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table>					ROCK TYPE	PARALLEL	ACROSS	ON	AVERAGE																				
ROCK TYPE	PARALLEL	ACROSS	ON	AVERAGE																															
NO. 200					4.1																														
-200 (a)					2.81																														
F.M. (b)																																			

(a) CRD-C 105		(b) CRD-C 104		MORTAR								
MORTAR-BAR EXPANSION AT 100F, % (CPD-C 123):				FINE AGGREGATE				COARSE AGGREGATE				
				2 MO.	6 MO.	9 MO.	12 MO.	3 MO.	6 MO.	9 MO.	12 MO.	
LOW-ALK. CEMENT % Na ₂ O EQUIVALENT:												
HIGH-ALK. CEMENT % Na ₂ O EQUIVALENT:												
SOUNDNESS IN CONCRETE (CRD-C 40, 114):										F&T	HW-CD	WD-CW
FINE AGG.				COARSE AGG:				DFE ₁₀₀				
FINE AGG.				COARSE AGG:				DFE ₃₀₀				
PETROGRAPHIC DATA (CRD-C 127):												
REMARKS:												

STATE: <u>MISSISSIPPI</u>		AGGREGATE DATA SHEET		USADWES	
LAT. <u>36</u>	LONG. <u>86</u>	DATE: <u>16 November 1967</u>			
LAB SYMBOL NO.: <u>CRD G-31(7)(8), CRD MS-17(5)</u>			TYPE OF MATERIAL <u>Limestone</u>		
LOCATION: <u>Lat 36°10', Long 86° 35', off Hwy 70 N at Stone River, on Central Pike, near junction of Chandler Road</u>					
PRODUCER: <u>Lambert Division, Vulcan Materials Co., Hermitage, Tenn., Plant.</u>					
SAMPLED BY:					
TESTED FOR:					
USED AT:					
PROCESSING BEFORE TESTING:					
GEOLOGICAL FORMATION AND AGE <u>Carter Limestone - Ordovician</u>					

GRADING (CRD-C 103) (CUM. % PASSING):						TEST RESULTS																								
SIEVE	3-6"	1 1/2-3"	1-1 1/2"	3/4-1"	FINE AGG.	3-6"	1 1/2-3"	1-1 1/2"	3/4-1"	FINE AGG.																				
0 IN.						BULK SP GR, S.S.D. (CRD-C 107, 108)				2.71																				
5 IN.						ABSORPTION, % (CRD-C 107, 108)				0.5																				
4 IN.						ORGANIC IMPURITIES, FIG. NO. (CRD-C 121)																								
3 IN.						SOFT PARTICLES, % (CRD-C 130)																								
2 1/2 IN.						% LIGHTER THAN SP GR (CRD-C 122)																								
2 IN.						% FLAT AND ELONGATED (CRD-C 119, 120)																								
1 1/2 IN.						WT AV % LOSS, 5 CYC M ₂ SO ₄ (CRD-C 115)				7.9																				
1 IN.						L.A. ABRASION LOSS, % (CRD-C 117, 143) GRADING																								
3/4 IN.				100		UNIT WT, LB/CU FT (CRD-C 106)																								
3/8 IN.				99		FRIABLE PARTICLES, % (CRD-C 142)																								
1/2 IN.				70		SPEC HEAT, BTU/LB/DEG F. (CRD-C 124)																								
1/4 IN.				41	100	REACTIVITY WITH N80H	SC, MM/L:																							
NO. 4				0	98	ICRD-C 128):	RC, MM/L:																							
NO. 8					84																									
NO. 16					64	MORTAR-MAKING PROPERTIES (CRD-C 116)																								
NO. 30					47	TYPE _____ CEMENT, RATIO: _____ DAYS, _____ DAYS, _____																								
NO. 50					24	LINEAR THERMAL EXPANSION, MILLIONTHS/DEG F. (CRD-C 125, 126)																								
NO. 100					8	<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <th>ROCK TYPE</th> <th>PARALLEL</th> <th>ACROSS</th> <th>ON</th> <th>AVERAGE</th> </tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </table>					ROCK TYPE	PARALLEL	ACROSS	ON	AVERAGE															
ROCK TYPE	PARALLEL	ACROSS	ON	AVERAGE																										
NO. 200																														
-200 (b)					4.2																									
F.M. (b)					2.75																									

101 CRD-C 105		102 CRD-C 104		MORTAR:							
MORTAR-BAR EXPANSION AT 100F, % (CRD-C 123):				FINE AGGREGATE				COARSE AGGREGATE			
				2 MO.	6 MO.	9 MO.	12 MO.	3 MO.	6 MO.	9 MO.	12 MO.
LOW-ALK. CEMENT: % N ₂ O EQUIVALENT:											
HIGH-ALK. CEMENT: % N ₂ O EQUIVALENT:											
SOUNDNESS IN CONCRETE (CRD-C 40, 114):								F&T	HW-CD	HD-CW	
FINE AGG.				COARSE AGG:				DFE ₃₀₀			
FINE AGG.				COARSE AGG:				DFE ₃₀₀			
PETROGRAPHIC DATA (CRD-C 127):											
REMARKS:											

STATE Al	INDEX NO.	AGGREGATE DATA SHEET	TESTED BY. USAEWES	
LAT	LONG		DATE 16 November 1967	
LAB SYMBOL NO. MOB-19 G-1(4)		TYPE OF MATERIAL Eutaw graywacke		
LOCATION Stockpile 1-1/4 mi above Lock 14 on Warrior River				
PRODUCER Franklin Limestone Company, Eutaw, Al Shook's Quarry				
SAMPLED BY Mobile District				
TESTED FOR:				
USED AT:				
PROCESSING BEFORE TESTING				
GEOLOGICAL FORMATION AND AGE Pottsville Formation of Pennsylvanian Age				

GRADING (CRD-C 103) (CUM. % PASSING)						TEST RESULTS				
SIEVE	3/8"	1/2"	3/4"	#4"	FINE AGG.	3/8"	1/2"	3/4"	#4"	FINE AGG.
						BULK SP GR, S.S.D. (CRD-C 107, 108)				2.59
6 IN.						ABSORPTION, % (CRD-C 107, 108)				2.3
5 IN.						ORGANIC IMPURITIES, FIG. NO. (CRD-C 121)				
4 IN.						SOFT PARTICLES, % (CRD-C 130)				
3 IN.						% LIGHTER THAN SP GR. (CRD-C 122)				
2 1/2 IN.						% FLAT AND ELONGATED (CRD-C 119, 120)				
2 IN.						WT AV % LOSS, 5 CYC M ₉₀₀ (CRD-C 115)				
1 1/2 IN.						L.A. ABRASION LOSS, % (CRD-C 117, 145) GRADING				
1 IN.						UP. T WT. LB./CU FT (CRD-C 105)				
3/4 IN.				100		FRIABLE PARTICLES, % (CRD-C 142)				
3/8 IN.				75		SP. C HEAT, BTU/LB/DEG F. (CRD-C 124)				
3/16 IN.				43	100	REACTIVITY WITH NaOH	SE, MM/L:			
NO. 4				1	98	(CRD-C 128)	RE, MM/L:			
NO. 8					84					
NO. 16					65	MORTAR-MAKING PROPERTIES (CRD-C 116)				
NO. 30					43	TYPE CEMENT, RATIO: _____ DAYS. _____ %				
NO. 50					23	LINEAR THERMAL EXPANSION, MILLIONTHS/DEG F. (CRD-C 125, 126):				
NO. 100					9					
NO. 200										
-200 (a)					8.3					
F.M. (b)					2.78					

(a) CRD-C 105		(b) CRD-C 104		MORTAR:								
MORTAR-BAR EXPANSION AT 100F, % (CRD-C 123):				FINE AGGREGATE				COARSE AGGREGATE				
				2 MO.	6 MO.	9 MO.	12 MO.	3 MO.	6 MO.	9 MO.	12 MO.	
LOW-ALK. CEMENT: _____ % M ₉₀₀ EQUIVALENT:												
HIGH-ALK. CEMENT: _____ % M ₉₀₀ EQUIVALENT:												
SOUNDNESS IN CONCRETE (CRD-C 40, 114):										F&T	HW-CO	HD-CW
FINE AGG.				COARSE AGG:				D.F. E ₃₀₀				
FINE AGG.				COARSE AGG:				D.F. E ₃₀₀				
PETROGRAPHIC DATA (CRD-C 127):												
REMARKS.												

REPORT OF SELECTION OF CONCRETE MIXTURE PROPORTIONS (CRD-C 3)			
PROJECT NAME Triaxial Creep Tests		SYMBOL SERIAL NO.	DATE 5 Dec 67
CONCRETE REQUIRED FOR: Test specimens (high modulus)		MIXTURE NO.	
MATERIALS			
PORTLAND CEMENT, 35-C-192. TYPE II ADDITIONS: BRAND AND MILL: Alpha, Birmingham		POZZOLON OR OTHER CEMENT. TYPE SOURCE.	AIR ENT. ADMIXTURE TYPE None AMOUNT ¹ .
FINE AGGREGATE		COARSE AGGREGATE	
TYPE Natural		TYPE Natural SIZE 3/4 in.	
SOURCE American Sand and Gravel Co.		SOURCE American Sand and Gravel Co.	
MATERIALS	SAMPLE SERIAL NO.	SIZE RANGE	COARSE AGGR. (Y)
PORTLAND CEMENT	RC-586		
FINE AGGREGATE	WES-1 S-4(47)	--	
COARSE AGGREGATE (A)	WES-1 C-5(16)	No. 4	38
COARSE AGGREGATE (B)	WES-1 C-5(16)	3/8 in.	31
COARSE AGGREGATE (C)	WES-1 C-5(16)	1/2 in.	31
COARSE AGGREGATE (D)			
MIXTURE DATA		SPECIMEN DATA	
MATERIALS	MIX. BY WEIGHT	S. S. D. WEIGHTS ONE CU YD BATCH (LB)	SOLID VOL ONE CU YD (CU FT)
PORTLAND CEMENT	1.00	784.9	4.000
FINE AGGREGATE	1.57	1234.4	7.534
COARSE AGGREGATE (A)	0.86	674.3	4.295
COARSE AGGREGATE (B)	0.70	550.1	3.504
COARSE AGGREGATE (C)	0.70	550.0	3.503
COARSE AGGREGATE (D)			
WATER	0.33	259.43	4.164
AIR			
TOTAL		27.000	
W/C (WT): 0.33		S/A, % VOLUME: 40	
SLUMP (IN.) ⁴ : 1-3/4		THEO. UNIT WT (LB/CU FT):	
BLEEDING (%) ²		ACTUAL UNIT WT (LB/CU FT):	
AIR CONTENT (%) ³		THEO. CEMENT FACT (LB/CU YD):	
AIR CONTENT (%) ⁴		ACTUAL CEMENT FACT (LB/CU YD): 8.35	
¹ Calculated on the basis of: ² Expressed as the percentage of mixing water separating from the concrete when tested by CRD-C 9. ³ In the entire batch as mixed. ⁴ In that portion of the concrete containing aggregate smaller than the 1-1/2-in. sieve. [*] For "other cement," pozzolon, second size of fine aggregate, as may be required.			
REMARKS: Condition of mix, workability, plasticity, bleeding, etc.			
Specimens No. 210-212 Rd No. 1 Specimens No. 216-218 Rd No. 2			

REPORT OF SELECTION OF CONCRETE MIXTURE PROPORTIONS (CRD-C 3)							
PROJECT NAME Triaxial Creep Tests	SYMBOL SERIAL NO. 5 Dec 67						
CONCRETE REQUIRED FOR Test specimens (main modulus)							
MATERIALS							
PORTLAND CEMENT, SS-C-192, TYPE II ADDITIONS BRAND AND MILL Alpha, Birmingham	POZZOLON OR OTHER CEMENT TYPE None SOURCE						
AIR ENT. ADMIXTURE TYPE None AMOUNT							
FINE AGGREGATE	COARSE AGGREGATE						
TYPE Limestone SOURCE Vulcan Materials Company	TYPE Limestone SIZE 3/4 in. SOURCE Vulcan Materials Company						
MATERIALS	SAMPLE SERIAL NO	SIZE RANGE	COARSE AGGR (%)	BULK SP GR (SSD)	ABSORP *		
PORTLAND CEMENT	RC-586			3.15			
FINE AGGREGATE	CRD MS-17(5)	--		2.67	1.3		
COARSE AGGREGATE (A)	CRD G-31(7)(8)	No. 4	30	2.71	0.5		
COARSE AGGREGATE (B)	CRD G-31(7)(8)	3/8 in.	35	2.71	0.5		
COARSE AGGREGATE (C)	CRD G-31(7)(8)	1/2 in.	35	2.71	0.5		
COARSE AGGREGATE (D)							
MIXTURE DATA			SPECIMEN DATA				
MATERIALS	MIX. BY WEIGHT	S. S. D. WEIGHTS ONE CU YD BATCH (LB)	SOLID VOL ONE CU YD (CU FT)	CYLINDERS		BEAMS	
				SIZE: 6 by 12 in.		SIZE	
PORTLAND CEMENT	1.00	681.5	3.473	NO.	AGE	PSI	
				138	28	5750	
				139	28	6190	
FINE AGGREGATE	2.03	1381.5	8.305	140	28	6050	
COARSE AGGREGATE (A)	0.79	535.4	3.171	150	28	6200	
COARSE AGGREGATE (B)	0.92	624.5	3.699	151	28	5860	
COARSE AGGREGATE (C)	0.92	624.5	3.699	152	28	5890	
COARSE AGGREGATE (D)				Avg		5990	
WATER	0.425	289.86	4.653				
AIR							
TOTAL			27.000				
W/C (WT): 0.425			S/A % VOLUME: 44				
SLUMP (IN) ⁴ 2			THEO. UNIT WT (LB/CU FT):				
BLEEDING (%) ²			ACTUAL UNIT WT (LB/CU FT):				
AIR CONTENT (%) ³			THEO. CEMENT FACT (LB/CU YD):				
AIR CONTENT (%) ⁴			ACTUAL CEMENT FACT (LB/CU YD): 7.25				
¹ Calculated on the basis of: ² Expressed as the percentage of mixing water separating from the concrete when tested by CRD-C 9. ³ In the entire batch as mixed. ⁴ In that portion of the concrete containing aggregate smaller than the 1-1/2-in. sieve.							
* For "other cement," pozzolan, second size of fine aggregate, as may be required.							
REMARKS: Condition of mix, workability, plasticity, bleeding, etc.							
Specimens No. 138-140 Rd No. 1							
Specimens No. 150-152 Rd No. 2							

REPORT OF SELECTION OF CONCRETE MIXTURE PROPORTIONS (CRD-C 3)									
PROJECT NAME Triaxial Creep Tests	SYMBOL SERIAL NO. DATE 5 Dec 67								
CONCRETE REQUIRED FOR: Test specimens (low modulus)									
MATERIALS									
PORTLAND CEMENT, 55-C-192, TYPE II ADDITIONS: BRAND AND MILL Alpha, Birmingham	POZZOLON OR OTHER CEMENT TYPE None SOURCE:								
AIR ENT. ADMIXTURE TYPE None AMOUNT ¹ :									
FINE AGGREGATE	COARSE AGGREGATE								
TYPE: Greywacke	TYPE: Greywacke SIZE 3/4 in.								
SOURCE Franklin Limestone Company	SOURCE Franklin Limestone Company								
MATERIALS	SAMPLE SERIAL NO.	SIZE RANGE	COARSE AGGR (%)	BULK SP GR (SSD)	ABSORP %				
PORTLAND CEMENT	RC-586			3.15					
•									
•									
FINE AGGREGATE	MOB-19 G-1(4)s			2.59	2.5				
COARSE AGGREGATE (A)	MOB-19 G-1(4)	No. 4	33	2.59	2.3				
COARSE AGGREGATE (B)	MOB-19 G-1(4)	3/8 in.	32	2.59	2.3				
COARSE AGGREGATE (C)	MOB-19 G-1(4)	1/2 in.	35	2.59	2.3				
COARSE AGGREGATE (D)									
MIXTURE DATA			SPECIMEN DATA						
MATERIALS	MIX. BY WEIGHT	S. S. D. WEIGHTS ONE CU YD BATCH (LB)	SOLID VOL ONE CU YD (CU FT)	CYLINDERS		BEAMS			
				SIZE: 6 by 12 in.		SIZE:			
PORTLAND CEMENT	1.00	775.5	3.952	NO.	AGE	PSI	NO.	AGE	PSI
•				198	28	6180			
•				199	28	6280			
FINE AGGREGATE	1.58	1224.1	7.586	200	28	6280			
COARSE AGGREGATE (A)	0.69	535.6	3.319	207	28	6110			
COARSE AGGREGATE (B)	0.67	519.3	3.218	208	28	6120			
COARSE AGGREGATE (C)	0.73	568.0	3.520	209	28	6140			
COARSE AGGREGATE (D)				Avg		6180			
WATER	0.43	336.76	5.405						
AIR									
TOTAL			27.000						
W/C (WT): 0.43			S/A. % VOLUME: 43						
SLUMP (IN.) ⁴ : 2			THEO. UNIT WT (LB/CU FT):						
BLEEDING (%) ² :			ACTUAL UNIT WT (LB/CU FT):						
AIR CONTENT (%) ³ :			THEO. CEMENT FACT (LB/CU YD):						
AIR CONTENT (%) ⁴ :			ACTUAL CEMENT FACT (LB/CU YD): 8.25						
¹ Calculated on the basis of: ² Expressed as the percentage of mixing water separating from the concrete when tested by CRD-C 9. ³ In the entire batch as mixed. ⁴ In that portion of the concrete containing aggregate smaller than the 1-1/2-in. sieve. [*] For "other cement," pozzolan, second size of fine aggregate, as may be required.									
REMARKS: Condition of mix, workability, plasticity, bleeding, etc.									
Specimens No. 198-200 Rd No. 1 Specimens No. 207-209 Rd No. 2									

APPENDIX B
CONTROL STRAINS
BEFORE AND AFTER LOADING

Table B1

Control Strains Before Loading
Batch I, High Modulus

Time, days	AC						AD					
	Strain, millionths						Strain, millionths					
	Axial			Radial			Axial			Radial		
	E-29	A-29	Avg	E-30	A-30	Avg	F-25	B-29	Avg	F-26	B-30	Avg
0	23	-12	6	-38	-38	-38	5	12	8	-20	-16	-18
4	14	-36	-11	-44	-48	-46	-5	1	-2	-23	-29	-26
1	17	-31	-7	-35	-38	-36	-3	4	1	-10	-9	-10
2	25	-25	0	-30	-26	-28	-12	-10	-11	-13	-22	-18
3	-15	-14	-14	-20	-18	-19	-10	-10	-10	12	-18	-3
4	-10	-11	-10	-20	-12	-16	-8	-6	-7	-8	-13	-10
7	0	0	0	0	0	0	0	0	0	0	0	0
10	4	5	4	7	7	7	46	46	46	18	19	18
15	7	11	9	16	14	15	75	75	75	37	43	40
21	8	18	13	23	19	21	97	95	96	50	58	54
31	7	23	15	28	22	25	112	111	112	61	75	68
85	3	31	17	42	26	34	168	160	164	99	129	114
89	3	--	--	47	--	--	165	--	--	98	--	--
90	3	--	--	47	--	--	165	--	--	100	--	--

Table B2

Control Strains Before Loading
Batch IV, High Modulus

Time, days	AC						AD					
	Strain, millionths						Strain, millionths					
	Axial			Radial			Axial			Radial		
	F-35	C-25	Avg	F-36	C-26	Avg	F-37	C-27	Avg	F-38	C-28	Avg
0	-29	--	--	-24	--	--	--	--	--	--	--	--
1	-20	-17	-18	-18	-18	-18	-3	7	2	8	-4	2
2	-6	-10	-8	-14	-12	-13	-4	0	-2	4	-7	-2
3	-10	-6	-8	-5	-6	-6	-6	3	-2	3	-7	-2
5	-8	25	8	-3	-32	-28	-6	3	-2	1	-6	-2
6	-4	1	-2	1	0	1	-4	0	-2	1	-6	-2
7	0	0	0	0	0	0	0	0	0	0	0	0
12	3	6	4	5	4	4	44	46	45	26	20	23
85	-10	-3	-6	-8	-12	-10	139	134	136	101	82	92
90	-10	12	1	-8	-35	-22	131	128	130	101	82	92

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Table B3

Control Strains Before Loading
Batch VII, High Modulus

Time, days	AC						AD					
	Strain, millionths						Strain, millionths					
	Axial			Radial			Axial			Radial		
	F-49	D-9	Avg	F-50	D-10	Avg	F-47	D-7	Avg	F-48	D-8	Avg
0	-19	-33	-26	-1	-22	-12	4	22	13	-44	-6	-25
1	-37	-49	-43	-17	-29	-23	-9	4	-2	-22	-6	-14
2	-30	-36	-33	-11	-21	-16	0	17	8	-7	6	0
3	-16	-23	-20	-19	-13	-16	-9	3	-3	-7	4	-2
4	-14	-12	-13	-5	-6	-6	-9	0	-4	-4	-4	-4
7	0	0	0	0	0	0	0	0	0	0	0	0
9	5	4	4	2	2	2	5	0	2	2	1	2
14	18	13	16	6	6	6	72	61	67	10	18	14
22	31	21	26	9	6	8	116	99	108	20	34	27
23	33	21	27	10	8	9	121	105	113	21	35	28
70	51	32	42	9	0	4	207	188	198	41	76	58
92	54	--		7	--		206	--		44	--	

Table B4

Control Strains Before Loading
Batch II, Main Modulus

Time days	AC						AD					
	Strain, millionths						Strain, millionths					
	Axial			Radial			Axial			Radial		
	F-27	C-17	Avg	F-28	C-18	Avg	F-29	C-19	Avg	F-30	C-20	Avg
0	-10	220	105	-25	-22	-24	48	27	38	35	30	32
1	-3	218	108	-15	-18	-16	39	38	38	41	20	30
2	-15	202	94	-27	-32	-30	8	20	14	10	-2	4
3	-10	-10	-10	-20	-21	-20	4	14	9	9	-1	4
5	-6	-4	-5	-10	-9	-10	1	14	8	10	3	6
6	-6	-1	-4	-5	-5	-5	-3	11	4	8	2	5
7	0	0	0	0	0	0	0	0	0	0	0	0
13	8	7	8	17	17	17	63	48	56	60	91	76
20	11	12	12	25	26	26	95	71	83	93	127	110
83	-4	0	-2	25	30	28	163	144	154	178	232	205
90	-3	--		25	--		155	--		179	--	

Table B5

Control Strains Before Loading
Batch VI, Main Modulus

Time, days	AC						AD					
	Strain, millionths						Strain, millionths					
	Axial			Radial			Axial			Radial		
	F-43	D-3	Avg	F-44	D-4	Avg	F-45	D-5	Avg	F-46	D-6	Avg
0	51	145	98	29	143	86	76	77	76	39	49	44
1	0	-11	-6	-8	-6	-7	80	24	52	44	11	28
2	-4	-12	-8	-8	-8	-8	13	13	13	0	6	3
5	0	-2	-1	0	-3	-2	3	3	3	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
12	14	18	16	22	22	22	70	72	71	36	47	42
41	10	28	19	23	40	32	152	149	150	89	103	96
85	-7	26	10	10	41	26	221	215	218	125	148	136
90	-4	--		15	--		222	--		133	--	

Table B6

Control Strains Before Loading
Batch III, Low Modulus

Time, days	AC						AD					
	Strain, millionths						Strain, millionths					
	Axial			Radial			Axial			Radial		
	F-31	C-21	Avg	F-32	C-22	Avg	F-33	C-23	Avg	F-34	C-24	Avg
0	-51	-33	-42	-53	-66	-60	30	63	46	51	31	41
1	-46	-47	-46	-36	-43	-40	22	33	28	31	25	28
2	-24	-25	-24	-22	-25	-24	14	21	18	17	19	18
3	-15	-14	-14	-16	-15	-16	8	16	12	14	14	14
5	-1	-6	-4	-4	-4	-4	1	7	4	10	10	10
7	0	0	0	0	0	0	0	0	0	0	0	0
13	16	10	13	16	19	18	171	176	174	143	131	137
20	23	14	18	24	25	24	257	267	262	207	194	200
84	15	-6	4	1	7	4	524	549	534	476	466	471
89	14	--		1	--		499	--		472	--	
90	14	--		1	--		495	--		471	--	

TABLE 27

Control Strains Before Loading
Batch VIII, Low Modulus

Time, days	AC						AD					
	Strain, millionths						Strain, millionths					
	Axial			Radial			Axial			Radial		
	F-51	D-11	Avg	F-52	D-12	Avg	F-53	D-13	Avg	F-54	D-14	Avg
0	-41	-47	-44	-53	-99	-76	45	57	51	36	-2	17
1	-67	-68	-68	-77	-71	-74	15	43	29	24	32	28
3	-31	-31	-31	-35	-32	-34	4	14	9	13	16	14
6	-4	--		-5	--		0	1	0	3	5	4
7	0	0	0	0	0	0	0	0	0	0	0	0
8	4	3	4	3	4	4	64	62	63	41	39	40
13	16	17	16	19	14	16	226	246	236	--	161	
22	24	25	24	29	18	24	353	396	374	--	250	
55	22	28	25	28	9	18	591	680	636	--	271	
79	22	28	25	16	5	10	668	786	727	--	--	
90	22	--		15	--		619	--		--	--	

Table B8

Control Strains After Loading
Batch I, High Modulus

Time, days	AC				AD			
	73°F		150°F		73°F		150°F	
	Strain, millionths				Strain, millionths			
	Axial	Radial	Axial	Radial	Axial	Radial	Axial	Radial
0	0	0	0	0	0	0	0	0
1	-3	0	-4	-3	-1	1	-1	-7
5	-3	0	-7	-12	-1	1	-5	-15
6	-3	0	-8	-14	-3	1	-6	-17
7	-3	1	-8	-15	-4	2	-7	-20
8	-3	1	-11	-17	-4	2	-8	-23
9	-4	0	-11	-18	-5	2	-10	-24
12	-3	0	-11	-20	-5	-3	-12	-25
14	-1	1	-11	-21	-5	2	-13	-27
16	-1	1	-11	-23	-5	2	-14	-28
19	-1	2	-15	-24	-6	2	-17	-34
21	-3	0	-13	-26	-8	3	-17	-34
22	-6	-2	-12	-29	-8	-1	-17	-34
26	-6	0	-13	-30	-10	4	-19	-34
31	-1	2	-12	-30	-10	3	-20	-35
37	-3	3	-11	-31	-10	4	-20	-36
44	-3	3	-12	-33	-12	4	-21	-36
58	-6	2	-11	-34	-14	5	-23	-36
84	-7	-1	-11	-34	-17	5	-23	-35
92	-5	2	-8	-38	-17	6	-31	-38
106	-7	2	-8	-39	-17	5	-31	-36
120	-7	2	-5	-38	-17	5	-34	-36
169	-7	2	--	--	-18	3	-33	-31
197	-8	3	8	-38	-20	3	-34	-24
225	-10	2	12	-38	-21	3	-34	-19
254	-8	2	19	-36	-21	3	-34	-13
285	-10	3	23	-34	-21	2	-34	-8
314	-10	3	32	-30	-21	3	-32	-1
348	-10	3	42	-23	-21	3	-32	7
363	-12	2	46	-22	-22	2	-32	7
366	-11	2	49	-15	-21	3	-32	13
373	-8	4	53	-13	-21	3	-32	16
386	-12	3	62	-7	-22	1	-32	21
397	-10	4	66	-3	-21	4	-34	26
418	-14	1	GF*	12	-23	1	-31	38
435	-11	2		32	-21	4	-31	51
460	-11	3		GF	-20	3	-30	70
483	-8	4			-20	3	-27	103

* GF denotes gage failure

Table B9

Control Strains After Loading
Batch II, Main Modulus

Time, days	AC				AD			
	73°F		150°F		73°F		150°F	
	Strain, millionths				Strain, millionths			
	Axial	Radial	Axial	Radial	Axial	Radial	Axial	Radial
0	0	0	0	GF	0	0	0	0
1	0	0	0		0	1	0	-2
2	0	0	-1		-1	0	-4	-7
3	0	0	-1		-1	1	-5	-9
6	1	1	-19		-5	2	-25	-33
8	0	2	-20		-8	2	-20	-28
9	3	-3	-12		-8	2	-19	-27
13	3	4	-12		-12	1	-20	-30
16	3	5	-7		-12	1	-17	-30
21	4	6	-10		-15	-1	-20	-36
31	3	5	-12		-22	-3	-23	-44
42	0	2	-17		-31	-10	-29	-57
71	0	2	-39		-41	-15	-5	-91
79	12	1	-13		-43	-19	-16	-71
93	-3	1	-9		-49	-21	-24	-71
111	0	2	-1		-50	-22	GF	-71
156	1	8	14		-54	-22		-74
188	4	9	36		-61	-26		-72
212	3	10	80		-64	-27		-72
241	3	13	GF*		-67	-28		-73
272	8	17			-67	-27		-73
302	8	16			-70	-29		-74
335	10	21			-70	-27		-73
365	12	23			-71	-27		-73
373	17	26			-68	-22		-73
393	11	21			-74	-28		-72
419	11	21			-81	-32		-71
440	14	25			-75	-29		-69
461	15	25			-78	-29		-67
482	15	26			-76	-29		-66

* GF denotes gage failure

Table B10

Control Strains After Loading
Batch III, Low Modulus

Time, days	AC				AD			
	73°F		150°F		73°F		150°F	
	Strain, millionths				Strain, millionths			
	Axial	Radial	Axial	Radial	Axial	Radial	Axial	Radial
0	0	0	0	0	0	0	0	0
1	-3	-3	-6	-3	-4	-16	-5	-5
2	-3	-1	-17	-4	-6	-1	-8	-8
6	-3	-3	-13	-14	-41	-22	-22	-24
8	-17	-3	-11	-18	-21	-13	-27	-28
9	-3	-3	-21	-19	-24	-10	-29	-31
14	-1	-3	-11	-23	-33	-15	-35	-37
27	-4	-5	-14	-29	-51	-27	-44	-47
41	-5	-5	-13	-27	-60	-35	-42	-48
64	-3	-4	-17	-34	-76	-46	-44	-59
86	-3	-4	-11	-35	-78	-54	-28	-61
104	0	-3	-11	-35	-86	-62	GF	-64
149	0	0	-16	-30	-104	-76		GF
181	0	0	-16	GF	-110	-86		GF
205	4	3	-17		-114	-90		GF
238	5	3	-20		--	-98		-71
265	5	3	-20		-126	-104		--
295	8	4	-20		-128	-105		-67
328	8	5	-20		-134	-112		-64
363	10	1	-17		-138	-116		--
364	11	7	-17		-136	-114		-56
365	10	5	-18		-137	-116		-56
373	11	8	-21		-138	-117		-53
392	11	7	-16		-144	-122		-45
419	14	11	-10		-154	-122		-42
440	14	12	-1		-141	-137		-36
458	15	12	GF*		-143	-121		GF
484	18	16			-152	-133		
489	18	16			-148	-132		

* GF denotes gage failure

Table B11

Control Strains After Loading
Batch IV, High Modulus

Time, days	AC				AD			
	73°F		150°F		73°F		150°F	
	Strain, millionths				Strain, millionths			
	Axial	Radial	Axial	Radial	Axial	Radial	Axial	Radial
0	0	0	0	0	0	0	0	0
1	0	-1	--	--	0	0	--	--
2	0	-1	--	--	-1	-1	--	--
3	0	0	--	--	-1	-1	-11	-3
4	0	-1	--	--	-3	0	--	--
5	0	0	8	-21	-3	1	-25	-6
20	0	-3	--	--	-8	-1	--	--
27	-3	-3	--	--	-9	0	--	--
28	-3	-4	--	--	-11	-1	--	--
33	-3	-3	--	--	-9	1	--	--
34	-4	-4	--	--	-11	0	--	--
55	-4	-5	-15	-18	-16	-1	-27	-13
77	-6	-5	-20	-25	-16	-1	-32	-15
95	-6	-7	--	--	-20	-4	--	--
113	-7	-8	-17	-27	-24	-7	-34	-17
131	-7	-8	-11	-24	-24	-7	-32	-15
147	-8	-10	-6	-24	-28	-12	-32	-14
167	-8	-10	0	-22	-28	-12	-34	-13
196	-8	-10	10	-21	-32	-13	--	--
229	-10	-12	24	-21	-34	-15	-34	-10
256	-11	-12	43	-20	-36	-18	-34	-7
286	-13	-13	79	-20	-36	-18	-34	-3
319	-13	-13	GF*	--	-39	-18	-32	1
362	-13	-13		-17	-39	-20	-32	8
363	-13	-13		-17	-39	-23	-32	10
376	-14	-13		-17	-38	-19	-35	13
392	-15	-14		--	-40	-20	---	---
417	-13	-13		-10	-39	-19	-32	21
440	-14	-13		-6	-39	-19	-28	29
466	-13	-13		-3	-40	-19	-27	39
480	-13	-13		1	-39	-22	-29	46
487	-13	-13		4	-39	-19	-27	43

* GF denotes gage failure

Table B12

Control Strains After Loading
Batch V, Main Modulus

Time, days	AC				AD			
	73°F		150°F		73°F		150°F	
	Strain, millionths				Strain, millionths			
	Axial	Radial	Axial	Radial	Axial	Radial	Axial	Radial
0	0	0	0	0	0	0	0	0
1	3	1	-3	-3	1	-1	-3	-3
2	3	1	-4	-4	0	-1	-5	5
7	3	3	--	--	0	5	--	--
14	-4	-6	-22	-22	-14	-3	-26	-26
20	-4	-6	-29	-23	-17	-3	-30	-30
29	-6	-4	--	--	-20	-5	--	--
42	-6	-7	--	--	-25	-7	-68	-67
64	-8	-8	-34	-23	-32	-13	-69	-53
83	-8	-8	--	--	-33	-13	--	--
100	-8	-6	-28	--	-35	-16	-61	-59
118	-8	-7	-26	-15	-37	-18	-65	-63
134	-6	-3	-28	--	-33	-16	-69	-70
154	-7	-4	-22	-5	-40	-20	-74	-72
183	-7	-6	-16	0	-44	-24	--	--
216	-6	-3	-7	7	-45	-26	-82	-80
244	-4	-1	0	9	-47	-28	-88	-85
273	-7	-3	7	17	-48	-30	-88	-85
306	-3	-1	14	23	-48	-30	-90	-85
349	-1	3	27	31	-48	-27	-90	-82
365	3	5	33	35	-47	-24	-92	-82
380	-4	0	42	37	-51	-32	-92	-79
392	-4	-1	45	41	-55	-34	-90	-79
407	-4	-1	48	43	-55	-35	-90	-79
432	-1	1	57	49	-56	-32	GF*	-72
453	0	3	62	52	-52	-32		-71
467	-1	3	69	57	-54	-34		-66
481	0	4	75	63	-54	-34		-60

* GF denotes gage failure

Table B12

Control Strains After Loading
Batch VI, Main Modulus

Time, days	AC				AD			
	73°F		150°F		73°F		150°F	
	Strain, millionths				Strain, millionths			
	Axial	Radial	Axial	Radial	Axial	Radial	Axial	Radial
0	0	0	0	0	0	0	0	0
5	-2	-3	--	--	-11	-4	--	--
6	-3	-3	--	--	-13	-4	--	--
8	-3	-3	-29	-20	-16	-4	-26	-30
11	-4	-4	-33	-21	-20	-5	-27	-35
20	-6	-5	-43	-26	-30	-8	-27	-45
21	-4	-4	-44	-26	-30	-5	-25	-45
26	-4	-3	--	--	-33	-3	--	--
39	-6	-5	-51	-28	-42	-7	-7	-54
43	-6	-5	-52	-28	-41	-8	0	-57
61	-7	-5	-55	-29	-52	-9	GF	-65
77	-1	-4	-59	-30	-50	-8		-73
97	-6	-5	-59	-31	-60	-11		-77
120	-8	-8	-60	-31	-67	-15		-85
126	-8	-8	-60	-31	-68	-16		-86
159	-8	-8	-60	-29	-75	-19		-91
187	-10	-8	-60	-29	-80	-20		-95
216	-10	-10	-59	-19	-83	-24		-98
249	-11	-8	-58	-6	-84	-24		-99
292	-8	-8	-57	10	-88	-27		-101
307	-8	-10	-56	GF*	-88	-28		-101
347	-10	-10	-55		-94	-31		-99
361	-10	-10	-53		-96	-31		-97
365	-8	-10	--		-94	-32		--
382	-11	-11	-52		-96	-35		-95
396	-10	-11	-53		-96	-33		-98
410	-10	-11	-51		-98	-35		-95
424	-7	-15	-51		-96	-35		-95
445	-7	-10	-52		-95	-36		-89
467	-8	-10	-49		-96	-37		-83
480	-7	-10	-43		-99	-36		-78

* GF denotes gage failure

Table B14

Control Strains After Loading
Batch VII, High Modulus

Time, days	AC				AD			
	73°F		150°F		73°F		150°F	
	Strain, millionths				Strain, millionths			
	Axial	Radial	Axial	Radial	Axial	Radial	Axial	Radial
0	0	0	0	0	0	0	0	0
1	0	-1	1	-2	-1	1	2	-2
2	0	-1	-1	-3	-1	2	-3	-4
3	1	0	0	-4	-1	2	-3	-5
6	1	-1	-1	-6	-4	5	-7	-11
9	1	-1	-3	-7	-4	6	-7	-11
15	3	-1	-3	-8	-5	9	-8	-15
23	3	-2	-4	-8	-9	12	-8	-17
34	5	-4	-4	-8	-12	15	-14	-18
43	4	-4	-3	-8	-14	18	-11	-21
51	4	-4	-3	-8	-15	19	-11	-22
62	5	-9	-3	-8	-18	13	-10	-22
79	5	-6	--	--	-20	23	--	--
90	5	-7	-3	-8	-22	21	-6	-23
120	5	-9	-1	-8	-26	24	-3	-23
154	8	-10	0	-11	-27	23	3	-23
196	9	-11	-1	-11	-30	21	14	-24
211	4	-14	-3	-16	-32	20	19	-24
251	9	-14	-1	-11	-32	18	64	-26
274	11	-14	-3	-12	-33	-17	GF	-26
279	11	-13	-1	-12	-33	20		-26
286	12	-15	-1	-12	-31	20		-26
293	11	-13	-3	-12	-33	20		-25
300	11	-14	-1	-12	-33	14		-28
314	12	-16	-4	-11	-33	20		-26
328	12	-18	-3	-9	-33	20		-25
342	11	-14	-1	-8	-33	19		-25
356	12	-14	-3	-4	-33	19		-28
366	13	-14	-4	0	-33	19		-26
381	9	-14	-4	4	-33	17		-27
398	13	-14	-4	17	-33	19		-30
420	13	-14	-4	47	-35	16		-25
442	13	-14	-4	GF*	-35	15		-29
467	16	-14	-4		-35	18		-25
483	16	-14	-4		-35	17		-27

* GF denotes gage failure

Table B15

Control Strains After Loading
Batch VIII, Low Modulus

Time, days	AC				AD			
	73°F		150°F		73°F		150°F	
	Strain, millionths				Strain, millionths			
	Axial	Radial	Axial	Radial	Axial	Radial	Axial	Radial
0	0	0	0	0	0	GF	0	0
1	0	0	-3	-4	-3		-9	-4
2	0	0	-6	-7	-6		-6	-6
4	0	-1	-13	-13	-11		-12	-12
10	-1	-2	-24	-21	-23		-21	-22
11	-1	-2	-24	-23	-26		-25	-25
17	0	-2	-32	-28	-35		--	--
21	1	-3	-36	-29	-38		-32	-34
29	0	-3	-40	-33	-46		-38	-39
38	0	-3	-46	-39	-53		-43	-43
49	3	-3	-52	-49	-58		-46	-48
78	6	-3	-64	-56	-68		-54	-55
108	8	-1	-71	-64	-72		-58	-60
141	7	-2	-80	-75	-76		-61	-60
183	12	0	-87	-86	-82		-61	-60
198	9	-4	-89	-89	-81		-60	-60
238	13	-3	-94	-97	-83		-60	-53
261	17	3	-97	-97	-78		-61	-49
266	9	4	-102	-109	-79		-73	-50
273	19	5	-102	-102	-86		-59	-45
280	19	5	-100	-107	-76		-50	-44
287	19	6	-102	-106	-107		-70	-42
301	19	6	-103	-107	-76		-46	-39
308	19	8	-102	-107	-78		-44	-37
324	23	8	-103	-110	-74		-41	-31
336	23	9	-105	-112	-73		-43	-33
350	24	10	-106	-112	-108		-42	-31
365	27	12	-103	-114	-71		-45	GF
371	25	12	-103	-115	-96		-36	
378	21	12	-106	-117	GF*		--	
385	25	12	-106	-117			-38	
392	24	12	-109	-134			-27	
407	28	14	-111	-121			-38	
420	31	15	-109	-120			-20	
435	32	16	-111	-122			-15	
448	32	17	-115	-123			-20	
462	32	18	-117	-126			-14	
484	35	20	-120	-124			0	

* GF denotes gage failure

APPENDIX C
AFTER-LOADING TOTAL STRAIN AND
SPECIFIC-CREEP STRAIN DATA

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Table C1

Specimen I-1

Modulus - High
Curing - As Cast

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	85	85	0	-15	-15	0
1.0	87	90	0.008	-16	-16	-0.002
4.8	93	96	0.018	-16	-16	-0.002
5.8	93	96	0.018	-16	-16	-0.002
7.0	93	96	0.018	-16	-17	-0.003
8.0	93	96	0.018	-16	-17	-0.003
9.0	93	97	0.020	-16	-16	-0.002
12.0	96	99	0.023	-17	-17	-0.003
14.2	96	97	0.020	-17	-18	-0.005
15.9	96	97	0.020	-18	-19	-0.007
19.0	97	98	0.022	-16	-18	-0.005
21.0	97	100	0.025	-16	-16	-0.002
21.9	96	102	0.028	-18	-16	-0.002
26.0	97	103	0.030	-19	-19	-0.007
30.9	99	100	0.025	-17	-19	-0.007
37.0	100	103	0.030	-17	-20	-0.008
43.9	100	103	0.030	-18	-21	-0.010
57.8	101	107	0.037	-20	-22	-0.012
84.0	101	108	0.038	-22	-23	-0.013
92.0	101	106	0.035	-22	-24	-0.015
105.9	101	108	0.038	-23	-25	-0.017
119.9	101	108	0.038	-24	-26	-0.018
168.9	104	111	0.043	-26	-28	-0.022
196.9	108	116	0.052	-26	-28	-0.022
224.9	112	122	0.062	-28	-30	-0.025
253.9	112	120	0.058	-29	-31	-0.027
284.8	110	120	0.058	-29	-31	-0.027
314.1	108	118	0.055	-29	-32	-0.028
347.9	117	127	0.070	-31	-34	-0.032
363.1	113	125	0.067	-33	-35	-0.033
366	114	125	0.067	-31	-33	-0.030
366	27	38		-21	-24	
366	27	37		-18	-22	
367	27	37		-14	-18	
368	27	35		-14	-18	

(Continued)

Table C1 (Concluded)

Specimen I-1

Modulus - High
Curing - As Cast

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
369	27	37		-14	-18	
370	26	37		-16	-19	
371	26	36		-14	-17	
372	27	37		-13	-17	
373	27	35		-12	-16	
376	27	37		-11	-16	
377	26	36		-14	-19	
379	24	35		-13	-17	
383	23	34		-14	-17	
384	23	34		-14	-18	
386	20	32		-16	-19	
387	24	34		-12	-16	
390	23	34		-13	-18	
392	23	31		-13	-17	
397	23	33		-13	-17	
405	19	31		-15	-17	
412	20	32		-14	-17	
418	16	30		-17	-18	
421	16	28		-17	-19	
425	16	26		-12	-16	
428	19	30		-13	-18	
432	19	29		-15	-19	
435	19	30		-13	-15	
439	19	31		-13	-15	
442	19	29		-14	-18	
446	16	27		-15	-18	
453	18	29		-14	-17	
460	16	27		-14	-17	
483	18	29		-13	-16	

Table C2

Specimen I-2

Modulus - High
Curing - Air Dried

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	89	89	0	-16	-16	0
1.0	91	92	0.005	-15	-16	0
4.8	96	97	0.013	-14	-15	0.002
5.8	96	99	0.017	-12	-13	0.005
7.0	96	100	0.018	-13	-15	0.002
8.0	96	100	0.018	-12	-14	0.003
9.0	94	99	0.017	-12	-14	0.003
12.0	95	100	0.018	-12	-14	0.003
14.2	95	100	0.018	-11	-13	0.005
15.9	95	100	0.018	-13	-15	0.002
19.0	95	101	0.020	-10	-12	0.007
21.0	94	102	0.022	-10	-13	0.005
21.9	94	102	0.022	-16	-15	0.002
26.0	94	104	0.025	-12	-16	0
30.9	91	101	0.020	-12	-15	0.002
37.0	94	104	0.025	-8	-12	0.007
43.9	93	105	0.027	-9	-13	0.005
57.8	93	107	0.030	-9	-14	0.003
84.0	91	108	0.032	-10	-15	0.002
92.0	91	108	0.032	-10	-16	0
105.9	91	108	0.032	-8	-13	0.005
119.9	90	NR	0.033	-12	-17	-0.002
168.9	91	109	0.033	-15	-18	-0.003
196.9	93	113	0.040	-16	-19	-0.005
224.9	96	117	0.047	-17	-20	-0.007
253.9	96	117	0.047	-18	-21	-0.008
284.8	94	115	0.043	-19	-21	-0.008
314.1	94	115	0.043	-17	-20	-0.007
347.9	101	122	0.055	-20	-23	-0.012
363.1	97	119	0.050	-23	-25	-0.015
366	97	118	0.048	-20	-23	-0.012
366	12	33		-5	-8	
366	12	33		-4	-7	
367	10	31		-3	-6	
368	10	31		-4	-7	

(Continued)

Table C2 (Concluded)

Specimen I-2

Modulus - High
Curing - Air Dried

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
369	10	31		-4	-7	
370	10	31		-5	-7	
371	12	33		-2	-5	
372	12	33		-4	-7	
373	12	33		-2	-7	
376	12	33		-1	-4	
377	10	31		-2	-5	
379	10	31		-4	-7	
383	9	30		-5	-7	
384	10	31		-3	-6	
386	8	30		-6	-7	
387	10	31		-2	-5	
390	9	30		-4	-7	
392	9	30		-4	-7	
397	9	30		-3	-7	
405	6	27		-3	-6	
412	6	27		-3	-6	
418	4	27		-8	-9	
421	4	27		-8	-10	
428	6	26		-1	-5	
432	6	26		-2	-6	
435	6	26		-2	-6	
439	6	27		-2	-6	
442	5	25		-1	-5	
446	5	26		-3	-6	
453	5	26		-2	-5	
460	5	25		-3	-6	
483	4	25		-2	-5	

Table C3

Specimen I-3

Modulus - High
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	363	363	0	-64	-64	0
1.0	373	376	0.005	-63	-63	0
4.9	388	391	0.012	-63	-63	0
5.8	393	396	0.014	-63	-63	0
7.0	391	394	0.013	-63	-64	0
8.0	392	395	0.013	-63	-64	0
9.0	391	395	0.013	-63	-63	0
12.0	399	402	0.016	-64	-64	0
14.2	403	404	0.017	-64	-65	0
15.9	407	408	0.019	-66	-67	-0.001
19.1	410	411	0.020	-64	-66	-0.001
21.1	415	418	0.023	-70	-70	-0.002
26.0	412	418	0.023	-67	-67	-0.001
30.9	416	417	0.022	-66	-68	-0.002
37.0	422	425	0.026	-66	-69	-0.002
44.0	431	434	0.030	-69	-72	-0.003
57.9	436	442	0.033	-72	-74	-0.004
85.1	448	455	0.038	-74	-73	-0.004
93.0	448	453	0.038	-77	-79	-0.006
107.0	452	459	0.040	-78	-80	-0.007
121.1	454	461	0.041	-78	-80	-0.007
170.1	464	471	0.045	-82	-84	-0.008
198.1	474	482	0.050	-82	-84	-0.008
226.1	476	486	0.051	-83	-85	-0.009
255.1	472	480	0.049	-84	-86	-0.009
284.8	483	493	0.054	-86	-88	-0.010
314.0	486	496	0.055	-87	-90	-0.011
347.8	498	508	0.060	-89	-92	-0.012
363.0	496	508	0.060	-92	-94	-0.012
366	497	508	0.060	-91	-91	-0.011
366	146	157		-31	-33	
366	138	148		-31	-35	
367	133	143		-33	-37	
368	130	138		-32	-36	

(Continued)

Table C3 (Concluded)

Specimen I-3

Modulus - High
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
369	129	139		-32	-36	
370	129	139		-32	-35	
371	127	137		-30	-33	
372	129	139		-31	-35	
373	127	135		-29	-33	
376	127	137		-30	-35	
377	125	135		-28	-33	
379	125	136		-29	-33	
383	119	130		-31	-34	
384	119	130		-29	-33	
386	117	129		-31	-34	
387	119	129		-29	-33	
390	117	128		-28	-33	
392	117	125		-28	-32	
397	113	123		-28	-32	
405	110	122		-28	-30	
412	110	122		-28	-31	
416	103	117		-30	-31	
421	105	117		-30	-32	
425	107	117		-26	-30	
428	106	117		-26	-31	
432	105	115		-27	-31	
435	105	116		-28	-30	
439	103	115		-27	-29	
442	105	115		-27	-31	
446	105	116		-28	-31	
453	102	113		-27	-30	
460	101	112		-28	-31	
483	98	109		-26	-29	

Table C4

Specimen I-4

Modulus - High
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	389	389	0	-67	-67	0
1.0	404	405	0.007	-66	-67	0
4.9	419	420	0.013	-64	-65	0.001
5.8	424	427	0.016	-63	-64	0.001
7.0	423	427	0.016	-63	-65	0.001
8.0	424	428	0.016	-63	-65	0.001
9.0	424	429	0.017	-63	-65	0.001
12.0	430	435	0.019	-63	-60	0.003
14.2	433	438	0.020	-63	-65	0.001
15.9	437	442	0.022	-65	-67	0
19.1	440	446	0.024	-62	-64	0.001
21.1	444	452	0.026	-65	-68	0
26.0	438	448	0.024	-64	-68	0
30.9	443	453	0.027	-63	-66	0
37.0	449	459	0.029	-63	-67	0
44.0	458	470	0.034	-64	-68	0
57.9	461	475	0.036	-64	-69	-0.001
85.1	471	488	0.041	-67	-72	-0.002
93.0	471	488	0.041	-67	-73	-0.002
107.0	471	488	0.041	-67	-72	-0.002
121.1	474	491	0.042	-70	-75	-0.003
170.1	484	502	0.047	-72	-75	-0.003
198.1	489	509	0.050	-73	-76	-0.004
226.1	490	511	0.051	-74	-77	-0.004
255.1	492	513	0.052	-75	-78	-0.004
284.8	496	517	0.053	-76	-78	-0.004
314.0	500	521	0.055	-76	-79	-0.005
347.8	512	533	0.060	-79	-82	-0.006
363.0	510	532	0.060	-83	-85	-0.008
366	510	531	0.059	-81	-82	-0.006
366	126	147		-20	-23	
366	122	143		-19	-22	
367	118	139		-18	-21	
368	116	137		-18	-21	

(Continued)

Table C4 (Concluded)

Specimen I-4

Modulus - High
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
369	114	135		-18	-21	
370	114	135		-18	-20	
371	113	134		-16	-19	
372	113	134		-17	-20	
373	112	133		-15	-18	
376	111	132		-12	-15	
377	108	129		-13	-16	
379	107	128		-14	-17	
383	113	124		-16	-18	
384	104	125		-13	-16	
386	102	124		-16	-17	
387	103	124		-13	-16	
390	102	123		-13	-16	
392	100	121		-13	-16	
397	98	119		-13	-17	
405	94	115		-13	-16	
412	94	115		-12	-15	
418	91	114		-16	-17	
421	89	112		-15	-17	
425	91	110		-11	-15	
428	90	110		-11	-15	
432	89	109		-11	-15	
435	88	109		-11	-15	
439	88	109		-11	-15	
442	88	108		-10	-14	
446	86	107		-12	-15	
453	85	106		-11	-14	
460	84	104		-11	-14	
482	81	101		-11	-14	

Table C5

Specimen I-5

Modulus - High
Curing - As Cast

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	84	84	0	-14	-14	0
1.1	94	98	0.023	-17	-14	0
5.0	106	113	0.048	-23	-11	0.005
6.0	106	114	0.050	-25	-11	0.005
7.1	106	114	0.050	-26	-11	0.005
8.1	106	117	0.055	-27	-10	0.007
9.1	106	117	0.055	-29	-11	0.005
12.1	111	122	0.063	-31	-11	0.005
14.3	114	125	0.068	-32	-11	0.005
16.0	115	126	0.070	-33	-10	0.007
19.2	112	127	0.072	-37	-13	0.002
21.1	114	127	0.072	-38	-12	0.003
22.0	--			-40	-11	0.005
26.1	115	128	0.073	-39	-9	0.008
31.1	116	128	0.073	-41	-11	0.005
36.9	118	129	0.075	-42	-11	0.005
44.0	120	132	0.080	-44	-11	0.005
58.0	124	135	0.085	-47	-13	0.002
84.2	130	141	0.095	-50	-16	-0.003
92.1	127	135	0.085	-55	-17	-0.005
106.0	130	138	0.090	-56	-17	-0.005
120.0	133	138	0.090	-58	-20	-0.010
197.1	150	142	0.097	-66		
225.1	157	145	0.102	-69		
254.1	161			-70		
284.9	165			-72		
314.1	167			-72		
348.0	179			-74		
363.2	180			-75		
366	180			-74		
366	102			-61		
367	101			-62		
368	102			-61		
369	101			-61		
370	101			-63		
371	101			-61		

(Continued)

Table C5 (Concluded)

Specimen I-5

Modulus - High
Curing - As Cast

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
372	101			-61		
373	101			-61		
376	101			-61		
377	101			-60		
379	99			-60		
383	99			-61		
384	101			-62		
386	99			-60		
387	101			-60		
390	101			-66		
392	101			-60		
397	101			-60		
405	101			-59		
412	102			-59		
418	102			-60		
421	103			-59		
425	103			-60		
428	106			-59		
432	106			-56		
435	106			-57		
439	106			-57		
442	107			-55		
446	107			-55		
453	108			-54		
460	110			-54		
483	112			-53		

Table C6

Specimen I-6

Modulus - High
Curing - Air Dried

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	91	91	0	-14	-14	0
1.1	102	103	0.020	-18	-11	0.005
5.0	111	116	0.042	-25	-10	0.007
6.0	111	117	0.043	-26	-9	0.008
7.1	111	118	0.045	-28	-8	0.010
8.1	111	119	0.047	-29	-6	0.013
9.1	111	121	0.050	-31	-7	0.012
12.1	114	126	0.058	-32	-7	0.012
14.3	116	129	0.063	-33	-6	0.013
16.0	116	130	0.065	-34	-6	0.013
19.2	116	133	0.070	--		
21.1	116	133	0.070	-38	-4	0.017
22.0	116	133	0.070	-38	-4	0.017
26.1	117	136	0.075	-38	-4	0.017
31.0	120	140	0.082	-39	-4	0.017
36.9	126	146	0.092	-39	-3	0.018
44.0	125	146	0.095	-40	-4	0.017
58.0	134	157	0.110	-40	-4	0.017
84.2	144	167	0.123	--		
92.1	142	173	0.137	-40	-2	0.020
106.0	147	178	0.145	-38	-2	0.020
120.0	152	186		-38	-2	0.020
169.1	175	208		-30	1	
197.1	185	219		-20	4	
225.1	200	234		-7	12	
254.1	210	244		GF		
284.9	220	254				
314.2	230	262				
348.0	256	288				
363.3	263	295				
366	267	299				
366	180	212				
367	180	213				
368	184	216				
369	185	217				
370	186	218				

(Continued)

Table C6 (Concluded)

Specimen I-6

Modulus - High
Curing - Air Dried

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
371	187	219				
372	187	219				
373	190	222				
376	192	224				
377	194	226				
379	195	227				
383	199	231				
384	200	233				
386	202	234				
387	205	237				
390	210	244				
392	212	244				
397	217	251				
405	222	253				

TABLE C7

Specimen I-7

Modulus - High
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	362	362	0	-57	-57	0
1.0	441	445	0.034	-73	-70	-0.005
5.0	488	495	0.055	-86	-74	-0.007
6.0	497	505	0.060	-89	-75	-0.008
7.1	499	507	0.060	-91	-76	-0.008
8.0	504	515	0.064	-92	-75	-0.008
9.0	507	518	0.065	-94	-76	-0.008
12.0	524	535	0.072	-97	-77	-0.008
14.3	532	543	0.075	-99	-78	-0.009
16.0	541	552	0.079	-102	-77	-0.008
19.2	547	562	0.083	-104	-80	-0.010
21.2	546	559	0.082	-106	-80	-0.010
26.1	562	575	0.089	-110	-80	-0.010
31.0	566	578	0.090	-110	-80	-0.010
36.8	571	582	0.092	-110	-80	-0.010
44.0	595	607	0.102	-114	-81	-0.010
57.9	608	619	0.107	-115	-81	-0.010
84.1	644	655	0.122	-117	-83	-0.010
92.0	635	643	0.117	-122	-84	-0.011
106.0	652	660	0.124	-123	-84	-0.011
120.1	663	668	0.128	-123	-85	-0.012
	GF			GF		

Table C8

Specimen I-8

Modulus - High
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	367	367	0	-58	-58	0
1.0	450	451	0.035	-72	-65	-0.003
5.0	498	503	0.057	-85	-70	-0.005
6.0	507	495	0.053	-87	-70	-0.005
7.1	509	516	0.062	-89	-69	-0.004
8.0	512	520	0.064	-91	-68	-0.004
9.0	516	526	0.066	-92	-68	-0.004
12.0	531	543	0.073	-96	-71	-0.005
14.3	538	551	0.077	-98	-71	-0.005
16.0	546	560	0.080	-100	-72	-0.006
19.2	554	571	0.085	-104	-70	-0.005
21.2	562	589	0.092	-110	-76	-0.008
21.9	--			-101	-67	-0.004
26.1	--			-107	-73	-0.006
31.0	569	589	0.092	-109	-74	-0.007
36.8	578	598	0.096	-111	-75	-0.007
44.0	578	599	0.097	-114	-78	-0.008
57.9	609	632	0.110	-115	-79	-0.009
84.1	639	662	0.123	-115	-80	-0.009
92.0	637	668	0.125	-123	-85	-0.011
106.0	647	678	0.130	-123	-87	-0.012
120.1	657	691	0.135	-124	-88	-0.012
169.1	686	719	0.147	-124	-93	
197.1	707	741	0.156	-123	-99	
224.9	723	757	0.162	-122	-103	
253.9	740	774	0.170	-121	-108	
284.9	764	798	0.180	-120	-112	
314.1	GF			-118	-117	
348.0				-118	-125	
350.0				-117	-124	
363.0				-119	-126	
366				-117	-140	
366				-72		
366				-73		
367				-74		
368				-74		

(Continued)

Table C8 (Concluded)

Specimen C-8

Modulus - High
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
369				-73		
370				-74		
371				-72		
372				-72		
373				-71		
376				-71		
377				-70		
379				-71		
383				-71		
384				-71		
386				-69		
387				-69		
390				-68		
392				-68		
397				-68		
405				-67		
412				-66		
418				-65		
421				-64		
425				-64		
428				-64		
432				-65		
435				-62		
439				-62		
442				-61		
446				-61		
453				-60		
460				-60		

Table C9

Specimen II-1

Modulus - Main
Curing - As Cast

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	95	95	0	-23	-23	0
1.0	114	114	0.032	-24	-24	-0.002
1.9	116	116	0.035	-25	-25	-0.003
2.8	123	123	0.047	-19	-19	0.007
5.9	123	122	0.045	-21	-22	0.002
7.8	125	124	0.048	-21	-22	0.002
7.9	124	124	0.048	-20	-22	0.002
8.7	128	125	0.050	-20	-23	0
15.8	130	127	0.053	-18	-22	0.002
20.5	134	131	0.060	-16	-21	0.003
30.8	134	130	0.058	-19	-25	-0.003
41.6	133	130	0.058	-25	-30	-0.012
70.9	141	141	0.077	-21	-23	0
78.8	139	142	0.078	-27	-28	-0.008
92.8	141	144	0.082	-25	-26	-0.005
110.5	145	145	0.083	-22	-24	-0.002
155.8	155	154	0.098	-22	-30	-0.012
187.8	159	155	0.100	-22	-31	-0.013
211.7	165	162	0.112	-23	-33	-0.017
240.7	167	164	0.115	-22	-35	-0.020
271.7	170	162	0.112	-19	-17	-0.021
301.6	170	162	0.112	-21	-37	-0.023
334.6	181	171	0.127	-20	-41	-0.030
365	180	168	0.122	-22	-45	-0.037
365	86	74		5	-18	
365	86	75		7	-16	
365	86	72		8	-14	
366	88	76		10	-10	
367	85	71		9	-14	
370	89	74		14	-11	
371	86	75		12	-12	
372	88	74		14	-10	
373	90	73		18	-8	
374	85	71		11	-14	
377	85	68		14	-11	

(Continued)

Table C9 (Concluded)

Specimen II-1

Modulus - Main
Curing - As Cast

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
379	85	70		12	-13	
381	80	69		5	-16	
384	80	69		7	-14	
393	82	71		13	-8	
399	82	71		12	-12	
405	89	72		22	-6	
408	85	73		16	-8	
412	81	66		11	-14	
415	76	65		6	-16	
419	77	66		6	-15	
422	76	65		8	-14	
426	76	66		7	-15	
429	76	66		8	-14	
433	80	72		11	-14	
440	80	66		11	-14	
447	80	66		11	-14	
456	78	66		10	-16	
461	78	65		11	-14	
477	80	65		13	-14	
479	80	65		12	-15	
482	80	65		12	-14	

Table C10

Specimen II-2

Modulus - Main
Curing - Air Dried

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	102	102	0	-24	-24	0
1.0	118	121	0.032	-26	-27	-0.005
1.9	119	123	0.035	-27	-27	-0.005
2.8	123	127	0.042	-23	-24	0
5.9	122	130	0.047	-24	-26	-0.003
7.8	122	132	0.050	-23	-25	-0.002
7.9	119	130	0.047	-24	-26	-0.003
8.7	123	134	0.053	-24	-26	-0.003
12.8	122	137	0.055	-21	-22	0.003
15.8	122	137	0.058	-24	-25	0.002
20.5	123	141	0.065	-22	-21	0.005
30.8	117	141	0.065	-28	-25	-0.002
41.6	113	147	0.075	-33	-23	0.002
70.9	112	155	0.088	-36	-21	0.005
78.8	108	154	0.087	-40	-21	0.005
92.8	106	158	0.093	--	--	--
110.5	109	162	0.100	-38	-16	0.013
155.8	112	169	0.112	-39	-17	0.012
187.8	109	173	0.118	-41	-15	0.015
211.7	112	179	0.128	-46	-19	0.008
240.7	113	182	0.133	-45	-17	0.012
271.7	114	183	0.135	-41	-14	0.017
301.5	112	184	0.137	-42	-29	0.018
334.5	121	193	0.152	-42	-15	0.015
365	121	195	0.155	-42	-15	0.015
365	3	77		-15	12	
365	1	75		-13	15	
365	1	75		-14	14	
366	3	77		-13	14	
367	0	74		-13	15	
370	5	76		-9	16	
371	3	74		-11	15	
372	4	76		-8	16	
373	6	77		-5	17	
374	0	74		-11	15	
377	3	75		-9	15	

(Continued)

Table C10 (Concluded)

Specimen II-2

Modulus - Main
Curing - Air Dried

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
379	-1	73		-10	16	
381	-8	70		-15	15	
384	-8	71		-14	16	
393	-4	72		-9	17	
399	-4	72		-9	18	
405	-6	72		-8	19	
408	-4	68		-7	18	
412	-6	68		-10	16	
415	-14	65		-15	17	
419	-14	69		-14	18	
422	-13	67		-13	18	
426	-14	66		-13	19	
429	-14	66		-14	18	
433	-12	66		-11	18	
440	-12	66		-11	18	
447	-13	66		-11	18	
456	-13	66		-11	18	
461	-14	67		-11	18	
477	-14	67		-10	19	
479	-14	67		-11	19	
482	-14	65		-11	18	

Table C11

Specimen II-3

Modulus - Main
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected		Total millionths	Corrected	
0	412	412	0	GF		
0.9	458	458	0.019			
2.3	468	468	0.023			
3.2	487	487	0.031			
6.3	501	500	0.037			
16.2	528	525	0.047			
20.9	533	529	0.049			
31.2	556	553	0.059			
41.6	567	567	0.064			
70.8	588	588	0.073			
78.8	589	590	0.074			
92.7	595	598	0.078			
110.5	607	607	0.081			
155.8	632	631	0.091			
187.8	640	636	0.093			
211.7	642	639	0.094			
240.7	648	645	0.097			
271.7	660	652	0.100			
301.5	667	659	0.103			
334.5	682	672	0.108			
365	688	676	0.110			
365	265	253				
365	261	252				
365	261	250				
366	259	247				
367	254	240				
370	253	238				
371	250	239				
372	248	234				
373	250	233				
374	244	230				
377	247	230				
379	242	227				
381	235	224				
384	234	223				
393	235	224				

(Continued)

Table C11 (Concluded)

Specimen II-3

Modulus - Main
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
399	235	224				
405	242	225				
408	235	223				
412	231	216				
415	223	212				
419	222	211				
422	223	212				
426	221	210				
429	221	211				
433	225	211				
440	222	208				
447	223	209				
456	222	208				
461	221	206				
477	221	206				
479	221	206				
482	221	206				

Table C12

Specimen II-4

Modulus - Main
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	436	436	0	-107	-107	0
0.9	486	486	0.021	-114	-115	-0.003
2.3	499	500	0.027	-114	-114	-0.003
3.2	517	518	0.034	-112	-113	-0.002
6.3	533	538	0.042	-113	-115	-0.003
13.2	562	574	0.058	-106	-107	0
16.2	560	572	0.058	-106	-107	0
20.9	564	579	0.060	-105	-104	0.001
31.2	586	608	0.072	-114	-111	-0.001
41.6	593	624	0.078	-121	-111	-0.002
70.8	614	655	0.090	-127	-112	-0.002
78.8	610	653	0.090	-127	-118	-0.004
92.7	614	663	0.095	-133	-112	-0.002
110.5	625	675	0.100	-132	-110	-0.001
155.8	644	698	0.109	-134	-112	-0.002
187.8	650	711	0.114	-139	-113	-0.002
211.7	652	716	0.117	-135	-108	0
240.7	656	723	0.120	-137	-109	-0.001
271.7	664	731	0.123	-134	-107	0
301.5	667	737	0.125	-137	-108	0
334.5	684	754	0.132	-137	-110	-0.001
365	685	756	0.133	-140	-113	-0.002
365	228	300		-38	-11	
365	223	294		-36	-8	
365	224	295		-35	-7	
366	219	290		-33	-6	
367	225	296		-32	-4	
370	224	292		-28	-3	
371	224	292		-29	-3	
372	228	298		-25	-1	
373	228	296		-22	0	
374	218	289		-28	-2	
377	--			-25	-1	
379	--			-27	-1	
381	--			-31	-1	
384	--			-31	-1	

(Continued)

Table C12 (continued)

Specimen: II-4

Modulus - Main
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
393	--			-26	2	
399	--			-26	1	
405	--			-15	4	
412	192	263		-27	-1	
415	194	270		-32	0	
419	200	281		-31	1	
422	191	269		-31	0	
426	199	277		-31	1	
429	198	276		-31	1	
433	195	270		-28	1	
440	201	276		-28	1	
447	--			-28	1	
456	--			-28	1	
461	197	275		-28	1	
477	197	275		-25	4	
479	197	275		-28	2	
482	188	264		-28	1	

Table C13

Specimen 11-5

Modulus - Main
Curing - As Cast

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total	Corrected		Total	Corrected	
	millionths	millionths		millionths	millionths	
0	106	106	0	-19	-19	0
0.9	111	114	0.013	-21	-19	0
2.1	115	119	0.022	-24	-22	-0.005
2.9	116	120	0.023	-25	-23	-0.007
6.1	99	121	0.025	-47	-27	-0.013
8.1	111	125	0.032	-39	-19	0
8.9	114	128	0.037	-38	-18	0.002
12.9	118	132	0.043	-41	-19	0
16.0	123	133	0.045	-40	-18	0.002
20.7	124	137	0.052	-45	-21	-0.003
30.9	125	139	0.055	-51	-26	-0.012
41.9	120	140	0.057	-64		
79.0	129	145	0.065	-84		
92.9	134	146	0.067	-79		
121.9	153			-90		
156.1	148			-94		
188.1	154			-98		
212.0	160			-98		
240.9	159			-103		
271.8	156			-107		
301.9	154			-107		
334.9	160			-108		
365	156			-110		
365	41			-97		
365	39			-99		
365	38			-100		
366	35			-100		
367	34			-101		
370	28			-104		
371	28			-103		
372	26			-104		
373	26			-103		
374	26			-103		
377	22			-104		
379	24			-103		

(Continued)

Table C13 (Concluded)

Specimen II-5

Modulus - Main
Curing - As Cast

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
381	22			-103		
384	20			-104		
393	17			-103		
399	13			-103		
405	13			-104		
408	12			-104		
412	10			-104		
415	10			-104		
419	9			-104		
422	8			-103		
426	6			-103		
429	6			-104		
433	6			-104		
440	4			-103		
447	4			-102		
456	1			-102		
461	0			-102		
477	-1			-102		
479	-1			-102		
482	-1			-102		

Table C14

Specimen II-6

Modulus - Main
Curing - Air Dried

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths		millionths/psi	millionths		millionths/psi
	GF			GF		

Table C15

Specimen II-7

Modulus - Main
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	469	469	0	GF		
1.0	536	536	0.028			
1.9	559	560	0.038			
2.8	579	580	0.046			
5.9	595	614	0.060			
8.8	617	619	0.062			
12.8	635	647	0.074			
15.9	631	638	0.070			
20.6	672	682	0.089			
30.8	715	727	0.108			
41.7	735	752	0.118			
70.9	756	795	0.136			
78.9	784	797	0.137			
92.8	809	818	0.145			
121.8	843	844	0.156			
	GF					

Table C16

Specimen II-8

Modulus - Main
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	GF			-101	-101	0
1.0				-115	-113	-0.005
1.9				-117	-110	-0.004
2.8				-122	-113	-0.005
5.9				-142	-109	-0.003
7.9				-140	-112	-0.004
8.8				-138	-111	-0.004
12.8				-144	-114	-0.005
15.9				-131	-101	-0.002
20.6				-141	-105	-0.002
30.8				-153	-109	-0.003
41.7				-162	-105	-0.002
70.9				-198	-107	-0.002
78.9				-171	-100	
92.8				-168	-97	
121.8				-166	-95	
156.0				-162	-88	
188.0				-145	-73	
211.9				-136	-64	
240.8				-138	-65	
				GF		

Table C17

Specimen III-1

Modulus - Low
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	775	775	0	-96	-96	0
1.0	903	906	0.054	-109	-106	-0.004
1.9	928	931	0.065	-111	-110	-0.006
5.8	977	980	0.085	-120	-117	-0.009
8.0	--			-118	-115	-0.008
9.0	994	997	0.092	-118	-115	-0.008
13.6	1006	1007	0.097	-118	-115	-0.008
26.8	1075	1079	0.127	-127	-122	-0.011
40.8	1112	1117	0.142	-128	-123	-0.011
63.8	1150	1153	0.158	-129	-125	-0.012
86.0	1168	1171	0.165	-127	-123	-0.011
103.7	1187	1187	0.172	-129	-126	-0.012
148.9	1231	1231	0.190	-130	-130	-0.014
180.9	1256	1256	0.200	-130	-130	-0.014
204.6	1269	1265	0.204	-132	-135	-0.016
237.8	1284	1279	0.210	-128	-131	-0.014
264.8	1299	1294	0.216	-129	-132	-0.015
294.7	1314	1306	0.221	-130	-134	-0.016
327.7	1334	1326	0.230	-131	-136	-0.017
362.7	1353	1343	0.237	-132	-133	-0.015
363.6	1353	1342	0.236	-135	-142	-0.019
365	1352	1340	0.235	-133	-137	-0.017
365	718	708		-49	-54	
366	652	644		-43	-47	
367	650	645		-39	-46	
370	--			-38	-41	
371	627	617		-39	-44	
372	624	613		-37	-44	
373	622	611		-37	-45	
374	614	603		-35	-42	
377	610	599		-35	-43	
378	589	571		-39	-46	
379	586	576		-36	-41	
385	580	568		-34	-42	
392	578	567		-33	-40	
398	575	568		-39	-43	

(Continued)

Table C17 (Concluded)

Specimen III-1

Modulus - Low
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
401	573	563		-34	-39	
408	579	567		-27	-36	
412	575	561		-27	-38	
415	565	551		-26	-37	
419	570	556		-25	-36	
422	568	554		-24	-35	
426	567	553		-26	-35	
433	561	547		-25	-36	
440	561	547		-23	-35	
449	556	541		-23	-35	
454	558	542		-21	-33	
458	546	531		-20	-32	
468	547	531		-19	-32	
484	546	528		-18	-34	
489	546	528		-18	-34	

Table C18

Specimen III-2

Modulus - Low
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	785	785	0	GF		
1.0	861	863				
1.9	858	864				
5.8	858	899				
8.0	833	854				
9.0	834	858				
13.6	831	864				
	GF					

Table C19

Specimen III-3

Modulus - Low
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	924	924	0	-115	-115	0
1.0	1107	1113	0.079	-148	-145	-0.012
1.7	1165	1182	0.108	-157	-153	-0.016
5.7	GF			-186	-172	-0.024
7.8				-189	-171	-0.023
8.9				-191	-172	-0.024
13.5				-198	-175	-0.025
23.3				-220	-191	-0.032
26.3				-236	-207	-0.038
41.3				-243	-216	-0.042
64.0				-262	-228	-0.047
72.0				-266	-232	-0.049
86.0				-274	-239	-0.052
114.9				-301	-266	-0.063
149.0				-306	-266	-0.063
204.7				-329		
237.9				-339		
264.9				-348		
294.9				-359		
327.9				-362		
361.9				-366		
363.9				-366		
365				-366		
365				-267		
366				-264		
370				-258		
371				-267		
372				-257		
373				-257		
374				-257		
377				-255		
378				-258		
379				-258		
385				-256		
392				-250		
398				-250		

(Continued)

Table C19 (Concluded)

Specimen III-3

Modulus - Low
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths		millionths/psi	millionths		millionths/psi
401				-250		
405				-250		
408				-249		
412				-249		
415				-250		
419				-250		
422				-242		
426				-243		
433				-239		
440				-237		
449				-236		
454				-237		
458				-233		
468				-230		
484				-223		
489				-223		

Table C20

Specimen III-4

Modulus - Low
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths		millionths/psi	millionths		millionths/psi
0	875	875	0	-109	-109	0
1.0	1049	1054	0.074	-139	-134	-0.010
1.7	1092	1100	0.094	-149	-141	-0.013
5.7	1173	1195	0.133	-175	-151	-0.018
7.8	1195	1222	0.144	-183	-155	-0.019
8.9	1201	1230	0.148	-188	-157	-0.020
13.5	1201	1236	0.150	-195	-158	-0.020
23.3	1237	1281	0.169	-216	-169	-0.025
26.3	1279	1323	0.187	-223	-176	-0.028
41.3	GF			-236	-187	-0.032
64.0				-254	-195	-0.036
72.0				-256	-197	-0.037
86.0				-263	-202	-0.039
114.9				-278	-214	-0.044
149.0				-293	-228	-0.050
181.0				-305	-239	-0.054
204.7				-313	-246	-0.057
237.9				-321	-253	-0.060
264.9				-328	-257	-0.062
294.8				-333	-266	-0.065
327.8				-340	-276	-0.070
363.8				-344	-288	-0.074
365				-345	-289	-0.075
365				-259		
366				-257		
367				-251		
370				-250		
371				-250		
372				-250		
373				-249		
374				-248		
377				-249		
378				-248		
379				-250		
385				-247		

(Continued)

Table C20 (Concluded)

Specimen III-4

Modulus - Low
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
392				-245		
398				-243		
401				-246		
405				-241		
408				-242		
412				-241		
415				-241		
419				-240		
422				-240		
426				-240		
433				-237		
440				-236		
449				-234		
454				-234		
458				-234		
468				-231		
484				-231		

Table C21

Specimen III-5

Modulus - Low
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature 73°F

	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
<u>Time</u> <u>days</u>	<u>millionths</u>	<u>millionths</u>	<u>millionths/psi</u>	<u>millionths</u>	<u>millionths</u>	<u>millionths/psi</u>
	GF			GF		

Table C22

Specimen III-6

Modulus - Low
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	510	510	0	595	595	0
2.8	545	545	0.014	648	648	0.022
11.8	583	592	0.034	GF		
34.0	605	617	0.044			
	GF					

Table C23

Specimen III-7

Modulus - Low
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	551	551	0	613	613	0
0.2	593	593	0.018	672	672	0.024
	GF			GF		

Table C24

Specimen III-8

Modulus - Low
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths		millionths/psi	millionths		millionths/psi
0	GF			577	577	0
0.4				658	658	0.034
1.1				664	661	0.035
1.8				684	684	0.044
6.8				776	782	0.085
				GF		

Table C25

Specimen IV-1

Modulus - High
Curing - As Cast

Axial Stress - 600 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	51	51		54	54	
0.06	55	55		55	56	
1.0	56	56		61	62	
1.8	55	55		61	62	
2.1	55	55		61	62	
2.9	55	55		61	61	
3.7	55	55		61	62	
4.7	55	55		61	61	
	GF			GF		

Table G26

Specimen IV-2

Modulus - High
Curing - Air Dried

Axial Stress - 600 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	57	57	0	73	73	0
0.7	64	65	0.013	75	76	0.005
4.7	65	65	0.013	80	79	0.010
6.7	65	66	0.015	79	79	0.010
27.8	61	68	0.018	80	81	0.012
50.8	61	68	0.018			
68.1	59	70	0.022	80	84	0.018
86.0	62	77	0.033	83	90	0.028
104.0	62	77	0.033	83	90	0.028
120.1	60	79	0.037	80	92	0.032
140.3	56	75	0.030			
169.1	59	82	0.042	80	93	0.033
202.2	56	80	0.038	79	94	0.035
229.1	55	81	0.040	76	94	0.035
259.2	53	79	0.037	76	94	0.035
292.3	57	87	0.050	80	98	0.042
335.0	52	82	0.042	77	97	0.040
336.0	54	84	0.045	77	100	0.045
349.0	53	83	0.043	79	98	0.042
362.0	51	85	0.047	72	99	0.043
363.0	52	84	0.045	72	96	0.038
364.0	53	85	0.047	77	99	0.043
365	52	84	0.045	76	96	0.038
365	-15	17		1	28	
365	-15	17		1	24	
366	-8	22		1	23	
369	-8	22		4	23	
370	-8	22		3	30	
371	-8	22		1	21	
372	-7	23		3	22	
373	-7	23		5	24	
376	-8	19		3	22	
377	-9	21		1	20	
378	-8	22		4	23	

(Continued)

Table C26 (Concluded)

Specimen IV-2

Modulus - High
Curing - Air Dried

Axial Stress - 600 psi
Radial Stress - 600 psi

Temperature - 73°F

Time days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
379	-8	24		3	22	
383	-8	24		3	22	
386	-8	22		3	22	
390	-12	18		0	19	
397	-8	22		0	19	
404	-8	22		-1	18	
413	-9	21		0	19	
418	-9	30		0	19	
425	-9	21		0	19	
432	-9	25		0	19	
439	-9	23		-1	18	
447	-12	20		-1	18	
453	-12	18		-1	21	
460	-12	18		-1	18	
467	-12	18		-1	18	
474	-12	18		-1	13	
485	-12	18		-1	18	

Table C27

Specimen IV-3

Modulus - High
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths		millionths/psi	millionths		millionths/psi
0	GF			234	234	0
0.8				243	244	0.0042
1.0				246	247	0.0054
1.9				249	249	0.0062
2.6				252	253	0.0079
3.0				254	255	0.0088
3.7				250	250	0.0067
				GF		

Table C28

Specimen IV-4

Modulus - High
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	247	247	0	245	245	0
7.8	280	281	0.014	274	274	0.012
12.8	285	285	0.016	278	275	0.012
13.8	285	286	0.016	279	278	0.014
34.9	288	295	0.020	288	288	0.014
57.1	306	313	0.028	291	291	0.019
74.9	313	324	0.032	296	293	0.020
92.8	315	330	0.034	295	300	0.023
111.0	321	336	0.037	300	305	0.025
126.8	326	345	0.041	300	311	0.028
147.1	328	347	0.042	304	315	0.029
175.9	331	354	0.044	306	318	0.030
209.0	334	360	0.047	307	320	0.031
235.9	336	362	0.048	309	325	0.033
265.9	337	363	0.048	310	326	0.034
299.0	343	373	0.052	317	333	0.037
342.0	348	378	0.054	317	336	0.038
343.0	336	366	0.049	317	339	0.039
356.0	341	371	0.052	309	326	0.034
363.0	348	378	0.054	318.	335	0.037
364.0	349	379	0.055	319	339	0.039
365	345	377	0.054	315	335	0.037
365	99	129		81	100	
365	94	124		75	92	
369	78	112		59	83	
370	92	124		56	79	
371	82	118		60	80	
372	79	111		59	78	
373	79	109		59	59	
376	75	105		58	75	
378	75	105		52	71	
379	75	105		55	72	
383	75	102		55	72	
386	75	107		52	69	

(Continued)

Table C28 (Concluded)

Specimen IV-4

Modulus - High
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature - 73°F

Time days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	<u>Total</u> millionths	<u>Corrected</u> millionths		<u>Total</u> millionths	<u>Corrected</u> millionths	
390	72	104		52	69	
393	72	102		51	68	
397	68	98		48	65	
404	68	98		48	65	
411	67	97		47	64	
420	66	96		47	64	
425	64	94		46	63	
432	64	94		46	63	
439	62	96		46	63	
446	81	60		40	57	
454	60	92		40	59	
460	62	92		40	60	
467	62	92		40	57	
474	59	89		40	57	
481	59	89		40	57	

Table C29

Specimen IV-5

Modulus - High
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	256	256	0	GF		
0.04	271	271	0.006			
	GF					

Table C30

Specimen IV-6

Modulus - High
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	258	258	0	293	293	0
0.04	GF			316 GF	316	0.010

Table C31

Specimen V-1

Modulus - Main
Curing - As Cast

Axial Stress - 600 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths		millionths/psi	millionths		millionths/psi
0	39	39		38	38	0
2.7	39	39		45	45	0.012
11.9	42	42		49	50	0.020
34.1	42	45		49	52	0.023
52.8	50	53		57	60	0.037
69.9	50	53		60	60	0.037
87.8	42	45		57	58	0.033
103.8	--			64	61	0.038
124.8	52	53		61	60	0.037
153.6	52	53		63	63	0.042
186.7	GF			65	62	0.040
215.0				65	61	0.038
243.7				64	61	0.038
276.8				71	67	0.048
319.6				71	63	0.042
333.0				64	61	0.038
334.0				65	59	0.035
364.0				68	62	0.040
367				67	63	0.042
367				20	14	
368				21	14	
369				21	14	
370				20	16	
371				20	16	
374				20	13	
375				20	14	
376				18	12	
377				18	14	
381				17	10	
388				18	11	
402				11	4	
416				15	7	
423				15	7	
431				15	7	
437				15	7	

(Continued)

Table C31 (Concluded)

Specimen V-1

Modulus - Main
Curing - As Cast

Axial Stress - 600 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
444				15	7	
451				11	1	
458				13	3	
465				13	3	
472				11	1	
479				11	1	
486				11	1	

Table C32

Specimen V-2

Modulus - Main
Curing - Air Dried

Axial Stress - 600 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	41	41		44	44	
2.7	29	29		39	39	
11.9	31	35		--		
34.1	24	35		33	41	
52.8	30	42		33	41	
69.9	28	41		--		
87.8	27	42		27	40	
103.8	33	45		20	31	
124.8	24	43		13	28	
153.6	20	43		13	32	
186.7	19	43		13	23	
215.0	17	43		12	35	
243.7	15	42		9	33	
276.8	20	47		17	41	
319.6	17	44		11	33	
333.0	11	43		9	37	
334.0	15	45		7	31	
364.0	8	42		7	35	
367	8	43		6	35	
367	-30	5		-37	-7	
368	-23	8		-24	2	
369	-24	10		GF		
370	-26	8				
371	-26	8				
374	-22	9				
375	-24	10				
376	-26	8				
377	-26	8				
381	-23	8				
388	-23	8				
416	-26	5				
423	-26	5				
431	-26	12				
437	-26	6				
444	-26	6				

(Continued)

Table C32 (Concluded)

Specimen V-2

Modulus - Main
Curing - Air Dried

Axial Stress - 600 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths	millionths	millionths/psi	millionths	millionths	millionths/psi
451	-26	6				
458	-28	6				
465	-27	7				
472	-28	6				
479	-28	6				
486	-28	6				

Table C33

Specimen V-3

Modulus - Main
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	195	195	0	169	169	0
0.7	206	203	0.003	181	177	0.003
4.8	213	213	0.008	187	187	0.008
5.7	212	212	0.007	185	185	0.007
6.8	218	217	0.009	191	188	0.008
27.8	236	237	0.018	207	208	0.016
50.0	244	248	0.022	212	215	0.019
68.8	253	257	0.026	222	225	0.023
86.0	260	264	0.029	229	229	0.025
103.9	265	269	0.031	235	236	0.028
119.9	278	279	0.035	246	243	0.031
140.9	278	281	0.036	246	245	0.032
169.7	288	291	0.040	249	249	0.033
202.8	286	287	0.038	255	252	0.034
231.0	292	292	0.040	--		
259.9	295	298	0.043	262	259	0.038
293.0	303	302	0.044	271	267	0.041
335.7	311	308	0.047	277	269	0.042
350.0	308	308	0.047	--		
351.0	309	308	0.047	269	263	0.039
366	317	312	0.049	273	267	0.041
366	136	133		--		
366	127	124		--		
367	120	120		--		
370	112	109		--		
371	112	111		--		
372	110	109		--		
373	105	106		--		
374	104	105		95	91	
377	101	102		94	90	
378	101	102		94	90	
379	101	101		95	91	
384	97	96		91	85	
387	96	97		91	87	

(Continued)

Table C33 (Concluded)

Specimen V-3

Modulus - Main
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths	millionths	millionths/psi	millionths	millionths	millionths/psi
391	98	95		92	85	
398	94	91		91	84	
405	93	90		88	81	
419	90	87		87	80	
426	87	84		87	80	
433	86	82		86	78	
440	87	83		86	78	
448	85	81		84	76	
454	85	82		84	76	
461	83	80		84	76	
468	82	78		84	74	
475	82	78		82	72	
482	82	78		82	72	

Table C34

Specimen V-4

Modulus - Main
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	185	185		240	240	0
0.7	192	189		263	260	0.008
4.8	193	196		265	265	0.010
5.7	191	194		263	263	0.010
6.8	187	188		265	264	0.010
27.8	193	204		280	284	0.018
50.0	186	203		284	295	0.023
68.8	185	204		289	300	0.025
86.0	185	205		289	302	0.026
103.9	183	205		291	306	0.028
119.9	192	211		304	317	0.032
140.9	183	208		297	315	0.031
169.7	180	210		296	318	0.032
202.8	180	211		298	321	0.034
231.0	GF			300	326	0.036
259.5				302	329	0.037
293.0				308	335	0.040
335.8				312	336	0.040
350.0				307	338	0.041
351.0				305	332	0.038
366				316	339	0.041
366				85	111	
366				83	109	
367				81	111	
370				81	115	
371				78	106	
372				79	103	
373				72	103	
374				70	102	
377				69	101	
378				69	101	
379				70	101	
384				67	99	
387				67	99	
391				69	99	

(Continued)

Table C34 (Concluded)

Specimen V-4

Modulus - Main
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
398				67	98	
405				65	96	
419				63	93	
426				63	93	
433				61	91	
440				61	91	
448				60	91	
454				59	90	
461				59	90	
468				58	89	
475				58	89	
482				56	87	

Table C35

Specimen V-5

Modulus - Main
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	184	184	0	218	218	0
0.8	218	221	0.015	261	261	0.018
4.9	237	243	0.024	288	289	0.030
5.8	239	245	0.025	289	290	0.030
6.8	243	249	0.027	294	295	0.032
27.8	243	278	0.039	299	322	0.043
50.0	282	293	0.045	344	345	0.053
78.8	296	300	0.048	356	353	0.056
85.8	298	302	0.048	356	352	0.056
103.8	304	307	0.051	367	360	0.059
119.9	312	316	0.055	378	367	0.062
140.9	314	313	0.054	380	364	0.061
169.7	321	314	0.054	387	371	0.064
202.8	328	312	0.053	395	373	0.065
231.0	336	313	0.054	399	373	0.065
259.9	347	317	0.055	406	378	0.067
293.0	361	324	0.058	411	381	0.068
335.8	389	338	0.064	422	386	0.070
350.0	403	348	0.068	418	381	0.068
351.0	403	347	0.068	418	380	0.068
366	412	350	0.069	425	387	0.070
366	190	127		178	119	
366	193	129		178	119	
367	184	66		185	126	
370	174	108		173	113	
371	174	111		173	113	
372	173	107		172	112	
373	170	103		170	111	
374	170	102		168	108	
377	168	100		163	100	
378	168	100		162	100	
379	167	99		161	98	
384	166	98		153	90	
387	166	98		152	88	
391	164	93		148	84	

(Continued)

Table C35 (Concluded)

Specimen V-5

Modulus - Main
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
398	164	90		142	76	
405	166	90		138	71	
419	166	86		129	58	
426	171	87		125	53	
433	173	89		123	50	
440	177	91		119	45	
448	177	87		115	39	
454	186	93		113	34	
461	193	95		112	28	
468	193	95		108	24	
475	193	91		106	19	
482	GF			104	13	

Table C36

Specimen V-6

Modulus - Main
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	203	203	0	220	220	0
0.8	222	222	0.008	254	254	0.014
4.9	224	227	0.010	260	264	0.018
5.8	224	227	0.010	259	263	0.018
6.8	--			260	265	0.019
27.8	219	259	0.023	250	291	0.030
50.0	258	299	0.040	288	314	0.039
78.8	274	307	0.043	305	335	0.048
85.8	275	308	0.044	309	342	0.051
103.8	275	312	0.045	317	354	0.056
119.9	286	327	0.052	326	370	0.062
140.9	292	339	0.057	330	376	0.065
169.8	302	353	0.062	339	386	0.069
202.8	310	365	0.068	343	397	0.074
231.0	316	376	0.072	354	412	0.080
259.9	321	381	0.074	362	420	0.083
293.0	330	393	0.079	372	430	0.088
335.8	339	402	0.084	382	438	0.091
350.0	341	404	0.084	381	435	0.089
351.0	342	406	0.084	380	434	0.089
366	340	407	0.084	381	434	0.089
366	155	221		174	228	
366	139	202		166	219	
367	128	192		157	210	
370	115	181		146	203	
371	113	176		144	197	
372	111	177		141	197	
373	109	172		139	192	
374	109	172		137	189	
377	104	168		134	186	
378	102	165		132	185	
379	101	164		131	183	
384	94	157		127	177	
387	92	156		121	171	

(Continued)

Table C36 (Concluded)

Specimen V-6

Modulus - Main
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 2400 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths	millionths	millionths/psi	millionths	millionths	millionths/psi
391	88	151		117	176	
398	83	147		112	160	
405	79	143		106	155	
419	72			98	144	
426	69			96	140	
433	69			92	136	
440	62			88	130	
448	59			84	124	
454	57			83	127	
461	54			83	117	
468	53			78	112	
475	50			75	104	
482	48			75	103	

Table C37

Specimen V-7

Modulus - Main
Curing - As Cast

Axial Stress - 0 psi
Radial Stress - 600 psi

Temperature - 73°F

days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	-53	-53	0	78	78	0
0.8	-52	-55	-0.003	89	88	0.017
1.8	-56	-56	-0.005	89	88	0.017
13.8	-66	-62	-0.015	88	94	0.027
18.9	-64	-60	-0.012	91	97	0.032
19.8	-64	-60	-0.012	89	95	0.028
20.8	-62	-59	-0.010	93	96	0.030
41.9	-64	-58	-0.008	96	103	0.042
64.0	-70	-62	-0.015	93	101	0.038
82.8	-76	-68	-0.025	109	117	0.065
99.9	-76	-68	-0.025	107	113	0.058
117.9	-78	-70	-0.028	104	111	0.055
133.9	-74	-68	-0.025	116	119	0.068
154.9	-75	-68	-0.025	107	111	0.055
183.7	-80	-73	-0.033	108	114	0.060
216.8	-78	-72	-0.032	111	114	0.060
245.0	-77	-73	-0.033	111	112	0.057
273.9	-78	-71	-0.030	108	111	0.055
307.0	-78	-75	-0.037	119	120	0.070
349.8	-78	-77	-0.040	119	116	0.063
365	-79	-78	-0.042	115	114	0.060
365	-18	-15		40	39	
365	-20	-19		41	40	
365	-22	-18		39	38	
366	-26	-23		35	36	
370	-18	-18		39	35	
371	-25	-21		26	29	
372	-20	-19		36	33	
376	-13	-16		43	35	
379	-18	-17		35	32	
386	-26	-20		28	28	
390	-24	-18		24	25	
400	-23	-17		25	26	
404	-22	-21		26	27	

(Continued)

Table C37 (Concluded)

Specimen V-7

Modulus - Main
Curing - As Cast

Axial Stress - 0 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
411	-20	-19		26	25	
418	-20	-19		26	25	
432	-19	-18		26	25	
439	-18	-17		26	25	
446	-18	-18		24	21	
453	-17	-17		26	23	
461	-17	-17		26	23	
467	-16	-15		26	23	
473	-16	-15		25	22	
481	-16	-16		24	20	

Table C38

Specimen V-8

Modulus - Main
Curing - Air Dried

Axial Stress - 0 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	-53	-53	0	69	89	0
0.8	-57	-58	-0.008	100	101	0.020
1.8	-57	-59	-0.010	102	103	0.023
13.8	-81	-67	-0.023	105	108	0.032
18.9	-84	-67	-0.023	105	108	0.032
19.8	-83	-66	-0.022	105	108	0.032
20.8	-83	-67	-0.023	107	108	0.032
41.9	-91	-66	-0.022	106	113	0.040
64.0	-101	-69	-0.027	102	115	0.043
82.8	-109	-76	-0.038	112	125	0.060
99.9	-112	-77	-0.040	112	128	0.065
117.9	-116	-79	-0.043	111	129	0.067
133.9	-113	-80	-0.045	118	134	0.075
154.9	-116	-76	-0.038	109	129	0.067
183.7	-126	-82	-0.048	110	134	0.075
216.8	-126	-81	-0.047	110	136	0.078
245.0	-126	-79	-0.043	109	137	0.080
273.9	-129	-81	-0.047	106	136	0.078
307.0	-130	-82	-0.048	115	145	0.093
349.8	-131	-83	-0.050	114	141	0.087
365	-132	-82	-0.048	113	142	0.087
365	-68	-20		37	63	
365	-72	-22		36	66	
365	-73	-23		34	64	
366	-79	-27		29	61	
370	-68	-48		38	65	
371	-78	-22		28	64	
372	-70	-22		36	64	
376	-62	-19		44	66	
379	-71	-23		36	66	
386	-82	-27		26	60	
390	-79	-23		25	60	
400	-78	-23		25	60	
404	-74	-22		28	60	

(Continued)

Table C38 (Concluded)

Specimen V-8

Modulus - Main
Curing - Air Dried

Axial Stress - 0 psi
Radial Stress - 600 psi

Temperature 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
411	-75	-23		28	60	
418	-74	-22		28	62	
432	-74	-22		25	59	
439	-74	-22		27	59	
446	-74	-22		27	59	
453	-75	-22		27	59	
461	-74	-19		27	61	
467	-74	-20		27	61	
473	-73	-19		25	59	
481	-74	-20		27	61	

Table C39

Specimen V-9

Modulus - Main
Curing - As Cast

Axial Stress - 0 psi
Radial Stress - 600 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths		millionths/psi	millionths		millionths/psi
0	-47	-47	0	71	71	0
0.9	-53	-50	-0.005	77	80	0.015
1.9	-56	-52	-0.008	80	84	0.022
14.0	-82	-59	-0.020	79	101	0.050
14.9	-83	-57	-0.017	80	102	0.052
19.0	-88	-59	-0.020	80	103	0.053
20.3	-87	-59	-0.020	81	104	0.055
20.9	-88	-60	-0.022	81	104	0.055
42.1	-119			68	113	0.070
64.0	-106			100	118	0.078
92.8	-115			128		
99.8	-118			131		
117.8	-124			159		
133.9	-128			195		
153.9	-129			267		
182.9	-135			267		
215.9	-136			GF		
243.9	-146					
274.0	-150					
307.0	-154					
349.8	-160					
365	-162					
365	-107					
365	-107					
365	-104					
366	-104					
370	-100					
371	-102					
372	-103					
376	-99					
379	-98					
386	-100					
390	-101					
397	-96					
404	-96					
411	-96					
418	-96					
	GF					

Table C40

Specimen V-10

Modulus - Main
Curing - Air Dried

Axial Stress - 0 psi
Radial Stress - 600 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	-45	-45	0	74	74	0
0.9	-54	-51	-0.010	85	88	0.023
1.9	-57	-52	-0.012	88	93	0.052
14.0	-83	-57	-0.020	86	112	0.063
14.9	-84	-56	-0.018	86	112	0.063
19.0	-88	-58	-0.022	86	116	0.070
20.3	-88	-58	-0.022	86	116	0.070
20.9	-89	-57	-0.020	86	117	0.072
42.1	-116	-60	-0.025	68	135	0.102
64.0	-98	-29		90	143	0.115
92.9	-103	-42		100	157	0.138
99.8	-104	-43		99	158	0.140
117.8	-107	-42		99	162	0.147
133.9	-108	-39		95	165	0.152
153.9	-106	-32		94	166	0.153
182.9	-108			97	173	0.165
215.9	-102	-20		96	176	0.170
243.9	-101	-13		104	189	0.192
274.0	-95	-7		96	181	0.178
307.0	-80	10		104	189	0.192
349.8	GF			109	190	0.193
365				108	190	0.193
365				26	108	
365				22	104	
365				22	103	
366				21	102	
370				16	97	
371				14	95	
372				14	95	
376				12	91	
379				10	91	
386				8	87	
397				6	85	
404				4	83	
411				4	78	
418				4	79	
432				4	76	
439				4	74	
446				4	75	
				4	75	
				GF		

Table C41

Specimen VI-1

Modulus - Main
Curing - As Cast

Axial Stress - 0 psi
Radial Stress - 2400 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	-202	-202	0	359	359	0
1.3	-214	-214	-0.005	391	391	0.013
3.3	-219	-219	-0.007	401	401	0.018
6.2	-223	-222	-0.008	411	412	0.022
9.3	-225	-224	-0.009	421	422	0.026
15.3	-231	-228	-0.011	436	439	0.033
16.2	-230	-229	-0.011	440	441	0.034
27.2	-232	-230	-0.012	455	457	0.041
34.1	-238	-235	-0.014	459	462	0.043
38.0	-237	-234	-0.013	464	467	0.045
56.0	-248	-252	-0.021	480	483	0.052
72.1	-251	-252	-0.021	502	503	0.060
92.1	-258	-255	-0.022	504	507	0.062
115.2	-264	-258	-0.023	512	517	0.066
121.2	-265	-259	-0.024	514	519	0.067
153.9	-269	-263	-0.025	523	528	0.070
182.1	-274	-267	-0.027	530	535	0.073
211.1	-278	-271	-0.029	538	545	0.078
244.1	-282	-274	-0.030	553	558	0.083
287.0	-284	-278	-0.032	561	566	0.086
302.0	-290	-284	-0.034	566	573	0.089
342.0	-302	-295	-0.039	568	575	0.090
354.0	-302	-295	-0.039	568	575	0.090
365	-289	-283	-0.034	568	575	0.090
365	-101	-95		211	218	
365	-99	-93		198	206	
365	-99	-93		195	203	
366	-94	-87		189	196	
367	-92	-85		184	191	
370	-92	-85		176	183	
371	-91	-85		175	183	
374	-86	-80		172	180	
377	-86	-78		170	178	
378	-84	-77		170	177	

(Continued)

Table C41 (Concluded)

Specimen VI-1

Modulus - Main
Curing - As Cast

Axial Stress - 0 psi
Radial Stress - 2400 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
384	-84	-78		170	178	
386	-84	-77		165	173	
391	-84	-77		163	171	
394	-84	-78		158	165	
399	-79	-72		158	165	
400	-79	-72		156	163	
405	-79	-72		156	164	
412	-76	-72		153	165	
419	-79	-75		151	163	
426	-76	-69		148	159	
433	-75	-71		147	154	
440	-76	-72		146	153	
447	-74	-70		143	150	
454	-75	-71		143	150	
462	-73	-67		143	150	
475	-74	-68		141	148	
482	-74	-70		139	146	

Table C42

Specimen VI-2

Modulus - Main
Curing - Air Dried

Axial Stress - 0 psi
Radial Stress - 2400 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected		Total millionths	Corrected	
0	-189	-189	0	GF		
1.3	-203	-200	-0.005			
3.3	-209	-204	-0.006			
6.2	-212	-203	-0.006			
9.3	-216	-206	-0.007			
15.3	-223	-203	-0.006			
16.2	-223	-203	-0.006			
27.2	-229	-202	-0.005			
34.1	-233	-201	-0.005			
38.0	-237	-206	-0.007			
56.0	-250	-209	-0.008			
72.1	-258	-218	-0.012			
92.2	-269	-220	-0.013			
115.2	-278	-222	-0.014			
121.2	-279	-222	-0.014			
153.9	-286	-222	-0.014			
182.1	-294	-224	-0.015			
211.1	-301	-229	-0.017			
244.1	-304	-230	-0.017			
287.0	-312	-234	-0.019			
302.0	-320	-242	-0.022			
342.0	-323	-240	-0.021			
354.0	-327	-241	-0.022			
365	-322	-238	-0.021			
365	-132	-48				
365	-219	-47				
365	-129	-47				
366	-125	-38				
367	-124	-38				
370	-121	-37				
371	-121	-37				
374	-120	-36				
377	-120	-34				
378	-118	-33				
384	-117	-33				

(Continued)

Table C42 (Concluded)

Specimen VI-2

Modulus - Main
Curing - Air Dried

Axial Stress - 0 psi
Radial Stress - 2400 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths		millionths/psi	millionths		millionths/psi
386	-117	-31				
391	-117	-31				
394	-118	-32				
399	-118	-34				
400	-116	-29				
405	-116	-29				
412	-113	-29				
419	-113	-27				
426	-113	-24				
433	-113	-26				
440	-116	-29				
447	-113	-24				
454	-113	-26				
462	-113	-27				
475	-112	-23				
482	-112	-22				

Table C43

Specimen VI-3

Modulus - Main
Curing - As Cast

Axial Stress - 0 psi
Radial Stress - 2400 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	-197	-197	0	369	369	0
0.1	-207	-207	-0.004	397	397	0.012
	GF			GF		

Table C44

Specimen VI-4

Modulus - Main
Curing - Air Dried

Axial Stress - 0 psi
Radial Stress - 2400 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	-216	-216	0	354	354	0
4.0	-236	-237	-0.009	414	415	0.025
8.0	-247	-249	-0.014	429	430	0.032
	GF			GF		

Table C45

Specimen VI-5

Modulus - Main
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	342	342	0	-7	-7	0
1.0	368	368	0.011	-1	0	0.012
6.1	395	398	0.023	1	4	0.018
8.0	408	411	0.029	--		
10.8	407	411	0.029	1	5	0.020
14.1	415	420	0.032	1	5	0.020
20.1	429	435	0.039	4	9	0.027
21.0	430	434	0.038	6	10	0.028
31.8	439	444	0.042	16	21	0.047
38.7	442	448	0.044	15	20	0.045
42.6	447	453	0.046	16	21	0.047
60.6	462	469	0.053	16	21	0.047
76.7	485	486	0.060	22	26	0.055
96.7	497	503	0.067	14	19	0.043
119.8	500	508	0.069	16	24	0.052
125.8	494	502	0.067	16	24	0.052
158.7	509	517	0.073	18	26	0.055
186.9	524	534	0.080	16	24	0.052
215.8	524	534	0.080	15	25	0.053
248.8	538	549	0.086	23	31	0.063
292.0	555	563	0.092	23	31	0.063
307.0	539	554	0.088	23	33	0.067
347.0	560	570	0.095	22	32	0.065
361.0	557	567	0.094	21	31	0.063
364.0	557	565	0.093	22	32	0.065
365	558	570	0.095	22	32	0.065
365	224	232		40	50	
365	219	227		41	51	
368	203	213		40	51	
369	202	210		44	54	
370	201	209		44	54	
372	197	207		44	54	
375	193	203		44	54	
376	191	199		44	55	
379	189	--		44	--	

(Continued)

Table C45 (Concluded)

Specimen VI-5

Modulus - Main
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
382	187	198		44	55	
389	182	190		45	56	
396	177	187		44	55	
404	175	185		45	55	
410	173	183		46	57	
417	171	178		46	61	
424	171	178		46	61	
431	167	177		46	60	
438	166	173		46	56	
445	163	170		46	56	
452	162	169		46	56	
459	162	169		46	56	
475	185	166		45	55	
480	158	165		45	55	

Table C46

Specimen VI-6

Modulus - Main
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total	Corrected		Total	Corrected	
	millicnths			millionths		
0	GF			-12	-12	0
1.0				-6	-6	0.010
6.1				5	9	0.035
10.8				7	12	0.040
14.1				8	13	0.042
21.1				12	17	0.048
31.8				22	28	0.067
38.7				20	27	0.065
42.6				19	27	
60.6				17	26	
76.7				14	22	
96.7				6	17	
119.8				5	20	
125.8				5	21	
158.7				1	20	
186.9				-2	18	
215.8				-11	13	
248.8				-10	14	
292.0				-11	16	
307.0				-12	16	
347.0				-22	9	
361.0				-33	-2	
364.0				-22	10	
365				-23	9	
365				-18	14	
365				-19	13	
365				-19	13	
368				-23	10	
369				-22	10	
370				-30	2	
372				-21	12	
375				-24	8	
376				-25	8	
382				-25	10	

(Continued)

Table C46 (Concluded)

Specimen VI-6

Modulus - Main
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total	Corrected		Total	Corrected	
	millionths	millionths		millionths	millionths	
389				-34	-2	
396				-26	7	
404				-35	-2	
410				-37	-2	
417				-29	7	
431				-30	6	
438				-32	3	
445				-34	2	
452				-34	2	
459				-37	-1	
467				-38	-1	
480				-39	-3	

Table C47

Specimen VI-7

Modulus - Main
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	318	318	0	19	19	0
1.2	369	370	0.022	23	25	0.010
7.2	431	435	0.049	24	44	0.042
8.1	432	437	0.050	24	44	0.042
19.1	442	464	0.061	24	48	0.048
25.9	457	468	0.062	35	49	0.050
30.0	459	471	0.064	33		
47.9	486	502	0.077	32		
64.0	507	526	0.087	27		
84.0	523	543	0.094	27		
107.1	621	641		28		
113.1	GF			28		
145.9				32		
174.0				39		
203.0				61		
236.0				86		
279.0				147		
				GF		

Table C48

Specimen VI-8

Modulus - Main
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature ~ 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	350	350	0	-8	-8	
1.2	400	400	0.021	14	14	
7.2	455	455	0.044	GF		
19.1	462	489	0.058			
25.9	475	502	0.063			
30.0	475	504	0.064			
47.9	480	515	0.069			
64.0	516	559	0.087			
84.0	524	571	0.092			
107.1	495	586	0.098			
113.1	496	590	0.100			
145.9	552	613	0.110			
174.0	555	620	0.112			
238.0	581	650	0.125			
279.0	584	654	0.127			
294.0	575	645	0.123			
334.0	611	680	0.138			
348.0	610	676	0.136			
357.0	613	679	0.137			
362.0	607	673	0.134			
363.0	611	677	0.136			
365	611	676	0.136			
365	272					
365	272					
366	272					
369	251					
370	254					
371	254					
372	248					
373	246					
376	234					
378	227					
383	215					
386	231					

(Continued)

Table C48 (Concluded)

Specimen VI-8

Modulus - Main
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
392	208					
397	203					
404	198					
425	186					
432	176					
439	180					
446	175					
454	168					
462	156					
467	164					
474	164					
481	163					

Table C49

Specimen VII-1

Modulus - High
Curing - A3 Cast

Axial Stress - 0 psi
Radial Stress - 600 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths	millionths	millionths/psi	millionths	millionths	millionths/psi
0	-23	-23	0	69	69	0
0.9	-28	-28	-0.008	81	84	0.025
2.0	-30	-31	-0.013	82	86	0.028
3.0	-32	-31	-0.013	83	89	0.033
3.9	-34	-34	-0.018	84	90	0.035
7.1	-37	-36	-0.022	87	95	0.043
10.1	-40	-37	-0.023	90	100	0.052
15.9	-43	-40	-0.028	92	103	0.057
27.9	-39	-35		GF		
34.9	-37	-33				
44.1	-39	-36				
	GF					

Table C50

Specimen VII-2

Modulus - High
Curing - Air Dried

Axial Stress - 0 psi
Radial Stress - 600 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	-22	-22	0	75	75	0
0.9	-26	-25	-0.005	88	90	0.025
2.0	-29	-26	-0.007	92	96	0.035
3.0	-31	-27	-0.008	93	99	0.040
3.9	-34	-30	-0.013	99	106	0.052
7.1	-35	-27	-0.008	103	116	0.068
10.1	-38	-30	-0.013	103	116	0.068
15.9	-40	-30	-0.013	103	120	0.075
27.9	-42	-30	-0.013	106	126	0.085
34.9	GF			113	133	0.097
44.1				119	142	0.112
51.9				119	143	0.113
				GF		

Table C51

Specimen VII-3

Modulus - High
Curing - As Cast

Axial Stress - 0 psi
Radial Stress - 2400 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	-199	-199	0	337	337	0
0.1	-202	-202	-0.001	344	344	0.003
0.8	-211	-211	-0.005	365	367	0.012
1.9	-210	-209	-0.004	377	381	0.018
2.9	-210	-209	-0.004	383	389	0.022
3.8	-212	-212	-0.005	385	391	0.022
7.0	-224	-223	-0.010	404	412	0.031
10.1	-231	-228	-0.012	414	423	0.036
15.9	-241	-238	-0.016	422	433	0.040
24.1	-251	-247	-0.020	448	459	0.051
	GF			GF		

Table C52

Specimen VII-4

Modulus - High
Curing - Air Dried

Axial Stress - 0 psi
Radial Stress - 2400 psi

Temperature ~ 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	-116	-116	0	342	342	0
0.1	-118	-117	-0.001	353	353	0.004
0.8	-127	-126	-0.003	378	380	0.016
1.9	-128	-125	-0.002	394	398	0.023
2.9	-126	-122	-0.001	403	409	0.028
3.8	-129	-125	-0.002	410	417	0.031
7.0	-142	-134	-0.006	431	444	0.042
10.1	-151	-143	-0.010	444	457	0.048
15.9	-162	-152	-0.014	462	479	0.057
24.1	-171	-161	-0.018	480	499	0.065
34.9	-183	-168	-0.020	496	516	0.072
50.0	-153			477	500	0.066
51.8	-156			488	512	0.071
63.0	-169			508	532	0.079
91.0	GF			498		
121.1				466		
				GF		

Table C53

Specimen VII-5

Modulus - High
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	288	288	0	29	29	0
1.1	298	298	0.004	38	39	0.017
3.0	301	300	0.005	38	38	0.015
6.2	308	307	0.008	41	42	0.022
9.2	315	314	0.011	41	42	0.022
15.0	327	324	0.015	42	43	0.022
23.2	330	327	0.016	--		
34.0	335	330	0.018	48	52	0.038
43.2	338	334	0.019	49	53	0.040
51.2	339	335	0.020	51	55	0.043
62.3	--			48	57	0.047
79.1	364	359	0.030	44	50	0.035
90.2	374	369	0.034	45	52	0.038
120.2	379	374	0.036	44	53	0.040
154.0	391	383	0.040	49	59	0.050
196.0	401	392	0.043	48	59	0.050
211.0	395	387	0.041	45	59	0.050
251.0	410	401	0.047	46	60	0.052
279.0	407	396	0.045	46	59	0.050
286.0	407	395	0.044	46	61	0.053
293.0	409	398	0.046	48	61	0.053
300.0	417	406	0.049	46	60	0.052
314.0	417	405	0.049	45	61	0.053
321.0	410	398	0.046	45	59	0.050
328.0	410	398	0.046	44	62	0.055
337.0	419	408	0.050	44	58	0.048
342.0	422	422	0.051	44	58	0.048
363.0	--			46	60	0.052
366	423	410	0.051	46	60	0.052
366	164	151		19	33	
366	164	151		19	33	
366	162	149		19	33	
366	162	149		15	33	
367	153	140		13	27	

(Continued)

Table C53 (Concluded)

Specimen VII-5

Modulus - High
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
370	147	132		13	27	
371	147	132		13	27	
374				12	26	
378	142	129		7	21	
379	142	133		9	23	
381						
384	140	129		12	26	
391	140	129		12	26	
398	138	125		10	24	
405	137	124		12	26	
412	135	122		12	26	
420	135	122		12	26	
426	135	120		10	23	
433	134	122		10	23	
442	132	119		10	24	
448	132	117		10	23	
454	132	116		10	24	
461	132	116		10	24	
468	130	114		10	24	
475	127	111		10	24	
483	124	108		10	24	

Table C54

Specimen VII-6

Modulus - High
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	367	367	0	16	16	0
1.1	401	402	0.014	26	25	0.015
3.0	404	405	0.016	28	26	0.017
6.2	412	416	0.020	32	27	0.018
9.2	421	425	0.024	34	28	0.020
15.0	437	442	0.031	35	26	0.017
23.2	--			43	31	0.025
34.0	446	458	0.038	48	33	0.028
43.2	450	464	0.040	50	34	0.030
51.2	451	466	0.041	51	35	0.032
62.3	462	480	0.047	51	35	0.032
79.1	476	496	0.054	50	35	0.032
90.2	485	507	0.058	51	37	0.035
120.2	494	520	0.064	52	38	0.037
154.0	504	531	0.068	58	40	0.040
196.0	509	539	0.072	56	41	0.042
211.0	502	534	0.069	55		
251.0	507	539	0.072	56		
279.0	519	552	0.077	56		
286.0	522	553	0.077	58		
293.0	521	554	0.078	56		
300.0	520	553	0.077	55		
314.0	522	555	0.078	55		
321.0	522	555	0.078	55		
328.0	525	558	0.079	55		
337.0	524	557	0.079	56		
342.0	525	558	0.079	--		
356.0	521	554	0.078	59		
363.0	527	560	0.080	--		
366	527	560	0.080	57		
366	184	217	--	29		
366	182	215		28		
366	181	214		28		
366	178	211		28		
367	155	188		29		

(Continued)

Table C54 (Concluded)

Specimen VII-6

Modulus - High
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total	Corrected		Total	Corrected	
	millionths			millionths		
370	169	202		24		
371	170	203		24		
374	166	199		24		
378	166	198		22		
379	166	199		22		
381	166	199		22		
384	164	197		25		
391	161	194		21		
398	133	166		21		
405	130	163		21		
412	132	167		21		
420	129	164		21		
426	131	166		21		
433	131	166		18		
442	141	176		18		
448	136	171		18		
454	147	182		18		
461	147	182		21		
468	149	184		18		
475	125	160		18		
483	134	169	.	18		

Table C55

Specimen VII-7

Modulus - High
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	308	308	0	37	37	0
0.9	338	337	0.012	41	43	0.010
1.9	347	348	0.017	40	43	0.010
2.8	354	354	0.019	40	44	0.012
6.0	372	373	0.027	41	47	0.017
9.0	385	388	0.033	--		
14.8	403	406	0.041	40	48	0.018
23.0	407	411	0.043	45	53	0.027
33.8	423	427	0.040	48	56	0.032
43.0	436	439	0.054	46	54	0.028
56.9	--			46	54	0.028
57.9	444	447	0.058	48	56	0.032
62.0	454	457	0.062	48	56	0.032
90.1	470	473	0.069	46	58	0.036
120.0	492	493	0.077	53	61	0.040
153.8	--			74	86	
163.8	507	507	0.083	--		
196.0	526	527	0.091	88	99	
211.0	526	529	0.092	90	106	
251.0	527	528	0.092	107	118	
274.0	GF			120	132	
279.0				125	137	
286.0				130	142	
293.0				138	150	
300.0				142	154	
				GF		

Table C56

Specimen VII-8

Modulus - High
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	349	349	0	31	31	
0.9	390	388	0.016	42	44	
1.9	401	404	0.023	44	48	
2.8	403	406	0.024	44	49	
6.0	428	435	0.036	GF		
9.0	440	447	0.041			
14.8	456	464	0.048			
23.0	467	475	0.052			
33.8	483	497	0.062			
43.0	494	505	0.065			
56.9	495	505	0.065			
57.9	499	509	0.067			
62.0	503	513	0.068			
90.1	520	526	0.074			
120.0	539	545	0.082			
153.8	555	555	0.086			
196.0	566	566	0.090			
211.0	557	557	0.087			
251.0	579	579	0.096			
274.0	575	575	0.094			
279.0	574	574	0.094			
286.0	576	576	0.095			
293.0	575	575	0.094			
300.0	580	580	0.096			
314.0	585	585	0.098			
321.0	584	584	0.098			
328.0	584	584	0.098			
337.0	599	599	0.104			
342.0	600	600	0.105			
349.0	582	582	0.097			
356.0	596	596	0.103			
363.0	599	599	0.104			
366	607	607	0.108			
366	260					
367	213					

(Continued)

Table C56 (Concluded)

Specimen VII-8

Modulus - High
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
370	266					
371	266					
374	269					
378	268					
379	268					
381	269					
384	261					
391	241					
398	238					
405	268					
412	241					
420	260					
426	262					
433	271					
442	261					
	GF					

Table C57

Specimen VIII-1

Modulus - Low
Curing - As Cast

Axial Stress -- 600 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths	millionths	millionths/psi	millionths	millionths	millionths/psi
0	179	179	0	-21	-21	0
0.9	201	204	0.042	-28	-24	-0.005
1.9	208	214	0.058	-33	-26	-0.008
4.1	218	231	0.087	-41	-28	-0.011
10.2	240	264	0.142	-55	-34	-0.022
11.1	246	270	0.152	-57	-34	-0.022
17.2	259	291	0.187	-62	-34	-0.022
20.8	266	302	0.205	-64	-35	-0.023
29.2	279	319	0.233	-67	-34	-0.022
38.1	287	333	0.257	-72	-33	-0.021
49.1	293	345	0.277	-78	-35	-0.023
78.1	302	366	0.312	-91	-35	-0.023
107.1	305	376	0.328	-102	-38	-0.028
140.9	321	401	0.370	-114	-39	-0.030
182.9	323	410	0.385	-126	-40	-0.032
198.0	323	412	0.388	-133	-44	-0.038
238.0	326	419	0.400	-141	-44	-0.038
261.0	326	423	0.407	-148	-51	-0.050
266.0	327	429	0.416	-150	-41	-0.033
273.0	327	429	0.416	-147	-45	-0.040
280.0	327	427	0.413	-155	-48	-0.045
287.0	326	428	0.415	-155	-49	-0.047
301.0	326	429	0.417	-152	-45	-0.040
308.0	328	430	0.418	-152	-45	-0.040
315.0	326	429	0.417	-153	-45	-0.040
324.0	333	436	0.428	-145	-44	-0.038
329.0	324	429	0.417	-153	-43	-0.037
336.0	--			-155	-43	-0.037
343.0	336	441	0.437	-157	-45	-0.040
350.0	336	442	0.438	-157	-45	-0.040
358.0	--			-158	-44	-0.040
361.0	329	432		-170	-56	
365	327	430		-170	-56	
365	158	261		-139	-25	
365	159	262		-138	-24	

(Continued)

Table C57 (Concluded)

Specimen VIII-1

Modulus - Low
Curing - As Cast

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
366	158	261		-137	-23	
371	146	249		-137	-22	
372	146	249		-139	-24	
373	146	249		-136	-20	
374	146	251		-139	-23	
378	139	245		-136	-19	
380	139	248		-138	-21	
381	139	245		-138	-19	
385	137	243		-137	-20	
392	134	243		-142	-8	
399	129	238		-138	-19	
407	124	235		-137	-16	
413	124	238		-139	-20	
420	122	231		-138	-18	
429	120	235		-139	-17	
435	120	231		-139	-17	
441	116	233		-138	-13	
448	106	231		-139	-16	
455	112	224		-138	-15	
462	112	229		-139	-13	
470	112	229		-142	-18	
477	112	227		-139	-15	
484	111	231		-139	-15	

Table C58

Specimen VIII-2

Modulus - Low
Curing - Air Dried

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	197	197	0	-25	-25	0
0.9	218	232	0.058	-37	-32	-0.012
1.9	227	233	0.060	-45	-39	-0.023
4.1	233	245	0.080	-59	-47	-0.037
10.2	248	269	0.120	-82	-60	-0.058
11.1	249	274	0.128	-88	-63	-0.063
17.2	249	277	0.133	-98	-66	-0.068
20.8	250	282	0.142	-102	-68	-0.072
29.2	253	391	0.157	-110	-71	-0.077
38.1	253	296	0.165	-116	-73	-0.080
49.1	252	298	0.168	-122	-74	-0.080
78.1	249	303	0.177	-132	-77	-0.087
107.0	249	307	0.183	-139	-79	-0.090
140.8	262	323	0.210	-146	-86	-0.102
182.8	261	322	0.208	-157	-97	-0.120
198.0	255	315	0.197	-162	-102	
238.0	254	312	0.192	-171	-116	
261.0	253	314	0.195	-171	-119	
266.0	248	321	0.207	-171	-122	
273.0	260	319	0.203	-173	-128	
280.0	254	305		-173	-129	
287.0	260	330		-171	-129	
301.0	247	293		-176	-137	
308.0	238	282		-172	-136	
315.0	236	280		-173	-139	
324.0	256	297		-173	-142	
329.0	253	294		-173	-143	
336.0	257	280		-173	-140	
343.0	264	306		-172	-140	
358.0	256	298		-169	-144	
365	254	290		-167		
365	103	139		-148		
365	100	136		-148		
365	98	134		-149		
366	94	130		-154		
371	85	133		-154		

(Continued)

Table C58 (Concluded)

Specimen VIII-2

Modulus - Low
Curing - Air Dried

Axial Stress - 600 psi
Radial Stress - 0 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
372	84	119		-148		
373	85	126		-149		
374	82	117		-147		
378	79	112		-147		
380	78	110		-146		
381	77	109		-146		
385	75	113		-147		
392	75	102		-144		
399	71	107		-143		
407	68	106		-139		
413	67	105		-138		
420	64	84		-134		
429	63	83		-132		
435	62	77		-130		
441	61	83		-130		
448	58	78		-123		
455	58	71		-120		
462	58	72		-120		
470	57	62		-113		
477	56	58		-114		
484	56	56		-106		

Table C59

Specimen VIII-3

Modulus - Low
Curing - As Cast

Axial Stress - 0 psi
Radial Stress - 600 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	-29	-29	0	155	155	0
0.9	-38	-35	-0.010	172	175	0.033
3.1	-43	-40	-0.018	180	189	0.057
9.2	-55	-52	-0.038	196	214	0.098
10.1	-56	-53	-0.040	199	218	0.105
16.1	-59	-56	-0.045	207	231	0.127
19.9	-58	-55	-0.043	211	236	0.135
28.1	-60	-57	-0.047	212	242	0.145
37.1	-60	-57	-0.047	213	248	0.155
48.1	-65	-62	-0.055	216	261	0.177
77.2	-70	-67	-0.063	217	269	0.190
106.9	-60			217	278	0.205
139.9	-47			229	300	0.242
182.9	-46			230	311	0.260
197.0	-40			GF		
217.0	-36					
226.0	-33					
238.0	-34					
	GF					

Table C60

Specimen VIII-4

Modulus - Low
Curing - Air Dried

Axial Stress - 0 psi
Radial Stress - 600 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	-27	-27	0	174	174	0
0.9	-38	-40	-0.022	193	195	0.035
3.1	-47	-44	-0.028	199	207	0.055
9.2	-62	-50	-0.038	211	229	0.092
10.1	-66	-50	-0.038	212	233	0.098
16.1	-73	-53	-0.043	213	239	0.108
19.9	-77	-54	-0.045	213	243	0.115
28.1	-81	-52	-0.042	210	245	
37.1	-85	-51	-0.040	208	247	
48.1	-92	-54	-0.045	203	247	
77.2	-99	-54	-0.045	201	253	
106.9	-91	-41		199	256	
139.9	-79	-26		199	256	
182.9	-80	-28		GF		
197.0	-65	-13				
217.0	-110	-59	-0.053			
226.0	-121	-71				
238.0	-121	-69				
248.0	-139	-75				
254.0	-130	-84				
294.0	-128	-90				
315.0	-166	-132				
335.0	-170	-136				
364	-174	-146				
364	-148	-120				
370	-149	-109				
373	-149	-119				
379	-150	-126				
384	-150	-121				
391	-152	-134				
398	-152	-110				
406	-152	-123				
419	-152	-141				
434	-152	-146				
447	-154	-143				
461	-154	-148				
483	-154	-163				

Table C61

Specimen VIII-5

Modulus - Low
Curing - As Cast

Axial Stress - 0 psi
Radial Stress - 2400 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	-229	-229	0	739	739	0
0.9	-275	-274	-0.019	872	875	0.057
3.1	-303	-294	-0.027	939	948	0.087
9.2	-337	-317	-0.037	1014	1031	0.122
10.1	-343	-323	-0.039	1033	1051	0.130
16.1	-362	-335	-0.044	1086	1110	0.154
19.9	--			1111	1135	0.165
28.1	-389	-353	-0.052	1157	1186	0.186
37.1	-403	-361	-0.055	1194	1229	0.204
48.1	-419	-371	-0.059	1232	1277	0.224
77.1	-453	-394	-0.069	1310	1362	0.260
106.1	-482	-415	-0.078	GF		
139.9	-512	-436	-0.086			
182.9	-536	-453	-0.093			
197.0	-553	-469	-0.100			
237.0	-559	-471	-0.101			
260.0	-559	-466	-0.098			
301.0	-564	-465	-0.098			
315.0	-565	-467	-0.099			
328.0	-575	-474	-0.102			
	GF					

Table C62

Specimen VIII-6

Modulus - Low
Curing - Air Dried

Axial Stress - 0 psi
Radial Stress - 2400 psi

Temperature - 150°F

Time, d'ys	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	-225	-225	0	822	822	0
0.9	-266	-257	-0.013	978	980	0.066
3.1	-298	-296	-0.030	1054	1056	0.098
9.2	-333	-330	-0.044	1130	1138	0.132
10.1	-341	-329	-0.043	1149	1167	0.144
16.1	-361	-345	-0.050	1195	1216	0.164
19.9	-369	-346	-0.050	1215	1245	0.176
28.1	-389	-360	-0.056	1253	1288	0.194
37.1	-401	-367	-0.059	GF		
48.1	-417	-379	-0.064			
77.1	-448	-403	-0.074			
106.1	-473	-423	-0.082			
139.9	-496	-443				
182.9	-515	-463				
197.0	-523	-471				
237.0	-540	-488				
260.0	-550	-492				
301.0	-563	-526				
315.0	-582	-548				
328.0	-587	-555				
336.0	-606	-572				
349.0	-603	-569				
364	-608	-580				
364	-416	-388				
365	-403	-376				
366	-400	-373				
367	-398	-371				
370	-396	-356				
377	-392	-365				
384	-398	-369				
391	-397	-379				
398	-388	-346				
406	-398	-369				
419	-392	-381				
434	-390	-384				
447	-392	-381				
461	-392	-386				
483	-392	-401				

Table C63

Specimen VIII-7

Modulus - Low
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	700	700	0	49	49	0
0.2	752	753	0.022	51	51	0.003
1.1	790	790	0.038	50	50	0.002
2.1	815	815	0.048	57	57	0.013
4.3	841	841	0.059	61	62	0.022
10.5	872	873	0.072	73	75	0.043
11.5	882	883	0.076	75	77	0.047
17.5	905	905	0.085	--	--	--
21.4	916	917	0.090	80	83	0.057
29.6	939	939	0.100	81	84	0.058
38.5	959	959	0.108	84	87	0.063
49.5	979	976	0.115	87	90	0.068
78.2	1027	1021	0.134	98	101	0.087
108.3	1065	1057	0.149	--	--	--
141.4	1101	1094	0.164	107	109	0.100
183.4	1139	1127	0.178	111	111	0.103
198.0	1145	1136	0.182	111	115	0.110
238.0	1176	1163	0.193	114	117	0.113
261.0	1171	1154	0.189	118	115	0.110
266.0	1186	1177	0.199	119	115	0.110
280.0	1188	1169	0.195	119	115	0.110
287.0	1191	1172	0.197	119	114	0.108
301.0	1196	1177	0.199	119	114	0.108
308.0	1207	1188	0.203	119	111	0.103
315.0	1223	1202	0.209	--	--	--
324.0	1220	1197	0.207	121	113	0.107
329.0	1224	1201	0.209	--	--	--
336.0	1224	1201	0.209	--	--	--
343.0	1224	1199	0.208	126	116	0.112
350.0	1225	1201	0.209	125	115	0.110
358.0	1235	1210	0.212	118	108	--
361.0	1238	1213	0.214	117	106	--
365	1239	1213	0.214	117	105	--
365	699	673	--	77	65	--
366	644	619	--	73	61	--

(Continued)

Table C63 (Concluded)

Specimen VIII-7

Modulus - Low
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 73⁰F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
371	585	560		72	60	
378	607	586		73	61	
385	606	581		73	61	
392	570	546		73	61	
399	596	570		73	60	
407	586	558		73	59	
420	582	561		75	60	
435	578	546		76	60	
448	578	546		75	58	
462	569	537		76	58	
483	571	536		76	56	

Table C64

Specimen VIII-8

Modulus - Low
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
0	782	782	0	79	79	0
0.2	857	857	0.031	77	79	0
1.1	906	909	0.053	78	80	0.003
2.1	950	956	0.072	83	94	0.025
4.3	985	996	0.089	103	103	0.040
10.5	1025	1048	0.111	123	123	0.073
11.5				126	126	0.078
17.5				131	131	0.087
21.4				133		
29.6				133		
38.5				132		
49.5				130		
78.2				124		
108.3				118		
141.4				124		
183.4				116		
198.0				116		
238.0				107		
261.0				90		
266.0				106		
273.0				106		
280.0				104		
287.0				102		
301.0				97		
308.0				97		
315.0				99		
324.0				100		
329.0				91		
336.0				87		
343.0				104		
350.0				95		
358.0				91		
361.0				86		
525				90		

(Continued)

Table C64 (Concluded)

Specimen VIII-8

Modulus - Low
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 73°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
365	663	734		25		
366	625	696		9		
371	603	699		-1		
372	601	690		-3		
373	599	671		3		
374	597	673		2		
	GF			GF		

Table C65

Specimen VIII-9

Modulus - Low
Curing - As Cast

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths		millionths/psi	millionths		millionths/psi
0	GF			GF		

Table C66

Specimen VIII-10

Modulus - Low
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep millionths/psi	Strain		Specific Creep millionths/psi
	Total millionths	Corrected millionths		Total millionths	Corrected millionths	
C	695	695	0	87	87	0
0.8	742	756	0.025	93	98	0.018
1.8	894	900	0.085	94	100	0.022
4.0	943	955	0.108	96	108	0.035
10.1	1001	1022	0.136	104	126	0.065
11.1	1015	1040	0.144	106	131	0.073
17.1	1048	1076	0.159	107	134	0.078
20.9	1066	1098	0.168	104	138	0.085
29.1	1098	1136	0.184	106	145	0.097
38.1	1124	1167	0.200	103	146	
49.1				101	149	
78.6	1205	1259	0.235	94	149	
107.9	1246	1304	0.254	88	148	
140.9	1246	1307		93	153	
182.9	1271	1332		89	149	
198.0				88	148	
238.0				78	132	
261.0				78	127	
266.0				78	128	
273.0				78	123	
280.0				76	120	
287.0				74	116	
301.0				73	112	
308.0				73	110	
315.0				64	98	
324.0				72	103	
343.0				70		
365				70		
365	942	978		17		
365	908	944		14		
366	889	925		12		
371	858	906		4		
372	856	891		5		
373	851	892		5		
374	849	884		5		

(Continued)

Table C66 (Concluded)

Specimen VIII-10

Modulus - Low
Curing - Air Dried

Axial Stress - 2400 psi
Radial Stress - 600 psi

Temperature - 150°F

Time, days	Axial Gage			Radial Gage		
	Strain		Specific Creep	Strain		Specific Creep
	Total	Corrected		Total	Corrected	
	millionths		millionths/psi	millionths		millionths/psi
378	836	870		1		
385	822	860		-5		
392	814	841		-5		
399	808	844		-5		
407	799	837		-5		
413	794	832		-9		
420	787	807		-12		
435	780	785		-12		
448	767	787		-18		
462	758	772		-22		
484	753	753		-22		

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