ENGINEERING PROPERTIES OF CONCRETE IN A SULFATE ENVIRONMENT

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By

Scott Kidani

Thesis Committee:

Craig M. Newtson, Chairperson
Ian Robertson
Randall Akiona

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Concrete is one of the most widely used construction materials throughout the world. Its high compressive strength, low permeability, and low relative cost make it an excellent material for use in dams, bridges, piers, and other structures that are exposed to extreme environmental conditions. Sulfates, which are naturally occurring salt compounds found in soils, groundwater, seawater, and industrial effluents, pose a serious threat to the life expectancies of concrete structures. When sulfates come into contact with concrete, properties of concrete that are vital to the design and modeling of concrete structures such as compressive strength, tensile strength, and modulus of elasticity are affected. New compounds are formed as a result of reactions between sulfate ions and cement hydration products. The formation of the new products causes cracking and spalling of the concrete resulting in increased permeability and decreased strength. Consequently, a thorough understanding of the progression of sulfate attack on concrete and how to mitigate its effects are important to ensure the structure will remain useable throughout its life expectancy.

Concrete can be protected from sulfate attack in various ways, such as using sulfate resistant cements, introducing materials such as silica fume, fly ash, or other admixtures into the concrete, using proper mixing and curing procedures, and using waterproofing membranes (Kumar and Kameswara 1995). Depending on location, the use of sulfate resistant cements is probably the most

cost effective method to mitigate the effects of sulfate attack on a concrete structure.

1.2 Objective

This study investigated the effects of sulfate exposure on the mechanical properties of Portland cement concrete. Concrete specimens cast from mixtures composed of locally available aggregate and cement were exposed to a 10% (67,600 ppm) sodium sulfate solution for periods up to 2 years. During this exposure, the specimens were periodically tested for compressive strength, tensile strength, and dynamic modulus of elasticity to determine how the sulfate environment influenced the mechanical properties of concrete.

1.3 Scope

This report presents a study intended to evaluate changes in mechanical properties of concrete deteriorating due to sulfate attack. Chapter 2 presents a literature review for sulfate attack on concrete. Mechanisms and characteristics of sulfate attack are explained, and previous works by other investigators are summarized to provide insight to the accelerated testing methods used in the current study. Chapter 3 explains the experimental procedures used in this study, the materials used in the study, the mixing procedure, and the testing procedures. Results obtained from the laboratory tests are presented and discussed in Chapter 4. Chapter 5 presents a summary of the study and the conclusions derived from the test results.

CHAPTER 2

BACKGROUND AND LITERATURE REVIEW

2.1 Introduction

Sulfate attack on concrete can seriously affect the durability of concrete. Concrete deterioration due to sulfate attack not only affects the safety, but also the cost and serviceability of the structure. Sulfate ions are found naturally in soils and ground water, and are also found in sea water, industrial wastewater, and acid rain. Sulfate ion concentrations of 0-150 ppm, 150-1500 ppm, 1500-10,000 ppm, and above 10,000 ppm are classified as mild, moderate, severe, and very severe, respectively, (Akoz et al. 1994).

Sulfate attack is characterized by two different mechanisms, chemical reactions and the growth of crystals (Day 1993). The first chemical reaction that takes place is between the sulfate ions and crystalline calcium hydroxide. This reaction forms crystalline calcium sulfate or gypsum as shown in the following reaction:

$$Na_2SO_4 + Ca(OH)_2 + 2\,H_2O \rightarrow 2\,NaOH + CaSO_4 \cdot 2H_2O$$

The second chemical reaction, between gypsum ($CaSO_4 \cdot 2H_2O$) and hydrated calcium aluminate, forms calcium sulfoaluminate, commonly known as ettringite:

$$3CaO \cdot Al_2O_3 + 26H_2O + 3(CaSO_4 \cdot 2H_2O) \rightarrow 3CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 32H_2O$$

The second mechanism of sulfate attack involves the growth of crystals. The crystal growth is caused by the crystallization of sulfate salts in the pores of the concrete. This attack mechanism is usually found in areas where water is migrating through the concrete and evaporating at the surface, such as the exposed surfaces of concrete dams, retaining walls, and concrete basements (Day 1993).

2.2 Deterioration Effects

Some of the effects of sulfate attack are the loss of flexural and compressive strength, reduced modulus of elasticity, permanent deformation, cracking, and spalling (Kumar and Kameswara 1994).

Among the effects of sulfate attack, flexural strength is the most sensitive to sulfate exposure (Irassar 1989). The formation of gypsum and ettringite, and the formation of crystals are expansive mechanisms. When the gypsum and ettringite are produced, a large volume is required by the products. Since the space available for the products is limited to the space occupied by the original reactants, the increased volume creates tensile stresses within the concrete, decreasing the concrete's tensile capacity. The increase in volume also causes cracks in the concrete, allowing more sulfate ions to penetrate into the concrete and cause further deterioration.

2.3 Controlling Sulfate Attack

Sulfate attack can be controlled in various ways, including the use of cement with low tricalcium aluminate (C_3A) content, using a concrete mixture with a low

water-cement ratio, using pre-cast rather than cast-in-place construction, and using blended cements (Kumar and Kameswara 1995).

Since C_3A reacts with sulfate ions to produce ettringite, limiting the amount of C_3A in the cement will limit the amount of ettringite that is produced. Type V cement has a low C_3A content, and is classified as highly sulfate resistant. Type V cement should be used when high sulfate exposure is anticipated.

A concrete mix with a low water-cement ratio will produce concrete that is less permeable to water. Since the water carrying sulfate ions have a more difficult time penetrating the concrete, there will be less reaction between the C_3A and the sulfate ions. Consequently, less ettringite will be produced.

Another way to reduce sulfate attack is to use pre-cast structures rather than cast-in-place structures in sulfate environments. Structures that are cast-in-place in a sulfate environment are exposed to sulfates at a very early stage, before the concrete has had time to mature. Concrete used in pre-cast structures will have time to cure before being placed in a sulfate environment. Consequently, the concrete will be less permeable and more resistant to sulfate attack.

Using cements blended with materials such as silica fume and fly ash also improves sulfate resistance of concrete. The increase in sulfate resistance is attributed to reduced permeability, removal of calcium hydroxide formed during hydration of calcium silicates, unfavorable conditions for ettringite formation, a fine filler effect that stimulates hydration by dispersion of cement floccules, and reduction in C_3A content in the cement due to a replacement of cement with the blending material (Irassar 1989).

2.4 Sulfate Exposure

In this study, attempts were made to accelerate the sulfate attack on concrete. An accelerated program was used because sulfate concentrations found in the environment require long exposure periods before any significant deterioration is exhibited. Consequently, it is not practical for a laboratory study. The most common accelerated test methods are (Wafa 1994):

- Increasing the sulfate-solution concentrations
- Increasing the reaction surfaces
- Use of wetting and drying cycles
- Raising the temperature of the solution

Increasing the Na_2SO_4 concentration in the solution is one method that can be used to accelerate the sulfate attack. By increasing the Na_2SO_4 concentration, more sulfate ions are available to react with the calcium hydroxide and hydrated aluminates in the cement, causing more ettringite and gypsum to form, thus weakening the concrete (Kumar and Kameswara 1994). Using a 10% (67,600 ppm) sulfate solution has been shown to cause a 50% decrease in compressive strength after 15 months of exposure for specimens produced using Type I cement and a high water-cement ratio. Specimens produced with Type V cement and a low water-cement ratio produced dense concrete that showed no loss of strength after 15 months of exposure (Wafa 1994).

Increasing the reaction surface allows the sulfate ions to attack the concrete specimen over a greater area of concrete, thus allowing a greater amount of

sulfate ions to react with more calcium hydroxide and aluminates in the cement paste, causing the concrete to deteriorate.

Wetting and drying cycles allow sulfate ions to penetrate the pores in the concrete. Thus, allowing the sulfate ions to react with a greater amount of calcium hydroxide and aluminates in the concrete.

Raising the temperature of the sulfate solution increases the rate at which cement hydrates. Consequently, the rate at which the sulfate ions react with calcium hydroxide and aluminates is also increased. Previous investigators used a sulfate solution with a temperature of 40°C. These investigators found that raising the temperature did not accelerate the deterioration of the specimens. Instead, the raised temperature improved many properties of the specimen (Akoz et al. 1999).

2.5 Testing

Compressive strength, flexural strength, slump, and dynamic modulus tests were conducted for all of the concrete mixtures produced in this study. These tests are described in this section.

2.5.1 Compressive Strength Test (ASTM C 39), Flexural Strength Test (ASTM C 78), Slump Test (ASTM C 143)

All compressive strength tests, flexural strength tests, and slump tests performed in this study were conducted according to the appropriate ASTM specifications.

2.5.2 Dynamic Modulus Test (ASTM C 215)

In this study, the effect of sulfate attack on the elastic modulus of concrete was measured using a dynamic modulus test. Dynamic modulus tests are used to determine changes in dynamic modulus of elasticity of specimens undergoing chemical attack or other deterioration. By exciting a beam into the first mode of vibration, the single degree-of-freedom assumption can be used and the resonant frequency and damping of the fundamental mode can be examined (Clarke 1991).

To record accurate measurements from the specimen, a support system that provided free-free boundary conditions was used for each test. The free-free boundary condition was achieved by suspending the specimen at nodal locations on tensioned piano wire as shown in Figure 2.1. This minimized the influence of the supports on the prism, allowing the prism to vibrate freely (Clarke 1991).

To calculate the dynamic modulus, the fundamental frequency of the concrete specimen was first measured using the impact-resonance method. In this test method, a supported specimen is struck with a small impactor that causes vibration of the prism. A load cell on the impactor measures the impact force, and the response of the specimen is measured with an accelerometer attached to the specimen. The software then uses a Fast Fourier Transform (FFT) to transform the time domain data into the frequency domain. The ratio of the Fourier transform of the output signal to the Fourier transform of the input signal is called the frequency response function which contains a complete mathematical description of the vibration characteristics of the prism over the

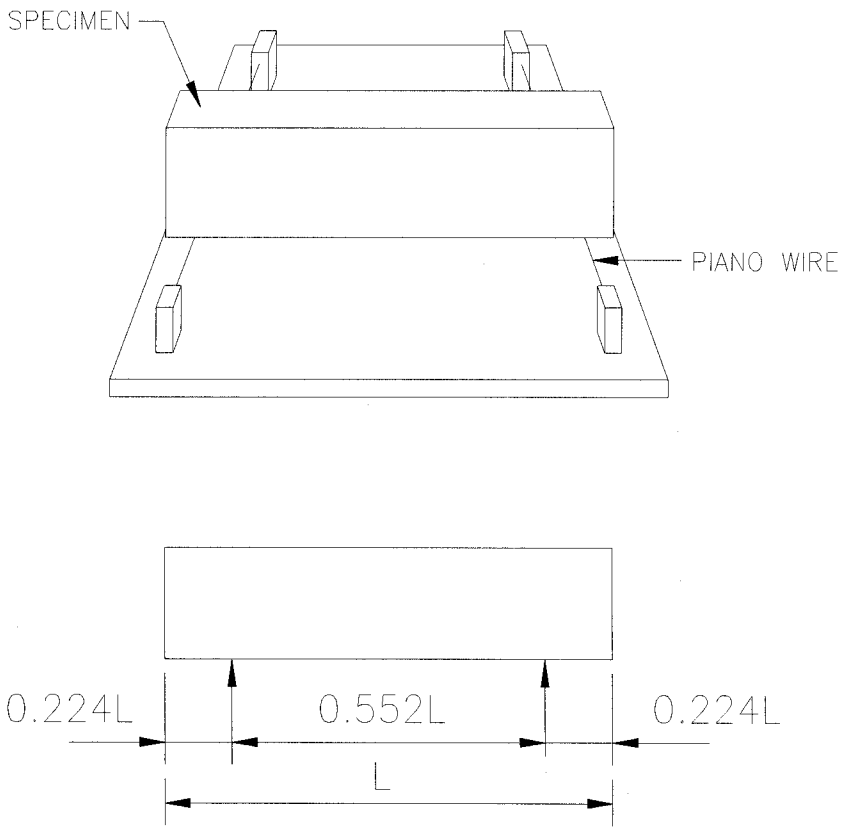


Figure 2.1 Schematic of Specimen Support System.

range of frequencies excited by the impact (Clarke 1991). The dynamic modulus of the specimen is calculated using the following equation:

$$\text{Dynamic } E = CWn^2 \tag{2.1}$$

Where:

W = weight of specimen, kg (lb),

n = fundamental transverse frequency, Hz,

C = $0.9464\ (L^3T/bt^3)$, $N \cdot s^2/(kg \cdot m^2)$

= $0.00245\ (L^3T/bt^3)$, $s^2/in.^2$,

L = length of specimen, m (in.),

t, b = dimensions of cross section of prism, m (in.), t being in the direction in which it is driven, and

T = a correction factor which depends on the ratio of the radius of gyration, K, ($K = 0.2887t$) to the length of the specimen, L, and on Poisson's ratio.

2.6 Summary

This chapter presented background information on sulfate attack, the different mechanisms of attack, various methods to prevent sulfate attack, accelerated test methods that have been used to study sulfate attack under laboratory conditions, and the dynamic test method used in this study to evaluate sulfate attack.

CHAPTER 3
EXPERIMENTAL PROCEDURES

3.1 Introduction

The experimental procedures for this study involved the use of concrete specimens produced from concrete mixtures with water-cement ratios that varied from 0.40 to 0.55. This chapter will focus on the materials that were used in these mixtures, the preparation of the materials before the mixtures were produced, and the curing of the concrete specimens after they were cast. The procedures used in mixing the concrete, measuring the compressive strength, modulus of rupture, and dynamic elastic modulus will also be presented in this chapter.

3.2 Materials

3.2.1 Fine Aggregates

Two fine aggregates were used in the concrete mixtures. The first was dune sand from an aeolian deposit of coral on the island of Maui. The second was crushed basalt from the Kapaa quarry on the island of Oahu. The grain size distribution and fineness modulus for both fine aggregates were determined according to ASTM C 136. The results from the grain size distribution tests are presented in Table 3.1 along with the values for a blended sand comprised of 80% basalt sand and 20% Maui dune sand. The two sands were blended to satisfy the ASTM C 33 requirement that the blended sand produce a fineness

Table 3.1 Particle Size Distribution For Fine Aggregates

	Percent Passing By Weight (%)			
Sieve Size	Maui Dune Sand	Basalt Sand	Blended Sand	ASTM C 33 Requirements
4.75 mm (No. 4)	98.8	97.5	97.7	95 to 100
2.36 mm (No. 8)	97.5	90.9	92.2	80 to 100
1.18 mm (No. 16)	95	56.7	64.4	50 to 85
600 μm (No. 30)	91.2	32.4	44.2	25 to 60
300 μm (No. 50)	66.6	11.6	22.6	10 to 30

modulus between 2.3 and 3.1. The fineness modulus values for all fine aggregates are presented in Table 3.2.

The bulk specific gravity and absorption of the fine aggregates were determined according to ASTM C 128. The bulk specific gravity for the blended sand was calculated with Equation 3.1. Bulk specific gravity values and absorptions are provided in Table 3.3.

$$G = \frac{1}{\frac{P_1}{100G_1} + \frac{P_2}{100G_2}} \tag{3.1}$$

where: G is the average specific gravity of the blended sand,

G_1, G_2 are specific gravity values for each of the sands blended,

P_1, P_2 are the percentages of each fine aggregate.

Table 3.2 Fineness Modulus of Fine Aggregates

	Maui Dune Sand	Basalt Sand	Blended Sand	ASTM C 33 Requirements
Fineness Modulus	1.42	2.61	2.52	2.3 to 3.1

Table 3.3 Specific Gravity and Absorption For Fine Aggregates

	Bulk Specific Gravity	Absorption (%)
Maui Dune Sand	2.42	2.78
Basalt Sand	2.83	5.01
Blended Sand	2.54	Not Applicable

3.2.2 Coarse Aggregate

The coarse aggregate used in this study was crushed basalt from the Kapaa quarry on the island of Oahu. The top size for this aggregate was 19.1mm (3/4 in). ASTM C 33 requirements for coarse aggregates are shown in Table 3.4 along with the results from the sieve analysis performed on the coarse aggregate. The bulk specific gravity and the absorption of the coarse aggregate were also determined according to ASTM C 127, and are shown in Table 3.5.

3.2.3 Cement

The cement used in this study was a Type I-II cement produced on the island of Oahu.

Table 3.4 Particle Size Distribution For Coarse Aggregate

	Percent Passing By Weight (%)	
Sieve Size	¾" Top Size Basalt	ASTM Requirement
25 mm (1 in.)	100	100
19 mm (¾ in.)	99.2	90 to 100
12.5 mm (½ in.)	66.3	NA
9.5 mm (3/8 in.)	33.3	25 to 55
4.75 mm (No. 4)	4.6	0 to 10

Table 3.5 Specific Gravity and Absorption For Coarse Aggregate

	Bulk Specific Gravity	Absorption (%)
3/4" Top Size Aggregate	2.63	2.75

3.3 Mixtures

The concrete mixture proportions used in this study were computed using PCA recommendations and water-cement ratios of 0.40, 0.45, 0.50, and 0.55. Two mixtures were prepared for each water-cement ratio, one mixture was wet cured for 28 days, while the other was wet cured for 14 days. The proportions of each mixture are presented in Table 3.6.

Table 3.6 Mixture Proportions For Design Mixtures

Water-cement Ratio	**0.40**	**0.45**	**0.50**	**0.55**
Design Slump, mm (in.)	75-100 (3 – 4)	75-100 (3 – 4)	75-100 (3 – 4)	75-100 (3 – 4)
Coarse Aggregate, kg/m^3 (lb/yd^3)	1027 (1730)	1027 (1730)	1027 (1730)	1027 (1730)
Maui Dune Sand, kg/m^3 (lb/yd^3)	127 (214)	137 (231)	145 (244)	151 (255)
Basalt Sand, kg/m^3 (lb/yd^3)	508 (856)	548 (923)	580 (977)	606 (1021)
Cement, kg/m^3 (lb/yd^3)	504.5 (850)	449 (756)	403.5 (680)	367 (618)
Water, kg/m^3 (lb/yd^3)	202 (340)	202 (340)	202 (340)	202 (340)

3.4 Sulfate Solution

A 10% (67,600 ppm) sodium sulfate (Na_2SO_4) solution was used in this study to try to accelerate sulfate attack on the concrete specimens. The sodium sulfate solution was prepared by mixing sodium sulfate crystals with the appropriate amount of de-ionized water.

3.5 Specimens

A total of eleven 102 by 203 mm (4 by 8 inch) cylinders and nine 76 x 102 x 406 mm (3" x 4" x 16") prisms were cast from each concrete mixture. Compressive strength tests in accordance with ASTM C 39 were performed on the cylinders, while dynamic modulus tests and modulus of rupture tests were conducted on the prisms.

3.5.1 Preparation

Prior to mixing the concrete, the moisture content for both the Maui dune sand and the basalt sand were controlled by oven drying the sands at a temperature of 110° C for a minimum of 48 hours. This ensured a zero moisture content for both sands. The moisture content for the coarse aggregate was determined according to ASTM C 566. The moisture content obtained from the coarse aggregate was then used to adjust the water content in the mixture proportions.

3.5.2 Mixing Process

For each of the concrete mixtures a 0.0142 m^3 (0.5 ft^3) butter batch was produced prior to the 0.0637 m^3 (2.25 ft^3) design mixture. The materials for the butter batch and design mixture were weighed out and placed in buckets prior to mixing the concrete. During this time, the Maui dune sand and basalt sand were allowed to cool to room temperature. Mixing was conducted according to ASTM C 192.

3.5.3 Casting Specimens

The freshly mixed concrete was placed into cylinder and prism molds that were treated with a form release agent. For the 102 by 203 mm (4 by 8 inch) cylinders, the concrete was placed in three equal lifts, after each lift was placed in the mold the concrete was rodded 25 times in a circular motion with a 16 mm (0.625 in.) diameter steel rod. For the prisms, the concrete was placed in the mold, then consolidated on a vibrating table. After the concrete was allowed to

cure for approximately 24 hours, the specimens were removed from the molds and wet cured for either 14 or 28 days.

3.5.4 Process After Curing Period

Once the specimens were removed from the curing tank, both the cylinders and prisms were placed in a 10% (67,600 ppm) sodium sulfate solution. The specimens that were allowed to cure for 28 days in the curing tank remained in the sulfate solution for a minimum of 420 days, while the specimens that cured in the curing tank for 14 days remained in the sulfate solution for a minimum of 365 days. After the respective 420 or 365 days, the specimens were subjected to wet-dry cycling. During the wet-dry cycling, the cylinders and prisms were allowed to dry for one week, then set back in the sulfate solution for one week then allowed to dry again. The cycling of the specimens continued for another 150 days for the specimens that cured for 28 days in the curing tank, or another 100 days for the specimens that cured for 14 days in the curing tank.

3.6 Testing Procedures

3.6.1 Slump Test

Slump tests were performed on each mixture according to the requirements of ASTM C 143.

3.6.2 Compressive Strength and Modulus of Rupture Tests

Compressive strength and Modulus of Rupture testing were conducted at three different times for each mixture. The first tests were performed after the specimens were cured for 14 or 28 days in the curing tank. The next tests were

performed prior to initiating the wet-dry cycles of the specimens, and the last tests were performed at the end of the cycling. Approximately 24 hours prior to testing, the ends of the cylinders chosen for compressive strength testing were capped with sulfur, then returned to the curing tank and allowed to complete the curing process. In each set of tests, three cylinders and three prisms were tested.

3.6.3 Dynamic Modulus of Elasticity Test

The dynamic modulus for each specimen was determined by the impact resonance method in accordance with ASTM C 215. During each test the transverse frequency of the specimen was measured and recorded along with the weight of the specimen. The dynamic modulus for each specimen was then calculated using Equation 2.1. The prisms were tested weekly for dynamic modulus during the early stages of curing. After 30 days, they were tested once every other week for the remainder of the study. A schematic drawing of the impact resonance test is shown in Figure 3.1.

3.7 Summary

This chapter first described the materials used in this study, the material preparation, and the material properties. This chapter then presented the proportions of all materials used in the various mixture designs and the specimens cast from the mixtures. Lastly the experimental procedures for casting, curing, and testing the concrete specimens were presented.

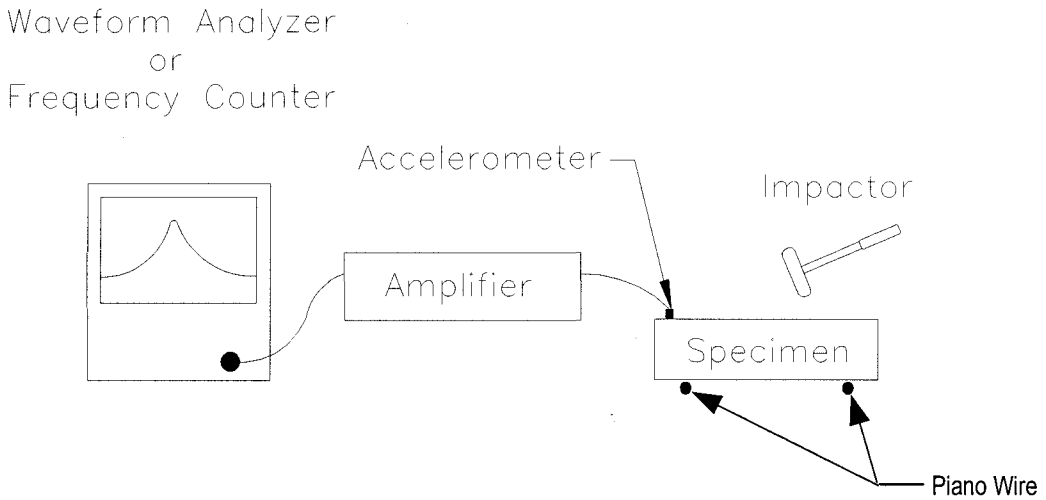


Figure 3.1 Schematic of Impact Resonance Test.

In this study Maui dune sand and basalt sand were oven dried, then blended together to produce a fine aggregate with a fineness modulus of 2.52. This fineness modulus meets the ASTM requirement of 2.3 to 3.1. The zero moisture content fine aggregate, and coarse aggregate, along with Type I-II cement and water were used in concrete mixtures with water-cement ratios that varied from 0.40 to 0.55. Eleven 102 by 203 mm (4 by 8 inch) cylinders and nine 76 x 102 x 406 mm (3"x4"x16") prisms were cast from each mixture. The specimens were then cured in a curing tank for a period of 14 or 28 days, then introduced to a 10% Na_2SO_4 bath. The specimens that were cured for 14 days remained in the sulfate bath for 365 days while the specimens that cured for 28 days remained in the sulfate bath for 460 days. After the continuous exposure to the sulfate, the specimens were then subjected to wet-dry cycling.

During the course of the study the specimens were tested for tensile strength, compressive strength, and dynamic modulus. Compressive and tensile strength tests were conducted at the end of curing, beginning of cycling and at the end of the test period. Dynamic modulus testing was performed weekly while the specimens were in the early stages of exposure to the sulfate solution, and once every other week for the remainder of the study.

CHAPTER 4
RESULTS and DISCUSSION

4.1 Introduction

Dynamic modulus, compressive strength, and modulus of rupture tests were performed on specimens cast for the concrete mixtures described in Chapter 3. The results for these tests are presented in this chapter.

4.2 Slump Test

To measure the workability of the concrete mixtures, slump tests were performed in accordance with ASTM C 143. The slump values measured for the concrete mixtures ranged from 95 mm (3.75 in.) to 150 mm (6 in.), and are presented in Table 4.1.

Table 4.1 Slump Test Results

Water-Cement Ratio	Slump, mm (in.)
14-Day	
0.40	140 (5.50)
0.45	140 (5.50)
0.50	145 (5.75)
0.55	150 (6.00)
28-Day	
0.40	95 (3.75)
0.45	115 (4.50)
0.50	125 (5.00)
0.55	145 (5.75)

4.3 Specimens

Specimens from three series of mixtures were exposed to a sulfate environment. The first series of mixtures were produced using water-cement ratios of 0.40, 0.45, 0.50, and 0.55. For this series, nine 76 x 102 x 406 mm (3"x4"x16") prisms and eleven 102 by 203 mm (4 by 8 inch) cylinders were cast for each mixture, then the specimens were allowed to cure in a water bath for 14 days. After the 14 day curing period, the specimens (cylinders and prisms) were placed in the sodium sulfate solution. The second series of mixtures were used to produce the same quantity of specimens and used concrete mixtures with the same proportions as the first set. However, the specimens from the second series were allowed to cure in the water bath for 28 days before being placed in the sodium sulfate solution. A third series of specimens consisted of five sets of three 76 x 102 x 406 mm (3"x4"x16") prisms cast from a 0.55 water-cement concrete mixture. Each series of specimens were subjected to differing curing conditions for a 70 day period. Since the second series of specimens (28-day) were allowed to cure for a longer period of time, they were exposed to the sulfate environment at greater maturity than the first set of specimens (14-day). Therefore, properties such as compressive strength, dynamic modulus, and modulus of rupture are higher for the 28-day specimens than for the 14-day specimens.

4.4 Initial Dynamic Elastic Modulus

The initial dynamic elastic modulus for the 14 and 28-day specimens are presented in Table 4.2. As expected, mixtures with lower water-cement ratios have higher dynamic modulus values, while mixtures with the highest water-cement ratio have the lowest dynamic modulus.

4.5 Relative Dynamic Modulus

Figures 4.1 through 4.4 show the relative dynamic modulus $((E/E_{initial})x100)$ vs. duration of exposure to the sulfate solution for the 14-day batches, and Figures 4.5 through 4.8 show the relative dynamic modulus vs. duration of exposure to the sulfate solution for the 28-day batches. Each figure presents the data for the six individual specimens and the average for all

Table 4.2 Initial Dynamic Elastic Modulus.

Water-cement Ratio	Initial Dynamic Elastic Modulus, MPa (psi)
14-Day	
0.40	3.94×10^4 (5.72×10^6)
0.45	3.80×10^4 (5.51×10^6)
0.50	3.83×10^4 (5.55×10^6)
0.55	3.78×10^4 (5.49×10^6)
28-Day	
0.40	4.04×10^4 (5.86×10^6)
0.45	3.83×10^4 (5.56×10^6)
0.50	4.00×10^4 (5.80×10^6)
0.55	3.36×10^4 (4.88×10^6)

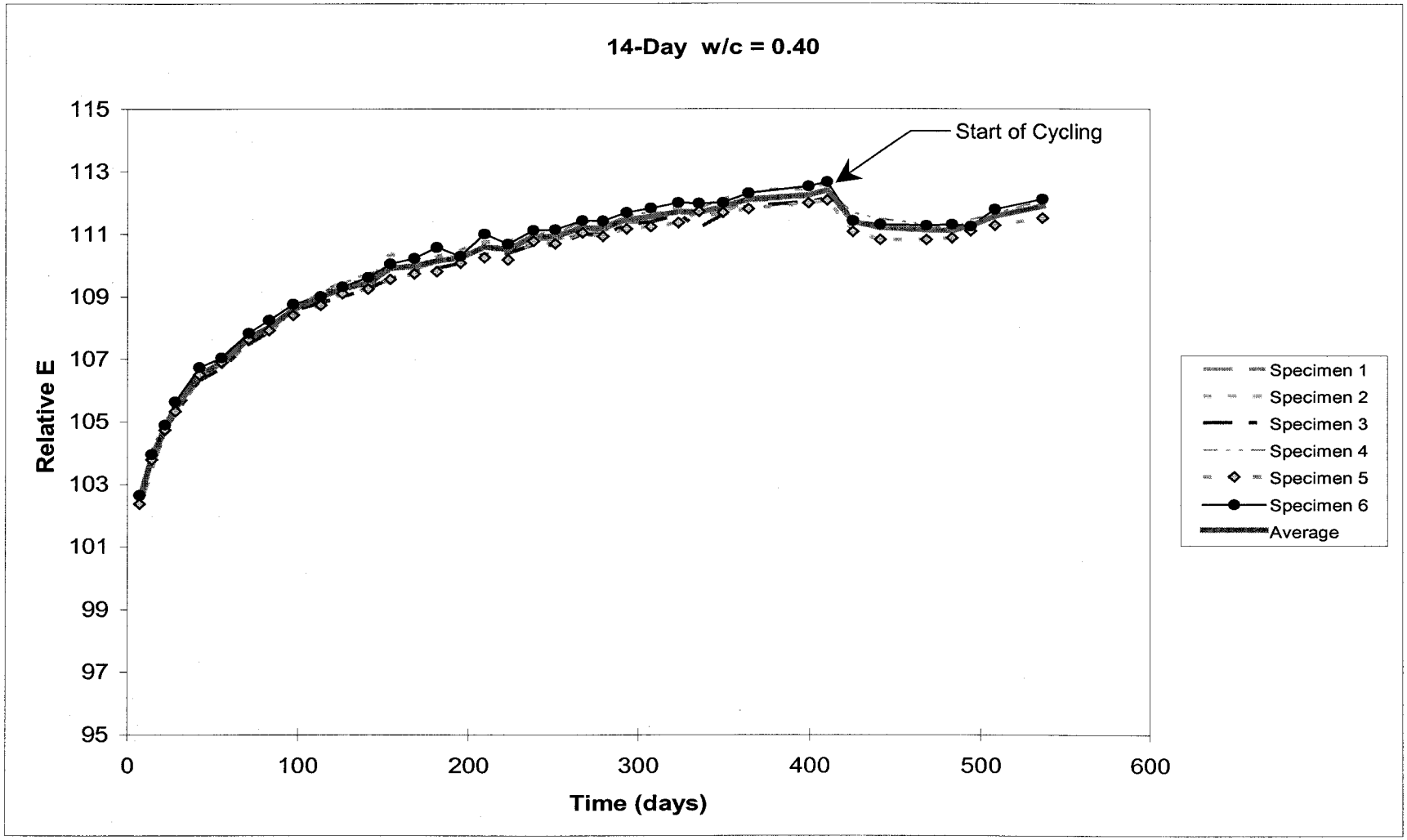


Figure 4.1 Relative E_{dyn} vs. Time For 14-Day, 0.40 Water-Cement Ratio Specimens.

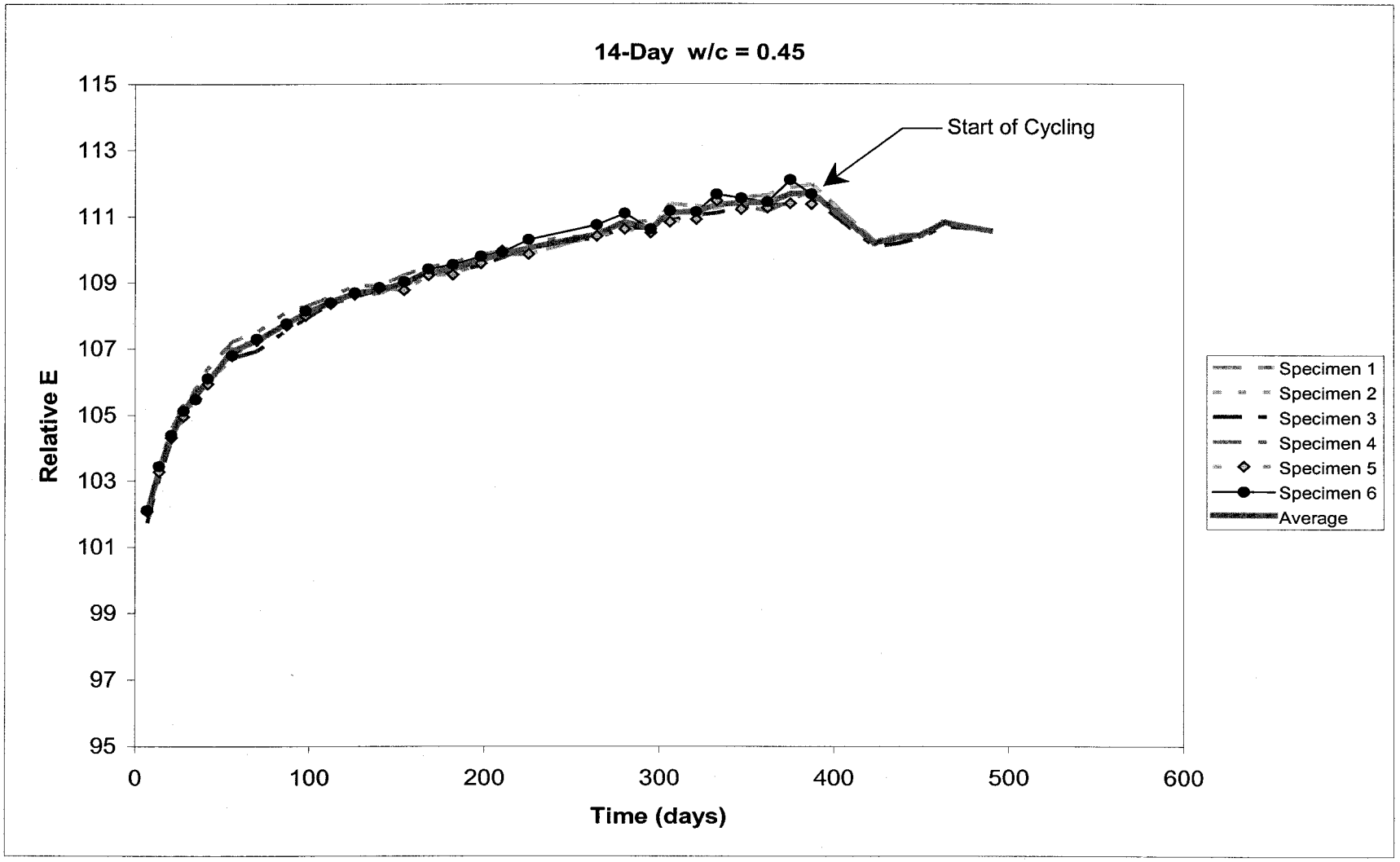


Figure 4.2 Relative E_{dyn} vs. Time For 14-Day, 0.45 Water-Cement Ratio Specimens.

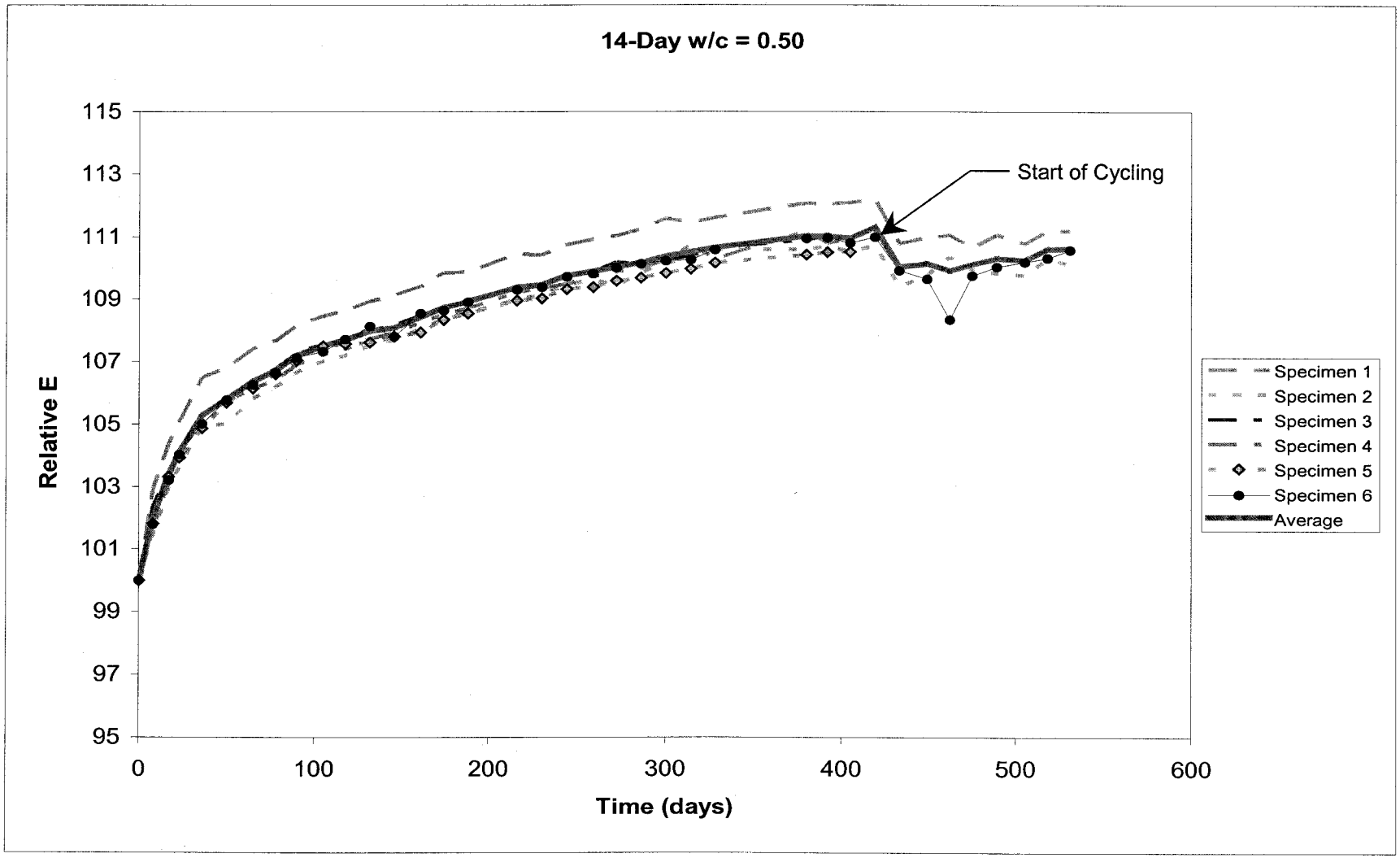


Figure 4.3 Relative E_{dyn} vs. Time For 14-Day, 0.50 Water-Cement Ratio Specimens.

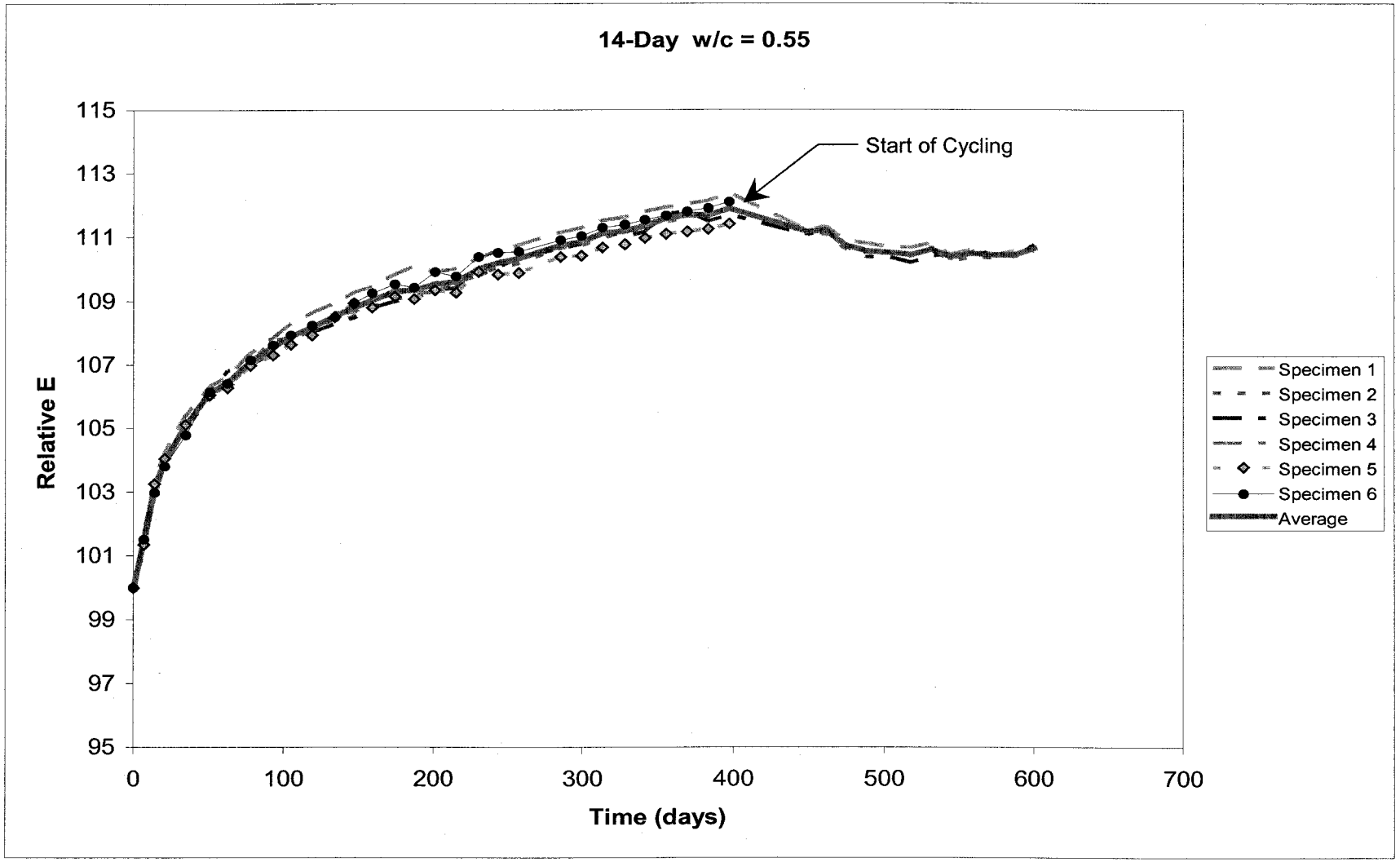


Figure 4.4 Relative E_{dyn} vs. Time For 14-Day, 0.55 Water-Cement Ratio Specimens.

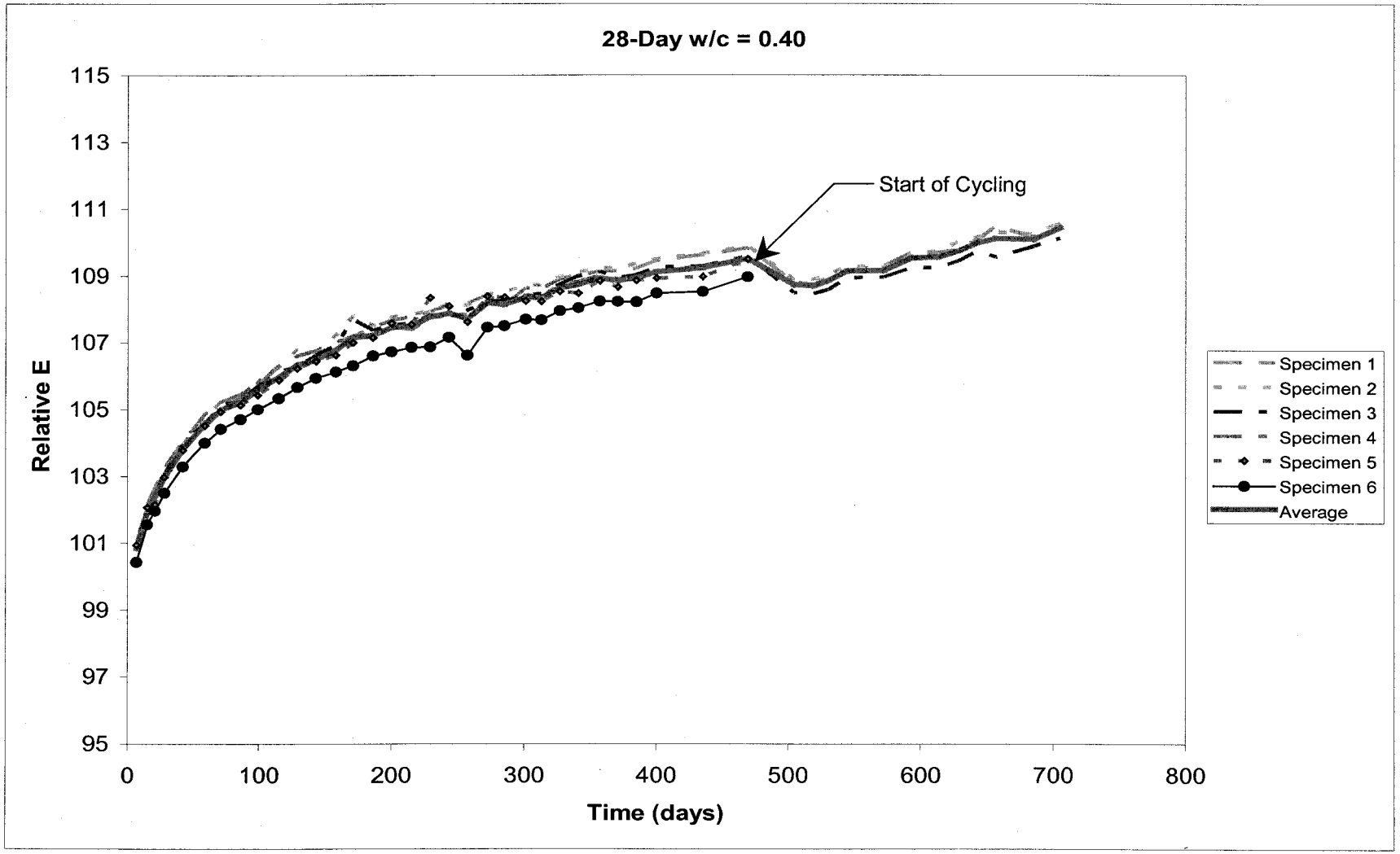


Figure 4.5 Relative E_{dyn} vs. Time For 28-Day, 0.40 Water-Cement Ratio Specimens.

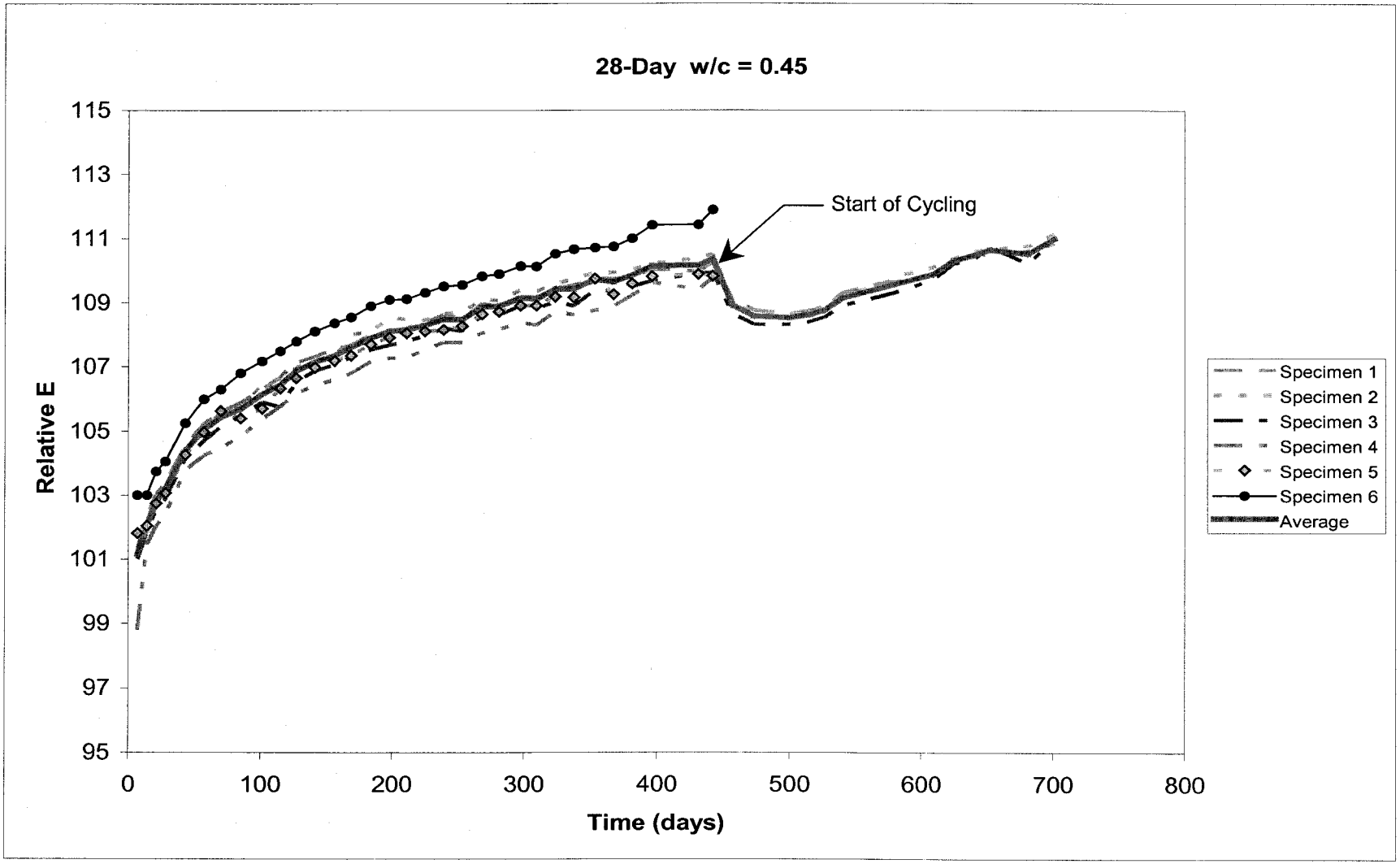


Figure 4.6 Relative E_{dyn} vs. Time For 28-Day, 0.45 Water-Cement Ratio Specimens.

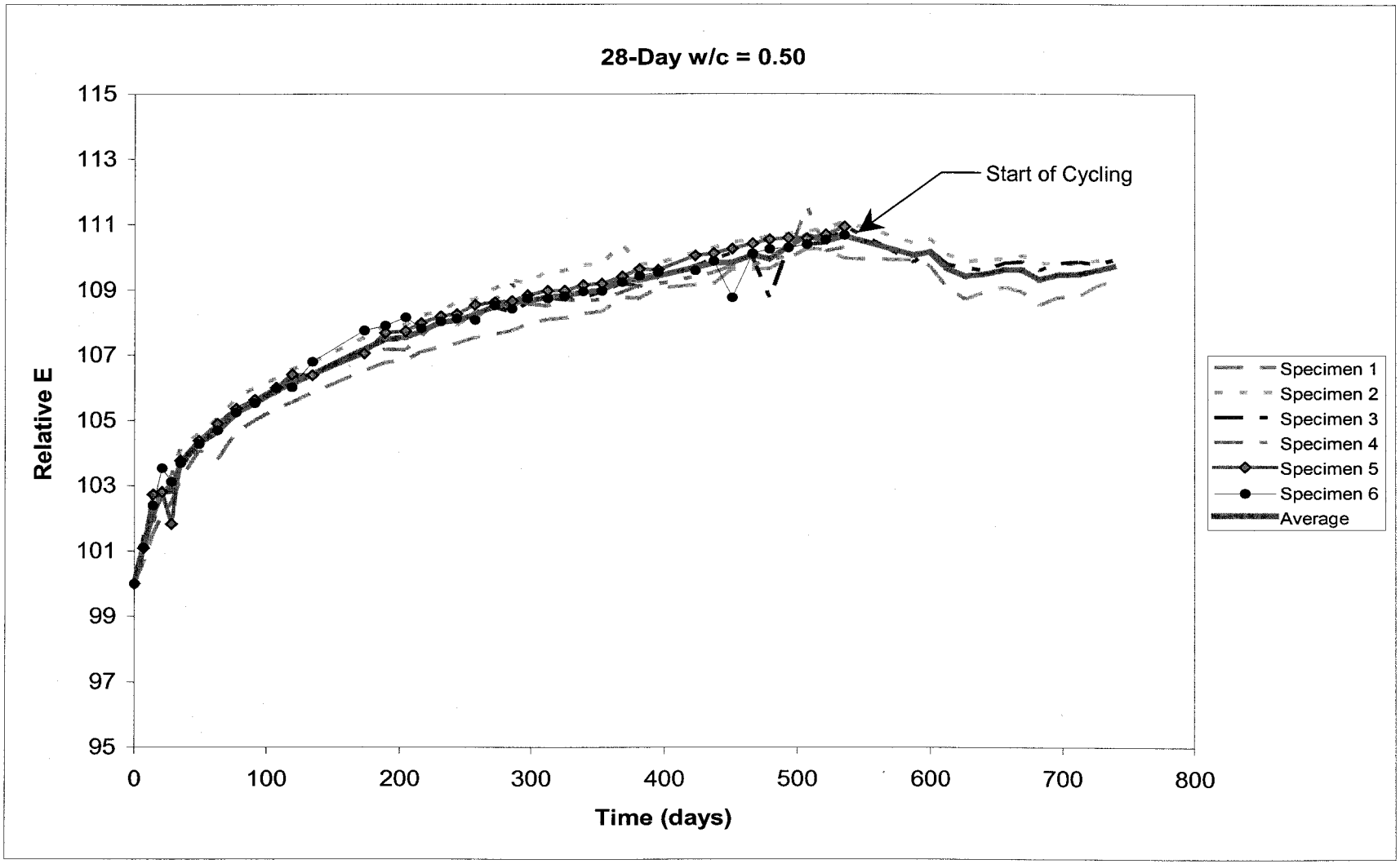


Figure 4.7 Relative E_{dyn} vs. Time For 28-Day, 0.50 Water-Cement Ratio Specimens.

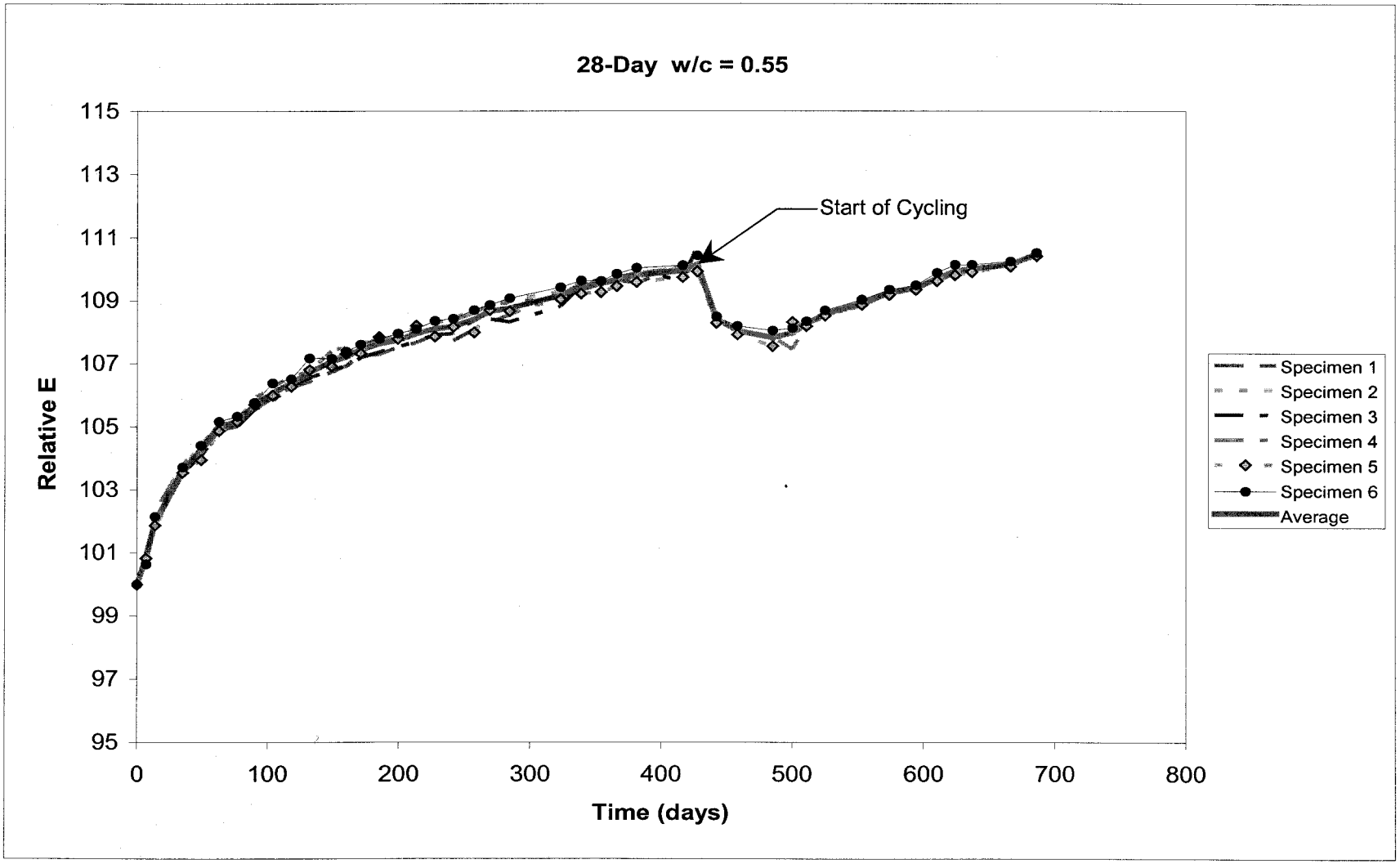


Figure 4.8 Relative E_{dyn} vs. Time For 28-Day, 0.55 Water-Cement Ratio Specimens.

specimens. These figures show that the relative dynamic modulus of the specimens gradually increased as the length of sulfate exposure increased. This is contrary to what would be expected. As the length of sulfate exposure increased, the chemical and physical characteristics of sulfate ions attacking the specimen should have caused the relative dynamic modulus to decrease.

Since the specimens did not experience a decrease in dynamic modulus, wet-dry cycling was initiated to accelerate the sulfate attack process. At the initiation of wet-dry cycling, three cylinders and three prisms were tested for compressive and tensile strengths. Consequently, the lines in Figures 4.1 - 4.8 that represent specimens tested for tensile strength end at 365 days for the 14-day specimens, and 420 days for the 28-day specimens. During wet-dry cycling the specimens were allowed to dry in air (approximately 55% humidity) for one week, then were returned to the sulfate solution for a week. The wet-dry cycling was intended to allow internal water to evaporate during the drying phase of the cycle, and allow fresh sulfate solution to enter the concrete during the wet phase of the cycle. After each wet phase of the cycling, a dynamic modulus test was performed on the specimen. A decrease in relative dynamic modulus is observed when the specimens began the wet-dry cycling. This decrease in dynamic modulus was expected because of the initial drying of the specimen. As the water trapped within the voids of the concrete evaporates, the voids begin to fill with air causing the dynamic modulus to drop. After the initial decrease, the relative dynamic modulus continued to increase gradually until the end of the testing period. This gradual increase in dynamic modulus shows that the wet-dry

cycling had little effect on accelerating the sulfate attack. Wet-dry cycling probably had little effect on the specimens because the maturity of the concrete was able to provide sufficient protection against the sulfate.

The increasing dynamic modulus of the specimens can be attributed to the cement used in this study. The cement used was Type I-II. This type of cement is the only type that is readily available in Hawaii and is currently used in every concrete project in the state. Since this cement was Type I-II, it was moderately resistant to sulfate attack. Cements with low C_3A (tri-calcium aluminate) content are considered to be sulfate resistant. According to the Portland Cement Association (1988), cements with a C_3A content of 8% or less are classified as Type II or moderately sulfate resistant. Laboratory tests on the cement used in this study show a C_3A content of 6.6%, which could explain why the dynamic modulus of the specimens continued to increase while exposed to a sulfate environment.

The graphs for the 14 and 28-day specimens show that the relative dynamic modulus for each series of specimens had low variation in the results using the impact resonance testing method. The low variation in the results indicate that the impact resonance method is a repeatable testing method for evaluating the condition of concrete undergoing chemical attack, varying curing conditions or a combination of both.

4.6 Control Mixtures

Because the specimens did not exhibit the decrease in dynamic modulus that was expected, five control mixtures were cast to investigate the potential cause of the increase in dynamic modulus that was observed. The first control mixture was cast, cured in water for 14 days, then subjected to wet-dry cycling in water with 14 day cycles (7 days wet, 7 days drying). This control mixture was cast to evaluate the effects of wet-dry cycling on a specimen that was allowed to cure before being subjected to wet-dry cycling. Similarly, the second control mixture was cast, and cured in water for 14 days, but was cycled in sodium sulfate solution instead of water. This control mixture was used to determine if the sulfate solution had any effect on the specimen during wet-dry cycling. Dynamic modulus measurements for control mixtures 1 and 2 were performed every other day for the duration of the study. The third control mixture was cured for 14 days in water, and then cured in air for the remainder of the 70-day period. The fourth control mixture was cast and allowed to cure in air for the entire 70 day period. Control mixtures 3 and 4 were cast to determine if curing the specimens in water had any effect on the specimens. Lastly, the fifth control mixture was cast and cured in water for 70 days. This control mixture was used to evaluate the effects of the sulfate solution on the specimens under continuous exposure. Dynamic modulus measurements for control mixtures 3, 4, and 5 were taken at weekly intervals.

Figures 4.9 through 4.13 show relative dynamic modulus vs. time for the five control mixtures used in this study. Control mixtures 1 and control mixture 2

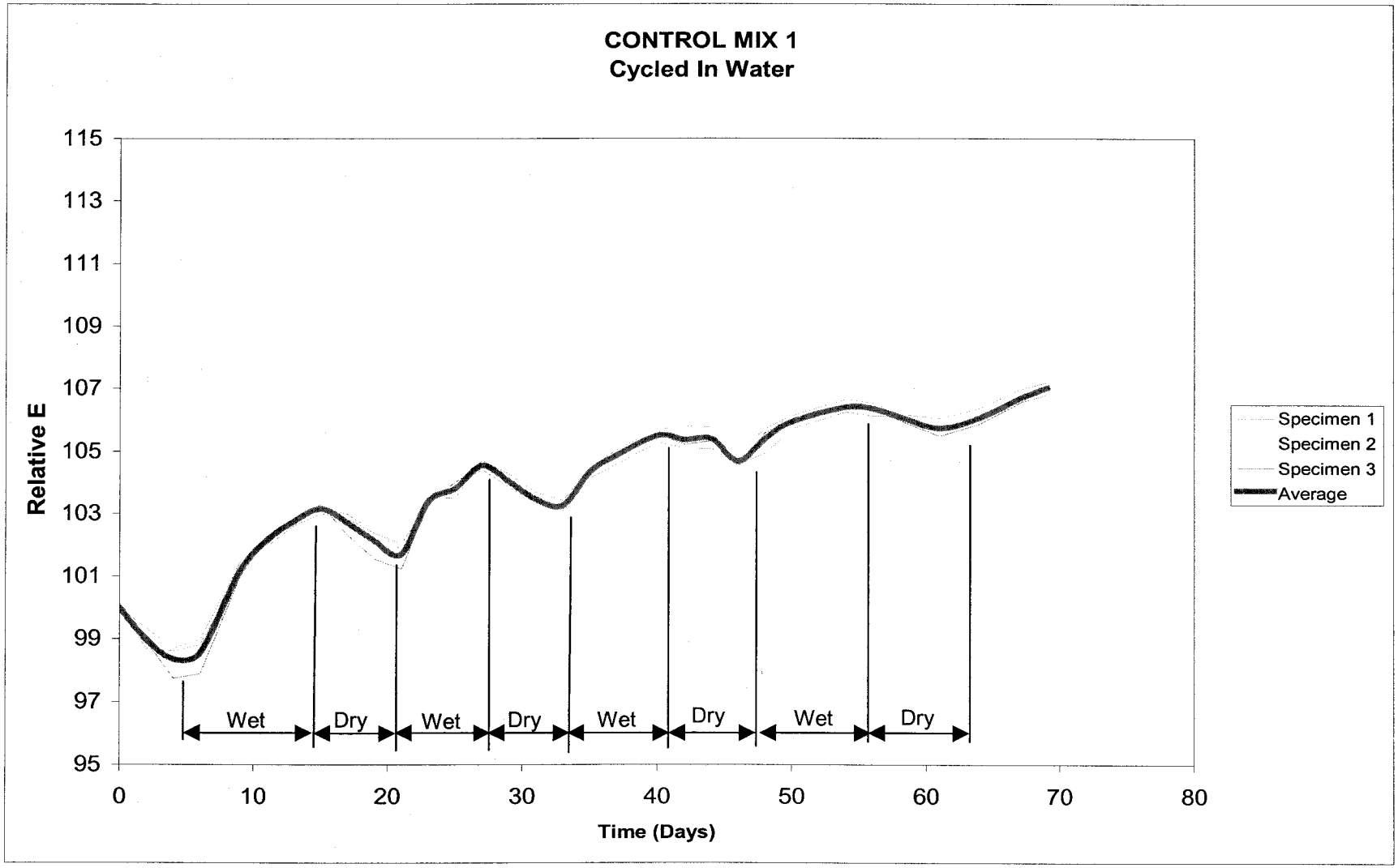
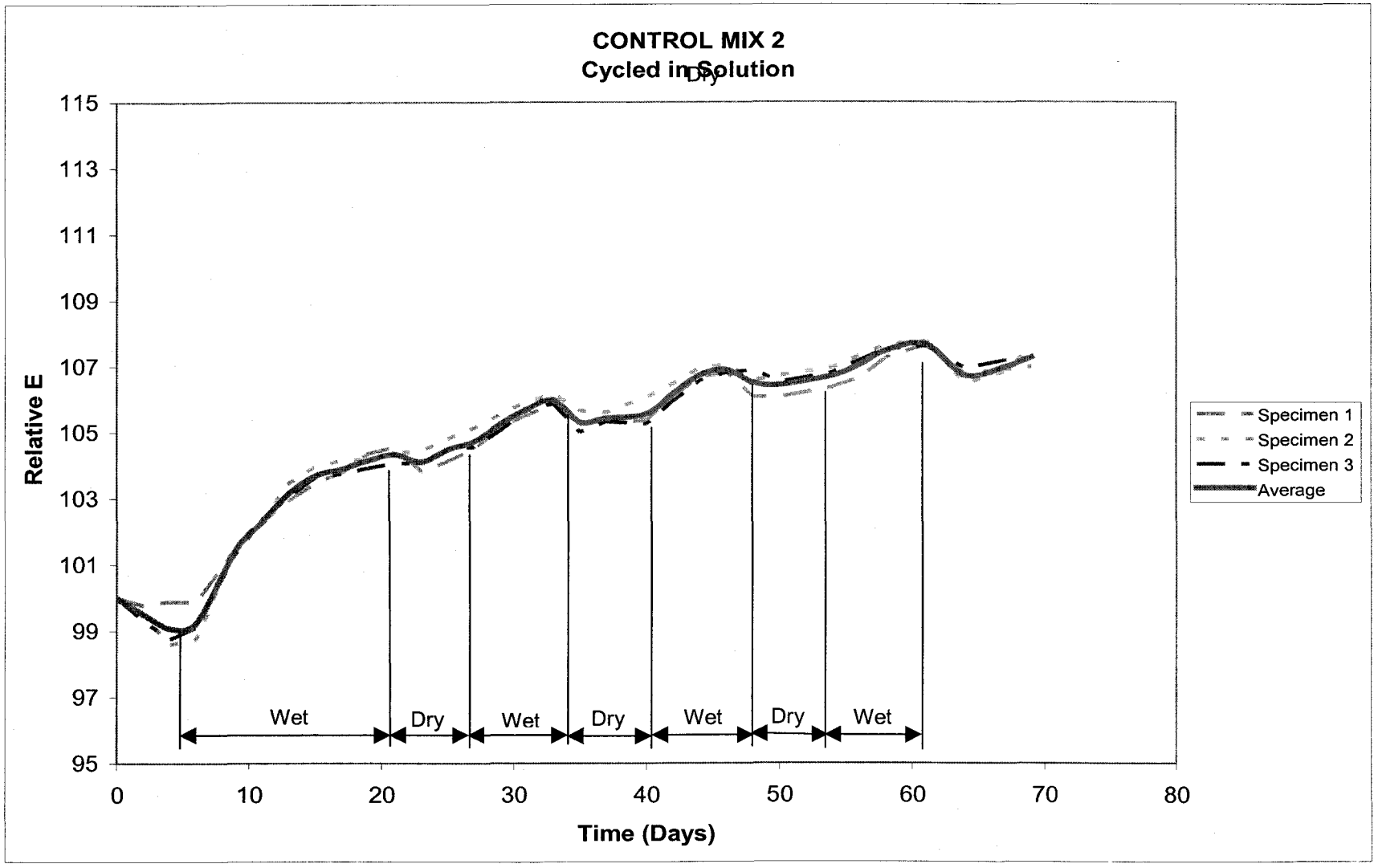
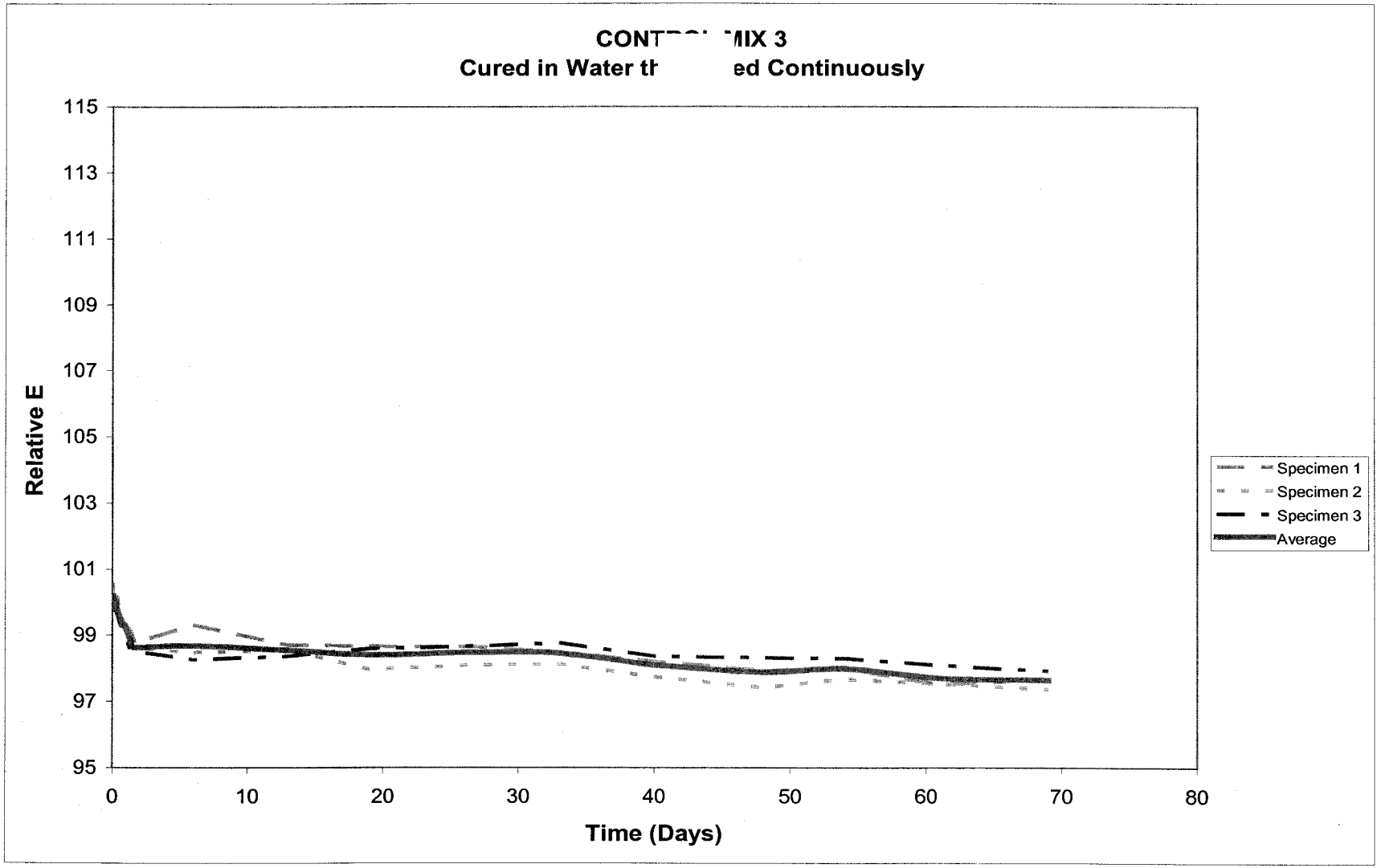

CONTROL MIX 1
Cycled In Water
Relative E
115
113
111
109
107
105
103
101
99
97
95
0
10
20
30
40
50
60
70
80
Time (Days)
Wet
Dry
Wet
Dry
Wet
Dry
Wet
Dry
Specimen 1
Specimen 2
Specimen 3
Average

Figure 4.9 Relative E_{dyn} vs. Time For Control Mixture 1.



36

Figure 4.10 Relative E_{dyn} vs. Time For Control Mixture 2.



37

Figure 4.11 Relative E_{dyn} vs. Time For Control Mixture 3.

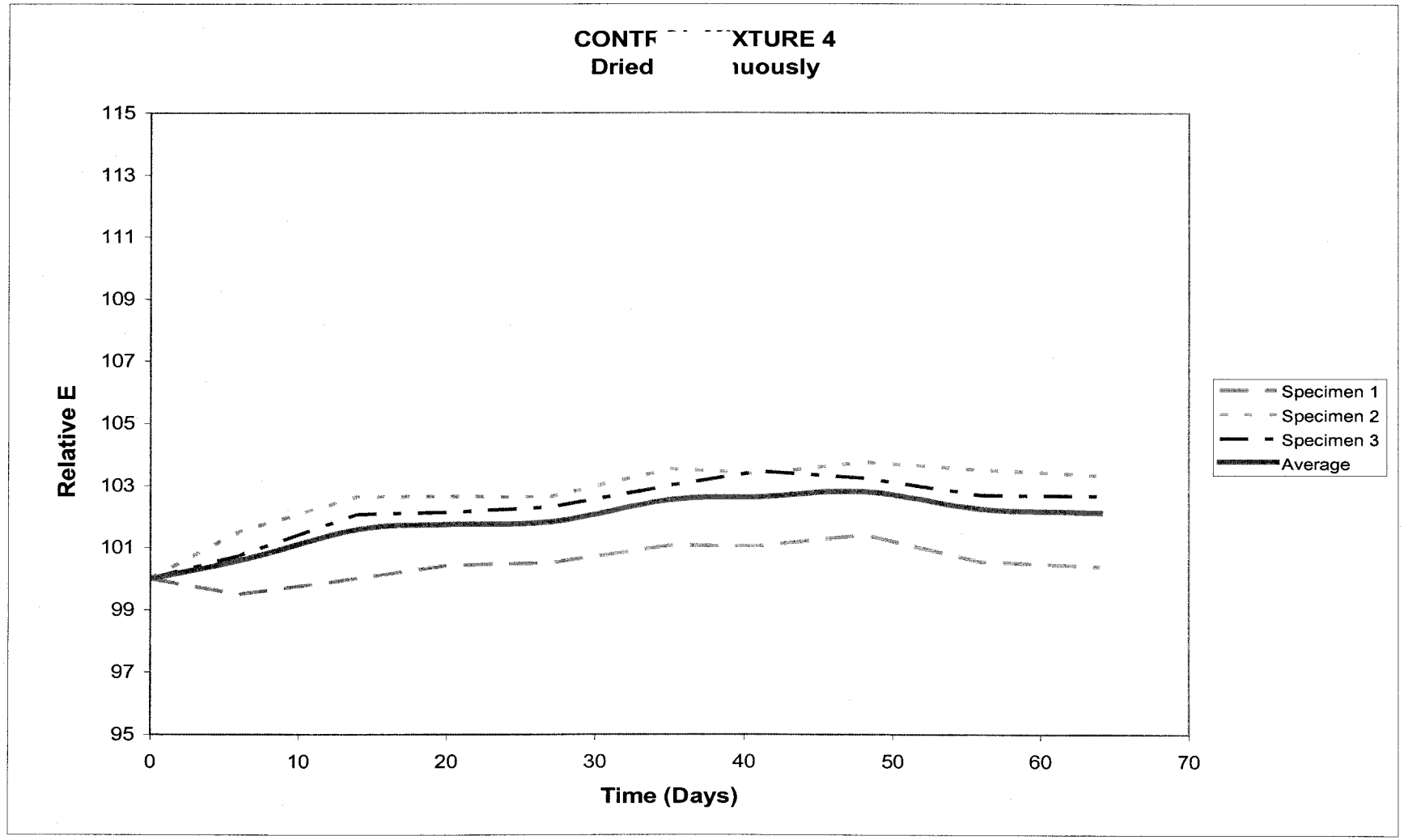


Figure 4.12 Relative E_{dyn} vs. Time For Control Mixture 4.

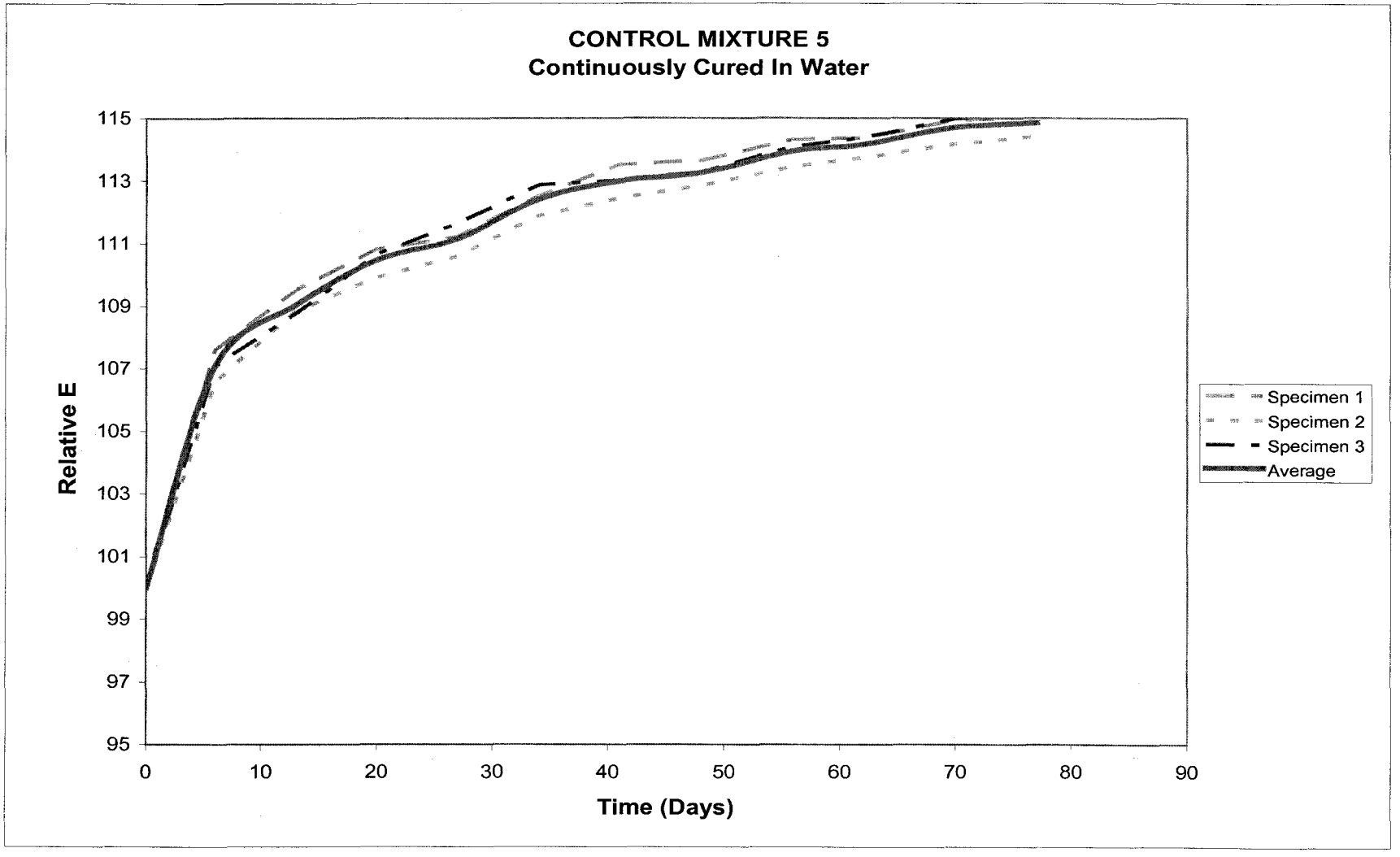


Figure 4.13 Relative E_{dyn} vs. Time For Control Mixture 5.

were tested every other day, while control mixtures 3, 4, and 5 were tested at weekly intervals. Figures 4.9 and 4.10 show the relative dynamic modulus for control mixtures 1 and 2, respectively. Both mixtures show similar dynamic modulus vs. time curves. The dynamic modulus for both mixtures increases over a period of time, then decreases over the next period. This increase then decrease trend was primarily due to the wet-dry cycling of the specimens. When the specimens are immersed in water or sulfate solution, the water or solution fills voids in the concrete, causing the dynamic modulus to increase. When the specimens are removed from the water or solution, the voids fill with air causing the dynamic modulus to decrease. This helps to explain the drop in dynamic modulus at the start of cycling for the 14 and 28-day specimens. When the specimens were allowed to dry, water in the voids evaporates causing small pockets of air to form. After the specimens are returned to the sulfate bath, solution began to fill the voids (but not completely). The reduced pore water (even after rewetting) causes the decrease in dynamic modulus.

Figure 4.10 shows an extended wetting cycle at the beginning of testing. This can be attributed to a drying phase that was missed. Instead of placing the specimens in air to dry, the specimens were mistakenly returned to the sulfate solution for an additional week. Consequently, the first wetting cycle was two weeks long.

Figure 4.11 illustrates the changes to the relative dynamic modulus for specimens in control mixture 3. The relative dynamic modulus for these specimens first showed a steep decrease, then a gradual decrease for the

remainder of the 70 day study period. This trend can be explained by the curing of the specimens. Once the specimens were taken out of the water-cure environment the specimens began to dry, leaving voids in the concrete. The absence of water in the voids may also cause the hydration process of the cement to slow down. Additionally, as the concrete continued to dry, more water evaporated from the voids, causing the dynamic modulus to decrease further. It also appears that the rapid drop in dynamic modulus observed at the beginning of testing for control mixture 3 is similar to the drop seen in the 14 and 28-day specimens at the start of wet-dry cycling (365 or 420 days).

Figure 4.12 shows the relative dynamic modulus for specimens in control mixture 4. The dynamic modulus for these specimens increased with time and continued to increase until the end of the study. This increase is caused by the hydration of the cement in the concrete. After the specimens were cast, the cement hydrates with the water in the specimen. Since these specimens were not wet cured, the hydration process slows as the amount of water within the specimen decreases. Consequently, the dynamic modulus of the concrete will continue to increase until there is not enough moisture in the concrete for hydration to continue. By comparing control mixtures 3 and 4, the effects of curing the concrete in water can be evaluated. As shown in Figure 4.11, once the specimens were removed from the water bath, a rapid drop in dynamic modulus occurs. Since the specimens in control mixture 4 were not wet-cured this drop does not occur in Figure 4.12. Thus, the wet-curing of concrete provides excess water for the hydration process which results in a rapidly

increasing dynamic modulus.

Figure 4.13 shows the dynamic modulus for specimens in control mixture 5. As with the specimens in control mixture 4, the dynamic modulus for these specimens increased with time and continued to increase until the end of the study. The increasing dynamic modulus of the specimens can be attributed to the hydration of the cement and the voids in the concrete remaining filled with water. Since the specimens in control mixture 5 were continuously cured in water, excess water was available for hydration. This explains why the values for relative dynamic modulus are about 10% higher than those of control mixture 4.

In control mixtures 1-3 and 5, the variability of the relative dynamic modulus vs. time plots for the specimens in each mixture is low (less than 1%). The specimens in control mixture 4 show a higher variability in the plots of the relative dynamic modulus vs. time due to the drying of the specimens.

Figure 4.14 compares the relative dynamic modulus results from control mixture 5 and the relative dynamic modulus results from the 14-day, 0.55 water-cement mixture up to 70 days. To compare the two mixtures, the graph for control mixture 5 was started at 14 days instead of zero days. This graph shows that both mixtures have similar relative dynamic modulus vs. time curves. Because the 14-day specimens that were exposed to a sulfate environment have a similar relative dynamic modulus vs. time curve to the specimens in control mixture 5 that were not exposed to a sulfate environment, it can be concluded that the sulfate exposure had little or no effect on the 14-day specimens for the 70 day period.

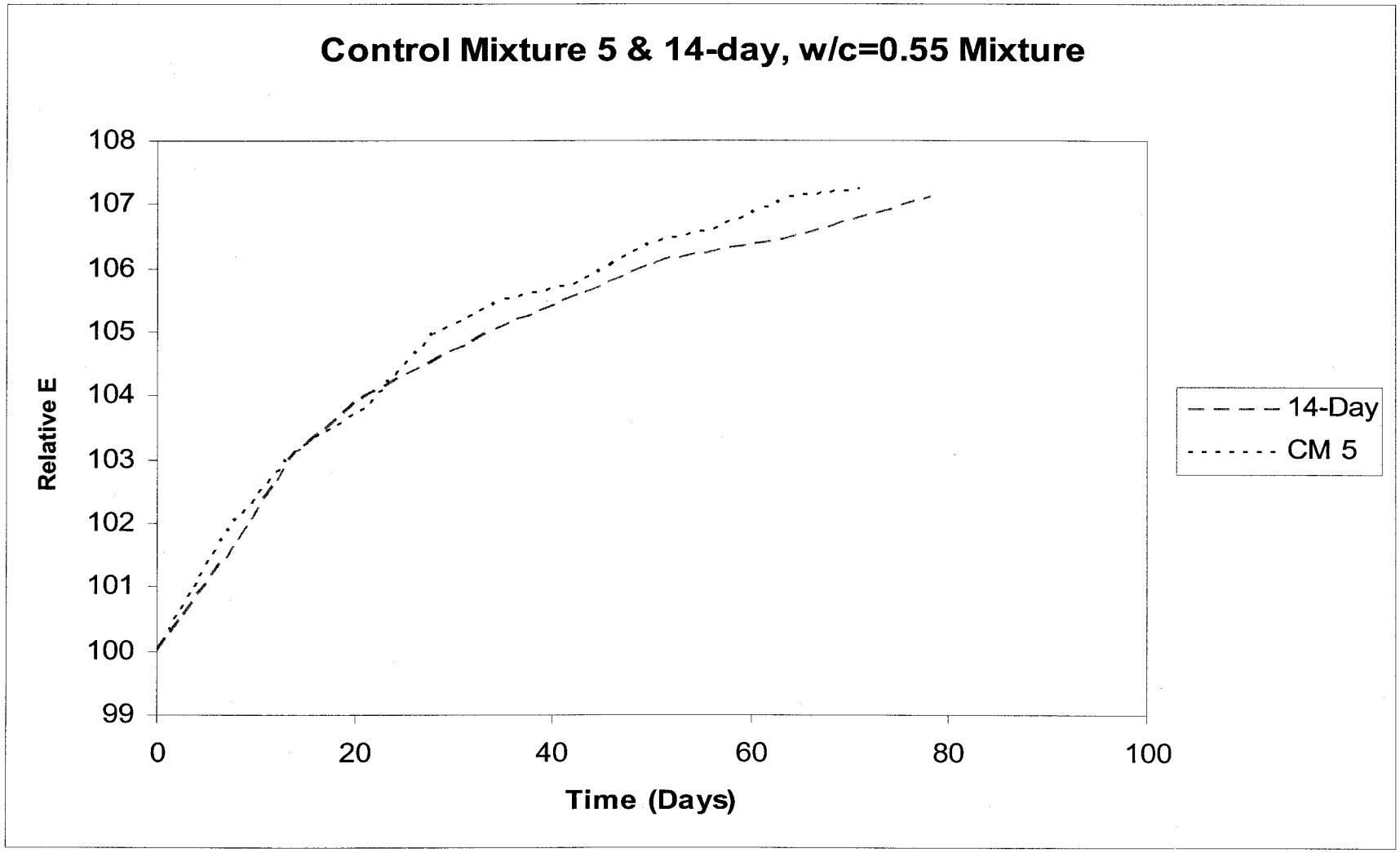


Figure 4.14 Relative E_{dyn} vs. Time For Control Mixture 5 and 14-Day, w/c=0.55 Mixture.

4.7 Compressive Strength Tests

Compressive strengths for the mixtures used in this study are presented in Table 4.3. At the end of the initial 14 or 28 day curing period, the compressive strengths of the four mixtures generally show that higher compressive strengths are achieved with a lower water-cement ratio. At the start of wet-dry cycling (365 days for 14-day specimens and 420 days for 28-day specimens) the compressive strengths of the mixtures exhibit the expected inverse relationship between water-cement ratio and compressive strength. At the end of the wet-dry cycling period (465 days for 14-day specimens, 570 days for 28-day specimens), the compressive strengths of the 0.40, 0.45, and 0.55 water-cement ratio 28 day mixtures as well as the 0.50 water-cement ratio 14 day mixture showed a decrease in strength, while the other mixtures showed an increase in strength.

4.8 Modulus of Rupture Tests

Results for modulus of rupture tests are shown in Table 4.3. The modulus of rupture for all mixtures increased in strength from the 14^{th} or 28^{th} day test to the start of cycling (365 days for 14-day specimens, 420 days for 28-day specimens). During the period from the start of cycling to the end of cycling (465 days for 14-day specimens, 570 days for 28-day specimens), the modulus of rupture for the 0.45 and 0.55 water-cement ratio 28 day mixtures, and the 0.40 and 0.45 water-cement ratio 14 day mixtures showed a decrease in strength while the other mixtures showed an increase in strength.

Table 4.3 Compressive Strength Tests Results.

		Compressive Strength, MPa (psi)		
	W/C Ratio	**Initial (28 Days)**	**Start Of Cycling (420 Days)**	**End Of Cycling (570 Days)**
28-Day	0.40	54.6 (7920)	78.5 (11380)	68.40 (9910)
	0.45	48.30 (7010)	64.90 (9410)	64.10 (9300)
	0.50	54.20 (7870)	64.80 (9400)	77.40 (11230)
	0.55	42.10 (6110)	58.30 (8460)	55.40 (8030)
	W/C Ratio	**Initial (14 Days)**	**Start Of Cycling (365 Days)**	**End Of Cycling (465 Days)**
14-Day	0.40	54.30 (7870)	75.40 (10940)	83.70 (12140)
	0.45	49.40 (7170)	76.00 (11020)	77.70 (11270)
	0.50	43.30 (6280)	64.00 (9280)	60.20 (8730)
	0.55	42.30 (6140)	54.80 (7940)	67.50 (9800)

Table 4.4 Modulus of Rupture Test Results.

		Modulus of Rupture, MPa (psi)		
	W/C Ratio	**Initial (28 Days)**	**Start Of Cycling (420 Days)**	**End Of Cycling (570 Days)**
28-Day	0.40	6.78 (983)	8.15 (1183)	8.22 (1192)
	0.45	6.09 (883)	7.70 (1117)	7.29 (1058)
	0.50	5.72 (830)	8.60 (1248)	9.47 (1373)
	0.55	5.72 (830)	7.37 (1069)	7.17 (1040)
	W/C Ratio	**Initial (14 Days)**	**Start Of Cycling (365 Days)**	**End Of Cycling (465 Days)**
14-Day	0.40	5.84 (848)	8.55 (1240)	8.06 (1169)
	0.45	5.23 (758)	8.33 (1208)	7.67 (1113)
	0.50	5.43 (788)	7.93 (1150)	8.02 (1163)
	0.55	5.10 (740)	7.45 (1081)	8.06 (1169)

4.9 Summary

Results for the dynamic modulus testing, compressive strength testing, and modulus of rupture testing were presented in this chapter. The specimens cast from the concrete mixtures showed a gradual increase in relative dynamic modulus until the end of the study. Because the specimens gradually increased in strength, wet-dry cycling was initiated in an attempt to speed up the sulfate attack process. The wet-dry cycling caused and initial decrease in dynamic modulus then a gradual increase in dynamic modulus. Compressive strength and modulus of rupture tests showed an increase in strength from the time the specimens were cast to the start of wet-dry cycling. At the end of wet-dry cycling, some mixtures showed an increase in strength, while others showed a decrease. The exposure to the sodium sulfate environment had little or no effect on the specimens because Type I-II cement was used in concrete mixtures. Type I-II cement is moderately sulfate resistant because the content of tricalcium aluminate (C_3A) in the cement is low.

CHAPTER 5
Summary

5.1 Summary and Conclusions

An exploratory experimental investigation was conducted to evaluate the effects of sulfate attack on concrete specimens cast from concrete mixtures with water-cement ratios of 0.40, .45, .050, and 0.55. Three sets of specimens were used in this study. The first and second sets of specimens, were composed of nine 76 x 102x 406 mm (3 x 4 x 16 inch) prisms and eleven 102 by 203 mm (4 by 8 inch) cylinders cast for each water-cement ratio for a total of 36 prisms, and 44 cylinders per set. The first set of specimens was allowed to cure in a water bath for 14 days, while the second set was allowed to cure in the same water bath for 28 days. After the specimens were allowed to cure, they were immersed in a 10% (67,600 ppm) sodium sulfate solution. Dynamic modulus testing, compressive strength tests, and modulus of rupture tests were performed on the specimens. The third set of specimens contained the control mixtures for the study. These specimens were subjected to various curing conditions to evaluate the effects of different curing methods and sulfate exposure.

The results from the study show that exposure to a 10% (67,600 ppm) sodium sulfate solution had little or no effect on concrete produced with Type I-II cement. As the length of sulfate exposure increased, dynamic modulus, compressive strength, and modulus of rupture tests showed an increase in strength instead of the expected decrease in strength. Because the specimens showed an increase in strength rather than a decrease, wet-dry cycling was

initiated to speed up the sulfate attack mechanisms. The wet-dry cycling caused an initial decrease in the dynamic elastic modulus of the specimens. After the initial decrease, the dynamic elastic modulus of the specimens continued to increase until the end of the study.

Control mixtures were cast to investigate the effects of curing on the specimens and the effects of sulfate exposure. Specimens that were not exposed to a sulfate environment and specimens that were exposed to a sulfate environment showed similar trends in dynamic elastic modulus. Therefore, the sulfate solution had little or no effect on the physical properties of the concrete. The sulfate exposure had a minimal effect on the concrete for two main reasons:

1) The type of cement used
2) The maturity of the specimens

The cement used in this study was a locally produced, Type I-II cement. Laboratory tests performed on the cement show a C_3A content of 6.6% which classifies it as moderately sulfate resistant. The resistance to sulfates provided by the low level of C_3A can explain the increase in dynamic modulus rather than the expected decrease that sulfate attack should have caused. Another reason the sulfate exposure had a minimal effect on the concrete could have been the age of the concrete. Since the specimens were allowed to cure in water for a 14 or 28-day period before exposure to a sulfate environment began, the concrete was able to develop sufficient resistance to sulfate attack.

Based on the results of this study, concrete produced with the cement available in Hawaii provides adequate resistance to sulfate levels up to 67,600

ppm if sufficient maturity is provided prior to exposure. Consequently, the structures constructed in Hawaii should be able to withstand sulfate attack from naturally occurring sources.

5.2 Recommendations for Future Research

In future attempts to produce sulfate attack in concrete, Type I cement should be used in the concrete mixtures. Using Type I cement should provide sufficient amounts of C_3A to react with the sulfate ions, thus providing a measurable effect of the sulfate attack on the concrete. Exposing the concrete to a sulfate environment immediately after casting the specimens can also be used to ensure the maturity of the concrete doesn't provide additional sulfate resistance. Elevating the temperature of the sulfate solution, using a stronger concentration of Na_2SO, using wet-dry cycling from the beginning of testing, and using higher water-cement ratios could also be used to accelerate sulfate attack in future studies. However, there is little evidence here or in the literature to support such measures.

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APPENDIX A

Matlab Program For Computing Dynamic Elastic Modulus

```
% circular best fit

[Fvec XferDat] = vna('get','meas');

x = real(XferDat);
y = imag(XferDat);
freq = Fvec;

sumx=0;
sumy=0;
sumx2=0;
sumy2=0;
sumxy=0;
sumx2y2=0;
sumx2y2x=0;
sumx2y2y=0;
sumx2w=0;
sumy2w=0;
sumxyw=0;

for i=1:401,
      x2 = x(i)*x(i);
      y2 = y(i)*y(i);
      xy = x(i)*y(i);

      sumx = sumx+x(i);
      sumy = sumy+y(i);
      sumx2 = sumx2+x2;
      sumy2 = sumy2+y2;
      sumxy = sumxy+xy;

      sumx2y2 = sumx2y2+(x2+y2);
      sumx2y2x = sumx2y2x+(x2+y2)*x(i);
      sumx2y2y = sumx2y2y+(x2+y2)*y(i);

      sumx2w = sumx2w+x2*Fvec(i);
      sumy2w = sumy2w+y2*Fvec(i);
      sumxyw = sumxyw+xy*Fvec(i);
end

a(1,1) = sumx2;
a(1,2) = sumxy;
a(1,3) = sumx;
a(2,1) = sumxy;
a(2,2) = sumy2;
a(2,3) = sumy;
a(3,1) = sumx;
a(3,2) = sumy;
a(3,3) = 401;
b(1,1) = -sumx2y2x;
b(2,1) = -sumx2y2y;
b(3,1) = -sumx2y2;

A = a\b;
Xc = -A(1,1)/2;
```

```
Yc = -A(2,1)/2;
R = sqrt(A(1,1)*A(1,1)/4+A(2,1)*A(2,1)/4-A(3,1));

alpha = atan(Xc/Yc);
Xo = Xc + R*sin(alpha);
Yo = Yc + R*cos(alpha);

d(1,1) = Xo*Xo*sumx2 + 2*Xo*Yo*sumxy + Yo*Yo*sumy2;
d(1,2) = Xo*Yo*sumx2 - Xo*Xo*sumxy + Yo*Yo*sumxy - Xo*Yo*sumy2;
d(2,1) = d(1,2);
d(2,2) = Yo*Yo*sumx2 - 2*Xo*Yo*sumxy + Xo*Xo*sumy2;
e(1,1) = Xo*Xo*sumx2w + 2*Xo*Yo*sumxyw + Yo*Yo*sumy2w;
e(2,1) = Xo*Yo*sumx2w + Yo*Yo*sumxyw - Xo*Xo*sumxyw - Xo*Yo*sumy2w;

B = d\e;

Fund = B(1,1)
sigma = B(2,1);
Q = Fund/(2*sigma)
c = sigma/Fund;

E = .00245*1.4*16^3*16.8835*Fund*Fund/(3*64)
```

APPENDIX B

Dynamic Testing Data

Table B.1 Raw Data For Specimen 1 With w/c = 0.40, Wet Cured For 14 Days.

Casting Date: 2/13/00
Start Date: 2/27/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7843.3	2122.6	5702697.9	100.0
3/5/00	7	7	7843.3	2146.6	5832386.5	102.3
3/12/00	7	14	7845.0	2159.1	5901789.0	103.5
3/20/00	8	22	7846.1	2171.6	5971160.2	104.7
3/26/00	6	28	7847.4	2177.5	6004645.0	105.3
4/9/00	14	42	7849.3	2188.1	6064716.1	106.3
4/22/00	13	55	7851.0	2191.7	6086006.5	106.7
5/8/00	16	71	7851.8	2200.0	6132814.2	107.5
5/20/00	12	83	7852.6	2203.3	6151853.2	107.9
6/3/00	14	97	7853.8	2209.7	6188589.7	108.5
6/19/00	16	113	7854.8	2216.0	6224720.6	109.2
7/2/00	13	126	7855.4	2217.0	6230815.7	109.3
7/17/00	15	141	7856.3	2217.5	6234340.7	109.3
7/30/00	13	154	7856.4	2224.9	6276099.2	110.1
8/13/00	14	168	7857.0	2223.1	6266426.8	109.9
8/26/00	13	181	7857.6	2225.2	6278750.7	110.1
9/9/00	14	195	7857.6	2226.6	6286653.8	110.2
9/23/00	14	209	7858.1	2229.4	6302876.0	110.5
10/7/00	14	223	7856.9	2229.5	6302478.9	110.5
10/22/00	15	238	7857.7	2232.6	6320661.1	110.8
11/4/00	13	251	7858.2	2232.6	6321063.3	110.8
11/20/00	16	267	7857.8	2234.4	6330937.6	111.0
12/2/00	12	279	7858.5	2235.2	6336036.2	111.1
12/16/00	14	293	7858.8	2237.8	6351027.5	111.4
12/30/00	14	307	7859.6	2237.8	6351674.0	111.4
1/15/01	16	323	7859.3	2242.0	6375295.2	111.8
1/27/01	12	335	7859.3	2239.5	6361085.3	111.5
2/10/01	14	349	7860.0	2240.8	6369039.7	111.7
2/25/01	15	364	7860.9	2244.3	6389682.9	112.0
4/2/01	35	399	7861.0	2245.8	6398308.4	112.2
4/13/01	11	410	7860.5	2248.2	6411583.1	112.4

Table B.2 Raw Data For Specimen 2 With w/c = 0.40, Wet Cured For 14 Days.

Casting Date: 2/13/00
Start Date: 2/27/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7858.2	2120.6	5702769.4	100.0
3/5/00	7	7	7857.6	2146.9	5844653.5	102.5
3/12/00	7	14	7859.5	2161.0	5923108.3	103.9
3/20/00	8	22	7861.1	2168.6	5966057.7	104.6
3/26/00	6	28	7862.7	2177.8	6018010.1	105.5
4/9/00	14	42	7865.2	2188.9	6081445.7	106.6
4/22/00	13	55	7866.1	2192.2	6100494.3	107.0
5/8/00	16	71	7867.8	2200.2	6146428.7	107.8
5/20/00	12	83	7867.8	2206.1	6179437.1	108.4
6/3/00	14	97	7868.7	2208.8	6195280.8	108.6
6/19/00	16	113	7870.1	2213.4	6222218.8	109.1
7/2/00	13	126	7870.1	2217.2	6243602.0	109.5
7/17/00	15	141	7871.9	2216.6	6241650.5	109.4
7/30/00	13	154	7871.9	2225.8	6293569.9	110.4
8/13/00	14	168	7872.4	2223.7	6282098.8	110.2
8/26/00	13	181	7872.7	2224.9	6289120.4	110.3
9/9/00	14	195	7872.4	2226.9	6300192.2	110.5
9/23/00	14	209	7873.0	2229.5	6315393.6	110.7
10/7/00	14	223	7872.2	2229.4	6314185.4	110.7
10/22/00	15	238	7872.8	2233.8	6339616.8	111.2
11/4/00	13	251	7873.5	2233.3	6337342.5	111.1
11/20/00	16	267	7873.8	2235.5	6350076.3	111.4
12/2/00	12	279	7873.6	2236.1	6353324.1	111.4
12/16/00	14	293	7874.3	2239.3	6372087.6	111.7
12/30/00	14	307	7874.8	2240.3	6378184.9	111.8
1/15/01	16	323	7875.3	2240.4	6379159.4	111.9
1/27/01	12	335	7874.7	2240.3	6378104.0	111.8
2/10/01	14	349	7875.9	2242.6	6392180.8	112.1
2/25/01	15	364	7875.8	2245.7	6409783.7	112.4
4/2/01	35	399	7875.5	2246.2	6412394.0	112.4
4/13/01	11	410	7876.0	2247.8	6421940.2	112.6

Table B.3 Raw Data For Specimen 3 With w/c = 0.40, Wet Cured For 14 Days.

Casting Date: 2/13/00
Start Date: 2/27/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7794.7	2131.9	5717132.8	100.0
3/5/00	7	7	7792.9	2158.7	5860422.2	102.5
3/12/00	7	14	7794.5	2172.5	5936808.6	103.8
3/20/00	8	22	7795.5	2181.8	5988514.0	104.7
3/26/00	6	28	7796.7	2186.9	6017469.4	105.3
4/9/00	14	42	7799.7	2197.5	6078282.5	106.3
4/22/00	13	55	7800.9	2201.4	6100815.0	106.7
5/8/00	16	71	7802.1	2209.3	6145625.8	107.5
5/20/00	12	83	7802.9	2213.2	6167974.7	107.9
6/3/00	14	97	7803.8	2220.2	6207769.0	108.6
6/19/00	16	113	7804.7	2222.4	6220795.0	108.8
7/2/00	13	126	7805.7	2224.1	6231114.0	109.0
7/17/00	15	141	7806.7	2226.7	6246491.1	109.3
7/30/00	13	154	7806.9	2229.9	6264618.2	109.6
8/13/00	14	168	7807.1	2232.4	6278833.8	109.8
8/26/00	13	181	7808.0	2233.2	6284059.1	109.9
9/9/00	14	195	7807.6	2234.9	6293307.7	110.1
9/23/00	14	209	7808.3	2237.6	6309088.4	110.4
10/7/00	14	223	7808.0	2237.9	6310537.8	110.4
10/22/00	15	238	7808.0	2240.8	6326903.6	110.7
11/4/00	13	251	7808.3	2240.7	6326581.9	110.7
11/20/00	16	267	7808.8	2244.0	6345637.0	111.0
12/2/00	12	279	7809.1	2243.7	6344184.1	111.0
12/16/00	14	293	7809.3	2247.1	6363589.0	111.3
12/30/00	14	307	7809.9	2247.8	6368043.6	111.4
1/15/01	16	323	7810.3	2250.1	6381408.9	111.6
1/27/01	12	335	7810.4	2245.7	6356557.4	111.2
2/10/01	14	349	7811.0	2250.0	6381413.6	111.6
2/25/01	15	364	7810.8	2252.7	6396574.4	111.9
4/2/01	35	399	7811.9	2253.9	6404292.8	112.0
4/13/01	11	410	7811.3	2255.2	6411190.2	112.1

Table B.4 Raw Data For Specimen 4 With w/c = 0.40, Wet Cured For 14 Days.

Casting Date: 2/13/00
Start Date: 2/27/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7898.3	2125.5	5758389.8	100.0
3/5/00	7	7	7897.5	2152.0	5902274.3	102.5
3/12/00	7	14	7899.5	2168.2	5992989.3	104.1
3/20/00	8	22	7901.4	2177.6	6046519.8	105.0
3/26/00	6	28	7902.5	2183.1	6077948.0	105.5
4/9/00	14	42	7905.1	2193.2	6136335.0	106.6
4/22/00	13	55	7906.3	2196.6	6156309.8	106.9
5/8/00	16	71	7907.9	2204.9	6204177.0	107.7
5/20/00	12	83	7908.2	2205.7	6208915.5	107.8
6/3/00	14	97	7909.6	2214.3	6258534.6	108.7
6/19/00	16	113	7910.8	2218.9	6285518.1	109.2
7/2/00	13	126	7911.6	2221.5	6300894.0	109.4
7/17/00	15	141	7912.3	2224.9	6320755.0	109.8
7/30/00	13	154	7912.6	2225.6	6324972.7	109.8
8/13/00	14	168	7913.2	2228.3	6340809.1	110.1
8/26/00	13	181	7913.9	2228.6	6343077.7	110.2
9/9/00	14	195	7913.6	2230.8	6355366.3	110.4
9/23/00	14	209	7914.0	2233.4	6370511.3	110.6
10/7/00	14	223	7913.7	2233.0	6367988.2	110.6
10/22/00	15	238	7914.1	2237.1	6391717.1	111.0
11/4/00	13	251	7915.0	2237.3	6393587.0	111.0
11/20/00	16	267	7914.7	2241.1	6415081.0	111.4
12/2/00	12	279	7914.8	2239.7	6407149.6	111.3
12/16/00	14	293	7915.2	2242.6	6424077.1	111.6
12/30/00	14	307	7915.9	2244.0	6432669.3	111.7
1/15/01	16	323	7916.2	2243.4	6429473.4	111.7
1/27/01	12	335	7915.6	2245.1	6438733.3	111.8
2/10/01	14	349	7917.1	2247.9	6456026.8	112.1
2/25/01	15	364	7917.4	2248.3	6458569.3	112.2
4/2/01	35	399	7917.6	2249.5	6465628.8	112.3
4/13/01	11	410	7916.6	2251.0	6473436.8	112.4
4/28/01	15	425	7896.4	2246.3	6429983.7	111.7
5/14/01	16	441	7889.3	2245.5	6419627.2	111.5
6/11/01	27	468	7885.8	2244.1	6408780.4	111.3
6/26/01	15	483	7891.8	2241.6	6399374.5	111.1
7/7/01	11	494	7893.5	2244.6	6417897.1	111.5
7/21/01	14	508	7889.2	2247.1	6428697.4	111.6
8/18/01	28	536	7890.1	2251.4	6454060.8	112.1

Table B.5 Raw Data For Specimen 5 With w/c = 0.40, Wet Cured For 14 Days.

Casting Date: 2/13/00
Start Date: 2/27/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7852.9	2142.5	5817239.5	100.0
3/5/00	7	7	7852.0	2167.9	5955304.9	102.4
3/12/00	7	14	7853.2	2182.6	6037264.1	103.8
3/20/00	8	22	7854.4	2192.4	6092532.0	104.7
3/26/00	6	28	7855.9	2198.5	6127652.2	105.3
4/9/00	14	42	7858.0	2210.4	6195822.8	106.5
4/22/00	13	55	7859.5	2214.3	6218892.6	106.9
5/8/00	16	71	7860.3	2221.8	6261729.0	107.6
5/20/00	12	83	7860.9	2224.7	6278565.1	107.9
6/3/00	14	97	7862.0	2229.6	6307135.6	108.4
6/19/00	16	113	7863.5	2232.6	6325326.5	108.7
7/2/00	13	126	7863.7	2236.3	6346470.7	109.1
7/17/00	15	141	7864.6	2237.8	6355714.7	109.3
7/30/00	13	154	7864.9	2240.9	6373579.0	109.6
8/13/00	14	168	7865.8	2242.6	6383983.5	109.7
8/26/00	13	181	7866.3	2243.2	6387806.0	109.8
9/9/00	14	195	7865.5	2246.0	6403111.4	110.1
9/23/00	14	209	7866.1	2247.7	6413297.3	110.2
10/7/00	14	223	7865.9	2247.1	6409710.8	110.2
10/22/00	15	238	7865.8	2253.1	6443903.9	110.8
11/4/00	13	251	7867.0	2252.1	6439167.3	110.7
11/20/00	16	267	7866.0	2255.8	6459521.4	111.0
12/2/00	12	279	7866.9	2254.5	6452816.7	110.9
12/16/00	14	293	7867.3	2256.9	6466891.3	111.2
12/30/00	14	307	7867.5	2257.5	6470494.7	111.2
1/15/01	16	323	7868.1	2258.7	6477869.5	111.4
1/27/01	12	335	7867.7	2262.5	6499353.9	111.7
2/10/01	14	349	7868.7	2261.9	6496732.8	111.7
2/25/01	15	364	7869.2	2263.1	6504041.3	111.8
4/2/01	35	399	7869.4	2264.9	6514557.2	112.0
4/13/01	11	410	7869.5	2265.8	6519818.5	112.1
4/28/01	15	425	7848.4	2258.6	6461078.2	111.1
5/14/01	16	441	7841.7	2257.0	6446419.4	110.8
6/11/01	27	468	7840.2	2257.2	6446328.6	110.8
6/26/01	15	483	7846.0	2257.0	6449954.3	110.9
7/7/01	11	494	7847.9	2258.9	6462382.9	111.1
7/21/01	14	508	7842.5	2261.6	6473383.5	111.3
8/18/01	28	536	7844.8	2263.6	6486739.6	111.5

Table B.6 Raw Data For Specimen 6 With w/c = 0.40, Wet Cured For 14 Days.

Casting Date: 2/13/00
Start Date: 2/27/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7802.2	2112.2	5617361.5	100.0
3/5/00	7	7	7801.7	2140.1	5766371.2	102.7
3/12/00	7	14	7802.4	2153.4	5838789.9	103.9
3/20/00	8	22	7803.5	2163.1	5892340.7	104.9
3/26/00	6	28	7804.3	2170.6	5933880.2	105.6
4/9/00	14	42	7806.4	2181.6	5995788.0	106.7
4/22/00	13	55	7807.6	2184.6	6013213.6	107.0
5/8/00	16	71	7808.8	2192.5	6057713.4	107.8
5/20/00	12	83	7809.5	2196.6	6080935.6	108.3
6/3/00	14	97	7810.6	2201.6	6109511.0	108.8
6/19/00	16	113	7811.7	2203.9	6123145.0	109.0
7/2/00	13	126	7812.1	2207.0	6140697.1	109.3
7/17/00	15	141	7813.3	2209.9	6157791.2	109.6
7/30/00	13	154	7813.0	2214.3	6182099.1	110.1
8/13/00	14	168	7813.5	2216.0	6191991.4	110.2
8/26/00	13	181	7814.3	2219.4	6211642.6	110.6
9/9/00	14	195	7814.0	2216.6	6195741.4	110.3
9/23/00	14	209	7814.4	2223.6	6235254.5	111.0
10/7/00	14	223	7814.1	2220.4	6217082.4	110.7
10/22/00	15	238	7814.0	2224.8	6241666.7	111.1
11/4/00	13	251	7814.6	2225.0	6243268.3	111.1
11/20/00	16	267	7814.3	2227.9	6259313.2	111.4
12/2/00	12	279	7814.7	2227.7	6258509.8	111.4
12/16/00	14	293	7815.5	2230.3	6273769.4	111.7
12/30/00	14	307	7815.7	2231.7	6281809.0	111.8
1/15/01	16	323	7816.0	2233.3	6291061.1	112.0
1/27/01	12	335	7816.0	2233.1	6289934.3	112.0
2/10/01	14	349	7816.5	2233.3	6291463.5	112.0
2/25/01	15	364	7817.0	2236.2	6308216.9	112.3
4/2/01	35	399	7817.3	2238.4	6320877.8	112.5
4/13/01	11	410	7817.3	2239.7	6328221.9	112.7
4/28/01	15	425	7794.7	2230.6	6258756.0	111.4
5/14/01	16	441	7789.1	2230.2	6252016.6	111.3
6/11/01	27	468	7786.1	2230.3	6250169.1	111.3
6/26/01	15	483	7791.9	2229.9	6252581.5	111.3
7/7/01	11	494	7793.4	2229.1	6249298.8	111.2
7/21/01	14	508	7789.5	2235.1	6279842.0	111.8
8/18/01	28	536	7790.7	2238.1	6297681.2	112.1

Table B.7 Raw Data For Specimen 1 With w/c = 0.45, Wet Cured For 14 Days.

Casting Date: 3/27/00
Start Date: 4/10/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7828.3	2102.2	5582911.5	100.0
4/17/00	7	7	7827.3	2123.8	5697501.3	102.1
4/24/00	7	14	7827.3	2136.9	5768004.6	103.3
5/1/00	7	21	7828.4	2148.2	5829987.9	104.4
5/8/00	7	28	7829.9	2154.7	5866445.7	105.1
5/15/00	7	35	7830.8	2162.1	5907488.8	105.8
5/22/00	7	42	7830.6	2162.2	5907884.3	105.8
6/5/00	14	56	7832.5	2174.5	5976741.1	107.1
6/19/00	14	70	7833.4	2176.5	5988428.4	107.3
7/6/00	17	87	7834.9	2181.3	6016022.8	107.8
7/17/00	11	98	7834.8	2184.3	6032505.2	108.1
7/31/00	14	112	7836.4	2187.3	6050322.4	108.4
8/14/00	14	126	7837.0	2190.0	6065733.1	108.6
8/28/00	14	140	7837.1	2190.2	6066918.4	108.7
9/11/00	14	154	7836.7	2193.3	6083794.2	109.0
9/25/00	14	168	7837.0	2196.8	6103460.0	109.3
10/9/00	14	182	7837.1	2197.4	6106872.4	109.4
10/25/00	16	198	7837.8	2199.9	6121322.7	109.6
11/6/00	12	210	7837.8	2201.9	6132457.9	109.8
11/21/00	15	225	7838.0	2202.1	6133728.5	109.9
12/30/00	39	264	7840.1	2207.4	6164940.6	110.4
1/15/01	16	280	7840.4	2211.8	6189779.0	110.9
1/31/01	15	295	7840.0	2208.9	6173243.3	110.6
2/11/01	11	306	7840.6	2216.8	6217954.5	111.4
2/26/01	15	321	7841.5	2216.0	6214180.7	111.3
3/10/01	12	333	7840.7	2215.4	6210182.4	111.2
3/24/01	14	347	7840.8	2218.5	6227653.8	111.5
4/8/01	15	362	7841.3	2219.4	6233105.1	111.6
4/21/01	13	375	7841.5	2221.5	6245065.5	111.9
5/5/01	12	387	7841.8	2222.4	6250365.8	112.0
6/11/01	36	423	7817.6	2208.8	6155048.1	110.2
6/26/01	15	438	7822.4	2210.1	6166079.0	110.4
7/7/01	11	449	7823.7	2210.0	6166545.7	110.5
7/21/01	14	463	7813.0	2215.6	6189360.2	110.9
8/18/01	26	489	7815.9	2212.1	6172110.9	110.6

Table B.8 Raw Data For Specimen 2 With w/c = 0.45, Wet Cured For 14 Days.

Casting Date: 3/27/00
Start Date: 4/10/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial		.	7882.7	2100.7	5613688.2	100.0
4/17/00	7	7	7882.3	2120.0	5717022.5	102.1
4/24/00	7	14	7882.8	2134.9	5798034.6	103.3
5/1/00	7	21	7882.4	2146.4	5860369.6	104.4
5/8/00	7	28	7883.9	2154.5	5905808.0	105.1
5/15/00	7	35	7884.9	2158.6	5929058.7	105.8
5/22/00	7	42	7885.3	2161.8	5946952.4	105.8
6/5/00	14	56	7887.0	2169.5	5990683.4	107.1
6/19/00	14	70	7887.8	2175.3	6023368.4	107.3
7/6/00	17	87	7888.8	2179.6	6047971.9	107.8
7/17/00	11	98	7889.3	2182.9	6066684.0	108.1
7/31/00	14	112	7890.9	2187.0	6090729.7	108.4
8/14/00	14	126	7891.6	2188.9	6101858.4	108.6
8/28/00	14	140	7891.4	2190.4	6110069.3	108.7
9/11/00	14	154	7891.4	2193.0	6124583.2	109.0
9/25/00	14	168	7891.7	2195.5	6138788.5	109.3
10/9/00	14	182	7891.9	2195.6	6139503.3	109.4
10/25/00	16	198	7892.2	2198.9	6158206.7	109.6
11/6/00	12	210	7892.7	2200.3	6166441.4	109.8
11/21/00	15	225	7892.3	2203.5	6184077.3	109.9
12/30/00	39	264	7894.3	2208.3	6212622.8	110.4
1/15/01	16	280	7894.8	2209.2	6218081.6	110.9
1/31/01	15	295	7894.4	2208.1	6211576.3	110.6
2/11/01	11	306	7895.1	2210.4	6225075.1	111.4
2/26/01	15	321	7895.3	2213.3	6241578.3	111.3
3/10/01	12	333	7894.3	2213.7	6243043.7	111.2
3/24/01	14	347	7895.0	2216.0	6256578.0	111.5
4/8/01	15	362	7895.3	2218.6	6271506.4	111.6
4/21/01	13	375	7895.4	2218.8	6272716.6	111.9
5/5/01	12	387	7895.5	2220.5	6282412.0	112.0
6/11/01	36	423	7870.8	2204.7	6173949.9	110.2
6/26/01	15	438	7875.8	2207.4	6193012.7	110.4
7/7/01	11	449	7877.6	2205.2	6182087.0	110.5
7/21/01	14	463	7865.1	2211.1	6205349.3	110.9
8/18/01	26	489	7868.6	2210.1	6202496.6	110.6

Table B.9 Raw Data For Specimen 3 With w/c = 0.45, Wet Cured For 14 Days.

Casting Date: 3/27/00
Start Date: 4/10/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7836.1	2094.6	5548139.7	100.0
4/17/00	7	7	7835.4	2112.7	5643935.7	101.7
4/24/00	7	14	7836.2	2126.8	5720105.4	103.1
5/1/00	7	21	7837.7	2138.4	5783779.7	104.2
5/8/00	7	28	7839.4	2145.3	5822427.7	104.9
5/15/00	7	35	7839.4	2151.5	5856130.5	105.6
5/22/00	7	42	7840.3	2155.7	5879691.5	106.0
6/5/00	14	56	7841.7	2163.1	5921185.1	106.7
6/19/00	14	70	7843.1	2165.1	5933198.7	106.9
7/6/00	17	87	7844.4	2171.2	5967667.4	107.6
7/17/00	11	98	7844.3	2174.9	5987947.7	107.9
7/31/00	14	112	7846.6	2179.2	6013411.3	108.4
8/14/00	14	126	7847.3	2180.7	6022229.8	108.5
8/28/00	14	140	7847.2	2183.0	6034862.9	108.8
9/11/00	14	154	7846.3	2184.5	6042466.1	108.9
9/25/00	14	168	7847.3	2188.0	6062616.7	109.3
10/9/00	14	182	7847.7	2188.4	6065142.7	109.3
10/25/00	16	198	7848.1	2190.4	6076543.5	109.5
11/6/00	12	210	7848.6	2192.5	6088588.4	109.7
11/21/00	15	225	7848.3	2196.1	6108365.8	110.1
12/30/00	39	264	7850.5	2198.1	6121212.1	110.3
1/15/01	16	280	7851.2	2201.1	6138479.4	110.6
1/31/01	15	295	7851.0	2201.2	6138880.8	110.6
2/11/01	11	306	7851.8	2203.4	6151784.8	110.9
2/26/01	15	321	7852.4	2204.8	6160075.5	111.0
3/10/01	12	333	7851.6	2205.6	6163918.5	111.1
3/24/01	14	347	7851.7	2207.2	6172943.3	111.3
4/8/01	15	362	7852.3	2207.8	6176771.8	111.3
4/21/01	13	375	7852.7	2208.1	6178765.3	111.4
5/5/01	12	387	7853.1	2210.0	6189718.4	111.6
6/11/01	36	423	7829.1	2198.5	6106748.0	110.1
6/26/01	15	438	7834.2	2199.1	6114061.9	110.2
7/7/01	11	449	7835.5	2200.4	6122308.4	110.3
7/21/01	14	463	7822.4	2205.6	6140995.0	110.7
8/18/01	26	489	7827.4	2204.0	6136008.1	110.6

Table B.10 Raw Data For Specimen 4 With w/c = 0.45, Wet Cured For 14 Days.

Casting Date: 3/27/00
Start Date: 4/10/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7852.1	2090.2	5536135.7	100.0
4/17/00	7	7	7851.4	2112.4	5653854.6	102.1
4/24/00	7	14	7852.0	2126.5	5730021.9	103.5
5/1/00	7	21	7852.8	2137.0	5787337.4	104.5
5/8/00	7	28	7854.1	2144.8	5830626.8	105.3
5/15/00	7	35	7854.8	2149.1	5854551.1	105.8
5/22/00	7	42	7855.5	2155.5	5889997.4	106.4
6/5/00	14	56	7856.5	2163.7	5935651.9	107.2
6/19/00	14	70	7858.0	2166.5	5952160.4	107.5
7/6/00	17	87	7859.1	2172.6	5986563.4	108.1
7/17/00	11	98	7859.9	2174.0	5994891.4	108.3
7/31/00	14	112	7861.2	2176.7	6010785.3	108.6
8/14/00	14	126	7861.6	2180.1	6029884.5	108.9
8/28/00	14	140	7861.9	2180.0	6029561.4	108.9
9/11/00	14	154	7861.7	2183.3	6047676.0	109.2
9/25/00	14	168	7861.7	2185.7	6060979.1	109.5
10/9/00	14	182	7862.2	2186.9	6068022.1	109.6
10/25/00	16	198	7862.5	2189.3	6081580.1	109.9
11/6/00	12	210	7862.4	2190.3	6087059.7	110.0
11/21/00	15	225	7862.5	2193.2	6103266.7	110.2
12/30/00	39	264	7864.7	2194.8	6113885.2	110.4
1/15/01	16	280	7865.0	2199.0	6137541.0	110.9
1/31/01	15	295	7865.0	2198.9	6136982.8	110.9
2/11/01	11	306	7865.5	2200.6	6146866.4	111.0
2/26/01	15	321	7865.6	2202.3	6156445.4	111.2
3/10/01	12	333	7865.0	2203.9	6164923.8	111.4
3/24/01	14	347	7865.0	2203.9	6164923.8	111.4
4/8/01	15	362	7865.7	2201.7	6153169.5	111.1
4/21/01	13	375	7865.8	2204.8	6170587.5	111.5
5/5/01	12	387	7866.4	2207.8	6187863.2	111.8

Table B.11 Raw Data For Specimen 5 With w/c = 0.45, Wet Cured For 14 Days.

Casting Date: 3/27/00
Start Date: 4/10/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7873.7	2108.7	5650068.0	100.0
4/17/00	7	7	7872.5	2130.8	5768239.2	102.1
4/24/00	7	14	7872.4	2143.2	5835495.9	103.3
5/1/00	7	21	7873.1	2153.8	5893886.0	104.3
5/8/00	7	28	7874.4	2160.2	5929944.3	105.0
5/15/00	7	35	7874.5	2165.8	5960804.9	105.5
5/22/00	7	42	7875.0	2170.2	5985429.2	105.9
6/5/00	14	56	7876.6	2178.7	6033632.8	106.8
6/19/00	14	70	7877.7	2183.2	6059429.0	107.2
7/6/00	17	87	7878.5	2187.8	6085608.3	107.7
7/17/00	11	98	7878.8	2190.7	6101984.6	108.0
7/31/00	14	112	7880.7	2194.1	6122416.2	108.4
8/14/00	14	126	7881.4	2196.8	6138038.8	108.6
8/28/00	14	140	7881.8	2198.7	6148972.9	108.8
9/11/00	14	154	7880.7	2198.3	6145878.0	108.8
9/25/00	14	168	7881.5	2202.7	6171131.5	109.2
10/9/00	14	182	7881.8	2202.9	6172487.1	109.2
10/25/00	16	198	7882.1	2206.2	6191229.7	109.6
11/6/00	12	210	7881.8	2210.1	6212901.6	110.0
11/21/00	15	225	7882.5	2209.0	6207269.9	109.9
12/30/00	39	264	7883.9	2214.2	6237635.9	110.4
1/15/01	16	280	7884.5	2216.3	6249948.9	110.6
1/31/01	15	295	7884.3	2215.2	6243588.1	110.5
2/11/01	11	306	7884.6	2218.4	6261877.9	110.8
2/26/01	15	321	7884.9	2219.1	6266068.7	110.9
3/10/01	12	333	7884.9	2224.7	6297734.1	111.5
3/24/01	14	347	7884.3	2222.3	6283675.2	111.2
4/8/01	15	362	7885.0	2222.6	6285929.9	111.3
4/21/01	13	375	7885.2	2223.9	6293445.0	111.4
5/5/01	12	387	7885.9	2223.6	6292305.7	111.4

Table B.12 Raw Data For Specimen 6 With w/c = 0.45, Wet Cured For 14 Days.

Casting Date: 3/27/00
Start Date: 4/10/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7803.5	2106.8	5589607.0	100.0
4/17/00	7	7	7801.5	2129.2	5707635.7	102.1
4/24/00	7	14	7801.4	2143.1	5782326.8	103.4
5/1/00	7	21	7801.9	2152.8	5835162.7	104.4
5/8/00	7	28	7804.4	2159.9	5875597.4	105.1
5/15/00	7	35	7804.5	2163.5	5895275.5	105.5
5/22/00	7	42	7804.8	2170.0	5930980.1	106.1
6/5/00	14	56	7806.6	2176.8	5969585.9	106.8
6/19/00	14	70	7807.4	2181.7	5997105.8	107.3
7/6/00	17	87	7808.2	2186.4	6023589.7	107.8
7/17/00	11	98	7809.2	2190.1	6044768.2	108.1
7/31/00	14	112	7810.4	2192.5	6058954.6	108.4
8/14/00	14	126	7810.9	2195.5	6075935.8	108.7
8/28/00	14	140	7811.6	2196.9	6084232.4	108.8
9/11/00	14	154	7810.7	2198.9	6094613.0	109.0
9/25/00	14	168	7811.3	2202.6	6115610.3	109.4
10/9/00	14	182	7811.3	2204.0	6123387.1	109.5
10/25/00	16	198	7812.4	2206.3	6137038.1	109.8
11/6/00	12	210	7812.0	2207.6	6143957.8	109.9
11/21/00	15	225	7812.4	2211.4	6165443.2	110.3
12/30/00	39	264	7813.7	2215.6	6189914.7	110.7
1/15/01	16	280	7814.3	2219.0	6209403.8	111.1
1/31/01	15	295	7814.3	2214.3	6183127.7	110.6
2/11/01	11	306	7814.7	2219.7	6213640.1	111.2
2/26/01	15	321	7815.0	2219.3	6211639.3	111.1
3/10/01	12	333	7814.9	2224.6	6241263.4	111.7
3/24/01	14	347	7814.8	2223.5	6235012.9	111.5
4/8/01	15	362	7815.5	2222.3	6228842.6	111.4
4/21/01	13	375	7814.9	2228.9	6265414.6	112.1
5/5/01	12	387	7815.3	2224.6	6241582.8	111.7

Table B.13 Raw Data For Specimen 1 With w/c = 0.50, Wet Cured For 14 Days.

Casting Date: 1/18/01
Start Date: 2/2/01

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7646.3	2114.7	5518157.4	100.0
2/10/01	8	8	7736.5	2132.7	5678704.7	102.9
2/19/01	9	17	7738.9	2147.3	5758507.0	104.4
2/25/01	6	23	7741.1	2154.4	5798298.6	105.1
3/10/01	13	36	7743.3	2168.4	5875571.3	106.5
3/24/01	14	50	7743.7	2171.7	5893772.9	106.8
4/8/01	15	65	7746.3	2177.5	5927285.7	107.4
4/21/01	13	78	7746.8	2180.1	5941832.3	107.7
5/5/01	12	90	7748.2	2184.8	5968557.9	108.2
5/20/01	15	105	7749.0	2187.6	5984484.0	108.5
6/2/01	13	118	7749.7	2189.3	5994330.2	108.6
6/16/01	14	132	7751.5	2192.1	6011068.7	108.9
6/30/01	14	146	7751.0	2194.1	6021653.9	109.1
7/15/01	15	161	7752.1	2196.7	6036790.2	109.4
7/26/01	13	174	7751.9	2201.2	6061392.2	109.8
8/11/01	14	188	7752.9	2201.2	6062174.2	109.9
9/8/01	28	216	7755.5	2206.8	6095101.9	110.5
9/22/01	14	230	7754.0	2206.5	6092266.3	110.4
10/6/01	14	244	7755.1	2209.8	6111369.7	110.8
10/21/01	15	259	7755.6	2211.4	6120617.4	110.9
11/3/01	13	272	7756.5	2212.3	6126311.2	111.0
11/17/01	14	286	7756.2	2214.6	6138818.7	111.2
12/1/01	14	300	7756.5	2217.8	6156810.3	111.6
12/15/01	14	314	7757.0	2216.5	6149991.0	111.5
12/29/01	14	328	7757.8	2217.9	6158397.5	111.6
2/19/02	52	380	7758.5	2222.4	6183970.9	112.1
3/3/02	12	392	7757.9	2222.3	6182936.2	112.0
3/16/02	13	405	7758.8	2222.6	6185323.2	112.1
3/30/02	14	419	7758.6	2223.5	6190173.9	112.2
4/13/02	14	433	7735.8	2212.9	6113276.4	110.8
4/29/02	16	449	7732.3	2215.3	6123771.9	111.0
5/12/02	13	462	7732.2	2216.1	6128116.4	111.1
5/25/02	13	475	7727.2	2212.7	6105376.4	110.6
6/8/02	14	489	7728.3	2216.7	6128342.6	111.1
6/24/02	16	505	7731.7	2213.3	6112245.4	110.8
7/7/02	13	518	7732.9	2217.4	6135863.6	111.2
7/20/02	13	531	7730.9	2217.6	6135383.3	111.2

Table B.14 Raw Data For Specimen 2 With w/c = 0.50, Wet Cured For 14 Days.

Casting Date: 1/18/01
Start Date: 2/2/01

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7804.1	2117.5	5646962.2	100.0
2/10/01	8	8	7795.7	2134.1	5729673.4	101.5
2/19/01	9	17	7798.0	2149.3	5813297.2	102.9
2/25/01	6	23	7799.5	2156.2	5851807.9	103.6
3/10/01	13	36	7801.5	2169.7	5926833.3	105.0
3/24/01	14	50	7802.8	2169.9	5928913.8	105.0
4/8/01	15	65	7805.0	2178.1	5975493.2	105.8
4/21/01	13	78	7805.9	2181.9	5997053.0	106.2
5/5/01	12	90	7806.6	2186.5	6022906.3	106.7
5/20/01	15	105	7807.6	2190.0	6042977.9	107.0
6/2/01	13	118	7808.3	2191.7	6052905.9	107.2
6/16/01	14	132	7809.6	2194.9	6071604.7	107.5
6/30/01	14	146	7809.9	2196.7	6081800.8	107.7
7/15/01	15	161	7810.5	2200.1	6101110.6	108.0
7/26/01	13	174	7810.9	2203.3	6119184.7	108.4
8/11/01	14	188	7811.4	2205.3	6130691.3	108.6
9/8/01	28	216	7812.6	2209.4	6154453.7	109.0
9/22/01	14	230	7813.3	2210.8	6162807.9	109.1
10/6/01	14	244	7814.2	2213.8	6180256.6	109.4
10/21/01	15	259	7813.3	2215.7	6190156.6	109.6
11/3/01	13	272	7815.0	2213.4	6178655.9	109.4
11/17/01	14	286	7815.3	2217.8	6203483.5	109.9
12/1/01	14	300	7815.6	2220.6	6219396.0	110.1
12/15/01	14	314	7815.7	2222.6	6230683.9	110.3
12/29/01	14	328	7816.1	2225.0	6244466.7	110.6
2/19/02	52	380	7817.2	2224.9	6244784.2	110.6
3/3/02	12	392	7816.9	2226.1	6251282.3	110.7
3/16/02	13	405	7817.0	2224.1	6240134.5	110.5
3/30/02	14	419	7817.1	2226.3	6252565.6	110.7
4/13/02	14	433	7796.9	2215.6	6176605.9	109.4
4/29/02	16	449	7794.1	2220.0	6198935.8	109.8
5/12/02	13	462	7793.6	2225.8	6230969.2	110.3
5/25/02	13	475	7789.0	2222.4	6208281.2	109.9
6/8/02	14	489	7790.1	2221.1	6201895.9	109.8
6/24/02	16	505	7792.1	2220.1	6197903.5	109.8
7/7/02	13	518	7793.1	2225.3	6227770.5	110.3
7/20/02	13	531	7790.8	2223.7	6216982.8	110.1

Table B.15 Raw Data For Specimen 3 With w/c = 0.50, Wet Cured For 14 Days.

Casting Date: 1/18/01
Start Date: 2/2/01

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7827.8	2099.5	5568224.0	100.0
2/10/01	8	8	7820.7	2125.0	5699132.0	102.4
2/19/01	9	17	7821.6	2135.9	5758410.9	103.4
2/25/01	6	23	7823.2	2143.1	5798484.8	104.1
3/10/01	13	36	7824.8	2153.1	5853921.1	105.1
3/24/01	14	50	7826.1	2160.1	5893025.6	105.8
4/8/01	15	65	7828.3	2165.6	5924738.2	106.4
4/21/01	13	78	7827.2	2169.5	5945261.4	106.8
5/5/01	12	90	7829.9	2174.2	5973108.7	107.3
5/20/01	15	105	7831.1	2177.0	5989421.1	107.6
6/2/01	13	118	7831.2	2178.4	5997203.6	107.7
6/16/01	14	132	7832.6	2181.1	6013153.9	108.0
6/30/01	14	146	7832.5	2182.9	6023006.1	108.2
7/15/01	15	161	7833.2	2185.8	6039559.7	108.5
7/26/01	13	174	7833.5	2188.1	6052508.4	108.7
8/11/01	14	188	7833.7	2190.6	6066501.7	108.9
9/8/01	28	216	7836.2	2194.5	6090064.6	109.4
9/22/01	14	230	7835.6	2195.4	6094594.2	109.5
10/6/01	14	244	7835.9	2198.6	6112608.1	109.8
10/21/01	15	259	7836.1	2199.4	6117213.4	109.9
11/3/01	13	272	7838.6	2202.2	6134755.2	110.2
11/17/01	14	286	7837.0	2201.8	6131275.1	110.1
12/1/01	14	300	7837.1	2203.2	6139152.9	110.3
12/15/01	14	314	7837.4	2204.4	6146077.5	110.4
12/29/01	14	328	7837.7	2207.0	6160820.0	110.6
2/19/02	52	380	7839.0	2209.3	6174691.5	110.9
3/3/02	12	392	7838.5	2211.1	6184362.7	111.1
3/16/02	13	405	7839.0	2208.6	6170779.4	110.8

Table B.16 Raw Data For Specimen 4 With w/c = 0.50, Wet Cured For 14 Days.

Casting Date: 1/18/01
Start Date: 2/2/01

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7785.1	2114.7	5618326.1	100.0
2/10/01	8	8	7776.5	2133.2	5710742.1	101.6
2/19/01	9	17	7778.2	2148.3	5793142.1	103.1
2/25/01	6	23	7780.0	2156.3	5837718.9	103.9
3/10/01	13	36	7782.2	2170.1	5914351.1	105.3
3/24/01	14	50	7783.1	2174.8	5940684.3	105.7
4/8/01	15	65	7785.4	2178.4	5962129.5	106.1
4/21/01	13	78	7785.9	2181.5	5979494.5	106.4
5/5/01	12	90	7787.1	2186.3	6006762.8	106.9
5/20/01	15	105	7788.4	2189.3	6024264.3	107.2
6/2/01	13	118	7788.7	2191.1	6034406.9	107.4
6/16/01	14	132	7790.1	2194.2	6052581.9	107.7
6/30/01	14	146	7789.9	2196.2	6063465.0	107.9
7/15/01	15	161	7791.1	2199.3	6081531.3	108.2
7/26/01	13	174	7790.8	2202.0	6096237.8	108.5
8/11/01	14	188	7791.4	2203.9	6107233.0	108.7
9/8/01	28	216	7793.2	2208.9	6136392.8	109.2
9/22/01	14	230	7793.1	2210.3	6144094.9	109.4
10/6/01	14	244	7793.2	2211.6	6151403.3	109.5
10/21/01	15	259	7793.8	2213.9	6164679.1	109.7
11/3/01	13	272	7794.5	2215.3	6173032.7	109.9
11/17/01	14	286	7795.0	2216.3	6179003.3	110.0
12/1/01	14	300	7794.6	2219.1	6194308.0	110.3
12/15/01	14	314	7795.2	2223.7	6220494.0	110.7
12/29/01	14	328	7796.3	2219.1	6195659.0	110.3
2/19/02	52	380	7796.2	2228.1	6245936.2	111.2
3/3/02	12	392	7796.7	2224.2	6224489.2	110.8
3/16/02	13	405	7794.3	2226.1	6233208.8	110.9

Table B.17 Raw Data For Specimen 5 With w/c = 0.50, Wet Cured For 14 Days.

Casting Date: 1/18/01
Start Date: 2/2/01

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7752.3	2096.1	5496671.5	100.0
2/10/01	8	8	7741.4	2116.5	5596303.7	101.8
2/19/01	9	17	7746.3	2131.4	5678968.4	103.3
2/25/01	6	23	7744.8	2137.9	5712552.4	103.9
3/10/01	13	36	7746.2	2147.3	5763938.9	104.9
3/24/01	14	50	7747.3	2155.6	5809408.8	105.7
4/8/01	15	65	7749.1	2159.9	5833964.4	106.1
4/21/01	13	78	7749.6	2164.6	5859759.8	106.6
5/5/01	12	90	7751.0	2168.9	5884126.7	107.0
5/20/01	15	105	7751.7	2173.4	5909102.2	107.5
6/2/01	13	118	7751.6	2174.1	5912832.9	107.6
6/16/01	14	132	7753.4	2174.3	5915294.1	107.6
6/30/01	14	146	7753.2	2176.3	5926028.4	107.8
7/15/01	15	161	7753.8	2177.5	5933024.5	107.9
7/26/01	13	174	7753.6	2181.5	5954688.5	108.3
8/11/01	14	188	7754.6	2183.4	5965834.9	108.5
9/8/01	28	216	7755.6	2187.4	5988486.0	108.9
9/22/01	14	230	7755.6	2188.1	5992319.4	109.0
10/6/01	14	244	7755.4	2191.2	6009155.7	109.3
10/21/01	15	259	7756.0	2191.7	6012363.6	109.4
11/3/01	13	272	7756.8	2193.6	6023413.6	109.6
11/17/01	14	286	7757.6	2194.4	6028429.5	109.7
12/1/01	14	300	7757.5	2195.9	6036596.1	109.8
12/15/01	14	314	7757.0	2197.3	6043906.3	110.0
12/29/01	14	328	7758.1	2199.1	6054671.0	110.2
2/19/02	52	380	7758.8	2201.7	6069543.9	110.4
3/3/02	12	392	7758.5	2202.5	6073720.7	110.5
3/16/02	13	405	7754.5	2203.2	6074448.6	110.5

Table B.18 Raw Data For Specimen 6 With w/c = 0.50, Wet Cured For 14 Days.

Casting Date: 1/18/01
Start Date: 2/2/01

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7785.3	2083.5	5453905.1	100.0
2/10/01	8	8	7776.3	2103.3	5551632.0	101.8
2/19/01	9	17	7778.2	2117.6	5628752.9	103.2
2/25/01	6	23	7780.1	2125.7	5673281.6	104.0
3/10/01	13	36	7781.0	2135.6	5726911.3	105.0
3/24/01	14	50	7782.0	2143.2	5768486.0	105.8
4/8/01	15	65	7784.1	2147.9	5795377.6	106.3
4/21/01	13	78	7785.2	2151.6	5816183.0	106.6
5/5/01	12	90	7786.1	2156.4	5842838.0	107.1
5/20/01	15	105	7787.6	2158.1	5853181.4	107.3
6/2/01	13	118	7787.7	2162.0	5874431.0	107.7
6/16/01	14	132	7789.2	2165.9	5896779.3	108.1
6/30/01	14	146	7789.2	2162.7	5879367.9	107.8
7/15/01	15	161	7789.5	2170.0	5919353.4	108.5
7/26/01	13	174	7789.9	2170.9	5924568.7	108.6
8/11/01	14	188	7790.9	2173.4	5938984.2	108.9
9/8/01	28	216	7792.0	2177.2	5960611.5	109.3
9/22/01	14	230	7791.7	2178.1	5965310.7	109.4
10/6/01	14	244	7791.2	2181.5	5983564.9	109.7
10/21/01	15	259	7792.7	2182.2	5988558.2	109.8
11/3/01	13	272	7793.6	2183.9	5998585.1	110.0
11/17/01	14	286	7794.1	2185.2	6006114.1	110.1
12/1/01	14	300	7793.8	2186.1	6010831.1	110.2
12/15/01	14	314	7794.1	2186.4	6012712.4	110.2
12/29/01	14	328	7795.5	2189.4	6030307.0	110.6
2/19/02	52	380	7796.1	2193.0	6050620.1	110.9
3/3/02	12	392	7796.1	2193.2	6051723.7	111.0
3/16/02	13	405	7795.7	2191.6	6042587.1	110.8
3/30/02	14	419	7795.9	2193.5	6053224.1	111.0
4/13/02	14	433	7774.1	2185.8	5993992.3	109.9
4/29/02	16	449	7767.7	2184.0	5979197.9	109.6
5/12/02	13	462	7768.0	2171.0	5908457.0	108.3
5/25/02	13	475	7763.5	2185.7	5985271.8	109.7
6/8/02	14	489	7765.4	2188.2	6000439.7	110.0
6/24/02	16	505	7768.0	2189.4	6009034.0	110.2
7/7/02	13	518	7768.4	2190.6	6015932.6	110.3
7/20/02	13	531	7765.4	2193.6	6030091.8	110.6

Table B.19 Raw Data For Specimen 1 With w/c = 0.55, Wet Cured For 14 Days.

Casting Date: 11/11/00
Start Date: 11/25/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7757.3	2075.9	5394717.0	100.0
12/2/00	7	7	7757.7	2092.0	5479003.3	101.6
12/9/00	7	14	7757.6	2111.0	5578906.3	103.4
12/16/00	7	21	7759.5	2119.2	5623709.1	104.2
12/30/00	14	35	7761.7	2130.7	5686521.5	105.4
1/15/01	16	51	7763.5	2139.7	5735992.2	106.3
1/27/01	12	63	7763.7	2142.6	5751699.2	106.6
2/11/01	15	78	7766.0	2149.8	5792135.6	107.4
2/26/01	15	93	7767.4	2154.4	5817998.0	107.8
3/10/01	12	105	7766.2	2159.0	5841966.6	108.3
3/24/01	14	119	7766.8	2162.5	5861375.9	108.7
4/8/01	15	134	7768.2	2165.1	5876537.8	108.9
4/23/01	13	147	7769.4	2168.3	5894832.1	109.3
5/5/01	12	159	7769.6	2170.1	5904775.3	109.5
5/20/01	15	174	7770.7	2173.8	5925766.4	109.8
6/2/01	13	187	7770.8	2176.3	5939480.7	110.1
6/16/01	14	201	7772.9	2174.2	5929625.7	109.9
6/30/01	14	215	7772.4	2175.3	5935245.4	110.0
7/15/01	15	230	7772.6	2178.4	5952327.2	110.3
7/28/01	13	243	7773.3	2180.8	5965987.3	110.6
8/11/01	14	257	7773.7	2182.4	5975052.2	110.8
9/8/01	28	285	7774.9	2186.2	5996803.4	111.2
9/22/01	14	299	7775.5	2187.4	6003851.7	111.3
10/6/01	14	313	7775.3	2189.8	6016879.0	111.5
10/21/01	15	328	7776.0	2190.6	6021818.2	111.6
11/3/01	13	341	7776.4	2192.4	6032028.7	111.8
11/17/01	14	355	7776.5	2193.6	6038711.3	111.9
12/1/01	14	369	7776.8	2194.6	6044451.5	112.0
12/15/01	14	383	7777.3	2195.5	6049799.1	112.1
12/29/01	14	397	7777.6	2197.7	6062163.4	112.4
2/19/02	52	449	7756.4	2189.3	5999512.6	111.2
3/3/02	12	461	7750.3	2191.5	6006848.5	111.3
3/16/02	13	474	7745.3	2187.8	5982720.3	110.9
3/30/02	14	488	7741.1	2187.5	5977836.3	110.8
4/13/02	14	502	7734.7	2187.2	5971255.9	110.7
4/29/02	16	518	7736.9	2186.8	5970769.9	110.7
5/12/02	13	531	7737.8	2187.9	5977473.4	110.8
5/25/02	13	544	7734.3	2184.9	5958396.0	110.4
6/8/02	14	558	7735.5	2186.3	5966959.9	110.6
6/24/02	16	574	7737.9	2184.4	5958441.3	110.4
7/7/02	13	587	7740.4	2185.1	5964187.1	110.6
7/20/02	13	600	7740.1	2185.4	5965593.6	110.6

Table B.20 Raw Data For Specimen 2 With w/c = 0.55, Wet Cured For 14 Days.

Casting Date: 11/11/00
Start Date: 11/25/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7894.3	2092.8	5579744.3	100.0
12/2/00	7	7	7891.4	2105.2	5643986.9	101.2
12/9/00	7	14	7892.7	2123.9	5745647.0	103.0
12/16/00	7	21	7894.1	2132.5	5793298.7	103.8
12/30/00	14	35	7896.4	2144.6	5860935.8	105.0
1/15/01	16	51	7898.5	2153.5	5911253.6	105.9
1/27/01	12	63	7898.8	2155.8	5924112.1	106.2
2/11/01	15	78	7901.1	2165.1	5977074.9	107.1
2/26/01	15	93	7902.1	2171.5	6013224.3	107.8
3/10/01	12	105	7901.4	2172.4	6017676.7	107.8
3/24/01	14	119	7901.8	2174.4	6029067.3	108.1
4/8/01	15	134	7903.0	2176.6	6042191.0	108.3
4/23/01	13	147	7903.5	2178.9	6055350.3	108.5
5/5/01	12	159	7904.1	2181.8	6071940.7	108.8
5/20/01	15	174	7905.0	2184.1	6085442.0	109.1
6/2/01	13	187	7905.2	2185.2	6091727.4	109.2
6/16/01	14	201	7906.6	2186.9	6102289.9	109.4
6/30/01	14	215	7908.2	2188.7	6113576.3	109.6
7/15/01	15	230	7906.8	2191.3	6127025.0	109.8
7/28/01	13	243	7907.1	2193.8	6141246.3	110.1
8/11/01	14	257	7907.6	2195.0	6148355.3	110.2
9/8/01	28	285	7908.4	2199.6	6174776.9	110.7
9/22/01	14	299	7908.9	2200.2	6178536.6	110.7
10/6/01	14	313	7908.4	2202.5	6191069.5	111.0
10/21/01	15	328	7909.2	2204.6	6203508.5	111.2
11/3/01	13	341	7909.6	2205.3	6207762.5	111.3
11/17/01	14	355	7910.4	2208.5	6226420.8	111.6
12/1/01	14	369	7910.2	2209.7	6233031.4	111.7
12/15/01	14	383	7910.8	2208.5	6226735.7	111.6
12/29/01	14	397	7910.8	2211.3	6242534.6	111.9
2/19/02	52	449	7890.7	2207.6	6205853.5	111.2
3/3/02	12	461	7885.4	2207.0	6198314.6	111.1
3/16/02	13	474	7880.0	2203.2	6172758.4	110.6
3/30/02	14	488	7875.2	2202.7	6166198.7	110.5
4/13/02	14	502	7869.3	2203.2	6164376.6	110.5
4/29/02	16	518	7869.9	2202.9	6163167.9	110.5
5/12/02	13	531	7871.4	2204.2	6171620.3	110.6
5/25/02	13	544	7867.3	2201.2	6151626.2	110.2
6/8/02	14	558	7868.4	2202.3	6158637.0	110.4
6/24/02	16	574	7870.8	2201.7	6157159.2	110.3
7/7/02	13	587	7871.9	2202.4	6161936.0	110.4
7/20/02	13	600	7870.1	2204.0	6169481.3	110.6

Table B.21 Raw Data For Specimen 3 With w/c = 0.55, Wet Cured For 14 Days.

Casting Date: 11/11/00
Start Date: 11/25/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7948.2	2108.2	5700823.9	100.0
12/2/00	7	7	7946.8	2125.5	5793749.6	101.6
12/9/00	7	14	7947.5	2141.4	5881273.2	103.2
12/16/00	7	21	7949.9	2149.7	5928742.6	104.0
12/30/00	14	35	7951.4	2160.6	5990148.1	105.1
1/15/01	16	51	7953.2	2171.8	6053782.0	106.2
1/27/01	12	63	7953.9	2178.0	6088931.6	106.8
2/11/01	15	78	7955.5	2179.6	6099107.6	107.0
2/26/01	15	93	7956.4	2183.8	6123328.4	107.4
3/10/01	12	105	7956.2	2187.8	6145626.3	107.8
3/24/01	14	119	7955.8	2190.1	6158245.0	108.0
4/8/01	15	134	7957.2	2192.5	6172835.4	108.3
4/23/01	13	147	7957.8	2194.5	6184568.6	108.5
5/5/01	12	159	7957.7	2197.7	6202540.3	108.8
5/20/01	15	174	7958.7	2199.5	6213485.4	109.0
6/2/01	13	187	7959.1	2200.4	6218883.9	109.1
6/16/01	14	201	7960.8	2202.8	6233788.5	109.3
6/30/01	14	215	7959.9	2203.6	6237612.0	109.4
7/15/01	15	230	7960.1	2207.4	6259300.7	109.8
7/28/01	13	243	7960.4	2210.1	6274858.8	110.1
8/11/01	14	257	7961.3	2212.8	6290910.9	110.4
9/8/01	28	285	7961.9	2215.8	6308455.6	110.7
9/22/01	14	299	7962.3	2217.1	6316177.4	110.8
10/6/01	14	313	7962.7	2221.0	6338736.4	111.2
10/21/01	15	328	7962.5	2219.4	6329447.9	111.0
11/3/01	13	341	7963.0	2220.8	6337833.6	111.2
11/17/01	14	355	7963.6	2226.3	6369744.7	111.7
12/1/01	14	369	7963.4	2227.0	6373590.9	111.8
12/15/01	14	383	7964.0	2223.7	6355194.7	111.5
12/29/01	14	397	7963.9	2225.9	6367695.9	111.7
2/19/02	52	449	7942.8	2222.6	6332008.1	111.1
3/3/02	12	461	7937.1	2224.8	6339996.6	111.2
3/16/02	13	474	7933.3	2220.3	6311352.2	110.7
3/30/02	14	488	7928.1	2217.7	6292452.3	110.4
4/13/02	14	502	7921.8	2218.7	6293123.6	110.4
4/29/02	16	518	7922.9	2216.6	6282088.5	110.2
5/12/02	13	531	7924.3	2218.7	6295109.6	110.4
5/25/02	13	544	7919.7	2219.4	6295425.8	110.4
6/8/02	14	558	7918.6	2220.0	6297955.3	110.5
6/24/02	16	574	7922.8	2220.0	6301295.7	110.5
7/7/02	13	587	7923.8	2218.1	6291308.3	110.4
7/20/02	13	600	7921.9	2222.5	6314778.4	110.8

Table B.22 Raw Data For Specimen 4 With w/c = 0.55, Wet Cured For 14 Days.

Casting Date: 11/11/00
Start Date: 11/25/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7859.0	2075.8	5464916.4	100.0
12/2/00	7	7	7855.3	2090.3	5538921.8	101.4
12/9/00	7	14	7855.9	2105.8	5621800.2	102.9
12/16/00	7	21	7857.7	2116.2	5678767.4	103.9
12/30/00	14	35	7859.0	2128.3	5744843.4	105.1
1/15/01	16	51	7861.7	2137.6	5797150.4	106.1
1/27/01	12	63	7861.6	2140.1	5810644.4	106.3
2/11/01	15	78	7863.3	2146.7	5847803.6	107.0
2/26/01	15	93	7865.2	2151.1	5873218.9	107.5
3/10/01	12	105	7863.9	2154.9	5893013.6	107.8
3/24/01	14	119	7865.1	2158.4	5913074.2	108.2
4/8/01	15	134	7868.3	2162.3	5936876.6	108.6
4/23/01	13	147	7867.0	2162.7	5938092.1	108.7
5/5/01	12	159	7867.4	2166.3	5958180.4	109.0
5/20/01	15	174	7868.4	2168.9	5973250.2	109.3
6/2/01	13	187	7868.9	2168.2	5969774.5	109.2
6/16/01	14	201	7870.7	2168.5	5972792.5	109.3
6/30/01	14	215	7870.2	2171.5	5988949.5	109.6
7/15/01	15	230	7870.7	2174.2	6004233.3	109.9
7/28/01	13	243	7871.0	2177.0	6019937.6	110.2
8/11/01	14	257	7871.6	2178.4	6028142.2	110.3
9/8/01	28	285	7872.6	2182.3	6050514.5	110.7
9/22/01	14	299	7873.0	2183.6	6058033.1	110.9
10/6/01	14	313	7873.5	2185.8	6070631.8	111.1
10/21/01	15	328	7873.5	2186.8	6076187.7	111.2
11/3/01	13	341	7874.5	2188.5	6086411.4	111.4
11/17/01	14	355	7874.7	2189.4	6091573.1	111.5
12/1/01	14	369	7874.6	2190.9	6099845.4	111.6
12/15/01	14	383	7875.5	2191.7	6104998.6	111.7
12/29/01	14	397	7875.3	2193.5	6114875.3	111.9

Table B.23 Raw Data For Specimen 5 With w/c = 0.55, Wet Cured For 14 Days.

Casting Date: 11/11/00
Start Date: 11/25/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7806.9	2079.9	5450153.6	100.0
12/2/00	7	7	7805.7	2094.0	5523450.0	101.3
12/9/00	7	14	7806.3	2113.6	5627766.3	103.3
12/16/00	7	21	7808.1	2121.5	5671222.1	104.1
12/30/00	14	35	7810.2	2132.0	5729038.9	105.1
1/15/01	16	51	7813.1	2141.0	5779655.3	106.0
1/27/01	12	63	7812.0	2143.4	5791804.7	106.3
2/11/01	15	78	7814.4	2150.2	5830403.0	107.0
2/26/01	15	93	7815.9	2153.3	5848349.2	107.3
3/10/01	12	105	7814.4	2156.9	5866794.5	107.6
3/24/01	14	119	7814.9	2159.7	5882412.8	107.9
4/8/01	15	134	7816.8	2165.2	5913849.3	108.5
4/23/01	13	147	7817.0	2169.4	5936966.5	108.9
5/5/01	12	159	7817.9	2167.9	5929441.9	108.8
5/20/01	15	174	7818.4	2171.4	5948983.6	109.2
6/2/01	13	187	7818.8	2170.5	5944357.3	109.1
6/16/01	14	201	7820.3	2173.1	5959750.2	109.4
6/30/01	14	215	7819.6	2172.3	5954829.9	109.3
7/15/01	15	230	7820.2	2178.7	5990429.3	109.9
7/28/01	13	243	7820.3	2177.9	5986107.4	109.8
8/11/01	14	257	7820.8	2178.3	5988689.3	109.9
9/8/01	28	285	7821.8	2183.1	6015880.3	110.4
9/22/01	14	299	7821.9	2183.5	6018161.9	110.4
10/6/01	14	313	7822.4	2185.9	6031784.5	110.7
10/21/01	15	328	7822.3	2186.9	6037227.4	110.8
11/3/01	13	341	7823.1	2188.7	6047788.2	111.0
11/17/01	14	355	7823.5	2189.9	6054731.3	111.1
12/1/01	14	369	7823.5	2190.6	6058602.7	111.2
12/15/01	14	383	7823.4	2191.5	6063504.5	111.3
12/29/01	14	397	7824.2	2193.0	6072428.7	111.4

Table B.24 Raw Data For Specimen 6 With w/c = 0.55, Wet Cured For 14 Days.

Casting Date: 11/11/00
Start Date: 11/25/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7790.0	2069.8	5385666.3	100.0
12/2/00	7	7	7784.0	2086.1	5466612.5	101.5
12/9/00	7	14	7785.5	2101.0	5546050.7	103.0
12/16/00	7	21	7788.5	2109.1	5591050.1	103.8
12/30/00	14	35	7790.4	2118.7	5643440.0	104.8
1/15/01	16	51	7793.0	2132.0	5716422.2	106.1
1/27/01	12	63	7793.1	2134.7	5730983.6	106.4
2/11/01	15	78	7795.9	2141.7	5770703.4	107.1
2/26/01	15	93	7797.5	2146.1	5795628.1	107.6
3/10/01	12	105	7795.9	2149.5	5812813.3	107.9
3/24/01	14	119	7798.0	2152.3	5829537.0	108.2
4/8/01	15	134	7799.0	2154.7	5843294.3	108.5
4/23/01	13	147	7799.6	2159.0	5867091.1	108.9
5/5/01	12	159	7800.4	2162.0	5884010.9	109.3
5/20/01	15	174	7801.1	2164.7	5899245.9	109.5
6/2/01	13	187	7801.6	2163.6	5893629.7	109.4
6/16/01	14	201	7803.7	2168.1	5919764.1	109.9
6/30/01	14	215	7803.4	2166.8	5912439.9	109.8
7/15/01	15	230	7803.4	2172.7	5944681.8	110.4
7/28/01	13	243	7804.2	2173.9	5951860.4	110.5
8/11/01	14	257	7805.0	2174.2	5954113.5	110.6
9/8/01	28	285	7805.6	2177.6	5973209.2	110.9
9/22/01	14	299	7805.8	2178.9	5980496.4	111.0
10/6/01	14	313	7806.3	2181.3	5994062.3	111.3
10/21/01	15	328	7806.7	2182.2	5999317.0	111.4
11/3/01	13	341	7807.4	2183.5	6007005.7	111.5
11/17/01	14	355	7807.7	2184.8	6014391.7	111.7
12/1/01	14	369	7807.7	2186.0	6021000.3	111.8
12/15/01	14	383	7808.6	2186.9	6026653.8	111.9
12/29/01	14	397	7808.7	2188.9	6037759.3	112.1

Table B.25 Raw Data For Specimen 1 With w/c = 0.40, Wet Cured For 28 Days.

Casting Date: 12/30/99
Start Date: 1/27/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7853.3	2155.8	5889987.1	100.0
2/3/00	7	7	7855.8	2166.0	5947747.7	101.0
2/11/00	8	15	7856.9	2178.0	6014675.4	102.1
2/17/00	6	21	7857.9	2183.5	6045860.3	102.6
2/24/00	7	28	7858.2	2189.7	6080475.4	103.2
3/9/00	14	42	7859.8	2197.9	6127348.3	104.0
3/26/00	17	59	7861.3	2206.5	6176571.2	104.9
4/7/00	12	71	7862.7	2210.0	6197285.0	105.2
4/22/00	15	86	7862.9	2212.4	6210910.5	105.4
5/4/00	13	99	7864.1	2215.2	6227591.7	105.7
5/20/00	16	115	7864.1	2221.2	6261373.0	106.3
6/3/00	14	129	7865.3	2224.2	6279255.9	106.6
6/17/00	14	143	7865.8	2225.7	6288127.9	106.8
7/2/00	15	158	7866.7	2228.2	6302983.2	107.0
7/15/00	13	171	7866.9	2230.0	6313331.2	107.2
7/30/00	15	186	7867.2	2232.8	6329436.6	107.5
8/13/00	14	200	7867.2	2235.0	6341915.7	107.7
8/28/00	15	215	7867.7	2236.0	6347995.5	107.8
9/9/00	14	229	7867.8	2237.6	6357164.3	107.9
9/23/00	14	243	7867.9	2239.6	6368614.6	108.1
10/7/00	14	257	7867.6	2240.2	6371784.4	108.2
10/22/00	15	272	7867.8	2242.7	6386176.2	108.4
11/4/00	13	285	7867.7	2239.6	6368452.7	108.1
11/20/00	16	301	7867.7	2244.9	6398630.2	108.6
12/2/00	12	313	7867.8	2244.5	6396431.4	108.6
12/16/00	14	327	7869.0	2247.6	6415090.8	108.9
12/30/00	14	341	7869.6	2248.7	6421861.2	109.0
1/15/01	16	357	7869.5	2249.8	6428063.9	109.1
1/29/01	14	371	7869.6	2249.8	6428145.5	109.1
2/12/01	14	385	7869.4	2250.8	6433697.7	109.2
2/27/01	15	400	7870.3	2253.0	6447018.1	109.5
4/2/01	35	435	7870.3	2254.9	6457896.5	109.6
5/6/01	34	469	7869.8	2257.0	6469519.6	109.8
6/11/01	35	504	7849.6	2249.3	6408959.3	108.8
6/26/01	15	519	7853.4	2247.9	6404082.4	108.7
7/7/01	11	530	7854.1	2250.4	6418907.0	109.0
7/21/01	14	544	7843.7	2253.9	6430362.9	109.2
8/18/01	28	572	7845.2	2254.9	6437300.9	109.3
9/8/01	21	593	7841.6	2259.5	6460625.9	109.7
9/28/01	20	613	7842.7	2259.5	6461532.2	109.7
10/14/01	16	629	7841.6	2260.5	6466345.8	109.8
10/28/01	14	643	7838.2	2264.2	6484718.5	110.1
11/10/01	13	656	7839.8	2267.9	6507257.7	110.5
12/9/01	29	685	7846.6	2263.7	6488801.3	110.2
12/29/01	20	705	7844.3	2268.2	6512715.5	110.6

Table B.26 Raw Data For Specimen 2 With w/c = 0.40, Wet Cured For 28 Days.

Casting Date: 12/30/99
Start Date: 1/27/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7886.7	2147.0	5866845.2	100.0
2/3/00	7	7	7888.7	2157.0	5923125.7	101.0
2/11/00	8	15	7890.5	2165.6	5971813.4	101.8
2/17/00	6	21	7890.8	2173.8	6017352.1	102.6
2/24/00	7	28	7892.8	2179.1	6048262.6	103.1
3/9/00	14	42	7893.8	2188.1	6099098.8	104.0
3/26/00	17	59	7895.8	2196.5	6147574.1	104.8
4/7/00	12	71	7897.2	2200.9	6173322.6	105.2
4/22/00	15	86	7897.7	2202.8	6184377.4	105.4
5/4/00	13	99	7897.4	2207.2	6208872.3	105.8
5/20/00	16	115	7898.4	2211.7	6235004.6	106.3
6/3/00	14	129	7899.5	2217.1	6266360.6	106.8
6/17/00	14	143	7899.9	2215.9	6259896.1	106.7
7/2/00	15	158	7900.7	2221.3	6291080.2	107.2
7/15/00	13	171	7900.9	2227.3	6325272.2	107.8
7/30/00	15	186	7901.4	2224.1	6307509.1	107.5
8/13/00	14	200	7902.0	2226.8	6323312.8	107.8
8/28/00	15	215	7902.0	2227.5	6327289.0	107.8
9/9/00	14	229	7902.1	2228.6	6333619.8	108.0
9/23/00	14	243	7902.4	2230.5	6344664.8	108.1
10/7/00	14	257	7901.7	2230.4	6343533.9	108.1
10/22/00	15	272	7901.8	2233.8	6362969.2	108.5
11/4/00	13	285	7902.2	2234.2	6365570.5	108.5
11/20/00	16	301	7902.4	2236.6	6379415.2	108.7
12/2/00	12	313	7902.5	2236.4	6378355.0	108.7
12/16/00	14	327	7903.3	2238.9	6393270.5	109.0
12/30/00	14	341	7903.6	2240.2	6400940.0	109.1
1/15/01	16	357	7903.6	2241.6	6408943.0	109.2
1/29/01	14	371	7904.3	2241.3	6407795.1	109.2
2/12/01	14	385	7904.1	2242.9	6416784.7	109.4
2/27/01	15	400	7904.0	2244.2	6424144.0	109.5
4/2/01	35	435	7904.7	2245.9	6434450.1	109.7
5/6/01	34	469	7905.1	2248.0	6446814.9	109.9
6/11/01	35	504	7883.0	2240.9	6388247.0	108.9
6/26/01	15	519	7887.3	2240.4	6388879.6	108.9
7/7/01	11	530	7888.6	2241.3	6395067.5	109.0
7/21/01	14	544	7878.1	2246.0	6413368.7	109.3
8/18/01	28	572	7879.7	2245.0	6408960.5	109.2
9/8/01	21	593	7874.6	2250.2	6434517.1	109.7
9/28/01	20	613	7874.8	2250.9	6438684.6	109.7
10/14/01	16	629	7874.0	2253.9	6455203.2	110.0
10/28/01	14	643	7870.9	2255.7	6462972.3	110.2
11/10/01	13	656	7872.5	2257.1	6472312.7	110.3
12/9/01	29	685	7879.4	2255.4	6468231.0	110.3
12/29/01	20	705	7877.2	2259.3	6488807.6	110.6

Table B.27 Raw Data For Specimen 3 With w/c = 0.40, Wet Cured For 28 Days.

Casting Date: 12/30/99
Start Date: 1/27/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7860.9	2148.1	5853646.3	100.0
2/3/00	7	7	7862.5	2157.7	5907286.0	100.9
2/11/00	8	15	7864.5	2167.0	5959833.9	101.8
2/17/00	6	21	7864.4	2174.7	6002187.0	102.5
2/24/00	7	28	7866.4	2179.9	6032459.1	103.1
3/9/00	14	42	7867.1	2189.2	6084582.3	103.9
3/26/00	17	59	7868.2	2195.9	6122738.7	104.6
4/7/00	12	71	7869.8	2201.2	6153581.0	105.1
4/22/00	15	86	7870.6	2202.8	6163156.5	105.3
5/4/00	13	99	7870.3	2207.1	6187005.8	105.7
5/20/00	16	115	7871.7	2211.5	6212803.8	106.1
6/3/00	14	129	7872.0	2213.1	6222034.0	106.3
6/17/00	14	143	7872.5	2216.5	6241563.0	106.6
7/2/00	15	158	7873.2	2219.4	6258462.7	106.9
7/15/00	13	171	7873.3	2227.5	6304308.3	107.7
7/30/00	15	186	7874.2	2223.9	6284665.5	107.4
8/13/00	14	200	7875.2	2225.5	6294511.2	107.5
8/28/00	15	215	7874.9	2226.1	6297665.7	107.6
9/9/00	14	229	7874.6	2228.6	6311578.3	107.8
9/23/00	14	243	7875.2	2229.0	6314325.2	107.9
10/7/00	14	257	7874.9	2230.0	6319751.4	108.0
10/22/00	15	272	7874.9	2233.0	6336766.6	108.3
11/4/00	13	285	7874.5	2233.0	6336444.7	108.2
11/20/00	16	301	7875.1	2234.7	6346579.9	108.4
12/2/00	12	313	7875.2	2235.2	6349500.9	108.5
12/16/00	14	327	7875.7	2238.0	6365822.8	108.7
12/30/00	14	341	7876.2	2240.5	6380457.9	109.0
1/15/01	16	357	7876.3	2241.8	6387945.4	109.1
1/29/01	14	371	7876.5	2239.9	6377284.0	108.9
2/12/01	14	385	7876.7	2240.8	6382571.9	109.0
2/27/01	15	400	7876.7	2243.1	6395681.0	109.3
4/2/01	35	435	7877.2	2243.4	6397798.0	109.3
5/6/01	34	469	7877.2	2246.3	6414349.3	109.6
6/11/01	35	504	7853.9	2238.4	6350471.6	108.5
6/26/01	15	519	7858.0	2237.6	6349245.9	108.5
7/7/01	11	530	7859.9	2238.6	6356458.8	108.6
7/21/01	14	544	7848.8	2243.8	6377005.2	108.9
8/18/01	28	572	7849.5	2244.0	6378710.9	109.0
9/8/01	21	593	7844.0	2247.7	6395279.0	109.3
9/28/01	20	613	7842.8	2247.8	6394869.6	109.2
10/14/01	16	629	7842.4	2250.1	6407636.2	109.5
10/28/01	14	643	7840.3	2253.3	6424153.8	109.7
11/10/01	13	656	7841.2	2251.4	6414060.8	109.6
12/9/01	29	685	7848.1	2253.6	6432257.4	109.9
12/29/01	20	705	7846.4	2256.4	6446854.1	110.1

Table B.28 Raw Data For Specimen 4 With w/c = 0.40, Wet Cured For 28 Days.

Casting Date: 12/30/99
Start Date: 1/27/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7823.7	2154.4	5860168.3	100.0
2/3/00	7	7	7825.1	2163.3	5909743.3	100.8
2/11/00	8	15	7826.2	2176.3	5981824.7	102.1
2/17/00	6	21	7826.6	2181.0	6007996.7	102.5
2/24/00	7	28	7827.3	2186.1	6036667.4	103.0
3/9/00	14	42	7828.4	2194.9	6086220.8	103.9
3/26/00	17	59	7829.7	2202.8	6131129.3	104.6
4/7/00	12	71	7830.8	2206.9	6154838.5	105.0
4/22/00	15	86	7831.9	2210.1	6173567.5	105.3
5/4/00	13	99	7831.6	2215.6	6204094.8	105.9
5/20/00	16	115	7832.2	2216.0	6206810.7	105.9
6/3/00	14	129	7833.5	2220.8	6234763.2	106.4
6/17/00	14	143	7832.7	2221.5	6238057.1	106.4
7/2/00	15	158	7834.3	2225.2	6260132.4	106.8
7/15/00	13	171	7834.4	2226.6	6268092.1	107.0
7/30/00	15	186	7835.4	2229.5	6285232.4	107.3
8/13/00	14	200	7835.7	2231.7	6297883.8	107.5
8/28/00	15	215	7835.5	2231.0	6293773.0	107.4
9/9/00	14	229	7835.5	2234.4	6312970.8	107.7
9/23/00	14	243	7835.8	2235.5	6319430.0	107.8
10/7/00	14	257	7835.3	2235.6	6319592.1	107.8
10/22/00	15	272	7835.9	2238.8	6338181.9	108.2
11/4/00	13	285	7835.6	2239.0	6339071.7	108.2
11/20/00	16	301	7835.6	2241.6	6353802.5	108.4
12/2/00	12	313	7836.0	2241.3	6352426.2	108.4
12/16/00	14	327	7836.6	2244.7	6372201.7	108.7
12/30/00	14	341	7837.0	2245.6	6377638.0	108.8
1/15/01	16	357	7837.1	2247.4	6387947.8	109.0
1/29/01	14	371	7837.0	2246.4	6382182.9	108.9
2/12/01	14	385	7836.8	2246.8	6384293.0	108.9
2/27/01	15	400	7837.6	2248.2	6392904.3	109.1
4/2/01	35	435	7837.6	2250.5	6405991.3	109.3
5/6/01	34	469	7837.8	2250.9	6408432.3	109.4

Table B.29 Raw Data For Specimen 5 With w/c = 0.40, Wet Cured For 28 Days.

Casting Date: 12/30/99
Start Date: 1/27/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7873.4	2140.4	5820997.6	100.0
2/3/00	7	7	7872.4	2150.7	5876409.3	101.0
2/11/00	8	15	7875.0	2162.2	5941382.4	102.1
2/17/00	6	21	7875.4	2163.0	5946081.8	102.1
2/24/00	7	28	7876.1	2171.6	5993991.3	103.0
3/9/00	14	42	7877.1	2179.9	6040664.6	103.8
3/26/00	17	59	7878.3	2187.5	6083785.0	104.5
4/7/00	12	71	7880.0	2191.7	6108487.0	104.9
4/22/00	15	86	7880.7	2193.6	6119626.1	105.1
5/4/00	13	99	7880.6	2196.7	6136857.0	105.4
5/20/00	16	115	7881.2	2201.3	6163054.9	105.9
6/3/00	14	129	7882.6	2204.8	6183766.9	106.2
6/17/00	14	143	7882.2	2207.0	6195799.2	106.4
7/2/00	15	158	7884.1	2208.7	6206843.6	106.6
7/15/00	13	171	7883.6	2212.7	6228950.4	107.0
7/30/00	15	186	7884.8	2214.0	6237221.0	107.2
8/13/00	14	200	7884.6	2218.5	6262442.5	107.6
8/28/00	15	215	7885.6	2217.9	6259849.4	107.5
9/9/00	14	229	7884.7	2226.4	6307202.6	108.4
9/23/00	14	243	7885.4	2223.6	6291906.7	108.1
10/7/00	14	257	7884.8	2218.9	6264859.9	107.6
10/22/00	15	272	7884.9	2226.8	6309629.1	108.4
11/4/00	13	285	7885.3	2226.4	6307682.5	108.4
11/20/00	16	301	7884.8	2225.3	6301051.6	108.2
12/2/00	12	313	7885.3	2225.1	6300318.5	108.2
12/16/00	14	327	7885.8	2228.1	6317719.4	108.5
12/30/00	14	341	7886.5	2227.4	6314310.8	108.5
1/15/01	16	357	7886.9	2231.2	6336195.3	108.9
1/29/01	14	371	7886.5	2229.4	6325655.3	108.7
2/12/01	14	385	7886.4	2231.4	6336929.5	108.9
2/27/01	15	400	7886.9	2232.0	6340739.8	108.9
4/2/01	35	435	7887.3	2232.4	6343334.4	109.0
5/6/01	34	469	7887.7	2237.7	6373813.1	109.5

Table B.30 Raw Data For Specimen 6 With w/c = 0.40, Wet Cured For 28 Days.

Casting Date: 12/30/99
Start Date: 1/27/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7780.4	2163.0	5874354.9	100.0
2/3/00	7	7	7779.8	2167.7	5899456.5	100.4
2/11/00	8	15	7781.7	2179.5	5965315.9	101.5
2/17/00	6	21	7781.7	2183.9	5989425.9	102.0
2/24/00	7	28	7782.8	2189.5	6021032.7	102.5
3/9/00	14	42	7784.3	2197.6	6066833.5	103.3
3/26/00	17	59	7785.6	2205.1	6109334.2	104.0
4/7/00	12	71	7787.8	2209.2	6133806.6	104.4
4/22/00	15	86	7787.6	2212.2	6150318.8	104.7
5/4/00	13	99	7788.3	2215.3	6168122.4	105.0
5/20/00	16	115	7788.6	2218.7	6187308.7	105.3
6/3/00	14	129	7790.1	2222.0	6206923.0	105.7
6/17/00	14	143	7789.3	2225.0	6223055.6	105.9
7/2/00	15	158	7790.2	2226.8	6233848.6	106.1
7/15/00	13	171	7790.9	2228.7	6245052.2	106.3
7/30/00	15	186	7791.7	2231.7	6262519.2	106.6
8/13/00	14	200	7792.5	2232.8	6269337.9	106.7
8/28/00	15	215	7792.0	2234.3	6277361.4	106.9
9/9/00	14	229	7792.4	2234.4	6278245.6	106.9
9/23/00	14	243	7792.9	2237.3	6294957.0	107.2
10/7/00	14	257	7792.2	2231.7	6262921.0	106.6
10/22/00	15	272	7792.3	2240.5	6312491.1	107.5
11/4/00	13	285	7792.4	2240.9	6314826.3	107.5
11/20/00	16	301	7791.6	2243.1	6326581.9	107.7
12/2/00	12	313	7792.9	2242.7	6325381.0	107.7
12/16/00	14	327	7792.9	2245.6	6341750.0	108.0
12/30/00	14	341	7793.9	2246.3	6346518.7	108.0
1/15/01	16	357	7793.4	2248.4	6357982.6	108.2
1/29/01	14	371	7793.3	2248.4	6357901.1	108.2
2/12/01	14	385	7793.7	2248.2	6357096.3	108.2
2/27/01	15	400	7793.7	2250.9	6372374.7	108.5
4/2/01	35	435	7793.7	2251.4	6375206.1	108.5
5/6/01	34	469	7794.6	2255.8	6400888.1	109.0

Table B.31 Raw Data For Specimen 1 With w/c = 0.45, Wet Cured For 28 Days.

Casting Date: 1/1/00
Start Date: 1/29/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7741.5	2104.4	5532570.1	100.0
2/5/00	7	7	7743.8	2117.9	5605446.9	101.3
2/12/00	7	14	7744.7	2128.0	5659695.5	102.3
2/19/00	7	21	7745.2	2135.3	5698960.6	103.0
2/26/00	7	28	7745.7	2139.3	5720701.3	103.4
3/12/00	15	43	7746.8	2150.8	5783192.1	104.5
3/26/00	14	57	7748.0	2157.9	5822338.6	105.2
4/7/00	13	70	7748.4	2161.3	5841002.0	105.6
4/22/00	15	85	7750.2	2164.1	5857506.5	105.9
5/8/00	16	101	7751.1	2168.4	5881489.9	106.3
5/22/00	14	115	7751.0	2172.3	5902589.2	106.7
6/3/00	12	127	7751.6	2176.8	5927528.2	107.1
6/17/00	14	141	7752.0	2178.5	5937096.5	107.3
7/2/00	15	156	7753.3	2180.8	5950637.3	107.6
7/15/00	13	169	7753.1	2181.9	5956488.2	107.7
7/30/00	15	184	7753.7	2185.1	5974435.1	108.0
8/13/00	14	198	7753.9	2186.3	5981153.2	108.1
8/26/00	13	211	7754.7	2187.1	5986148.7	108.2
9/9/00	14	225	7754.2	2189.2	5997263.0	108.4
9/23/00	14	239	7754.3	2191.4	6009400.3	108.6
10/7/00	14	253	7754.6	2190.1	6002504.7	108.5
10/22/00	15	268	7754.4	2194.9	6028689.2	109.0
11/4/00	13	281	7754.3	2194.3	6025315.9	108.9
11/20/00	16	297	7755.4	2196.9	6040459.8	109.2
12/2/00	12	309	7755.0	2196.9	6040148.2	109.2
12/16/00	14	323	7756.1	2199.4	6054761.8	109.4
12/30/00	14	337	7755.9	2200.5	6060663.4	109.5
1/15/01	16	353	7756.6	2202.2	6070579.2	109.7
1/29/01	14	367	7756.5	2202.3	6071052.3	109.7
2/12/01	14	381	7756.7	2202.7	6073414.4	109.8
2/27/01	15	396	7757.4	2205.3	6088310.0	110.0
4/2/01	35	431	7756.6	2204.6	6083818.1	110.0
4/13/01	11	442	7756.7	2207.5	6099913.0	110.3
4/28/01	15	457	7730.9	2199.3	6034540.7	109.1
5/14/01	16	473	7723.3	2197.2	6017101.0	108.8
6/11/01	27	500	7718.5	2196.7	6010624.9	108.6
6/26/01	15	515	7725.9	2196.7	6016387.5	108.7
7/7/01	11	526	7728.5	2197.3	6021700.4	108.8
7/21/01	14	540	7722.8	2202.7	6046871.1	109.3
8/18/01	28	568	7724.0	2205.5	6063196.0	109.6
9/8/01	21	589	7722.6	2206.6	6068145.5	109.7
9/28/01	20	609	7720.7	2208.5	6077104.5	109.8
10/14/01	16	625	7719.4	2213.6	6104176.1	110.3
10/28/01	14	639	7719.8	2215.2	6113320.3	110.5
11/10/01	13	652	7718.7	2215.4	6113553.0	110.5
12/9/01	29	681	7726.3	2215.3	6119020.1	110.6
12/29/01	20	701	7725.5	2217.9	6132756.7	110.8

Table B.32 Raw Data For Specimen 2 With w/c = 0.45, Wet Cured For 28 Days.

Casting Date: 1/1/00
Start Date: 1/29/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7752.7	2089.1	5460301.9	100.0
2/5/00	7	7	7752.2	2099.9	5516548.2	101.0
2/12/00	7	14	7754.2	2107.8	5559567.6	101.8
2/19/00	7	21	7753.9	2117.1	5608518.5	102.7
2/26/00	7	28	7755.4	2124.3	5647823.5	103.4
3/12/00	15	43	7756.9	2133.4	5697416.8	104.3
3/26/00	14	57	7758.1	2141.4	5741114.2	105.1
4/7/00	13	70	7759.1	2144.7	5759564.8	105.5
4/22/00	15	85	7760.7	2147.4	5775266.3	105.8
5/8/00	16	101	7761.7	2154.0	5811569.9	106.4
5/22/00	14	115	7761.8	2156.1	5822982.2	106.6
6/3/00	12	127	7762.3	2159.3	5840655.8	107.0
6/17/00	14	141	7762.6	2162.0	5855497.6	107.2
7/2/00	15	156	7763.5	2162.7	5859969.2	107.3
7/15/00	13	169	7764.3	2169.4	5896941.2	108.0
7/30/00	15	184	7764.7	2170.5	5903226.9	108.1
8/13/00	14	198	7765.2	2174.6	5925931.6	108.5
8/26/00	13	211	7765.8	2174.1	5923664.5	108.5
9/9/00	14	225	7765.2	2173.9	5922117.1	108.5
9/23/00	14	239	7765.3	2175.9	5933095.3	108.7
10/7/00	14	253	7765.5	2176.2	5934884.3	108.7
10/22/00	15	268	7765.5	2180.4	5957814.7	109.1
11/4/00	13	281	7766.1	2179.9	5955542.7	109.1
11/20/00	16	297	7766.0	2183.0	5972416.3	109.4
12/2/00	12	309	7766.6	2182.6	5970689.1	109.3
12/16/00	14	323	7766.6	2185.0	5983827.1	109.6
12/30/00	14	337	7767.4	2186.4	5992114.8	109.7
1/15/01	16	353	7767.9	2188.2	6002371.5	109.9
1/29/01	14	367	7767.6	2188.2	6002139.7	109.9
2/12/01	14	381	7768.9	2189.0	6007534.5	110.0
2/27/01	15	396	7768.8	2190.9	6017890.3	110.2
4/2/01	35	431	7768.7	2192.6	6027155.4	110.4
4/13/01	11	442	7768.7	2193.9	6034304.5	110.5
4/28/01	15	457	7741.1	2182.6	5951085.6	109.0
5/14/01	16	473	7733.4	2180.3	5932642.8	108.7
6/11/01	27	500	7730.3	2180.3	5930264.7	108.6
6/26/01	15	515	7737.6	2180.4	5936409.3	108.7
7/7/01	11	526	7741.2	2181.4	5944620.3	108.9
7/21/01	14	540	7733.6	2185.8	5962766.0	109.2
8/18/01	28	568	7735.9	2188.9	5981469.7	109.5
9/8/01	21	589	7735.4	2192.5	6000773.0	109.9
9/28/01	20	609	7734.5	2194.6	6011574.2	110.1
10/14/01	16	625	7732.1	2197.7	6026698.9	110.4
10/28/01	14	639	7730.6	2200.0	6038148.4	110.6
11/10/01	13	652	7731.3	2200.7	6042538.6	110.7
12/9/01	29	681	7740.9	2200.3	6047842.5	110.8
12/29/01	20	701	7739.8	2204.0	6067337.3	111.1

Table B.33 Raw Data For Specimen 3 With w/c = 0.45, Wet Cured For 28 Days.

Casting Date: 1/1/00
Start Date: 1/29/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7732.7	2107.4	5542048.6	100.0
2/5/00	7	7	7734.4	2117.7	5597585.3	101.0
2/12/00	7	14	7735.5	2126.5	5645005.7	101.9
2/19/00	7	21	7735.7	2133.5	5682378.1	102.5
2/26/00	7	28	7736.6	2137.1	5702234.2	102.9
3/12/00	15	43	7738.5	2149.7	5771088.3	104.1
3/26/00	14	57	7739.4	2155.4	5802408.1	104.7
4/7/00	13	70	7740.3	2159.8	5826799.6	105.1
4/22/00	15	85	7741.6	2163.2	5846141.1	105.5
5/8/00	16	101	7742.9	2167.2	5868766.8	105.9
5/22/00	14	115	7743.1	2165.7	5860797.0	105.8
6/3/00	12	127	7743.4	2173.7	5904404.8	106.5
6/17/00	14	141	7743.6	2177.0	5922498.9	106.9
7/2/00	15	156	7744.2	2179.0	5933845.6	107.1
7/15/00	13	169	7745.0	2181.2	5946447.9	107.3
7/30/00	15	184	7745.0	2183.6	5959541.0	107.5
8/13/00	14	198	7745.7	2185.0	5967724.6	107.7
8/26/00	13	211	7746.4	2186.1	5974274.7	107.8
9/9/00	14	225	7745.3	2187.8	5982720.3	108.0
9/23/00	14	239	7746.4	2190.1	5996157.4	108.2
10/7/00	14	253	7746.2	2189.4	5992170.4	108.1
10/22/00	15	268	7746.4	2194.1	6018080.2	108.6
11/4/00	13	281	7746.4	2194.4	6019726.0	108.6
11/20/00	16	297	7746.9	2197.1	6034938.0	108.9
12/2/00	12	309	7746.7	2196.2	6029839.2	108.8
12/16/00	14	323	7747.2	2198.3	6041766.1	109.0
12/30/00	14	337	7747.5	2197.0	6034856.1	108.9
1/15/01	16	353	7748.4	2201.9	6062509.5	109.4
1/29/01	14	367	7747.7	2201.6	6060310.1	109.4
2/12/01	14	381	7748.1	2203.0	6068333.3	109.5
2/27/01	15	396	7748.8	2204.7	6078251.6	109.7
4/2/01	35	431	7749.0	2207.0	6091097.4	109.9
4/13/01	11	442	7748.7	2207.2	6091965.6	109.9
4/28/01	15	457	7723.3	2197.9	6020935.6	108.6
5/14/01	16	473	7716.2	2195.6	6002817.5	108.3
6/11/01	27	500	7712.3	2196.2	6003063.1	108.3
6/26/01	15	515	7719.8	2195.9	6007259.4	108.4
7/7/01	11	526	7723.1	2196.9	6015302.2	108.5
7/21/01	14	540	7713.8	2201.9	6035437.8	108.9
8/18/01	28	568	7717.0	2204.3	6051111.0	109.2
9/8/01	21	589	7715.7	2206.8	6063822.8	109.4
9/28/01	20	609	7714.8	2210.0	6080712.0	109.7
10/14/01	16	625	7713.5	2215.2	6108331.3	110.2
10/28/01	14	639	7711.9	2216.4	6113682.6	110.3
11/10/01	13	652	7712.2	2220.6	6137113.7	110.7
12/9/01	29	681	7721.8	2213.9	6107729.1	110.2
12/29/01	20	701	7720.4	2221.8	6150280.8	111.0

Table B.34 Raw Data For Specimen 4 With w/c = 0.45, Wet Cured For 28 Days.

Casting Date: 1/1/00
Start Date: 1/29/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7824.4	2122.1	5686276.2	100.0
2/5/00	7	7	7825.9	2109.1	5617898.1	98.8
2/12/00	7	14	7827.5	2136.9	5768151.9	101.4
2/19/00	7	21	7827.7	2143.1	5801820.2	102.0
2/26/00	7	28	7829.4	2146.8	5823135.2	102.4
3/12/00	15	43	7831.2	2160.9	5901234.5	103.8
3/26/00	14	57	7831.9	2165.6	5927462.8	104.2
4/7/00	13	70	7832.8	2168.0	5941290.8	104.5
4/22/00	15	85	7833.9	2171.3	5960228.5	104.8
5/8/00	16	101	7834.8	2177.0	5992250.9	105.4
5/22/00	14	115	7835.2	2181.1	6015150.0	105.8
6/3/00	12	127	7836.0	2184.8	6036191.6	106.2
6/17/00	14	141	7836.0	2187.5	6051120.0	106.4
7/2/00	15	156	7836.7	2189.4	6062177.8	106.6
7/15/00	13	169	7837.7	2191.2	6072924.7	106.8
7/30/00	15	184	7837.9	2194.9	6093606.6	107.2
8/13/00	14	198	7838.6	2196.0	6100260.7	107.3
8/26/00	13	211	7839.4	2196.0	6100883.2	107.3
9/9/00	14	225	7838.5	2198.4	6113523.9	107.5
9/23/00	14	239	7839.1	2200.8	6127348.4	107.8
10/7/00	14	253	7838.8	2200.8	6127113.9	107.8
10/22/00	15	268	7838.1	2203.9	6143838.5	108.0
11/4/00	13	281	7839.4	2204.9	6150435.1	108.2
11/20/00	16	297	7839.2	2206.9	6161440.7	108.4
12/2/00	12	309	7839.5	2206.3	6158326.5	108.3
12/16/00	14	323	7839.5	2210.6	6182354.6	108.7
12/30/00	14	337	7840.5	2209.3	6175873.1	108.6
1/15/01	16	353	7840.7	2210.8	6184419.9	108.8
1/29/01	14	367	7840.7	2212.1	6191695.2	108.9
2/12/01	14	381	7841.3	2215.4	6210657.7	109.2
2/27/01	15	396	7841.9	2219.4	6233582.1	109.6
4/2/01	35	431	7841.7	2217.2	6221071.3	109.4
4/13/01	11	442	7841.4	2220.8	6241050.9	109.8

Table B.35 Raw Data For Specimen 5 With w/c = 0.45, Wet Cured For 28 Days.

Casting Date: 1/1/00
Start Date: 1/29/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7768.9	2106.8	5564823.2	100.0
2/5/00	7	7	7744.6	2129.2	5666007.2	101.8
2/12/00	7	14	7746.0	2131.4	5678748.5	102.0
2/19/00	7	21	7746.4	2138.6	5717474.8	102.7
2/26/00	7	28	7747.5	2141.8	5735412.1	103.1
3/12/00	15	43	7749.4	2153.9	5801821.6	104.3
3/26/00	14	57	7750.1	2161.1	5841202.3	105.0
4/7/00	13	70	7751.1	2167.8	5878235.5	105.6
4/22/00	15	85	7752.6	2165.2	5865278.4	105.4
5/8/00	16	101	7753.8	2168.1	5881910.8	105.7
5/22/00	14	115	7753.7	2174.6	5917155.5	106.3
6/3/00	12	127	7754.1	2177.8	5934889.0	106.7
6/17/00	14	141	7754.2	2181.2	5953511.5	107.0
7/2/00	15	156	7755.5	2183.1	5964887.8	107.2
7/15/00	13	169	7755.9	2184.7	5973942.5	107.4
7/30/00	15	184	7755.0	2188.4	5993498.9	107.7
8/13/00	14	198	7755.2	2190.5	6005162.1	107.9
8/26/00	13	211	7755.2	2191.9	6012840.6	108.1
9/9/00	14	225	7755.1	2192.5	6016055.4	108.1
9/23/00	14	239	7755.5	2192.9	6018561.1	108.2
10/7/00	14	253	7755.8	2194.0	6024833.7	108.3
10/22/00	15	268	7755.1	2197.9	6045726.2	108.6
11/4/00	13	281	7756.1	2198.6	6050357.9	108.7
11/20/00	16	297	7756.4	2200.4	6060503.2	108.9
12/2/00	12	309	7755.9	2200.5	6060663.4	108.9
12/16/00	14	323	7756.6	2203.2	6076093.7	109.2
12/30/00	14	337	7756.5	2202.9	6074360.8	109.2
1/15/01	16	353	7757.5	2208.6	6106623.4	109.7
1/29/01	14	367	7757.1	2203.8	6079795.4	109.3
2/12/01	14	381	7758.1	2207.0	6098250.5	109.6
2/27/01	15	396	7758.2	2209.3	6111046.3	109.8
4/2/01	35	431	7758.4	2209.9	6114523.6	109.9
4/13/01	11	442	7757.7	2209.5	6111758.9	109.8

Table B.36 Raw Data For Specimen 6 With w/c = 0.45, Wet Cured For 28 Days.

Casting Date: 1/1/00
Start Date: 1/29/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7753.3	2113.2	5587441.8	100.0
2/5/00	7	7	7812.1	2136.5	5754648.6	103.0
2/12/00	7	14	7813.6	2136.3	5754676.0	103.0
2/19/00	7	21	7814.7	2143.9	5796509.8	103.7
2/26/00	7	28	7814.9	2147.1	5813975.4	104.1
3/12/00	15	43	7816.6	2159.2	5880968.4	105.3
3/26/00	14	57	7818.0	2166.6	5922408.5	106.0
4/7/00	13	70	7819.8	2169.4	5939093.1	106.3
4/22/00	15	85	7821.1	2174.4	5967493.2	106.8
5/8/00	16	101	7822.2	2178.1	5988661.5	107.2
5/22/00	14	115	7822.1	2181.2	6005643.7	107.5
6/3/00	12	127	7822.7	2184.2	6022637.2	107.8
6/17/00	14	141	7823.0	2187.4	6040528.9	108.1
7/2/00	15	156	7823.6	2189.9	6054808.7	108.4
7/15/00	13	169	7824.1	2191.7	6065153.9	108.5
7/30/00	15	184	7825.0	2195.0	6084131.8	108.9
8/13/00	14	198	7825.2	2197.0	6095379.9	109.1
8/26/00	13	211	7825.0	2197.3	6096888.8	109.1
9/9/00	14	225	7825.1	2199.2	6107515.4	109.3
9/23/00	14	239	7825.7	2201.1	6118542.2	109.5
10/7/00	14	253	7825.6	2201.6	6121244.1	109.6
10/22/00	15	268	7825.1	2204.4	6136431.9	109.8
11/4/00	13	281	7825.6	2205.0	6140165.1	109.9
11/20/00	16	297	7826.3	2207.3	6153531.6	110.1
12/2/00	12	309	7826.2	2207.3	6153453.0	110.1
12/16/00	14	323	7826.6	2211.1	6174973.9	110.5
12/30/00	14	337	7827.0	2212.5	6183112.0	110.7
1/15/01	16	353	7827.9	2212.8	6185500.0	110.7
1/29/01	14	367	7827.6	2213.2	6187499.3	110.7
2/12/01	14	381	7827.9	2215.7	6201723.5	111.0
2/27/01	15	396	7827.7	2219.9	6225098.3	111.4
4/2/01	35	431	7827.7	2220.0	6225659.1	111.4
4/13/01	11	442	7828.0	2224.6	6251725.5	111.9

Table B.37 Raw Data For Specimen 1 With w/c = 0.50, Wet Cured For 28 Days.

Casting Date: 6/12/00
Start Date: 7/10/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7811.1	2124.7	5690529.1	100.0
7/17/00	7	7	7807.1	2132.3	5728376.8	100.7
7/24/00	7	14	7807.7	2141.2	5776739.8	101.5
7/31/00	7	21	7809.1	2147.1	5809660.4	102.1
8/7/00	7	28	7809.6	2151.2	5832242.7	102.5
8/14/00	7	35	7810.2	2158.2	5870711.6	103.2
8/28/00	14	49	7810.7	2167.7	5922888.1	104.1
9/11/00	14	63	7811.2	2164.6	5906337.8	103.8
9/25/00	14	77	7811.6	2173.3	5954215.9	104.6
10/9/00	14	91	7811.8	2177.0	5974659.9	105.0
10/25/00	16	107	7812.7	2180.5	5994577.1	105.3
11/6/00	12	119	7813.2	2182.6	6006513.5	105.6
11/21/00	15	134	7813.6	2185.6	6023345.2	105.8
12/30/00	39	173	7815.5	2192.1	6060698.9	106.5
1/15/00	16	189	7815.6	2194.8	6075715.7	106.8
1/30/01	15	204	7816.2	2195.4	6079504.7	106.8
2/11/01	12	216	7816.8	2197.9	6093826.4	107.1
2/26/01	15	231	7817.5	2199.5	6103248.3	107.3
3/10/01	12	243	7816.8	2200.6	6108807.4	107.4
3/24/01	14	257	7816.4	2202.6	6119603.2	107.5
4/8/01	15	272	7817.5	2203.4	6124911.2	107.6
4/21/01	13	285	7818.1	2204.5	6131498.8	107.7
5/5/01	12	297	7818.4	2206.4	6142308.2	107.9
5/20/01	15	312	7819.2	2207.9	6151291.9	108.1
6/2/01	13	325	7818.7	2208.3	6153127.5	108.1
6/16/01	14	339	7820.3	2209.5	6161077.1	108.3
6/30/01	14	353	7819.6	2210.2	6164429.7	108.3
7/15/01	15	368	7819.8	2214.5	6188597.4	108.8
7/28/01	13	381	7820.2	2214.2	6187237.3	108.7
8/11/01	14	395	7820.9	2217.4	6205689.4	109.1
9/8/01	28	423	7822.5	2218.1	6210878.5	109.1
9/22/01	14	437	7822.0	2218.5	6212721.6	109.2
10/6/01	14	451	7822.0	2223.1	6238512.2	109.6
10/21/01	15	466	7822.9	2223.0	6238668.7	109.6
11/3/01	13	479	7823.1	2223.1	6239389.5	109.6
11/17/01	14	493	7823.3	2226.2	6256962.6	110.0
12/1/01	14	507	7823.4	2229.2	6273917.8	110.3
12/15/01	14	521	7823.6	2228.8	6271826.8	110.2
12/29/01	14	535	7823.8	2226.1	6256800.4	110.0
2/19/02	52	587	7802.7	2228.6	6253949.6	109.9
3/3/02	12	599	7797.0	2227.6	6243773.9	109.7
3/16/02	13	612	7792.9	2221.5	6206359.9	109.1
3/30/02	14	626	7788.9	2218.3	6185316.2	108.7
4/13/02	14	640	7784.0	2221.4	6198713.7	108.9
4/29/02	16	656	7785.6	2222.6	6206688.2	109.1
5/12/02	13	669	7783.6	2221.4	6198395.2	108.9
5/25/02	13	682	7781.2	2217.6	6175302.3	108.5
6/8/02	14	696	7783.3	2219.7	6188673.2	108.8
6/24/02	16	712	7785.7	2219.7	6190581.5	108.8
7/7/02	13	725	7786.9	2222.7	6208283.1	109.1
7/20/02	13	738	7785.2	2224.7	6218102.9	109.3

Table B.38 Raw Data For Specimen 2 With w/c = 0.50, Wet Cured For 28 Days.

Casting Date: 6/12/00
Start Date: 7/10/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7895.1	2124.8	5752266.1	100.0
7/17/00	7	7	7892.7	2138.7	5826001.0	101.3
7/24/00	7	14	7893.4	2148.0	5877300.3	102.2
7/31/00	7	21	7895.5	2155.5	5919989.1	102.9
8/7/00	7	28	7895.8	2159.5	5942207.0	103.3
8/14/00	7	35	7897.4	2168.1	5990843.5	104.1
8/28/00	14	49	7897.4	2172.7	6016291.7	104.6
9/11/00	14	63	7898.1	2177.4	6042884.4	105.1
9/25/00	14	77	7899.2	2183.9	6079863.4	105.7
10/9/00	14	91	7898.9	2187.1	6097462.2	106.0
10/25/00	16	107	7900.1	2189.8	6113454.9	106.3
11/6/00	12	119	7900.4	2192.7	6129890.7	106.6
11/21/00	15	134	7901.5	2194.8	6142492.9	106.8
12/30/00	39	173	7903.5	2202.2	6185548.2	107.5
1/15/00	16	189	7903.6	2205.9	6206429.3	107.9
1/30/01	15	204	7904.4	2206.1	6208183.1	107.9
2/11/01	12	216	7904.6	2208.9	6224109.5	108.2
2/26/01	15	231	7905.5	2210.2	6232147.3	108.3
3/10/01	12	243	7904.9	2213.1	6248038.2	108.6
3/24/01	14	257	7905.6	2213.9	6253109.8	108.7
4/8/01	15	272	7905.6	2217.3	6272331.0	109.0
4/21/01	13	285	7905.9	2219.9	6287288.0	109.3
5/5/01	12	297	7907.0	2218.8	6281932.6	109.2
5/20/01	15	312	7907.2	2222.5	6303060.6	109.6
6/2/01	13	325	7907.2	2222.6	6303627.8	109.6
6/16/01	14	339	7908.7	2224.1	6313336.5	109.8
6/30/01	14	353	7908.4	2224.6	6315935.9	109.8
7/15/01	15	368	7908.2	2230.6	6349890.8	110.4
7/28/01	13	381	7908.9	2224.4	6315199.5	109.8
8/11/01	14	395	7909.6	2224.6	6316894.2	109.8
9/8/01	28	423	7910.7	2227.7	6335392.7	110.1
9/22/01	14	437	7910.8	2229.1	6343438.4	110.3
10/6/01	14	451	7911.1	2230.8	6353358.5	110.4
10/21/01	15	466	7911.5	2231.4	6357098.0	110.5
11/3/01	13	479	7912.0	2232.5	6363769.4	110.6
11/17/01	14	493	7912.1	2233.2	6367841.2	110.7
12/1/01	14	507	7912.4	2234.0	6372645.9	110.8
12/15/01	14	521	7912.5	2234.5	6375579.4	110.8
12/29/01	14	535	7912.8	2236.9	6389524.6	111.1
2/19/02	52	587	7895.5	2232.7	6351636.0	110.4
3/3/02	12	599	7889.9	2234.7	6358507.3	110.5
3/16/02	13	612	7885.0	2230.7	6331830.1	110.1
3/30/02	14	626	7880.0	2229.2	6319307.7	109.9
4/13/02	14	640	7873.6	2230.7	6322675.6	109.9
4/29/02	16	656	7875.7	2230.6	6323794.9	109.9
5/12/02	13	669	7874.6	2231.8	6329716.6	110.0
5/25/02	13	682	7871.5	2230.1	6317589.4	109.8
6/8/02	14	696	7872.7	2229.4	6314586.5	109.8
6/24/02	16	712	7875.3	2229.3	6316105.2	109.8
7/7/02	13	725	7875.9	2230.0	6320553.9	109.9
7/20/02	13	738	7874.6	2231.1	6325746.6	110.0

Table B.39 Raw Data For Specimen 3 With w/c = 0.50, Wet Cured For 28 Days.

Casting Date: 6/12/00
Start Date: 7/10/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7939.9	2151.4	5930653.9	100.0
7/17/00	7	7	7939.9	2166.4	6013641.6	101.4
7/24/00	7	14	7936.4	2174.5	6056024.0	102.1
7/31/00	7	21	7938.2	2181.3	6095341.7	102.8
8/7/00	7	28	7938.3	2185.1	6116674.4	103.1
8/14/00	7	35	7939.3	2190.3	6146595.5	103.6
8/28/00	14	49	7939.9	2197.4	6186976.9	104.3
9/11/00	14	63	7940.2	2201.7	6211449.3	104.7
9/25/00	14	77	7941.3	2207.3	6243951.9	105.3
10/9/00	14	91	7941.1	2209.9	6258512.5	105.5
10/25/00	16	107	7942.0	2214.5	6285306.6	106.0
11/6/00	12	119	7942.3	2218.2	6306565.5	106.3
11/21/00	15	134	7942.8	2218.5	6308668.6	106.4
12/30/00	39	173	7945.6	2226.7	6357631.2	107.2
1/15/00	16	189	7945.3	2229.4	6372817.9	107.5
1/30/01	15	204	7945.6	2229.7	6374773.9	107.5
2/11/01	12	216	7946.5	2232.0	6388655.7	107.7
2/26/01	15	231	7946.5	2234.7	6404121.5	108.0
3/10/01	12	243	7946.5	2235.6	6409280.9	108.1
3/24/01	14	257	7946.2	2237.6	6420511.3	108.3
4/8/01	15	272	7947.1	2239.6	6432722.5	108.5
4/21/01	13	285	7947.3	2238.1	6424270.2	108.3
5/5/01	12	297	7947.8	2241.0	6441334.6	108.6
5/20/01	15	312	7948.2	2242.4	6449709.8	108.8
6/2/01	13	325	7948.4	2241.7	6445845.9	108.7
6/16/01	14	339	7949.7	2242.4	6450927.0	108.8
6/30/01	14	353	7949.2	2244.0	6459729.7	108.9
7/15/01	15	368	7949.3	2246.9	6476518.3	109.2
7/28/01	13	381	7950.0	2245.7	6470172.0	109.1
8/11/01	14	395	7950.0	2248.7	6487470.4	109.4
9/8/01	28	423	7951.3	2252.0	6507589.2	109.7
9/22/01	14	437	7951.4	2254.1	6519813.6	109.9
10/6/01	14	451	7951.8	2255.9	6530559.0	110.1
10/21/01	15	466	7951.7	2254.3	6521216.6	110.0
11/3/01	13	479	7852.3	2255.6	6447127.7	108.7
11/17/01	14	493	7952.4	2258.1	6543796.4	110.3
12/1/01	14	507	7952.5	2258.5	6546197.2	110.4
12/15/01	14	521	7952.4	2259.0	6549013.7	110.4
12/29/01	14	535	7953.3	2264.0	6578781.0	110.9
2/19/02	52	587	7935.0	2255.4	6513873.2	109.8
3/3/02	12	599	7930.0	2259.7	6534614.6	110.2
3/16/02	13	612	7925.8	2256.1	6510360.2	109.8
3/30/02	14	626	7922.4	2255.6	6504683.3	109.7
4/13/02	14	640	7917.2	2255.4	6499261.1	109.6
4/29/02	16	656	7918.8	2257.5	6512685.6	109.8
5/12/02	13	669	7918.3	2257.9	6514582.3	109.8
5/25/02	13	682	7915.3	2255.7	6499430.1	109.6
6/8/02	14	696	7916.4	2257.9	6513019.2	109.8
6/24/02	16	712	7918.2	2257.9	6514500.1	109.8
7/7/02	13	725	7918.6	2257.2	6510790.3	109.8
7/20/02	13	738	7917.4	2258.7	6518458.6	109.9

Table B.40 Raw Data For Specimen 4 With w/c = 0.50, Wet Cured For 28 Days.

Casting Date: 6/12/00
Start Date: 7/10/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7847.4	2135.5	5775241.6	100.0
7/17/00	7	7	7844.2	2148.5	5843386.2	101.2
7/24/00	7	14	7844.8	2155.7	5883066.2	101.9
7/31/00	7	21	7846.2	2163.7	5927870.2	102.6
8/7/00	7	28	7846.4	2168.9	5956549.0	103.1
8/14/00	7	35	7847.8	2173.3	5981808.5	103.6
8/28/00	14	49	7847.2	2179.6	6016079.1	104.2
9/11/00	14	63	7848.7	2185.1	6047635.1	104.7
9/25/00	14	77	7849.5	2189.5	6072634.1	105.1
10/9/00	14	91	7849.1	2193.4	6093976.3	105.5
10/25/00	16	107	7850.4	2196.5	6112226.2	105.8
11/6/00	12	119	7850.8	2199.0	6126459.8	106.1
11/21/00	15	134	7851.9	2201.7	6142374.1	106.4
12/30/00	39	173	7853.3	2208.8	6183155.9	107.1
1/15/00	16	189	7853.9	2209.8	6189228.6	107.2
1/30/01	15	204	7854.1	2209.7	6188826.0	107.2
2/11/01	12	216	7855.1	2213.6	6211482.0	107.6
2/26/01	15	231	7855.6	2220.7	6251789.8	108.3
3/10/01	12	243	7855.3	2217.3	6232422.8	107.9
3/24/01	14	257	7855.5	2221.4	6255652.1	108.3
4/8/01	15	272	7855.7	2224.9	6275540.0	108.7
4/21/01	13	285	7855.8	2230.3	6306119.6	109.2
5/5/01	12	297	7856.4	2223.8	6269894.8	108.6
5/20/01	15	312	7857.0	2223.1	6266426.8	108.5
6/2/01	13	325	7856.9	2225.0	6277062.8	108.7
6/16/01	14	339	7858.2	2224.5	6275280.1	108.7
6/30/01	14	353	7858.2	2224.9	6277537.1	108.7
7/15/01	15	368	7858.1	2227.2	6290442.6	108.9
7/28/01	13	381	7858.2	2229.3	6302390.8	109.1
8/11/01	14	395	7859.0	2229.7	6305294.5	109.2
9/8/01	28	423	7860.2	2231.8	6318141.7	109.4
9/22/01	14	437	7860.1	2233.1	6325423.9	109.5
10/6/01	14	451	7860.4	2235.1	6337001.1	109.7
10/21/01	15	466	7860.7	2235.1	6337243.0	109.7
11/3/01	13	479	7861.0	2236.9	6347696.5	109.9
11/17/01	14	493	7861.4	2238.0	6354264.3	110.0
12/1/01	14	507	7961.6	2238.7	6439280.9	111.5
12/15/01	14	521	7861.5	2239.5	6362865.9	110.2
12/29/01	14	535	7861.8	2240.7	6369929.7	110.3

Table B.41 Raw Data For Specimen 5 With w/c = 0.50, Wet Cured For 28 Days.

Casting Date: 6/12/00
Start Date: 7/10/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7869.7	2144.7	5841663.0	100.0
7/17/00	7	7	7866.8	2156.7	5905039.5	101.1
7/24/00	7	14	7867.2	2174.1	6001011.3	102.7
7/31/00	7	21	7869.2	2174.6	6005298.1	102.8
8/7/00	7	28	7769.3	2178.1	5948161.3	101.8
8/14/00	7	35	7871.1	2184.6	6062119.7	103.8
8/28/00	14	49	7871.9	2190.8	6097197.3	104.4
9/11/00	14	63	7872.6	2196.2	6127836.6	104.9
9/25/00	14	77	7873.6	2200.9	6154874.3	105.4
10/9/00	14	91	7873.2	2203.8	6170791.3	105.6
10/25/00	16	107	7874.5	2207.5	6192551.5	106.0
11/6/00	12	119	7875.5	2211.5	6215803.0	106.4
11/21/00	15	134	7875.8	2211.2	6214353.4	106.4
12/30/00	39	173	7878.7	2217.7	6253244.0	107.0
1/15/00	16	189	7879.1	2224.3	6290838.8	107.7
1/30/01	15	204	7879.7	2224.6	6293015.0	107.7
2/11/01	12	216	7879.1	2227.3	6307819.6	108.0
2/26/01	15	231	7880.2	2229.3	6320035.1	108.2
3/10/01	12	243	7880.3	2230.0	6324085.0	108.3
3/24/01	14	257	7880.0	2232.9	6340302.6	108.5
4/8/01	15	272	7880.7	2233.6	6344842.0	108.6
4/21/01	13	285	7880.8	2234.0	6347195.3	108.7
5/5/01	12	297	7881.9	2235.7	6357746.3	108.8
5/20/01	15	312	7882.1	2237.1	6365872.8	109.0
6/2/01	13	325	7882.0	2237.1	6365792.0	109.0
6/16/01	14	339	7883.4	2238.6	6375463.7	109.1
6/30/01	14	353	7883.7	2239.1	6378554.7	109.2
7/15/01	15	368	7883.0	2241.4	6391098.0	109.4
7/28/01	13	381	7883.3	2243.7	6404464.9	109.6
8/11/01	14	395	7884.3	2243.3	6402993.7	109.6
9/8/01	28	423	7885.5	2247.6	6428542.2	110.0
9/22/01	14	437	7884.9	2248.4	6432629.8	110.1
10/6/01	14	451	7885.7	2249.6	6440151.4	110.2
10/21/01	15	466	7885.7	2251.2	6449315.6	110.4
11/3/01	13	479	7886.2	2252.5	6457175.7	110.5
11/17/01	14	493	7886.6	2252.9	6459796.9	110.6
12/1/01	14	507	7887.0	2252.7	6458977.6	110.6
12/15/01	14	521	7886.5	2253.9	6465450.8	110.7
12/29/01	14	535	7887.7	2256.2	6479638.7	110.9

Table B.42 Raw Data For Specimen 6 With w/c = 0.50, Wet Cured For 28 Days.

Casting Date: 6/12/00
Start Date: 7/10/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7908.8	2142.6	5859195.8	100.0
7/17/00	7	7	7905.1	2154.9	5923887.9	101.1
7/24/00	7	14	7904.7	2168.7	5999700.5	102.4
7/31/00	7	21	7906.4	2180.5	6066471.8	103.5
8/7/00	7	28	7906.5	2176.2	6042645.3	103.1
8/14/00	7	35	7907.6	2182.0	6075743.1	103.7
8/28/00	14	49	7908.6	2188.0	6109975.4	104.3
9/11/00	14	63	7908.8	2192.3	6134169.6	104.7
9/25/00	14	77	7909.5	2198.0	6166654.6	105.2
10/9/00	14	91	7909.9	2200.9	6183250.4	105.5
10/25/00	16	107	7911.0	2205.5	6209987.5	106.0
11/6/00	12	119	7911.0	2205.9	6212240.3	106.0
11/21/00	15	134	7911.4	2213.8	6257132.1	106.8
12/30/00	39	173	7914.0	2223.4	6313591.3	107.8
1/15/00	16	189	7914.3	2224.9	6322352.7	107.9
1/30/01	15	204	7913.9	2227.5	6336817.5	108.2
2/11/01	12	216	7914.7	2224.0	6317558.1	107.8
2/26/01	15	231	7916.0	2225.9	6329396.5	108.0
3/10/01	12	243	7915.3	2227.0	6335093.5	108.1
3/24/01	14	257	7914.8	2226.5	6331849.2	108.1
4/8/01	15	272	7916.5	2230.9	6358265.2	108.5
4/21/01	13	285	7916.4	2229.8	6351916.4	108.4
5/5/01	12	297	7916.9	2233.0	6370563.1	108.7
5/20/01	15	312	7917.2	2233.0	6370804.5	108.7
6/2/01	13	325	7917.6	2233.7	6375121.5	108.8
6/16/01	14	339	7919.0	2235.0	6383672.8	109.0
6/30/01	14	353	7918.5	2235.2	6384412.2	109.0
7/15/01	15	368	7918.2	2238.0	6400175.0	109.2
7/28/01	13	381	7919.3	2239.8	6411364.9	109.4
8/11/01	14	395	7919.5	2240.8	6417253.2	109.5
9/8/01	28	423	7920.8	2241.2	6420598.2	109.6
9/22/01	14	437	7921.0	2244.1	6437387.4	109.9
10/6/01	14	451	7831.3	2245.5	6372431.8	108.8
10/21/01	15	466	7921.1	2246.4	6450671.0	110.1
11/3/01	13	479	7921.5	2247.8	6459040.1	110.2
11/17/01	14	493	7922.1	2248.2	6461828.5	110.3
12/1/01	14	507	7922.4	2249.2	6467823.1	110.4
12/15/01	14	521	7922.2	2250.6	6475713.8	110.5
12/29/01	14	535	7922.6	2252.0	6484100.2	110.7

Table B.43 Raw Data For Specimen 1 With w/c = 0.55, Wet Cured For 28 Days.

Casting Date: 1/11/00
Start Date: 2/7/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7859.1	2124.3	5723342.4	100.0
2/14/00	7	7	7859.8	2133.7	5774620.2	100.9
2/21/00	7	14	7861.3	2143.6	5829443.3	101.9
3/13/00	21	35	7859.9	2161.4	5925602.7	103.5
3/27/00	14	49	7861.7	2167.6	5961011.6	104.2
4/10/00	14	63	7863.2	2175.0	6002927.0	104.9
4/24/00	14	77	7863.9	2176.3	6010640.1	105.0
5/8/00	13	90	7865.2	2181.6	6040950.0	105.5
5/22/00	14	104	7866.3	2185.3	6062306.0	105.9
6/5/00	14	118	7866.0	2188.8	6081508.5	106.3
6/19/00	14	132	7867.6	2190.3	6091085.5	106.4
7/6/00	17	149	7868.2	2193.3	6108248.3	106.7
7/17/00	11	160	7869.2	2195.2	6119613.4	106.9
7/31/00	11	171	7870.6	2198.6	6139676.8	107.3
8/14/00	14	185	7870.8	2198.7	6140391.3	107.3
8/28/00	14	199	7871.3	2201.1	6154194.7	107.5
9/11/00	14	213	7870.5	2202.5	6161399.6	107.7
9/25/00	14	227	7870.9	2205.1	6176268.8	107.9
10/9/00	14	241	7870.8	2203.2	6165551.7	107.7
10/25/00	16	257	7871.3	2206.6	6184988.7	108.1
11/6/00	12	269	7871.6	2209.0	6198686.4	108.3
11/21/00	15	284	7871.7	2211.4	6212242.0	108.5
12/30/00	39	323	7873.7	2218.2	6252093.8	109.2
1/15/01	16	339	7874.2	2219.0	6257001.6	109.3
1/30/01	15	354	7873.9	2220.9	6267482.4	109.5
2/11/01	12	366	7874.6	2222.2	6275379.7	109.6
2/26/01	15	381	7874.6	2221.2	6269733.1	109.5
4/2/01	35	416	7874.8	2226.8	6301546.9	110.1
4/13/01	11	427	7875.5	2222.3	6276661.8	109.7

Table B.44 Raw Data For Specimen 2 With w/c = 0.55, Wet Cured For 28 Days.

Casting Date: 1/11/00
Start Date: 2/7/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7763.5	2099.9	5524589.4	100.0
2/14/00	7	7	7764.2	2111.2	5584710.8	101.1
2/21/00	7	14	7766.1	2117.9	5621589.1	101.8
3/13/00	21	35	7765.5	2137.9	5727820.7	103.7
3/27/00	14	49	7767.6	2145.3	5769100.9	104.4
4/10/00	14	63	7769.5	2151.4	5803374.8	105.0
4/24/00	14	77	7770.6	2152.7	5811213.0	105.2
5/8/00	13	90	7771.8	2159.8	5850512.4	105.9
5/22/00	14	104	7773.2	2163.0	5868918.8	106.2
6/5/00	14	118	7773.8	2167.0	5891100.1	106.6
6/19/00	14	132	7774.8	2167.9	5896753.0	106.7
7/6/00	17	149	7775.4	2175.1	5936444.5	107.5
7/17/00	11	160	7776.2	2175.4	5938693.2	107.5
7/31/00	11	171	7777.5	2177.0	5948426.4	107.7
8/14/00	14	185	7777.1	2177.2	5949213.5	107.7
8/28/00	14	199	7780.0	2178.9	5960729.5	107.9
9/11/00	14	213	7777.7	2180.5	5967722.1	108.0
9/25/00	14	227	7777.7	2183.4	5983606.4	108.3
10/9/00	14	241	7778.2	2184.4	5989473.7	108.4
10/25/00	16	257	7779.0	2186.9	6003808.6	108.7
11/6/00	12	269	7778.8	2187.9	6009146.1	108.8
11/21/00	15	284	7778.9	2190.4	6022964.0	109.0
12/30/00	39	323	7780.8	2192.8	6037644.2	109.3
1/15/01	16	339	7781.7	2195.3	6052119.0	109.5
1/30/01	15	354	7780.9	2195.3	6051496.8	109.5
2/11/01	12	366	7782.1	2196.7	6060152.1	109.7
2/26/01	15	381	7782.2	2198.5	6070165.7	109.9
4/2/01	35	416	7782.8	2199.8	6077815.1	110.0
4/13/01	11	427	7782.9	2199.8	6077893.2	110.0

Table B.45 Raw Data For Specimen 3 With w/c = 0.55, Wet Cured For 28 Days.

Casting Date: 1/11/00
Start Date: 2/7/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7815.8	2075.1	5431211.5	100.0
2/14/00	7	7	7815.4	2084.6	5480774.0	100.9
2/21/00	7	14	7816.2	2094.6	5534050.0	101.9
3/13/00	21	35	7817.5	2110.8	5620918.4	103.5
3/27/00	14	49	7819.5	2116.7	5653831.0	104.1
4/10/00	14	63	7820.2	2124.0	5693405.3	104.8
4/24/00	14	77	7820.8	2125.7	5702960.2	105.0
5/8/00	13	90	7822.6	2130.9	5732215.1	105.5
5/22/00	14	104	7823.3	2133.7	5747803.6	105.8
6/5/00	14	118	7824.2	2137.9	5771117.8	106.3
6/19/00	14	132	7824.9	2140.7	5786762.2	106.5
7/6/00	17	149	7825.7	2143.1	5800337.8	106.8
7/17/00	11	160	7826.4	2144.2	5806813.0	106.9
7/31/00	11	171	7827.6	2146.7	5821254.1	107.2
8/14/00	14	185	7827.5	2148.5	5830945.9	107.4
8/28/00	14	199	7828.4	2150.1	5840305.2	107.5
9/11/00	14	213	7827.8	2151.7	5848552.3	107.7
9/25/00	14	227	7827.9	2154.0	5861137.2	107.9
10/9/00	14	241	7828.1	2154.3	5862919.7	107.9
10/25/00	16	257	7828.5	2158.4	5885557.9	108.4
11/6/00	12	269	7828.6	2158.8	5887814.8	108.4
11/21/00	15	284	7828.7	2157.9	5882981.7	108.3
12/30/00	39	323	7831.4	2162.4	5909581.0	108.8
1/15/01	16	339	7831.4	2169.1	5946258.3	109.5
1/30/01	15	354	7831.8	2170.8	5955886.8	109.7
2/11/01	12	366	7832.1	2171.4	5959407.9	109.7
2/26/01	15	381	7832.4	2172.6	5966225.0	109.9
4/2/01	35	416	7832.2	2170.8	5956191.0	109.7
4/13/01	11	427	7832.8	2180.8	6011653.4	110.7

Table B.46 Raw Data For Specimen 4 With w/c = 0.55, Wet Cured For 28 Days.

Casting Date: 1/11/00
Start Date: 2/7/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7795.9	2100.4	5550287.7	100.0
2/14/00	7	7	7797.2	2107.9	5590928.0	100.7
2/21/00	7	14	7798.9	2124.2	5678967.4	102.3
3/13/00	21	35	7803.0	2138.6	5759250.3	103.8
3/27/00	14	49	7804.6	2146.0	5800364.7	104.5
4/10/00	14	63	7805.7	2151.2	5829330.1	105.0
4/24/00	14	77	7806.5	2152.9	5839145.5	105.2
5/8/00	13	90	7808.1	2157.6	5865870.2	105.7
5/22/00	14	104	7809.0	2161.7	5888863.5	106.1
6/5/00	14	118	7809.6	2164.0	5901854.8	106.3
6/19/00	14	132	7811.3	2167.1	5920064.5	106.7
7/6/00	17	149	7811.3	2174.8	5962208.8	107.4
7/17/00	11	160	7812.4	2173.4	5955373.6	107.3
7/31/00	11	171	7813.3	2175.9	5969769.8	107.6
8/14/00	14	185	7813.6	2178.3	5983176.0	107.8
8/28/00	14	199	7813.7	2178.1	5982153.9	107.8
9/11/00	14	213	7813.5	2181.0	5997940.7	108.1
9/25/00	14	227	7813.9	2183.4	6011456.1	108.3
10/9/00	14	241	7814.1	2184.0	6014914.4	108.4
10/25/00	16	257	7815.3	2186.0	6026861.2	108.6
11/6/00	12	269	7814.6	2189.0	6042873.4	108.9
11/21/00	15	284	7815.0	2189.5	6045943.7	108.9
12/30/00	39	323	7816.7	2191.3	6057205.9	109.1
1/15/01	16	339	7817.7	2195.5	6081225.4	109.6
1/30/01	15	354	7817.0	2195.2	6079019.2	109.5
2/11/01	12	366	7818.0	2195.9	6083674.9	109.6
2/26/01	15	381	7818.3	2198.3	6097214.4	109.9
4/2/01	35	416	7818.6	2200.2	6107993.0	110.0
4/13/01	11	427	7818.6	2201.2	6113546.5	110.1
4/28/01	15	442	7794.7	2187.7	6020328.0	108.5
5/14/01	16	458	7787.7	2183.9	5994044.0	108.0
6/11/01	27	485	7783.9	2182.9	5985633.9	107.8
6/26/01	15	500	7754.2	2183.1	5963888.0	107.5
7/7/01	11	511	7799.0	2185.0	6008789.9	108.3
7/21/01	14	525	7788.8	2189.2	6024023.4	108.5
8/18/01	28	553	7793.6	2191.5	6040408.1	108.8
9/8/01	21	574	7791.3	2195.6	6061241.5	109.2
9/28/01	20	594	7791.6	2197.0	6069207.4	109.3
10/14/01	16	610	7787.1	2200.2	6083384.8	109.6
10/28/01	14	624	7786.6	2202.8	6097379.4	109.9
11/10/01	13	637	7790.2	2203.4	6103522.0	110.0
12/9/01	29	666	7801.6	2203.1	6110789.4	110.1
12/29/01	20	686	7801.3	2207.2	6133319.3	110.5

Table B.47 Raw Data For Specimen 5 With w/c = 0.55, Wet Cured For 28 Days.

Casting Date: 1/11/00
Start Date: 2/7/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial		0	7757.6	2088.3	5459569.2	100.0
2/14/00	7	7	7757.6	2096.9	5504628.8	100.8
2/21/00	7	14	7757.7	2107.6	5561021.6	101.9
3/13/00	21	35	7758.4	2124.8	5652668.3	103.5
3/27/00	14	49	7760.1	2128.7	5674681.0	103.9
4/10/00	14	63	7761.9	2137.9	5725165.4	104.9
4/24/00	14	77	7762.1	2140.9	5741392.2	105.2
5/8/00	13	90	7763.4	2146.2	5770820.5	105.7
5/22/00	14	104	7764.9	2148.9	5786467.2	106.0
6/5/00	14	118	7765.2	2151.7	5801780.6	106.3
6/19/00	14	132	7765.9	2157.0	5830922.9	106.8
7/6/00	17	149	7766.7	2157.9	5836391.0	106.9
7/17/00	11	160	7768.0	2161.8	5858486.9	107.3
7/31/00	11	171	7768.6	2161.9	5859481.4	107.3
8/14/00	14	185	7769.3	2167.0	5887690.0	107.8
8/28/00	14	199	7769.8	2166.3	5884265.5	107.8
9/11/00	14	213	7769.3	2170.6	5907268.4	108.2
9/25/00	14	227	7769.1	2167.1	5888081.8	107.8
10/9/00	14	241	7769.7	2170.2	5905395.5	108.2
10/25/00	16	257	7769.7	2168.4	5895603.5	108.0
11/6/00	12	269	7769.8	2175.5	5934351.0	108.7
11/21/00	15	284	7770.0	2175.1	5932321.7	108.7
12/30/00	39	323	7771.9	2178.6	5952884.0	109.0
1/15/01	16	339	7772.5	2180.3	5962638.2	109.2
1/30/01	15	354	7772.5	2180.7	5964826.2	109.3
2/11/01	12	366	7773.1	2182.6	5975686.1	109.5
2/26/01	15	381	7773.3	2183.8	5982412.7	109.6
4/2/01	35	416	7773.7	2185.3	5990942.2	109.7
4/13/01	11	427	7773.2	2187.1	6000429.6	109.9
4/28/01	15	442	7748.9	2174.2	5911317.1	108.3
5/14/01	16	458	7743.6	2171.3	5891525.9	107.9
6/11/01	27	485	7740.8	2168.0	5871507.5	107.5
6/26/01	15	500	7750.7	2174.4	5913778.1	108.3
7/7/01	11	511	7754.5	2172.5	5906342.0	108.2
7/21/01	14	525	7749.3	2176.6	5924680.6	108.5
8/18/01	28	553	7750.6	2179.8	5943111.0	108.9
9/8/01	21	574	7749.5	2183.2	5960819.2	109.2
9/28/01	20	594	7750.1	2184.7	5969475.1	109.3
10/14/01	16	610	7746.8	2187.9	5984426.0	109.6
10/28/01	14	624	7745.5	2190.0	5994913.3	109.8
11/10/01	13	637	7748.9	2190.4	5999735.9	109.9
12/9/01	29	666	7760.1	2190.6	6009505.0	110.1
12/29/01	20	686	7759.7	2194.0	6027863.3	110.4

Table B.48 Raw Data For Specimen 6 With w/c = 0.55, Wet Cured For 28 Days.

Casting Date: 1/11/00
Start Date: 2/7/00

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial			7830.1	2102.2	5584195.2	100.0
2/14/00	7	7	7829.7	2108.9	5619560.0	100.6
2/21/00	7	14	7830.8	2124.5	5703807.0	102.1
3/13/00	21	35	7834.1	2140.3	5791400.9	103.7
3/27/00	14	49	7836.2	2147.2	5830364.8	104.4
4/10/00	14	63	7837.4	2154.8	5872610.1	105.2
4/24/00	14	77	7838.1	2156.3	5881314.2	105.3
5/8/00	13	90	7839.3	2160.6	5905698.2	105.8
5/22/00	14	104	7840.6	2166.7	5940077.1	106.4
6/5/00	14	118	7841.4	2167.9	5947265.4	106.5
6/19/00	14	132	7842.1	2174.6	5984617.0	107.2
7/6/00	17	149	7842.8	2174.4	5984050.3	107.2
7/17/00	11	160	7844.1	2176.5	5996608.3	107.4
7/31/00	11	171	7844.7	2178.6	6008645.1	107.6
8/14/00	14	185	7845.6	2180.3	6018716.5	107.8
8/28/00	14	199	7846.2	2181.9	6028014.3	107.9
9/11/00	14	213	7845.7	2183.4	6035920.7	108.1
9/25/00	14	227	7845.5	2186.0	6050150.2	108.3
10/9/00	14	241	7845.8	2186.7	6054257.1	108.4
10/25/00	16	257	7846.6	2189.4	6069836.0	108.7
11/6/00	12	269	7846.8	2191.0	6078865.8	108.9
11/21/00	15	284	7846.0	2193.2	6090458.6	109.1
12/30/00	39	323	7848.3	2196.3	6109478.4	109.4
1/15/01	16	339	7848.9	2198.4	6121635.2	109.6
1/30/01	15	354	7849.2	2198.3	6121312.2	109.6
2/11/01	12	366	7849.8	2200.4	6133481.8	109.8
2/26/01	15	381	7849.5	2202.3	6143843.9	110.0
4/2/01	35	416	7850.2	2203.1	6148856.5	110.1
4/13/01	11	427	7850.2	2206.2	6166172.9	110.4
4/28/01	15	442	7818.6	2191.1	6057572.4	108.5
5/14/01	16	458	7812.8	2189.0	6041481.5	108.2
6/11/01	27	485	7810.4	2187.9	6033557.2	108.0
6/26/01	15	500	7820.6	2187.3	6038123.6	108.1
7/7/01	11	511	7824.1	2188.9	6049666.8	108.3
7/21/01	14	525	7819.7	2193.0	6068936.2	108.7
8/18/01	28	553	7821.3	2196.2	6087906.0	109.0
9/8/01	21	574	7820.9	2199.5	6105902.8	109.3
9/28/01	20	594	7821.3	2200.9	6113990.8	109.5
10/14/01	16	610	7819.5	2205.0	6135378.9	109.9
10/28/01	14	624	7815.4	2208.2	6149973.4	110.1
11/10/01	13	637	7816.3	2208.1	6150124.6	110.1
12/9/01	29	666	7827.5	2207.6	6156148.2	110.2
12/29/01	20	686	7827.6	2210.3	6171294.8	110.5

Table B.49 Raw Data For Specimen 1, Control Mix #1, w/c = 0.55, Cycled in Water Tested Every Other Day

Casting Date: 5/5/02
Start Date: 5/20/02

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7810.6	2039.5	5242965.9	100.0
5/22/02	2	2	7709.5	2039.4	5174593.8	98.7
5/24/02	2	4	7689.1	2041.2	5170015.5	98.6
5/26/02	2	6	7677.1	2044.9	5180677.6	98.8
5/29/02	3	9	7790.8	2053.4	5301202.4	101.1
5/31/02	2	11	7798.0	2061.0	5345452.0	102.0
6/2/02	2	13	7802.5	2067.1	5380244.0	102.6
6/4/02	2	15	7808.4	2070.1	5399952.3	103.0
6/6/02	2	17	7739.0	2077.8	5391846.9	102.8
6/8/02	2	19	7716.6	2076.1	5367446.7	102.4
6/10/02	2	21	7700.8	2074.8	5349750.7	102.0
6/12/02	2	23	7788.7	2076.1	5417597.4	103.3
6/14/02	2	25	7801.0	2080.4	5448653.4	103.9
6/16/02	2	27	7806.1	2084.6	5474252.1	104.4
6/18/02	2	29	7738.3	2088.0	5444421.9	103.8
6/20/02	2	31	7714.6	2086.0	5417354.3	103.3
6/22/02	2	33	7700.0	2087.5	5414880.9	103.3
6/24/02	2	35	7786.1	2084.5	5459702.7	104.1
6/26/02	2	37	7792.0	2088.2	5483253.8	104.6
6/29/02	3	40	7805.8	2093.3	5519828.5	105.3
7/1/02	2	42	7750.4	2098.9	5510015.6	105.1
7/3/02	2	44	7728.7	2101.7	5509258.1	105.1
7/5/02	2	46	7711.7	2098.9	5482502.5	104.6
7/7/02	2	48	7757.6	2096.2	5500954.3	104.9
7/9/02	2	50	7799.0	2098.5	5542453.8	105.7
7/13/02	4	54	7804.5	2103.1	5570704.9	106.3
7/15/02	2	56	7761.7	2107.6	5563888.9	106.1
7/17/02	2	58	7730.1	2111.8	5563343.8	106.1
7/20/02	3	61	7707.0	2110.6	5540416.9	105.7
7/23/02	3	64	7781.8	2103.3	5555558.5	106.0
7/26/02	3	67	7801.2	2106.6	5586898.6	106.6
7/28/02	2	69	7805.0	2108.4	5599176.3	106.8

Table B.50 Raw Data For Specimen 2, Control Mix #1, w/c = 0.55, Cycled in Water Tested Every Other Day

Casting Date: 5/5/02
Start Date: 5/20/02

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7744.5	2026.5	5132533.8	100.0
5/22/02	2	2	7647.4	2032.5	5098238.3	99.3
5/24/02	2	4	7622.3	2029.6	5067014.7	98.7
5/26/02	2	6	7609.7	2033.8	5079596.8	99.0
5/29/02	3	9	7729.3	2043.2	5207234.6	101.5
5/31/02	2	11	7736.2	2050.5	5249191.9	102.3
6/2/02	2	13	7740.0	2055.8	5278954.3	102.9
6/4/02	2	15	7746.2	2058.2	5295525.6	103.2
6/6/02	2	17	7684.8	2064.5	5285761.5	103.0
6/8/02	2	19	7652.8	2063.3	5257633.9	102.4
6/10/02	2	21	7633.7	2059.9	5227241.7	101.8
6/12/02	2	23	7730.0	2063.3	5310671.9	103.5
6/14/02	2	25	7741.3	2062.2	5312765.9	103.5
6/16/02	2	27	7745.8	2073.4	5373752.8	104.7
6/18/02	2	29	7688.5	2076.8	5351508.1	104.3
6/20/02	2	31	7655.8	2075.3	5321052.8	103.7
6/22/02	2	33	7637.3	2075.2	5307683.1	103.4
6/24/02	2	35	7728.1	2073.4	5361473.2	104.5
6/26/02	2	37	7737.9	2078.0	5392118.4	105.1
6/29/02	3	40	7747.2	2083.0	5424610.1	105.7
7/1/02	2	42	7702.0	2090.2	5430307.5	105.8
7/3/02	2	44	7675.7	2093.3	5427829.0	105.8
7/5/02	2	46	7652.6	2088.3	5385673.3	104.9
7/7/02	2	48	7729.8	2085.7	5426466.9	105.7
7/9/02	2	50	7740.7	2088.2	5447153.8	106.1
7/13/02	4	54	7748.2	2092.3	5473863.3	106.7
7/15/02	2	56	7708.6	2096.6	5468294.4	106.5
7/17/02	2	58	7672.7	2097.9	5449579.6	106.2
7/20/02	3	61	7642.6	2100.7	5442700.3	106.0
7/23/02	3	64	7723.6	2092.9	5459614.1	106.4
7/26/02	3	67	7741.7	2096.4	5490727.1	107.0
7/28/02	2	69	7745.9	2098.1	5502619.4	107.2

Table B.51 Raw Data For Specimen 3, Control Mix #1, w/c = 0.55, Cycled in Water Tested Every Other Day

Casting Date: 5/5/02
Start Date: 5/20/02

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7712.6	2053.6	5249014.1	100.0
5/22/02	2	2	7614.9	2055.5	5192116.0	98.9
5/24/02	2	4	7588.7	2046.7	5130042.7	97.7
5/26/02	2	6	7575.9	2050.0	5137918.1	97.9
5/29/02	3	9	7698.0	2065.7	5300997.8	101.0
5/31/02	2	11	7704.6	2077.3	5365296.9	102.2
6/2/02	2	13	7709.1	2082.5	5395341.2	102.8
6/4/02	2	15	7715.9	2086.7	5421904.2	103.3
6/6/02	2	17	7644.2	2086.6	5371006.3	102.3
6/8/02	2	19	7610.3	2083.3	5330287.4	101.5
6/10/02	2	21	7595.2	2082.1	5313584.6	101.2
6/12/02	2	23	7698.4	2089.6	5424653.6	103.3
6/14/02	2	25	7710.9	2094.6	5459495.2	104.0
6/16/02	2	27	7715.7	2099.1	5486391.7	104.5
6/18/02	2	29	7652.3	2102.1	5456874.3	104.0
6/20/02	2	31	7621.5	2100.1	5424573.8	103.3
6/22/02	2	33	7604.6	2100.0	5412029.8	103.1
6/24/02	2	35	7698.4	2100.3	5480350.8	104.4
6/26/02	2	37	7709.9	2104.5	5510510.4	105.0
6/29/02	3	40	7717.9	2108.9	5539318.5	105.5
7/1/02	2	42	7663.1	2113.2	5522438.8	105.2
7/3/02	2	44	7632.2	2118.6	5528316.5	105.3
7/5/02	2	46	7611.4	2113.4	5486219.4	104.5
7/7/02	2	48	7699.9	2112.0	5542658.6	105.6
7/9/02	2	50	7711.1	2114.1	5561764.6	106.0
7/13/02	4	54	7719.9	2116.5	5580761.2	106.3
7/15/02	2	56	7674.4	2123.6	5585153.1	106.4
7/17/02	2	58	7630.6	2125.4	5562695.1	106.0
7/20/02	3	61	7605.5	2124.0	5537095.5	105.5
7/23/02	3	64	7696.9	2115.1	5556775.8	105.9
7/26/02	3	67	7714.6	2119.5	5592750.9	106.5
7/28/02	2	69	7718.2	2124.3	5620732.9	107.1

Table B.52 Raw Data For Specimen 1, Control Mix #2, w/c = 0.55, Cycled in Solution Tested Every Other Day

Casting Date: 5/5/02
Start Date: 5/20/02

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7857.2	2058.2	5371408	100.0
5/22/02	2	2	7772.1	2067.1	5359282	99.8
5/24/02	2	4	7746.3	2071.8	5365809	99.9
5/26/02	2	6	7733.3	2073.4	5365081	99.9
5/29/02	3	9	7829.5	2077.3	5452274	101.5
5/31/02	2	11	7831.6	2085	5494243	102.3
6/2/02	2	13	7832.7	2091.5	5529329	102.9
6/4/02	2	15	7835	2096.5	5557429	103.5
6/6/02	2	17	7792.8	2105.4	5574527	103.8
6/8/02	2	19	7774.3	2113.8	5605757	104.4
6/10/02	2	21	7763.4	2117.3	5616451	104.6
6/12/02	2	23	7809.9	2103.4	5576150	103.8
6/14/02	2	25	7818.2	2105.5	5593228	104.1
6/16/02	2	27	7821.8	2108.5	5611761	104.5
6/18/02	2	29	7793.4	2119.4	5649344	105.2
6/20/02	2	31	7780.4	2124.5	5667097	105.5
6/22/02	2	33	7771.8	2129.6	5688044	105.9
6/24/02	2	35	7807.4	2118.5	5654687	105.3
6/26/02	2	37	7813.2	2118.2	5657285	105.3
6/29/02	3	40	7818.6	2117.7	5658523	105.3
7/1/02	2	42	7787.5	2129.5	5698999	106.1
7/3/02	2	44	7777.8	2136.6	5729918	106.7
7/5/02	2	46	7769.2	2139.2	5737521	106.8
7/7/02	2	48	7802.6	2127.1	5697186	106.1
7/9/02	2	50	7808.9	2126.2	5696962	106.1
7/13/02	4	54	7814.7	2128.5	5713534	106.4
7/15/02	2	56	7797	2133.7	5728481	106.6
7/17/02	2	58	7776.7	2142.6	5761330	107.3
7/20/02	3	61	7764	2148.2	5782028	107.6
7/23/02	3	64	7795.5	2134.9	5733823	106.7
7/26/02	3	67	7807.6	2134.8	5742185	106.9
7/28/02	2	69	7809.6	2135.4	5746885	107.0

Table B.53 Raw Data For Specimen 2, Control Mix #2, w/c = 0.55, Cycled in Solution Tested Every Other Day

Casting Date: 5/5/02
Start Date: 5/20/02

Date	Days	Total Days	Weight	Transverse Freq	E	Rel E
initial	0	0	7876.5	2042.3	5301730	100.0
5/22/02	2	2	7775.8	2049.9	5272974	99.5
5/24/02	2	4	7751.7	2044.1	5226927	98.6
5/26/02	2	6	7738	2047.7	5236084	98.8
5/29/02	3	9	7852.8	2060.9	5382494	101.5
5/31/02	2	11	7855.5	2068.3	5423081	102.3
6/2/02	2	13	7856.3	2080.1	5485696	103.5
6/4/02	2	15	7859.1	2084.7	5511949	104.0
6/6/02	2	17	7812.3	2092.9	5522314	104.2
6/8/02	2	19	7790.1	2096	5522946	104.2
6/10/02	2	21	7778.7	2099.7	5534351	104.4
6/12/02	2	23	7831.8	2093.1	5537156	104.4
6/14/02	2	25	7840.1	2095.7	5556804	104.8
6/16/02	2	27	7844.3	2098.4	5574116	105.1
6/18/02	2	29	7811.7	2106.7	5594949	105.5
6/20/02	2	31	7797.2	2112.7	5616420	105.9
6/22/02	2	33	7789.2	2116	5628198	106.2
6/24/02	2	35	7828.2	2105.7	5601446	105.7
6/26/02	2	37	7834.7	2104.3	5598645	105.6
6/29/02	3	40	7840.4	2108.1	5622971	106.1
7/1/02	2	42	7813.8	2115.8	5644906	106.5
7/3/02	2	44	7799	2122.5	5669954	106.9
7/5/02	2	46	7788.9	2124.9	5675424	107.0
7/7/02	2	48	7827.8	2114.9	5650210	106.6
7/9/02	2	50	7833.8	2115.6	5658285	106.7
7/13/02	4	54	7839.4	2117.1	5670362	107.0

Table B.54 Raw Data For Specimen 3, Control Mix #2, w/c = 0.55, Cycled in Solution, Tested Every Other Day

Casting Date: 5/5/02
Start Date: 5/20/02

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7772.4	2052.6	5284562.2	100.0
5/22/02	2	2	7673.5	2058.8	5248884.7	99.3
5/24/02	2	4	7650.8	2055.9	5218370.6	98.7
5/26/02	2	6	7638.6	2061.3	5237709.3	99.1
5/29/02	3	9	7750.5	2069.4	5356286.9	101.4
5/31/02	2	11	7754.0	2079.3	5410100.4	102.4
6/2/02	2	13	7754.7	2086.1	5446035.5	103.1
6/4/02	2	15	7757.4	2091.7	5477220.1	103.6
6/6/02	2	17	7706.9	2099.6	5482745.3	103.8
6/8/02	2	19	7686.3	2104.2	5492076.5	103.9
6/10/02	2	21	7675.9	2107.0	5499251.7	104.1
6/12/02	2	23	7730.9	2099.7	5500343.0	104.1
6/14/02	2	25	7739.6	2102.6	5521754.0	104.5
6/16/02	2	27	7743.7	2102.8	5525730.2	104.6
6/18/02	2	29	7706.9	2112.9	5552426.6	105.1
6/20/02	2	31	7684.5	2122.0	5584079.5	105.7
6/22/02	2	33	7685.8	2123.8	5594503.2	105.9
6/24/02	2	35	7727.5	2109.4	5548838.9	105.0
6/26/02	2	37	7734.2	2111.7	5565767.4	105.3
6/29/02	3	40	7740.0	2110.2	5562031.1	105.3
7/1/02	2	42	7713.3	2120.9	5599198.0	106.0
7/3/02	2	44	7699.4	2128.9	5631351.4	106.6
7/5/02	2	46	7690.5	2132.6	5644410.7	106.8
7/7/02	2	48	7729.1	2127.9	5647764.4	106.9
7/9/02	2	50	7734.8	2123.5	5628579.9	106.5
7/13/02	4	54	7740.8	2125.7	5644623.9	106.8
7/15/02	2	56	7703.9	2134.4	5663794.4	107.2
7/17/02	2	58	7691.4	2139.6	5682190.6	107.5
7/20/02	3	61	7680.4	2142.0	5686800.5	107.6
7/23/02	3	64	7718.4	2129.8	5650022.1	106.9
7/26/02	3	67	7730.6	2130.8	5664268.0	107.2
7/28/02	2	69	7733.1	2131.1	5667695.4	107.3

Table B.55 Raw Data For Specimen 1, Control Mix #3, w/c = 0.55, Cured in Water for 14 Days Then Dried Continuously, Tested Weekly

Casting Date: 5/5/02
Start Date: 5/20/02

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7811.0	2064.6	5373084.9	100.0
5/20/02	1 hr		7801.5	2071.9	5404567.1	100.6
5/20/02	2 hr		7790.5	2069.3	5383410.1	100.2
5/20/02	3 hr		7786.1	2070.6	5387132.0	100.3
5/20/02	4 hr		7779.8	2069.6	5377575.1	100.1
5/20/02	5 hr		7775.7	2071.5	5384614.2	100.2
5/20/02	6 hr		7772.1	2070.1	5374848.8	100.0
5/20/02	7 hr		7768.0	2072.5	5384476.8	100.2
5/20/02	15 hr		7751.9	2067.2	5345869.7	99.5
5/21/02	24 hr		7734.9	2067.6	5336210.7	99.3
5/21/02	32 hr		7722.4	2067.5	5327071.8	99.1
5/21/02	40 hr		7717.1	2064.2	5306435.5	98.8
5/26/02	6	6	7668.8	2076.4	5335740.1	99.3
6/2/02	7	13	7634.2	2074.8	5303483.6	98.7
6/8/02	6	19	7621.6	2076.2	5301878.2	98.7
6/16/02	8	27	7606.2	2078.0	5300343.9	98.6
6/22/02	6	33	7601.2	2076.9	5291253.3	98.5
6/29/02	7	40	7590.2	2075.5	5276475.3	98.2
7/7/02	8	48	7583.9	2073.5	5261940.0	97.9
7/13/02	6	54	7578.1	2075.0	5265525.9	98.0
7/20/02	7	61	7572.1	2070.7	5239573.4	97.5
7/28/02	8	69	7566.5	2073.1	5247842.1	97.7

Table B.56 Raw Data For Specimen 2, Control Mix #3, w/c = 0.55, Cured in Water for 14 Days Then Dried Continuously, Tested Weekly

Casting Date: 5/5/02
Start Date: 5/20/02

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7827.6	2086.1	5497232.3	100.0
5/20/02	1 hr		7820.3	2087.2	5497899.1	100.0
5/20/02	2 hr		7813.4	2089.3	5504107.2	100.1
5/20/02	3 hr		7808.3	2088.9	5498408.6	100.0
5/20/02	4 hr		7802.9	2089.1	5495658.2	100.0
5/20/02	5 hr		7797.7	2088.4	5488316.0	99.8
5/20/02	6 hr		7795.4	2088.1	5485121.0	99.8
5/20/02	7 hr		7790.6	2088.1	5481743.5	99.7
5/20/02	15 hr		7775.7	2088.1	5471259.3	99.5
5/21/02	24 hr		7758.4	2088.4	5460655.2	99.3
5/21/02	32 hr		7745.5	2085.4	5435924.5	98.9
5/21/02	40 hr		7740.3	2083.4	5421860.4	98.6
5/26/02		6	7694.1	2088.0	5413324.1	98.5
6/2/02	7	13	7681.1	2090.6	5417644.8	98.6
6/8/02	6	19	7646.3	2089.1	5385363.3	98.0
6/16/02	8	27	7635.0	2092.1	5392859.9	98.1
6/22/02	6	33	7631.0	2092.9	5394157.6	98.1
6/29/02	7	40	7619.3	2090.4	5373027.8	97.7
7/7/02	8	48	7611.8	2088.0	5355420.5	97.4
7/13/02	6	54	7606.3	2091.4	5368993.5	97.7
7/20/02	7	61	7602.3	2090.5	5361552.5	97.5
7/28/02	8	69	7595.8	2089.6	5352356.8	97.4

Table B.57 Raw Data For Specimen 3, Control Mix #3, w/c = 0.55, Cured in Water for 14 Days Then Dried Continuously, Tested Weekly

Casting Date: 5/5/02
Start Date: 5/20/02

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7840.2	2090.3	5528274.5	100.0
5/20/02	1 hr		7832.1	2090.6	5524148.4	99.9
5/20/02	2 hr		7825.3	2091.3	5523048.9	99.9
5/20/02	3 hr		7820.7	2091.8	5522442.0	99.9
5/20/02	4 hr		7815.7	2091.6	5517856.0	99.8
5/20/02	5 hr		7811.1	2091.5	5514081.2	99.7
5/20/02	6 hr		7808.2	2091.4	5511506.9	99.7
5/20/02	7 hr		7804.2	2091.9	5511317.7	99.7
5/20/02	15 hr		7787.5	2089.8	5488488.1	99.3
5/21/02	24 hr		7773.3	2088.5	5471666.3	99.0
5/21/02	32 hr		7761.4	2085.4	5447083.4	98.5
5/21/02	40 hr		7756.7	2085.8	5445873.4	98.5
5/26/02	6	6	7710.9	2089.4	5432421.6	98.3
6/2/02	7	13	7679.8	2094.7	5437994.9	98.4
6/8/02	6	19	7671.5	2098.2	5450285.8	98.6
6/16/02	8	27	7658.3	2100.9	5454919.6	98.7
6/22/02	6	33	7654.6	2102.3	5459553.2	98.8
6/29/02	7	40	7642.4	2099.8	5437895.3	98.4
7/7/02	8	48	7633.6	2100.5	5435255.8	98.3
7/13/02	6	54	7628.3	2101.0	5434068.2	98.3
7/20/02	7	61	7622.2	2099.6	5422489.1	98.1
7/28/02	8	69	7617.1	2098.6	5413700.3	97.9

Table B.58 Raw Data For Specimen 1, Control Mix #4, w/c = 0.55, Cured in Air, Tested Weekly

Casting Date: 5/26/02
Start Date: 6/2/02

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7456.2	1884.1	4271404.2	100.0
6/8/02	6	6	7433.1	1882.3	4250038.6	99.5
6/16/02	8	14	7420.1	1888.8	4271957.5	100.0
6/22/02	6	20	7420	1892.7	4289559.4	100.4
6/29/02	7	27	7410.6	1894.7	4293184.0	100.5
7/7/02	8	35	7405.1	1900.6	4316756.9	101.1
7/13/02	6	41	7402	1900.9	4316312.1	101.1
7/20/02	7	48	7400.3	1904.4	4331226.4	101.4
7/28/02	8	56	7396	1896.8	4294229.0	100.5
8/5/02	8	64	7393.1	1895.8	4288020.3	100.4

Table B.59 Raw Data For Specimen 2, Control Mix #4, w/c = 0.55, Cured in Air, Tested Weekly

Casting Date: 5/26/02
Start Date: 6/2/02

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7454.8	1868.8	4201524.2	100.0
6/8/02	6	6	7429.1	1886.1	4264919.6	101.5
6/16/02	8	14	7415.0	1898.3	4312072.6	102.6
6/22/02	6	20	7412.8	1898.7	4312610.2	102.6
6/29/02	7	27	7403.1	1899.8	4311958.8	102.6
7/7/02	8	35	7396.6	1909.0	4349999.5	103.5
7/13/02	6	41	7393.2	1907.9	4342990.6	103.4
7/20/02	7	48	7389.9	1911.9	4359273.6	103.8
7/28/02	8	56	7385.8	1910.1	4348655.2	103.5
8/5/02	8	64	7382.6	1908.8	4340856.3	103.3

Table B.60 Raw Data For Specimen 3, Control Mix #4, w/c = 0.55, Cured in Air, Tested Weekly

Casting Date: 5/26/02
Start Date: 6/2/02

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7394.4	1835.2	4018971.8	100.0
6/8/02	6	6	7372.3	1844.7	4048551.9	100.7
6/16/02	8	14	7360.0	1858.4	4102054.5	102.1
6/22/02	6	20	7357.2	1859.3	4104466.5	102.1
6/29/02	7	27	7349.0	1861.9	4111366.3	102.3
7/7/02	8	35	7343.2	1869.0	4139512.3	103.0
7/13/02	6	41	7339.9	1873.5	4157600.5	103.4
7/20/02	7	48	7334.8	1872.2	4148947.9	103.2
7/28/02	8	56	7332.9	1867.4	4126631.5	102.7
8/5/02	8	64	7330.6	1867.5	4125779.0	102.7

Table B.61 Raw Data For Specimen 1, Control Mix #5, w/c = 0.55, Cured in Water, Tested Weekly

Casting Date: 1/19/03
Start Date: 1/26/03

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7727.3	1950.4	4743734.4	100.0
2/4/03	9	6	7742.5	2021.4	5105413.9	107.6
2/11/03	7	13	7746.8	2038.6	5195550.9	109.5
2/18/03	7	20	7748.0	2050.5	5257198.5	110.8
2/25/03	7	27	7749.4	2054.0	5276114.1	111.2
3/4/03	7	34	7750.5	2065.7	5337150.4	112.5
3/11/03	7	41	7753.0	2074.6	5384975.7	113.5
3/18/03	7	48	7753.8	2075.6	5390724.5	113.6
3/26/03	8	56	7755.2	2081.6	5422914.8	114.3
4/1/03	6	62	7756.5	2081.9	5425387.3	114.4
4/9/03	8	70	7756.6	2087.1	5452593.6	114.9
4/16/03	7	77	7757.3	2087.7	5456221.4	115.0

Table B.62 Raw Data For Specimen 2, Control Mix #5, w/c = 0.55, Cured in Water, Tested Weekly

Casting Date: 1/19/03
Start Date: 1/26/03

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7680.1	1969.3	4806576.5	100.0
2/4/03	9	6	7694.0	2031.1	5122241.1	106.6
2/11/03	7	13	7698.0	2052.2	5231936.8	108.8
2/18/03	7	20	7699.5	2062.1	5283566.6	109.9
2/25/03	7	27	7701.5	2068.2	5316252.6	110.6
3/4/03	7	34	7702.9	2080.0	5378066.2	111.9
3/11/03	7	41	7703.8	2085.1	5405103.2	112.5
3/18/03	7	48	7704.5	2088.6	5423757.0	112.8
3/26/03	8	56	7705.3	2094.1	5452926.0	113.4
4/1/03	6	62	7706.2	2096.6	5466591.9	113.7
4/9/03	8	70	7707.2	2100.6	5488182.8	114.2
4/16/03	7	77	7707.0	2102.8	5499541.9	114.4

Table B.63 Raw Data For Specimen 3, Control Mix #5, w/c = 0.55, Cured in Water, Tested Weekly

Casting Date: 1/19/03
Start Date: 1/26/03

Date	Days	Total Days	Mass (g)	Transverse Freq (Hz)	E (psi)	Rel E
initial	0	0	7718.8	1978.7	4877024.2	100.0
2/4/03	9	6	7734.4	2045.6	5222918.8	107.1
2/11/03	7	13	7739.6	2061.0	5305419.4	108.8
2/18/03	7	20	7741.0	2078.5	5396874.8	110.7
2/25/03	7	27	7743.1	2087.6	5445711.9	111.7
3/4/03	7	34	7745.6	2098.5	5504504.5	112.9
3/11/03	7	41	7746.4	2099.8	5511895.8	113.0
3/18/03	7	48	7748.2	2101.9	5524209.5	113.3
3/26/03	8	56	7749.3	2109.3	5563965.1	114.1
4/1/03	6	62	7749.6	2112.0	5578434.4	114.4
4/9/03	8	70	7749.8	2117.6	5608201.0	115.0
4/16/03	7	77	7751.1	2118.4	5613380.7	115.1

APPENDIX C

Strength Test Data

Table C.1 Raw Data For Compressive Strength Tests

Compressive Strength Results												
	Initial				Start of Cycling				End of Cycling			
W/C Ratio	14-Day		28-Day		14-Day		28-Day		14-Day		28-Day	
	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi	MPa	psi
0.4	54.6	7931.5	54.5	7903.2	75.4	10937.9	76.8	11144.2	80.6	11698.1	57.7	8370.3
	55.5	8052.1	52.9	7672.3	71.7	10411.7	77.9	11301.8	85.3	12384.6	70.8	10269.8
	52.6	7632.2	56.5	8197.1	79.1	11474.0	80.5	11686.8	84.9	12327.4	76.5	11102.6
0.45	49.9	7241.4	45.9	6654.7	75.8	10997.4	66.4	9635.8	78.7	11428.2	64.5	9361.1
	49.8	7223.1	48.7	7065.7	74.9	10870.3	62.3	9047.2	76.3	11070.0	61.6	8938.1
	48.5	7040.2	50.3	7299.9	77.1	11189.6	65.9	9557.9	78.0	11319.2	66.2	9602.6
0.5	43.4	6295.5	54.2	7873.2	64.8	9410.0	67.5	9799.5	62.8	9111.6	76.6	11120.9
	43.4	6303.4	54.3	7885.1	65.2	9469.7	58.7	8526.3	58.1	8435.2	78.3	11359.7
	43.0	6241.6	54.0	7838.9	61.7	8952.4	68.1	9883.9	59.6	8654.0	77.2	11200.5
0.55	42.8	6206.2	41.1	5966.6	58.1	8432.4	56.2	8156.4	68.5	9947.2	56.3	8174.2
	42.6	6187.6	42.3	6142.8	58.1	8432.8	59.1	8579.8	66.5	9648.7	55.7	8079.9
	41.5	6026.9	42.9	6224.7	48.0	6965.8	59.6	8647.8	67.4	9788.0	54.0	7835.2

Table C.2 Raw Data For Modulus of Rupture Tests 14-Day Specimens

	Age								
	14 Days			Start of Cycling			End of Cycling		
W/C Ratio	MPa	psi	$R/(f'_c)^{.5}$	MPa	psi	$R/(f'_c)^{.5}$	MPa	psi	$R/(f'_c)^{.5}$
0.4	5.9	856.3	11.1	8.6	1250	16.1	8	1162.5	15.0
	5.8	837.5	10.8	8.2	1193.8	15.4	8.6	1243.8	16.1
	5.9	850	11.0	8.8	1275	16.5	7.6	1100	14.2
0.45	5.9	856.3	11.7	7.8	1125	15.4	7.2	1050	14.4
	5.3	762.5	10.4	8.4	1225	16.8	8.1	1168.8	16.0
	4.5	656.3	9.0	8.8	1275	17.5	7.7	1118.8	15.3
0.5	5.4	787.5	11.4	8.2	1193.8	17.3	7.5	1081.3	15.6
	4.8	700	10.1	7.1	1037.5	15.0	8.1	1168.8	16.9
	6	875	12.7	8.4	1218.8	17.6	8.5	1237.5	17.9
0.55	4.1	593.8	9.1	8.2	1187.5	18.3	7.8	1137.5	17.5
	5.8	837.5	12.9	6.1	881.3	13.6	8.4	1218.8	18.8
	5.4	787.5	12.1	8.1	1175	18.1	7.9	1150	17.7

Table C.3 Raw Data For Modulus of Rupture Tests 28-Day Specimens

	Age								
	14 Days			Start of Cycling			End of Cycling		
W/C Ratio	MPa	psi	$R/(f'_c)^{.5}$	MPa	psi	$R/(f'_c)^{.5}$	MPa	psi	$R/(f'_c)^{.5}$
0.4	6.5	950	12.3	8.1	1181.3	15.3	8.4	1212.5	15.7
	6	868.8	11.2	8.5	1231.3	15.9	8.4	1218.8	15.7
	7.8	1131.3	14.6	7.8	1137.5	14.7	7.9	1143.8	14.8
0.45	6.3	918.8	12.6	7.7	1118.8	15.3	7.2	1043.8	14.3
	5.9	862.5	11.8	8.1	1175	16.1	7.3	1056.3	14.5
	6	868.8	11.9	7.3	1056.3	14.5	7.4	1075	14.7
0.5	5.3	775	11.2	8.4	1212.5	17.5	9.3	1350	19.5
	6.2	893.8	12.9	8.9	1293.8	18.7	9.6	1387.5	20.1
	5.6	818.8	11.9	8.5	1237.5	17.9	9.5	1381.3	20.0
0.55	5.6	806.3	12.4	7.9	1143.8	17.6	6.7	975	15.0
	5.9	862.5	13.3	6.5	943.8	14.5	7.5	1093.8	16.8
	5.6	818.8	12.6	7.7	1118.8	17.2	7.2	1050	16.2