Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration

by

Amy E. Eskridge, BCE

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Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration

Approved by
Supervising Committee:

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Richard Klingner, Supervisor

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Michael Kreger, Supervisor

Dedication

To Mom and Dad, for encouraging me to pursue graduate school.

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Abstract

Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration

Amy E. Eskridge, MSE

The University of Texas at Austin, 2002

Supervisors: Richard Klingner and Michael Kreger

This thesis describes part of the work associated with Texas Department of Transportation Study 4069 ("Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration"). The Texas Department of Transportation is interested in developing techniques for mitigating or remediating premature concrete deterioration due to alkali silica reaction (ASR), delayed ettringite formation (DEF), or both, in order to extend the life of potentially affected structures. The parts of Study 4069 reported here consist of: a literature search for mitigation or remediation techniques; fabrication of concrete specimens intentionally susceptible to premature deterioration; and the application and monitoring of the mitigation techniques using laboratory testing and acoustic emission (AE) procedures. Specimens were exposed to three series of environmental conditions: an indoor series; an outdoor series; and a wet/dry series. Expansion and internal relative humidity were measured to determine the efficacy of the mitigation techniques at reducing expansion from premature concrete deterioration. Based on the test results, recommendations are made for choosing mitigation treatments now, and for additional research.

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CHAPTER 1
Introduction

1.1 BACKGROUND OF TXDOT STUDY 4069

In 1995, the Texas Department of Transportation (TxDOT) began identifying in-service structures with premature concrete deterioration. Damage was found across the state to prestressed beams, abutments, columns and bents, often requiring repair of the structure or removal from service after only several years. The damage was manifested as external and internal cracking, and as "map cracking." The mechanisms of damage were identified as Alkali-Silica Reaction (ASR), Delayed Ettringite Formation (DEF), or both (Boenig 2000). Consequences of ASR/DEF damage are progressive loss of member function and increased susceptibility to corrosion and other forms of environmental attack[1].

TxDOT Study 1857 ("Structural Assessment of In-Service Bridges with Premature Concrete Deterioration") was conducted to develop methods to predict the capacity of damaged structural elements. Field observations and laboratory tests were used to develop damage indices and finite element models and nondestructive testing methods for identifying deterioration in the field (Boenig 2000).

TxDOT Study 4069 ("Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration") is a follow-up to Study 1857. TxDOT is interested in developing techniques for mitigating or remediating premature concrete deterioration due to ASR, DEF, or both, in order to extend the life of potentially affected structures.

1.2 SCOPE AND OBJECTIVES OF STUDY 4069[2]

TxDOT Study 4069 is divided into six tasks:

1) Conduct an extensive literature search to identify treatments being used or tested worldwide to mitigate or remediate deterioration from ASR, DEF, or both. Compile the results as a bibliography and report of various mitigation or remediation techniques. Evaluate the published results and select the mitigation or remediation techniques to be used in Tasks 2 and 3.
2) Fabricate a large number of concrete specimens with a combination of aggregates and cement with a high susceptibility to ASR, DEF, or both. Induce premature deterioration by exposing the specimens to cycles of wetting and drying and to heat.
3) Use non-destructive evaluation (NDE) procedures and physical testing to evaluate the effectiveness of the mitigation or remediation techniques chosen in Task 1 on the concrete specimens with premature deterioration.
4) Prepare a report on the results of Tasks 2 and 3, with a recommendation for mitigation or remediation techniques to be evaluated in the field.
5) After acceptance by TxDOT of the proposal from Task 4, apply the recommended techniques to field structures with documented ASR/DEF deterioration. The effectiveness of the treatments will be evaluated with the NDE procedures developed in Study 1857 and used in Task 3.
6) Prepare a comprehensive report summarizing the results of the entire project.

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[1] Klingner, R.E., T.J. Fowler, and M.E. Kreger, "Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration," proposal to Texas Department of Transportation, 2000.

1.3 SCOPE OF THESIS

The parts of Study 4069 reported here cover Tasks 1 through 4. The work consisted of: a literature search for mitigation or remediation techniques for premature concrete deterioration; fabrication of concrete prisms with deterioration; and application and monitoring of the mitigation techniques using laboratory testing and NDE procedures.

1.3.1 Literature Review

A literature search was conducted to identify treatments being used or tested worldwide to mitigate or remediate deterioration from ASR, DEF, or both. The initial focus of this literature search was treatments specific to the mitigation or remediation of ASR, DEF, or both. The next step in this literature search was to examine the known causes of ASR/DEF, and to investigate actions that have shown some success in addressing those causes. The second focus of the search was treatments specific to the mitigation or remediation of other forms of concrete deterioration, such as sulfate attack, chloride ingress, and carbonation. The fundamental mechanisms of these forms of deterioration were studied, and literature was gathered on available methods of mitigation and remediation for them, including coatings, membranes, sealers, and electrochemical processes.

1.3.2 Specimen Fabrication

A large number of concrete prisms were fabricated with a combination of aggregates and cement with a high susceptibility to ASR, DEF, or both. The reactivity of the fine aggregate and cement was evaluated as part of TxDOT Study

[2] Klingner, R.E., T.J. Fowler, and M.E. Kreger, "Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration," proposal to Texas Department of Transportation, 2000.

4085 (“Preventing Premature Concrete Deterioration due to ASR/DEF in New Concrete”). The specimens were subject to three exposure conditions to promote premature deterioration: accelerated indoor ASTM C 1293, outdoor, and wet/dry. Each set of specimens was then coated with one or a combination of the selected mitigation treatments.

1.3.3 Expansion and Internal Moisture Monitoring

The length change of the prisms was measured at intervals according to the procedure of ASTM C 1293 to determine if expansion was occurring due to ASR/DEF. The internal moisture was measured at the same intervals to determine the vapor permeability of the treatments.

1.3.4 Acoustic Emission Monitoring

The NDE procedure of acoustic emission (AE) monitoring advanced in Study 1857 was used to quantify the internal cracking due to ASR/DEF deterioration. Monitoring was conducted at intervals reflecting those of the expansion testing, to follow the progression of cracking over time.

1.4 Objectives of Thesis

The results of expansion and internal moisture testing and the AE monitoring will be used to determine which treatments were most effective at mitigating or remediating premature deterioration from ASR/DEF for different exposure conditions representing field exposure.

CHAPTER 2

Literature Search

2.1 INTRODUCTION

2.1.1 Objectives

This literature search was conducted to identify treatments being used or tested worldwide to mitigate or remediate deterioration from alkali-silica reaction (ASR), delayed ettringite formation (DEF), or both. The proposed treatments are evaluated, according to published results, for use on Texas Department of Transportation structures displaying this damage. In addition, treatments used to mitigate other types of concrete deterioration are explored for their potential benefit against ASR/DEF deterioration.

2.1.2 How this Literature Search was Conducted

The initial focus of this literature search was treatments specific to the mitigation or remediation of ASR, DEF, or both. In this report, "mitigation" refers to actions that reduce the rate at which deterioration occurs, while "remediation" refers to actions that completely arrest deterioration and restore all or part of the structure's original strength, durability, and appearance. The ideal literature would describe the effects and efficacy of different treatments in mitigating or remediating ASR/DEF deterioration. Studies on treatment of ASR, though, are not extensive, and literature on treatment of DEF is very limited. The next step in this literature search, therefore, was to examine the known causes of ASR/DEF, and to investigate actions that have shown some success in addressing those causes.

The second focus of the search was treatments specific to the mitigation or remediation of other forms of concrete deterioration, such as sulfate attack, chloride ingress, and carbonation. The fundamental mechanisms of these forms of deterioration were studied, and literature was gathered on available methods of mitigation and remediation for them, including coatings, membranes, sealers, and electrochemical processes.

2.2 METHODS FOR MITIGATING OR REMEDIATING ASR

2.2.1 Causes of ASR[1]

ASR is a reaction between siliceous aggregate and high-alkali pore water in the surrounding cementitious matrix. A high alkali concentration in the pore water provides the hydroxyl ions that react with the silica to form a gel at the cementitious matrix and aggregate interface. This gel grows as it absorbs water from the environment, consequently generating expansive forces that can produce map cracking or surface pop-outs.

ASR deterioration requires the following conditions:

- high alkali concentration in the pore water;
- aggregate with reactive silica; and
- water.

[1]Klingner, R.E., T.J. Fowler, and M.E. Kreger, "Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration," proposal to Texas Department of Transportation, 2000.

2.2.2 The Goal of Mitigation or Remediation Methods for ASR

The goal for treating existing ASR-affected structures is to prevent water infiltration, one prerequisite for the reaction. At the same time, the treatment should permit the escape of water already in the structure, so that it does not continue to promote the reaction. Accordingly, the treatment, whether a penetrating coating or an encapsulation, must be impermeable to liquid water and permeable to water vapor.

2.2.3 Published Information on Mitigation or Remediation of ASR

2.2.3.1 ASR Mitigation Reference No. 1 (Abe et al. 1992)

This article addresses the comparative effectiveness of two coatings, one impermeable to water and the other permeable to water vapor, in reducing ASR-related expansion. The impermeable coating consisted of three layers of epoxy. The vapor-permeable coating consisted of silane followed by a flexible polymer-modified cement mortar (PCM). The control specimens were uncoated.

All specimens were placed outside for two years. Specimens with the vapor-permeable coating showed continuous negative expansion, whereas after six months the specimens with the impermeable coating had much greater expansion than the uncoated specimens. The investigators attribute this high expansion to the excess initial pore water that could not escape through the impermeable epoxy coating.

2.2.3.2 ASR Mitigation Reference No. 2 (Kamimoto et al. 1992)

The study described in this article measured the performance of several concentrations of a PCM using the criteria of water permeability, water-vapor permeability, elongation, adhesion, and expansion of a concrete specimen in the field. Water permeability and water-vapor permeability decreased with increasing polymer ratio, with the lowest permeability corresponding to the greatest tested polymer ratio, 0.75. Elongation of the PCM increased as the polymer ratio increased. Adhesion was greatest for a polymer ratio of 0.525.

For the field expansion tests, small, rectangular specimens were coated with either PCM or epoxy, while other specimens were left uncoated. Expansion was measured by change in length, and vapor permeability was measured by change in weight. The PCM-coated specimens had consistently low expansion, while the uncoated and epoxy-coated specimens had much higher overall expansion and greater rates of expansion. As the water-vapor permeability of the PCM increased, the specimens' expansion decreased.

2.2.3.3 ASR Mitigation Reference No. 3 (Fujii et al. 1989)

The specimens in this study were subject to outdoor conditions and cycles of wetting and drying, considered the most severe environmental conditions for Japan. The coatings were applied to newly constructed specimens when their moisture content had reduced to 10%. In the outdoor series, silane- and urethane-coated specimens had expansion equivalent to that of a non-reactive specimen, actually showing negative expansion. Epoxy-coated and methyl-methacrylate-coated specimens expanded severely and the coatings cracked. Sodium silicate-coated specimens showed expansion equivalent to that of the uncoated reactive specimens. All specimens had very high expansion under cycles of wetting and drying.

Expansion was found to be related to ratios of surface area to volume and treated surface area to total surface area. As those ratios increase, expansion decreases. It was concluded that structures with large ratios of surface area to volume would especially benefit from surface treatment.

The final series of tests was a comparison of the performance of silane, silane with a PCM cover, and silane with a methyl-methacrylate cover under cycles of wetting and drying. Silane/PCM-coated specimens had four times the expansion of specimens with the other two coatings after 32 weeks of exposure, but still less than all specimens from the first series of tests.

2.2.3.4 ASR Mitigation Reference No. 4 (Stokes 2000)

In this article the use of a lithium-based solution to treat ASR was described. Tests were conducted to compare the penetration ability of various lithium solutions, to assess the efficacy of the best solution, and to study how the timing of the treatment influenced this efficacy.

Penetration ability was assessed by placing various lithium salt solutions at several concentrations in cavities in cylinders, and then recording the volume of solution entering the cylinder. The greatest penetration was achieved with a 30% lithium nitrate solution with a blend of surfactants, surpassing the penetration of lithium hydroxide, formate, and acetate.

Reactive mortar bars and concrete prisms were then used to study efficacy and application timing. In reactive mortar bars, one-half the amount of lithium required as an admixture to control ASR reduced expansion to as little as 55% of that of uncoated control specimens. Also, lithium nitrate reduced expansion twice as much as lithium hydroxide. The lithium nitrate was used on concrete prisms, applied in one and five coats. The one-coat specimens exhibited 0.1% expansion and the 5-coat specimens exhibited 0.05% expansion. The investigators concluded from the timing tests on both mortar bars and concrete prisms that some prior expansion aided penetration, and thus effectiveness, by inducing cracking. Existing cracks provided a path for the coating to penetrate.

2.2.3.5 ASR Mitigation Reference No. 5 (Whitmore et al. 2000)

Electrochemical chloride extraction, used to drive chloride ions out of salt-contaminated structures, can easily be adapted to drive lithium ions into a structure. The potential benefits are shortened treatment time and an increase in the effective amount of lithium in the structure.

The anode for the process is a titanium-coated metallic mesh, the same as is often used for cathodic protection and chloride extraction. Reinforcement in the structure is the cathode. The impressed current comes from AC/DC rectifiers, which convert high-voltage AC to low-voltage DC. Lithium solutions supply the lithium ions and act as the electrolyte providing electrical continuity between the anode and cathode. An electric field is created between the mesh and reinforcement. Lithium, being a positive ion, is driven away from the mesh and toward the reinforcement, and is thus distributed in the concrete.

Field application to bridge decks in Virginia and Delaware, carried out by the investigating companies, showed rapid migration of the ion into the concrete in the first week of treatment. Each treatment period lasted eight weeks. No samples were taken to determine the total lithium content at the end of treatment.

2.2.3.6 ASR Mitigation Reference No. 6 (Baillemont et al. 2000)

This article describes the diagnosis, treatment and monitoring of an ASR-affected bridge in northeastern France. Considerable map cracking was found on all the piles and one deck. Measurements on several cracks from 1982 through 1995 indicated continuing opening.

A treatment of silane followed by a thin polymer-cement coating was applied to the piles and deck. This combination was chosen for its flexibility, good adhesion to concrete, and resistance to de-icing salts. Sensors were installed over six cracks to record opening. Temperature was also recorded. After one year of measurement, the width of the cracks was seen to vary only with temperature, indicating that the reaction had been slowed. Measurements will be continued for several years.

2.3 METHODS FOR MITIGATING OR REMEDIATING DEF

2.3.1 Causes of DEF[2]

Ettringite, a normal hydration product, is a reaction between sulfates, calcium aluminates and water. Primary ettringite, which forms before the concrete sets, is not deleterious. Damage is caused by DEF in the hardened concrete. Delayed ettringite forms from a reaction between decomposed primary ettringite and water, creating nests of ettringite in the paste. Research indicates that high amounts of sulfur, contributed by the clinker, may be another source of the reaction. In both cases, exposure to water over time causes the ettringite to reform, producing expansive forces. Hime (1996) claims that the reaction requires substantial water exposure over months or years, but other sources say ambient temperature and moisture are sufficient for the reaction (G.M. Idorn 2001). DEF, like ASR, shows as map cracking.

DEF deterioration requires the following conditions:

- decomposed ettringite or high amounts of sulfur; and
- water.

[2] Merrill, Brian D., *Premature Concrete Deterioration*, internal report, Texas Department of Transportation, 1997.

2.3.2 The Goal of Mitigation or Remediation Treatments for DEF

The goal of treating existing DEF-affected structures is the same as for ASR-affected structures -- prevent water infiltration and allow water vapor release.

2.3.3 Published Information on Mitigation or Remediation of DEF

No references were found for mitigation or remediation of existing DEF deterioration.

2.4 OTHER TYPES OF DETERIORATION IN REINFORCED CONCRETE

2.4.1 Damage to Concrete

In addition to ASR/DEF deterioration, concrete is susceptible to damage from sulfate attack, salt crystallization, and freeze/thaw cycling. These mechanisms involve direct damage to the cementitious matrix. They are discussed here because some techniques to mitigate or remediate them may be relevant to ASR/DEF.

2.4.1.1 Sulfate Attack

Sulfate attack is caused by water-soluble sulfates entering the concrete. The sulfates react either chemically or physically with calcium aluminate hydrates in the paste, causing the cementitious matrix to weaken and disintegrate (Mehta *et al* 1993).

2.4.1.2 Salt Crystallization

Salt crystallization is the physical action of salts crystallizing out of solution in the pores of concrete. The pressure of the salts in the pores can be great enough to cause cracking and scaling (local delamination) of the concrete surface (Mehta *et al* 1993).

2.4.1.3 Freeze/Thaw Cycling

Freeze/thaw damage occurs by mechanisms similar to those of salt crystallization. Water freezing in the pores generates large hydraulic pressures, causing scaling and cracking. The use of de-icing salt magnifies freeze/thaw damage. Salt is hygroscopic, absorbing and retaining water in the pores, and thereby promoting a higher degree of saturation. Also, salt-concentration gradients in the concrete promote partial or differential freezing, generating osmotic pressures (Mehta *et al* 1993).

2.4.2 Corrosion of Reinforcement

Reinforced concrete elements can also deteriorate because of corrosion of their reinforcement. Corrosion of reinforcement deteriorates the concrete by filling it with a volume of corrosion products exceeding that of the original reinforcement, thereby inducing tensile stress in the surrounding concrete. Corrosion also reduces the cross-sectional area of the reinforcement and the bond between the concrete and reinforcement, thereby reducing the strength of the member.

Corrosion itself is an electrochemical process, requiring an anode, a cathode, an electrical conductor, and an electrolyte. The reinforcement acts as anode, cathode, and conductor, while any water in the concrete is the electrolyte. Normally, a passive layer of oxide film, maintained by the alkaline concrete, protects the steel. Corrosion of reinforcement is accelerated when the passivating layer is disrupted, which can occur by ingress of chlorides, carbonation, or electrolytic solutions (ACI 222 1996).

2.4.2.1 Ingress of Chlorides

The ingress of chlorides reduces the passive protective layer around the reinforcement. Pitting-type corrosion is produced on the steel surface where the passive layer is diminished by chlorides in the presence of oxygen and moisture. Chlorides diffuse into the concrete in solution, and can come from de-icing salts, fog, mist, or marine spray (Leeming 1990).

2.4.2.2 Carbonation

Concrete is generally very alkaline, providing an immune surrounding and maintaining the passivity. In the carbonation reaction, carbon dioxide from the air diffuses into the concrete and reacts with the cement to reduce this alkalinity. Below a pH of 9-10 the passive layer on the reinforcement breaks down and general corrosion begins. For carbonation to occur the concrete must be moist, but not saturated (Leeming 1990).

2.4.2.3 Lowered Resistivity

The corrosion process requires a conducting electrolyte. Dry concrete is highly resistive and prevents corrosion of the reinforcement. Conversely, pore water with dissolved salt is an electrolyte providing very low resistance for corrosion current. Reinforcement in wet concrete corrodes at a much higher rate than in dry concrete (Leeming 1990).

2.4.3 Relation of Other Types of Deterioration to ASR/DEF Deterioration

In all the types of concrete deterioration discussed above, water is the common factor.

- For freeze/thaw cycles and lowered resistivity, water is the root of the problem.
- Sulfate attack, salt scaling, and ingress of chloride all require water to transport the sulfate, salt, or chlorides that are the cause of the deterioration.
- Water is the agent that allows CO_2 to create carbonation damage.

Similarly, an external source of water is required for ASR/DEF deterioration. Many of the mitigating or remediating treatments for sulfate attack, salt scaling, freeze/thaw cycling, ingress of chlorides, carbonation, and lowered resistivity seek to prevent water infiltration, and therefore may be applicable as treatments for ASR/DEF deterioration. These treatments are discussed in Section 2.5.

2.5 SURFACE TREATMENTS FOR MITIGATING OR REMEDIATING OTHER TYPES OF DETERIORATION IN REINFORCED CONCRETE

A large body of literature has been accumulated over many years related to surface treatments, penetrating sealers, epoxies, and crack sealers for the purpose of keeping water out of concrete and thereby mitigating or remediating concrete deterioration. These surface treatments are discussed here for their potential benefit in mitigating or remediating ASR/DEF deterioration.

2.5.1 Coatings and Membranes

Coatings and membranes include epoxies, polymer cements, and urethanes. All of these provide a layer on the surface of the concrete. Membranes are impermeable to water, while coatings may or may not be impermeable.

2.5.2 Published Information on Coatings and Membranes

2.5.2.1 Coating Reference No. 1 (ACI 515-1985)

Chapter 4 of ACI 515 deals with waterproofing barrier systems, which are coatings intended to completely prevent the movement of moisture into concrete. Traditional systems use hot-applied, bituminous-saturated felt. Today many cold-applied systems are also used, including bituminous materials, elastomeric membranes, cementitious membranes, and metallic oxides.

Both cold and hot bituminous systems use fabrics for strength. They are not as adaptable to irregular shapes as cold liquid systems.

Chapter 4 of ACI 515 lists neoprene, neoprene-bituminous blends, polyurethane, polyurethane-bituminous blends, and epoxy-bituminous blends as elastomeric membranes. All have good elongation characteristics. Some need fiberglass cloth for reinforcement or to bridge cracks and joints larger than 1.5 mm (0.06 in.). All are liquid-applied systems, requiring multiple coats for complete coverage.

Cementitious membranes can be applied to damp, smooth, rough, or irregular surfaces, usually by trowel. Because cementitious membranes are rigid, they should have the same thermal coefficient as the substrate on which they are applied to minimize differential thermal expansion and resultant cracking. Also, cementitious membranes should not be used to span moving joints.

Metallic oxides are another type of rigid barrier. Fine metallic filings, sand, cement, water, and a catalyst oxidize to fill the pores of the concrete, decreasing permeability. Metallic oxides require 3 to 5 coats, constant moist curing for a proper finish, and good quality control.

2.5.2.2 Coating Reference No. 2 (O'Donoghue et al. 1998)

Moisture-cured urethanes react with ambient moisture to create polymers. For this reason they are inherently beneficial in applications where moisture is present. Their curing temperature is as low as 20°F (-7°C). Moisture-cured urethanes can cure very rapidly, however, preventing penetration into the concrete surface. In such cases, the urethane acts more like a coating than a penetrating sealer.

2.5.3 Penetrating Sealers

Penetrating sealers are solutions or suspensions that diffuse into the concrete near the surface. These include silane, siloxane, oils, high-molecular-weight methacrylate (HMWM), and penetrating epoxies. While not impermeable to liquid water, they create a hydrophobic layer, sometimes (as in the case of silane and siloxane) by chemical reaction with the concrete. Because they are clear, penetrating sealers offer the advantage of permitting continued observation of the concrete surface.

2.5.4 Published Information on Penetrating Sealers

2.5.4.1 Penetrating Sealer Reference No. 1 (ACI 515-1985)

Chapter 5 of ACI 515 deals with dampproofing barrier systems, which are coatings capable of reducing the rate of transmission of water into the concrete, but are not impermeable to liquid water. Dampproofing is suitable for areas not subjected to hydraulic pressure, while waterproofing is necessary if hydraulic pressure is present. Chapter 5 claims that dampproofing systems are not capable of bridging cracks. Advantages are low application cost and minimal surface preparation. Multiple coats are needed for complete coverage. Above-grade systems are listed as: water-based portland cement paste; portland cement with stearic acid, water repellants, or latex emulsions; latex paint; two-component epoxy paint; solvent-based, chlorinated rubber paint; two-component or moisture-cured polyurethane paints; and fish oil-based materials with mica and asbestos fillers.

Chapter 6 of ACI 515 deals with protective barrier systems, which provide resistance to degradation by chemicals, prevent staining, and prevent liquids from being contaminated by the concrete. These systems are more durable than waterproofing or dampproofing barriers. Chapter 6 categorizes protective barrier systems as providing protection against mild, intermediate, and severe exposures. The category most related to mitigation and remediation of ASR/DEF deterioration is “mild,” which addresses damage from de-icing salts, freeze/thaw cycling, and acidic solutions. Applicable systems are a mixture of moisture-permeable and impermeable sealers, including: polyvinyl butyral; polyurethane; methyl-methacrylate; alkyl-alkoxysilane; epoxy resins; acrylic resins; chlorinated rubber; styrene-acrylic copolymer; asphalt; coal tar; vinyl; and neoprene.

2.5.4.2 Penetrating Sealer Reference No. 2 (Wright et al. 1993)

In this investigation boiled linseed oil was compared to silane and siloxane for penetration ability, salt-water absorption, vapor permeability and other characteristics. Each sealer was applied to three concrete pavement sites for the field investigation. Cores were taken from each site to determine the penetration depth, salt-water absorption, and chloride intrusion. Laboratory specimens were cubes, prisms, and slabs, used for tests of sealer penetration, salt-water absorption, vapor permeability, abrasion, chloride intrusion, and freeze/thaw resistance.

Penetration of the linseed oil was comparable to that of the other sealers in the field tests, and two or more times greater in the laboratory tests. Linseed oil performed best at reducing salt-water absorption in the field, although absorption results in the laboratory were comparable to silane and worse than siloxane. The investigators also found that in the field, the volume of silane and siloxane in the pore structure of the concrete diminished over time, allowing more absorption. In contrast, the linseed oil maintained consistently low absorption. Chloride-ion content was lower for the linseed-oil cores both two and three years after application. Finally, linseed oil was less permeable to water vapor than the other sealers.

2.5.4.3 Penetrating Sealer Reference No. 3 (Marks 1988)

This article reports on the Iowa Department of Transportation's use of HMWM to seal the entire deck of a bridge that had full-depth cracks that were observed to leak. The cracks were found to lie above the transverse reinforcement, and the Department decided that sealing of the deck was needed to protect the steel. According to Marks, HMWM was chosen because the California Department of Transportation had successfully used it as a sealer.

One coat of HMWM was applied and cores were taken one week later. The HMWM penetrated the full 2 in. (51 mm) of every core. Continued leakage, though at a lower rate, was observed along the entire deck during a steady rain and under standing water. The Department applied a second coat, but observations had not been made at the time of the article. The initial application was made when the temperature ranged between 45F and 55F (7C and 13C); the

HMWM manufacturer suggested that the application temperature should be 50F (10C) or above. The second application was made at 60F (16C).

2.5.4.4 Penetrating Sealer Reference No. 4 (Basheer et al. 1998)

The article studied the effect of moisture in the concrete at the time of surface treatment application on the chloride intrusion and subsequent reinforcement corrosion. The surface treatments used were a 40% silane solution, a 100% silane solution, a silane-siloxane two-coat system, and a silane-acrylic two-coat system. Three moisture conditions were used: one very wet with little drying time; one very wet with considerably longer drying time; and one very dry. The specimens were repeatedly subjected to 7-day cycles of ponding with a sodium-chloride solution, followed by drying.

The depth of penetration of the treatments was greatest for the specimens that were driest. Very few specimens had corrosion of reinforcement, but those that did were from the group with the highest pre-application moisture condition. The investigators concluded that while all treatments reduced chloride infiltration, no one treatment was outstanding in this regard.

2.5.4.5 Penetrating Sealer Reference No. 5 (Rizzo et al. 1989)

This article investigated many penetrating sealers, including acrylic, polyurethane, gum resin, silicone, silane, and an acrylic topcoat for their permeability to water vapor and their resistance to absorption of water, ingress of chloride ions, and ingress of carbon dioxide. The silane sealers showed the lowest water absorption and chloride-ion ingress, although carbon-dioxide ingress was comparable to that of the other sealers.

A system of silane with an acrylic topcoat was then tested. It showed the positive benefits of the silane – reduced water absorption and chloride-ion ingress – while also reducing the ingress of carbon dioxide and remaining breathable.

The silane-acrylic system was subjected to additional sulfate exposure, accelerated weathering, and freeze-thaw testing, and showed good results over the uncoated specimen. Cores from field applications on a tunnel in the United Kingdom exposed to frequent applications of de-icing salts confirmed that the silane-acrylic system substantially reduced the ingress of chloride ions.

2.5.4.6 Product Literature on Penetrating Sealers

In contrast to experimental findings reported here, some product literature does advertise epoxy-based penetrating sealers that are supposedly impermeable to liquid water and permeable to water vapor.[3]

2.5.5 Crack Sealers

Crack sealers are low-viscosity, flexible polymers applied specifically to cracks in reinforced concrete. Ideally, they penetrate the crack completely, thus eliminating an easy path for water entrance, and also restore structural strength to the member. Crack sealers include HMWM, epoxies, and urethanes.

[3] Epoxy Systems™ Product #850

2.5.6 Published Information on Crack Sealers

2.5.6.1 Crack Sealer Reference No. 1 (Sprinkel et al. 1995)

In this article three epoxies, one HMWM, and one polyurethane were tested for penetration depth and flexural strength. Unreinforced beams measuring 3 x 4 x 11 in. (76 x 102 x 279 mm) were tested in flexure to failure and then repaired by applying one of the five crack sealers to the top surface of the beam while the sections were held together in a jig. Sealer was ponded on the top surface until the crack was entirely filled. After curing, the beams were again tested to failure in flexure and then split to measure penetration depth of the polymer. Additional penetration tests were conducted at varying temperatures, between 7°C and 35°C (45°F and 95°F), by pouring the polymers over sand. Under ideal temperatures, all five sealers filled cracks as narrow as 0.2 mm. Each of the five sealers reacted uniquely to high and low temperatures, with the HMWM performing consistently well over the entire range. All polymers restored 100% of original strength in laboratory flexural tests. Most test beams re-cracked in the concrete, rather than in the sealer. The investigators rated HMWM first for tested results, and third for overall results, ease of use, odor, safety, and cost.

The investigators found that while the polyurethane was easy to use and almost odor-free, it easily leaked and was not practical for overhead surfaces. The three epoxies ranged from low to very strong in odor, and from easy to difficult mixing ratios. The HMWM had very high odor, easily leaked because of low viscosity, was difficult to mix, and was potentially explosive if mixed incorrectly.

2.5.6.2 Crack Sealer Reference No. 2 (Fowler 1989)

The results of this investigation agree with those of Marks (1988). For this investigation, 4 x 6 x 12 in. (102 x 152 x 305 mm) slabs were cracked and then treated with three different HMWM. Slabs were treated under three conditions: dry, room temperature; dry, hot temperature; and wet, room temperature. HMWM restored 75-85% of the flexural strength under all conditions. HMWM filled 60-80% of the crack volume for the laboratory tests and in the cores taken from the treated field site. Cracks as small as 0.1 mm (0.004 in.) were filled. The investigators recommend 3 days drying time under normal conditions to achieve the best crack filling and strength gain.

2.6 ELECTROCHEMICAL TREATMENTS

The purpose of electrochemical treatment is to reverse corrosion damage of the reinforcement, with no direct benefit to the surrounding concrete and no attempt to prevent water infiltration. While these treatments do not remediate ASR/DEF deterioration, one finding in particular is worth noting.

Cathodic protection is the most common electrochemical method of arresting or reducing the corrosion of steel reinforcement. Cathodic protection produces hydroxyl ions, which can combine with reactive aggregates to cause ASR. The use of cathodic protection can therefore easily worsen an existing ASR problem (Thompson 1990).

2.7 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FROM LITERATURE SEARCH

2.7.1 Summary and Conclusions

While the articles referenced in this search do not comprise a complete list of mitigation and remediation treatments for ASR/DEF or other forms of concrete deterioration, they cover the range of methods currently researched and tested, and also contain important concepts. Many articles that corroborate the information given above or provide background are listed in Appendix G.

Polymer-modified cement mortar (PCM), silane, urethane, and lithium nitrate were found to be effective in reducing expansion from ASR. In some tests, the products were used as two-coat systems, such as silane with a PCM topcoat, with good results. Several references, however, report that epoxy promotes expansion. Methyl-methacrylate and sodium silicate are also not effective at reducing expansion.

Lithium can be used either in an applied solution or in an electrochemical process. Lithium nitrate is more effective and safer to use than lithium hydroxide. In the electrochemical process, lithium ions are driven into the concrete toward the reinforcement. The benefit of this process is an increase in the amount of useful lithium deposited in the concrete. Lithium is successful at reducing ASR expansion, but because it is not a hydrophobic sealer, it does not have the added benefit of protecting against other forms of deterioration.

Membranes and impermeable coatings promote expansion in existing concrete structures. They are therefore not appropriate for mitigation or remediation of ASR/DEF. The treatments described in Chapter 4 of ACI 515 are waterproofing membranes.

The treatments described in Chapters 5 and 6 of ACI 515 can be permeable or impermeable to liquid water. Many of the systems listed are discussed in other references in this report, including modified Portland cement, epoxy, polyurethane, methyl-methacrylate, silane, and acrylic resins.

Penetrating hydrophobic sealers have the greatest potential for controlling expansion from ASR/DEF. While not completely impermeable to water, they are permeable to water vapor. Silane, already mentioned as a specific ASR treatment, has been found to reduce chloride-ion content. Silane was especially effective at reducing chloride- and sulfate-ion ingress, carbon-dioxide intrusion, and weathering when applied with an acrylic topcoat. Silane systems remain breathable.

Boiled linseed oil performed as well or better than silane and siloxane in tests for salt-water and chloride intrusion. Linseed oil is inexpensive, but may need more frequent reapplication than other penetrating sealers.

Moisture-cured urethanes have promise for treating existing structures because of their need for moisture. Controlling the rate of cure so that moisture-cured urethanes can penetrate the concrete surface may improve their effectiveness at reducing expansion from ASR/DEF.

High-molecular-weight methacrylate (HMWM) has been reported as both a penetrating sealer and crack sealer. In Marks (1988), HMWM could not prevent leakage through the bridge deck. The poor results of the first application can possibly be attributed to the cool application temperature. As a crack sealer, the HMWM penetrated very small cracks and restored structural strength. Only sealing cracks in ASR/DEF-affected structures is not beneficial, however, because new cracks will inevitably form. Also, Stokes (2000) suggests that some cracking aids the penetration of the sealer.

2.7.2 Recommendations

To mitigate deterioration from ASR, DEF, or both, it is recommended to use the following treatments:

- Silane, PCM, urethane, and lithium nitrate solution, which reduce the expansion of ASR-affected specimens.
- Siloxane, which is similar in chemical makeup to silane, and performs like it in chloride-intrusion tests.
- Linseed oil, which performs as well as silane and siloxane in salt-water and chloride intrusion tests, and is much cheaper.
- HMWM, which has good penetration ability, but needs more research on its effectiveness as a penetrating sealer.
- Epoxy, which has shown negative results as a coating, but may be worth investigating as a penetrating sealer. It is safe to use and requires little or no re-application. It can also be used as a topcoat following treatment with lithium nitrate, silane, etc.

It is recommended to use these treatments, separately or in combination, on specimens made with aggregates and cement known to produce ASR/DEF deterioration, and to evaluate their effectiveness by measuring specimen expansion and internal moisture content, and by monitoring specimens with acoustic emission techniques.

2.7.3 Recommendations for Specific Structures

The mitigation options presented here apply to structures in general. Characteristics of specific studies may favor particular options or sets of options. One example of this, the Lake Ivie structure on FM 1929 is discussed in theses and reports for Study 1857. Such specific applications are not discussed further here.

CHAPTER 3

Development of Test Program

3.1 OBJECTIVES

The objective of the test program is to fabricate specimens with high potential for expansion due to ASR/DEF, and to monitor their deterioration with laboratory testing and AE. Cement with high alkalinity and aggregates with high silica content are used to achieve expansion. Specimens are coated with treatments chosen from those evaluated in the literature search of Chapter 2.

3.2 TEST SPECIMENS

3.2.1 Specimen Fabrication

All test specimens were fabricated according to ASTM C 1293-95 ("Standard Test Method for Concrete Aggregates by Determination of Length Change of Concrete Due to Alkali-Silica Reaction"). Specimens have a square cross-section of 3 in. (75 mm). Gage studs were cast into the ends with a nominal gage length between studs of 10 in. (250 mm). The specimens were cured in the molds for 24 hours at 23°C and 95% relative humidity per ASTM C 157. After removal from the molds, the specimens were placed in storage containers and aged for seven days at 60°C in the storage environment. The storage containers consist of 5-gallon (22 liter) polyethylene pails with airtight lids, lined with felt wicking material around the wall, and PVC racks capable of holding four prisms vertically.

The specimens were lightly cleaned by sandblast, water-blast, or sandpaper, to remove laitance prior to application of the mitigation treatments. Treatments were applied by brush according to manufacturer's instructions and allowed to cure for 24 hours. If a second treatment was required for a particular mitigation technique, the treatment was applied and allowed to cure for 24 hours. Specimens were then returned to the storage containers in the storage environment or placed outside, according to the exposure series described in Section 3.3.

Two plastic sleeves for moisture measurement were either cast or drilled into each specimen. Sleeves were placed at depths of 0.5 in. (12 mm) and 1.5 in. (40 mm) from the surface. The sleeves were plugged with rubber stoppers to prevent drying of the specimen interior. The specimens in the molds, with sleeves inserted during casting, are shown in Figure 3-1.

Figure 3-1 Specimens in molds

Concrete mixes were proportioned by the volume method. Quantities of cement, aggregate, and water and results of slump, yield, air content, and unit weight for each mix are presented in Appendix A.

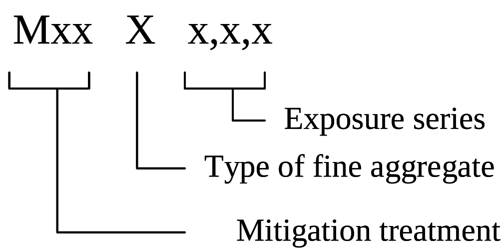
Coarse aggregate was acquired from a local source, and was not evaluated for reactivity. The aggregate was mechanically crushed and sieved to meet the gradation requirements of ASTM C 1293.

TxDOT Study 4085 evaluated various sources of fine aggregate in the state of Texas for reactivity using ASTM C 1260. Two of the fine aggregates evaluated in that study were chosen for use in this project. The first fine aggregate had a 14-day expansion of 0.675%, the largest of those tested. The second had a 14-day expansion of 0.248%, in the middle range of those tested (Bauer 2001).

TxDOT Study 4085 tested various cement sources from around the country for total alkali content. The cement chosen for this project is the same one used for ASTM C 1293 prisms in Study 4085. This cement met the requirement of ASTM C 1293 to have a total alkali content of 0.9±0.1% Na_2O_{eq} (Figurski 2001).

3.2.2 Specimen Nomenclature

The specimens are designated as follows:



- Mitigation treatment – The treatments selected based on the literature search are designated M1 through M23; control specimens are designated with “C” instead of “M.”
- Type of fine aggregate – “J” for Jobe fine aggregate; “F” for Fordyce fine aggregate.
- Exposure series – “a,b,c” for indoor series; “d,e,f” for outdoor series; and “g,h,j,k” for wet/dry series.

3.2.3 Mitigation Techniques

The mitigation techniques used were determined after the initial literature search was conducted. Table 3-1 shows the selected treatments.

Unless noted as a TxDOT specified product, mitigation treatments are commercially available. TxDOT-specified products were obtained from approved suppliers.

Table 3-1 Mitigation Techniques

Designation	Mitigation Technique	Abbreviation
M1	Moist-cure Urethane	Ureth
M2	Linseed Oil	Linsd Oil
M3	Polymer-Modified Cement Mortar	PCM
M4	Polyurethane	Poly
M5	Silane 20% solids	Silane 20
M6	Silane 40% solids	Silane 40
M7	Siloxane 20% solids	Silox 20
M8	Siloxane 40% solids	Silox 40
M9	Lithium Nitrate	$LiNO_3$
M10	Lithium Nitrate, followed by Silane 20%	$LiNO_3$+Sil
M11	Lithium Nitrate, followed by Siloxane 20%	$LiNO_3$+Silox
M12	Lithium Nitrate, followed by Linseed Oil	$LiNO_3$+Linsd
M13	Lithium Nitrate, followed by Polyurethane	$LiNO_3$+Poly
M14	High-Molecular-Weight Methacrylate	HMWM
M15	Penetrating Epoxy	Epoxy
M16	TxDOT Penetrating Concrete Surface Treatment Type I-Silane, followed by TxDOT Type 742h Appearance Coat paint	Sil+742
M17	TxDOT Penetrating Concrete Surface Treatment Type I-Silane, followed by TxDOT Type 742 Appearance Coat paint (thinned)	Sil+742th
M18	TxDOT Penetrating Concrete Surface Treatment Type I-Silane, followed by Class B Type II Latex paint	Sil+latex
M19	TxDOT Penetrating Concrete Surface Treatment Type I-Silane, followed by Polymer-Modified Cement Mortar	Sil+PCM
M20	TxDOT Type IV Epoxy	IV Epoxy
M21	Polyurethane	Poly
M22	Lithium Nitrate	$LiNO_3$
M23	Lithium Nitrate, followed by TxDOT Type 742h Appearance Coat paint	$LiNO_3$+742

3.3 EXPANSION AND MOISTURE TEST SETUP

Three series of tests were conducted, all using specimens fabricated as described in Section 3.2.1.

3.3.1 Indoor Series

An accelerated ASTM C 1293 procedure, developed at The University of Texas at Austin, was used to shorten the length of testing time. The accelerated procedure follows ASTM C 1293 for specimen fabrication and storage containers, but increases the temperature of the storage environment from 38°C to 60°C. The testing time is reduced from twelve months to thirteen weeks by increasing the temperature (Touma 2000).

Length readings for each specimen were taken using a length comparator (Figure 3-2) at 1 week, 2 weeks, 4 weeks, 8 weeks, and 13 weeks after fabrication. Readings were taken immediately after removing the specimens from the storage containers. Specimens were promptly returned to the storage containers and placed in the storage environment after completing the length readings.

Moisture readings were not taken for this series because the specimens were kept at constant humidity in the storage containers.

Figure 3-2 Length reading taken with length comparator

3.3.2 Outdoor Series

After coating, the specimens of the outdoor series were placed on racks outside Ferguson Structural Engineering Laboratory (FSEL), as shown in Figure 3-3. The purpose of the outdoor series is to subject the specimens to conditions as similar as possible to actual field conditions. For this series, mitigation treatments were applied outside, during midday of the summer, and the specimens remained outside for curing.

Length readings for each specimen were taken using a length comparator at 1 week, 2 weeks, 4 weeks, 8 weeks, 13 weeks, 17 weeks, 21 weeks, and 25 weeks after fabrication. Moisture readings were taken concurrently with length readings.

Figure 3-3 Specimens of outdoor series behind FSEL

3.3.3 Wet/Dry Series

The purpose of the wet/dry series is to examine the comparative performance of specimens under an environmental condition consisting of drastic changes in humidity, intended to promote the movement of moisture in and out of the specimens. By imposing a moisture gradient on the specimens, the effectiveness of each mitigation treatment for water impermeability and water vapor permeability can be evaluated.

The wet cycle was achieved by placing the specimens in the storage containers in the storage environment, therefore aging the specimens at 100% humidity. The dry cycle was achieved by placing the specimens in the storage environment without the buckets; the storage environment was maintained at a relative humidity less than 10%. The specimens were subjected to one week of wet aging prior to application of the mitigation treatment, then one week of dry aging, then to alternating two-week periods of wet and dry aging. The storage environment was maintained at 60°C, as specified in the accelerated ASTM C 1293 procedure.

Specimens “g” and “h” were cleaned prior to application of treatment with sandblasting in a blast cabinet. Specimens “j” and “k” were cleaned with a water-blast, using four passes from 18 in. (0.5 m) with a high-pressure water sprayer.

Length readings for each specimen were taken using a length comparator at 1 week, 2 weeks, 4 weeks, 6 weeks, 8 weeks, 10 weeks, 12 weeks, and 13 weeks after fabrication. Moisture readings were taken concurrently with length readings.

Damage indices (DI) were calculated at 7 weeks, 8 weeks, 10 weeks, 12 weeks, and 13 weeks after fabrication for specimens “h” and “k”. One face of the prism was chosen to measure the cracks at each interval. Cracks visible through the coating were measured for width and length using a crack comparator card. The index was calculated as $DI = \sum_i w_i l_i$ and as $DI = \sum_i w_i^2 l_i$, where w is the crack width in thousandths of an inch, and l is the crack length in inches (Boenig 2000).

3.4 ACOUSTIC EMISSION TEST SETUP

The AE monitoring advanced in Study 1857 was used to quantify the internal cracking due to ASR/DEF deterioration for the indoor series and the wet/dry series. Monitoring was conducted at intervals reflecting those of the expansion testing, to follow the progression of cracking over time. The important data collected from AE testing include amount of emission during loading, amplitude of hits, historic index, and Felicity ratio.

The instrumentation for the AE testing included a six-channel MISTRAS 2001 instrument manufactured by Physical Acoustic Corporation (PAC). Two PAC R6I resonant sensors were mounted with a couplant material to the prisms at 2.5 in. (6 cm) from the ends. The R6I sensor has a resonant frequency of 60 kHz and incorporates an integral 40 dB preamplifier (Chotickai 2001). The electric signal from a 5 kip (22 kN) load cell was used to record the applied load as part of the MISTRAS data file.

The prisms were loaded under third-point bending, per ASTM C 78. Load was applied with a hand-operated hydraulic ram. The testing frame, ram, and instrumentation are shown in Figure 3-4 and Figure 3-5.

Before each test, the sensors were checked for proper function and contact with the prism using pencil lead breaks. Three 0.3 mm Pentel 2H leads were broken 1 in. (2.5 cm) from each sensor. The leads were extended approximately 2.5 mm for each break and held at 30° from the surface. The average amplitude recorded by a sensor was not allowed to vary more than 4 dB from the average of all sensors. A sensor not recording an amplitude or failing to meet the average criteria was replaced, until both sensors were working correctly (Chotickai 2000)

To determine the Felicity ratio, the following stepped loading schedule was used: 300-pound (1.3 kN) increase in load; hold; 150-pound (0.7 kN) unload; and hold. The Felicity ratio, defined as the load at the onset of significant acoustic emission divided by the maximum previous load, is the most useful AE measure of structural deterioration for concrete (Tinkey 2000). Load was held until acoustic emission ceased. The loading sequence was continued to 1,200 pounds (5.3 kN) for Fordyce specimens and 600 pounds (2.7 kN) for Jobe specimens; the reduced load for Jobe specimens is a result of failure of several specimens above 600 pounds (2.7 kN).

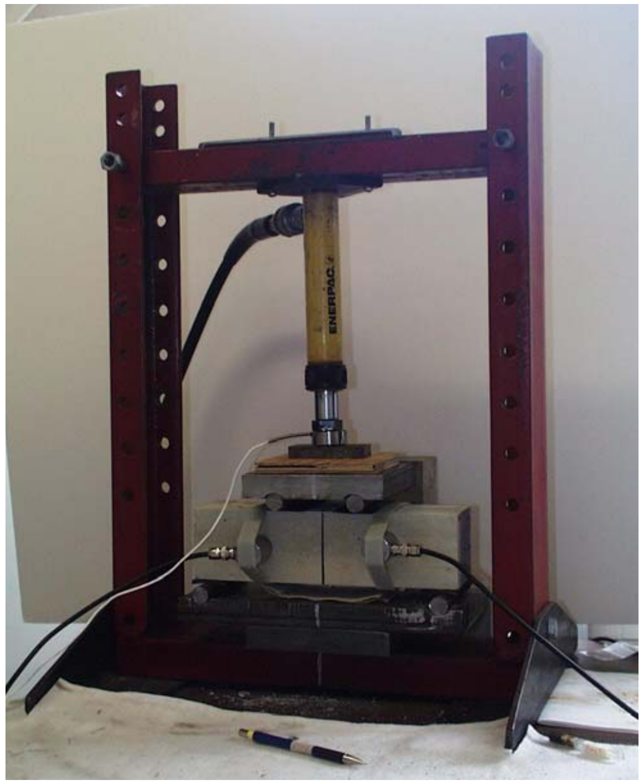


Figure 3-4 Test frame and ram with specimen

Figure 3-5 MISTRAS 2001 instrument

CHAPTER 4

Test Results

This chapter presents the data and observations from the tests described in Chapter 3. Results are discussed in Chapter 5.

4.1 RESULTS OF EXPANSION AND MOISTURE TESTING

4.1.1 Indoor Series

Figure 4-1 and Figure 4-2 show the average expansion of the indoor series, comprising the control specimens and specimens treated with seven different mitigation techniques. Plots for the eight other techniques are presented in Appendix B.

Expansion is defined as the change in length between successive measurements. Positive changes in length denote lengthening; negative changes denote shortening. The change in length is plotted versus the age of the specimens, in weeks, after fabrication.

For the remainder of this thesis, specimens fabricated with Jobe fine aggregate are referred to as Jobe specimens; likewise for Fordyce fine aggregate.

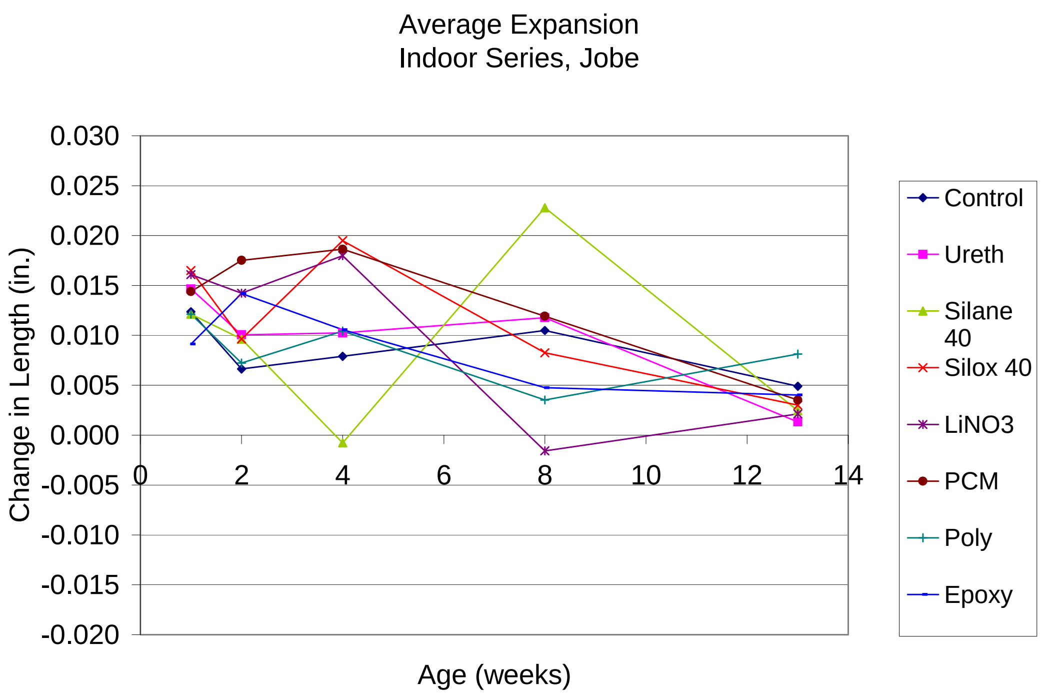


Figure 4-1 Average Expansion, Indoor Series, Jobe Specimens

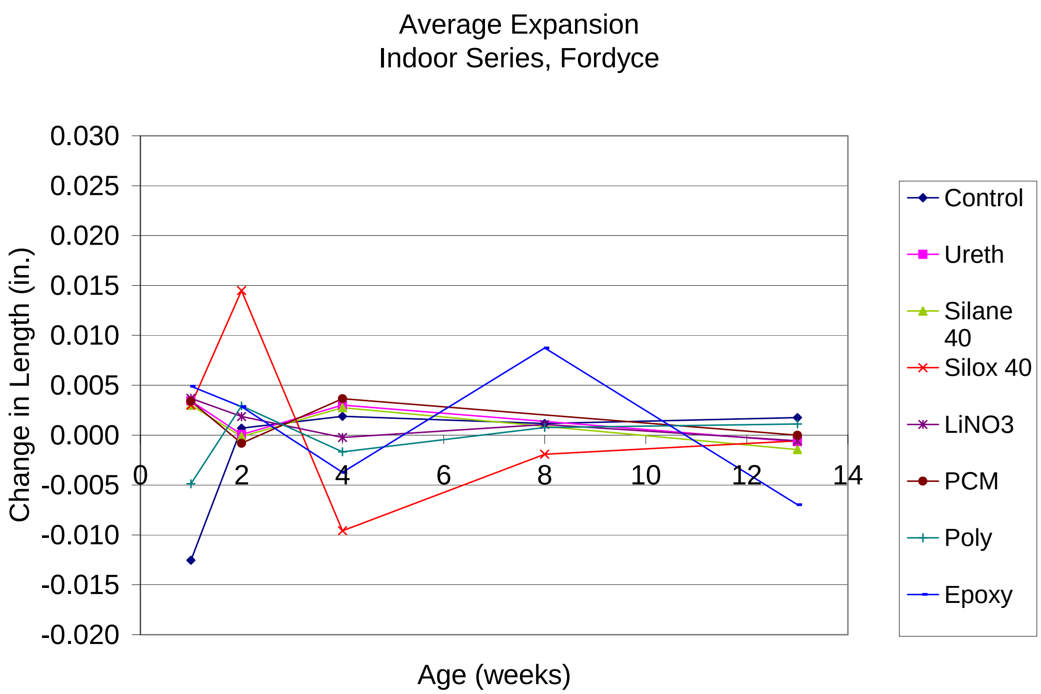


Figure 4-2 Average Expansion, Indoor Series, Fordyce Specimens

4.1.2 Outdoor Series

4.1.2.1 Expansion

Figure 4-3 and Figure 4-4 show the average expansion of the prisms for the outdoor series, comprising the control specimens and specimens treated with seven different mitigation techniques. Plots for the eight other techniques are presented in Appendix B.

The horizontal axis of these figures shows dates that specimens were placed outside; each specimen, therefore, has a different starting point. Also plotted is the daily rainfall, so that the expansion and effectiveness of the mitigation technique can be correlated with the amount of moisture present.

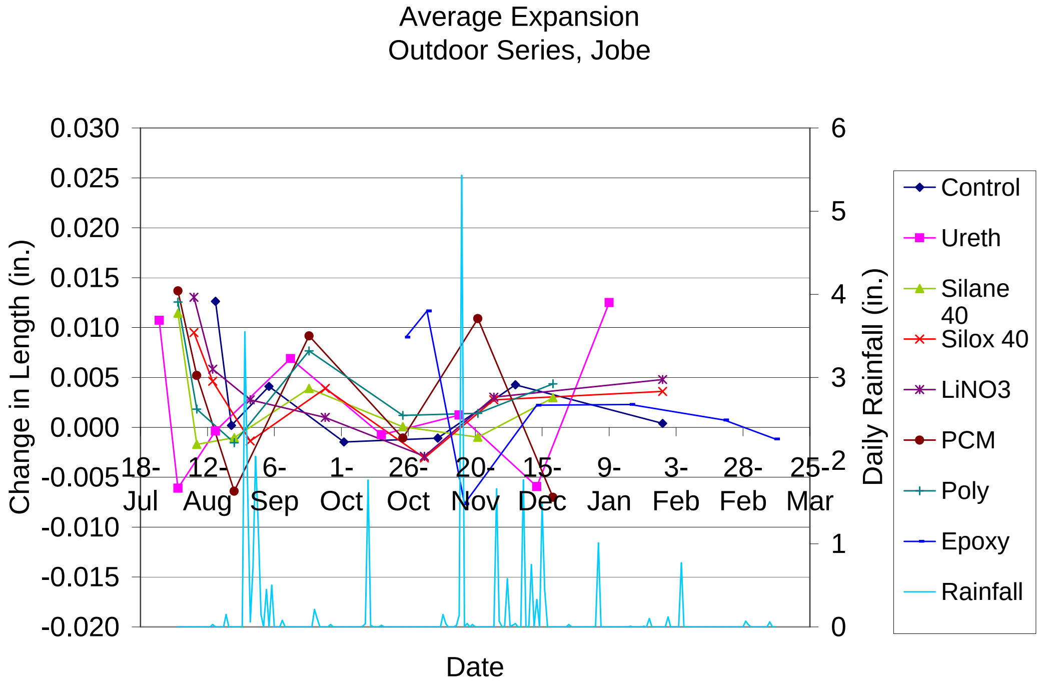


Figure 4-3 Average Expansion, Outdoor Series, Jobe Specimens

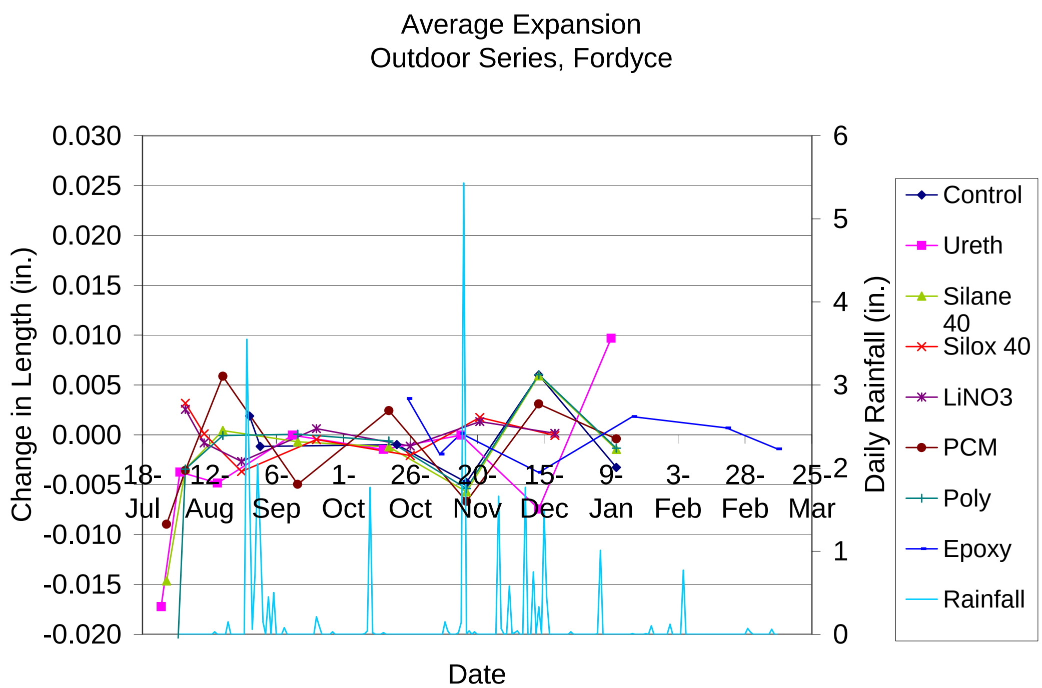


Figure 4-4 Average Expansion, Outdoor Series, Fordyce Specimens

4.1.2.2 Moisture

Figure 4-5 and Figure 4-6 show the relative humidity of the Jobe specimens at depth of 0.5 in. (12mm) and 1.5 in. (40 mm) from the surface, comprising the control specimens and specimens treated with seven different mitigation techniques. Figure 4-7 and Figure 4-8 show the relative humidity of the Fordyce specimens at depth of 0.5 in. (12 mm) and 1.5 in. (40 mm) from the surface, comprising the control specimens and specimens treated with seven different mitigation techniques. Plots for the eight other techniques are presented in Appendix B.

The internal relative humidity of the concrete is used to determine the impermeability of the mitigation techniques to liquid water and the permeability to water vapor. The relative humidity can be correlated with the daily rainfall, which is also plotted versus time.

Plots of the change in relative humidity versus time were considered, but disregarded because they provided no more insight than that already gained from Figure 4-5 through Figure 4-8.

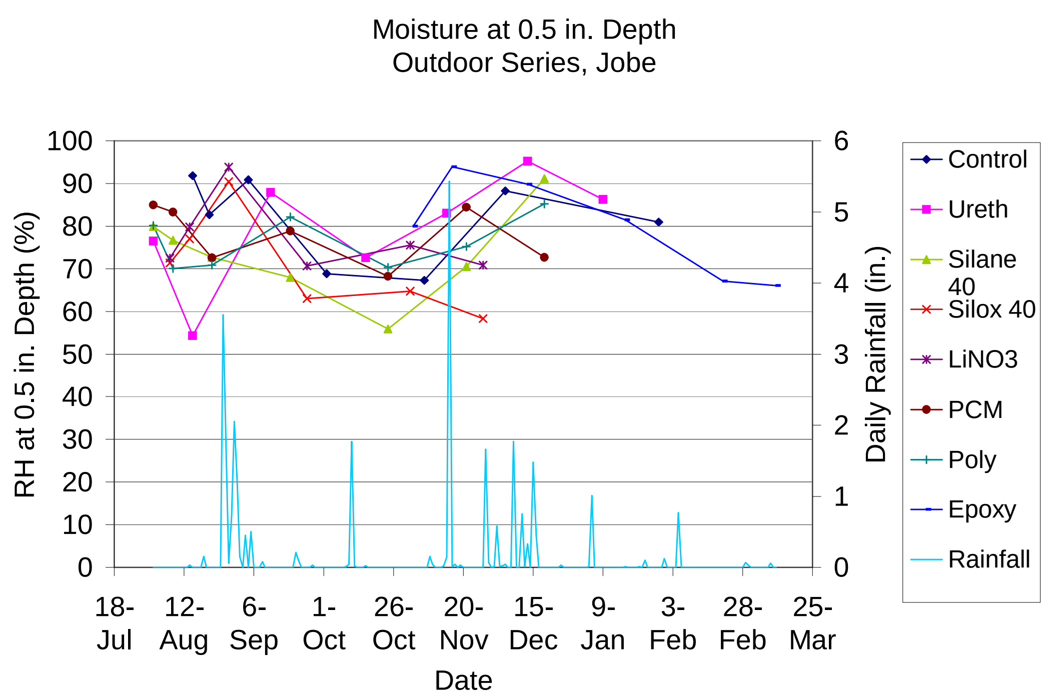


Figure 4-5 Moisture at 0.5 in. Depth, Outdoor Series, Jobe Specimens

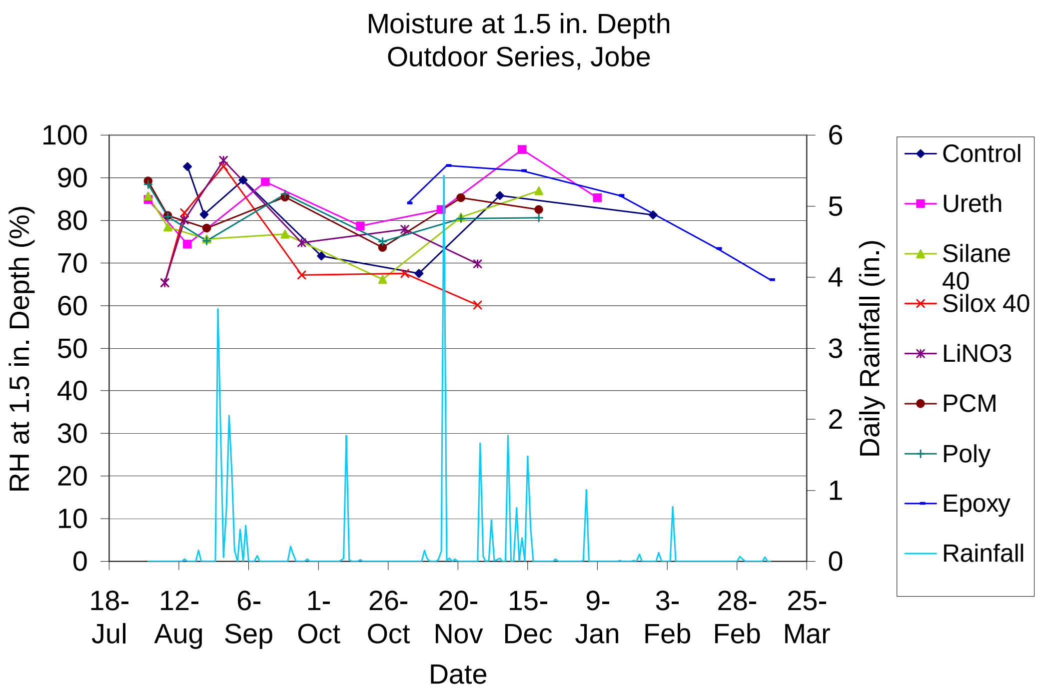


Figure 4-6 Moisture at 1.5 in. Depth, Outdoor Series, Jobe Specimens

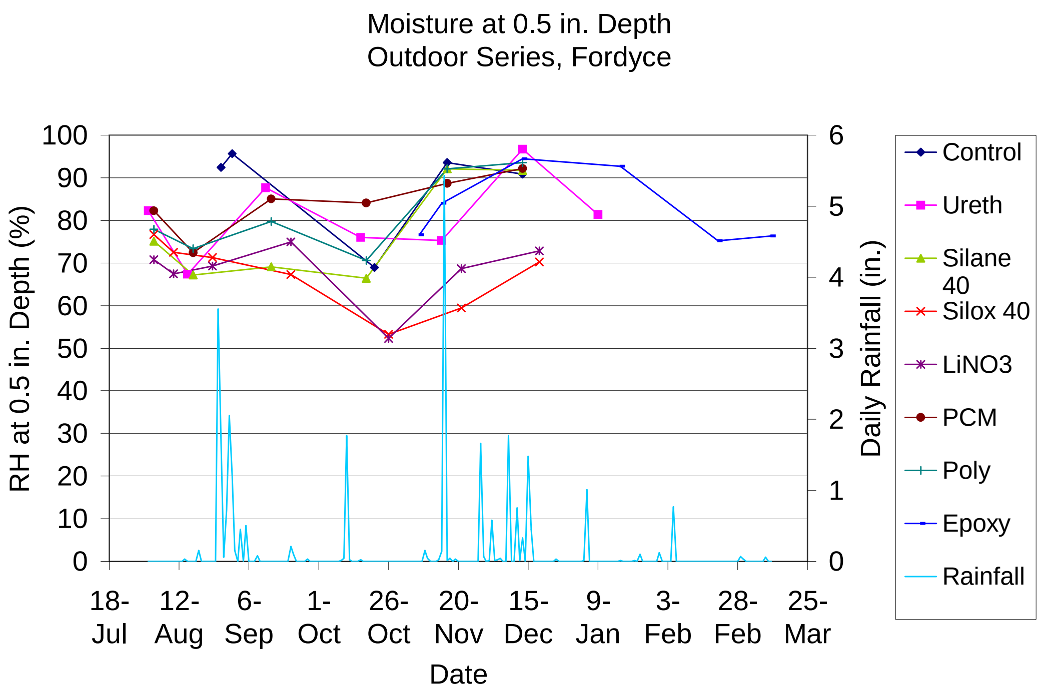


Figure 4-7 Moisture at 0.5 in. Depth, Outdoor Series, Fordyce Specimens

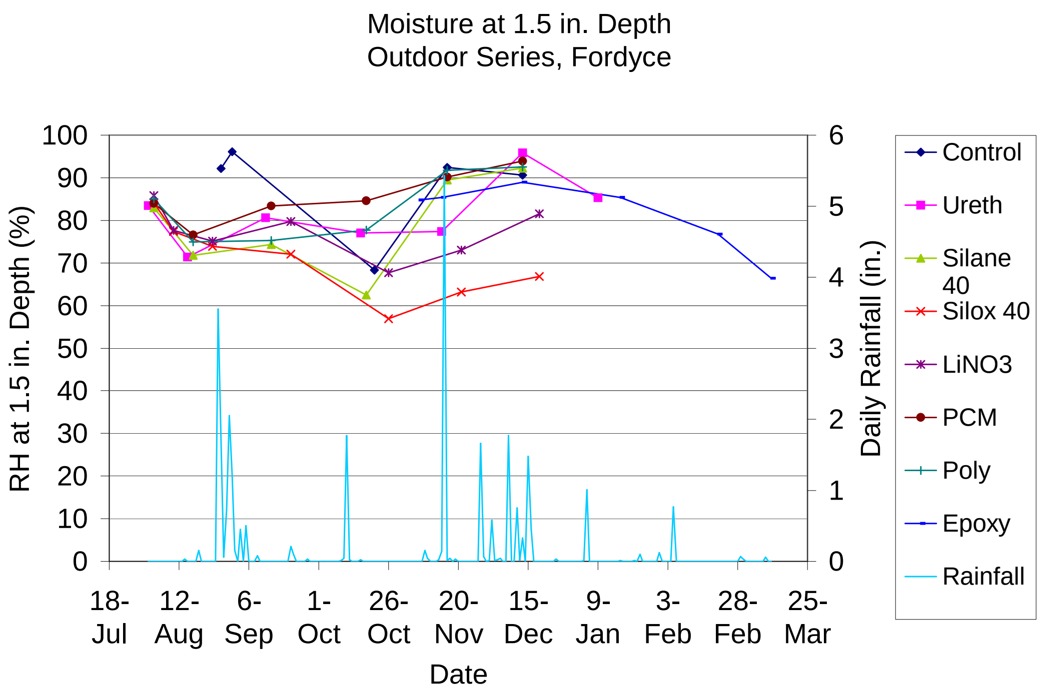


Figure 4-8 Moisture at 1.5 in. Depth, Outdoor Series, Fordyce Specimens

4.1.3 Wet/Dry Series

4.1.3.1 Expansion

Figure 4-9 shows the average expansion of the specimens for the wet/dry series, including the control specimens and all mitigation techniques used in this series.

In that figure the change in length is plotted versus age of the specimens, in weeks, after fabrication. The wet/dry cycles imposed on the specimens during each interval are shown along the horizontal axis.

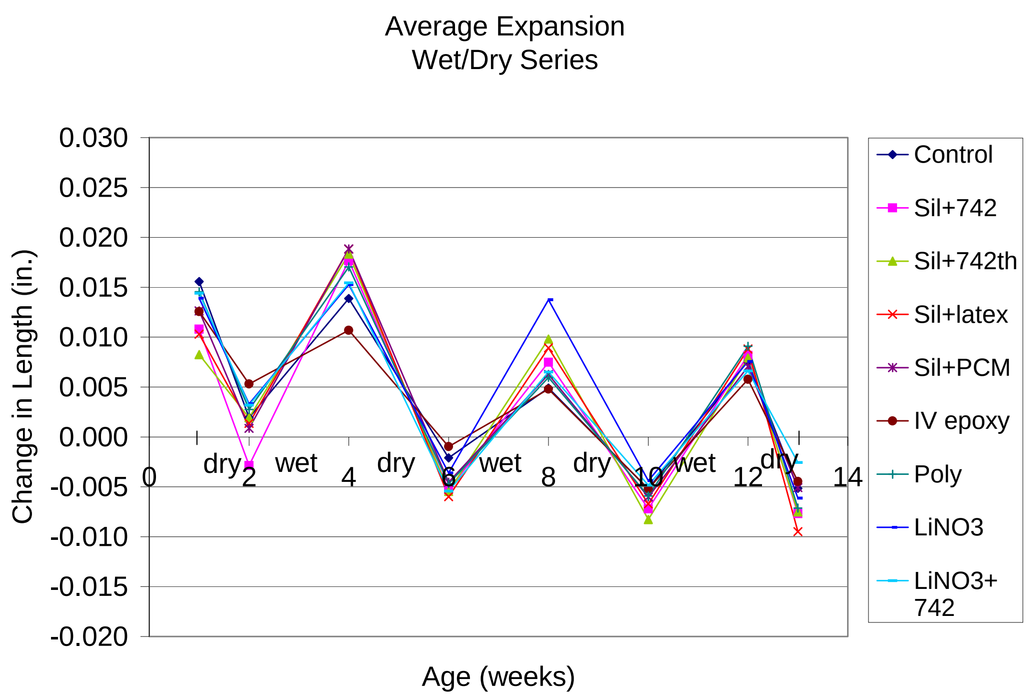


Figure 4-9 Average Expansion, Wet/Dry Series

4.1.3.2 Moisture

Figure 4-10 and Figure 4-11 show the relative humidity of the specimens at depth of 0.5 in. (12 mm) and 1.5 in. (40 mm) from the surface, including the control specimens and all mitigation techniques used in this series.

The relative humidity is plotted versus the age of the prisms, in weeks, after fabrication. The wet/dry cycles imposed on the specimens during each interval are shown along the horizontal axis.

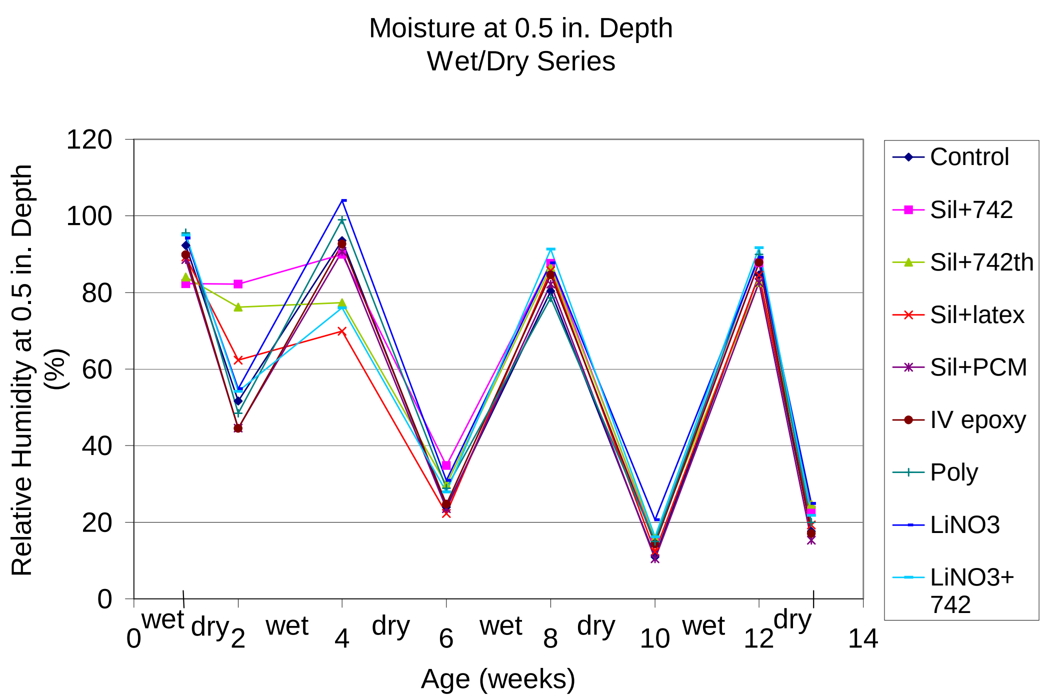


Figure 4-10 Moisture at 0.5 in. Depth, Wet/Dry Series

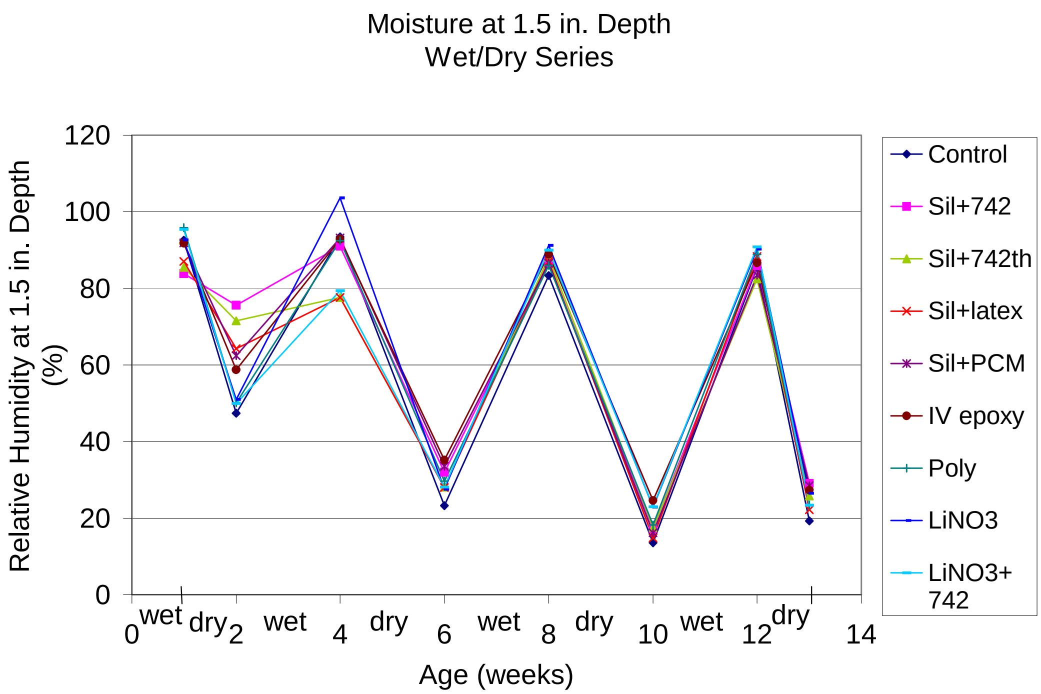


Figure 4-11 Moisture at 1.5 in.Depth, Wet/Dry Series

4.1.3.3 Damage Indices

The average damage indices for Specimens "h" and "k" are plotted versus the age of the specimens, in weeks, after fabrication. Figure 4-12 shows the index calculated as $DI = \sum_i w_i l_i$. Figure 4-13 shows the index calculated as $DI = \sum_i w_i^2 l_i$. Damage indices are a rapid, visual method to quantify the amount of cracking in the specimens.

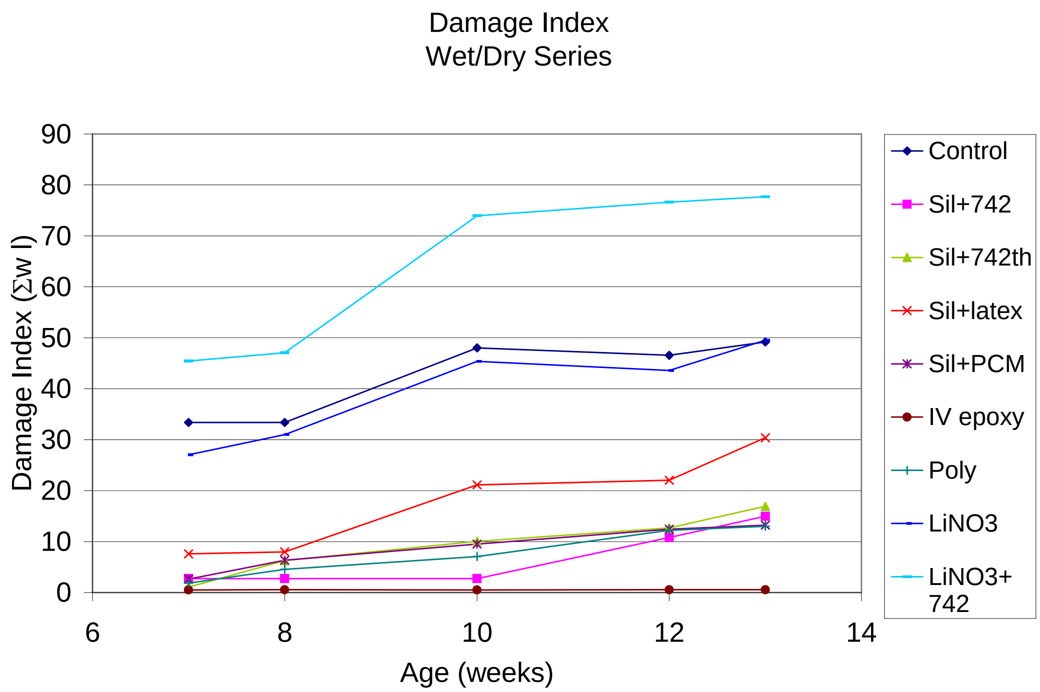


Figure 4-12 Damage Index "Σwl", Wet/Dry Series

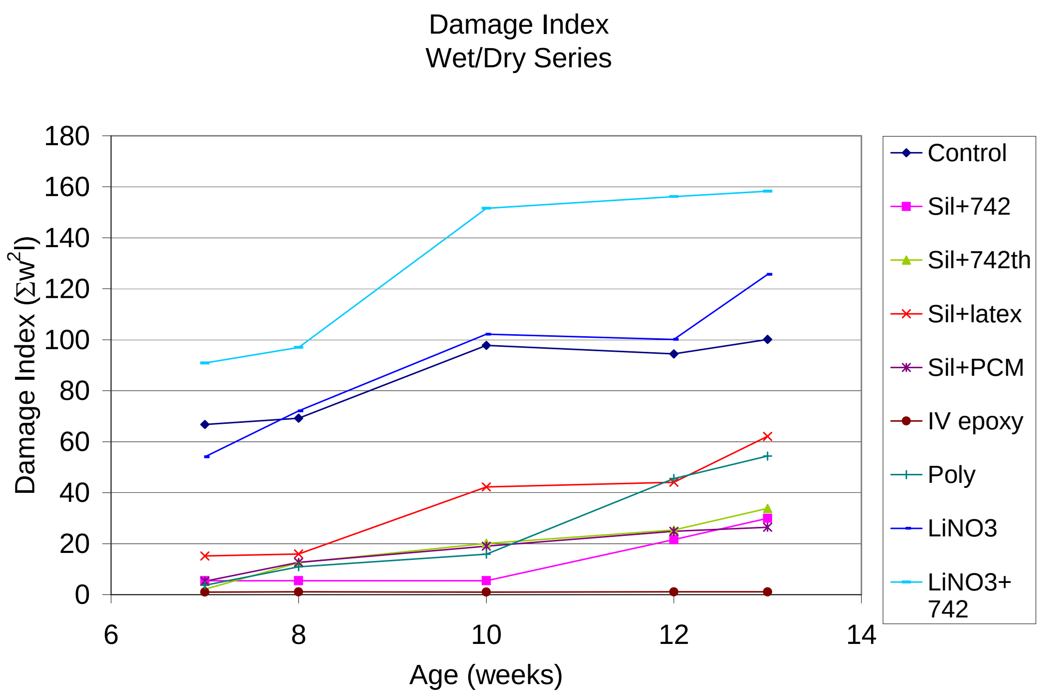


Figure 4-13 Damage Index "$\Sigma w^2 l$", Wet/Dry Series

4.2 RESULTS OF ACOUSTIC EMISSION MONITORING

Data collected from AE monitoring were used to calculate the Felicity ratio, defined as the load at the onset of significant acoustic emission divided by the maximum previous load. To do this, emission that signifies deterioration must be identified. The criteria for significant emission proposed in Study 1857 were used to analyze this data. These criteria were developed from tests on prestressed concrete girders with premature concrete deterioration (Chotickai 2001).

The criteria for significant emission are:

Curvature	>12
Historic Index	>1.5

Curvature is the rate of change of the slope of the cumulative signal strength curve. Historic index is a comparison of the signal strength of recent hits to the signal strength of all hits. Large increases in either of these measures indicated damage. Curvature and historic index were used here because both are independent of the rate of loading. A criteria for slope of the cumulative signal strength curve was also proposed by Study 1857, but not employed here because of the dependence of slope on the rate of loading (Chotickai 2001).

Table 4-1 through Table 4-6 present the results for the indoor and wet/dry series. In the first column of each table was recorded the maximum load after each 300-pound (1.3 kN) load increase. When significant emission was identified, the load at which the emission occurred was recorded in the table for the corresponding previous maximum load, and the Felicity ratio was calculated. For maximum loads where no significant emission was identified, "NSE" is recorded in the table. The tables also provide the number of hits recorded during unloading of the specimen, which is another indication of deterioration. The same procedure was carried out for the indoor series and the wet/dry series.

4.2.1 Indoor Series

Table 4-1 shows the results for a Fordyce control specimen and Table 4-2 for a Fordyce specimen with a mitigation technique. Table 4-3 and Table 4-4 show corresponding results for a Jobe specimen. These results are typical for all mitigation techniques evaluated.

Table 4-1 AE results for Indoor Series Specimen CF a

Specimen C F a

pour date	18-Sep
test date	23-Oct
age	35

previous max load (lb)	curvature load (lb)	FR	historic index load (lb)	FR	emission during unloading, hits
255	NSE	-	NSE	-	3
451	NSE	-	NSE	-	2
609	NSE	-	NSE	-	0
754	NSE	-	NSE	-	0
907	NSE	-	NSE	-	3
1073	NSE	-	NSE	-	3
1208	NSE	-	NSE	-	-

pour date	18-Sep
test date	14-Nov
age	57

previous max load (lb)	curvature load (lb)	FR	historic index load (lb)	FR	emission during unloading, hits
309	NSE	-	NSE	-	2
450	NSE	-	NSE	-	0
602	NSE	-	584	0.97	2
750	NSE	-	NSE	-	0
898	NSE	-	NSE	-	4
1058	NSE	-	NSE	-	0
1201	NSE	-	NSE	-	-

pour date	18-Sep
test date	19-Dec
age	92

previous max load (lb)	curvature load (lb)	FR	historic index load (lb)	FR	emission during unloading, hits
315	NSE	-	NSE	-	21
469	NSE	-	NSE	-	10
617	597	0.97	NSE	-	8
761	NSE	-	NSE	-	6
934	NSE	-	NSE	-	9
1062	NSE	-	NSE	-	12
1273	NSE	-	NSE	-	-

Table 4-2 AE results for Indoor Series Specimen M7F b

Specimen M 7F b

pour date	2-Oct
test date	6-Nov
age	35

previous max load	curvature		historic index		emission during
(lb)	load (lb)	FR	load (lb)	FR	unloading, hits
302	NSE	-	NSE	-	9
477	NSE	-	NSE	-	1
597	NSE	-	NSE	-	0
751	NSE	-	NSE	-	0
901	NSE	-	NSE	-	6
1053	NSE	-	NSE	-	9
1205	NSE	-	NSE	-	-

Table 4-3 AE results for Indoor Series Specimen CJ b

Specimen C J b

pour date	20-Sep
test date	1-Nov
age	42

previous max load	curvature		historic index		emission during
(lb)	load (lb)	FR	load (lb)	FR	unloading, hits
307.35	NSE	-	NSE	-	3
461.26	NSE	-	NSE	-	3
620.24	583	0.94	NSE	-	6
750.18	-	-	-	-	-

Table 4-4 AE results for Indoor Series Specimen M7J b

Specimen M7 J b

pour date	11-Oct
test date	9-Nov
age	29

previous max load (lb)	curvature load (lb)	curvature FR	historic index load (lb)	historic index FR	emission during unloading, hits
295	NSE	-	NSE	-	21
451	NSE	-	NSE	-	13
600	NSE	-	NSE	-	-

pour date	11-Oct
test date	5-Dec
age	55

previous max load (lb)	curvature load (lb)	curvature FR	historic index load (lb)	historic index FR	emission during unloading, hits
325	NSE	-	NSE	-	15
477	NSE	-	NSE	-	9
606	NSE	-	NSE	-	-

pour date	11-Oct
test date	15-Jan
age	96

previous max load (lb)	curvature load (lb)	curvature FR	historic index load (lb)	historic index FR	emission during unloading, hits
330	NSE	-	NSE	-	0
475	NSE	-	NSE	-	3
613	NSE	-	NSE	-	4
760	NSE	-	NSE	-	7
901	NSE	-	NSE	-	58
broken					

4.2.2 Wet/Dry Series

Table 4-5 shows the results for a control specimen, and Table 4-6 for a specimen with a mitigation technique. These results are typical for all mitigation techniques evaluated.

Table 4-5 AE results for Wet/Dry Series Specimen CJ g

Specimen C J g

pour date	1-Jan
test date	14-Feb
age	44

previous max load (lb)	curvature load (lb)	curvature FR	historic index load (lb)	historic index FR	emission during unloading, hits
321	NSE	-	NSE	-	0
469	NSE	-	NSE	-	1
607	NSE	-	NSE	-	1
788	NSE	-	NSE	-	-

pour date	1-Jan
test date	14-Mar
age	72

previous max load (lb)	curvature load (lb)	curvature FR	historic index load (lb)	historic index FR	emission during unloading, hits
374	NSE	-	NSE	-	0
461	NSE	-	NSE	-	2
633	NSE	-	NSE	-	2
782	NSE	-	NSE	-	-

Table 4-6 AE results for Wet/Dry Series Specimen M17J g

Specimen M17 J g

pour date	30-Dec
test date	12-Feb
age	44

previous max load (lb)	curvature load (lb)	curvature FR	historic index load (lb)	historic index FR	emission during unloading, hits
397	NSE	-	NSE	-	0
570	NSE	-	NSE	-	0
770	NSE	-	NSE	-	0
792	NSE	-	783	0.99	-

pour date	30-Dec
test date	12-Mar
age	72

previous max load (lb)	curvature load (lb)	curvature FR	historic index load (lb)	historic index FR	emission during unloading, hits
302	NSE	-	NSE	-	0
509	NSE	-	NSE	-	1
643	NSE	-	NSE	-	0
811	NSE	-	NSE	-	-

CHAPTER 5

Significance of Test Results

This chapter discusses the significance of the test results presented in Chapter 4. Results of the three exposure series are evaluated based on water impermeability and water-vapor permeability, and on shrinkage. Damage indices and AE monitoring are used to quantify the amount of cracking.

5.1 SIGNIFICANCE OF EXPANSION AND MOISTURE TESTING

When evaluating the test data, two concepts appeared to be most useful for understanding the expansion observed. The first concept is the impermeability to liquid water and the permeability to water vapor of the mitigation techniques. Water impermeability and water-vapor permeability were identified in the literature search as essential prerequisites for mitigation technique to be effective at treating ASR, DEF, or both.

The second concept is shrinkage. In hardened concrete, shrinkage occurs by three dominant mechanisms: drying shrinkage; carbonation shrinkage; and autogenous shrinkage. Others shrinkage mechanisms have been identified by various authors. Different mechanisms are often lumped together because of the difficulty in distinguishing among them (Wittmann 1982, Neville 1981). The most important of these is drying shrinkage, the volume change that occurs by the loss of water from the pores of the cement paste. Drying produces shrinkage in the range of 350-650 x 10^{-6} $\mu\varepsilon$ (Somayaji 2001). Carbonation shrinkage occurs by the chemical reaction of calcium hydroxide in the cement with carbon dioxide in the air. A product of the reaction is water, which evaporates and causes a decrease in volume at the surface (Wittmann 1982). Carbonation shrinkage is a long-term effect (Neville 1981). Autogenous shrinkage is the volume change that occurs because of hydration of the cement with no movement of water to or from the paste (Neville 1981). Autogenous shrinkage is mostly a concern for mixes with low water to cement (w:c) ratios because less water is available for hydration. The average w:c ratio of the test specimens is 0.42, although several mixes dropped to 0.33; as a consequence, autogenous shrinkage should not be significant in this study.

5.1.1 Indoor Series

For the indoor series, the specimens were aged for the entire test duration in the storage containers at 100% relative humidity. Because the specimens were never in contact with liquid water, the test cannot be used to evaluate the mitigating effect of impermeability to liquid water. All test results are considered due to the effects of the water-vapor permeability of the different mitigation techniques.

Although relative humidity readings were not taken for this series, it can be assumed that the relative humidity of the specimens was very high when the mitigation techniques were applied, because the specimens had been aged for one week in 100% relative humidity. Under these conditions, if a mitigation technique is water-vapor permeable, the relative humidity of the specimen would be kept high, and ASR/DEF expansion would be expected to continue at a constant or increasing rate. Such expansion would cease only when the reactive material had been consumed. If the mitigation technique is not water-vapor permeable, the moisture contained inside would be consumed by hydration and ASR/DEF expansion, and such expansion will decrease over time. The total expansion would be less than in the previous case.

Concrete maintained in a moist environment from the time of casting will swell from absorption of water into the cement paste, to about 100-150 x 10^{-6} με (Neville 1981). This expansion occurs over several days and then levels off. For this series, drying or carbonation shrinkage is not possible because the specimens were aged for the entire test duration at 100% relative humidity.

Most of the Jobe specimens showed positive expansion for the duration of the test, and a decrease in expansion over time. At 13 weeks, the expansion of most of the specimens treated with mitigating techniques is slightly less than the expansion for the control specimens, and there is little difference between the behaviors of the individual techniques. Judging by this, either all the mitigation techniques are water-vapor impermeable and mitigate the deterioration, or a moist environment alone does not provide enough water to maintain the expansive reaction.

In the Fordyce specimens, expansion is very small for the entire test duration. The Fordyce fine aggregate has a 14-day ASTM C 1260 expansion less than half of that for the Jobe fine aggregate (Bauer 2001). Several Fordyce specimens experienced negative expansion at different points during the test. Autogenous shrinkage is a likely explanation for negative expansion at 1 week; apparent negative expansion at later ages is most likely a result of scatter in data.

5.1.2 Outdoor Series

In the outdoor series, the specimens were exposed both to liquid water in the form of rain, and to water vapor in the air. Because of this exposure, the outdoor series theoretically can be used to evaluate both water impermeability and water-vapor permeability.

Figure 5-1 shows the relative humidity of the Jobe specimens for the outdoor series, and also the total daily rainfall and average daily ambient relative humidity. Clearly, the relative humidity of the specimens increases when there is rainfall, and decreases when there is not. On the other hand, a correlation between ambient relative humidity and relative humidity of the specimens is not so apparent. The ambient relative humidity fluctuates considerably, even within a single day. The relative humidity of a specimen cannot respond as quickly, and the ambient relative humidity can be expected to change before any appreciable difference can be seen in the relative humidity of the specimen. The outdoor series, therefore, is considered an evaluation of water impermeability only.

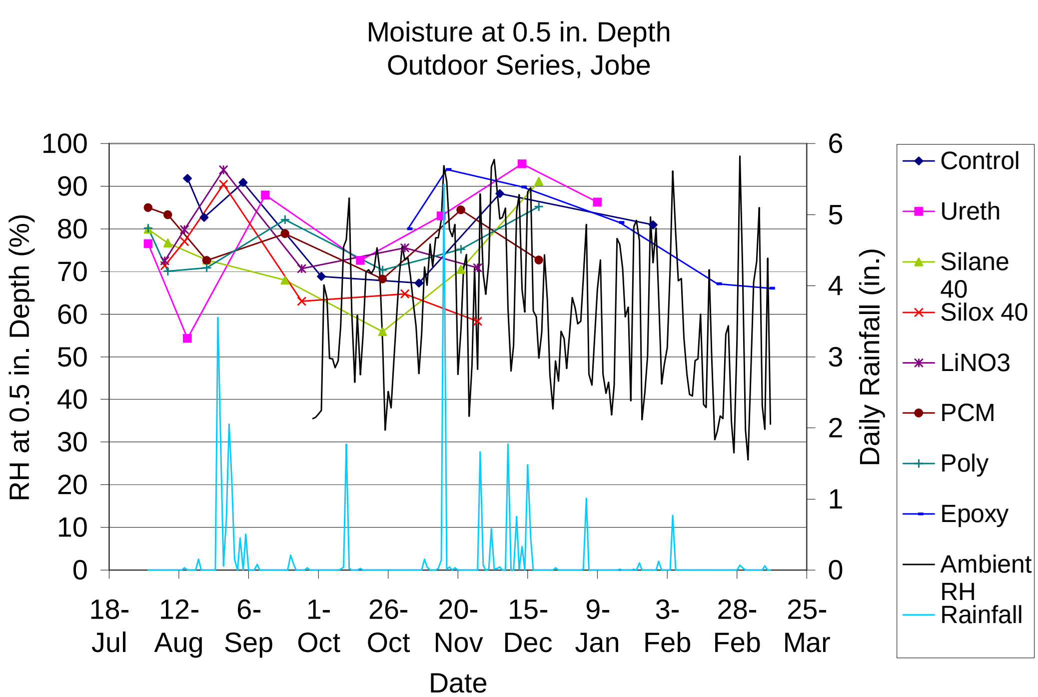


Figure 5-1 Moisture in specimens plotted against rainfall and ambient relative humidity

The outdoor series also provides evidence that the indoor series is not a useful test for differentiating among treatments. The indoor series is a measure of water-vapor permeability only, but it is seen that relative humidity alone appears to have considerably less influence on the expansion due to ASR/DEF deterioration than exposure to liquid water. Field observations also show that portions of girders directly in contact with liquid water, such as under joints or scuppers, have considerably worse deterioration than the interior girders, which are covered by the deck (Boenig 2000). The mitigation techniques in the indoor series, therefore, behave similarly because not enough water was provided to promote the deterioration reaction.

For both Jobe and Fordyce specimens, expansion and relative humidity clearly increase during rainy periods and decrease over dry periods.

Jobe specimens treated with silane, siloxane, or $LiNO_3$ behave similarly to the control specimens. Jobe specimens treated with PCM, moist-cured urethane, and polyurethane have expansion slightly greater than the control specimens. Toward the end of the readings, specimens treated with PCM and moist-cured urethane diverge from the readings for the other techniques.

Similar to the indoor series, the Fordyce specimens exhibit less expansion than the Jobe specimens. Toward the end of the readings, specimens treated with PCM, moist-cured urethane, linseed oil, or $LiNO_3$ plus siloxane diverge from the readings for the other techniques. The remaining specimens behaved like the control specimens.

From readings at Week 1, the relative humidity of the specimens at time of coating was between upper 70% and lower 90%, and was mostly about 80%. If the mitigation technique is water-impermeable, the initial moisture will be consumed by hydration and ASR/DEF expansion; over time, the expansion will decrease. Because the relative humidity of the specimens increases with rain, there is some degree of water permeability.

Both drying shrinkage and wetting expansion can affect this series. The former is governed by water-vapor permeability, and the latter by water impermeability.

Because none of the mitigated specimens varies distinctly from the control specimens, it is difficult to determine which techniques have the greatest water impermeability. The lack of differentiation can be attributed to the exposure condition itself. The total amount of rain is low, and the duration of exposure to rain is very short. It is possible that not enough water was available for ASR/DEF deterioration to proceed.

During application of the PCM to the specimens in all series, the researcher observed that it was unlike any of the other mitigation techniques. While the other treatments provided a smooth, sleek coating, the PCM was granular and slightly porous. From appearance, the PCM did not seem to be water-impermeable.

5.1.3 Wet/Dry Series

Like the indoor series, the prisms of the wet/dry series were never in contact with liquid water; therefore, the test cannot be used to evaluate the water impermeability of the mitigation techniques. All test results are considered on the basis of water-vapor permeability.

All specimens show negative expansion and decrease in relative humidity over dry cycles, and positive expansion and increase in relative humidity over wet cycles. After six weeks, there is little difference between the relative humidity readings for different techniques at both 0.5 in. (12 mm) and 1.5 in. (40 mm) depths. Because the relative humidity of the specimens is easily correlated with the exposure cycle, all the mitigation techniques appear to be water vapor-permeable.

It is possible that prolonged exposure to very high temperature altered the water-vapor permeability of the treatments. Although all treatments were allowed to cure for the manufacturers' specified time before placement in the storage environment, a few treatments were observed to be sticky for the first several weeks in the high temperature.

As explained with the indoor series, concrete expands when maintained in a moist environment. The expansion seen at one week is due to this, and possibly also to expansion from ASR/DEF. Assuming no ASR/DEF deterioration, successive dry cycles are expected to promote drying shrinkage and wet cycles to promote wetting expansion. While 30% to 60% of the initial drying shrinkage is permanent, concrete experiences reversible shrinkage and expansion when exposed to alternating dry and wet cycles (Murdock 1979). In these tests, the magnitude of negative expansion after a dry cycle is consistent for all techniques at 6, 10, and 13 weeks, suggesting that the dominant mechanism is drying shrinkage. At 2 weeks, most specimens continue to show expansion, although much less than before. The change in relative humidity from Week 1 to Week 2 is less than for subsequent dry cycles. This is probably because more water is retained in the specimens, allowing for deterioration to occur along with or prior to the effect of drying shrinkage.

The magnitude of positive expansion after wet cycles at 4 and 8 weeks varies, however, indicating that deterioration may be occurring during the wet cycles along with wetting expansion. By Week 12, the expansion is similar for all but one specimen, and the corresponding increase in relative humidity is the same as the decrease over the previous period. At this point, any deterioration can be assumed to have ceased, and the only mechanism occurring is wetting expansion.

In comparison to the outdoor series, the wet/dry series is a very severe exposure, and is not an accurate or useful indication of the expansion caused by ASR, DEF, or both. The internal relative humidity of the outdoor specimens does not fall below 50%, whereas the wet/dry series specimens are dried to a relative humidity of 10%. The ambient relative humidity in Austin, recorded by Project 4085 between September 2001 to April 2002, ranges from upper 10% to upper 90%, with an average value of 60%. The relative humidity of the storage environment during dry cycles is less than 10%. By Week 6, the expansion and shortening are controlled primarily by reversible wetting and drying deformations. Any potential for expansion from ASR/DEF deterioration appears to be precluded by the extreme drying cycle.

5.1.4 Damage Indices

Damage indices were recorded only for the wet/dry series. The plots of $DI = \sum_i w_i l_i$ and $DI = \sum_i w_i^2 l_i$ both show the trend of increase in damage index with time. Over the period of observation, none of the specimens developed cracks any wider than 0.003 inches (0.08 mm). Because the cracks remain narrow and of comparable width for all mitigation techniques, squaring the width term in the second formulation of the damage index does not affect the result.

Figure 5-2 shows sketches of the cracks used to calculate damage indices for a control specimen, a Type IV epoxy (M20) specimen, and a silane+742 (M16) specimen. Very little surface cracking is observed on the silane+742 and Type IV epoxy specimens, as seen in Figure 5-2. Silane+742th, silane+PCM, and polyurethane also exhibit small damage indices, while silane+latex is slightly greater than the previous five mitigation techniques. These six mitigation techniques prevent or retard surface cracking by preventing rapid moisture loss from the surface. Also, cracks were observed under the surface of the painted specimens, but were not included in the damage indices because the paint itself had not cracked.

Both the $LiNO_3$ and $LiNO_3$+742 specimens exhibited cracking equivalent to or greater than the control specimens. The lithium nitrate, which may only penetrate slightly into the surface by brush application, increases surface cracking.

Figure 5-2 Sketches of cracks on specimens of wet/dry series

5.2 SIGNIFICANCE OF ACOUSTIC EMISSION MONITORING

5.2.1 Indoor Series

For all the specimens, very little significant emission was recorded. When significant emission was identified, the Felicity ratio was 0.94 or greater. A Felicity ratio this large does not represent deterioration (Chotickai 2001). While the specimens do exhibit cracking under load, the cracks are not sufficiently large to be of structural concern. Specimens tested after a year of aging would most likely have developed structural cracking and exhibit significant emission.

As observed during testing, the Jobe specimens produced many more AE hits than the Fordyce specimens. Although the testing procedure prescribes holding the load until quieting (cessation of emission), the Jobe specimens rarely quieted. Load was held on these for two minutes. The greater number of hits recorded for the Jobe specimens indicates that these specimens had more internal cracks than the Fordyce specimens.

5.2.2 Wet/Dry Series

As with the indoor series, very little significant AE emission was recorded. The emission during unloading of these specimens is less than for the indoor series. The same conclusion can be reached: deterioration had not proceeded far enough to create structurally significant cracking.

CHAPTER 6

Summary, Conclusions, and Recommendations

6.1 SUMMARY

This thesis describes part of the work associated with TxDOT Study 4069 ("Mitigation Techniques for In-Service Structures with Premature Concrete Deterioration"). TxDOT is interested in developing techniques for mitigating or remediating premature concrete deterioration due to alkali silica reaction (ASR), delayed ettringite formation (DEF), or both, in order to extend the life of potentially affected structures. The parts of Study 4069 reported here consist of: a literature search for mitigation or remediation techniques; fabrication of concrete specimens intentionally susceptible to premature deterioration; and the application and monitoring of the mitigation techniques using laboratory testing and acoustic emission (AE) procedures.

6.1.1 Literature Search

The literature search was conducted to identify treatments being used or tested worldwide to mitigate or remediate deterioration from ASR, DEF, or both. The proposed treatments were evaluated, according to published results, for use on Texas Department of Transportation structures displaying this damage. In addition, treatments used to mitigate other types of concrete deterioration were explored for their potential use to mitigate or remediate ASR/DEF deterioration.

The search identified treatments that were effective at reducing expansion of ASR-affected specimens or preventing other types of concrete deterioration. These treatments are: silane; siloxane; linseed oil; high-molecular-weight methacrylate (HMWM), epoxy, polymer-modified cement mortar (PCM); urethane; and lithium nitrate.

It was recommended to use these treatments, separately or in combination, on specimens made with aggregates and cement known to produce ASR/DEF deterioration, and to evaluate their effectiveness by measuring specimens' expansion and internal moisture content, and by monitoring them with acoustic emission techniques. Applications of these techniques to specific structures, such as FM 1929 at Lake Ivie, are discussed in theses and reports for Study 1857. It is not discussed further here.

6.1.2 Expansion and Moisture Testing

Specimens were fabricated according to ASTM C 1293-95 with fine aggregates known to be reactive, and high-alkali cement. The specimens had a square cross-section of 3 in. (75 mm) and a nominal length of 10 in. (250 mm). Plastic sleeves were cast into the specimens at depths of 1.5 in. (40 mm) and 0.5 in. (12 mm) in order to measure internal relative humidity.

Expansion (defined as the change in length between successive measurements) and internal relative humidity were measured for specimens exposed to three series of environmental conditions: an indoor series; an outdoor series; and a wet/dry series.

The indoor series used an accelerated ASTM C 1293 procedure of high-temperature storage, reducing the required testing time from 2 years to 13 weeks. The temperature of the storage environment is increased from 38°C to 60°C. The length of each specimen was recorded at 1 week, 2 weeks, 4 weeks, 8 weeks, and 13 weeks. Moisture readings were not taken for this series because the specimens were kept at constant humidity in the storage containers.

The specimens in the outdoor series were coated and aged outside in order to subject them to conditions as similar as possible to actual field conditions. Length and moisture readings were taken at 1 week, 2 weeks, 4 weeks, 8 weeks, 13 weeks, 17 weeks, 21 weeks, and 25 weeks after fabrication.

For the wet/dry series, drastic changes in humidity were imposed on the specimens in order to evaluate the effectiveness of each mitigation treatment for water impermeability and water-vapor permeability. Length and moisture readings were taken at 1 week, 2 weeks, 4 weeks, 6 weeks, 8 weeks, 10 weeks, 12 weeks, and 13 weeks after fabrication. To provide a rapid visual measure of cracking, damage indices were calculated at 7 weeks, 8 weeks, 10 weeks, 12 weeks, and 13 weeks after fabrication.

6.1.3 Acoustic Emission Monitoring

Acoustic emission monitoring was used to evaluate the deterioration in the specimens from the indoor series and wet/dry series. The procedures and criteria developed in Project 1857 were used (Chotickai 2001). The important data collected from testing includes amount of emission during loading, amplitude of hits, historic index, and Felicity ratio.

The prisms were loaded under third-point bending, per ASTM C 78. To determine the Felicity ratio, a stepped loading schedule was used. The Felicity ratio, defined as the load at the onset of significant acoustic emission divided by the maximum previous load, is the most useful AE measure of structural deterioration (Tinkey 2000).

6.2 Conclusions

- From the indoor series, most of the Jobe specimens (those specimens made with Jobe fine aggregate) show positive expansion for the duration of the test, and a decrease in expansion over time. There is little difference between the behaviors of the individual techniques. Judging by this, a moist environment alone does not provide enough water to maintain the expansive reaction. The Fordyce specimens (those specimens made with Fordyce fine aggregate) show very small expansion for the entire test duration. The test procedure used for the indoor series is not useful for differentiating among treatments.
- From the outdoor series, expansion and relative humidity of both Jobe and Fordyce specimens increase during rainy periods and decrease over dry periods. A correlation between ambient relative humidity and relative humidity of the specimens is not so apparent.
- The lack of differentiation between performance of the mitigation techniques for the outdoor series can be attributed to the lack of sufficient water for ASR/DEF deterioration to proceed.
- The wet/dry series is a very severe exposure, and is not a realistic predictor of the expansion caused by ASR, DEF, or both.
- Silane+742, silane+742th, silane+latex, silane+PCM, Type IV epoxy, and polyurethane prevent or retard surface cracking by preventing rapid moisture loss from the surface. Lithium nitrate increases surface cracking.
- Acoustic emission monitoring was successfully used on small specimens, although the cracking in these specimens was not great enough for the AE to identify structural deterioration.

6.3 RECOMMENDATIONS

In this study, no particular mitigation technique was determined to be effective at reducing expansion from premature concrete deterioration under the three exposure series used. From the results of the indoor and the outdoor series, ambient relative humidity appears to have considerably less influence on the expansion due to ASR/DEF deterioration than exposure to liquid water. Because the outdoor series, which did provide exposure to rain, did not differentiate between performance of the mitigation techniques, a test series should be conducted that exposes the specimens to a large, measurable quantity of liquid water at regular intervals. Increasing the amount of water available for the expansive reaction should provide a greater opportunity to distinguish the efficacy of the different mitigation techniques. In Appendix H, one possible test procedure is proposed. It involves ASTM C 1293 specimens treated with mitigation techniques and exposed to cycles of immersion in water, storage at high temperature and 100% relative humidity, and drying in ambient temperature and relative humidity. The different mitigation techniques identified in this study should be further compared using the proposed test procedure.

At this time, it is recommended that current structures with premature concrete deterioration need not be treated with a mitigation technique. Study 1857 found that field girders with the largest crack widths were less damaged than the wetted laboratory-tested box girders. The flexural capacity of the damaged box girders was determined not to be significantly lower than for undamaged girders (Boenig 2000). Results from the first 4 weeks of the wet/dry series suggest that painted specimens do not behave significantly better or worse than control specimens. Therefore, paint may be applied to exterior girders for visual appearance, but need not be applied to interior girders, which have little exposure to rain.

APPENDIX A

Concrete Mixtures and Fresh Properties

Specimen				Coarse Aggregate SSD Weight lb/yd^3	Fine Aggregate SSD weight lb/yd^3	Cement lb/yd^3	Water lb/yd^3	W:C	Unit Weight lb/ft^3	Yield ft^3	Slump in.	Total Air Content % (Gravimetric)	Total Air Content % (Pressure Method)
Indoor Series													
C		F	a,b,c	1769.6	1080.9	708	295.3	0.42	136.8	0.92	0.5+	10.1	2
M	1	F	a,b,c	1769.6	1080.9	708	289.1	0.41	135.2	0.93	5.25	11.0	1.7
M	2	F	a,b,c	1769.6	1080.9	708	295.3	0.42	136.8	0.92	0.5+	10.1	1.7
M	3	F	a,b,c	1769.6	1080.9	708	289.1	0.41	135.2	0.93	5.25	11.0	1.7
M	4	F	a,b,c	1769.6	1080.9	708	295.3	0.42	136.8	0.92	0.5+	10.1	1.7
M	5	F	a,b,c	1769.6	1080.9	708	295.3	0.42	136.8	0.92	0.5+	10.1	1.7
M	6	F	a,b,c	1769.6	1080.9	708	289.1	0.41	135.2	0.93	5.25	11.0	1.7
M	7	F	a,b,c	1769.6	1080.9	708	289.1	0.41	135.2	0.93	5.25	11.0	1.7
M	8	F	a,b,c	1769.6	1080.9	708	235.0	0.33	145.2	0.85	3	6.0	1.7
M	9	F	a,b,c	1769.6	1080.9	708	235.0	0.33	145.2	0.85	3	6.0	1.7
M	10	F	a,b,c	1769.6	1080.9	708	235.0	0.33	145.2	0.85	3	6.0	1.7
M	11	F	a,b,c	1769.6	1080.9	708	235.0	0.33	145.2	0.85	3	6.0	1.7
M	12	F	a,b,c	1769.6	1080.9	708	291.1	0.41	145.2	0.52	-	5.9	1.7
M	13	F	a,b,c	1769.6	1080.9	708	291.1	0.41	145.2	0.52	-	5.9	1.7
M	14	F	a,b,c	1769.6	1080.9	708	250.8	0.36	144.2	0.85	3.25	5.7	1.7
M	15	F	a,b,c	1769.6	1080.9	708	250.8	0.36	144.2	0.85	3.25	5.7	1.7

Specimen				Coarse Aggregate SSD Weight lb/yd^3	Fine Aggregate SSD weight lb/yd^3	Cement lb/yd^3	Water lb/yd^3	W:C	Unit Weight lb/ft^3	Yield ft^3	Slump in.	Total Air Content % (Gravimetric)	Total Air Content % (Pressure Method)
Indoor Series													
C		J	a,b,c	1769.6	1050.7	708	299.6	0.42	145.2	0.88	4	1.1	-
M	1	J	a,b,c	1769.6	1050.7	708	279.0	0.40	-	-	3.5	-	-
M	1	J	replace	1769.6	1050.7	708	288.3	0.41	144	0.87	2.75	3.0	1.8
M	2	J	a,b,c	1769.6	1050.7	708	299.6	0.42	145.2	0.88	4	1.1	-
M	3	J	a,b,c	1769.6	1050.7	708	279.0	0.40	-	-	3.5	-	-
M	3	J	replace	1769.6	1050.7	708	288.3	0.41	144	0.87	2.75	3.0	1.8
M	4	J	a,b,c	1769.6	1050.7	708	299.6	0.42	145.2	0.88	4	1.1	-
M	5	J	a,b,c	1769.6	1050.7	708	299.6	0.42	145.2	0.88	4	1.1	-
M	6	J	a,b,c	1769.6	1050.7	708	279.0	0.40	-	-	3.5	-	-
M	6	J	replace	1769.6	1050.7	708	288.3	0.41	144	0.87	2.75	3.0	1.8
M	7	J	a,b,c	1769.6	1050.7	708	279.0	0.40	-	-	3.5	-	-
M	7	J	replace	1769.6	1050.7	708	288.3	0.41	144	0.87	2.75	3.0	1.8
M	8	J	a,b,c	1769.6	1050.7	708	301.0	0.43	146	0.86	3.5	0.4	1.9
M	9	J	a,b,c	1769.6	1050.7	708	301.0	0.43	146	0.86	3.5	0.4	1.9
M	10	J	a,b,c	1769.6	1050.7	708	301.0	0.43	146	0.86	3.5	0.4	1.9
M	11	J	a,b,c	1769.6	1050.7	708	301.0	0.43	146	0.86	3.5	0.4	1.9
M	12	J	a,b,c	1769.6	1050.7	708	288.3	0.41	144	0.87	2.75	3.0	1.8
M	13	J	a,b,c	1769.6	1050.7	708	288.3	0.41	144	0.87	2.75	3.0	1.8
M	14	J	a,b,c	1769.6	1050.7	708	289.2	0.41	144	0.87	3.75	3.5	2
M	15	J	a,b,c	1769.6	1050.7	708	289.2	0.41	144	0.87	3.75	3.5	2

Specimen				Coarse Aggregate SSD Weight lb/yd^3	Fine Aggregate SSD weight lb/yd^3	Cement lb/yd^3	Water lb/yd^3	W:C	Unit Weight lb/ft^3	Yield ft^3	Slump in.	Total Air Content % (Gravimetric)	Total Air Content % (Pressure Method)
Outdoor Series													
C		F	d,e,f	1769.6	1080.9	708	362.5	0.51	-	-	wet	-	1.6
M	1	F	d,e,f	1769.6	1080.9	708	311.7	0.44	144.2	0.32	2.25	0	-
M	2	F	d,e,f	1769.6	1080.9	708	311.7	0.44	144.2	0.32	2.25	0	-
M	3	F	d,e,f	1769.6	1080.9	708	296.9	0.42	-	-	wet	-	-
M	4	F	d,e,f	1769.6	1080.9	708	296.9	0.42	-	-	wet	-	-
M	5	F	d,e,f	1769.6	1080.9	708	296.9	0.42	-	-	wet	-	-
M	6	F	d,e,f	1769.6	1080.9	708	296.9	0.42	-	-	wet	-	-
M	7	F	d,e,f	1769.6	1080.9	708	275.3	0.39	-	-	wet	-	-
M	8	F	d,e,f	1769.6	1080.9	708	275.3	0.39	-	-	wet	-	-
M	9	F	d,e,f	1769.6	1080.9	708	275.3	0.39	-	-	wet	-	-
M	10	F	d,e,f	1769.6	1080.9	708	275.3	0.39	-	-	wet	-	-
M	11	F	d,e,f	1769.6	1080.9	708	362.5	0.51	-	-	wet	-	1.6
M	12	F	d,e,f	1769.6	1080.9	708	362.5	0.51	-	-	wet	-	1.6
M	13	F	d,e,f	1769.6	1080.9	708	362.5	0.51	-	-	wet	-	1.6
M	14	F	d,e,f	1769.6	1080.9	708	250.8	0.36	144.2	0.86	3.25	7.2	1.9
M	15	F	d,e,f	1769.6	1080.9	708	250.8	0.36	144.2	0.86	3.25	7.2	1.9

Specimen				Coarse Aggregate SSD Weight lb/yd^3	Fine Aggregate SSD weight lb/yd^3	Cement lb/yd^3	Water lb/yd^3	W:C	Unit Weight lb/ft^3	Yield ft^3	Slump in.	Total Air Content % (Gravimetric)	Total Air Content % (Pressure Method)
Outdoor Series													
C		J	d,e,f	1769.6	1050.7	708	291.6	0.41	147.2	0.71	3.5	0	1.7
M	1	J	d,e,f	1769.6	1050.7	708	315.9	0.45	-	-	2.75	-	-
M	2	J	d,e,f	1769.6	1050.7	708	321.7	0.46	-	-	2.75	-	-
M	3	J	d,e,f	1769.6	1050.7	708	290.9	0.41	-	-	4	-	-
M	4	J	d,e,f	1769.6	1050.7	708	290.9	0.41	-	-	4	-	-
M	5	J	d,e,f	1769.6	1050.7	708	290.9	0.41	-	-	4	-	-
M	6	J	d,e,f	1769.6	1050.7	708	290.9	0.41	-	-	4	-	-
M	7	J	d,e,f	1769.6	1050.7	708	291.6	0.41	147.6	0.71	2	0	2.1
M	8	J	d,e,f	1769.6	1050.7	708	291.6	0.41	147.6	0.71	2	0	2.1
M	9	J	d,e,f	1769.6	1050.7	708	291.6	0.41	147.6	0.71	2	0	2.1
M	10	J	d,e,f	1769.6	1050.7	708	291.6	0.41	147.6	0.71	2	0	2.1
M	11	J	d,e,f	1769.6	1050.7	708	291.6	0.41	147.2	0.71	3.5	0	1.7
M	12	J	d,e,f	1769.6	1050.7	708	291.6	0.41	147.2	0.71	3.5	0	1.7
M	13	J	d,e,f	1769.6	1050.7	708	291.6	0.41	147.2	0.71	3.5	0	1.7
M	14	J	d,e,f	1769.6	1050.7	708	289.2	0.41	144	0.87	3.75	3.5	2
M	15	J	d,e,f	1769.6	1050.7	708	297.6	0.42	144	0.87	3.75	3.5	2

Specimen				Coarse Aggregate SSD Weight lb/yd^3	Fine Aggregate SSD weight lb/yd^3	Cement lb/yd^3	Water lb/yd^3	W:C	Unit Weight lb/ft^3	Yield ft^3	Slump in.	Total Air Content % (Gravimetric)	Total Air Content % (Pressure Method)
Wet/Dry Series													
C		J	g,h,j,k	1769.6	1050.7	708	295.9	0.42	-	-	5	-	-
M	16	J	g,h,j,k	1769.6	1050.7	708	298.0	0.42	-	-	7	-	-
M	17	J	g,h,j,k	1769.6	1050.7	708	298.0	0.42	-	-	7	-	-
M	18	J	g,h,j,k	1769.6	1050.7	708	298.0	0.42	-	-	7	-	-
M	19	J	g,h,j,k	1769.6	1050.7	708	295.9	0.42	-	-	5	-	-
M	20	J	g,h,j,k	1769.6	1050.7	708	295.9	0.42	-	-	5	-	-
M	21	J	g,h,j,k	1769.6	1050.7	708	265.9	0.38	-	-	3.5	-	-
M	22	J	g,h,j,k	1769.6	1050.7	708	265.9	0.38	-	-	3.5	-	-
M	23	J	g,h,j,k	1769.6	1050.7	708	265.9	0.38	-	-	3.5	-	-

APPENDIX B

Results of Expansion and Moisture Testing

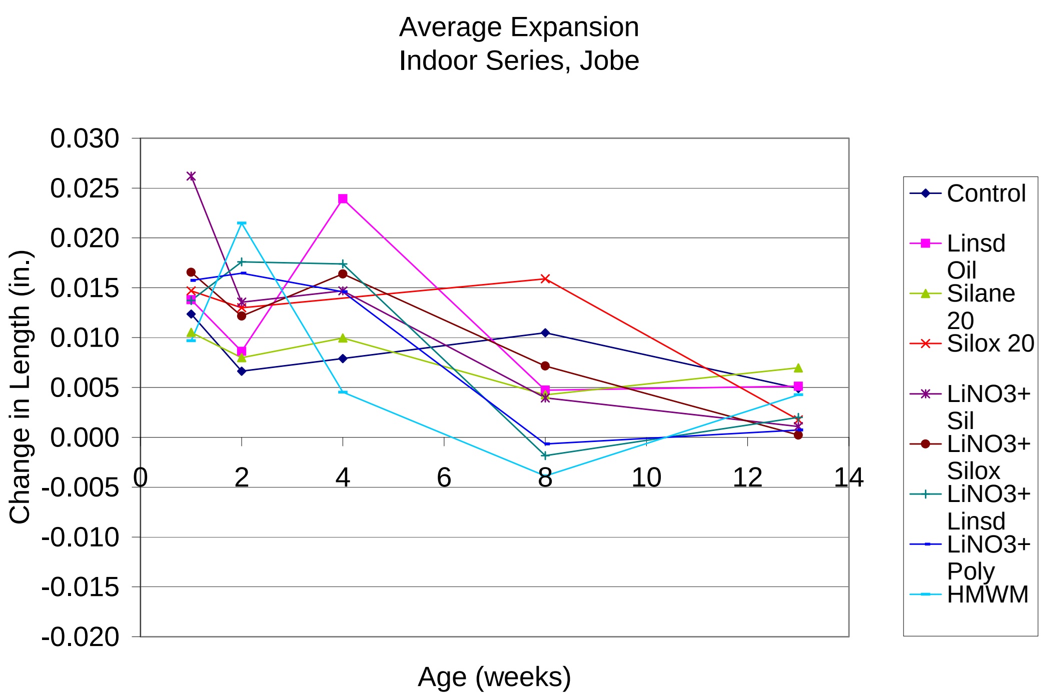


Figure B-1 Average Expansion, Indoor Series, Jobe Specimens

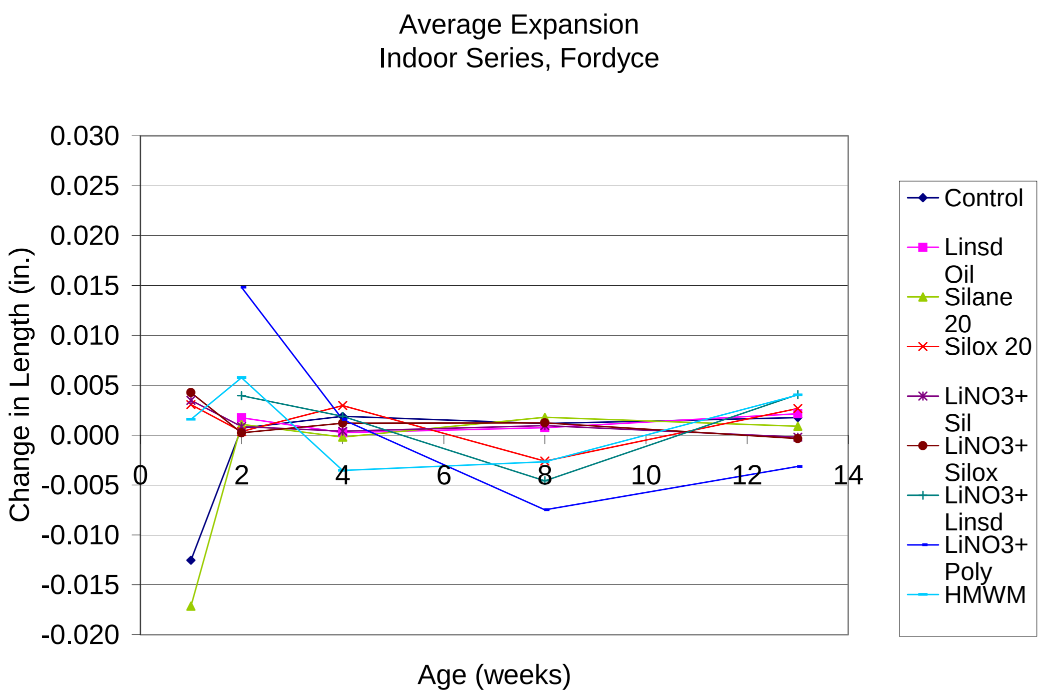


Figure B-2 Average Expansion, Indoor Series, Fordyce Specimens

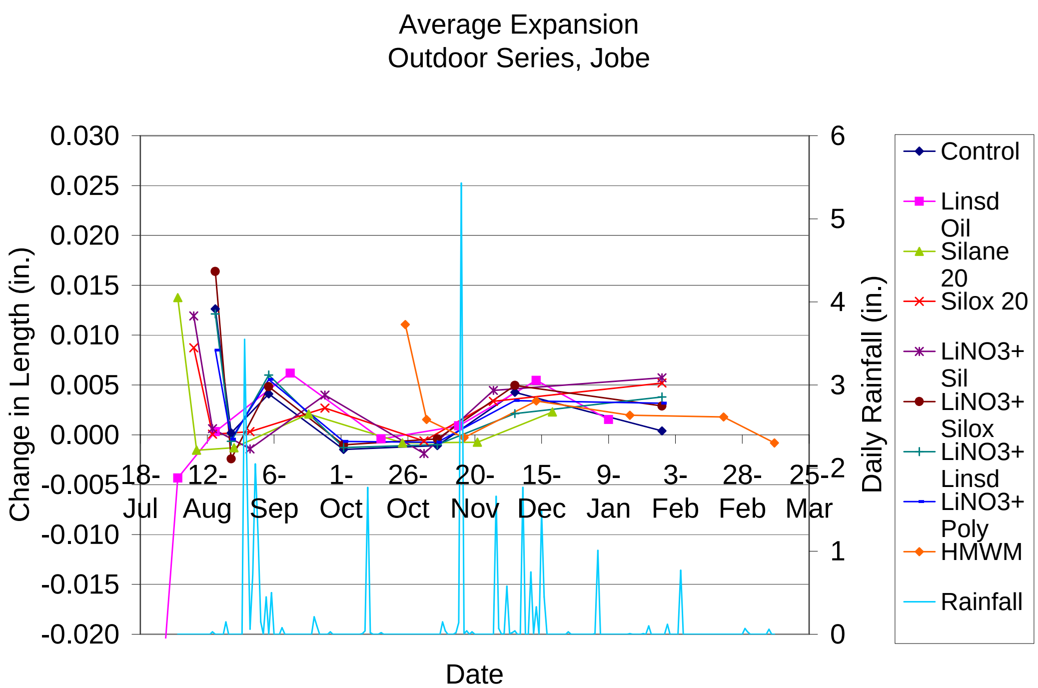


Figure B-3 Average Expansion, Outdoor Series, Jobe Specimens

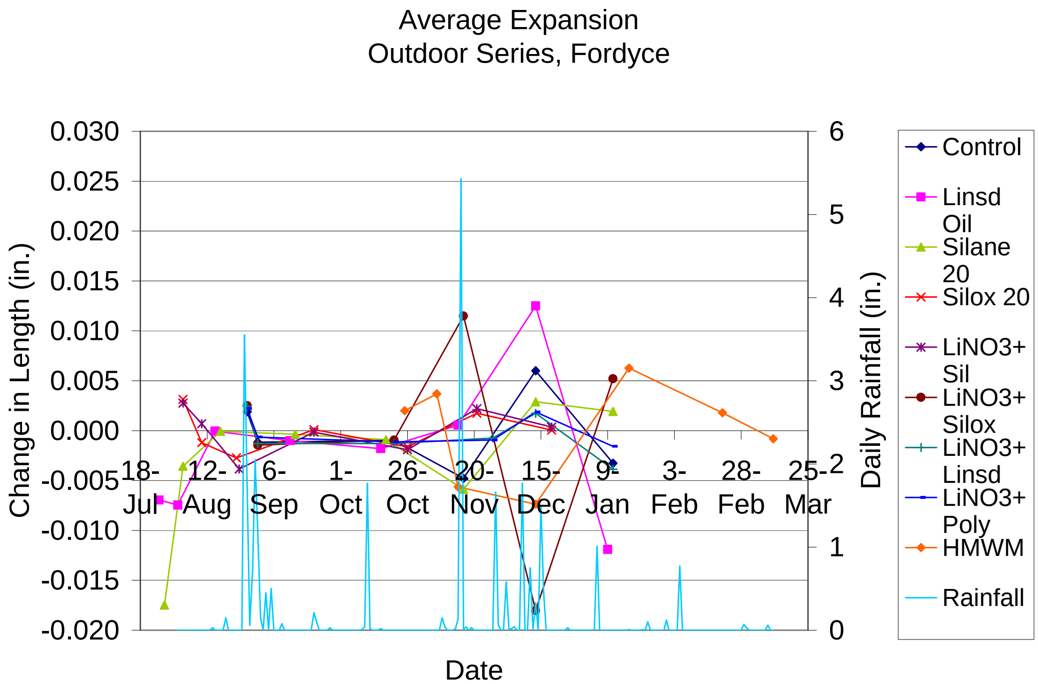


Figure B-4 Average Expansion, Outdoor Series, Fordyce Specimens

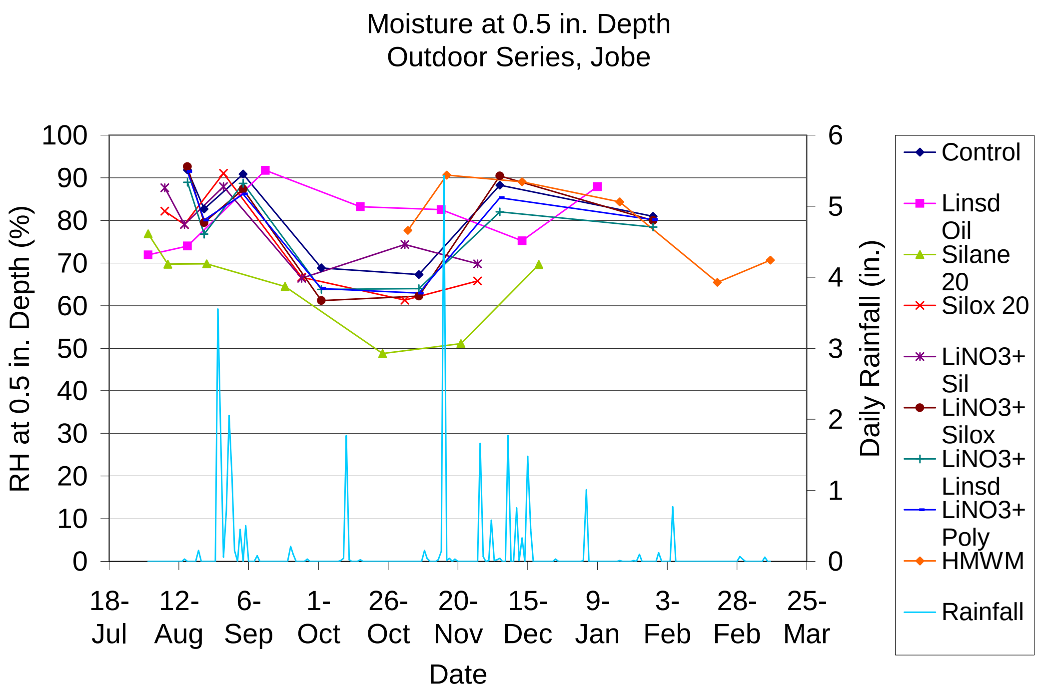


Figure B-5 Moisture at 0.5 in. Depth, Outdoor Series, Jobe Specimens

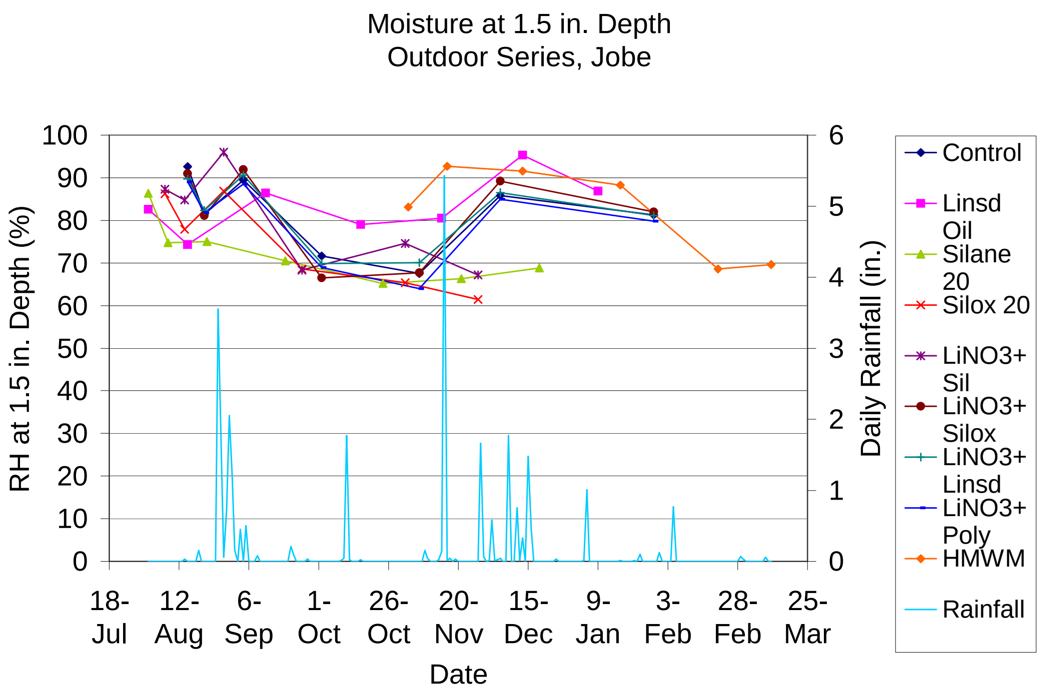


Figure B-6 Moisture at 1.5 in. Depth, Outdoor Series, Jobe Specimens

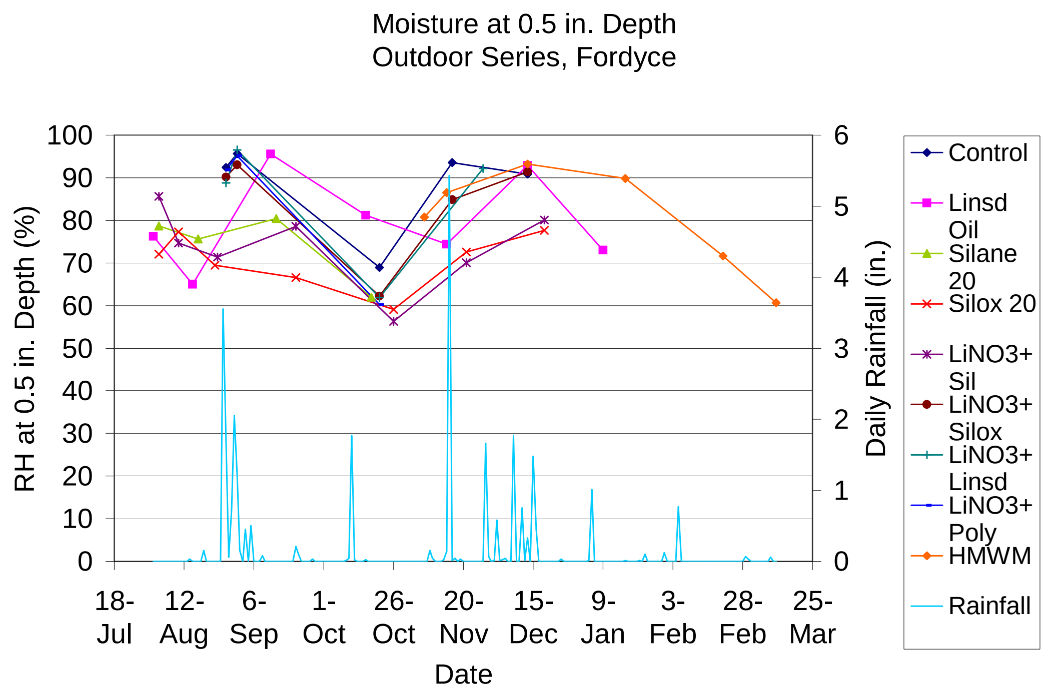


Figure B-7 Moisture at 0.5 in. Depth, Outdoor Series, Fordyce Specimens

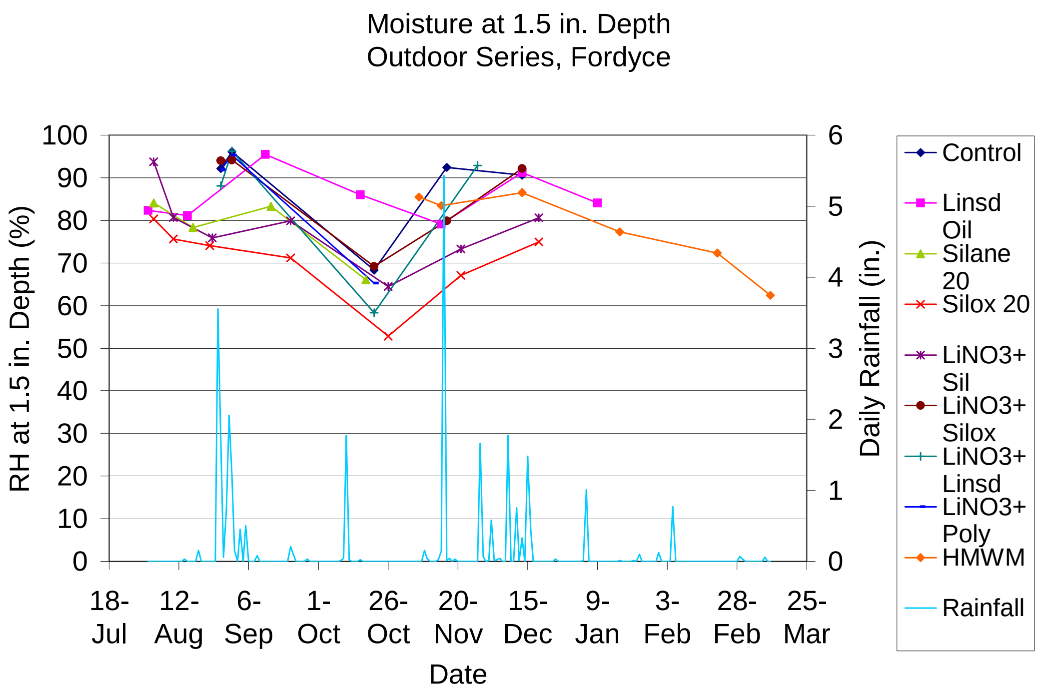


Figure B-8 Moisture at 1.5 in. Depth, Outdoor Series, Fordyce Specimens

APPENDIX C

Expansion and Moisture Data from Indoor Series

Treatment	control	slump	0.5+	in.	weight measure	7.2	lb.	cement	23	lb.
Product		unit weight	136.8	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	C	yield	0.921053		weight total	41.4	lb.	NaOH	40.5	g
Aggregate	F	air content	10.1	%				water	6	lb.
Exposure	a,b,c	air (pressure)	2	%	fine moisture	12	%	fine	39.4	lb.
		w:c	0.42		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
		18-Sep	18-Sep												
pour		18-Sep	18-Sep												
remove mold	0	19-Sep	19-Sep												
measure 0	0	19-Sep	19-Sep	0	blue										
measure 1	1 week	26-Sep	26-Sep	7	red		-0.0087			-0.0237			-0.0052		
measure 2	2 weeks	3-Oct	3-Oct	14	blue		-0.0079			-0.0235			-0.0041		
measure 4	4 weeks	17-Oct	17-Oct	28	red		-0.0043			-0.0227			-0.0028		
measure 8	8 weeks	14-Nov	14-Nov	56	blue		-0.0036			-0.0216			-0.0011		
measure 13	13 weeks	19-Dec	19-Dec	104	red		-0.0016			-0.0206			0.0012		

Treatment	urethane	slump	5.25	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Cevathane	unit weight	135.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M1	yield	0.00		weight total	41	lb.	NaOH	40.7	g
Aggregate	F	air content	0.0	%				water	6.4-.25	lb.
Exposure	a,b,c	air (pressure)	1.7	%	fine moisture	11	%	fine	39	lb.
		w:c	0.41		coarse moisture	SSD (damp)				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		2-Oct	2-Oct												
remove mold	0	3-Oct	3-Oct												
measure 0	0	3-Oct	3-Oct	0	blue		0.0459			-0.0257			0.0032		
measure 1	1 week	10-Oct	10-Oct	7	red		0.0489			-0.0219			0.0067		
measure 2	2 weeks	17-Oct	17-Oct	14	blue		0.0496			-0.0220			0.0063		
measure 4	4 weeks	31-Oct	31-Oct	28	red		0.0521			-0.0188			0.0096		
measure 8	8 weeks	28-Nov	-	56	blue		-			-			-		
measure 13	13 weeks	2-Jan	2-Jan	104	red		0.0514			-0.0199			0.0094		

Treatment	linseed oil	slump	0.5+	in.	weight measure	7.2	lb.	cement	23	lb.
Product	L50	unit weight	136.8	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M2	yield	0.92105		weight total	41.4	lb.	NaOH	40.5	g
Aggregate	F	air content	10.1	%				water	6	lb.
Exposure	a,b,c	air (pressure)	2	%	fine moisture	12	%	fine	39.4	lb.
		w:c	0.42		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		18-Sep	18-Sep												
remove mold	0	19-Sep	19-Sep												
measure 0	0	19-Sep	19-Sep	0	blue										
measure 1	1 week	26-Sep	26-Sep	7	red		-0.0406			-0.0042					
measure 2	2 weeks	3-Oct	3-Oct	14	blue		-0.0385			-0.0028					
measure 4	4 weeks	17-Oct	17-Oct	28	red		-0.0387			-0.0021					
measure 8	8 weeks	14-Nov	14-Nov	56	blue		-0.0376			-0.0017					
measure 13	13 weeks	19-Dec	19-Dec	104	red		-0.0362			0.0012					

Treatment	PCM	slump	5.25	in.	weight measure	7.2	lb.	cement	23	lb.
Product	P-10	unit weight	135.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M3	yield	0.00		weight total	41	lb.	NaOH	40.7	g
Aggregate	F	air content	0.0	%				water	6.4-.25	lb.
Exposure	a,b,c	air (pressure)	1.7	%	fine moisture	11	%	fine	39	lb.
		w:c	0.41		coarse moisture	SSD (damp)				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour															
remove mold	0	2-Oct	2-Oct												
measure 0	0	3-Oct	3-Oct	0	blue		0.0020			-0.0013			-0.0140		
measure 1	1 week	10-Oct	10-Oct	7	red		0.0058			0.0010			-0.0099		
measure 2	2 weeks	17-Oct	17-Oct	14	blue		0.0050			0.0000			-0.0105		
measure 4	4 weeks	31-Oct	31-Oct	28	red		0.0075			0.0039			-0.0059		
measure 8	8 weeks	28-Nov	-	56	blue		-			-			-		
measure 13	13 weeks	2-Jan	2-Jan	104	red		0.0072			0.0027			-0.0044		

Treatment	polyurethane	slump	0.5+	in.	weight measure	7.2	lb.	cement	23	lb.
Product	CUV 100	unit weight	136.8	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M4	yield	0.92105		weight total	41.4	lb.	NaOH	40.5	g
Aggregate	F	air content	10.1	%				water	6	lb.
Exposure	a,b,c	air (pressure)	2	%	fine moisture	12	%	fine	39.4	lb.
		w:c	0.42		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		18-Sep	18-Sep												
remove mold	0	19-Sep	19-Sep												
measure 0	0	19-Sep	19-Sep	0	blue										
measure 1	1 week	26-Sep	26-Sep	7	red		-0.004			-0.0027			-0.0079		
measure 2	2 weeks	3-Oct	3-Oct	14	blue		-0.0028			-0.0014			-0.0016		
measure 4	4 weeks	17-Oct	17-Oct	28	red		-0.0015			-0.0024			-0.0069		
measure 8	8 weeks	14-Nov	14-Nov	56	blue		0.0002			-0.0018			-0.0069		
measure 13	13 weeks	19-Dec	19-Dec	104	red		0.0005			-0.0004			-0.0052		

Treatment	silane 20	slump	0.5+	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Rainstopper 120	unit weight	136.8	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M5	yield	0.00		weight total	41.4	lb.	NaOH	40.5	g
Aggregate	F	air content	0.0	%				water	6	lb.
Exposure	a,b,c	air (pressure)	2	%	fine moisture	12	%	fine	39.4	lb.
		w:c	0.42		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		18-Sep	18-Sep												
remove mold	0	19-Sep	19-Sep												
measure 0	0	19-Sep	19-Sep	0	blue										
measure 1	1 week	26-Sep	26-Sep	7	red		-0.0371			-0.0104			-0.0039		
measure 2	2 weeks	3-Oct	3-Oct	14	blue		-0.0365			-0.0087			-0.0029		
measure 4	4 weeks	17-Oct	17-Oct	28	red		-0.0366			-0.0094			-0.0027		
measure 8	8 weeks	14-Nov	14-Nov	56	blue		-0.0329			-0.0079			-0.0025		
measure 13	13 weeks	19-Dec	19-Dec	104	red		-0.0332			-0.0066			-0.0008		

Treatment	silane 40	slump	5.25	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Rainstopper 140	unit weight	135.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M6	yield	0.93		weight total	41	lb.	NaOH	40.7	g
Aggregate	F	air content	11.0	%				water	6.4-.25	lb.
Exposure	a,b,c	air (pressure)	1.7	%	fine moisture	11	%	fine	39	lb.
		w:c	0.41		coarse moisture	SSD (damp)				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		2-Oct	2-Oct												
remove mold	0	3-Oct	3-Oct												
measure 0	0	3-Oct	3-Oct	0	blue		-0.0496			0.0023			-0.0023		
measure 1	1 week	10-Oct	10-Oct	7	red		-0.0488			0.0062			0.0020		
measure 2	2 weeks	17-Oct	17-Oct	14	blue		-0.0486			0.0062			0.0014		
measure 4	4 weeks	31-Oct	31-Oct	28	red		-0.0477			0.0097			0.0053		
measure 8	8 weeks	28-Nov	-	56	blue		-			-			-		
measure 13	13 weeks	2-Jan	2-Jan	104	red		-0.0505			0.0092			0.0043		

Treatment	siloxane 20	slump	5.25	in.	weight measure	7.2	lb.	cement	23	lb.
Product	SIL 20	unit weight	135.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M7	yield	0.00		weight total	41	lb.	NaOH	40.7	g
Aggregate	F	air content	0.0	%				water	6.4-.25	lb.
Exposure	a,b,c	air (pressure)	1.7	%	fine moisture	11	%	fine	39	lb.
		w:c	0.41		coarse moisture	SSD (damp)				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		2-Oct	2-Oct												
remove mold	0	3-Oct	3-Oct												
measure 0	0	3-Oct	3-Oct	0	blue		-0.0494			-0.0153			-0.0184		
measure 1	1 week	10-Oct	10-Oct	7	red		-0.0477			-0.0119			-0.0143		
measure 2	2 weeks	17-Oct	17-Oct	14	blue		-0.0476			-0.0114			-0.0138		
measure 4	4 weeks	31-Oct	31-Oct	28	red		-0.0438			-0.0086			-0.0115		
measure 8	8 weeks	28-Nov	28-Nov	56	blue		-0.0513			-0.0399			0.0195		
measure 13	13 weeks	2-Jan	2-Jan	104	red		-0.0449			-0.0071			-0.0117		

Treatment	siloxane 40	slump	3	in.	weight measure	7.2	lb.	cement	23	lb.
Product	SIL 40	unit weight	145.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M8	yield	0.85		weight total	43.5	lb.	NaOH	40.48	g
Aggregate	F	air content	6.0	%				water	6.74-2	lb.
Exposure	a,b,c	air (pressure)	2	%	fine moisture	10	%	fine	38.7	lb.
		w:c	0.33		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		4-Oct	4-Oct												
remove mold	0	5-Oct	5-Oct												
measure 0	0	5-Oct	5-Oct	0	blue		0.0029			0.0143			-0.0477		
measure 1	1 week	12-Oct	12-Oct	7	red		0.0068			0.0167			-0.0450		
measure 2	2 weeks	19-Oct	19-Oct	14	blue		0.0078			0.0182			-0.0040		
measure 4	4 weeks	2-Nov	2-Nov	28	red		0.0104			0.0231			-0.0402		
measure 8	8 weeks	30-Nov	30-Nov	56	blue		0.0096			0.0200			-0.0420		
measure 13	13 weeks	4-Jan	4-Jan	104	red		0.0089			0.0196			-0.0426		

Treatment	$LiNO_3$	slump	3	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Renew	unit weight	145.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M9	yield	0.00		weight total	43.5	lb.	NaOH	40.48	g
Aggregate	F	air content	0.0	%				water	6.74-2	lb.
Exposure	a,b,c	air (pressure)	2	%	fine moisture	10	%	fine	38.7	lb.
		w:c	0.33		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		4-Oct	4-Oct												
remove mold	0	5-Oct	5-Oct												
measure 0	0	5-Oct	5-Oct	0	blue		0.0063			0.0011			0.0000		
measure 1	1 week	12-Oct	12-Oct	7	red		0.0098			0.0050			0.0037		
measure 2	2 weeks	19-Oct	19-Oct	14	blue		0.0116			0.0075			0.0050		
measure 4	4 weeks	2-Nov	2-Nov	28	red		0.0118			0.0072			0.0044		
measure 8	8 weeks	30-Nov	3-Dec	56	blue		0.0127			0.0073			0.0066		
measure 13	13 weeks	4-Jan	4-Jan	104	red		0.0127			0.0066			0.0056		

Treatment	$LiNO_3$ + silane	slump	3	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Renew + Rain 140	unit weight	145.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M10	yield	0.85		weight total	43.5	lb.	NaOH	40.48	g
Aggregate	F	air content	6.0	%				water	6.74-2	lb.
Exposure	a,b,c	air (pressure)	2	%	fine moisture	10	%	fine	38.7	lb.
		w:c	0.33		coarse moisture	SSD				

	day	date scheduled	date done	days	color up	air temp	Specimen a length	Specimen a RH 0.5"	Specimen a RH 1.5"	Specimen b length	Specimen b RH 0.5"	Specimen b RH 1.5"	Specimen c length	Specimen c RH 0.5"	Specimen c RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		4-Oct	4-Oct												
remove mold	0	5-Oct	5-Oct												
measure 0	0	5-Oct	5-Oct	0	blue		-0.0287			-0.0197			0.0032		
measure 1	1 week	12-Oct	12-Oct	7	red		-0.0254			-0.0161			0.0068		
measure 2	2 weeks	19-Oct	19-Oct	14	blue		-0.0242			-0.0155			0.0076		
measure 4	4 weeks	2-Nov	2-Nov	28	red		-0.0248			-0.0147			0.0086		
measure 8	8 weeks	30-Nov	3-Dec	56	blue		-0.0231			-0.0142			0.0093		
measure 13	13 weeks	4-Jan	4-Jan	104	red		-0.0237			-0.0143			0.0094		

Treatment	$LiNO_3$ + siloxane	slump	3	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Renew + SIL 40	unit weight	145.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M11	yield	0.00		weight total	43.5	lb.	NaOH	40.48	g
Aggregate	F	air content	0.0	%				water	6.74-2	lb.
Exposure	a,b,c	air (pressure)	2	%	fine moisture	10	%	fine	38.7	lb.
		w:c	0.33		coarse moisture	SSD				

	day	date scheduled	date done	days	color up	air temp	Specimen a length	Specimen a RH 0.5"	Specimen a RH 1.5"	Specimen b length	Specimen b RH 0.5"	Specimen b RH 1.5"	Specimen c length	Specimen c RH 0.5"	Specimen c RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		4-Oct	4-Oct												
remove mold	0	5-Oct	5-Oct												
measure 0	0	5-Oct	5-Oct	0	blue		-0.0044			-0.0418			0.0018		
measure 1	1 week	12-Oct	12-Oct	7	red		-0.0001			-0.0369			0.0054		
measure 2	2 weeks	19-Oct	19-Oct	14	blue		0.0009			-0.0361			0.0043		
measure 4	4 weeks	2-Nov	2-Nov	28	red		0.0024			-0.0356			0.0059		
measure 8	8 weeks	30-Nov	3-Dec	56	blue		0.0029			-0.0343			0.0078		
measure 13	13 weeks	4-Jan	4-Jan	104	red		0.0026			-0.0342			0.0070		

Treatment	$LiNO_3$ + linseed	slump	-	in.	weight measure	7.2	lb.	cement	13.8	lb.
Product	Renew + L 50	unit weight	145.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	34.5	lb.
Abbrev.	M12	yield	0.51997		weight total	43.5	lb.	NaOH	21.6	g
Aggregate	F	air content	5.9	%				water	3.0-.1	lb.
Exposure	a,b,c	air (pressure)	2.8	%	fine moisture	15	%	fine	24.3	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		15-Oct	15-Oct												
remove mold	0	16-Oct	16-Oct												
measure 0	0	16-Oct	16-Oct	0	blue		-0.0211			0.0124			0.0035		
measure 1	1 week	23-Oct	-	7	red		-			-			-		
measure 2	2 weeks	30-Oct	30-Oct	14	blue		-0.0177			0.0162			0.0082		
measure 4	4 weeks	13-Nov	14-Nov	28	red		-0.0159			0.0181			0.0102		
measure 8	8 weeks	11-Dec	11-Dec	56	blue		-0.0210			0.0153			0.0044		
measure 13	13 weeks	15-Jan	14-Jan	104	red		-0.0162			0.0180			0.0091		

Treatment	$LiNO_3$ + polyurethane	slump	-	in.	weight measure	7.2	lb.	cement	13.8	lb.
Product	Renew + CUV 100	unit weight	145.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	34.5	lb.
Abbrev.	M13	yield	0		weight total	43.5	lb.	NaOH	21.6	g
Aggregate	F	air content	0.0	%				water	3.0-.1	lb.
Exposure	a,b,c	air (pressure)	2.8	%	fine moisture	15	%	fine	24.3	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		15-Oct	15-Oct												
remove mold	0	16-Oct	16-Oct												
measure 0	0	16-Oct	16-Oct	0	blue		0.0007			0.0008			-0.0224		
measure 1	1 week	23-Oct	-	7	red		-			-			-		
measure 2	2 weeks	30-Oct	30-Oct	14	blue		0.0067			0.0073			0.0096		
measure 4	4 weeks	13-Nov	14-Nov	28	red		0.0055			0.0056			0.0172		
measure 8	8 weeks	11-Dec	11-Dec	56	blue		0.0038			0.0026			-0.0005		
measure 13	13 weeks	15-Jan	14-Jan	104	red		0.0066			0.0056			-0.0157		

Treatment	HMWM	slump	3.25	in.	weight measure	7.2	lb.	cement	23	lb.
Product	SikaPronto 19	unit weight	144.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M14	yield	0.85		weight total	43.25	lb.	NaOH	40.6	g
Aggregate	F	air content	5.7	%				water	5.7-1.5	lb.
Exposure	a,b,c	air (pressure)	1.9	%	fine moisture	13	%	fine	39.7	lb.
		w:c	0.36		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		16-Oct	16-Oct												
remove mold	0	17-Oct	17-Oct												
measure 0	0	17-Oct	17-Oct	0	blue		-0.0125			-0.0136			-0.0062		
measure 1	1 week	24-Oct	24-Oct	7	red		-0.0104			-0.0129			-0.0042		
measure 2	2 weeks	31-Oct	31-Oct	14	blue		-0.0061			-0.0065			0.0024		
measure 4	4 weeks	14-Nov	14-Nov	28	red		-0.0062			-0.0088			-0.0058		
measure 8	8 weeks	12-Dec	13-Dec	56	blue		-0.0116			-0.0122			-0.0050		
measure 13	13 weeks	16-Jan	16-Jan	104	red		-0.0075			-0.0089			-0.0003		

Treatment	penetrating epoxy	slump	3.25	in.	weight measure	7.2	lb.	cement	23	lb.
Product	#850	unit weight	144.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M15	yield	0.00		weight total	43.25	lb.	NaOH	40.6	g
Aggregate	F	air content	0.0	%				water	5.7-1.5	lb.
Exposure	a,b,c	air (pressure)	1.9	%	fine moisture	13	%	fine	39.7	lb.
		w:c	0.36		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		16-Oct	16-Oct												
remove mold	0	17-Oct	17-Oct												
measure 0	0	17-Oct	17-Oct	0	blue		-0.0019			0.0112			-0.0187		
measure 1	1 week	25-Oct	25-Oct	7	red		0.0029			0.0172			-0.0148		
measure 2	2 weeks	31-Oct	31-Oct	14	blue		0.0067			0.0197			-0.0125		
measure 4	4 weeks	14-Nov	14-Nov	28	red		0.0023			0.0163			-0.0159		
measure 8	8 weeks	12-Dec	13-Dec	56	blue		-0.0015			0.0438			-0.0134		
measure 13	13 weeks	16-Jan	16-Jan	104	red		0.0053			0.0172			-0.0145		

Treatment	control	slump	4	in.	weight measure	7.2	lb.	cement	23	lb.
Product		unit weight	145.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	C	yield	0.88		weight total	43.5	lb.	NaOH	40.5	g
Aggregate	J	air content	1.1	%				water	8.5?	lb.
Exposure	a,b,c	air (pressure)	-	%	fine moisture	5.5	%	fine	38?	lb.
		w:c	0.42		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		20-Sep	20-Sep												
remove mold	0	21-Sep	21-Sep												
measure 0	0	21-Sep	21-Sep	0	blue		-0.0209			-0.0376			-0.0010		
measure 1	1 week	28-Sep	28-Sep	7	red		-0.0080			-0.0271			0.0127		
measure 2	2 weeks	5-Oct	5-Oct	14	blue		-0.0021			-0.0209			0.0205		
measure 4	4 weeks	19-Oct	19-Oct	28	red		-0.0212			0.0001			0.0423		
measure 8	8 weeks	16-Nov	19-Nov	56	blue		broken			broken			0.0528		
measure 13	13 weeks	21-Dec	19-Dec	104	red								0.0577		

Treatment	urethane	slump	3.5	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Cevathane	unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M1	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	J	air content	-	%				water	8	lb.
Exposure	a,b,c	air (pressure)	-	%	fine moisture	5	%	fine	35.91	lb.
		w:c	0.40		coarse moisture	-				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		27-Sep	27-Sep												
remove mold	0	28-Sep	28-Sep												
measure 0	0	28-Sep	28-Sep	0	blue		-0.0480			-0.0218			0.0246		
measure 1	1 week	5-Oct	5-Oct	7	red		-			-0.0034			0.0334		
measure 2	2 weeks	12-Oct	12-Oct	14	blue		-			0.0069			0.0422		
measure 4	4 weeks	26-Oct	26-Oct	28	red		-			0.0172			0.0524		
measure 8	8 weeks	23-Nov	23-Nov	56	blue		-			0.0253			0.0624		
measure 13	13 weeks	28-Dec	29-Nov	104	red		-			0.0267			0.0654		

Treatment	urethane	slump	2.75	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Cevathane	unit weight	144	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M1 (replace)	yield	0.87		weight total	43.2	lb.	NaOH	40.5	g
Aggregate	J	air content	3.0	%				water	7.7-.25	lb.
Exposure	a,b,c	air (pressure)	1.8	%	fine moisture	7.5	%	fine	36.7	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		11-Oct	11-Oct												
remove mold	0	12-Oct	12-Oct												
measure 0	0	12-Oct	12-Oct	0	blue		-0.0064			-			-		
measure 1	1 week	19-Oct	19-Oct	7	red		0.0104			-			-		
measure 2	2 weeks	26-Oct	26-Oct	14	blue		0.0215			-			-		
measure 4	4 weeks	9-Nov	-	28	red		-			-			-		
measure 8	8 weeks	7-Dec	7-Dec	56	blue		0.0387			-			-		
measure 13	13 weeks	11-Jan	11-Jan	104	red		0.0383			-			-		

Treatment	linseed oil	slump	4	in.	weight measure	7.2	lb.	cement	23	lb.
Product	L50	unit weight	145.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M2	yield	0		weight total	43.5	lb.	NaOH	40.5	g
Aggregate	J	air content	0.0	%				water	8.5?	lb.
Exposure	a,b,c	air (pressure)	-	%	fine moisture	5.5	%	fine	38?	lb.
		w:c	0.42		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		20-Sep	20-Sep												
remove mold	0	21-Sep	21-Sep												
measure 0	0	21-Sep	21-Sep	0	blue		-0.0023			-0.0102			-0.0085		
measure 1	1 week	28-Sep	28-Sep	7	red		0.0120			0.0033			0.0051		
measure 2	2 weeks	5-Oct	5-Oct	14	blue		0.0220			0.0105			0.0138		
measure 4	4 weeks	19-Oct	19-Oct	28	red		0.0466			0.0326			0.0389		
measure 8	8 weeks	16-Nov	19-Nov	56	blue		0.0495			0.0385			0.0443		
measure 13	13 weeks	21-Dec	19-Dec	104	red		0.0583			0.0419			0.0475		

Treatment	PCM	slump	3.5	in.	weight measure	7.2	lb.	cement	23	lb.
Product	P-10	unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M3	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	J	air content	-	%				water	8	lb.
Exposure	a,b,c	air (pressure)	-	%	fine moisture	5	%	fine	35.9	lb.
		w:c	0.40		coarse moisture	-				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		27-Sep	27-Sep												
remove mold	0	28-Sep	28-Sep												
measure 0	0	28-Sep	28-Sep	0	blue		0.0319			0.0643			-0.0483		
measure 1	1 week	5-Oct	5-Oct	7	red		0.0445			0.0780			-		
measure 2	2 weeks	12-Oct	12-Oct	14	blue		0.0617			0.0974			-		
measure 4	4 weeks	26-Oct	26-Oct	28	red		0.0784			0.1180			-		
measure 8	8 weeks	23-Nov	21-Nov	56	blue		0.0856			0.1253			-		
measure 13	13 weeks	28-Dec	29-Dec	104	red		0.0880			0.1275			-		

Treatment	PCM	slump	2.75	in.	weight measure	7.2	lb.	cement	23	lb.
Product	P-10	unit weight	144	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M3 (replace)	yield	0.00		weight total	43.2	lb.	NaOH	40.5	g
Aggregate	J	air content	0.0	%				water	7.7-.25	lb.
Exposure	a,b,c	air (pressure)	1.8	%	fine moisture	7.5	%	fine	36.7	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		11-Oct	11-Oct												
remove mold	0	12-Oct	12-Oct												
measure 0	0	12-Oct	12-Oct	0	blue		-			-			-0.0399		
measure 1	1 week	19-Oct	19-Oct	7	red		-			-			-0.0230		
measure 2	2 weeks	26-Oct	26-Oct	14	blue		-			-			-0.0070		
measure 4	4 weeks	9-Nov	-	28	red		-			-			-		
measure 8	8 weeks	7-Dec	7-Dec	56	blue		-			-			0.0143		
measure 13	13 weeks	11-Jan	11-Jan	104	red		-			-			0.0203		

Treatment	polyurethane	slump	4	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Cevathane	unit weight	145.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M4	yield	0.88		weight total	43.5	lb.	NaOH	40.5	g
Aggregate	J	air content	1.1	%				water	8.5?	lb.
Exposure	a,b,c	air (pressure)	-	%	fine moisture	5.5	%	fine	38?	lb.
		w:c	0.42		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		20-Sep	20-Sep												
remove mold	0	21-Sep	21-Sep												
measure 0	0	21-Sep	21-Sep	0	blue		-0.0072			-0.0085			-0.0201		
measure 1	1 week	28-Sep	28-Sep	7	red		0.0027			0.0058			-0.0079		
measure 2	2 weeks	5-Oct	5-Oct	14	blue		0.0101			0.0132			-0.0010		
measure 4	4 weeks	19-Oct	19-Oct	28	red		0.0205			0.0238			0.0093		
measure 8	8 weeks	16-Nov	19-Nov	56	blue		0.0233			0.0288			0.0121		
measure 13	13 weeks	21-Dec	19-Dec	104	red		0.0331			0.0345			0.0210		

Treatment	silane 20	slump	4	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Rainstopper 120	unit weight	145.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M5	yield	0		weight total	43.5	lb.	NaOH	40.5	g
Aggregate	J	air content	0.0	%				water	8.5?	lb.
Exposure	a,b,c	air (pressure)	-	%	fine moisture	5.5	%	fine	38?	lb.
		w:c	0.42		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		20-Sep	20-Sep												
remove mold	0	21-Sep	21-Sep												
measure 0	0	21-Sep	21-Sep	0	blue		-0.0009			-0.0342			-0.0079		
measure 1	1 week	28-Sep	28-Sep	7	red		0.0095			-0.0243			0.0034		
measure 2	2 weeks	5-Oct	5-Oct	14	blue		0.0161			-0.0172			0.0137		
measure 4	4 weeks	19-Oct	19-Oct	28	red		0.0277			-0.0066			0.0214		
measure 8	8 weeks	16-Nov	19-Nov	56	blue		0.0321			-0.0022			0.0254		
measure 13	13 weeks	21-Dec	19-Dec	104	red		0.0380			0.0020			0.0362		

Treatment	silane 40	slump	3.5	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Rainstopper 140	unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M6	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	J	air content	-	%				water	8	lb.
Exposure	a,b,c	air (pressure)	-	%	fine moisture	5	%	fine	35.9	lb.
		w:c	0.40		coarse moisture	-				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		27-Sep	27-Sep												
remove mold	0	28-Sep	28-Sep												
measure 0	0	28-Sep	28-Sep	0	blue		0.0064			-0.0488			-0.0033		
measure 1	1 week	5-Oct	5-Oct	7	red		0.0172			-			0.0107		
measure 2	2 weeks	12-Oct	12-Oct	14	blue		0.0255			-			0.0193		
measure 4	4 weeks	26-Oct	26-Oct	28	red		0.0367			-			0.0311		
measure 8	8 weeks	23-Nov	21-Nov	56	blue		broken			-			0.0347		
measure 13	13 weeks	28-Dec	29-Dec	104	red					-			0.0353		

Treatment	silane 40	slump	2.75	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Rainstopper 140	unit weight	144	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M6 (replace)	yield	0.00		weight total	43.2	lb.	NaOH	40.5	g
Aggregate	J	air content	0.0	%				water	7.7-.25	lb.
Exposure	a,b,c	air (pressure)	1.8	%	fine moisture	7.5	%	fine	36.7	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		11-Oct	11-Oct												
remove mold	0	12-Oct	12-Oct												
measure 0	0	12-Oct	12-Oct	0	blue		-			0.0017			-		
measure 1	1 week	19-Oct	19-Oct	7	red		-			0.0133			-		
measure 2	2 weeks	26-Oct	26-Oct	14	blue		-			0.0253			-		
measure 4	4 weeks	9-Nov	-	28	red		-			-			-		
measure 8	8 weeks	7-Dec	7-Dec	56	blue		-			0.0420			-		
measure 13	13 weeks	11-Jan	11-Jan	104	red		-			0.0463			-		

Treatment	siloxane 20	slump	3.5	in.	weight measure	7.2	lb.	cement	23	lb.
Product	SIL 20	unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M7	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	J	air content	-	%				water	8	lb.
Exposure	a,b,c	air (pressure)	-	%	fine moisture	5	%	fine	35.9	lb.
		w:c	0.40		coarse moisture	-				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		27-Sep	27-Sep												
remove mold	0	28-Sep	28-Sep												
measure 0	0	28-Sep	28-Sep	0	blue		-0.0478			-0.0488			-0.0299		
measure 1	1 week	5-Oct	5-Oct	7	red		-			-0.0489			-0.0180		
measure 2	2 weeks	12-Oct	12-Oct	14	blue		-			-			-0.0075		
measure 4	4 weeks	26-Oct	26-Oct	28	red		-			-			0.0066		
measure 8	8 weeks	23-Nov	21-Nov	56	blue		-			-			0.0179		
measure 13	13 weeks	28-Dec	29-Dec	104	red		-			-			0.0207		

Treatment	siloxane 20	slump	2.75	in.	weight measure	7.2	lb.	cement	23	lb.
Product	SIL 20	unit weight	144	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M7 (replace)	yield	0.00		weight total	43.2	lb.	NaOH	40.5	g
Aggregate	J	air content	0.0	%				water	7.7-.25	lb.
Exposure	a,b,c	air (pressure)	1.8	%	fine moisture	7.5	%	fine	36.7	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		11-Oct	11-Oct												
remove mold	0	12-Oct	12-Oct												
measure 0	0	12-Oct	12-Oct	0	blue		-0.0046			0.0031			0.0135		
measure 1	1 week	19-Oct	19-Oct	7	red		0.0093			0.0181			0.0287		
measure 2	2 weeks	26-Oct	26-Oct	14	blue		0.0226			0.0315			0.0410		
measure 4	4 weeks	9-Nov	-	28	red		-			-			-		
measure 8	8 weeks	7-Dec	7-Dec	56	blue		0.0373			0.0488			0.0567		
measure 13	13 weeks	11-Jan	11-Jan	104	red		0.0394			0.0470			0.0617		

Treatment	siloxane 40	slump	3.5	in.	weight measure	7.2	lb.	cement	23	lb.
Product	SIL 40	unit weight	146	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M8	yield	0.86		weight total	43.7	lb.	NaOH	40.6	g
Aggregate	J	air content	0.4	%				water	8.58	lb.
Exposure	a,b,c	air (pressure)	1.9	%	fine moisture	5.4	%	fine	35.9	lb.
		w:c	0.43		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		9-Oct	9-Oct												
remove mold	0	10-Oct	10-Oct												
measure 0	0	10-Oct	10-Oct	0	blue		-0.0043			-0.0219			-0.0161		
measure 1	1 week	17-Oct	17-Oct	7	red		0.0110			-0.0037			-0.0001		
measure 2	2 weeks	24-Oct	24-Oct	14	blue		0.0206			0.0064			0.0091		
measure 4	4 weeks	7-Nov	7-Nov	28	red		0.0399			0.0267			0.0280		
measure 8	8 weeks	5-Dec	5-Dec	56	blue		0.0483			0.0345			0.0366		
measure 13	13 weeks	9-Jan	9-Jan	104	red		-			0.0376			0.0395		

Treatment	$LiNO_3$	slump	3.5	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Renew	unit weight	146	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M9	yield	0.00		weight total	43.7	lb.	NaOH	40.6	g
Aggregate	J	air content	0.0	%				water	8.58	lb.
Exposure	a,b,c	air (pressure)	1.9	%	fine moisture	5.4	%	fine	35.9	lb.
		w:c	0.43		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		9-Oct	9-Oct												
remove mold	0	10-Oct	10-Oct												
measure 0	0	10-Oct	10-Oct	0	blue		-0.0270			-0.0248			0.0022		
measure 1	1 week	17-Oct	17-Oct	7	red		-0.0102			-0.0085			0.0174		
measure 2	2 weeks	24-Oct	24-Oct	14	blue		0.0043			0.0064			0.0307		
measure 4	4 weeks	7-Nov	7-Nov	28	red		0.0227			0.0250			0.0477		
measure 8	8 weeks	5-Dec	5-Dec	56	blue		0.0205			0.0218			0.0484		
measure 13	13 weeks	9-Jan	9-Jan	104	red		0.0228			0.0230			0.0513		

Treatment	$LiNO_3$ + silane	slump	3.5	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Renew + Rain 140	unit weight	146	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M10	yield	0.86		weight total	43.7	lb.	NaOH	40.6	g
Aggregate	J	air content	0.4	%				water	8.58	lb.
Exposure	a,b,c	air (pressure)	1.9	%	fine moisture	5.4	%	fine	35.9	lb.
		w:c	0.43		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		9-Oct	9-Oct												
remove mold	0	10-Oct	10-Oct												
measure 0	0	10-Oct	10-Oct	0	blue		-0.0086			-0.0325			0.0110		
measure 1	1 week	17-Oct	17-Oct	7	red		0.0078			-0.0158			0.0278		
measure 2	2 weeks	24-Oct	24-Oct	14	blue		0.0179			0.0036			0.0390		
measure 4	4 weeks	7-Nov	7-Nov	28	red		0.0324			broken			0.0539		
measure 8	8 weeks	5-Dec	5-Dec	56	blue		0.0324						0.0618		
measure 13	13 weeks	9-Jan	9-Jan	104	red		0.0344						0.0620		

Treatment	$LiNO_3$ + siloxane	slump	3.5	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Renew + SIL 40	unit weight	146	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M11	yield	0.00		weight total	43.7	lb.	NaOH	40.6	g
Aggregate	J	air content	0.0	%				water	8.58	lb.
Exposure	a,b,c	air (pressure)	1.9	%	fine moisture	5.4	%	fine	35.9	lb.
		w:c	0.43		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		9-Oct	9-Oct												
remove mold	0	10-Oct	10-Oct												
measure 0	0	10-Oct	10-Oct	0	blue		-0.0025			0.0026			-0.0050		
measure 1	1 week	17-Oct	17-Oct	7	red		0.0147			0.0187			0.0114		
measure 2	2 weeks	24-Oct	24-Oct	14	blue		0.0259			0.0321			0.0233		
measure 4	4 weeks	7-Nov	7-Nov	28	red		0.0429			0.0491			0.0385		
measure 8	8 weeks	5-Dec	5-Dec	56	blue		0.0509			0.0554			0.0457		
measure 13	13 weeks	9-Jan	9-Jan	104	red		0.0514			0.0553			0.0460		

Treatment	$LiNO_3$ + linseed oil	slump	2.75	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Renew + L 50	unit weight	144	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M12	yield	0.87		weight total	43.2	lb.	NaOH	40.6	g
Aggregate	J	air content	3.0	%				water	7.7-.25	lb.
Exposure	a,b,c	air (pressure)	1.8	%	fine moisture	7.5	%	fine	36.7	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		11-Oct	11-Oct												
remove mold	0	12-Oct	12-Oct												
measure 0	0	12-Oct	12-Oct	0	blue		0.0201			0.0046			0.0269		
measure 1	1 week	19-Oct	19-Oct	7	red		0.0348			0.0195			0.0385		
measure 2	2 weeks	26-Oct	26-Oct	14	blue		0.0522			0.0364			0.0570		
measure 4	4 weeks	9-Nov	14-Nov	28	red		0.0698			0.0542			0.0738		
measure 8	8 weeks	7-Dec	7-Dec	56	blue		0.0673			0.0518			0.0732		
measure 13	13 weeks	11-Jan	11-Jan	104	red		0.0682			0.0529			0.0772		

Treatment	$LiNO_3$ + polyurethane	slump	2.75	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Renew + CUV 100	unit weight	144	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M13	yield	0.00		weight total	43.2	lb.	NaOH	40.6	g
Aggregate	J	air content	0.0	%				water	7.7-.25	lb.
Exposure	a,b,c	air (pressure)	1.8	%	fine moisture	7.5	%	fine	36.7	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		11-Oct	11-Oct												
remove mold	0	12-Oct	12-Oct												
measure 0	0	12-Oct	12-Oct	0	blue		-0.0128			-0.0222			-0.0006		
measure 1	1 week	19-Oct	19-Oct	7	red		0.0040			-0.0051			0.0127		
measure 2	2 weeks	26-Oct	26-Oct	14	blue		0.0177			0.0113			0.0320		
measure 4	4 weeks	9-Nov	14-Nov	28	red		0.0326			0.0248			0.0474		
measure 8	8 weeks	7-Dec	7-Dec	56	blue		0.0309			0.0237			0.0482		
measure 13	13 weeks	11-Jan	11-Jan	104	red		0.0330			0.0261			0.0459		

Treatment	HMWM	slump	3.75	in.	weight measure	7.2	lb.	cement	23	lb.
Product	SikaPronto 19	unit weight	144	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M14	yield	0.87		weight total	43.2	lb.	NaOH	40.6	g
Aggregate	J	air content	3.5	%				water	7.3-.3	lb.
Exposure	a,b,c	air (pressure)	2	%	fine moisture	8.9	%	fine	37.2	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		18-Oct	18-Oct												
remove mold	0	19-Oct	19-Oct												
measure 0	0	19-Oct	19-Oct	0	blue		-0.0001			-0.0006			-0.0162		
measure 1	1 week	26-Oct	26-Oct	7	red		0.0080			0.0101			-0.0059		
measure 2	2 weeks	2-Nov	2-Nov	14	blue		0.0297			0.0314			0.0712		
measure 4	4 weeks	16-Nov	19-Nov	28	red		0.0702			0.0451			0.0306		
measure 8	8 weeks	14-Dec	13-Dec	56	blue		0.0541			0.0439			0.0363		
measure 13	13 weeks	18-Jan	18-Jan	104	red		0.0547			0.0526			0.0398		

Treatment	penetrating epoxy	slump	3.75	in.	weight measure	7.2	lb.	cement	23	lb.
Product	#850	unit weight	144	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M15	yield	0.00		weight total	43.2	lb.	NaOH	40.6	g
Aggregate	J	air content	0.0	%				water	7.3-0.3	lb.
Exposure	a,b,c	air (pressure)	2	%	fine moisture	8.9	%	fine	37.2	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen a			Specimen b			Specimen c		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		18-Oct	18-Oct												
remove mold	0	19-Oct	19-Oct												
measure 0	0	19-Oct	19-Oct	0	blue		-0.0001			0.0154			-0.0248		
measure 1	1 week	26-Oct	26-Oct	7	red		0.0096			0.0242			-0.0159		
measure 2	2 weeks	2-Nov	2-Nov	14	blue		0.0257			0.0372			-0.0024		
measure 4	4 weeks	16-Nov	19-Nov	28	red		0.0372			0.0480			0.0070		
measure 8	8 weeks	14-Dec	13-Dec	56	blue		0.0370			0.0541			0.0154		
measure 13	13 weeks	18-Jan	18-Jan	104	red		0.0454			0.0571			0.0161		

APPENDIX D

Expansion and Moisture Data from Outdoor Series

Treatment	control	slump	wet	in.	weight measure	7.2	lb.	cement	27.6	lb.
Product		unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	23.04	lb.
Abbrev.	C	yield	-		weight total	-	lb.	NaOH	48.6	g
Aggregate	F	air content	-	%				water	8.12-1.5	lb.
Exposure	d,e,f	air (pressure)	1.6	%	fine moisture	19.6	%	fine	46.4	lb.
		w:c	0.51		coarse moisture	SSD				

							Specimen d			Specimen e			Specimen f		
	day	date schedule	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		16-Aug	16-Aug												
remove mold	0	17-Aug	17-Aug												
measure 0	0	17-Aug	17-Aug	0	blue		-0.0068	-	-	-0.0095	-	-	-0.0243		
measure 1	1 week	24-Aug	27-Aug	7	red	102.3	-0.0049	93.7	94.8	-0.0074	91.2	89.5	-0.0226		
measure 2	2 weeks	31-Aug	31-Aug	14	blue	84.1	-0.0058	95.9	96.3	-0.0088	95.4	95.9	-0.0238		
measure 4	4 weeks	14-Sep		28	red	-	-	-	-	-	-	-	-		
measure 8	8 weeks	12-Oct	21-Oct	56	blue	86.9	-0.0069	68.8	66.5	-0.0097	69.1	70.1	-0.0247		
measure 13	13 weeks	16-Nov	16-Nov	104	red	-	-0.0116	93.4	92.9	-0.0144	93.8	91.9	-0.0296		
measure 17	17 weeks	14-Dec	13-Dec	119	blue	-	-0.0058	89.6	88.3	-0.0084	92.1	92.9	-0.0234		
measure 21	21 weeks	11-Jan	11-Jan	147	red	-	-0.0106	-	-	-0.0101	-	-	-0.0267		
measure 25	25 weeks	8-Feb		175	blue	-	-	-	-	-	-	-	-		

Treatment	urethane	slump	2.25	in.	weight measure	7.5	lb.	cement	12.29	lb.
Product	Cevathane	unit weight	144.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	10.04	lb.
Abbrev.	M1	yield	0.3	ft^3	weight total	43.55	lb.	NaOH	21.59	g
Aggregate	F	air content	0	%				water	5.55-0.5	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture	3.96	%	fine	19.15	lb.
		w:c	0.44		coarse moisture	-				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		17-Jul	17-Jul												
remove mold	0	18-Jul	18-Jul												
measure 0	0	18-Jul	18-Jul	0	blue	-	0.0118	-	-	0.0189	-	-	0.0101		
measure 1	1 week	25-Jul	25-Jul	7	red	-	-0.0027	-	-	-0.0092	-	-	0.0010		
measure 2	2 weeks	1-Aug	1-Aug	14	blue	103.8	-0.0111	80.1	84.5	-0.0180	84.4	82.4	0.0070		
measure 4	4 weeks	15-Aug	15-Aug	28	red	108.2	-0.0112	68.2	69.4	-0.0171	66.5	73.4	-0.0083		
measure 8	8 weeks	12-Sep	12-Sep	56	blue	101.6	-0.0107	79.8	80.8	-0.0178	95.4	80.4	-0.0082		
measure 13	13 weeks	17-Oct	16-Oct	104	red	78.1	-0.0128	63.5	73.6	-0.0192	88.4	80.4	-0.0091		
measure 17	17 weeks	14-Nov	14-Nov	119	blue	74.4	-0.0129	74.4	81.4	-0.0215	76.1	73.3	-0.0068		
measure 21	21 weeks	12-Dec	13-Dec	147	red	-	-0.0231	96.7	95.2	-0.0294	96.7	96.5	-0.0110		
measure 25	25 weeks	9-Jan	9-Jan	175	blue	78.9	-0.0104	81.1	87.1	-0.0169	81.6	83.5	-0.0071		

Treatment	linseed oil	slump	2.25	in.	weight measure	7.5	lb.	cement	12.29	lb.	
Product	L50	unit weight	144.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	10.04	lb.	
Abbrev.	M2	yield	0.3	ft^3	weight total	43.55	lb.	NaOH	21.59	g	
Aggregate	F	air content	0	%				water	5.55-0.5	lb.	-0.05
Exposure	d,e,f	air (pressure)	-	%	fine moisture	3.96	%	fine	19.15	lb.	
		w:c	0.44		coarse moisture						

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		17-Jul	17-Jul												
remove mold	0	18-Jul	18-Jul												
measure 0	0	18-Jul	18-Jul	0	blue		0.0073	-	-	0.0042	-	-	0.0123		
measure 1	1 week	25-Jul	25-Jul	7	red		0.0020	-	-	0.0053	-	-	-0.0027		
measure 2	2 weeks	1-Aug	1-Aug	14	blue	103.8	broken			-0.0022	76.2	82.3	-0.0101		
measure 4	4 weeks	15-Aug	15-Aug	28	red	108.2				-0.0026	65.0	81.1	-0.0098		
measure 8	8 weeks	12-Sep	12-Sep	56	blue	101.6				-0.0034	95.6	95.5	-0.0110		
measure 13	13 weeks	17-Oct	16-Oct	104	red	78.1				-0.0053	81.2	86.0	-0.0127		
measure 17	17 weeks	14-Nov	14-Nov	119	blue					-0.0049	74.4	79.1	-0.0120		
measure 21	21 weeks	12-Dec	13-Dec	147	red					-0.0044	92.9	91.2	0.0125		
measure 25	25 weeks	9-Jan	9-Jan	175	blue	78.9				-0.0037	73.0	84.1	-0.0120		

Treatment	PCM	slump	wet	in.	weight measure	7.2	lb.	cement	23.05	lb.
Product	P-10	unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	19.2	lb.
Abbrev.	M3	yield	-		weight total	-	lb.	NaOH	40.49	g
Aggregate	F	air content	-	%				water	9.68?	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture		%	fine	35.19	lb.
		w:c	0.42		coarse moisture					

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		19-Jul	19-Jul												
remove mold	0	20-Jul	20-Jul												
measure 0	0	20-Jul	20-Jul	0	blue		0.0053	-	-	0.0111	-	-	0.0082		
measure 1	1 week	27-Jul	27-Jul	7	red		0.0089	-	-	-0.0069	-	-	-0.0043		
measure 2	2 weeks	3-Aug	3-Aug	14	blue		-0.0104	82.7	87.8	0.0056	81.8	80.2	-0.0082		
measure 4	4 weeks	17-Aug	17-Aug	28	red	100.6	-0.0095	73.4	75.3	0.0060	71.4	77.8	0.0081		
measure 8	8 weeks	14-Sep	14-Sep	56	blue	95.3	-0.0099	85.1	82.8	0.0065	84.9	83.9	-0.0069		
measure 13	13 weeks	19-Oct	18-Oct	104	red	88.7	-0.0099	81.2	83.6	0.0061	87.0	85.6	0.0008		
measure 17	17 weeks	16-Nov	16-Nov	119	blue		-0.0147	87.3	90.2	0.0007	90.1	90.1	-0.0090		
measure 21	21 weeks	14-Dec	13-Dec	147	red		-0.0091	90.8	93.4	-0.0826	93.5	94.5	-0.0084		
measure 25	25 weeks	11-Jan	11-Jan	175	blue		-0.0102	-	-	0.0053	-	-	-0.0081		

Treatment	polyurethane	slump	wet	in.	weight measure	7.2	lb.	cement	23.05	lb.
Product	CUV 100	unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	19.2	lb.
Abbrev.	M4	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	F	air content	-	%				water	9.68?	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture	-	%	fine	35.19?	lb.
		w:c	0.42		coarse moisture	-				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		19-Jul	19-Jul												
remove mold	0	20-Jul	20-Jul												
measure 0	0	20-Jul	20-Jul	0	blue		0.0054	-	-	0.0444	-	-	0.0267		
measure 1	1 week	27-Jul	27-Jul	7	red		-0.0026	-	-	-0.0402	-	-	-0.0231		
measure 2	2 weeks	3-Aug	3-Aug	14	blue		-0.0062	75.3	86.2	-0.0438	80.5	83.9	-0.0262		
measure 4	4 weeks	17-Aug	17-Aug	28	red	100.6	-0.0059	74.7	73.9	-0.0441	72.1	76.0	-0.0264		
measure 8	8 weeks	14-Sep	14-Sep	56	blue	95.3	-0.0064	74.4	75.9	-0.0440	85.1	74.7	-0.0258		
measure 13	13 weeks	19-Oct	18-Oct	104	red	88.7	-0.0065	67.2	80.3	-0.0447	74.0	75.2	-0.0268		
measure 17	17 weeks	16-Nov	16-Nov	119	blue		-0.0122	91.0	94.1	-0.0500	93.1	89.3	-0.0319		
measure 21	21 weeks	14-Dec	13-Dec	147	red		-0.0061	93.5	92.8	-0.0441	93.6	92.3	-0.0258		
measure 25	25 weeks	11-Jan	11-Jan	175	blue		-0.0071	-	-	-0.0453	-	-	-0.0276		

Treatment	silane 20	slump	wet	in.	weight measure	7.2	lb.	cement	23.05	lb.
Product	Rainstopper 120	unit weight	-	lb/ft^3	vol.measure		ft^3	coarse	19.2	lb.
Abbrev.	M5	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	F	air content	-	%				water	9.68?	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture	-	%	fine	35.19?	lb.
		w:c	0.42		coarse moisture	-				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		19-Jul	19-Jul												
remove mold	0	20-Jul	20-Jul												
measure 0	0	20-Jul	20-Jul	0	blue		0.0077	-	-	0.0050	-	-	0.0196		
measure 1	1 week	27-Jul	27-Jul	7	red		-0.0034	-	-	-0.0011	-	-	-0.0156		
measure 2	2 weeks	3-Aug	3-Aug	14	blue		-0.0072	77.8	84.8	-0.0045	79.5	83.4	-0.0191		
measure 4	4 weeks	17-Aug	17-Aug	28	red	100.6	-0.0067	74.4	76.0	-0.0046	76.9	80.6	-0.0197		
measure 8	8 weeks	14-Sep	14-Sep	56	blue	95.3	-0.0077	71.0	72.7	-0.0048	89.8	93.9	-0.0196		
measure 13	13 weeks	19-Oct	18-Oct	104	red	88.7	-0.0085	63.9	68.7	-0.0057	60.1	63.5	-0.0206		
measure 17	17 weeks	16-Nov	16-Nov	119	blue		-0.0146	-	-	-0.0115	-	-	-0.0263		
measure 21	21 weeks	14-Dec	13-Dec	147	red		-0.0172	93.7	92.9	-0.0059	92.2	93.2	-0.0206		
measure 25	25 weeks	11-Jan	11-Jan	175	blue		-0.0097	-	-	-0.0066	-	-	-0.0216		

Treatment	silane 40	slump	wet	in.	weight measure	7.2	lb.	cement	23.05	lb.
Product	Rainstopper 140	unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	19.2	lb.
Abbrev.	M6	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	F	air content	-	%				water	9.68?	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture	-	%	fine	35.19?	lb.
		w:c	0.42		coarse moisture	-				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		19-Jul	19-Jul												
remove mold	0	20-Jul	20-Jul												
measure 0	0	20-Jul	20-Jul	0	blue		0.0069	-	-	0.0116	-	-	0.0091		
measure 1	1 week	27-Jul	27-Jul	7	red		-0.0034	-	-	-0.0074	-	-	-0.0055		
measure 2	2 weeks	3-Aug	3-Aug	14	blue		-0.0070	77.3	82.5	-0.0106	73.0	83.3	-0.0090		
measure 4	4 weeks	17-Aug	17-Aug	28	red	100.6	-0.0062	63.1	74.2	-0.0100	71.3	69.4	-0.0091		
measure 8	8 weeks	14-Sep	14-Sep	56	blue	95.3	-0.0072	70.2	71.8	-0.0110	68.0	76.8	-0.0092		
measure 13	13 weeks	19-Oct	18-Oct	104	red	88.7	-0.0084	70.3	59.6	-0.0121	62.5	65.3	-0.0105		
measure 17	17 weeks	16-Nov	16-Nov	119	blue		-0.0142	92.3	89.4	-0.0180	91.8	89.5	-0.0159		
measure 21	21 weeks	14-Dec	13-Dec	147	red		-0.0083	91.3	92.2	-0.0116	92.1	92.3	-0.0104		
measure 25	25 weeks	11-Jan	11-Jan	175	blue		-0.0095	-	-	-0.0128	-	-	-0.0124		

Treatment	siloxane 20	slump	wet	in.	weight measure	7.2	lb.	cement	23.05	lb.
Product	SIL 20	unit weight	-	lb/ft^3	vol.measure		ft^3	coarse	19.2	lb.
Abbrev.	M7	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	F	air content	-	%				water	9.68-1.5	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture	3.96	%	fine	35.78	lb.
		w:c	0.39		coarse moisture	wet				

							Specimen f			Specimen e			Specimen d		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		26-Jul	26-Jul												
remove mold	0	27-Jul	27-Jul												
measure 0	0	27-Jul	27-Jul	0	blue		-0.0106	-	-	-0.0082	-	-	-0.0070		
measure 1	1 week	3-Aug	3-Aug	7	red		-0.0073	77.0	83.8	-0.0049	67.1	76.8	-0.0042		
measure 2	2 weeks	10-Aug	10-Aug	14	blue	100.4	-0.0096	71.6	70.1	-0.0055	82.9	81.1	-0.0049		
measure 4	4 weeks	24-Aug	23-Aug	28	red	108.3	-0.0117	68.3	72.8	-0.0086	70.6	75.3	-0.0079		
measure 8	8 weeks	21-Sep	21-Sep	56	blue	84.5	-0.0112	67.9	71.2	-0.0084	65.3	71.1	-0.0083		
measure 13	13 weeks	26-Oct	26-Oct	104	red	84.1	-0.0128	56.2	56.9	-0.0107	62.0	48.8	-0.0093		
measure 17	17 weeks	23-Nov	21-Nov	119	blue		-0.0112	68.7	61.8	-0.0085	76.4	72.4	-0.0079		
measure 21	21 weeks	21-Dec	19-Dec	147	red	51.8	-0.0114	72.9	70.8	-0.0085	82.4	79.1	-0.0075		
measure 25	25 weeks	18-Jan		175	blue		-	-	-	-	-	-	-		

Treatment	siloxane 40	slump	wet	in.	weight measure	7.2	lb.	cement	23.05	lb.
Product	SIL 40	unit weight	-	lb/ft^3	vol.measure		ft^3	coarse	19.2	lb.
Abbrev.	M8	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	F	air content	-	%				water	9.68-1.5	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture	3.96	%	fine	35.78	lb.
		w:c	0.39		coarse moisture	wet				

	day	date scheduled	date done	days	color up	air temp	Specimen f			Specimen e			Specimen d		
							length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		26-Jul	26-Jul												
remove mold	0	27-Jul	27-Jul												
measure 0	0	27-Jul	27-Jul	0	blue		-0.0063	-	-	-0.0082	-	-	-0.0102		
measure 1	1 week	3-Aug	3-Aug	7	red		-0.0030	84.1	79.8	-0.0054	69.3	88.4	-0.0068		
measure 2	2 weeks	10-Aug	10-Aug	14	blue	100.4	-0.0028	67.6	70.0	-0.0036	77.4	84.7	-0.0085		
measure 4	4 weeks	24-Aug	24-Aug	28	red	108.3	-0.0065	71.7	69.6	-0.0088	70.9	78.1	-0.0106		
measure 8	8 weeks	21-Sep	21-Sep	56	blue	84.5	-0.0068	64.8	67.5	-0.0094	69.7	76.6	-0.0111		
measure 13	13 weeks	26-Oct	26-Oct	104	red	84.1	-0.0094	54.8	50.5	-0.0108	51.7	63.4	-0.0133		
measure 17	17 weeks	23-Nov	21-Nov	119	blue		-0.0072	58.9	59.2	-0.0096	59.9	67.1	-0.0115		
measure 21	21 weeks	21-Dec	19-Dec	147	red	51.8	-0.0074	64.6	62.6	-0.0096	75.8	71.1	-0.0115		
measure 25	25 weeks	18-Jan		175	blue		-	-	-	-	-	-	-		

Treatment	$LiNO_3$	slump	wet	in.	weight measure	7.2	lb.	cement	23.05	lb.
Product	Renew	unit weight	-	lb/ft^3	vol.measure		ft^3	coarse	19.2	lb.
Abbrev.	M9	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	F	air content	-	%				water	96.8-1.5	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture	3.96	%	fine	35.78	lb.
		w:c	0.39		coarse moisture	wet				

							Specimen f			Specimen e			Specimen d		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		26-Jul	26-Jul												
remove mold	0	27-Jul	27-Jul												
measure 0	0	27-Jul	27-Jul	0	blue		-0.0031	-	-	-0.0391	-	-	-0.0101		
measure 1	1 week	3-Aug	3-Aug	7	red		-0.0008	57.1	83.9	-0.0362	84.5	87.8	-0.0076		
measure 2	2 weeks	10-Aug	10-Aug	14	blue	100.4	-0.0008	52.9	73.3	-0.0379	82.0	82.0	-0.0083		
measure 4	4 weeks	24-Aug	24-Aug	28	red	108.3	-0.0044	66.7	74.9	-0.0396	71.8	75.3	-0.0110		
measure 8	8 weeks	21-Sep	21-Sep	56	blue	98.4	-0.0037	59.9	74.0	-0.0391	90.0	85.5	-0.0103		
measure 13	13 weeks	26-Oct	26-Oct	104	red	84.1	-0.0037	44.8	63.9	-0.0412	59.8	71.6	-0.0116		
measure 17	17 weeks	23-Nov	21-Nov	119	blue		-0.0036	57.9	71.6	-0.0387	79.4	74.4	-0.0102		
measure 21	21 weeks	21-Dec	19-Dec	147	red	51.8	-0.0033	63.6	79.7	-0.0386	82.1	83.4	-0.0101		
measure 25	25 weeks	18-Jan		175	blue		-	-	-	-	-	-	-		

Treatment	$LiNO_3$ + silane	slump	wet	in.	weight measure	7.2	lb.	cement	23.05	lb.
Product	Renew + Rain 140	unit weight	-	lb/ft^3	vol.measure		ft^3	coarse	19.2	lb.
Abbrev.	M10	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	F	air content	-	%				water	9.68-1.5	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture	3.96	%	fine	35.78	lb.
		w:c	0.39		coarse moisture	wet				

							Specimen f			Specimen e			Specimen d		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		26-Jul	26-Jul												
remove mold	0	27-Jul	27-Jul												
measure 0	0	27-Jul	27-Jul	0	blue		-0.0250	-	-	-0.0276	-	-	-0.0194		
measure 1	1 week	3-Aug	3-Aug	7	red		-0.0223	85.1	91.0	-0.0246	86.1	96.4	-0.0168		
measure 2	2 weeks	10-Aug	10-Aug	14	blue	100.4	-0.0194	67.5	78.4	-0.0249	81.9	83.0	-0.0173		
measure 4	4 weeks	24-Aug	24-Aug	28	red	108.3	-0.0255	71.8	74.0	-0.0277	71.0	77.7	-0.0199		
measure 8	8 weeks	21-Sep	21-Sep	56	blue	98.4	-0.0255	81.9	82.0	-0.0279	75.2	77.8	-0.0201		
measure 13	13 weeks	26-Oct	26-Oct	104	red	84.1	-0.0274	58.8	61.3	-0.1604	53.9	67.6	-0.0220		
measure 17	17 weeks	23-Nov	21-Nov	119	blue		-0.0251	70.7	69.5	-0.0277	69.4	77.1	-0.0199		
measure 21	21 weeks	21-Dec	19-Dec	147	red	51.8	-0.0247	80.3	78.6	-0.0273	79.9	82.6	-0.0196		
measure 25	25 weeks	18-Jan		175	blue		-	-	-	-	-	-	-		

Treatment	$LiNO_3$ + siloxane	slump	wet	in.	weight measure	7.2	lb.	cement	27.6	lb.
Product	Renew + SIL 40	unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	23.04	lb.
Abbrev.	M11	yield	-		weight total	-	lb.	NaOH	48.6	g
Aggregate	F	air content	-	%				water	8.12-1.5	lb.
Exposure	d,e,f	air (pressure)	1.6	%	fine moisture	19.6	%	fine	46.4	lb.
		w:c	0.51		coarse moisture	SSD				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		16-Aug	16-Aug												
remove mold	0	17-Aug	17-Aug												
measure 0	0	17-Aug	17-Aug	0	blue		-0.0270	-	-	-0.0037	-	-	-0.0194		
measure 1	1 week	24-Aug	27-Aug	7	red	102.3	-0.0240	89.3	93.2	-0.0014	91.0	94.8	-0.0172		
measure 2	2 weeks	31-Aug	31-Aug	14	blue	83.8	-0.0254	92.1	93.8	-0.0032	93.9	94.5	-0.0183		
measure 4	4 weeks	14-Sep	-	28	red		-	-	-	-	-	-	-		
measure 8	8 weeks	12-Oct	21-Oct	56	blue	86.9	-0.0266	64.9	72.2	-0.0039	59.5	66.1	-0.0192		
measure 13	13 weeks	16-Nov	16-Nov	104	red		-0.0309	85.7	79.2	-0.0084	84.0	80.6	0.0241		
measure 17	17 weeks	14-Dec	13-Dec	119	blue		-0.0370	92.2	92.7	-0.0029	90.6	91.6	-0.0294		
measure 21	21 weeks	11-Jan	11-Jan	147	red		-0.0280	-	-	-0.0073	-	-	-0.0184		
measure 25	25 weeks	8-Feb		175	blue		-	-	-	-	-	-	-		

Treatment	$LiNO_3$ + linseed	slump	wet	in.	weight measure	7.2	lb.	cement	27.6	lb.
Product	Renew + L50	unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	23.04	lb.
Abbrev.	M12	yield	-		weight total	-	lb.	NaOH	48.6	g
Aggregate	F	air content	-	%				water	8.12-1.5	lb.
Exposure	d,e,f	air (pressure)	1.6	%	fine moisture	19.6	%	fine	46.4	lb.
		w:c	0.51		coarse moisture	SSD				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		16-Aug	16-Aug												
remove mold	0	17-Aug	17-Aug												
measure 0	0	17-Aug	17-Aug	0	blue		-0.0110	-	-	-0.0102	-	-	-0.0403		
measure 1	1 week	24-Aug	27-Aug	7	red	102.3	-0.0085	87.6	81.6	-0.0075	90.0	94.6	-0.0382		
measure 2	2 weeks	31-Aug	31-Aug	14	blue	83.8	-0.0096	96.2	96.7	-0.0086	96.8	95.8	-0.0399		
measure 4	4 weeks	14-Sep	-	28	red	-	-	-	-	-	-	-	-		
measure 8	8 weeks	12-Oct	21-Oct	56	blue	86.9	-0.0113	62.0	51.1	-0.0099	61.8	65.6	-0.0408		
measure 13	13 weeks	16-Nov	27-Nov	104	red	-	-0.0117	92.2	92.9	-0.0107	-	-	-0.0418		
measure 17	17 weeks	14-Dec	13-Dec	119	blue	-	-0.0100	-	-	-0.0090	-	-	-0.0400		
measure 21	21 weeks	11-Jan	11-Jan	147	red	-	-0.0127	-	-	-0.0135	-	-	-0.0444		
measure 25	25 weeks	8-Feb		175	blue	-	-	-	-	-	-	-	-		

Treatment	$LiNO_3$ + polyurethane	slump	wet	in.	weight measure	7.2	lb.	cement	27.6	lb.
Product	Renew + CUV 100	unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	23.04	lb.
Abbrev.	M13	yield	-		weight total	-	lb.	NaOH	48.6	g
Aggregate	F	air content	-	%				water	8.12-1.5	lb.
Exposure	d,e,f	air (pressure)	1.6	%	fine moisture	19.6	%	fine	46.4	lb.
		w:c	0.51		coarse moisture	SSD				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		16-Aug	16-Aug												
remove mold	0	17-Aug	17-Aug												
measure 0	0	17-Aug	17-Aug	0	blue	-	-0.0223	-	-	-0.0089	-	-	-0.0094		
measure 1	1 week	24-Aug	27-Aug	7	red	102.3	-0.0203	93.2	92.0	-0.0066	90.4	91.6	-0.0071		
measure 2	2 weeks	31-Aug	31-Aug	14	blue	83.8	-0.0216	95.0	94.5	-0.0070	95.2	96.1	-0.0073		
measure 4	4 weeks	14-Sep	-	28	red	-	-	-	-	-	-	-	-		
measure 8	8 weeks	12-Oct	21-Oct	56	blue	86.9	-0.0223	63.2	66.9	-0.0079	57.2	63.6	-0.0091		
measure 13	13 weeks	16-Nov	27-Nov	104	red	-	-0.0232	-	-	-0.0089	-	-	-0.0100		
measure 17	17 weeks	14-Dec	13-Dec	119	blue	-	-0.0211	90.4	90.9	-0.0072	82.8	85.3	-0.0082		
measure 21	21 weeks	11-Jan	11-Jan	147	red	-	-0.0230	-	-	-0.0085	-	-	-0.0097		
measure 25	25 weeks	8-Feb		175	blue	-	-	-	-	-	-	-	-		

Treatment	HMWM	slump	3.25	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Sika Pronto 19	unit weight	144.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M14	yield	0.9	ft^3	weight total	43.25	lb.	NaOH	40.6	g
Aggregate	F	air content	7.2	%				water	5.7-1.5	lb.
Exposure	d,e,f	air (pressure)	1.9	%	fine moisture	13	%	fine	39.7	lb.
		w:c	0.36		coarse moisture	SSD				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		16-Oct	16-Oct												
remove mold	0	17-Oct	17-Oct												
measure 0	0	17-Oct	17-Oct	0	blue	-	-0.0077	-	-	0.0043	-	-	-0.0058		
measure 1	1 week	24-Oct	25-Oct	7	red	-	-0.0053	-	-	0.0060	-	-	-0.0039		
measure 2	2 weeks	31-Oct	6-Nov	14	blue	82.7	-0.0078	81.9	85.3	0.0096	79.7	85.6	0.0061		
measure 4	4 weeks	14-Nov	14-Nov	28	red	74.4	-0.0050	87.5	84.2	0.0036	85.6	82.7	-0.0076		
measure 8	8 weeks	12-Dec	13-Dec	56	blue	-	-0.0165	94.7	83.3	-0.0054	91.8	89.7	-0.0092		
measure 13	13 weeks	16-Jan	17-Jan	104	red	58.4	-0.0086	92.4	78.5	0.0034	87.3	76.0	-0.0071		
measure 17	17 weeks	13-Feb	21-Feb	119	blue	78.0	-0.0071	78.6	74.1	0.0053	64.7	70.6	-0.0051		
measure 21	21 weeks	13-Mar	12-Mar	147	red	82.1	-0.0077	60.4	64.1	0.0044	61.0	60.7	-0.0060		
measure 25	25 weeks	10-Apr	-	175	blue	-	-	-	-	-	-	-	-		

Treatment	penetrating epoxy	slump	3.25	in.	weight measure	7.2	lb.	cement	23 lb.
Product	#850	unit weight	144.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6 lb.
Abbrev.	M15	yield	0.9	ft^3	weight total	43.25	lb.	NaOH	40.6 g
Aggregate	F	air content	7.2	%				water	5.7-1.5 lb.
Exposure	d,e,f	air (pressure)	1.9	%	fine moisture	13	%	fine	39.7 lb.
		w:c	0.36		coarse moisture	SSD			

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		16-Oct	16-Oct												
remove mold	0	17-Oct	17-Oct												
measure 0	0	17-Oct	17-Oct	0	blue	-	0.0001	-	-	-0.0293	-	-	-0.0070		
measure 1	1 week	24-Oct	25-Oct	7	red	-	0.0047	-	-	-0.0259	-	-	-0.0041		
measure 2	2 weeks	31-Oct	6-Nov	14	blue	82.7	0.0027	74.7	84.7	-0.0296	78.5	84.8	-0.0042		
measure 4	4 weeks	14-Nov	14-Nov	28	red	74.4	0.0041	82.9	87.0	-0.0293	85.1	83.8	-0.0055		
measure 8	8 weeks	12-Dec	13-Dec	56	blue	-	-0.0027	94.8	84.8	-0.0320	94.0	93.1	-0.0073		
measure 13	13 weeks	16-Jan	17-Jan	104	red	58.4	-0.0004	92.2	81.1	-0.0302	93.2	89.6	-0.0059		
measure 17	17 weeks	13-Feb	21-Feb	119	blue	78.0	0.0008	76.7	73.7	-0.0291	73.7	79.8	-0.0061		
measure 21	21 weeks	13-Mar	12-Mar	147	red	82.1	-0.0004	75.1	59.00	-0.0301	77.6	73.8	-0.0081		
measure 25	25 weeks	10-Apr	-	175	blue	-	-	-	-	-	-	-	-		

Treatment	control	slump	3.5	in.	weight measure	7.2	lb.	cement	27.66	lb.
Product		unit weight	147.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	23.04	lb.
Abbrev.	C	yield	0.7	ft^3	weight total	44.0	lb.	NaOH	48.6	g
Aggregate	J	air content	0	%				water	10.58	lb.
Exposure	d,e,f	air (pressure)	1.7	%	fine moisture	3.8 assume	%	fine	42.8	lb.
		w:c	0.41		coarse moisture					

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		6-Aug	6-Aug												
remove mold	0	7-Aug	7-Aug												
measure 0	0	7-Aug	7-Aug	0	blue		-0.0096	-	-	-0.0069	-	-	-0.0387		
measure 1	1 week	14-Aug	15-Aug	7	red	104.7	0.0047	93.5	91.5	0.0052	90.2	93.7	-0.0272		
measure 2	2 weeks	21-Aug	21-Aug	14	blue	104.8	0.0038	82.6	80.1	0.0058	82.8	82.7	-0.0263		
measure 4	4 weeks	4-Sep	4-Sep	28	red	87.3	0.0077	91.3	88.8	0.0100	90.5	90.2	-0.0221		
measure 8	8 weeks	2-Oct	2-Oct	56	blue	88.5	0.0064	68.5	71.9	0.0080	69.2	71.3	-0.0232		
measure 13	13 weeks	6-Nov	6-Nov	104	red	85.1	0.0046	68.3	68.0	0.0076	66.3	67.0	-0.0242		
measure 17	17 weeks	4-Dec	5-Dec	119	blue	73.3	0.0096	87.5	86.1	0.0118	89.0	85.5	-0.0206		
measure 21	21 weeks	1-Jan		147	red		-	-	-	-	-	-	-		
measure 25	25 weeks	29-Jan	29-Jan	175	blue	78.6	0.0095	81.3	81.4	0.0117	80.5	81.2	-0.0192		

Treatment	urethane	slump	2.75	in.	weight measure	7.2	lb.	cement	12.29	lb.
Product	Cevathane	unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	10.24	lb.
Abbrev.	M1	yield	-		weight total	-	lb.	NaOH	21.59	g
Aggregate	J	air content	-	%				water	5.06	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture	4.2	%	fine	18.24	lb.
		w:c	0.45		coarse moisture	-				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		17-Jul	17-Jul												
remove mold	0	18-Jul	18-Jul												
measure 0	0	18-Jul	18-Jul	0	blue		0.0057	-	-	0.0061	-	-	0.0003		
measure 1	1 week	25-Jul	25-Jul	7	red		0.0147	-	-	0.0101	-	-	0.0195		
measure 2	2 weeks	1-Aug	1-Aug	14	blue	103.8	0.0085	73.4	81.9	0.0047	79.6	87.8	0.0128		
measure 4	4 weeks	15-Aug	15-Aug	28	red	108.2	0.0075	54.7	72.3	0.0048	54.0	76.5	0.0126		
measure 8	8 weeks	12-Sep	12-Sep	56	blue	101.6	0.0147	80.5	94.7	0.0108	95.3	83.4	0.0201		
measure 13	13 weeks	17-Oct	16-Oct	104	red	78.1	0.0139	65.6	71.1	0.0105	79.6	86.3	0.0190		
measure 17	17 weeks	14-Nov	14-Nov	119	blue	74.4	0.0142	81.4	81.5	0.0123	84.7	83.5	0.0206		
measure 21	21 weeks	12-Dec	13-Dec	147	red	-	0.0093	94.6	96.6	0.0050	95.9	96.6	0.0150		
measure 25	25 weeks	9-Jan	9-Jan	175	blue	78.9	0.0220	84.0	86.2	0.0173	88.5	84.3	0.0275		

Treatment	linseed oil	slump	2.75	in.	weight measure	7.2	lb.	cement	12.29	lb.
Product	L50	unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	10.24	lb.
Abbrev.	M2	yield	-		weight total	-	lb.	NaOH	21.59	g
Aggregate	J	air content	-	%				water	5.16	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture	4.2	%	fine	18.24	lb.
		w:c	0.46		coarse moisture	-				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		17-Jul	17-Jul												
remove mold	0	18-Jul	18-Jul												
measure 0	0	18-Jul	18-Jul	0	blue		0.0067	-	-	0.0228	-	-	0.0400		
measure 1	1 week	25-Jul	25-Jul	7	red		0.0119	-	-	-0.0069	-	-	-0.0233		
measure 2	2 weeks	1-Aug	1-Aug	14	blue	103.8	0.0066	73.3	80.3	-0.0109	70.5	84.9	-0.0270		
measure 4	4 weeks	15-Aug	15-Aug	28	red	108.2	0.0079	77.4	74.7	-0.0117	70.5	73.9	-0.0265		
measure 8	8 weeks	12-Sep	12-Sep	56	blue	101.6	0.0132	92.2	86.9	-0.0046	91.2	86.0	-0.0203		
measure 13	13 weeks	17-Oct	16-Oct	104	red	78.1	0.0135	87.4	82.6	-0.0059	79.0	75.4	-0.0205		
measure 17	17 weeks	14-Nov	14-Nov	119	blue	74.4	0.0137	87.1	82.0	-0.0040	78.0	79.0	-0.0199		
measure 21	21 weeks	12-Dec	13-Dec	147	red	-	0.0195	53.6	95.0	-0.0145	96.8	95.6	0.0012		
measure 25	25 weeks	9-Jan	9-Jan	175	blue	78.9	0.0210	89.1	89.5	0.0028	86.7	84.3	-0.0130		

Treatment	PCM	slump	4	in.	weight measure	7.2	lb.	cement	23.05	lb.
Product	P-10	unit weight	-	lb/ft^3	vol.measure		ft^3	coarse	19.2	lb.
Abbrev.	M3	yield	-		weight total	-	lb.	NaOH	40.49	g
Aggregate	J	air content	-	%				water	8.8	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture	3.79	%	fine	34.88	lb.
		w:c	0.41		coarse moisture	-				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		24-Jul	24-Jul												
remove mold	0	25-Jul	25-Jul												
measure 0	0	25-Jul	25-Jul	0	blue		-0.0194			-0.0107	-	-	-0.0103	-	-
measure 1	1 week	1-Aug	1-Aug	7	red		-0.0060			0.0020	84.9	89.2	0.0046	-	-
measure 2	2 weeks	8-Aug	8-Aug	14	blue	101.8	0.0031			0.0168	87.1	77.1	-0.0037	79.4	85.1
measure 4	4 weeks	22-Aug	22-Aug	28	red	104.7	0.0031			0.0021	73.2	78.4	-0.0082	71.9	77.9
measure 8	8 weeks	19-Sep	19-Sep	56	blue	86.4	0.0095			0.0115	79.5	89.4	0.0035	78.2	81.6
measure 13	13 weeks	24-Oct	24-Oct	104	red	103.5	0.0105			0.0102	64.1	71.8	0.0006	72.3	75.5
measure 17	17 weeks	21-Nov	21-Nov	119	blue	-	0.0110			0.0259	83.8	83.4	0.0171	85.0	87.2
measure 21	21 weeks	19-Dec	19-Dec	147	red	51.8	0.0126			0.0152	70.2	79.2	0.0052	75.2	85.8
measure 25	25 weeks	16-Jan		175	blue	-	-			-	-	-	-	-	-

Treatment	polyurethane	slump	4	in.	weight measure	7.2	lb.	cement	23.05	lb.
Product	Cevathane	unit weight	-	lb/ft^3	vol.measure		ft^3	coarse	19.2	lb.
Abbrev.	M4	yield	-		weight total	-	lb.	NaOH	40.49	g
Aggregate	J	air content	-	%				water	8.8	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture	3.79	%	fine	34.88	lb.
		w:c	0.41		coarse moisture	-				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		24-Jul	24-Jul												
remove mold	0	25-Jul	25-Jul												
measure 0	0	25-Jul	25-Jul	0	blue		-0.0107	-	-	-0.0444	-	-	-0.0097		
measure 1	1 week	1-Aug	1-Aug	7	red		0.0050	86.3	91.4	-0.0325	74.1	85.5	0.0004		
measure 2	2 weeks	8-Aug	8-Aug	14	blue	101.8	0.0128	80.3	85.0	-0.0334	59.9	76.7	-0.0010		
measure 4	4 weeks	22-Aug	22-Aug	28	red	104.7	0.0111	74.1	75.2	-0.0347	67.6	75.2	-0.0026		
measure 8	8 weeks	19-Sep	19-Sep	56	blue	86.4	0.0193	80.5	94.3	-0.0272	83.8	78.1	0.0047		
measure 13	13 weeks	24-Oct	24-Oct	104	red	103.5	0.0212	75.3	84.0	-0.0261	65.4	66.1	0.0053		
measure 17	17 weeks	21-Nov	21-Nov	119	blue	-	0.0226	76.6	90.4	-0.0246	73.8	70.5	0.0066		
measure 21	21 weeks	19-Dec	19-Dec	147	red	51.8	0.0277	84.7	85.1	-0.0196	85.7	76.1	0.0096		
measure 25	25 weeks	16-Jan		175	blue	-	-	-	-	-	-	-	-		

Treatment	silane 20	slump	4	in.	weight measure	7.2	lb.	cement	23.05	lb.
Product	Rainstopper 120	unit weight	-	lb/ft^3	vol.measure		ft^3	coarse	19.2	lb.
Abbrev.	M5	yield	-		weight total	-	lb.	NaOH	40.49	g
Aggregate	J	air content	-	%				water	8.8	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture	3.79	%	fine	34.88	lb.
		w:c	0.41		coarse moisture	-				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		24-Jul	24-Jul												
remove mold	0	25-Jul	25-Jul												
measure 0	0	25-Jul	25-Jul	0	blue		-0.0042	-	-	-0.0122	-	-	-0.0068		
measure 1	1 week	1-Aug	1-Aug	7	red		0.0115	77.4	85.7	0.0004	76.3	87.0	0.0062		
measure 2	2 weeks	8-Aug	8-Aug	14	blue	101.8	0.0090	79.2	76.3	0.0004	60.3	73.2	0.0041		
measure 4	4 weeks	22-Aug	22-Aug	28	red	104.7	0.0078	70.5	76.1	-0.0012	69.1	73.9	0.0030		
measure 8	8 weeks	19-Sep	19-Sep	56	blue	86.4	0.0096	66.9	71.3	0.0011	62.1	69.7	0.0052		
measure 13	13 weeks	24-Oct	24-Oct	104	red	103.5	0.0093	55.3	69.1	-0.0007	42.1	61.3	0.0049		
measure 17	17 weeks	21-Nov	21-Nov	119	blue		0.0081	50.2	68.4	-0.0009	51.9	64.3	0.0041		
measure 21	21 weeks	19-Dec	19-Dec	147	red	51.8	0.0088	69.3	68.6	-0.0001	70.0	69.0	0.0095		
measure 25	25 weeks	16-Jan		175	blue	-	-	-	-	-	-	-	-		

Treatment	silane 40	slump	4	in.	weight measure	7.2	lb.	cement	23.05	lb.
Product	Rainstopper 140	unit weight	-	lb/ft^3	vol.measure		ft^3	coarse	19.2	lb.
Abbrev.	M6	yield	-		weight total	-	lb.	NaOH	40.49	g
Aggregate	J	air content	-	%				water	8.8	lb.
Exposure	d,e,f	air (pressure)	-	%	fine moisture	3.79	%	fine	34.88	lb.
		w:c	0.41		coarse moisture	-				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		24-Jul	24-Jul												
remove mold	0	25-Jul	25-Jul												
measure 0	0	25-Jul	25-Jul	0	blue		-0.0258	-	-	-0.0280	-	-	-0.0081		
measure 1	1 week	1-Aug	1-Aug	7	red		-0.0169	76.1	89.0	-0.0158	83.7	82.5	0.0051		
measure 2	2 weeks	8-Aug	8-Aug	14	blue	101.8	-0.0183	76.4	76.9	-0.0174	76.9	80.0	0.0030		
measure 4	4 weeks	22-Aug	22-Aug	28	red	104.7	-0.0193	71.0	76.8	-0.0184	74.4	74.5	0.0019		
measure 8	8 weeks	19-Sep	19-Sep	56	blue	86.4	-0.0151	66.0	74.4	-0.0138	70.0	79.1	0.0048		
measure 13	13 weeks	24-Oct	24-Oct	104	red	103.5	-0.0151	54.0	66.2	-0.0133	57.7	66.1	0.0045		
measure 17	17 weeks	21-Nov	21-Nov	119	blue		-0.0154	73.5	80.6	-0.0150	67.5	80.9	0.0036		
measure 21	21 weeks	19-Dec	19-Dec	147	red	51.8	-0.0105	94.0	90.6	-0.0114	88.3	83.3	0.0040		
measure 25	25 weeks	16-Jan		175	blue	-	-	-	-	-	-	-	-		

Treatment	siloxane 20	slump	2	in.	weight measure	7.2	lb.	cement	27.66	lb.
Product	SIL 20	unit weight	147.6	lb/ft^3	vol.measure	0.25	ft^3	coarse	23.04	lb.
Abbrev.	M7	yield	0.7	ft^3	weight total	44.1	lb.	NaOH	48.59	g
Aggregate	J	air content	0	%				water	10.58	lb.
Exposure	d,e,f	air (pressure)	2.1	%	fine moisture	3.8	%	fine	42.8	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		30-Jul	30-Jul												
remove mold	0	31-Jul	31-Jul												
measure 0	0	31-Jul	31-Jul	0	blue		-0.0090	-	-	-0.0081	-	-	-0.0115		
measure 1	1 week	7-Aug	7-Aug	7	red		0.0001	77.0	85.0	0.0013	87.3	87.5	-0.0038		
measure 2	2 weeks	14-Aug	14-Aug	14	blue	95.2	-0.0020	78.9	76.5	0.0012	79.1	79.3	-0.0014		
measure 4	4 weeks	28-Aug	28-Aug	28	red	90.0	0.0005	87.6	88.5	0.0005	94.4	85.2	-0.0022		
measure 8	8 weeks	25-Sep	25-Sep	56	blue	79.5	0.0036	63.0	68.4	0.0028	70.3	68.7	0.0005		
measure 13	13 weeks	30-Oct	1-Nov	104	red	89.6	0.0020	63.3	66.5	0.0031	59.2	64.3	0.0000		
measure 17	17 weeks	27-Nov	27-Nov	119	blue	49.9	0.0059	66.4	62.0	0.0061	65.2	60.9	0.0032		
measure 21	21 weeks	25-Dec	-	147	red		-	-	-	-	-	-	-		
measure 25	25 weeks	22-Jan	29-Jan	175	blue	-	0.0111	-	-	0.0116	-	-	0.0081		

Treatment	siloxane 40	slump	2	in.	weight measure	7.2	lb.	cement	27.66	lb.
Product	SIL 40	unit weight	147.6	lb/ft^3	vol.measure	0.25	ft^3	coarse	23.04	lb.
Abbrev.	M8	yield	0.7	ft^3	weight total	44.1	lb.	NaOH	48.59	g
Aggregate	J	air content	0	%				water	10.58	lb.
Exposure	d,e,f	air (pressure)	2.1	%	fine moisture	3.8	%	fine	42.8	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		30-Jul	30-Jul												
remove mold	0	31-Jul	31-Jul												
measure 0	0	31-Jul	31-Jul	0	blue		-0.0061	-	-	-0.0083	-	-	-0.0113		
measure 1	1 week	7-Aug	7-Aug	7	red	98.2	0.0017	64.1	56.3	-	78.7	74.5	-0.0001		
measure 2	2 weeks	14-Aug	14-Aug	14	blue	95.2	0.0048	74.2	78.7	0.0026	79.9	84.9	-0.0002		
measure 4	4 weeks	28-Aug	28-Aug	28	red	90.0	0.0030	91.7	96.4	0.0012	89.1	88.9	-0.0011		
measure 8	8 weeks	25-Sep	25-Sep	56	blue	79.5	0.0067	57.8	67.9	0.0050	68.2	66.5	0.0031		
measure 13	13 weeks	30-Oct	1-Nov	104	red	89.6	0.0037	58.6	62.7	0.0017	70.9	72.4	0.0002		
measure 17	17 weeks	27-Nov	27-Nov	119	blue	49.9	0.0068	57.6	58.8	0.0041	59.1	61.4	0.0030		
measure 21	21 weeks	25-Dec		147	red		-	-	-	-	-	-	-		
measure 25	25 weeks	22-Jan	29-Jan	175	blue	-	0.0104	-	-	0.0070	-	-	0.0073		

Treatment	$LiNO_3$	slump	2	in.	weight measure	7.2	lb.	cement	27.66	lb.
Product	Renew	unit weight	147.6	lb/ft^3	vol.measure	0.25	ft^3	coarse	23.04	lb.
Abbrev.	M9	yield	0.7	ft^3	weight total	44.1	lb.	NaOH	48.59	g
Aggregate	J	air content	0	%				water	10.58	lb.
Exposure	d,e,f	air (pressure)	2.1	%	fine moisture	3.8	%	fine	42.8	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		30-Jul	30-Jul												
remove mold	0	31-Jul	31-Jul												
measure 0	0	31-Jul	31-Jul	0	blue	-	-0.0411	-	-	-0.0106	-	-	-0.0054		
measure 1	1 week	7-Aug	7-Aug	7	red	-	-0.0265	74.4	59.5	-	70.6	71.2	0.0061		
measure 2	2 weeks	14-Aug	14-Aug	14	blue	95.2	-0.0217	82.6	79.5	0.0024	77.0	80.7	0.0058		
measure 4	4 weeks	28-Aug	28-Aug	28	red	90.0	-0.0226	94.1	96.2	0.0060	93.6	92.0	0.0114		
measure 8	8 weeks	25-Sep	25-Sep	56	blue	79.5	-0.0216	70.7	77.6	0.0070	70.6	72.0	0.0124		
measure 13	13 weeks	30-Oct	1-Nov	104	red	89.6	-0.0244	74.7	78.5	0.0040	76.4	77.3	0.0095		
measure 17	17 weeks	27-Nov	27-Nov	119	blue	49.9	-0.0217	71.0	70.5	0.0070	70.7	69.1	0.0129		
measure 21	21 weeks	25-Dec	-	147	red	-	-	-	-	-	-	-	-		
measure 25	25 weeks	22-Jan	29-Jan	175	blue	-	-0.0169	-	-	0.0117	-	-	0.0178		

Treatment	$LiNO_3$ + silane	slump	2	in.	weight measure	7.2	lb.	cement	27.66	lb.
Product	Renew + Rain 140	unit weight	147.6	lb/ft^3	vol.measure	0.25	ft^3	coarse	23.04	lb.
Abbrev.	M10	yield	0.7	ft^3	weight total	44.1	lb.	NaOH	48.59	g
Aggregate	J	air content	0	%				water	10.58	lb.
Exposure	d,e,f	air (pressure)	2.1	%	fine moisture	3.8	%	fine	42.8	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		30-Jul	30-Jul												
remove mold	0	31-Jul	31-Jul												
measure 0	0	31-Jul	31-Jul	0	blue	-	-0.0197	-	-	-0.0268	-	-	-0.0270		
measure 1	1 week	7-Aug	7-Aug	7	red	-	-0.0098	86.9	89.2	-0.0121	88.3	85.4	-0.0158		
measure 2	2 weeks	14-Aug	14-Aug	14	blue	95.2	-0.0081	74.2	86.8	-0.0116	83.8	82.8	-0.0161		
measure 4	4 weeks	28-Aug	28-Aug	28	red	90.0	-0.0092	90.9	95.9	-0.0138	84.9	96.1	-0.0170		
measure 8	8 weeks	25-Sep	25-Sep	56	blue	79.5	-0.0041	65.2	67.7	-0.0101	67.6	69.0	-0.0138		
measure 13	13 weeks	30-Oct	1-Nov	104	red	89.6	-0.0061	74.1	74.1	-0.0118	74.5	75.1	-0.0157		
measure 17	17 weeks	27-Nov	27-Nov	119	blue	49.9	-0.0011	70.3	68.1	-0.0071	69.3	66.2	-0.0120		
measure 21	21 weeks	25-Dec	-	147	red	-	-	-	-	-	-	-	-		
measure 25	25 weeks	22-Jan	29-Jan	175	blue	-	0.0029	-	-	-0.0014	-	-	-0.0045		

Treatment	$LiNO_3$ + siloxane	slump	3.5	in.	weight measure	7.2	lb.	cement	27.66	lb.
Product	Renew + SIL 40	unit weight	147.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	23.04	lb.
Abbrev.	M11	yield	0.7	ft^3	weight total	44.0	lb.	NaOH	48.6	g
Aggregate	J	air content	0	%				water	10.58	lb.
Exposure	d,e,f	air (pressure)	1.7	%	fine moisture	3.8 assume	%	fine	42.8	lb.
		w:c	0.41		coarse moisture	-				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		6-Aug	6-Aug												
remove mold	0	7-Aug	7-Aug												
measure 0	0	7-Aug	7-Aug	0	blue		-0.0136	-	-	-0.0207	-	-	-0.0087		
measure 1	1 week	14-Aug	15-Aug	7	red	104.7	0.0035	94.1	91.4	-0.0051	91.1	90.5	0.0078		
measure 2	2 weeks	21-Aug	21-Aug	14	blue	104.8	0.0021	79.5	80.9	-0.0084	79.5	81.4	0.0053		
measure 4	4 weeks	4-Sep	4-Sep	28	red	87.1	0.0063	88.0	93.2	-0.0035	86.6	90.6	0.0107		
measure 8	8 weeks	2-Oct	2-Oct	56	blue	88.5	0.0049	62.8	67.9	-0.0041	59.6	65.0	0.0097		
measure 13	13 weeks	6-Nov	6-Nov	104	red	85.1	0.0046	63.0	68.5	-0.0049	61.4	66.9	0.0096		
measure 17	17 weeks	4-Dec	5-Dec	119	blue	73.3	0.0110	87.6	85.9	-0.0003	93.2	92.5	0.0135		
measure 21	21 weeks	1-Jan	-	147	red	-	-	-	-	-	-	-	-		
measure 25	25 weeks	29-Jan	29-Jan	175	blue	-	0.0131	80.5	82.1	0.0026	79.4	81.8	0.0172		

Treatment	$LiNO_3$ + linseed oil	slump	3.5	in.	weight measure	7.2	lb.	cement	27.66	lb.
Product	Renew + L50	unit weight	147.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	23.04	lb.
Abbrev.	M12	yield	0.7	ft^3	weight total	44.0	lb.	NaOH	48.6	g
Aggregate	J	air content	0	%				water	10.58	lb.
Exposure	d,e,f	air (pressure)	1.7	%	fine moisture	3.8 assume	%	fine	42.8	lb.
		w:c	0.41		coarse moisture	-				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		6-Aug	6-Aug												
remove mold	0	7-Aug	7-Aug												
measure 0	0	7-Aug	7-Aug	0	blue		-0.0260	-	-	-0.0043	-	-	-0.0025		
measure 1	1 week	14-Aug	15-Aug	7	red	104.7	-0.0091	91.5	90.6	0.0038	86.4	88.9	0.0089		
measure 2	2 weeks	21-Aug	21-Aug	14	blue	104.8	-0.0117	80.4	82.5	0.0055	73.1	82.1	0.0079		
measure 4	4 weeks	4-Sep	4-Sep	28	red	87.1	-0.0054	87.1	89.8	0.0105	90.3	91.4	0.0146		
measure 8	8 weeks	2-Oct	2-Oct	56	blue	88.5	-0.0069	67.1	69.5	0.0091	60.5	70.3	0.0137		
measure 13	13 weeks	6-Nov	6-Nov	104	red	85.1	-0.0076	66.8	70.6	0.0083	61.2	69.5	0.0123		
measure 17	17 weeks	4-Dec	5-Dec	119	blue	73.3	-0.0065	74.1	89.0	0.0100	89.9	84.0	0.0159		
measure 21	21 weeks	1-Jan	-	147	red	-	-	-	-	-	-	-	-		
measure 25	25 weeks	29-Jan	29-Jan	175	blue	-	-0.0025	77.6	81.3	0.0141	79.3	81.0	0.0192		

Treatment	$LiNO_3$ + polyurethane	slump	3.5	in.	weight measure	7.2	lb.	cement	27.66	lb.
Product	Renew + CUV 100	unit weight	147.2	lb/ft^3	vol.measure	0.25	ft^3	coarse	23.04	lb.
Abbrev.	M13	yield	0.7	ft^3	weight total	44.0	lb.	NaOH	48.6	g
Aggregate	J	air content	0	%				water	10.58	lb.
Exposure	d,e,f	air (pressure)	1.7	%	fine moisture	3.8 assume	%	fine	42.8	lb.
		w:c	0.41		coarse moisture	-				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		6-Aug	6-Aug												
remove mold	0	7-Aug	7-Aug			-									
measure 0	0	7-Aug	7-Aug	0	blue	-	-0.0098	-	-	-0.0065	-	-	-0.0388		
measure 1	1 week	14-Aug	15-Aug	7	red	104.7	0.0003	91.4	90.1	0.0018	91.6	88.0	-0.0317		
measure 2	2 weeks	21-Aug	21-Aug	14	blue	104.8	-0.0013	79.5	81.4	0.0018	80.7	82.3	-0.0314		
measure 4	4 weeks	4-Sep	4-Sep	28	red	87.1	0.0042	84.6	89.7	0.0073	87.7	87.4	-0.0257		
measure 8	8 weeks	2-Oct	2-Oct	56	blue	88.5	0.0036	63.0	69.9	0.0066	64.9	68.0	-0.0264		
measure 13	13 weeks	6-Nov	6-Nov	104	red	85.1	0.0043	62.4	62.9	0.0054	63.5	65.0	-0.0281		
measure 17	17 weeks	4-Dec	5-Dec	119	blue	73.3	0.0064	85.7	85.6	0.0099	84.8	84.3	-0.0244		
measure 21	21 weeks	1-Jan	-	147	red	-	-	-	-	-	-	-	-		
measure 25	25 weeks	29-Jan	29-Jan	175	blue	-	0.0090	81.1	77.6	0.0136	79.2	82.1	-0.0212		

Treatment	HMWM	slump	3.75	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Sika Pronto 19	unit weight	144	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M14	yield	0.9	ft^3	weight total	43.2	lb.	NaOH	40.6	g
Aggregate	J	air content	3.5	%				water	7.3-0.3	lb.
Exposure	d,e,f	air (pressure)	2	%	fine moisture	8.9	%	fine	37.2	lb.
		w:c	0.41		coarse moisture	SSD				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		18-Oct													
remove mold	0	19-Oct													
measure 0	0	19-Oct	19-Oct	0	blue	-	0.0087	-	-	-0.0023	-	-	-0.0113		
measure 1	1 week	26-Oct	25-Oct	7	red	-	0.0220	-	-	0.0066	-	-	-0.0003		
measure 2	2 weeks	2-Nov	2-Nov	14	blue	82.7	0.0253	77.5	84.1	0.0086	77.8	82.1	-0.0010		
measure 4	4 weeks	16-Nov	16-Nov	28	red	-	0.0223	90.4	91.7	0.0090	90.8	93.7	0.0008		
measure 8	8 weeks	14-Dec	13-Dec	56	blue	-	0.0263	91.6	94.4	0.0121	86.4	88.8	0.0039		
measure 13	13 weeks	18-Jan	17-Jan	104	red	58.4	0.0284	88.3	91.9	0.0140	80.3	84.6	0.0058		
measure 17	17 weeks	15-Feb	21-Feb	119	blue	78.0	0.0304	60.1	67.7	0.0154	70.8	69.5	0.0078		
measure 21	21 weeks	15-Mar	12-Mar	147	red	82.1	0.0292	71.4	66.3	0.0150	69.9	72.9	0.0070		
measure 25	25 weeks	12-Apr	-	175	blue	-	-	-	-	-	-	-	-		

Treatment	penetrating epoxy	slump	3.75	in.	weight measure	7.2	lb.	cement	23	lb.
Product	#850	unit weight	144	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M15	yield	0.9	ft^3	weight total	43.2	lb.	NaOH	40.6	g
Aggregate	J	air content	3.5	%				water	7.3-.3	lb.
Exposure	d,e,f	air (pressure)	2	%	fine moisture	8.9	%	fine	37.2	lb.
		w:c	0.42		coarse moisture	SSD				

							Specimen d			Specimen e			Specimen f		
	day	date scheduled	date done	days	color up	air temp	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						°F	in.	%	%	in.	%	%	in.	%	%
pour		18-Oct													
remove mold	0	19-Oct													
measure 0	0	19-Oct	19-Oct	0	blue	-	-0.0019	-	-	0.0032	-	-	-0.0160		
measure 1	1 week	26-Oct	25-Oct	7	red	-	0.0075	-	-	0.0123	-	-	-0.0074		
measure 2	2 weeks	2-Nov	2-Nov	14	blue	82.7	0.0160	79.4	83.7	0.0160	80.5	84.4	0.0154		
measure 4	4 weeks	16-Nov	16-Nov	28	red	-	0.0143	93.4	92.8	0.0145	94.5	93.0	-0.0044		
measure 8	8 weeks	14-Dec	13-Dec	56	blue	-	0.0171	91.9	95.0	0.0169	87.7	88.3	-0.0029		
measure 13	13 weeks	18-Jan	17-Jan	104	red	58.4	0.0185	76.4	83.3	0.0190	86.5	88.4	0.0005		
measure 17	17 weeks	15-Feb	21-Feb	119	blue	78.0	0.0166	68.0	74.1	0.0214	66.2	72.6	0.0022		
measure 21	21 weeks	15-Mar	12-Mar	147	red	82.1	0.0156	71.2	62	0.0200	60.9	70.1	0.0011		
measure 25	25 weeks	12-Apr	-	175	blue	-	-	-	-	-	-	-	-		

APPENDIX E

Expansion and Moisture Data from Wet/Dry Series

Treatment	silane + 742	slump	7	in.	weight measure	7.2	lb.	cement	23	lb.
Product		unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M16	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	J	air content	-	%				water	6.5	lb.
Exposure	g, h, j, k	air (pressure)	-	%	fine moisture	11.2	%	fine	38	lb.
		w:c	0.42		coarse moisture	damp				

						Specimen g sandblast			Specimen h sandblast			Specimen j waterblast			Specimen k waterblast		
	day		date sched.	date done	color up	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						in.	%	%	in.	%	%	in.	%	%	in.	%	%
pour			30-Dec	30-Dec													
remove mold	0		31-Dec	31-Dec													
measure 0	0	wet	31-Dec	31-Dec	blue	-0.0152	-	-	-0.0050	-	-	-0.0282	-	-	0.0055	-	-
measure 1	1 week	dry	7-Jan	9-Jan	red	-0.0048	82.6	83.7	0.0064	84.5	88.5	-	79.2	81.6	0.0162	83.0	81.7
measure 2	2 weeks	wet	14-Jan	14-Jan	blue	-0.0028	79.5	81.6	0.0079	80.1	60.1	-0.0160	83.9	76.3	0.0173	85.4	84.4
measure 4	4 weeks	dry	28-Jan	28-Jan	red	0.0145	86.9	93.0	0.0280	92.7	92.9	-0.0015	91.7	88.2	0.0361	88.4	90.1
measure 6	6 weeks	wet	11-Feb	11-Feb	blue	0.0099	33.1	37.4	0.0224	29.2	24.2	-0.0069	43.4	35.0	0.0307	33.6	31.2
measure 8	8 weeks	dry	25-Feb	25-Feb	red	0.0171	87.8	85.9	0.0302	89.7	84.4	-	-	-	0.0382	86.5	88.4
measure 10	10 weeks	wet	11-Mar	11-Mar	blue	0.0102	17.7	21.7	0.0225	13.9	15.1	-	-	-	0.0311	14.6	16.2
measure 12	12 weeks	dry	25-Mar	25-Mar	red	0.0188	85.0	82.9	0.0284	90.5	87.0	-	-	-	0.0402	87.7	86.9
measure 13	13 weeks	wet	1-Apr	1-Apr	blue	0.0118	25.7	29.2	0.0229	22.2	27.4	-	-	-	0.0311	22.3	29.9

Treatment	silane+742th	slump	7	in.	weight measure	7.2	lb.	cement	23	lb.
Product		unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M17	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	J	air content	-	%				water	6.5	lb.
Exposure	g, h, j, k	air (pressure)	-	%	fine moisture	11.2	%	fine	38	lb.
		w:c	0.42		coarse moisture	damp				

						Specimen g			Specimen h			Specimen j			Specimen k		
						sandblast			sandblast			waterblast			waterblast		
	day		date sched.	date done	color up	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						in.	%	%	in.	%	%	in.	%	%	in.	%	%
pour			30-Dec	30-Dec													
remove mold	0		31-Dec	31-Dec													
measure 0	0	wet	31-Dec	31-Dec	blue	-0.0148	-	-	-0.0278	-	-	-0.0058	-	-	-0.0040	-	-
measure 1	1 week	dry	7-Jan	9-Jan	red	-0.0074	81.3	85.0	-0.0202	84.4	85.7	0.0042	87.4	89.7	0.0040	83.1	81.4
measure 2	2 weeks	wet	14-Jan	14-Jan	blue	-0.0044	68.5	56.3	-0.0165	77.3	83.8	0.0037	80.4	75.9	0.0055	78.7	70.3
measure 4	4 weeks	dry	28-Jan	28-Jan	red	0.0119	63.5	63.7	-0.0008	61.0	62.3	0.0245	93.4	92.3	0.0260	91.6	92.4
measure 6	6 weeks	wet	11-Feb	11-Feb	blue	0.0066	33.5	25.6	-0.0058	34.5	33.6	0.0191	28.7	24.0	0.0199	22.8	29.1
measure 8	8 weeks	dry	25-Feb	25-Feb	red	0.0133	87.3	86.4	0.0100	79.8	84.8	0.0264	88.6	90.5	0.0294	90.4	90.8
measure 10	10 weeks	wet	11-Mar	11-Mar	blue	0.0080	17.0	18.3	-0.0049	18.9	21.2	0.0206	16.0	15.7	0.0223	11.3	15.0
measure 12	12 weeks	dry	25-Mar	25-Mar	red	0.0154	79.9	83.6	0.0026	84.7	86.1	-	-	-	0.0307	82.9	80.2
measure 13	13 weeks	wet	1-Apr	1-Apr	blue	0.0088	23.0	23.4	-0.0048	25.5	27.1	-	-	-	0.0227	25.2	26.3

Treatment	silane+latex	slump	7	in.	weight measure	7.2	lb.	cement	23	lb.
Product		unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M18	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	J	air content	-	%				water	6.5	lb.
Exposure	g, h, j, k	air (pressure)	-	%	fine moisture	11.2	%	fine	38	lb.
		w:c	0.42		coarse moisture	damp				

						Specimen g sandblast			Specimen h sandblast			Specimen j waterblast			Specimen k waterblast		
	day		date sched.	date done	color up	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						in.	%	%	in.	%	%	in.	%	%	in.	%	%
pour			30-Dec	30-Dec													
remove mold	0		31-Dec	31-Dec													
measure 0	0	wet	31-Dec	31-Dec	blue	-0.0074	-	-	-0.0037	-	-	-0.0021	-	-	-0.0189	-	-
measure 1	1 week	dry	7-Jan	9-Jan	red	0.0053	82.1	86.7	0.0076	88.9	88.3	0.0073	91.8	87.1	-0.0111	94.1	86.2
measure 2	2 weeks	wet	14-Jan	14-Jan	blue	0.0025	77.6	75.6	0.0098	66.8	33.9	0.0103	65.7	79.2	-0.0080	39.3	68.2
measure 4	4 weeks	dry	28-Jan	28-Jan	red	0.0276	61.5	62.0	0.0281	88.9	89.5	0.0266	65.8	91.6	0.0076	63.4	67.4
measure 6	6 weeks	wet	11-Feb	11-Feb	blue	0.0207	20.6	31.4	0.0217	25.6	15.4	0.0212	22.7	33.1	0.0024	20.1	32.1
measure 8	8 weeks	dry	25-Feb	25-Feb	red	0.0311	87.7	85.82	0.0308	78.4	88.3	0.0296	93.4	86.0	0.0102	83.3	87.9
measure 10	10 weeks	wet	11-Mar	11-Mar	blue	0.0235	12.2	14.0	0.0238	12.7	9.8	0.0230	13.2	16.3	0.0046	11.2	19.4
measure 12	12 weeks	dry	25-Mar	25-Mar	red	0.0338	80.9	83.0	0.0328	86.2	85.4	0.0315	84.5	97.4	0.0121	86.6	87.5
measure 13	13 weeks	wet	1-Apr	1-Apr	blue	0.0235	20.1	23.3	0.0219	21.1	13.3	0.0053	14.5	27.1	0.0216	21.5	25.2

Treatment	control	slump	5	in.	weight measure	7.2	lb.	cement	23	lb.
Product		unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	C	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	J	air content	-	%				water	5.2	lb.
Exposure	g, h, j, k	air (pressure)	-	%	fine moisture	14.8	%	fine	39.3	lb.
		w:c	0.42		coarse moisture	SSD				

						Specimen g sandblast			Specimen h sandblast			Specimen j waterblast			Specimen k waterblast		
	day		date sched.	date done	color up	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						in.	%	%	in.	%	%	in.	%	%	in.	%	%
pour			1-Jan	1-Jan													
remove mold	0		2-Jan	2-Jan													
measure 0	0	wet	2-Jan	2-Jan	blue	-0.0025	-	-	-0.0067	-	-	-0.0255	-	-	-0.0044	-	-
measure 1	1 week	dry	9-Jan	9-Jan	red	0.0127	90.6	90.8	0.0112	93.4	92.4	-0.0109	93.8	93.1	0.0102	91.5	93.9
measure 2	2 weeks	wet	16-Jan	16-Jan	blue	0.0159	63.8	63.8	0.0135	46.5	44.7	-0.0085	35.7	37.5	0.0101	60.5	43.7
measure 4	4 weeks	dry	30-Jan	30-Jan	red	0.0300	93.1	91.9	0.0272	95.2	95.8	0.0038	92.8	92.3	0.0255	93.2	93.7
measure 6	6 weeks	wet	13-Feb	13-Feb	blue	0.0276	27.1	30.3	0.0249	23.0	20.7	0.0022	19.7	19.1	0.0234	26.0	23.0
measure 8	8 weeks	dry	27-Feb	27-Feb	red	0.0310	80.8	83.1	0.0305	80.8	84.3	0.0073	75.2	79.7	0.0289	84.5	86.3
measure 10	10 weeks	wet	13-Mar	13-Mar	blue	0.0269	11.9	13.2	0.0248	10.5	10.8	0.0019	8.5	14.6	0.0232	12.8	15.7
measure 12	12 weeks	dry	27-Mar	27-Mar	red	0.0351	83.1	85.1	0.0329	88.8	85.3	0.0089	82.8	84.0	0.0305	83.7	87.6
measure 13	13 weeks	wet	3-Apr	3-Apr	blue	0.0298	23.4	18.6	0.0277	17.6	19.5	0.0037	11.4	17.3	0.0256	18.1	21.7

Treatment	silane+PCM	slump	5	in.	weight measure	7.2	lb.	cement	23	lb.
Product		unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M19	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	J	air content	-	%				water	5.2	lb.
Exposure	g, h, j, k	air (pressure)	-	%	fine moisture	14.8	%	fine	39.3	lb.
		w:c	0.42		coarse moisture	SSD				

						Specimen g			Specimen h			Specimen j			Specimen k		
						sandblast			sandblast			waterblast			waterblast		
	day		date sched.	date done	color up	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						in.	%	%	in.	%	%	in.	%	%	in.	%	%
pour			1-Jan	1-Jan													
remove mold	0		2-Jan	2-Jan													
measure 0	0	wet	2-Jan	2-Jan	blue	-0.0082	-	-	-0.0228	-	-	-0.0362	-	-	-0.0102	-	-
measure 1	1 week	dry	9-Jan	9-Jan	red	0.0016	80.9	88.9	-0.0088	87.9	88.7	-0.0250	91.2	95.1	0.0053	94.5	95.0
measure 2	2 weeks	wet	16-Jan	16-Jan	blue	0.0038	37.4	62.6	-0.0072	59.2	66.4	-0.0251	32.7	57.6	0.0051	49.2	63.2
measure 4	4 weeks	dry	30-Jan	30-Jan	red	0.0220	87.5	90.3	0.0099	90.0	92.9	-0.0058	91.1	94.8	0.0259	94.5	94.5
measure 6	6 weeks	wet	13-Feb	13-Feb	blue	0.0193	20.7	35.3	0.0047	28.0	33.2	-0.0101	21.3	31.2	0.0200	24.4	34.4
measure 8	8 weeks	dry	27-Feb	27-Feb	red	0.0245	81.7	87.3	0.0116	85.2	85.9	-0.0043	78.9	85.9	0.0272	82.8	87.2
measure 10	10 weeks	wet	13-Mar	13-Mar	blue	0.0190	8.6	16.1	0.0057	15.5	16.3	-0.0099	8.6	15.4	0.0201	9.1	17.0
measure 12	12 weeks	dry	27-Mar	27-Mar	red	0.0249	81.0	81.5	0.0135	86.7	87.1	-0.0036	80.6	82.0	0.0284	82.0	83.1
measure 13	13 weeks	wet	3-Apr	3-Apr	blue	0.0199	10.3	26.0	0.008	22.6	33.7	-0.0082	11.0	24.8	0.0232	17.4	29.6

Treatment	Type IV epoxy	slump	5	in.	weight measure	7.2	lb.	cement	23	lb.
Product		unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M20	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	J	air content	-	%				water	5.2	lb.
Exposure	g, h, j, k	air (pressure)	-	%	fine moisture	14.8	%	fine	39.3	lb.
		w:c	0.42		coarse moisture	SSD				

						Specimen g sandblast			Specimen h sandblast			Specimen j waterblast			Specimen k waterblast		
	day		date sched.	date done	color up	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						in.	%	%	in.	%	%	in.	%	%	in.	%	%
pour			1-Jan	1-Jan													
remove mold	0		2-Jan	2-Jan													
measure 0	0	wet	2-Jan	2-Jan	blue	0.0026	-	-	-0.0277	-	-	-0.0162	-	-	-0.0081	-	-
measure 1	1 week	dry	9-Jan	9-Jan	red	0.0138	83.9	90.6	-0.0148	90.5	90.8	-0.0038	92.2	93.4	0.0057	92.7	92.5
measure 2	2 weeks	wet	16-Jan	16-Jan	blue	0.0313	38.2	69.8	-0.0145	40.2	49.7	-0.0019	55.3	62.9	0.0073	44.1	52.6
measure 4	4 weeks	dry	30-Jan	30-Jan	red	0.0292	92.5	94.3	0.0039	90.1	93.6	0.0116	92.8	91.2	0.0203	95.3	92.4
measure 6	6 weeks	wet	13-Feb	13-Feb	blue	0.0294	21.9	44.1	-0.0005	23.1	27.8	0.0117	31.4	37.8	0.0206	22.5	31.0
measure 8	8 weeks	dry	27-Feb	27-Feb	red	0.0349	87.6	87.2	0.0046	85.9	88.0	0.0161	86.3	91.8	0.0248	78.8	88.4
measure 10	10 weeks	wet	13-Mar	13-Mar	blue	0.0293	10.5	25.6	-0.0006	15.2	20.7	0.0112	18.9	27.0	0.0198	12.7	25.1
measure 12	12 weeks	dry	27-Mar	27-Mar	red	0.036	89.7	87.2	0.0058	89.5	85.3	0.0159	84.7	86.8	0.0251	87.5	87.4
measure 13	13 weeks	wet	3-Apr	5-Apr	blue	0.0312	13.0	28.5	0.0008	18.8	23.7	0.0123	20.1	30.2	0.0207	16.5	26.8

Treatment	polyurethane	slump	3.5	in.	weight measure	7.2	lb.	cement	23	lb.
Product	CUV 100	unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M21	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	J	air content	-	%				water	5.7-1	lb.
Exposure	g, h, j, k	air (pressure)	-	%	fine moisture	13.4	%	fine	38.8	lb.
		w:c	0.38		coarse moisture	SSD				

						Specimen g sandblast			Specimen h sandblast			Specimen j waterblast			Specimen k waterblast		
	day		date sched.	date done	color up	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						in.	%	%	in.	%	%	in.	%	%	in.	%	%
pour			3-Jan	3-Jan													
remove mold	0		4-Jan	4-Jan													
measure 0	0	wet	4-Jan	4-Jan	blue	-0.0248	-	-	-0.0072	-	-	-0.0087	-	-	-0.0053	-	-
measure 1	1 week	dry	11-Jan	11-Jan	red	-0.0112	96.7	95.4	0.0075	96.3	95.6	0.0059	95.4	97.0	0.0100	94.0	95.6
measure 2	2 weeks	wet	18-Jan	18-Jan	blue	-0.0073	61.3	30.9	0.0090	46.4	64.3	0.0099	47.5	47.9	0.0117	38.8	57.2
measure 4	4 weeks	dry	1-Feb	1-Feb	red	0.0105	109.1	95.3	0.0253	92.2	89.3	0.0266	103.5	91.4	0.0291	90.9	94.0
measure 6	6 weeks	wet	15-Feb	15-Feb	blue	0.0063	33.5	18.5	0.0204	28.5	36.5	0.0218	27.4	31.5	0.0243	26.2	32.1
measure 8	8 weeks	dry	1-Mar	1-Mar	red	0.0123	86.3	87.3	0.0271	63.6	84.8	0.0259	79.0	86.8	0.0314	85.6	85.0
measure 10	10 weeks	wet	15-Mar	14-Mar	blue	0.0062	18.1	11.5	0.0206	17.2	18.9	0.0214	12.8	21.3	0.0249	11.9	21.0
measure 12	12 weeks	dry	29-Mar	29-Mar	red	0.0163	90.6	90.7	0.0298	89.2	89.0	0.0305	89.4	88.1	0.0329	90.6	87.9
measure 13	13 weeks	wet	5-Apr	5-Apr	blue	0.0099	28.6	12.8	0.0230	22.4	29.1	0.0227	16.7	26.5	0.0254	12.3	25.5

Treatment	$LiNO_3$	slump	3.5	in.	weight measure	7.2	lb.	cement	23	lb.
Product	Renew	unit weight	-	lb/ft^3	vol.measure	0.25	ft^3	coarse	57.6	lb.
Abbrev.	M22	yield	-		weight total	-	lb.	NaOH	40.5	g
Aggregate	J	air content	-	%				water	5.7-1	lb.
Exposure	g, h, j, k	air (pressure)	-	%	fine moisture	13.4	%	fine	38.8	lb.
		w:c	0.38		coarse moisture	SSD				

						Specimen g sandblast			Specimen h sandblast			Specimen j waterblast			Specimen k waterblast		
	day		date sched.	date done	color up	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						in.	%	%	in.	%	%	in.	%	%	in.	%	%
pour			3-Jan	3-Jan													
remove mold	0		4-Jan	4-Jan													
measure 0	0	wet	4-Jan	4-Jan	blue	-0.0226	-	-	-0.0020	-	-	-0.0395	-	-	-0.0240	-	-
measure 1	1 week	dry	11-Jan	11-Jan	red	-0.0083	93.2	94.5	0.0133	93.8	94.5	-0.0266	94.8	88.1	-0.0109	94.9	93.4
measure 2	2 weeks	wet	18-Jan	18-Jan	blue	-0.0041	61.9	44.5	0.0153	63.3	47.7	-0.0234	57.4	61.0	-0.0070	36.8	50.7
measure 4	4 weeks	dry	1-Feb	1-Feb	red	0.0125	113.4	112.2	0.0302	95.7	96.3	-0.0094	113.3	112.4	0.0086	93.8	93.4
measure 6	6 weeks	wet	15-Feb	15-Feb	blue	0.0095	33.5	26.3	0.0273	36.3	24.6	-0.0136	28.3	27.0	0.0043	25.6	32.3
measure 8	8 weeks	dry	1-Mar	1-Mar	red	0.0133	89.5	93.2	0.0337	91.9	88.8	-0.0089	83.9	89.0	0.0096	85.7	93.8
measure 10	10 weeks	wet	15-Mar	14-Mar	blue	0.0087	20.1	23.2	0.0294	27.2	19.4	-0.0134	20.1	21.4	0.0055	15.3	27.6
measure 12	12 weeks	dry	29-Mar	29-Mar	red	0.0169	91.1	90.4	0.0361	89.3	91.0	-0.006	89.0	88.6	0.0118	87.3	91.0
measure 13	13 weeks	wet	5-Apr	5-Apr	blue	0.0110	29.0	26.1	0.0322	28.5	20.6	-0.0114	23.1	28.3	0.0060	19.0	31.0

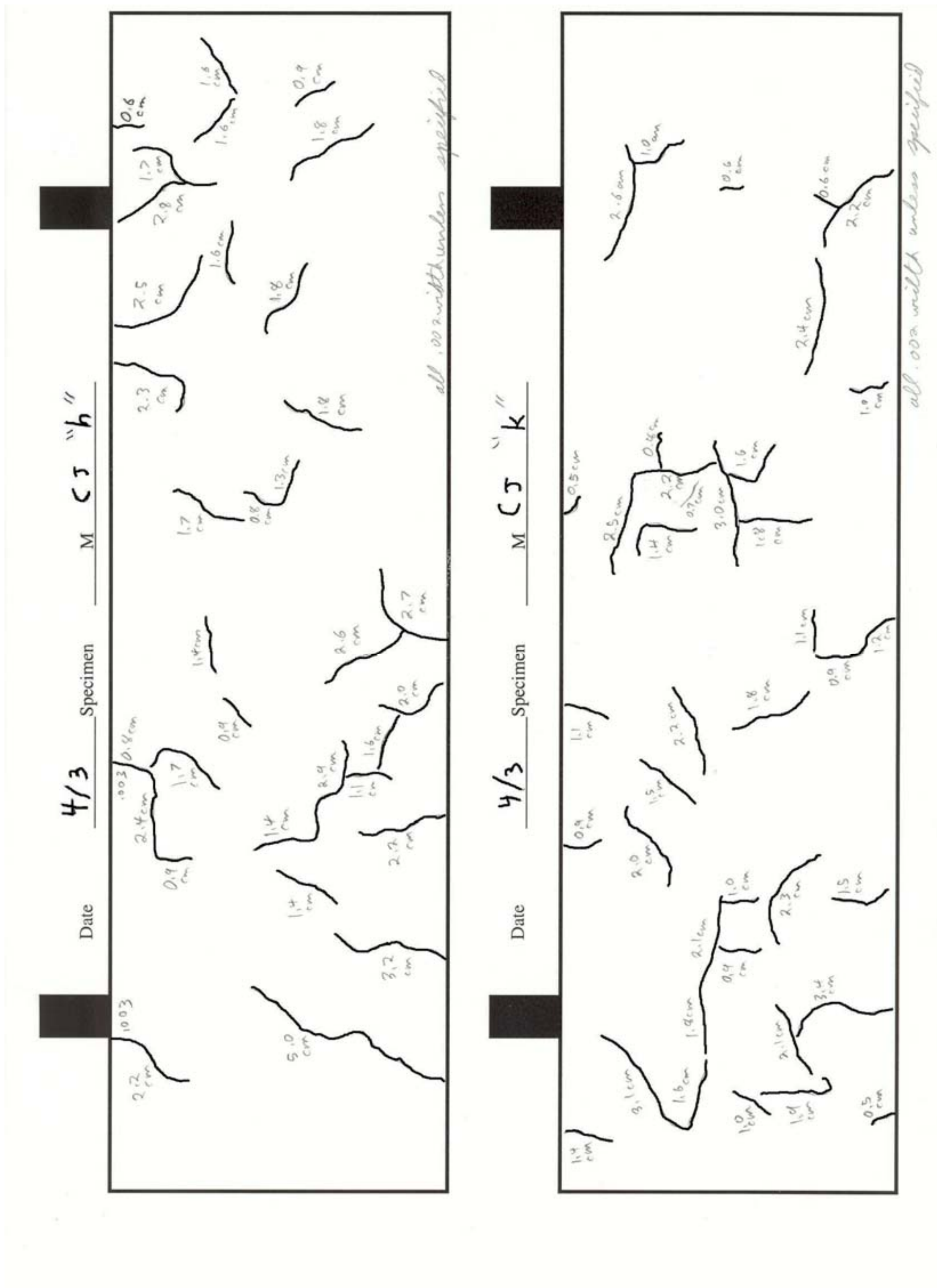
Treatment	$LiNO_3$+ 742	slump	3.5	in.	weight measure	7.2	lb.		cement	23	lb.
Product		unit weight	-	lb/ft^3	vol.measure	0.25	ft^3		coarse	57.6	lb.
Abbrev.	M23	yield	-		weight total	-	lb.		NaOH	40.5	g
Aggregate	J	air content	-	%					water	5.7-1	lb.
Exposure	g, h, j, k	air (pressure)	-	%	fine moisture	13.4	%		fine	38.8	lb.
		w:c	0.38		coarse moisture	SSD					

						Specimen g sandblast			Specimen h sandblast			Specimen j waterblast			Specimen k waterblast		
	day		date sched.	date done	color up	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"	length	RH 0.5"	RH 1.5"
						in.	%	%	in.	%	%	in.	%	%	in.	%	%
pour			3-Jan	3-Jan													
remove mold	0		4-Jan	4-Jan													
measure 0	0	wet	4-Jan	4-Jan	blue	-0.0076	-	-	-0.0182	-	-	-0.0095	-	-	-0.0298	-	-
measure 1	1 week	dry	11-Jan	11-Jan	red	0.0072	95.7	94.7	-0.0042	93.5	95.3	0.0058	95.8	95.7	-0.0163	94.8	95.8
measure 2	2 weeks	wet	18-Jan	18-Jan	blue	0.0101	65.8	39.8	0.0012	31.2	50.9	0.0086	58.1	54.8	-0.0146	61.7	54.3
measure 4	4 weeks	dry	1-Feb	1-Feb	red	0.0246	60.6	66.0	0.0156	64.3	61.3	0.0236	84.0	94.8	0.0033	94.9	95.5
measure 6	6 weeks	wet	15-Feb	15-Feb	blue	0.0176	30.6	24.2	0.0116	22.9	27.0	0.0191	29.3	28.2	-0.0029	29.0	33.1
measure 8	8 weeks	dry	1-Mar	1-Mar	red	0.0249	88.1	91.3	0.0162	92.2	90.3	0.0246	91.1	88.5	0.0057	93.7	89.8
measure 10	10 weeks	wet	15-Mar	14-Mar	blue	0.0203	21.2	20.8	0.0117	15.7	24.0	0.0197	20.9	21.4	0.0004	22.6	25.8
measure 12	12 weeks	dry	29-Mar	29-Mar	red	0.0273	89.7	94.5	0.0181	93.9	92.5	0.0261	91.5	88.5	0.0071	91.6	87.7
measure 13	13 weeks	wet	5-Apr	5-Apr	blue	0.0248	24.6	22.4	0.0143	13.8	20.3	0.0252	26.9	25.7	0.0041	22.0	25.0

APPENDIX F

Sketches of Crack Patterns on Wet/Dry Series Specimens

Presented here are the final sketches of crack patterns for each mitigation technique of the wet/dry series, and the tabulated crack widths and lengths for each week.


Date 4/3 Specimen M CJ "h"
Date 4/3 Specimen M CJ "k"

Specimen **CJ h**
Coating **Control**
Fabricated 2-Jan

Date 20-Feb

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.81	3.25	1.63
2	2		0.69	2.75	1.38
3	2		1.00	4.00	2.00
4	2		0.50	2.00	1.00
5	2		0.38	1.50	0.75
6	2		0.50	2.00	1.00
7	2		0.25	1.00	0.50
8	2		0.81	3.25	1.63
9	2		1.56	6.25	3.13
10	2		0.44	1.75	0.88
11	2		0.31	1.25	0.63
12	2		0.38	1.50	0.75
13	2		0.50	2.00	1.00
14	2		1.00	4.00	2.00
15	2		1.00	4.00	2.00
16	2		0.63	2.50	1.25
17	2		0.38	1.50	0.75
18	2		1.13	4.50	2.25
19	2		0.75	3.00	1.50
20	2		0.50	2.00	1.00
21	2		0.75	3.00	1.50
22	2		0.75	3.00	1.50
23	2		0.19	0.75	0.38
total				*60.75*	*30.38*

Specimen **CJ h** cont.
Coating **Control**
Fabricated 2-Jan

Date 27-Feb

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	3	1.2	0.47	4.25	1.42
2	2	5.1	2.01	8.03	4.02
3	2	3.2	1.26	5.04	2.52
4	2	1.3	0.51	2.05	1.02
5	2	2.4	0.94	3.78	1.89
6	2	0.9	0.35	1.42	0.71
7	3	2.6	1.02	9.21	3.07
8	2	0.8	0.31	1.26	0.63
9	2	1.4	0.55	2.20	1.10
10	2	4.6	1.81	7.24	3.62
11	2	1.1	0.43	1.73	0.87
12	2	2.3	0.91	3.62	1.81
13	2	2.4	0.94	3.78	1.89
14	2	3.2	1.26	5.04	2.52
15	2	1.6	0.63	2.52	1.26
16	2	2.0	0.79	3.15	1.57
17	2	2.8	1.10	4.41	2.20
18	2	1.7	0.67	2.68	1.34
19	2	1.2	0.47	1.89	0.94
20	2	2.1	0.83	3.31	1.65
21	2	2.4	0.94	3.78	1.89
22	3	1.6	0.63	5.67	1.89
total				*86.06*	*39.84*

Specimen **CJ h** cont.
Coating **Control**
Fabricated 2-Jan
Date 13-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		1.00	4.00	2.00
2	2		2.00	8.00	4.00
3	2		1.38	5.50	2.75
4	2		0.44	1.75	0.88
5	2		0.75	3.00	1.50
6	2		0.50	2.00	1.00
7	2		0.88	3.50	1.75
8	2		1.25	5.00	2.50
9	2		0.56	2.25	1.13
10	3		1.19	10.69	3.56
11	2		0.38	1.50	0.75
12	2		0.50	2.00	1.00
13	2		0.63	2.50	1.25
14	2		0.88	3.50	1.75
15	2		1.00	4.00	2.00
16	2		1.13	4.50	2.25
17	2		0.88	3.50	1.75
18	2		1.13	4.50	2.25
19	2		0.56	2.25	1.13
20	2		0.63	2.50	1.25
21	2		0.81	3.25	1.63
22	2		1.00	4.00	2.00
23	2		0.25	1.00	0.50
24	2		5.80	23.20	11.60
total				*107.89*	*52.16*

Specimen	**CJ h**	cont.			
Coating	**Control**				
Fabricated	2-Jan				
Date	27-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	3	2.2	0.87	7.80	2.60
2	2	5.0	1.97	7.87	3.94
3	2	3.1	1.22	4.88	2.44
4	2	1.4	0.55	2.20	1.10
5	2	1.0	0.39	1.57	0.79
6	2	2.4	0.94	3.78	1.89
7	2	2.8	1.10	4.41	2.20
8	2	1.5	0.59	2.36	1.18
9	2	2.3	0.91	3.62	1.81
10	2	3.1	1.22	4.88	2.44
11	2	1.1	0.43	1.73	0.87
12	2	1.2	0.47	1.89	0.94
13	2	0.8	0.31	1.26	0.63
14	2	1.4	0.55	2.20	1.10
15	2	2.1	0.83	3.31	1.65
16	2	3.7	1.46	5.83	2.91
17	2	1.7	0.67	2.68	1.34
18	2	0.3	0.12	0.47	0.24
19	2	1.8	0.71	2.83	1.42
20	2	1.8	0.71	2.83	1.42
21	2	1.6	0.63	2.52	1.26
22	2	3.0	1.18	4.72	2.36
23	2	2.2	0.87	3.46	1.73
24	2	2.4	0.94	3.78	1.89
25	2	0.6	0.24	0.94	0.47
26	2	1.7	0.67	2.68	1.34
27	2	0.9	0.35	1.42	0.71
28	2	1.7	0.67	2.68	1.34
29	2	1.6	0.63	2.52	1.26
total				*93.15*	*45.28*

Specimen	**CJ h**	cont.			
Coating	**Control**				
Fabricated	2-Jan				
Date	3-Apr				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	3	2.2	0.87	7.80	2.60
2	2	5.0	1.97	7.87	3.94
3	2	3.2	1.26	5.04	2.52
4	2	1.4	0.55	2.20	1.10
5	2	0.9	0.35	1.42	0.71
6	2	2.4	0.94	3.78	1.89
7	2	1.4	0.55	2.20	1.10
8	2	2.2	0.87	3.46	1.73
9	3	0.8	0.31	2.83	0.94
10	2	1.7	0.67	2.68	1.34
11	2	2.9	1.14	4.57	2.28
12	2	1.1	0.43	1.73	0.87
13	2	1.6	0.63	2.52	1.26
14	2	2.0	0.79	3.15	1.57
15	2	0.9	0.35	1.42	0.71
16	2	1.4	0.55	2.20	1.10
17	2	2.6	1.02	4.09	2.05
18	2	2.7	1.06	4.25	2.13
19	2	1.7	0.67	2.68	1.34
20	2	0.8	0.31	1.26	0.63
21	2	1.3	0.51	2.05	1.02
22	2	2.3	0.91	3.62	1.81
23	2	1.8	0.71	2.83	1.42
24	2	1.8	0.71	2.83	1.42
25	2	2.5	0.98	3.94	1.97
26	2	1.6	0.63	2.52	1.26
27	2	2.8	1.10	4.41	2.20
28	2	1.7	0.67	2.68	1.34
29	2	0.6	0.24	0.94	0.47
30	2	1.6	0.63	2.52	1.26
31	2	1.6	0.63	2.52	1.26
32	2	0.9	0.35	1.42	0.71
33	2	1.8	0.71	2.83	1.42
total				*102.28*	*49.37*

Specimen **CJ k**
Coating **Control**
Fabricated 2-Jan

Date 20-Feb

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.4	1.50	0.75
2	2		0.4	1.75	0.88
3	2		0.9	3.50	1.75
4	2		1.4	5.50	2.75
5	2		1.1	4.50	2.25
6	2		0.6	2.50	1.25
7	2		0.8	3.00	1.50
8	2		0.8	3.00	1.50
9	2		0.3	1.25	0.63
10	2		1.0	4.00	2.00
11	2		0.6	2.50	1.25
12	2		0.4	1.50	0.75
13	2		0.6	2.50	1.25
14	2		0.8	3.00	1.50
15	2		0.4	1.75	0.88
16	2		0.8	3.25	1.63
17	2		0.6	2.50	1.25
18	2		0.8	3.00	1.50
19	2		0.3	1.25	0.63
20	2		0.3	1.25	0.63
21	2		0.9	3.50	1.75
22	2		1.0	4.00	2.00
23	2		0.7	2.75	1.38
24	2		0.6	2.50	1.25
25	2		0.4	1.50	0.75
26	2		1.1	4.50	2.25
27	2		0.3	1.00	0.50
total				*72.75*	*36.38*

Specimen **CJ k** cont.
Coating **Control**
Fabricated 2-Jan

Date 27-Feb

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.4	0.55	2.20	1.10
2	2	1.0	0.39	1.57	0.79
3	2	3.1	1.22	4.88	2.44
4	2	2.5	0.98	3.94	1.97
5	2	1.0	0.39	1.57	0.79
6	2	2.1	0.83	3.31	1.65
7	2	3.5	1.38	5.51	2.76
8	2	0.5	0.20	0.79	0.39
9	2	2.3	0.91	3.62	1.81
10	2	1.4	0.55	2.20	1.10
11	2	2.3	0.91	3.62	1.81
12	2	1.1	0.43	1.73	0.87
13	2	1.9	0.75	2.99	1.50
14	2	1.1	0.43	1.73	0.87
15	2	2.2	0.87	3.46	1.73
16	2	4.1	1.61	6.46	3.23
17	2	0.7	0.28	1.10	0.55
18	2	0.6	0.24	0.94	0.47
19	2	1.4	0.55	2.20	1.10
20	2	2.2	0.87	3.46	1.73
21	2	1.9	0.75	2.99	1.50
22	2	1.5	0.59	2.36	1.18
23	2	2.7	1.06	4.25	2.13
24	2	0.7	0.28	1.10	0.55
25	2	1.1	0.43	1.73	0.87
total				*69.76*	*34.88*

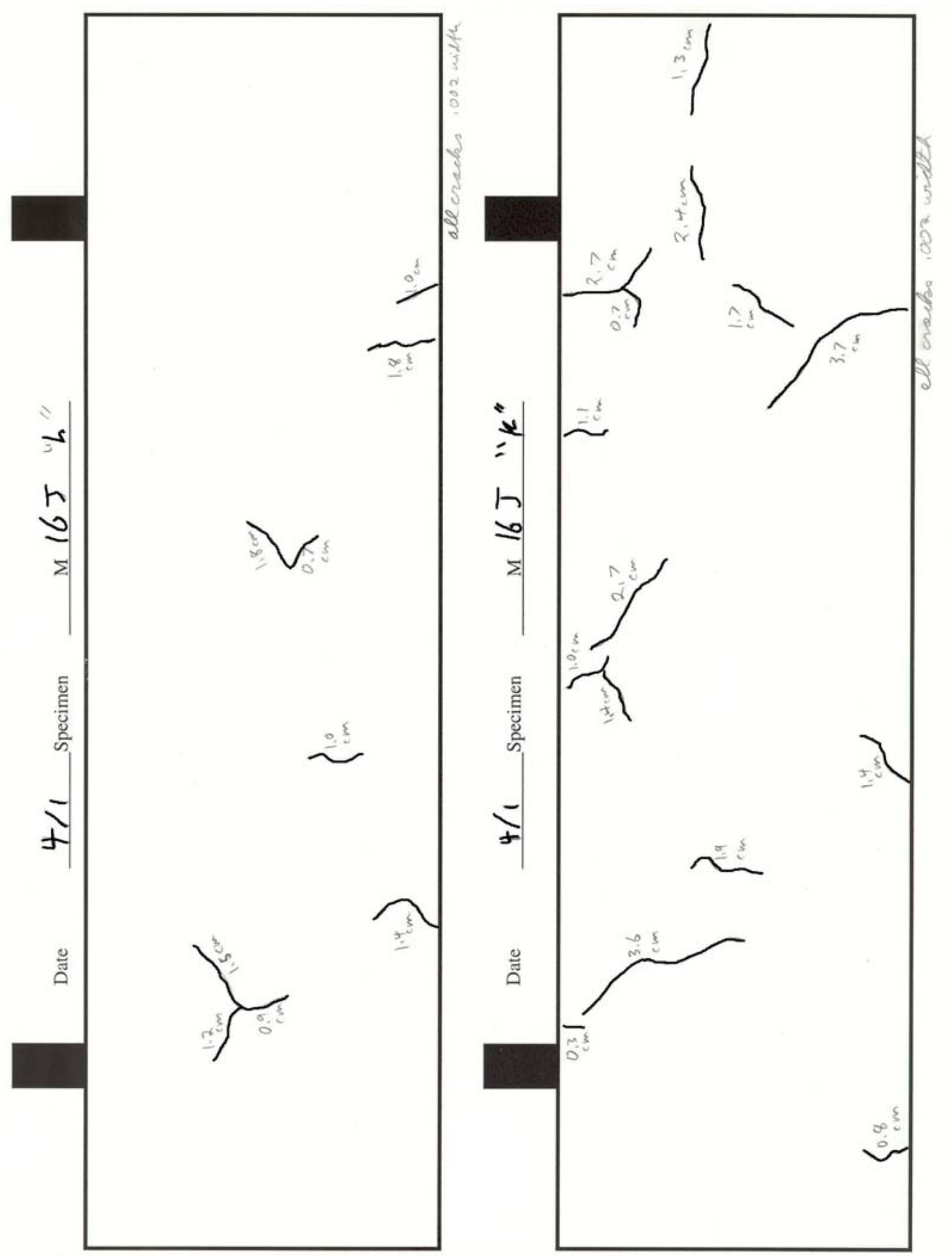
Specimen **CJ k** cont.
Coating **Control**
Fabricated 2-Jan

Date 13-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.56	2.25	1.13
2	2		0.38	1.50	0.75
3	2		0.75	3.00	1.50
4	2		0.13	0.50	0.25
5	2		1.50	6.00	3.00
6	2		2.25	9.00	4.50
7	2		1.13	4.50	2.25
8	2		0.31	1.25	0.63
9	2		1.00	4.00	2.00
10	2		0.56	2.25	1.13
11	2		0.31	1.25	0.63
12	2		0.88	3.50	1.75
13	2		0.75	3.00	1.50
14	2		0.44	1.75	0.88
15	2		0.38	1.50	0.75
16	2		0.88	3.50	1.75
17	2		0.75	3.00	1.50
18	2		1.25	5.00	2.50
19	2		0.63	2.50	1.25
20	2		0.19	0.75	0.38
21	2		0.75	3.00	1.50
22	2		0.25	1.00	0.50
23	2		0.63	2.50	1.25
24	2		0.88	3.50	1.75
25	2		0.25	1.00	0.50
26	2		0.44	1.75	0.88
27	2		0.94	3.75	1.88
28	2		0.88	3.50	1.75
29	2		0.38	1.50	0.75
30	2		0.75	3.00	1.50
31	2		0.25	1.00	0.50
32	2		0.56	2.25	1.13
total				*87.75*	*43.88*

Specimen	**CJ k**	cont.			
Coating	**Control**				
Fabricated	2-Jan				
Date	27-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.5	0.59	2.36	1.18
2	2	1.0	0.39	1.57	0.79
3	2	2.0	0.79	3.15	1.57
4	2	0.5	0.20	0.79	0.39
5	2	3.0	1.18	4.72	2.36
6	2	1.5	0.59	2.36	1.18
7	2	2.1	0.83	3.31	1.65
8	2	3.5	1.38	5.51	2.76
9	2	2.0	0.79	3.15	1.57
10	2	2.0	0.79	3.15	1.57
11	2	1.1	0.43	1.73	0.87
12	2	2.7	1.06	4.25	2.13
13	2	1.3	0.51	2.05	1.02
14	2	0.9	0.35	1.42	0.71
15	2	1.5	0.59	2.36	1.18
16	2	2.3	0.91	3.62	1.81
17	2	1.9	0.75	2.99	1.50
18	2	1.0	0.39	1.57	0.79
19	2	2.3	0.91	3.62	1.81
20	2	1.2	0.47	1.89	0.94
21	2	0.4	0.16	0.63	0.31
22	2	1.9	0.75	2.99	1.50
23	2	1.5	0.59	2.36	1.18
24	2	3.1	1.22	4.88	2.44
25	2	1.9	0.75	2.99	1.50
26	2	1.7	0.67	2.68	1.34
27	2	0.7	0.28	1.10	0.55
28	2	2.3	0.91	3.62	1.81
29	2	0.8	0.31	1.26	0.63
30	2	1.1	0.43	1.73	0.87
31	2	2.5	0.98	3.94	1.97
32	2	2.1	0.83	3.31	1.65
33	2	0.7	0.28	1.10	0.55
34	2	1.0	0.39	1.57	0.79
35	2	2.1	0.83	3.31	1.65
36	2	1.7	0.67	2.68	1.34
total				*95.75*	*47.87*

Specimen	**CJ k**	cont.			
Coating	**Control**				
Fabricated	2-Jan				
Date	3-Apr				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.4	0.55	2.20	1.10
2	2	3.1	1.22	4.88	2.44
3	2	1.6	0.63	2.52	1.26
4	2	1.0	0.39	1.57	0.79
5	2	1.9	0.75	2.99	1.50
6	2	0.5	0.20	0.79	0.39
7	2	2.1	0.83	3.31	1.65
8	2	3.4	1.34	5.35	2.68
9	2	1.8	0.71	2.83	1.42
10	2	2.1	0.83	3.31	1.65
11	2	0.9	0.35	1.42	0.71
12	2	1.0	0.39	1.57	0.79
13	2	2.3	0.91	3.62	1.81
14	2	1.5	0.59	2.36	1.18
15	2	2.0	0.79	3.15	1.57
16	2	0.9	0.35	1.42	0.71
17	2	1.5	0.59	2.36	1.18
18	2	2.2	0.87	3.46	1.73
19	2	1.1	0.43	1.73	0.87
20	2	1.8	0.71	2.83	1.42
21	2	0.9	0.35	1.42	0.71
22	2	1.1	0.43	1.73	0.87
23	2	1.2	0.47	1.89	0.94
24	2	1.8	0.71	2.83	1.42
25	2	3.0	1.18	4.72	2.36
26	2	1.6	0.63	2.52	1.26
27	2	0.7	0.28	1.10	0.55
28	2	1.4	0.55	2.20	1.10
29	2	2.2	0.87	3.46	1.73
30	2	0.8	0.31	1.26	0.63
31	2	2.5	0.98	3.94	1.97
32	2	0.5	0.20	0.79	0.39
33	2	1.0	0.39	1.57	0.79
34	2	2.4	0.94	3.78	1.89
35	2	2.2	0.87	3.46	1.73
36	2	0.6	0.24	0.94	0.47
37	2	0.6	0.24	0.94	0.47
38	2	1.0	0.39	1.57	0.79
39	2	2.6	1.02	4.09	2.05
total				*97.95*	*48.98*



Date 4/1 Specimen M 16J "L"
all cracks .002 width
Date 4/1 Specimen M 16J "K"
all cracks .002 width

Specimen **M16J h**
Coating **Silane + 742 Paint**
Fabricated 31-Dec

Date 20-Feb

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	0		0.00	0	0
total				*0*	*0*

Date 25-Feb

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	0		0.00	0	0
total				*0*	*0*

Date 11-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.375	1.5	0.75
total				*1.5*	*0.75*

Date 25-Mar

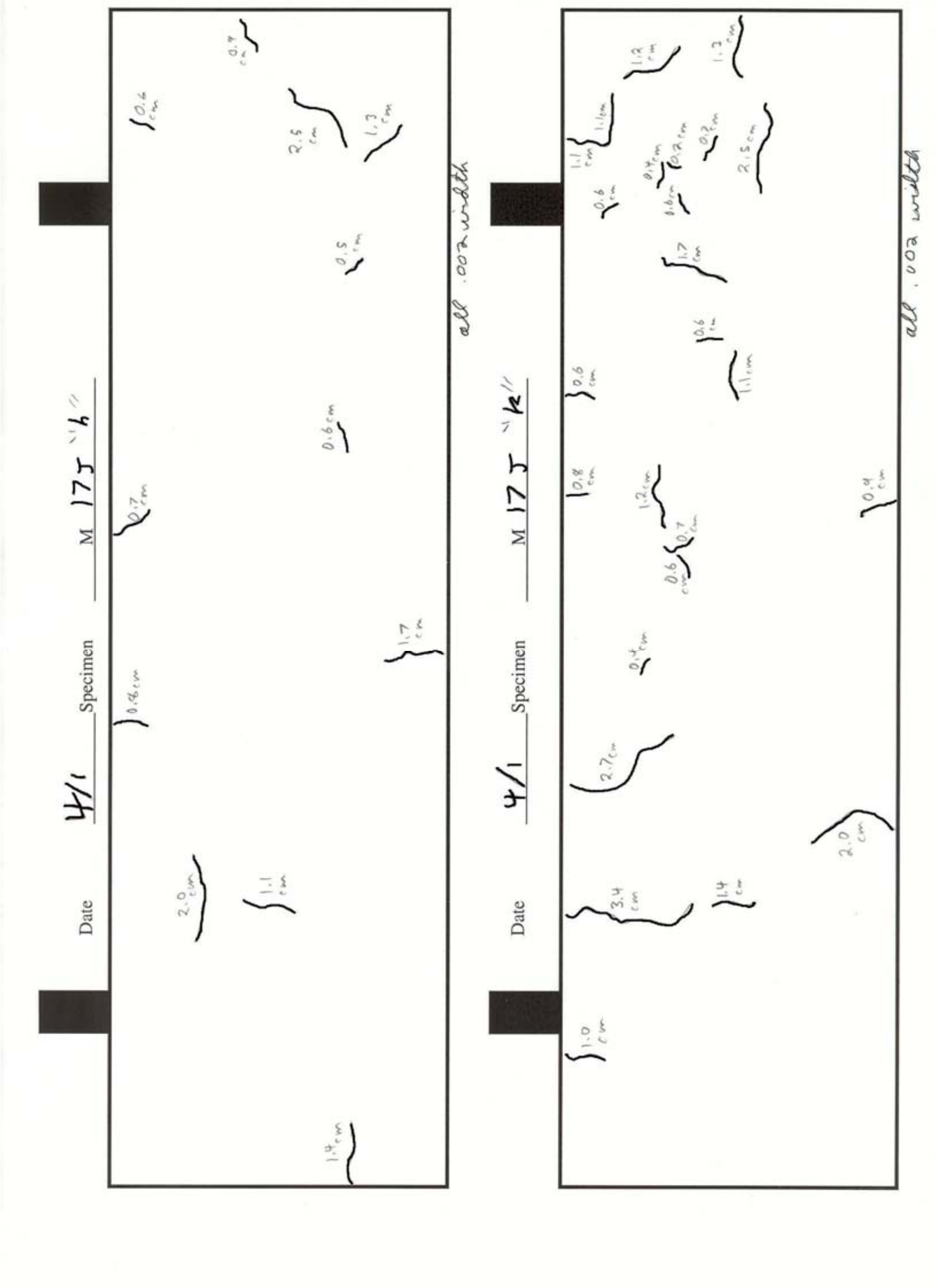
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.8	0.71	2.83	1.42
2	2	1.0	0.39	1.57	0.79
total				*4.41*	*2.20*

Date 1-Apr

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.2	0.47	1.89	0.94
2	2	0.9	0.35	1.42	0.71
3	2	1.5	0.59	2.36	1.18
4	2	1.4	0.55	2.20	1.10
5	2	1.0	0.39	1.57	0.79
6	2	0.7	0.28	1.10	0.55
7	2	1.8	0.71	2.83	1.42
8	2	1.8	0.71	2.83	1.42
9	2	1.0	0.39	1.57	0.79
total				*17.80*	*8.90*

Specimen	M16J k				
Coating	**Silane + 742 Paint**				
Fabricated	31-Dec				
Date	20-Feb				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.75	3	1.5
2	2		0.625	2.5	1.25
total				*5.5*	*2.75*
Date	25-Feb				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.75	3	1.5
2	2		0.625	2.5	1.25
total				*5.5*	*2.75*
Date	11-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.75	3	1.5
2	2		0.625	2.5	1.25
total				*5.5*	*2.75*
Date	25-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	0.4	0.16	0.63	0.31
2	2	3.1	1.22	4.88	2.44
3	2	0.6	0.24	0.94	0.47
4	2	2.7	1.06	4.25	2.13
5	2	1.9	0.75	2.99	1.50
6	2	2.9	1.14	4.57	2.28
7	2	1.5	0.59	2.36	1.18
8	2	0.6	0.24	0.94	0.47
total				*21.57*	*10.79*

Specin	M16J k cont.				
Coatin	**Silane + 742 Paint**				
Fabrica	31-Dec				
Date	1-Apr				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	0.3	0.12	0.47	0.24
2	2	3.6	1.42	5.67	2.83
3	2	0.8	0.31	1.26	0.63
4	2	1.9	0.75	2.99	1.50
5	2	1.4	0.55	2.20	1.10
6	2	1.4	0.55	2.20	1.10
7	2	1.0	0.39	1.57	0.79
8	2	2.7	1.06	4.25	2.13
9	2	1.1	0.43	1.73	0.87
10	2	3.7	1.46	5.83	2.91
11	2	1.7	0.67	2.68	1.34
12	2	0.7	0.28	1.10	0.55
13	2	2.4	0.94	3.78	1.89
14	2	2.7	1.06	4.25	2.13
15	2	1.3	0.51	2.05	1.02
total				*42.05*	*21.02*


Date 4/1 Specimen M 17J "h"
all .002 width
Date 4/1 Specimen M 17J "k"
all .002 width

Specimen **M17J h**
Coating **Silane + 742 Paint thinned**
Fabricated 31-Dec

Date 20-Feb

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.50	2	1
total				*2*	*1*

Date 26-Feb

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.9	0.75	2.99	1.50
2	2	0.6	0.24	0.94	0.47
3	2	1.3	0.51	2.05	1.02
4	2	1.1	0.43	1.73	0.87
5	2	0.9	0.35	1.42	0.71
6	2	0.6	0.24	0.94	0.47
total				*10.08*	*5.04*

Date 11-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.75	3	1.5
2	2		0.3125	1.25	0.625
3	2		0.25	1	0.5
4	2		0.5	2	1
5	2		0.4375	1.75	0.875
6	2		0.25	1	0.5
7	2		0.375	1.5	0.75
total				*11.5*	*5.75*

Date 25-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.75	3	1.5
2	2		0.3125	1.25	0.625
3	2		0.25	1	0.5
4	2		0.5	2	1
5	2		0.4375	1.75	0.875
6	2		0.25	1	0.5
7	2		0.375	1.5	0.75
total				*11.5*	*5.75*

Specimen **M17J h** cont.
Coating **Silane + 742 Paint thinned**
Fabricated 31-Dec

Date 1-Apr

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.4	0.55	2.20	1.10
2	2	2	0.79	3.15	1.57
3	2	1.1	0.43	1.73	0.87
4	2	0.8	0.31	1.26	0.63
5	2	1.7	0.67	2.68	1.34
6	2	0.7	0.28	1.10	0.55
7	2	0.6	0.24	0.94	0.47
8	2	0.5	0.20	0.79	0.39
9	2	1.3	0.51	2.05	1.02
10	2	2.5	0.98	3.94	1.97
11	2	0.9	0.35	1.42	0.71
12	2	0.6	0.24	0.94	0.47
total				*22.20*	*11.10*

Specimen **M17J k**
Coating **Silane + 742 Paint thinned**
Fabricated 31-Dec

Date 20-Feb

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.19	0.75	0.375
2	2		0.375	1.5	0.75
				2.25	1.125

Date 26-Feb

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1	0.39	1.57	0.79
2	2	3.3	1.30	5.20	2.60
3	2	2	0.79	3.15	1.57
4	2	0.5	0.20	0.79	0.39
5	2	1.2	0.47	1.89	0.94
6	2	0.9	0.35	1.42	0.71
7	2	0.6	0.24	0.94	0.47
total				*14.96*	*7.48*

Date 11-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.375	1.5	0.75
2	2		1.4375	5.75	2.875
3	2		0.375	1.5	0.75
4	2		0.875	3.5	1.75
5	2		1.125	4.5	2.25
6	2		0.1875	0.75	0.375
7	2		0.25	1	0.5
8	2		0.3125	1.25	0.625
9	2		0.375	1.5	0.75
10	2		0.4375	1.75	0.875
11	2		0.3125	1.25	0.625
12	2		0.25	1	0.5
13	2		0.875	3.5	1.75
total				*28.75*	*14.375*

Specimen **M17J k** cont.
Coating **Silane + 742 Paint thinned**
Fabricated 31-Dec

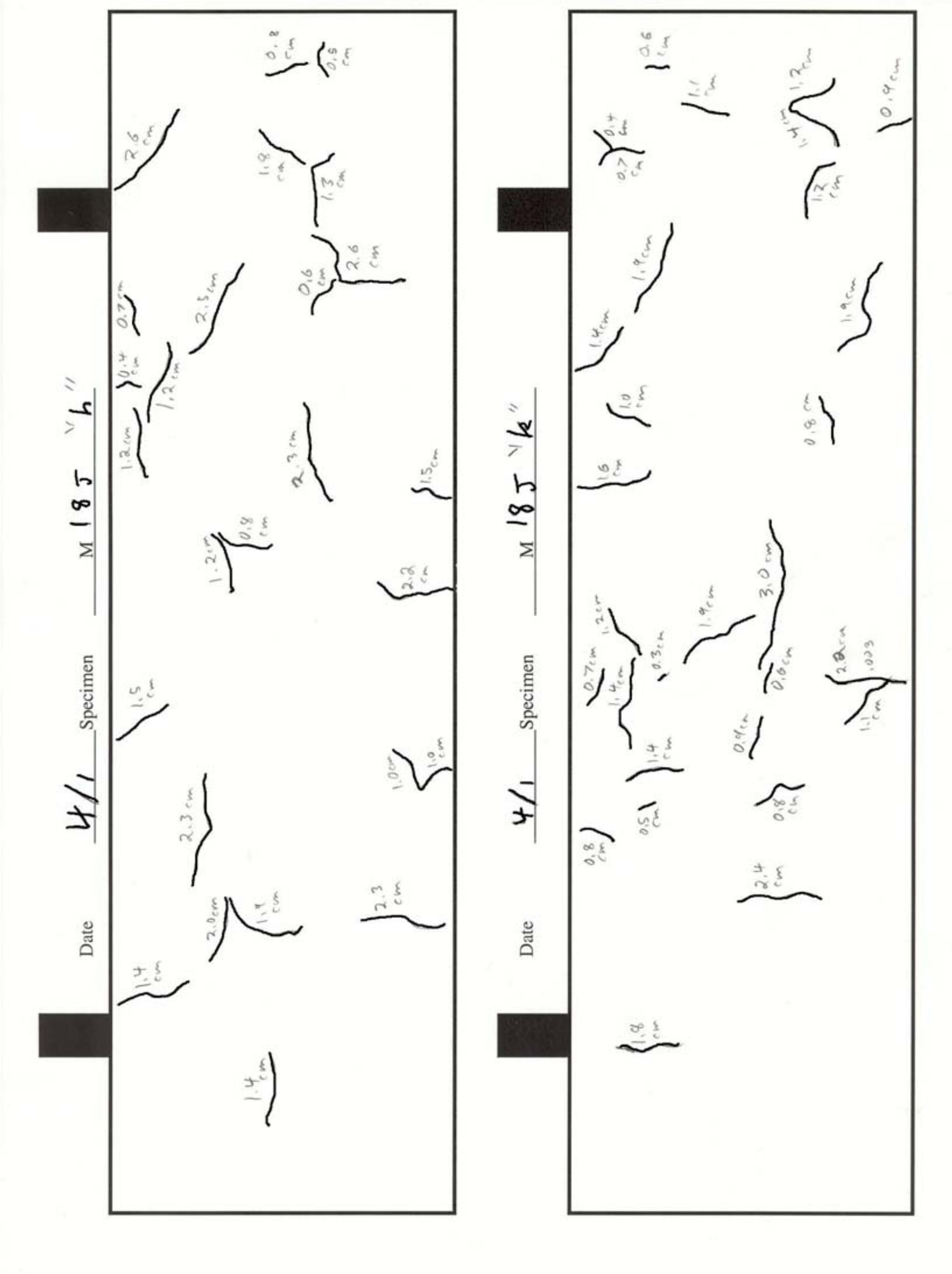
Date 25-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.1	0.43	1.73	0.87
2	2	0.7	0.28	1.10	0.55
3	2	2.7	1.06	4.25	2.13
4	2	1.1	0.43	1.73	0.87
5	2	2.1	0.83	3.31	1.65
6	2	2.7	1.06	4.25	2.13
7	2	0.5	0.20	0.79	0.39
8	2	0.6	0.24	0.94	0.47
9	2	0.9	0.35	1.42	0.71
10	2	0.8	0.31	1.26	0.63
11	2	0.7	0.28	1.10	0.55
12	2	1.2	0.47	1.89	0.94
13	2	0.6	0.24	0.94	0.47
14	2	1.1	0.43	1.73	0.87
15	2	0.6	0.24	0.94	0.47
16	2	1.6	0.63	2.52	1.26
17	2	2.3	0.91	3.62	1.81
18	2	2.3	0.91	3.62	1.81
19	2	1.3	0.51	2.05	1.02
total				*35.91*	*17.95*

Specimen **M17J k** cont.
Coating **Silane + 742 Paint thinned**
Fabricated 31-Dec

Date 1-Apr

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1	0.39	1.57	0.79
2	2	1.4	0.55	2.20	1.10
3	2	3.4	1.34	5.35	2.68
4	2	2	0.79	3.15	1.57
5	2	2.7	1.06	4.25	2.13
6	2	0.4	0.16	0.63	0.31
7	2	0.6	0.24	0.94	0.47
8	2	0.7	0.28	1.10	0.55
9	2	1.2	0.47	1.89	0.94
10	2	0.9	0.35	1.42	0.71
11	2	0.8	0.31	1.26	0.63
12	2	0.6	0.24	0.94	0.47
13	2	1.1	0.43	1.73	0.87
14	2	0.6	0.24	0.94	0.47
15	2	1.7	0.67	2.68	1.34
16	2	0.6	0.24	0.94	0.47
17	2	0.6	0.24	0.94	0.47
18	2	0.4	0.16	0.63	0.31
19	2	0.2	0.08	0.31	0.16
20	2	0.7	0.28	1.10	0.55
21	2	2.5	0.98	3.94	1.97
22	2	1.1	0.43	1.73	0.87
23	2	1.1	0.43	1.73	0.87
24	2	1.2	0.47	1.89	0.94
25	2	1.3	0.51	2.05	1.02
total				*45.35*	*22.68*


Date 4/1 Specimen M 185 "h"
Date 4/1 Specimen M 185 "k"

Specimen	**M18J h**				
Coating	**Silane + Latex Paint**				
Fabricated	31-Dec				
Date	20-Feb				
Crack	Width	Length	Length	w^2l	wl
	$(10^{-3}$ in)	(cm)	(in)		
1	2		0.63	2.5	1.25
2	2		0.375	1.5	0.75
3	2		1.625	6.5	3.25
total				10.5	5.25
Date	26-Feb				
Crack	Width	Length	Length	w^2l	wl
	$(10^{-3}$ in)	(cm)	(in)		
1	2	1.6	0.6299	2.5197	1.2598
2	2	1	0.3937	1.5748	0.7874
3	2	1	0.3937	1.5748	0.7874
4	2	1.5	0.5906	2.3622	1.1811
5	2	0.8	0.3150	1.2598	0.6299
6	2	2.5	0.9843	3.9370	1.9685
7	2	2.6	1.0236	4.0945	2.0472
total				*9.2913*	*4.6457*
Date	11-Mar				
Crack	Width	Length	Length	w^2l	wl
	$(10^{-3}$ in)	(cm)	(in)		
1	2		0.6875	2.75	1.375
2	2		0.875	3.5	1.75
3	2		0.875	3.5	1.75
4	2		0.5625	2.25	1.125
5	2		0.375	1.5	0.75
6	2		0.875	3.5	1.75
7	2		0.1875	0.75	0.375
8	2		1	4	2
9	2		1	4	2
10	2		0.875	3.5	1.75
11	2		0.25	1	0.5
12	2		1	4	2
13	2		0.375	1.5	0.75
total				*35.75*	*17.875*

Specimen	**M18J h**	cont.			
Coating	**Silane + Latex Paint**				
Fabricated	31-Dec				
Date	25-Mar				
Crack	Width	Length	Length	w^2l	wl
	$(10^{-3}$ in)	(cm)	(in)		
1	2	1.5	0.59	2.36	1.18
2	2	1.9	0.75	2.99	1.50
3	2	2.3	0.91	3.62	1.81
4	2	1	0.39	1.57	0.79
5	2	1.4	0.55	2.20	1.10
6	2	2.2	0.87	3.46	1.73
7	2	2.3	0.91	3.62	1.81
8	2	0.5	0.20	0.79	0.39
9	2	0.9	0.35	1.42	0.71
10	2	0.7	0.28	1.10	0.55
11	2	2.4	0.94	3.78	1.89
12	2	0.7	0.28	1.10	0.55
13	2	2.7	1.06	4.25	2.13
14	2	2.6	1.02	4.09	2.05
total				*36.38*	*18.19*

Specimen	**M18J h**	cont.			
Coating	**Silane + Latex Paint**				
Fabricated	31-Dec				
Date	1-Apr				
Crack	Width	Length	Length	w^2l	wl
	$(10^{-3}$ in)	(cm)	(in)		
1	2	1.4	0.55	2.20	1.10
2	2	1.4	0.55	2.20	1.10
3	2	2	0.79	3.15	1.57
4	2	1.9	0.75	2.99	1.50
5	2	2.3	0.91	3.62	1.81
6	2	2.3	0.91	3.62	1.81
7	2	1	0.39	1.57	0.79
8	2	1	0.39	1.57	0.79
9	2	1.5	0.59	2.36	1.18
10	2	2.2	0.87	3.46	1.73
11	2	1.2	0.47	1.89	0.94
12	2	0.8	0.31	1.26	0.63
13	2	2.3	0.91	3.62	1.81
14	2	1.5	0.59	2.36	1.18
15	2	1.2	0.47	1.89	0.94
16	2	1.2	0.47	1.89	0.94
17	2	0.4	0.16	0.63	0.31
18	2	2.5	0.98	3.94	1.97
19	2	0.7	0.28	1.10	0.55
20	2	0.6	0.24	0.94	0.47
21	2	2.6	1.02	4.09	2.05
22	2	1.3	0.51	2.05	1.02
23	2	1.8	0.71	2.83	1.42
24	2	2.6	1.02	4.09	2.05
25	2	0.8	0.31	1.26	0.63
26	2	0.5	0.20	0.79	0.39
total				*61.42*	*30.71*

Specimen **M18J k**
Coating **Silane + Latex Paint**
Fabricated 31-Dec

Date 20-Feb

Crack	Width (10^{-3} in)	Length (cm)	Length (in)	w^2l	wl
1	2		0.19	0.75	0.375
2	2		0.1875	0.75	0.375
3	2		0.5	2	1
4	2		0.5	2	1
5	2		0.5	2	1
6	2		1.125	4.5	2.25
7	2		0.625	2.5	1.25
8	2		0.375	1.5	0.75
9	2		0.4375	1.75	0.875
10	2		0.5	2	1
total				*19.75*	*9.875*

Date 26-Feb

Crack	Width (10^{-3} in)	Length (cm)	Length (in)	w^2l	wl
1	2	0.4	0.16	0.63	0.31
2	2	0.6	0.24	0.94	0.47
3	2	1.3	0.51	2.05	1.02
4	2	2.4	0.94	3.78	1.89
5	2	1.9	0.75	2.99	1.50
6	2	1.6	0.63	2.52	1.26
7	2	1.1	0.43	1.73	0.87
8	2	1.1	0.43	1.73	0.87
9	2	1.9	0.75	2.99	1.50
10	2	0.8	0.31	1.26	0.63
11	2	1.3	0.51	2.05	1.02
total				*22.68*	*11.34*

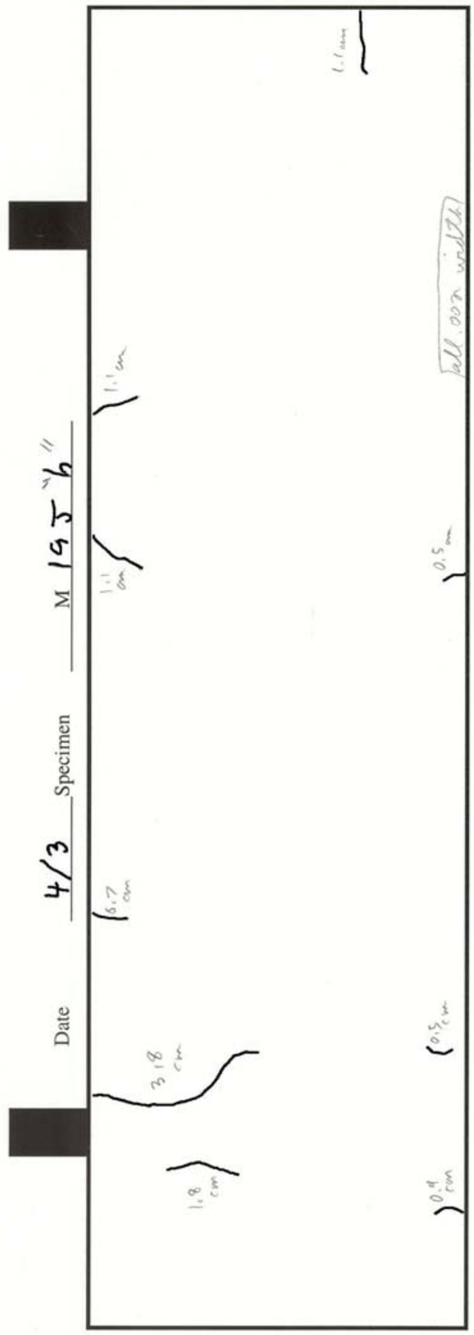
Specimen **M18J k** cont.
Coating **Silane + Latex Paint**
Fabricated 31-Dec

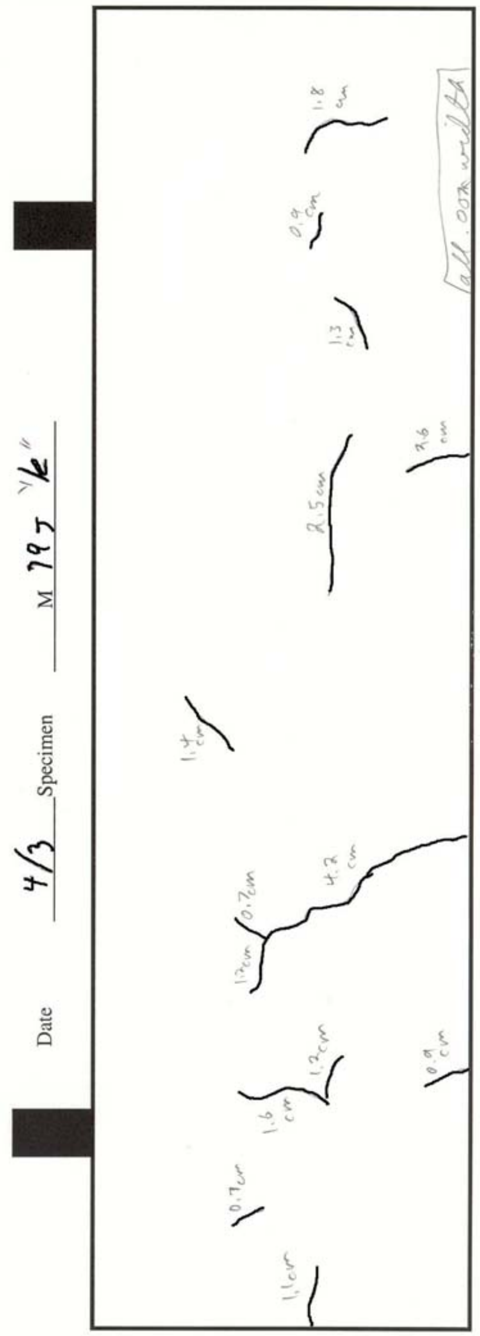
Date 11-Mar

Crack	Width (10^{-3} in)	Length (cm)	Length (in)	w^2l	wl
1	2		0.38	1.50	0.75
2	2		0.19	0.75	0.38
3	2		0.56	2.25	1.13
4	2		1.00	4.00	2.00
5	2		0.31	1.25	0.63
6	2		0.25	1.00	0.50
7	2		0.19	0.75	0.38
8	2		0.50	2.00	1.00
9	2		0.31	1.25	0.63
10	2		0.75	3.00	1.50
11	2		0.25	1.00	0.50
12	2		1.25	5.00	2.50
13	2		0.63	2.50	1.25
14	2		0.88	3.50	1.75
15	2		0.69	2.75	1.38
16	2		0.38	1.50	0.75
17	2		0.56	2.25	1.13
18	2		0.75	3.00	1.50
19	2		0.31	1.25	0.63
20	2		0.25	1.00	0.50
21	2		0.50	2.00	1.00
22	2		1.00	4.00	2.00
23	2		0.31	1.25	0.63
total				*48.75*	*24.38*

Specimen	M18J k	cont.			
Coating	Silane + Latex Paint				
Fabricated	31-Dec				
Date	25-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	0.8	0.31	1.26	0.63
2	2	2.4	0.94	3.78	1.89
3	2	0.5	0.20	0.79	0.39
4	2	0.9	0.35	1.42	0.71
5	2	1.4	0.55	2.20	1.10
6	2	0.8	0.31	1.26	0.63
7	2	1.6	0.63	2.52	1.26
8	2	2.3	0.91	3.62	1.81
9	2	0.6	0.24	0.94	0.47
10	2	0.8	0.31	1.26	0.63
11	2	0.6	0.24	0.94	0.47
12	2	1.3	0.51	2.05	1.02
13	2	0.3	0.12	0.47	0.24
14	2	1.9	0.75	2.99	1.50
15	2	3	1.18	4.72	2.36
16	2	1.2	0.47	1.89	0.94
17	2	1	0.39	1.57	0.79
18	2	0.9	0.35	1.42	0.71
19	2	2	0.79	3.15	1.57
20	2	1.6	0.63	2.52	1.26
21	2	1.9	0.75	2.99	1.50
22	2	1.4	0.55	2.20	1.10
23	2	2.4	0.94	3.78	1.89
24	2	0.8	0.31	1.26	0.63
25	2	0.5	0.20	0.79	0.39
total				*51.81*	*25.91*

Specimen	M18J k	cont.			
Coating	Silane + Latex Paint				
Fabricated	31-Dec				
Date	1-Apr				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.8	0.71	2.83	1.42
2	2	2.4	0.94	3.78	1.89
3	2	0.8	0.31	1.26	0.63
4	2	0.5	0.20	0.79	0.39
5	2	0.8	0.31	1.26	0.63
6	2	1.4	0.55	2.20	1.10
7	2	0.9	0.35	1.42	0.71
8	2	1.1	0.43	1.73	0.87
9	2	1.4	0.55	2.20	1.10
10	2	0.7	0.28	1.10	0.55
11	2	0.3	0.12	0.47	0.24
12	2	0.6	0.24	0.94	0.47
13	2	1.2	0.47	1.89	0.94
14	2	1.9	0.75	2.99	1.50
15	2	3	1.18	4.72	2.36
16	3	2.2	0.87	7.80	2.60
17	2	1.6	0.63	2.52	1.26
18	2	1	0.39	1.57	0.79
19	2	0.8	0.31	1.26	0.63
20	2	1.9	0.75	2.99	1.50
21	2	1.4	0.55	2.20	1.10
22	2	1.9	0.75	2.99	1.50
23	2	1.2	0.47	1.89	0.94
24	2	1.4	0.55	2.20	1.10
25	2	1.2	0.47	1.89	0.94
26	2	0.9	0.35	1.42	0.71
27	2	1.1	0.43	1.73	0.87
28	2	0.6	0.24	0.94	0.47
29	2	0.7	0.28	1.10	0.55
30	2	0.4	0.16	0.63	0.31
total				*62.76*	*30.08*


Date 4/3 Specimen M 19J "b"
all .007 width


Date 4/3 Specimen M 79J "k"
all .007 width

Specimen **M19J h**
Coating **Silane + PCM**
Fabricated 2-Jan

Date 20-Feb

Crack	Width (10^{-3} in)	Length (cm)	Length (in)	w^2l	wl
1	2		1.00	4.00	2.00
2	2		0.31	1.25	0.63
total				*5.25*	*2.63*

Date 27-Feb

Crack	Width (10^{-3} in)	Length (cm)	Length (in)	w^2l	wl
1	2	2.9	1.14	4.57	2.28
2	2	0.5	0.20	0.79	0.39
3	2	0.8	0.31	1.26	0.63
4	2	0.7	0.28	1.10	0.55
total				*7.72*	*3.86*

Date 13-Mar

Crack	Width (10^{-3} in)	Length (cm)	Length (in)	w^2l	wl
1	2		1.50	6.00	3.00
2	2		0.19	0.75	0.38
3	2		0.31	1.25	0.63
4	2		0.19	0.75	0.38
5	2		0.44	1.75	0.88
total				*10.50*	*5.25*

Specimen **M19J h** cont.
Coating **Silane + PCM**
Fabricated 2-Jan

Date 27-Mar

Crack	Width (10^{-3} in)	Length (cm)	Length (in)	w^2l	wl
1	2	1.8	0.71	2.83	1.42
2	2	0.9	0.35	1.42	0.71
3	2	2.7	1.06	4.25	2.13
4	2	1.0	0.39	1.57	0.79
5	2	0.5	0.20	0.79	0.39
6	2	0.7	0.28	1.10	0.55
7	2	1.2	0.47	1.89	0.94
8	2	0.5	0.20	0.79	0.39
9	2	1.1	0.43	1.73	0.87
total				*16.38*	*8.19*

Date 3-Apr

Crack	Width (10^{-3} in)	Length (cm)	Length (in)	w^2l	wl
1	2	1.8	0.71	2.83	1.42
2	2	0.9	0.35	1.42	0.71
3	2	3.8	1.50	5.98	2.99
4	2	0.5	0.20	0.79	0.39
5	2	0.7	0.28	1.10	0.55
6	2	1.1	0.43	1.73	0.87
7	2	0.5	0.20	0.79	0.39
8	2	1.1	0.43	1.73	0.87
9	2	1.1	0.43	1.73	0.87
total				*18.11*	*9.06*

Specimen **M19J k**
Coating **Silane + PCM**
Fabricated 2-Jan

Date 20-Feb

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.69	2.75	1.38
2	2		0.63	2.50	1.25
total				*5.25*	*2.63*

Date 27-Feb

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.6	0.63	2.52	1.26
2	2	5.8	2.28	9.13	4.57
3	2	1.6	0.63	2.52	1.26
4	2	1.3	0.51	2.05	1.02
5	2	0.9	0.35	1.42	0.71
total				*17.64*	*8.82*

Date 13-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.44	1.75	0.88
2	2		0.31	1.25	0.63
3	2		0.63	2.50	1.25
4	2		0.44	1.75	0.88
5	2		0.38	1.50	0.75
6	2		2.19	8.75	4.38
7	2		1.00	4.00	2.00
8	2		0.63	2.50	1.25
9	2		0.50	2.00	1.00
10	2		0.38	1.50	0.75
total				*27.50*	*13.75*

Specimen **M19J k** cont.
Coating **Silane + PCM**
Fabricated 2-Jan

Date 27-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.1	0.43	1.73	0.87
2	2	0.9	0.35	1.42	0.71
3	2	1.6	0.63	2.52	1.26
4	2	1.0	0.39	1.57	0.79
5	2	1.2	0.47	1.89	0.94
6	2	0.8	0.31	1.26	0.63
7	2	5.5	2.17	8.66	4.33
8	2	1.4	0.55	2.20	1.10
9	2	2.5	0.98	3.94	1.97
10	2	1.1	0.43	1.73	0.87
11	2	1.3	0.51	2.05	1.02
12	2	1.0	0.39	1.57	0.79
13	2	1.8	0.71	2.83	1.42
total				*33.39*	*16.69*

Date 1-Apr

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.1	0.43	1.73	0.87
2	2	0.7	0.28	1.10	0.55
3	2	1.6	0.63	2.52	1.26
4	2	1.2	0.47	1.89	0.94
5	2	0.9	0.35	1.42	0.71
6	2	1.2	0.47	1.89	0.94
7	2	0.7	0.28	1.10	0.55
8	2	4.2	1.65	6.61	3.31
9	2	1.4	0.55	2.20	1.10
10	2	2.5	0.98	3.94	1.97
11	2	2.6	1.02	4.09	2.05
12	2	1.3	0.51	2.05	1.02
13	2	0.9	0.35	1.42	0.71
14	2	1.8	0.71	2.83	1.42
total				*34.80*	*17.40*

Date 4/3 Specimen M 20J "h"

no cracks

Date 4/3 Specimen M 20J "k"

1.4cm

.002

Specimen **M20J h**
Coating **Type IV Epoxy**
Fabricated 2-Jan

Date	20-Feb				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	0		0	0	0
total				*0*	*0*

Date	27-Feb				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	0		0	0	0
total				*0*	*0*

Date	13-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	0		0	0	0
total				*0*	*0*

Date	27-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	0		0	0	0
total				*0*	*0*

Date	3-Apr				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	0		0	0	0
total				*0*	*0*

Specimen **M20J k**
Coating **Type IV Epoxy**
Fabricated 2-Jan

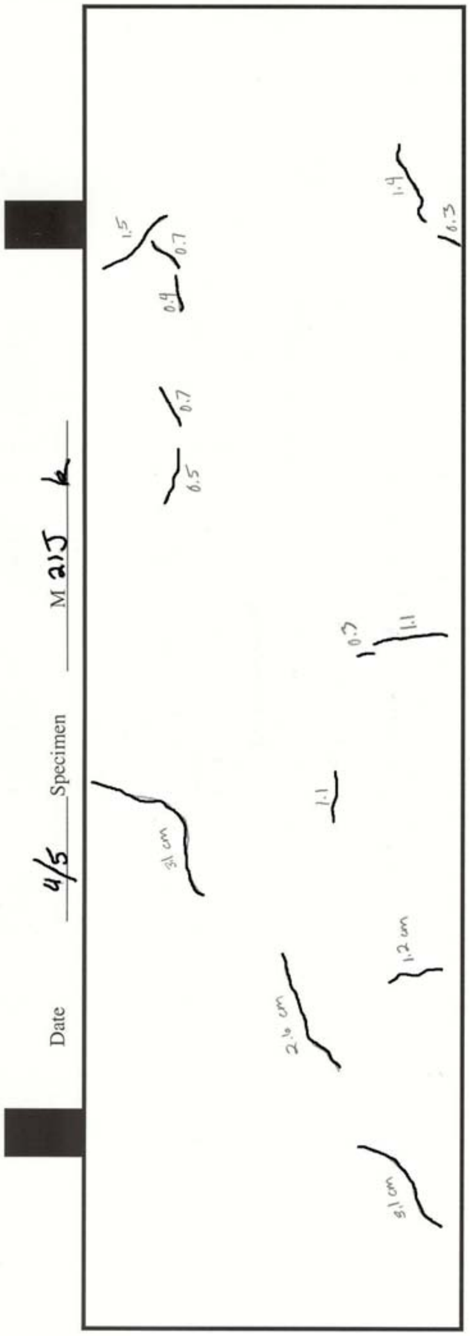
Date	20-Feb				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.50	2.00	1.00
total				*2.00*	*1.00*

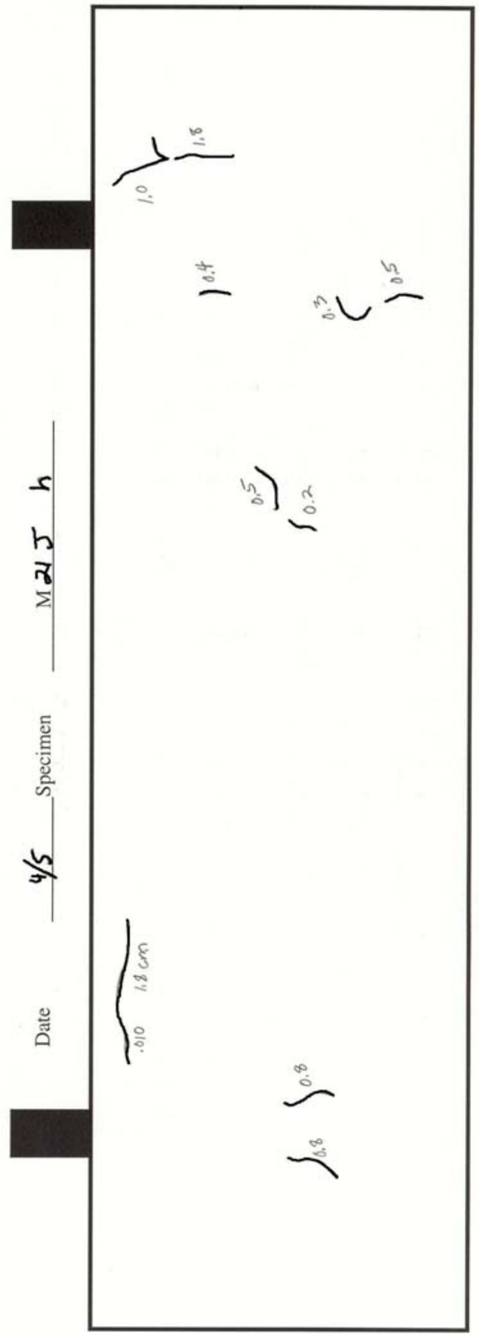
Date	27-Feb				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.4	0.55	2.20	1.10
total				*2.20*	*1.10*

Date	13-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.50	2.00	1.00
total				*2.00*	*1.00*

Date	27-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.4	0.55	2.20	1.10
total				*2.20*	*1.10*

Date	3-Apr				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.4	0.55	2.20	1.10
total				*2.20*	*1.10*


Date 4/5 Specimen M 21J k
3.1 cm
2.6 cm
1.2 cm
1.1
1.5
0.7
0.9
0.5
1.4
0.3


Date 4/5 Specimen M 21J h
1.8 cm
.010
0.8
1.0
1.8
0.4
0.3
0.5
0.2

Specimen **M21J h**
Coating **Polyurethane**
Fabricated 4-Jan

Date 22-Feb

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	0		0.00	0.00	0.00
total				0.00	0.00

Date 1-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.7	0.67	2.68	1.34
2	3	0.3	0.12	1.06	0.35
3	3	2.7	1.06	9.57	3.19
total				*13.31*	*4.88*

Date 14-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.7	0.67	2.68	1.34
2	3	0.3	0.12	1.06	0.35
3	3	2.7	1.06	9.57	3.19
total				*13.31*	*4.88*

Date 29-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	0.9	0.35	1.42	0.71
2	2	0.7	0.28	1.10	0.55
3	2	0.8	0.31	1.26	0.63
4	2	1.1	0.43	1.73	0.87
5	2	0.7	0.28	1.10	0.55
6	2	2.8	1.10	4.41	2.20
7	2	0.2	0.08	0.31	0.16
total				*11.34*	*5.67*

Date 5-Apr

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	0.8	0.31	1.26	0.63
2	2	0.8	0.31	1.26	0.63
3	2	0.5	0.20	0.79	0.39
4	2	0.2	0.08	0.31	0.16
5	2	0.4	0.16	0.63	0.31
6	2	0.5	0.20	0.79	0.39
7	2	1.8	0.71	2.83	1.42
8	2	1	0.39	1.57	0.79
total				*9.45*	*4.72*

Specimen **M21J k**
Coating **Polyurethane**
Fabricated 4-Jan

Date 22-Feb

Crack	Width (10^{-3} in)	Length (cm)	Length (in)	w^2l	wl
1	2		1.00	4.00	2.00
2	2		0.25	1.00	0.50
3	2		0.63	2.50	1.25
total				*7.50*	*3.75*

Date 1-Mar

Crack	Width (10^{-3} in)	Length (cm)	Length (in)	w^2l	wl
1	2	2.6	1.02	4.09	2.05
2	2	0.5	0.20	0.79	0.39
3	2	0.6	0.24	0.94	0.47
4	2	1.7	0.67	2.68	1.34
total				*8.50*	*4.25*

Date 14-Mar

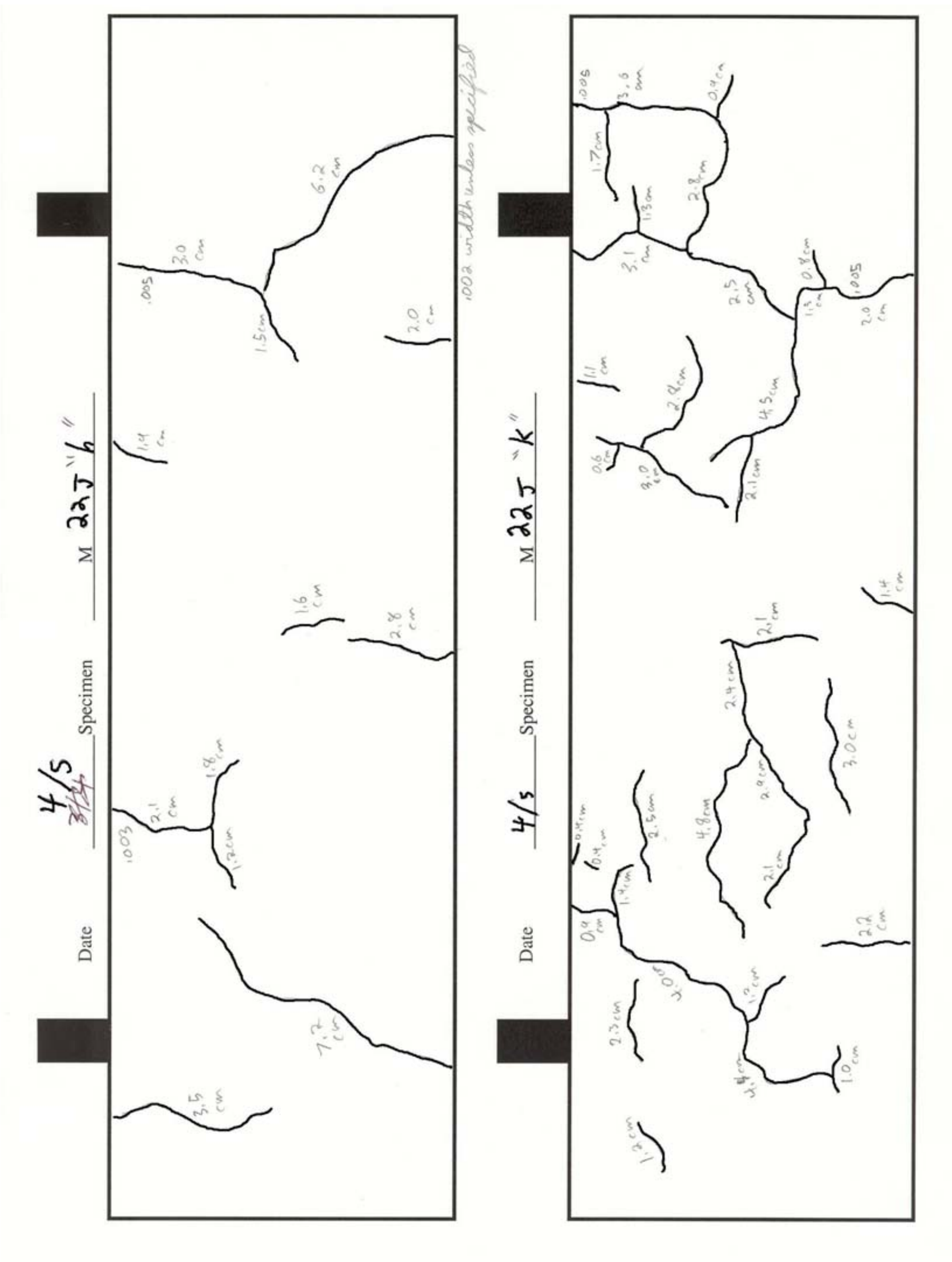
Crack	Width (10^{-3} in)	Length (cm)	Length (in)	w^2l	wl
1	2		0.75	3.00	1.50
2	2		0.56	2.25	1.13
3	2		1.00	4.00	2.00
4	2		0.50	2.00	1.00
5	2		0.75	3.00	1.50
6	2		0.19	0.75	0.38
7	2		0.25	1.00	0.50
8	2		0.63	2.50	1.25
total				*18.50*	*9.25*

Date 29-Mar

Crack	Width (10^{-3} in)	Length (cm)	Length (in)	w^2l	wl
1	2	3.1	1.22	4.88	2.44
2	2	2.1	0.83	3.31	1.65
3	2	1.2	0.47	1.89	0.94
4	2	1.1	0.43	1.73	0.87
5	2	3.2	1.26	5.04	2.52
6	2	0.3	0.12	0.47	0.24
7	2	1.1	0.43	1.73	0.87
8	2	0.5	0.20	0.79	0.39
9	2	0.7	0.28	1.10	0.55
10	2	0.4	0.16	0.63	0.31
11	2	0.7	0.28	1.10	0.55
12	2	1.5	0.59	2.36	1.18
13	2	0.3	0.12	0.47	0.24
total				*25.51*	*12.76*

Date 5-Apr

Crack	Width (10^{-3} in)	Length (cm)	Length (in)	w^2l	wl
1	2	3.1	1.22	4.88	2.44
2	2	2.6	1.02	4.09	2.05
3	2	1.2	0.47	1.89	0.94
4	2	1.1	0.43	1.73	0.87
5	2	3.1	1.22	4.88	2.44
6	2	0.3	0.12	0.47	0.24
7	2	1.1	0.43	1.73	0.87
8	2	0.5	0.20	0.79	0.39
9	2	0.7	0.28	1.10	0.55
10	2	0.4	0.16	0.63	0.31
11	2	0.7	0.28	1.10	0.55
12	2	1.5	0.59	2.36	1.18
13	2	1.4	0.55	2.20	1.10
14	2	0.3	0.12	0.47	0.24
total				*28.35*	*14.17*


Date 4/5 Specimen M 22J "h"
.002 width unless specified
Date 4/5 Specimen M 22J "K"

Specimen	**M22J h**				
Coating	**$LiNO_3$**				
Fabricated	4-Jan				

Date 22-Feb

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		1.25	5.00	2.50
2	2		2.88	11.50	5.75
3	2		0.50	2.00	1.00
4	2		1.63	6.50	3.25
5	2		0.63	2.50	1.25
6	2		1.13	4.50	2.25
7	2		1.25	5.00	2.50
total				*37.00*	*18.50*

Date 1-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	3.2	1.26	5.04	2.52
2	2	7.3	2.87	11.50	5.75
3	3	2.1	0.83	7.44	2.48
4	2	1.7	0.67	2.68	1.34
5	2	2.8	1.10	4.41	2.20
6	2	1.6	0.63	2.52	1.26
7	2	3.1	1.22	4.88	2.44
total				*38.46*	*17.99*

Date 14-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		1.63	6.50	3.25
2	2		2.75	11.00	5.50
3	2		0.50	2.00	1.00
4	3		1.69	15.19	5.06
5	2		0.63	2.50	1.25
6	2		1.13	4.50	2.25
7	2		0.75	3.00	1.50
8	2		1.63	6.50	3.25
9	2		2.63	10.50	5.25
total				*61.69*	*28.31*

Date 29-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	3	3.6	1.42	12.76	4.25
2	2	7	2.76	11.02	5.51
3	2	1.3	0.51	2.05	1.02
4	3	3.9	1.54	13.82	4.61
5	2	0.3	0.12	0.47	0.24
6	2	2.1	0.83	3.31	1.65
7	2	1.6	0.63	2.52	1.26
8	2	1.5	0.59	2.36	1.18
9	2	1.3	0.51	2.05	1.02
10	2	6.3	2.48	9.92	4.96
11	5	2.9	1.14	28.54	5.71
total				*88.82*	*31.42*

Date 5-Apr

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	3	2.1	0.83	7.44	2.48
2	2	3.5	1.38	5.51	2.76
3	2	7.2	2.83	11.34	5.67
4	2	1.2	0.47	1.89	0.94
5	2	1.8	0.71	2.83	1.42
6	2	1.6	0.63	2.52	1.26
7	2	2.8	1.10	4.41	2.20
8	2	1.9	0.75	2.99	1.50
9	2	1.5	0.59	2.36	1.18
10	5	3	1.18	29.53	5.91
11	2	6.2	2.44	9.76	4.88
12	2	2	0.79	3.15	1.57
total				*83.74*	*31.77*

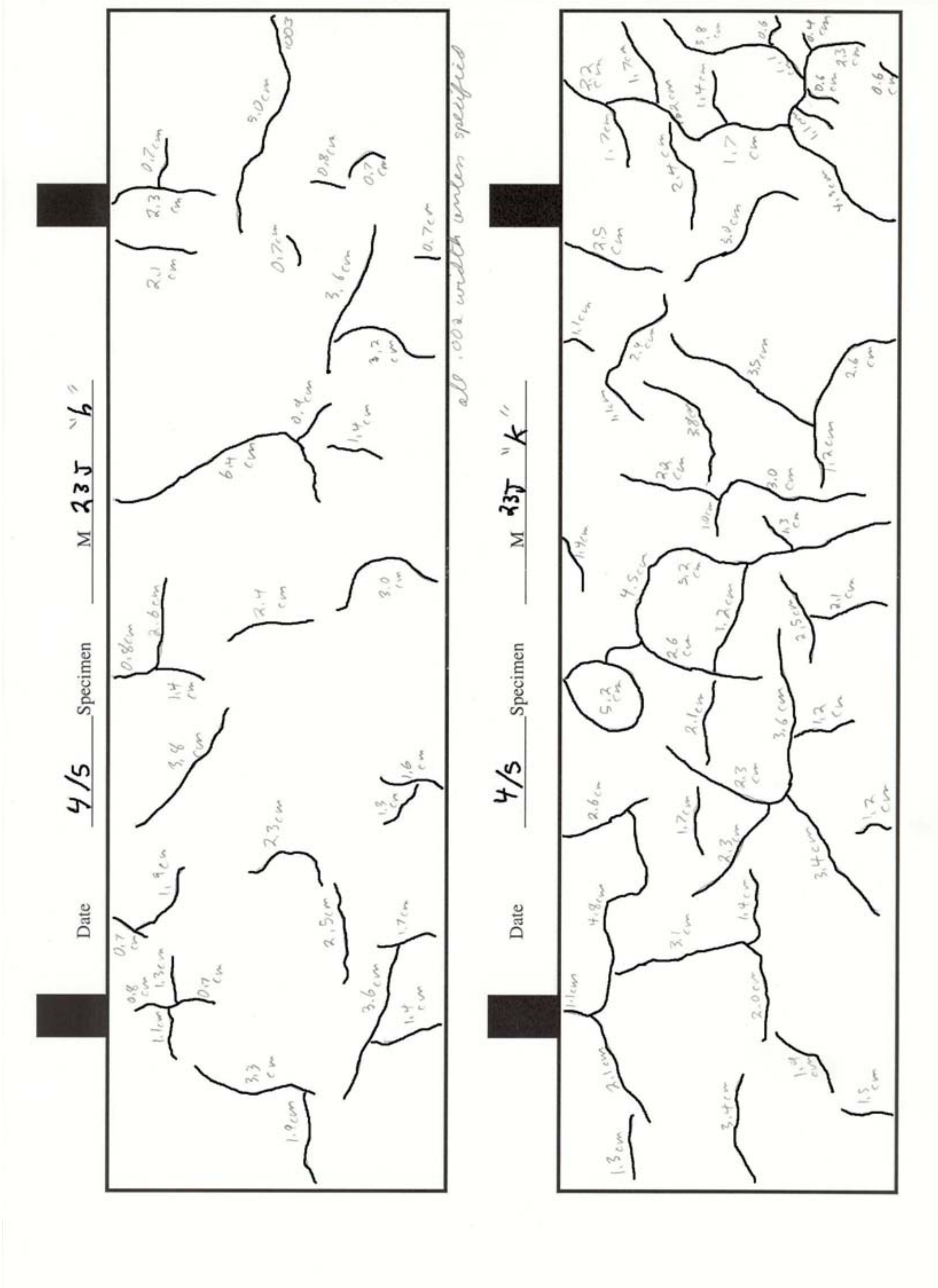
Specimen	**M22J k**				
Coating	**$LiNO_3$**				
Fabricated	4-Jan				
Date	22-Feb				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.38	1.50	0.75
2	2		0.63	2.50	1.25
3	2		0.85	3.40	1.70
4	2		0.31	1.25	0.63
5	2		0.81	3.25	1.63
6	2		1.13	4.50	2.25
7	2		1.00	4.00	2.00
8	2		2.88	11.50	5.75
9	2		1.19	4.75	2.38
10	2		0.88	3.50	1.75
11	2		1.00	4.00	2.00
12	2		2.25	9.00	4.50
13	2		1.00	4.00	2.00
14	2		0.50	2.00	1.00
15	2		0.75	3.00	1.50
16	2		0.50	2.00	1.00
17	2		0.75	3.00	1.50
18	2		1.00	4.00	2.00
total				*71.15*	*35.58*

Date	1-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.2	0.47	1.89	0.94
2	2	2.3	0.91	3.62	1.81
3	3	4.2	1.65	14.88	4.96
4	2	0.5	0.20	0.79	0.39
5	2	0.5	0.20	0.79	0.39
6	2	2.7	1.06	4.25	2.13
7	2	1.4	0.55	2.20	1.10
8	2	1	0.39	1.57	0.79
9	2	2.2	0.87	3.46	1.73
10	2	7.5	2.95	11.81	5.91
11	2	2.9	1.14	4.57	2.28
12	2	2.1	0.83	3.31	1.65
13	3	8	3.15	28.35	9.45
14	3	0.5	0.20	1.77	0.59
15	2	2.1	0.83	3.31	1.65
16	2	2.2	0.87	3.46	1.73
17	2	1.9	0.75	2.99	1.50
18	2	1.6	0.63	2.52	1.26
19	3	2.3	0.91	8.15	2.72
20	2	1.3	0.51	2.05	1.02
total				*105.75*	*44.02*

Date	14-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.50	2.00	1.00
2	2		0.50	2.00	1.00
3	2		0.38	1.50	0.75
4	2		1.50	6.00	3.00
5	2		0.88	3.50	1.75
6	3		0.88	7.88	2.63
7	3		1.94	17.44	5.81
8	2		2.00	8.00	4.00
9	2		2.88	11.50	5.75
10	2		0.88	3.50	1.75
11	2		1.38	5.50	2.75
12	2		0.50	2.00	1.00
13	2		0.88	3.50	1.75
14	2		1.25	5.00	2.50
15	3		3.13	28.13	9.38
16	2		1.25	5.00	2.50
17	2		0.44	1.75	0.88
18	2		0.25	1.00	0.50
19	2		3.63	14.50	7.25
20	2		0.75	3.00	1.50
21	2		0.88	3.50	1.75
22	2		0.50	2.00	1.00
23	2		0.75	3.00	1.50
24	2		0.38	1.50	0.75
total				*142.69*	*62.44*

Specimen	**M22J k**	cont.			
Coating	**$LiNO_3$**				
Fabricated	4-Jan				
Date	29-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.1	0.43	1.73	0.87
2	2	2.2	0.87	3.46	1.73
3	2	4.8	1.89	7.56	3.78
4	2	1	0.39	1.57	0.79
5	2	2.3	0.91	3.62	1.81
6	2	4.8	1.89	7.56	3.78
7	2	2.5	0.98	3.94	1.97
8	2	0.4	0.16	0.63	0.31
9	2	0.4	0.16	0.63	0.31
10	2	7.1	2.80	11.18	5.59
11	2	2.4	0.94	3.78	1.89
12	2	3.5	1.38	5.51	2.76
13	2	2.2	0.87	3.46	1.73
14	2	1.3	0.51	2.05	1.02
15	2	2.2	0.87	3.46	1.73
16	2	1.5	0.59	2.36	1.18
17	2	1.3	0.51	2.05	1.02
18	2	7.6	2.99	11.97	5.98
19	2	0.6	0.24	0.94	0.47
20	2	2.5	0.98	3.94	1.97
21	2	3	1.18	4.72	2.36
22	2	1.1	0.43	1.73	0.87
23	2	1.1	0.43	1.73	0.87
24	2	2	0.79	3.15	1.57
25	2	1.2	0.47	1.89	0.94
26	2	3	1.18	4.72	2.36
27	2	1.3	0.51	2.05	1.02
28	2	0.9	0.35	1.42	0.71
29	2	3.7	1.46	5.83	2.91
30	2	1.8	0.71	2.83	1.42
total				*111.50*	*55.75*

Date	5-Apr				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.2	0.47	1.89	0.94
2	2	2.3	0.91	3.62	1.81
3	2	4.4	1.73	6.93	3.46
4	2	1	0.39	1.57	0.79
5	2	1.2	0.47	1.89	0.94
6	2	4	1.57	6.30	3.15
7	2	0.9	0.35	1.42	0.71
8	2	1.4	0.55	2.20	1.10
9	2	0.4	0.16	0.63	0.31
10	2	0.4	0.16	0.63	0.31
11	2	2.5	0.98	3.94	1.97
12	2	4.8	1.89	7.56	3.78
13	2	2.1	0.83	3.31	1.65
14	2	2.9	1.14	4.57	2.28
15	2	2.2	0.87	3.46	1.73
16	2	2.1	0.83	3.31	1.65
17	2	3	1.18	4.72	2.36
18	2	2.4	0.94	3.78	1.89
19	2	2.1	0.83	3.31	1.65
20	2	1.4	0.55	2.20	1.10
21	2	3	1.18	4.72	2.36
22	2	2.1	0.83	3.31	1.65
23	2	0.6	0.24	0.94	0.47
24	2	2.8	1.10	4.41	2.20
25	2	4.5	1.77	7.09	3.54
26	2	1.1	0.43	1.73	0.87
27	2	2.5	0.98	3.94	1.97
28	2	1.5	0.59	2.36	1.18
29	5	2	0.79	19.69	3.94
30	2	0.8	0.31	1.26	0.63
31	2	3.1	1.22	4.88	2.44
32	2	1.3	0.51	2.05	1.02
33	2	2.8	1.10	4.41	2.20
34	2	1.7	0.67	2.68	1.34
35	2	0.9	0.35	1.42	0.71
36	5	3.6	1.42	35.43	7.09
total				*167.56*	*67.24*


Date 4/5 Specimen M 23J "L"
Date 4/5 Specimen M 23J "K"
all .002 width unless specified

Specimen	**M23J h**				
Coating	**$LiNO_3$ + 742 Paint**				
Fabricated	4-Jan				
Date	22-Feb				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.50	2.00	1.00
2	2		1.19	4.75	2.38
3	2		0.69	2.75	1.38
4	2		0.38	1.50	0.75
5	2		0.63	2.50	1.25
6	2		0.38	1.50	0.75
7	2		0.75	3.00	1.50
8	2		0.63	2.50	1.25
9	2		1.50	6.00	3.00
10	2		0.56	2.25	1.13
11	2		2.00	8.00	4.00
12	2		0.44	1.75	0.88
13	2		0.75	3.00	1.50
14	2		0.69	2.75	1.38
15	2		2.00	8.00	4.00
total				*52.25*	*26.13*

Date	1-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.1	0.43	1.73	0.87
2	2	1.6	0.63	2.52	1.26
3	2	0.9	0.35	1.42	0.71
4	2	1.4	0.55	2.20	1.10
5	2	3.1	1.22	4.88	2.44
6	2	1.8	0.71	2.83	1.42
7	2	1.1	0.43	1.73	0.87
8	2	2.3	0.91	3.62	1.81
9	2	1.7	0.67	2.68	1.34
10	2	0.7	0.28	1.10	0.55
11	2	3.9	1.54	6.14	3.07
12	1	1.5	0.59	0.59	0.59
13	1	6	2.36	2.36	2.36
14	3	2	0.79	7.09	2.36
15	2	1.8	0.71	2.83	1.42
16	3	5.4	2.13	19.13	6.38
total				*62.87*	*28.54*

Date	14-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.75	3.00	1.50
2	2		0.56	2.25	1.13
3	2		1.25	5.00	2.50
4	2		1.50	6.00	3.00
5	2		0.88	3.50	1.75
6	2		1.13	4.50	2.25
7	2		0.31	1.25	0.63
8	2		0.75	3.00	1.50
9	2		1.00	4.00	2.00
10	2		0.69	2.75	1.38
11	2		0.88	3.50	1.75
12	2		1.50	6.00	3.00
13	2		1.19	4.75	2.38
14	2		0.88	3.50	1.75
15	2		1.25	5.00	2.50
16	2		2.44	9.75	4.88
17	2		0.50	2.00	1.00
18	2		0.31	1.25	0.63
19	2		0.75	3.00	1.50
20	2		1.25	5.00	2.50
21	2		1.38	5.50	2.75
22	2		0.69	2.75	1.38
23	2		0.25	1.00	0.50
24	2		2.13	8.50	4.25
total				*96.75*	*48.38*

Specimen **M23J h** cont.
Coating **$LiNO_3$ + 742 Paint**
Fabricated 4-Jan

Date 29-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.9	0.75	2.99	1.50
2	2	3.3	1.30	5.20	2.60
3	2	1.1	0.43	1.73	0.87
4	2	3.6	1.42	5.67	2.83
5	2	1.4	0.55	2.20	1.10
6	2	0.8	0.31	1.26	0.63
7	2	0.7	0.28	1.10	0.55
8	2	1.3	0.51	2.05	1.02
9	2	2.5	0.98	3.94	1.97
10	2	1.7	0.67	2.68	1.34
11	2	0.7	0.28	1.10	0.55
12	2	1.9	0.75	2.99	1.50
13	2	2.3	0.91	3.62	1.81
14	2	1.3	0.51	2.05	1.02
15	2	1.6	0.63	2.52	1.26
16	2	3.8	1.50	5.98	2.99
17	2	0.8	0.31	1.26	0.63
18	2	2.6	1.02	4.09	2.05
19	2	2.4	0.94	3.78	1.89
20	2	3	1.18	4.72	2.36
21	2	6.3	2.48	9.92	4.96
22	2	1.4	0.55	2.20	1.10
23	2	0.9	0.35	1.42	0.71
24	2	3.2	1.26	5.04	2.52
25	2	3.5	1.38	5.51	2.76
26	2	0.7	0.28	1.10	0.55
27	2	0.7	0.28	1.10	0.55
28	2	2.1	0.83	3.31	1.65
29	2	1.9	0.75	2.99	1.50
30	3	5	1.97	17.72	5.91
31	2	0.8	0.31	1.26	0.63
32	2	0.7	0.28	1.10	0.55
total				*113.62*	*53.86*

Date 5-Apr

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.9	0.75	2.99	1.50
2	2	3.3	1.30	5.20	2.60
3	2	1.4	0.55	2.20	1.10
4	2	3.6	1.42	5.67	2.83
5	2	1.7	0.67	2.68	1.34
6	2	1.1	0.43	1.73	0.87
7	2	0.7	0.28	1.10	0.55
8	2	0.8	0.31	1.26	0.63
9	2	1.3	0.51	2.05	1.02
10	2	2.5	0.98	3.94	1.97
11	2	0.7	0.28	1.10	0.55
12	2	1.9	0.75	2.99	1.50
13	2	2.3	0.91	3.62	1.81
14	2	1.3	0.51	2.05	1.02
15	2	1.6	0.63	2.52	1.26
16	2	3.8	1.50	5.98	2.99
17	2	1.4	0.55	2.20	1.10
18	2	0.8	0.31	1.26	0.63
19	2	2.6	1.02	4.09	2.05
20	2	2.4	0.94	3.78	1.89
21	2	3	1.18	4.72	2.36
22	2	6.4	2.52	10.08	5.04
23	2	1.4	0.55	2.20	1.10
24	2	0.9	0.35	1.42	0.71
25	2	3.2	1.26	5.04	2.52
26	2	3.6	1.42	5.67	2.83
27	2	0.7	0.28	1.10	0.55
28	2	2.1	0.83	3.31	1.65
29	2	0.7	0.28	1.10	0.55
30	2	0.7	0.28	1.10	0.55
31	2	0.8	0.31	1.26	0.63
32	2	2.3	0.91	3.62	1.81
33	2	0.7	0.28	1.10	0.55
34	3	5	1.97	17.72	5.91
total				*117.87*	*55.98*

Specimen	**M23J k**				
Coating	**$LiNO_3$ + 742 Paint**				
Fabricated	4-Jan				
Date	22-Feb				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		1.38	5.50	2.75
2	2		0.88	3.50	1.75
3	2		0.38	1.50	0.75
4	2		1.00	4.00	2.00
5	2		1.38	5.50	2.75
6	2		1.38	5.50	2.75
7	2		1.00	4.00	2.00
8	2		1.00	4.00	2.00
9	2		1.00	4.00	2.00
10	2		0.50	2.00	1.00
11	2		0.63	2.50	1.25
12	2		0.56	2.25	1.13
13	2		0.38	1.50	0.75
14	2		1.88	7.50	3.75
15	2		0.38	1.50	0.75
16	2		0.88	3.50	1.75
17	2		1.25	5.00	2.50
18	2		1.25	5.00	2.50
19	2		1.75	7.00	3.50
20	2		0.38	1.50	0.75
21	2		0.50	2.00	1.00
22	2		0.88	3.50	1.75
23	2		1.13	4.50	2.25
24	2		0.38	1.50	0.75
25	2		0.50	2.00	1.00
26	2		0.44	1.75	0.88
27	2		1.19	4.75	2.38
28	2		1.25	5.00	2.50
29	2		1.13	4.50	2.25
30	2		1.56	6.25	3.13
31	2		0.63	2.50	1.25
32	2		0.94	3.75	1.88
33	2		1.50	6.00	3.00
34	2		0.38	1.50	0.75
35	2		0.50	2.00	1.00
36	2		0.31	1.25	0.63
total				*129.50*	*64.75*

Date	1-Mar				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1	0.39	1.57	0.79
2	2	2.2	0.87	3.46	1.73
3	2	2.3	0.91	3.62	1.81
4	2	3.3	1.30	5.20	2.60
5	2	3.4	1.34	5.35	2.68
6	2	2.8	1.10	4.41	2.20
7	2	2.6	1.02	4.09	2.05
8	2	3.5	1.38	5.51	2.76
9	2	5.8	2.28	9.13	4.57
10	2	0.3	0.12	0.47	0.24
11	2	5.2	2.05	8.19	4.09
12	2	0.8	0.31	1.26	0.63
13	2	3	1.18	4.72	2.36
14	2	6.3	2.48	9.92	4.96
15	2	3.3	1.30	5.20	2.60
16	2	1.2	0.47	1.89	0.94
17	2	3.2	1.26	5.04	2.52
18	2	2.1	0.83	3.31	1.65
19	2	3	1.18	4.72	2.36
20	2	1.1	0.43	1.73	0.87
21	2	1.4	0.55	2.20	1.10
22	2	2.9	1.14	4.57	2.28
23	2	3.5	1.38	5.51	2.76
24	2	1.2	0.47	1.89	0.94
25	2	2.7	1.06	4.25	2.13
26	2	1.1	0.43	1.73	0.87
27	2	3.7	1.46	5.83	2.91
28	2	1.6	0.63	2.52	1.26
29	2	3.8	1.50	5.98	2.99
30	2	3.2	1.26	5.04	2.52
31	2	1.1	0.43	1.73	0.87
32	2	0.7	0.28	1.10	0.55
total				*131.18*	*65.59*

Specimen **M23J k** cont.
Coating **$LiNO_3$ + 742 Paint**
Fabricated 4-Jan

Date 14-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2		0.50	2.00	1.00
2	2		1.38	5.50	2.75
3	2		1.38	5.50	2.75
4	2		0.75	3.00	1.50
5	2		0.88	3.50	1.75
6	2		2.50	10.00	5.00
7	2		1.63	6.50	3.25
8	2		1.00	4.00	2.00
9	2		0.63	2.50	1.25
10	2		1.13	4.50	2.25
11	2		1.38	5.50	2.75
12	2		0.44	1.75	0.88
13	2		2.38	9.50	4.75
14	2		0.50	2.00	1.00
15	2		0.63	2.50	1.25
16	2		1.00	4.00	2.00
17	2		1.81	7.25	3.63
18	2		1.25	5.00	2.50
19	2		1.00	4.00	2.00
20	2		0.88	3.50	1.75
21	2		0.50	2.00	1.00
22	2		3.88	15.50	7.75
23	2		0.50	2.00	1.00
24	2		0.38	1.50	0.75
25	2		2.13	8.50	4.25
26	2		1.38	5.50	2.75
27	2		0.50	2.00	1.00
28	2		1.50	6.00	3.00
29	3		0.50	4.50	1.50
30	2		1.00	4.00	2.00
31	2		1.00	4.00	2.00
32	2		1.25	5.00	2.50
33	2		1.38	5.50	2.75
34	2		0.94	3.75	1.88
35	2		2.00	8.00	4.00
36	2		0.38	1.50	0.75
37	2		0.25	1.00	0.50
38	2		0.25	1.00	0.50
39	2		1.38	5.50	2.75
40	2		0.69	2.75	1.38
41	3		1.94	17.44	5.81
42	2		0.63	2.50	1.25
43	2		0.75	3.00	1.50
44	2		0.50	2.00	1.00
total				*206.44*	*99.56*

Date 29-Mar

Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.3	0.51	2.05	1.02
2	2	3.4	1.34	5.35	2.68
3	2	1.5	0.59	2.36	1.18
4	2	2.1	0.83	3.31	1.65
5	2	1.9	0.75	2.99	1.50
6	2	1.1	0.43	1.73	0.87
7	2	2	0.79	3.15	1.57
8	2	3.2	1.26	5.04	2.52
9	2	4.7	1.85	7.40	3.70
10	2	1.4	0.55	2.20	1.10
11	2	2.3	0.91	3.62	1.81
12	2	3.4	1.34	5.35	2.68
13	2	1.2	0.47	1.89	0.94
14	2	1.7	0.67	2.68	1.34
15	2	2.6	1.02	4.09	2.05
16	2	5.9	2.32	9.29	4.65
17	2	5.2	2.05	8.19	4.09
18	2	2.1	0.83	3.31	1.65
19	2	1.2	0.47	1.89	0.94
20	2	2.6	1.02	4.09	2.05
21	2	9.7	3.82	15.28	7.64
22	2	3.2	1.26	5.04	2.52
23	2	2.5	0.98	3.94	1.97
24	2	1.4	0.55	2.20	1.10
25	2	2.1	0.83	3.31	1.65
26	2	1	0.39	1.57	0.79
27	2	1.3	0.51	2.05	1.02
28	2	2.2	0.87	3.46	1.73
29	2	3	1.18	4.72	2.36
30	2	1.1	0.43	1.73	0.87
31	2	3.8	1.50	5.98	2.99
32	2	1.2	0.47	1.89	0.94
33	2	1.1	0.43	1.73	0.87
34	2	2.9	1.14	4.57	2.28
35	2	3.5	1.38	5.51	2.76
36	2	2.6	1.02	4.09	2.05
37	2	2.5	0.98	3.94	1.97
38	2	3	1.18	4.72	2.36
39	2	2.4	0.94	3.78	1.89
40	2	4.5	1.77	7.09	3.54
41	2	1.7	0.67	2.68	1.34
42	2	1.7	0.67	2.68	1.34
43	2	1.1	0.43	1.73	0.87
44	2	1.4	0.55	2.20	1.10
45	2	1.2	0.47	1.89	0.94
46	2	3.9	1.54	6.14	3.07
47	2	0.6	0.24	0.94	0.47
48	2	4.9	1.93	7.72	3.86
49	2	2.3	0.91	3.62	1.81
50	2	0.6	0.24	0.94	0.47
51	2	1	0.39	1.57	0.79
total				*198.74*	*99.37*

Specimen	**M23J k**	cont.			
Coating	**$LiNO_3$ + 742 Paint**				
Fabricated	4-Jan				
Date	5-Apr				
Crack	Width	Length	Length	w^2l	wl
	(10^{-3} in)	(cm)	(in)		
1	2	1.3	0.51	2.05	1.02
2	2	3.4	1.34	5.35	2.68
3	2	1.5	0.59	2.36	1.18
4	2	2.1	0.83	3.31	1.65
5	2	1.9	0.75	2.99	1.50
6	2	2	0.79	3.15	1.57
7	2	1.1	0.43	1.73	0.87
8	2	4.8	1.89	7.56	3.78
9	2	3.1	1.22	4.88	2.44
10	2	1.4	0.55	2.20	1.10
11	2	2.6	1.02	4.09	2.05
12	2	1.7	0.67	2.68	1.34
13	2	2.3	0.91	3.62	1.81
14	2	3.4	1.34	5.35	2.68
15	2	1.2	0.47	1.89	0.94
16	2	2.3	0.91	3.62	1.81
17	2	5.2	2.05	8.19	4.09
18	2	2.1	0.83	3.31	1.65
19	2	3.6	1.42	5.67	2.83
20	2	1.2	0.47	1.89	0.94
21	2	2.6	1.02	4.09	2.05
22	2	2.5	0.98	3.94	1.97
23	2	4.5	1.77	7.09	3.54
24	2	3.2	1.26	5.04	2.52
25	2	2.1	0.83	3.31	1.65
26	2	5.2	2.05	8.19	4.09
27	2	1.4	0.55	2.20	1.10
28	2	1.3	0.51	2.05	1.02
29	2	1	0.39	1.57	0.79
30	2	2.2	0.87	3.46	1.73
31	2	3	1.18	4.72	2.36
32	2	1.1	0.43	1.73	0.87
33	2	3.8	1.50	5.98	2.99
34	2	1.2	0.47	1.89	0.94
35	2	1.1	0.43	1.73	0.87
36	2	2.9	1.14	4.57	2.28
37	2	3.5	1.38	5.51	2.76
38	2	2.6	1.02	4.09	2.05
39	2	2.5	0.98	3.94	1.97
40	2	3	1.18	4.72	2.36
41	2	1.7	0.67	2.68	1.34
42	2	2.4	0.94	3.78	1.89
43	2	4.5	1.77	7.09	3.54
44	2	1.7	0.67	2.68	1.34
45	2	1.2	0.47	1.89	0.94
46	2	2.2	0.87	3.46	1.73
47	2	1.1	0.43	1.73	0.87
48	2	1.7	0.67	2.68	1.34
49	2	1.4	0.55	2.20	1.10
50	2	3.8	1.50	5.98	2.99
51	2	1.1	0.43	1.73	0.87
52	2	0.6	0.24	0.94	0.47
53	2	0.6	0.24	0.94	0.47
54	2	0.4	0.16	0.63	0.31
55	2	2.3	0.91	3.62	1.81
56	2	0.6	0.24	0.94	0.47
total				*198.74*	*99.37*

APPENDIX G

Expanded Bibliography from Literature Search

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APPENDIX H

Recommended Test Procedure for Future Research

Step 1. Fabricate test specimens according to ASTM C 1293-95, using Jobe fine aggregate. Cast plastic sleeves for relative humidity measurement at depths of 0.5 in. (12 mm) and 1.5 in. (40 mm) from the surface. Plug the sleeves with rubber stoppers to prevent drying of the interior of the specimen. Cure the specimens in the molds per ASTM C 157.

Step 2. After removal from the molds, age the specimens in the storage containers for seven days at 60°C in the storage environment. Storage containers and storage environment should be set up according to ASTM C 1293.

Step 3. Lightly clean specimens with a sandblast to remove laitance prior to application of the mitigation treatments. Apply treatments to the entire surface area and allow to cure according to manufacturer's instructions.

Step 4. Immerse the specimens for 2 hours, with the plastic sleeves upward, in just enough water to cover the specimens but not over the tops of the plastic sleeves.

Step 5. Place the specimens in the storage containers and return to the storage environment. Age the specimens for 2 weeks in the storage environment.

Step 6. After 2 weeks, remove the specimens from the storage containers and immediately take length readings. Promptly return the specimens to the storage containers in the storage environment. Take relative humidity readings with the specimens in the storage containers.

Step 7. Remove the specimens from the storage containers and storage environment. Place the specimens on the PVC racks in an area where they are exposed to ambient temperature and relative humidity. Age the specimens for 2 weeks. Record the daily ambient temperature and relative humidity for the duration of the cycle.

Step 8. After 2 weeks, take length and relative humidity readings for the specimens.

Step 9. Repeat the cycles of immersion, high temperature storage, and exposure to ambient conditions for at least 13 weeks.

Intermediate relative humidity readings may be taken during a cycle to determine if a cycle needs to be shortened or lengthened to reach a desired internal relative humidity. Research has found that ASR occurs in concrete with a relative humidity greater than 80% (Bauer 2001).

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