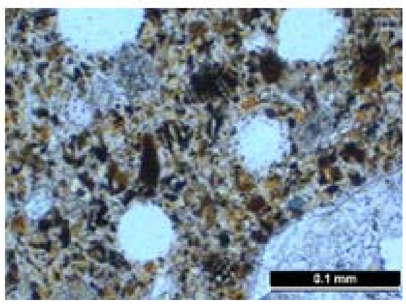
RESEARCH AND DEVELOPMENT OF CALCIUM ALUMINATE CEMENT-BASED CONCRETE FOR RAPID REPAIR APPLICATIONS



REPORT FOR THE

Illinois State Toll Highway Authority

CTLGroup Project No. 057177

February 14, 2017

Submitted by:

Matthew D. D'Ambrosia, Ph.D., P.E.

Benjamin Birch, P.E.

Jose Pacheco, Ph.D.

Jan Vosahlik

CTLGROUP
Building Knowledge. Delivering Results.

5400 Old Orchard Road
Skokie, Illinois 60077-1030

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

1. PROJECT BACKGROUND

This report has been developed by CTLGroup as an integral part of a research project focused on the characterization, evaluation, and testing of calcium aluminate cements (CAC) for rapid repairs. The objective of the research program was to characterize existing applications and performance of CAC using information gathered via literature review, site visits, laboratory investigations, and field applications, as well as to assist in the development of a specification for the use of CAC for rapid repairs, with primary focus on durability and long-term performance of CAC-based concrete mixtures. This report describes the work carried out for this project. It is composed of four phases as described below.

- Phase I (2014) - included a literature and specification review and a series of site visits to collect and document firsthand evidence of performance of CAC-based materials. Findings obtained during this phase were used to develop a testing protocol that was used to evaluate CAC mixtures in Phase II.
- Phase II (2014-2015) - consisted of results obtained from a large scale laboratory trial, and field implementation and validation of CAC repair placements by the Illinois Tollway.
- Phase III (2015) – composed of laboratory trials and testing of CAC concrete mixtures in the laboratory with variations of material proportions and tested properties.
- Phase IV (2016) - included the implementation and evaluation of a roadway repair.

Specifically, this report provides the pertinent findings of the:

- Literature review, including a brief overview of conversion, volume change and cracking potential, and published durability data.
- Summary of field surveys, including photographs, crack surveys, and durability report.
- Large scale laboratory placement, including early-age performance (i.e. strength development, workability, and air content), long-term strength development, and durability testing results.
- Additional laboratory investigations regarding volume instability and characterization of expansive properties.

2. PHASE I (2014)

2.1 LITERATURE AND SPECIFICATION REVIEW[1]

Calcium-aluminate cement (CAC) is a rapid hardening, hydraulic cementitious material, which has been used for both concrete repair and new construction, especially refractory applications and sewer pipe linings, for over 100 years. This chapter is a compilation of published data and research on CAC based-systems with a focus on the hydration, conversion phenomena, durability, and existing specifications. The aim of this literature review is to provide information which is pertinent to the Illinois Tollway from the rapid strength development to the long-term performance.

2.1.1 CAC BACKGROUND

Limestone and bauxite are the raw components which are fused to manufacture calcium aluminate cement. Bauxite is the only suitable alumina source existing in nature that can be used for calcium aluminate cement manufacturing. CAC typically used for infrastructure applications contain 38-40% Al_2O_3, which are made from ferruginous bauxites and contain up to 20% Fe_2O_3 (Campas, 1998).

Figure 2-1 illustrates the approximate composition range of calcium aluminate cements (Scrivener, 2003). This figure shows a ternary phase diagram of CaO-SiO_2-Al_2O_3 with comparison of composition ranges of ordinary portland cements. In CACs with lower alumina content the cementitious phases present can be complex. The principal reactive phase found in CAC is monocalcium aluminate, CA or $CaAl_2O_4$ which makes up roughly 40-60% by mass of the cement. The other key component of anhydrous CAC is $C_{12}A_7$ (mayenite), which is the most reactive calcium aluminate phase and thus responsible for the most rapid increases in setting. The amount of this component is strictly limited to prevent early stiffening or flash setting (Scrivener, 2003).

[1] This section of the report was authored by CTLGroup Laboratory Manager Dr. Anthony Bentivegna and is based on his dissertation (Bentivegna, 2012)

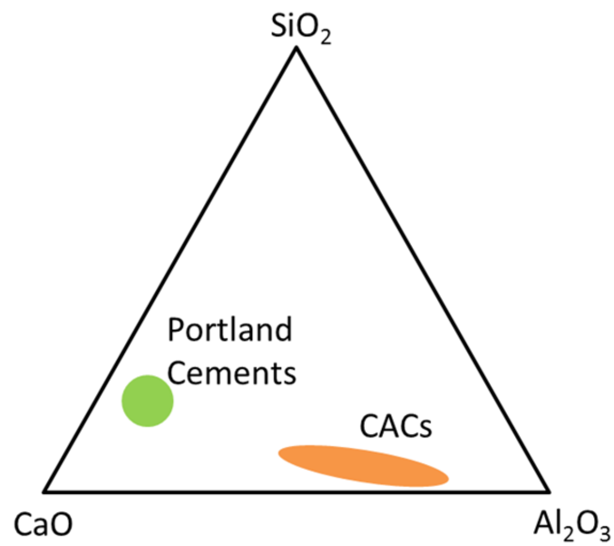


Figure 2-1 – Approximate Composition Range of CAC (Adapted from Scrivener, 2003)

2.1.2 HYDRATION AND CONVERSION

The hydration of calcium aluminate cement, strongly dependent on temperature, is governed by dissolution and precipitation processes. The anhydrous CAC phases dissolve upon contact with water and introduce ions into the solution, which then begin to precipitate in new chemical compounds, i.e. CAH_{10}, C_2AH_8, C_3AH_6, and poorly crystalline gel-phases (Scrivener, 2003).

When these phases mix together and recombine at the lowest possible energy state, stable hydrates (C_3AH_6 and AH_3) are formed. However, the formation of the phases in the lowest energy state is difficult due to the speed of nucleation, and is often preceded by the formation of temporary or metastable hydrates (CAH_{10} and C_2AH_8). The energy state of the metastable products is lower than the dissolved ions, thus there is a motivation for the new assemblage. However, since there is a lower energy state possible (stable hydrates), a driving force for these metastable hydrates to recombine to form stable hydrates exists. The transformation of metastable hydrates to the lowest energy state of stable hydration products is known as conversion (Scrivener, 2003).

The hydration process of CAC is a complex process that involves the formation of stable and metastable compounds (Scrivener & Campas, 1998). The stable hydration products are found predominantly when hydration occurs at stable environmental temperatures over 149°F (65°C). The hydration of calcium aluminate (CA) to its thermodynamically stable condition (lowest energy state) resulting in the formation of C_3AH_6 and AH_3 (gibbsite) is shown in Equation (1).

$$3CA + 12H \rightarrow C_3AH_6 + 2AH_3 \tag{1}$$

The stable hydration product C_3AH_6 has a compact cubic morphology and gibbsite is a poorly crystalline formless mass (Scrivener & Capmas, 1998).

At temperatures between 95-149°F (35-65°C), C_2AH_8 and AH_3 are the primary CAC hydration products that are formed. When the temperature is below 86°F (30°C), the first metastable CAC hydration product that forms is CAH_{10}. Equations (2) and (3) illustrate the hydration of CA (Scrivener & Capmas, 1998).

$$CA + 10H \rightarrow CAH_{10} \tag{2}$$

$$2CA + 16H \rightarrow C_2AH_8 + AH_3 \tag{3}$$

When the temporary or metastable hydration products form first, it is inevitable that they will eventually convert to the lowest energy state (stable hydrate assemblages). Equations (4) and (5) demonstrate the conversion reactions of the metastable hydrates. The conversion of CAH_{10} directly to C_3AH_6 is thermodynamically possible; however C_2AH_8 usually precedes the formation due to the ease of nucleation (Scrivener & Capmas, 1998).

$$2CAH_{10} \rightarrow C_2AH_8 + AH_3 + 9H \tag{4}$$

$$3C_2AH_8 \rightarrow C_3AH_6 + AH_3 + 15H \tag{5}$$

Beyond a transformation in hydration products through solution in hardened concrete, the actual consequences of this phase change have practical implications. The conversion from the metastable to the stable hydrates has the following impact on CAC systems:

1. There is a densification of hydration products, which results in an increased porosity and a reduction in strength.

2. Water is released, which can hydrate any remaining anhydrous cements particles.

Conversion has the largest impact on CAC concretes made with water-to-cement ratios (w/cm) greater than 0.5. Concrete mixtures fabricated with this w/cm or higher are severely affected by conversion because there is sufficient water to hydrate nearly all the anhydrous cement particles. Additionally, once water is consumed during hydration enough space is available for the less dense metastable hydrates (CAH_{10} and C_2AH_8) to form, resulting in false high early strength results. When conversion to the more dense stable hydrates (C_3AH_6 and AH_3) eventually occurs, there is a significant reduction in volume of the hardened phase and increase in porosity, ultimately resulting in a strength reduction (Scrivener, 2003).

When the w/cm is 0.4 or lower, there is insufficient space and water for all the anhydrous cement to react. Thus, when conversion occurs, water is released as part of the reaction and the remaining anhydrous cement reacts and forms hydrates that fill the pores created by the densification of the existing hydrates during conversion. Therefore, the strength reduction associated with conversion is less significant (Scrivener, 2003).

2.1.3 **PROPERTIES OF CAC CONCRETE**

This section describes the basic properties of CAC concrete, with emphasis on fresh, hardened, and durability characteristics. The focus is on concrete containing CAC as the sole binder without the addition of supplementary cementing materials.

2.1.3.1 **Fresh CAC Concrete Properties**

The fresh properties of CAC concrete are governed by the same basic parameters, such as water-to-cementitious (w/cm) ratio, water content, and cement content, which control traditional portland cement concrete.

2.1.3.1.1 Setting Time

CAC hardens and loses workability rapidly and the time between initial and final set is brief, around 30 minutes. A typical setting time for CAC cement, without set accelerators or retarders, is 3-5 hours. The setting time is drastically altered by the use of admixtures which is discussed in a later section of this report. Setting time is shortened in the temperature ranges from 32-50°F (0-10°C) and extended at temperature ranges from 77-86°F (25-30°C). This is attributed to the formation of C_2AH_8 + AH_3 from CAH_{10}. This maximum time of setting is dependent on the chemical composition of CAC, specifically the ratio of $C_{12}A_7$/CA. The time until setting decreases at temperatures above 86°C (30°C) (Bushnell-Watson & Sharp, 1986; Scrivener & Capmas, 1998).

2.1.3.1.2 Workability

The workability of CAC concrete is similar to that of portland cement concrete at similar w/c without the use of admixtures. The appearance of CAC concretes is “drier,” however, it flows well under vibration. Before the use of high-range water reducers (superplasticizers) became common, the historical approach to improve workability of CAC concrete at low w/cm was to use a higher cement content, usually greater than 674 lb/yd³ (400 kg/m³) (Scrivener, 2003). Today, there are a variety of plasticizers/water reducing agents available on the market. Section 2.1.4.3 summarizes the influence of lignosulfate, sulfonate, and polycarboxylate-based admixtures on the workability of CAC concrete.

2.1.3.2 **Hardened CAC Concrete Properties**

The most important property of CAC for use in civil engineering applications is its ability to rapidly harden and develop high early-age strength, thereby making it a desirable material for repair applications and fast-track, specialty construction.

2.1.3.2.1 Conversion and Strength Development

As discussed, the long-term stable strength of calcium aluminate cements is the result of the stable hydrates, C_3AH_6 and AH_3. Metastable hydrates, CAH_{10} and C_2AH_8, precede the formation of these stable hydrates when hydration occurs in small concrete elements at ambient temperatures. The metastable hydrates consume more water and space than the stable hydrates, thus they rapidly fill the space in a freshly placed matrix and give high early-age strength (Scrivener & Capmas, 1998).

During conversion the metastable hydrates “densify” to the stable hydrates, which causes an increase in porosity and a decrease in strength, but also releases water. If the initial w/cm is kept low, anhydrous cement remains after the initial hydration. This cement will hydrate with the release of the water from conversion and eventually lead to increase in strength. A typical strength evolution curve is shown in Figure 2-2 (Scrivener, 2003).

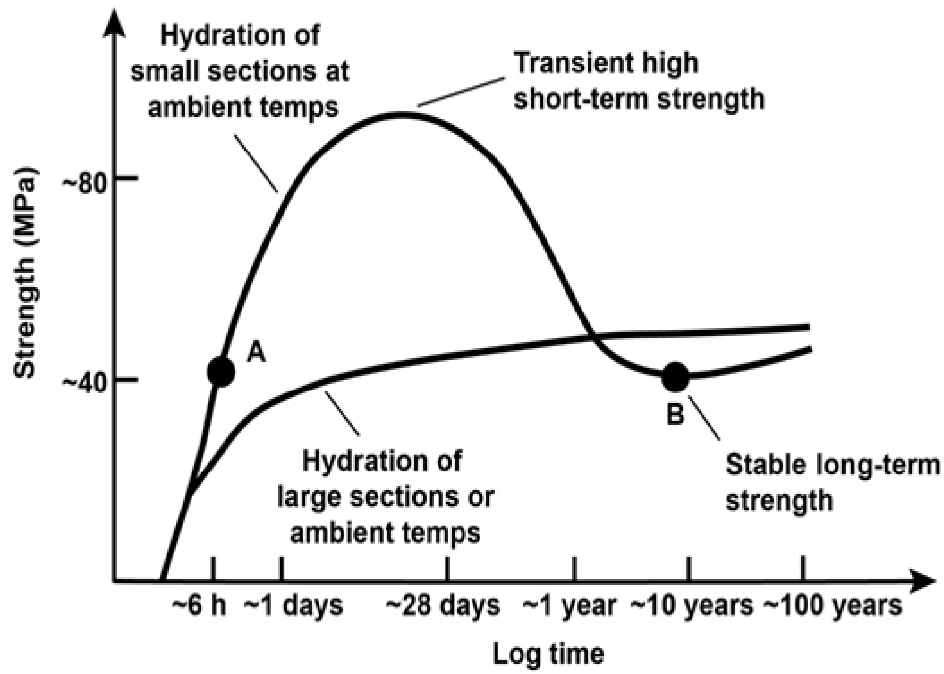


Figure 2-2 – Schematic Strength Development (Adapted from Campas, 1998)

The process of conversion cannot be prevented in concrete elements that are cured at ambient temperatures. Care must be taken to design for the long-term strength, after the converted microstructure is formed.

The temperature that CAC concrete is exposed to during its lifetime has a large impact on the rate of conversion. It is understood that conversion generally occurs in the first 5-10 years of being in service. Generally, CAC concrete that has been exposed to ambient conditions with w/cm near 0.5 have found converted strength greater than 3000 psi (21 MPa) which is generally above required design strengths for most applications. If CAC concrete is cured at 100°F (38°C) immediately after casting, the minimum strength occurs within the first 5 days. However, if the concrete is cured at 64°F (18°C) for 1 day and then moved to an environment at 100°F (38°C), the lowest point in strength development does not occur for three months. At temperatures above 158°F (70°C), the minimum strength of CAC concrete occurs in the first few hours, followed by a monotonic strength gain (Scrivener & Capmas, 1998).

Recent work by Muller (2010) aimed at developing a testing procedure that identified the lowest strength of CAC concrete in the first few days after casting. His research investigated the effect of curing CAC concrete at three different temperature regimes - 73°F, 100°F, and 122°F (23°C, 38°C, and 50°C). CAC concrete cured at 122°F (50°C) underwent conversion in the first few hours and had a monotonic strength gain thereafter. The other specimens had rapid strength development that later converted to the 100°F-cured concrete strength.

2.1.3.2.2 Durability of CAC Concrete

CAC was originally developed for use in aggressive environmental conditions where ordinary portland cement concrete had been shown to perform poorly. The long-term performance of CAC concrete is often controlled by the quality of the concrete and the exposure conditions, similar to portland cement. The two main factors that control the quality of the concrete are the w/cm and the cement content. These factors influence the pore structure and determine the ingress of chemicals that may be harmful to the concrete. It is believed that in order to achieve good performance and long-term durability, CAC concrete should have a porosity below 12%, which corresponds to a w/cm of 0.4 or lower (Scrivener & Capmas, 1998).

2.1.3.2.2.1 Sulfate Resistance

CAC concretes were originally developed for external sulfate resistance as in the case for the Paris-Lyon-Marseille (P.L.M.) Railway tunnel which was built through anhydrite and gypsum formations (Touche, 1926). Concrete used for this railway has reported excellent performance to date, with no distress observed in the structure or in companion test specimens immersed in gypsum solution.

In the United Kingdom, a comprehensive laboratory and field study was started in the 1970s by the Building Research Establishment (BRE) to investigate the sulfate resistance of concretes, including CAC concrete. Crammond (1990) reported results of 15 year-old for concretes with a w/cm that ranged from 0.47 to 0.60. The CAC concrete performed well with only minimal signs of damage. Additionally, it was reported that a dense outer layer was detected and observed on CAC concrete specimens. This layer, primarily comprised of metastable calcium aluminate hydrates, may explain the superior performance of CAC in sulfate-rich environments.

Conversion has been shown to have a significant impact on the sulfate resistance of CAC concrete. In a study completed by Dunster and Holton (2001), converted and unconverted CAC concrete samples were exposed to sodium sulfate solutions for a period of 5 years. The research showed significant deterioration of converted samples, while unconverted samples experienced no damage or deterioration.

2.1.3.2.2.2 Scaling Resistance

Limited studies have been carried out to investigate the ability of CAC concrete to resist degradation of cyclic freezing and thawing in the presence of deicing salts. Thomas et al. (2008) conducted laboratory investigation on various CAC mixtures. Their testing matrix included concretes with varying w/cm ratios (0.35, 0.40, and 0.45), plain CAC concrete, CAC with slag cement substitution, and converted samples. The converted and plain CAC mixtures demonstrated superior performance with negligible amounts of mass loss after 56 cycles, while the mixture containing 25% slag cement replacement failed the test.

Jolin and Gagnon (2008) conducted similar laboratory testing to evaluate the scaling resistance of air entrained and non-air entrained CAC mixtures, and the effect of various deicing chemicals (NaCl, $CaCl_2$, urea, and glycol). In their study, the standard 3% NaCl concentration was used to evaluate concrete scaling resistance. Air entrained CAC concretes performed superior to those that were not air entrained, and all CAC concretes performed superior to a control portland cement concrete mixture. In addition, various deicing chemicals and various application rates were evaluated. NaCl and glycol proved to be the more aggressive deicing chemicals in terms of mass loss of CAC slabs. However, concerns regarding the validity of the results obtained in this study were found. Behavior of tested concrete mixtures, such as increased deterioration with increased deicing chemical concentration, excessive damage in converted samples versus non-converted samples, and the overall magnitude of the mass loss, did not correspond to what was expected.

2.1.3.2.2.3 Carbonation

The process of concrete carbonation involves the reaction of carbon dioxide (CO_2) and certain hydration products that result in the precipitation of calcium carbonate ($CaCO_3$) (Bertolini, Elsener, Pedeferri, Redaelli, & Polder, 2013). In CAC concretes, hydration products responsible for carbonation are CAH_{10}, C_2AH_8 and C_3AH_6 which react with CO_2 to give calcium carbonate and aluminum hydroxide ($Al(OH)_3$). In both cases, carbonation is responsible for reducing the concrete pH, which leads to subsequent reinforcement corrosion of embedded steel.

As with portland cement concretes, depths and rates of carbonation are largely dependent on environment, mixture proportions, exposure duration, and curing. However, some studies on CAC carbonation found an increase in the compressive strength of carbonated CAC concrete in the absence of alkalies (Taylor, 1997). According to Dunster & Sergi (2008), the BRE carried out a laboratory study to evaluate the risk of reinforcement corrosion in a range of CAC concretes (0.40-0.80 w/cm). In this study, carbonation rates were found to be similar to those of portland cement concrete.

2.1.3.2.2.4 Reinforcement Corrosion

The alkalinity of the pore solution present in portland cement concrete provides the conditions for the formation of a passive layer of oxides on the surface carbon steel reinforcement. This layer provides a protection from corrosion of steel reinforcement in concrete. However, carbonation of concrete and the ingress of chloride ions are responsible for the destruction of the passive layer and the subsequent initiation of reinforcement corrosion. Thus, corrosion of steel reinforcement is the most common cause of premature deterioration of structural concrete. The formation of the passive layer in CAC concretes has not been investigated. Also limited published research is available regarding the corrosion performance of reinforcing steel.

Research completed by Mammoliti et al. (2008) investigated corrosion rates of carbon reinforcement in simulated CAC pore solutions. To simulate the pore solution of CAC concrete, pore solution was extracted from converted and non-converted CAC samples and analyzed using inductively coupled plasma mass spectroscopy for cations and ion chromatography for the anions. Carbon reinforcement was placed in simulated pore solutions, and sodium chloride was added at weekly intervals. Corrosion rates were monitored using linear polar polarization resistance. Observed corrosion rates were higher than that of simulated portland cement concrete pore solutions. Steel reinforcement placed in converted CAC pore solution corroded approximately 50% greater than that of the non-converted pore solution.

2.1.4 INFLUENCE OF ADMIXTURES ON CONCRETE PROPERTIES

The use of chemical admixtures in CAC concrete mixtures is common. Admixtures are used for the same purpose as in portland cement concrete, such as modifying setting time, rheology, strength, and cohesion in the fresh state.

Generally, alkalis and alkaline compounds shorten the time until setting of CAC while acids delay setting. Many exceptions to this rule exist and can the reverse of intended performance can be achieved if low dosages of the admixtures are used (Robson, 1962).

2.1.4.1 **Accelerators**

Solutions of sodium, potassium, and calcium hydroxides, as well as sodium and potassium carbonates, are active accelerators of CACs. Common sulfates and nitrates accelerate the set if used in concentrations of 0.5-1% by mass of cement; however, they have the opposite effect if used in dosages below 0.25% (Robson, 1962).

Admixtures containing lithium salts are the most common form of set accelerators used in CAC concretes. Minimal additions (~0.1% by mass) can reduce set times to just a few minutes. A lithium aluminate hydrate forms and serves as a heterogeneous nucleation site that allows for the rapid precipitation (Rodger & Double, 1984).

Gosselin (2008) found that the addition of lithium sulfate under 68°F (20°C) isothermal conditions leads to the massive precipitation of CAH_{10} and only stops because of the lack of water or space for hydration products. He showed the reduction until the induction period from 9h to 1h with the addition of 0.3% by mass of lithium sulfate.

The addition of portland cement and lime can also accelerate the hydration of CAC. When portland cement is added to CAC in increasing quantities, the setting time accelerates until the set becomes almost instantaneous. Combined systems are not typically used in reinforced concrete due to reduced ultimate strength seen with the faster set times (Robson, 1962).

2.1.4.2 **Retarders**

Rodger (1984) found citric acid to be an effective set retarder for CAC concrete. He suggested that an amorphous protective gel coating is presumed to form around the cement grains which complicates the hydrolysis and inhibits the growth of CA hydration products. The gel formation consumes the alumina ions in solution and impedes their use for CA hydration products until the citrate from the citric acid is precipitated

Robson (1962) also found salts of hydroxyl-carboxylic acid, including citric, tartaric, gluconic and carbohydrate salts to be effective. Other effective retarders for CAC include chlorides of sodium, potassium, barium, magnesium, and calcium in small concentrations. Although the initial strength of CAC with a retarder is often higher than strength of cements that are not retarted, the long-term strength was showed to be lower than strength of non-retarded cements.

2.1.4.3 **Water Reducers**

CAC concretes are generally considered harsher than portland cement concrete, which makes them more difficult to trowel or float, and they may also bleed excessively. Typical CAC concrete mixtures have a higher fine to coarse aggregate ratio to improve finishability; however this can increase the water/workability demand. The use of very small amounts of surface-active agents is often effective in improving the workability due to the air entrained in the concrete. When larger doses are used, more air becomes entrapped and significantly reduces the strength. Calcium lignosulfonate improves the workability, and does not retard time of setting or entrain much air when used in low dosages (Robson, 1962).

The use of sulfonated superplasticizers, including sulfonated naphthalene formaldehyde condensate, sulfonated phenol formaldehyde condensate, and sulfonated melamine formaldehyde condensate, have been investigated with CACs. These admixtures were investigated with a lithium citrate accelerator and a sodium gluconate retarder. The sulfonated superplasticizers were found not to be as effective as with portland cements, however, the sulfonated phenol formaldehyde condensate improved the workability of CAC paste and mortar for over 30 minutes at 41°F and 68°F (Banfill & Gill, 1993).

Fryda (2000) investigated the effects of poly-carboxylate based superplasticizers dosages from 0.05% to 0.40% by weight of cement to evaluate the effects on workability and time until the start of the heat of hydration (t_{off}). A slump greater than 6 in (150mm) was achieved in CAC concrete with a w/cm of 0.30 and 0.1-0.2% dosage of polycarboxylate superplasticizer. The polycarboxylate-based superplasticizer slightly retarded the time until t_{off}, and was offset by addition of lithium carbonate (Li_2CO_3) accelerator at dosages from 0.002% - 0.005% by weight of cement.

Recently, this work was revisited by Alonso (2011) and extended by the investigation of CAC with four polycarboxylate-based superplasticizers with varying carboxylate group concentrations. The authors compared the adsorption and zeta potential results of different admixtures and showed that higher zeta potential with corresponding higher absorption values similar to known behavior with portland cements improving the workability. However, there was a negligible effect of the carboxylate concentrations on these values with CAC, which is counter intuitive to known behavior of portland cements.

2.1.4.4 **Latex and Polymer Resins**

Latex and polymer resins are often added to concrete overlays and flatwork that demands low permeability and improved bonding action to an existing grade. This section briefly summarizes the existing data on the application of this technology with CAC and gives broad overview of applications with portland cements and other rapid hardening cementitious materials.

For CAC, natural and synthetic latex have been successfully used to produce chemically resistant floor toppings for the building chemistry market. In addition, styrene butadiene latex (SB latex), acrylic polymers, polyvinyl acetate and epoxy resins have been used to improve bonding to substrates for applications such as bridge deck repairs (Scrivener & Capmas, 1998). Generally, the latex comprises 6-15% of the cement mass and can create bond strengths between two concrete surfaces between 550-750 psi (Robson, 1962).

In a more recent study, Ukrainczyk and Rogina (2013) investigated the plastic and hardened properties of CAC mortars modified with SB latex. The study characterized the hydration kinetics of various dosages of SB latex with lithium carbonate accelerator using an isoperibolic calorimeter; where measurements of a true total temperature rise were recorded. The study showed the SB latex had a significant impact on the retardation of the hydration kinetics, and the retardation was more pronounced with an increase in the polymer content. When lithium carbonate was added to the mixtures containing 6 and 9% SB latex the hydration was significantly accelerated. The cumulative heat release of the mixtures evaluated in the calorimeter showed a decrease in total heat release with an increase in the lithium carbonate and SB latex.

Beyond the three studies mentioned, little information exists on the addition of latex and polymer resins additions to CAC concrete. These materials have been used in combination with portland cements to minimize the time and cost of rehabilitation of distressed concrete pavements by adding the bonding agent to allow for the new overlay concrete on top of the old substrate with a decreased permeability and increased bond strength (Barenberg, 1980; McCullough & Rasmussen, 1999)

2.1.5 SPECIFICATIONS OF CAC CONCRETE

Currently, there are a very limited number of specification-like documents related to the use of calcium aluminate cements available to the concrete industry. A few documents and organizations warned against its use due to the strength loss including the American Concrete Pavement Association (1998) which is referenced by the California Department of Transportation in their guidelines for partial depth repair (CalTrans, 2008).

To date, the only specification and guidelines developed specifically for calcium aluminate cement were developed by the Texas Department of Transportation (2010). Minimum early-strength is set to 3000 psi at 3 hours for concrete samples cured at ambient temperature. The ultimate compressive strength at 24 hours is required to be greater than 4000 psi for specimens cured in semi-adiabatic conditions. The specification provides recommendations for construction practice to avoid cold joints, segregation, and to achieve proper curing conditions. Testing of job concrete mixture has the identical strength requirements as the trial mixture as this document aims to identify the minimal strength that will be experienced due to conversion. This is achieved by curing selected concrete samples under adiabatic conditions. According to the specification, if the cylinder temperature does not exceed 140°F, the 7-day strength is required to be twice the design strength. Additionally, Texas Department of Transportation (TxDOT) published a complementary document, which provides supplementary technical background, mixture design recommendations and recommendations for use engineers (Barborak, 2010).

A specification published by the American Society for Testing and Materials (ASTM), ASTM C1600 (2011), is a document that covers all rapid hardening hydraulic cements. The specification classifies cements based on the very early-age strength development and does not consider specific cement compositions. Based on the hardening rate, the document distinguishes four cement categories: (1) ultra-rapid hardening cements, (2) very rapid hardening cements, (3) medium rapid hardening cements, and (4) general rapid hardening cements. The differentiation of cements is also done on a compressive strength basis, and at different ages. This specification also places limitations on cracking and durability behaviors utilizing standardized tests including drying shrinkage, sulfate resistance, alkali-silica reaction resistance, and heat of hydration. Calcium aluminate cements fall within the scope of this specification; however, some of the test methods referenced by this document require fabrication of test specimens with w/cm of 0.50, which is not appropriate for use with CACs.

Illinois Department of Transportation (IDOT) allows use of CAC concrete for pavement and bridge deck patching (Illinois Department of Transportation, 2016). In order for a mixture to meet the requirements of the PP-5 class of concrete, the use of 675 lbs. per cubic yard of calcium aluminate cement is required. Additionally, the minimum flexural strength of 600 psi or minimal compressive strength of 3200 psi should be achieved in 4 hours. No other CAC-specific requirements are part of the IDOT Specifications.

2.2 FIELD INVESTIGATIONS

CTLGroup initially identified five instances where CAC concrete has been used as a rapid repair material. Information related to selected field site visits and inspections were performed by others and transmitted to CTLGroup. These findings are summarized in Section 2.2.1. Additionally, CTLGroup representatives visited two field sites and performed inspection of the repair quality and performance in 2014.The goal of this phase of the research program was to visit as many locations as possible, however, due to the common construction practice in the Chicago are, many of the sites were overlaid with asphalt binder.

Repair case studies included in this report were placed by Henry Frerk Sons (HFS), a local mobile concrete repair company. HFS began using CAC for rapid repairs in 2006. The company switched to the use of CAC from calcium sulfoaluminate cement (CSA) due to issues with achieving rapid strength gain in cold weather environment and performance variability of CSA. All of these repairs were performed as part of an open contract with the city of Chicago to perform repairs requiring immediate action.

2.2.1 FIELD INVESTIGATIONS PERFORMED BY OTHERS

2.2.1.1 Full-Depth CAC Repair (Hermitage/Montrose Ave, Chicago, IL)

Year of Construction: 2006

The full-depth repair, shown in Figure 2-3, is located near the corner of Hermitage Avenue and Montrose Avenue on the north side of Chicago, IL. This was a full-depth 9 in. repair that was approximately 100 x 15 ft. An emergency repair of the roadway was needed due to the rupture of a water main underneath the roadway. A timely repair was necessary to minimize the impact on traffic. The slab was cast using CAC with 1% by mass of lithium sulfate accelerator (LSA) and no curing was performed on the repair. A site visit was conducted in 2009, approximately three years after the repair placement. At that time, no signs of cracking or deterioration were evident in this repair. The repair was placed with control joints at 15 ft. intervals and a tined surface.

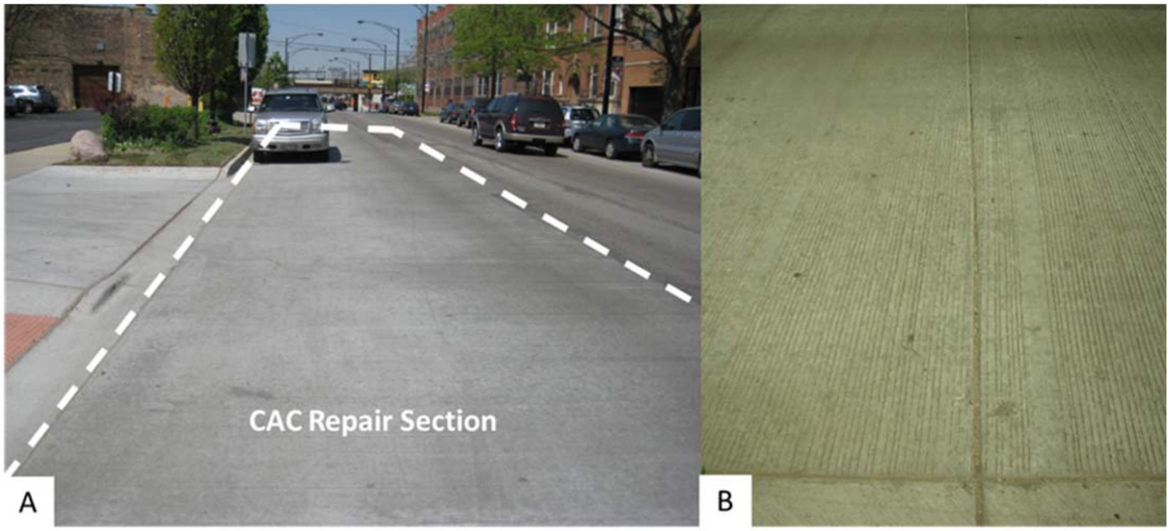


Figure 2-3 – Full-Depth CAC Repair in Downtown Chicago: (A) Overview; (B) Detail

2.2.1.2 **Bonded Concrete Overlay (Children's Memorial Hospital, Chicago, IL)**

Year of Construction: 2006

A partial depth bonded concrete overlay, shown in Figure 2-4, is located on the emergency entrance ramp of the Children's Memorial Hospital of Chicago. This ramp is the only entrance to the hospital for emergency vehicles, therefore a rapid repair work was required. Instead, CAC with 1.0% by mass of LSA was used to cast a 4 in. replacement slab over the existing portland cement concrete. The site visit was performed in 2009, approximately three years after the CAC overlay was placed. Cracking was observed extending out from the radial curves in the geometry. There were no control joints placed in the topping slab to regulate the cracking locations. In addition to cracking, pop-outs and occurrences of scaling were observed. Reportedly, this area is heavily salted to allow for safe access in the winter.

Figure 2-4 – (A) Emergency Entrance Ramp; (B) Cracking; (C) Scaling

2.2.1.3 **Full-Depth Repair (I-290, Chicago, IL)**

Year of Construction: 2007

A full-depth CAC repair, shown in Figure 2-5, is located on Interstate 290 in downtown Chicago, IL. CAC concrete with 1% by mass of LSA was used for a rapid repair of approximately 12 in.-deep roadway section with a tined driving surface. The site visit took place in 2009, approximately two years after the CAC repair was executed. Cracking was noticed on the surface of the repair, however no other signs of deterioration were observed and the repair appeared to be in good condition.

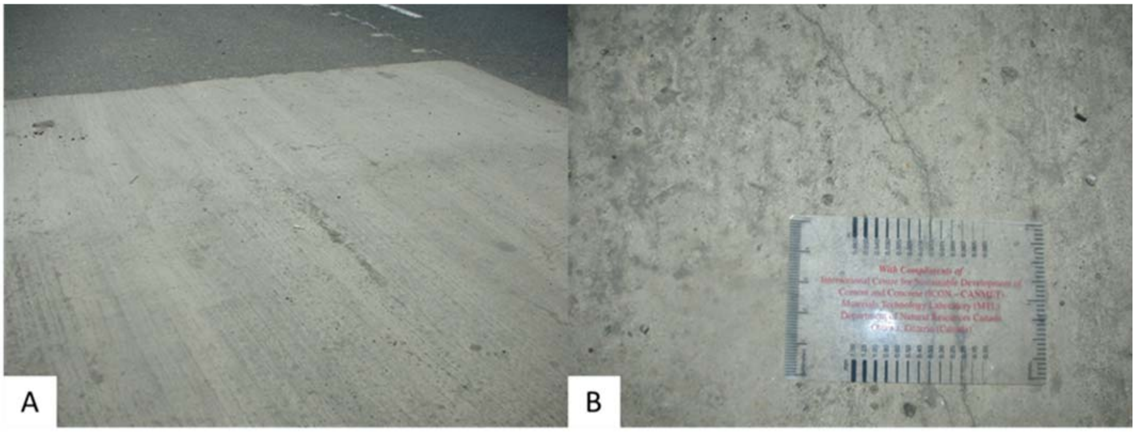


Figure 2-5 – Full-Depth CAC Repair on I-290, Chicago, IL: (A) Overview, (B) Cracking

2.2.1.4 **Partial-Depth Bridge Deck Repair**

Year of Construction: 2014

The process of a rapid bridge deck repair on the Roosevelt Bridge in downtown Chicago was witnessed, as shown in Figure 2-6. CAC was used to repair a small 3 x 3 ft. section on the bridge deck. The existing concrete was sawn cut to approximately 3 in. depth, removed with a jackhammer and subsequently the repair section of the deck was cleaned with a pressure washer. Welded wire mesh was placed in the repair section and the repair material was mixed using a volumetric mix truck. The mixture exhibited satisfactory workability and was rough finished with a lumber screed and final finished with hand trowels. The surface was tinned and the bridge was opened to traffic approximately three hours after the placement.

Figure 2-6 – Partial-Depth CAC Repair, Roosevelt Bridge, Chicago, IL

2.2.2 FIELD INVESTIGATIONS PERFORMED BY CTLGROUP

CTLGroup visited two locations where CAC concrete has been implemented for the rapid repair of a roadway and bridge deck.

2.2.2.1 Full-Depth CAC Repair (I-90/I-94, Chicago, IL)

Year of Construction: 2009

The full-depth repair site, shown in Figure 2-7, is located on Interstate 90/94 located near Madison Avenue in downtown Chicago, IL. The affected repair area was approximately 36 x 60 ft., reaching the depth of approximately 3 ft. deep. An emergency repair of the roadway was needed due to a collapse of an underground freight tunnel located below the roadway. The slab was cast using CAC concrete with lithium sulfate accelerator (LSA) with no curing performed on the repair. The site visit was conducted in 2014, approximately 5 years after the repair placement. Due to the heavy traffic conditions at the time of the inspection, access to the entire repair was not possible. However, the inspection included a review of the surface conditions, crack check, and surface resistivity measurements. At the time of the investigation, no evident signs of cracking, spalling, or other deterioration were apparent. The surface did not show any significant signs of wear due to abrasion. Overall, the general appearance of the repair was satisfactory with no signs or concerns related to the concretes durability.

Figure 2-7 – Full-Depth Repair, I-90/94, Downtown Chicago, IL

2.2.2.2 **Bridge Thin-Bonded Concrete Overlay (Highland Park, IL)**

Year of Construction: 2008

A thin-bonded latex modified CAC concrete overlay, shown in Figure 2-8, was used to repair a private concrete bridge which provides access to a water treatment plant near Chicago, Illinois. To this date, this site is one of the first thin-bonded, latex-modified CAC bridge deck overlays in service in the United States. The used CAC-based mixture utilized 15% latex and 1% LSA. A heavily tined surface was used to finish the bridge. A site visit was conducted in June 2014. The site investigation included a review of the surface conditions, crack inspection, and surface resistivity measurements. Crazing was observed over the middle span bridge, and some wear was observed at the crown of the roadway. The wear appears to be caused by abrasion or impact from snow plows, being that the crown of the roadway is protruding.

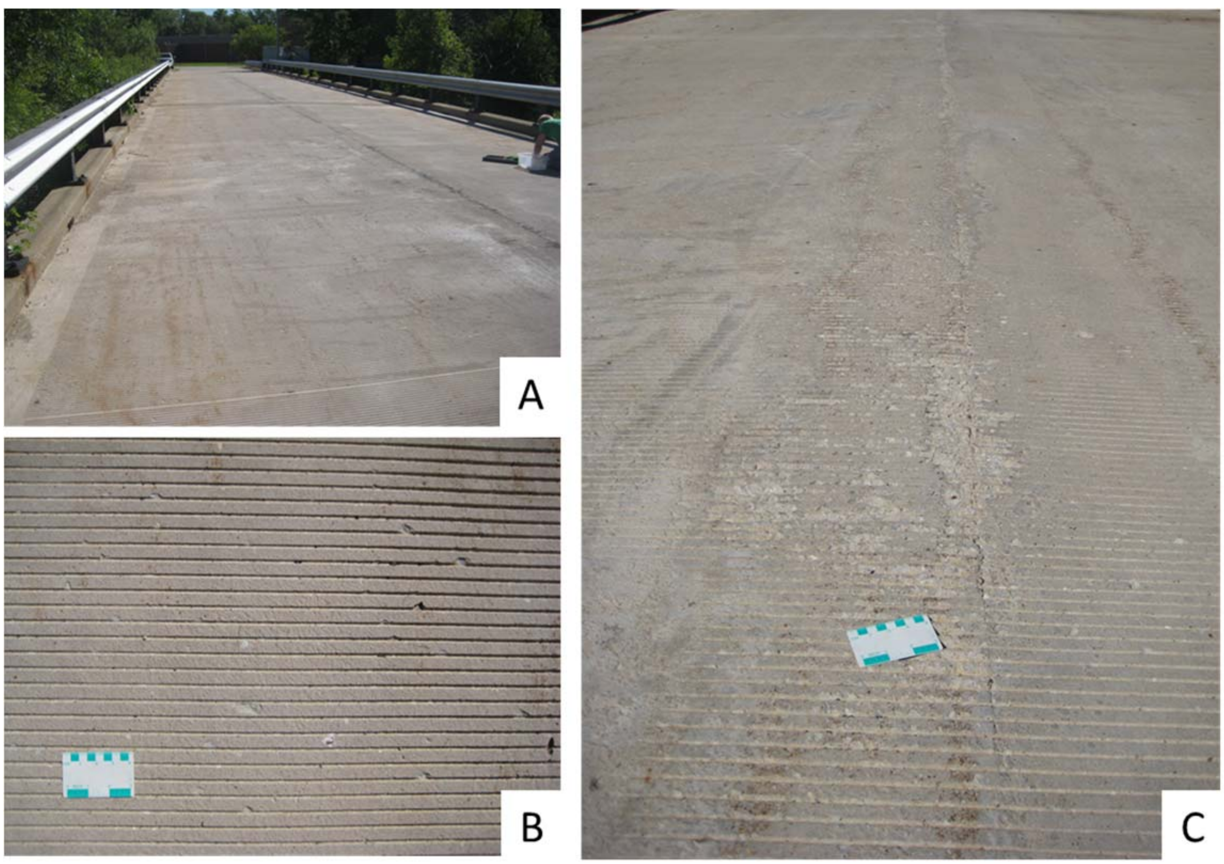


Figure 2-8 – (A), (B) Latex-Modified CAC Bridge Deck, (C) Abrasion Failure at Bridge Crown

2.2.3 SUMMARY OF SITE VISITS

2.2.3.1 Site inspections performed by others

Information transmitted on the selected site inspections performed by others showed satisfactory long-term durability of CAC placements under harsh environmental conditions typical for Chicago. The durability performance of CAC placements of up to 3 years of age showed that minor signs of deterioration were present except for cracking and scaling after being exposed to freeze-thawing and de-icing salts. In general, the performance of CAC placements is considered to be acceptable except for the presence of cracking.

2.2.3.2 Site inspections performed by CTLGroup

CAC repair placements witnessed by CTLGroup included one plain CAC concrete and a latex-modified CAC concrete. These site visits provided useful understanding of the demands of a rapid repair material, the execution process and provided qualitative assessments of their durability.

2.3 DISCUSSION AND SUMMARY

Based on the findings listed in the literature review, it is evident that the conversion process and the presence of cracking is a concern for CAC rapid repair concrete mixtures. In ordinary portland cement concretes, drying and restrained cracking is a physical process that is driven by surface tension in the capillary pores. However, there is limited knowledge related to the volume change behavior of CAC.

In the subsequent chapters, the mechanical and durability performance of CAC is investigated. Two CAC concrete mixtures are evaluated: plain (CAC) and latex-modified (LCAC) CAC concrete mixtures. The compressive strength, time of set, heat of hydration, drying and restrained shrinkage, chloride diffusion and electrical migration, freeze thaw and scaling resistance were determined. This laboratory study is composed of a large scale CAC placement and a number of various laboratory CAC mixtures. The large scale CAC placement was carried out with a mobile batching truck in 2014. Laboratory mixtures were performed during 2014 and 2015. The results obtained from this study are presented in the subsequent sections.

3. PHASE II (2014 - 2015)

3.1 LABORATORY INVESTIGATIONS

3.1.1 LARGE-SCALE CAC LABORATORY PLACEMENT

Two concrete mixtures were fabricated at CTLGroup laboratories by Henry Frerk Sons on June 26, 2014 using a volumetric mixing mobile batching truck.

3.1.1.1 Mixture Proportions, Mixing, and Fresh Properties

Two concrete mixtures were investigated in this part of the research program: a traditional calcium aluminate concrete mixture (mixture referred to as “CAC”) previously used for repair projects in Illinois, and a latex-modified calcium aluminate concrete mixture (henceforth referred to as “LCAC”). Both mixtures were identical in terms of cement, coarse aggregate, and fine aggregate proportions. Kerneos calcium-aluminate cement was utilized in both mixtures. A variety of chemical admixtures typically employed in CAC concretes were utilized in both mixtures. The CAC concrete mixture contained a lithium sulfate accelerating admixture, polycarboxylate-based high range water reducing admixture (HRWRA), and synthetic air-entraining agent. In addition to a liquid latex admixture, LCAC concrete utilized the same lithium sulfate accelerator as CAC mixture. Complete mixture proportions and measured fresh concrete properties are shown in Table 3-1 and Table 3-2, respectively.

Table 3-1 – Large Scale Laboratory Placement – Mixture Proportions

		Mix ID:	**CAC**	**LCAC**
		Fabricated:	***6/26/2014***	***6/26/2014***
Material	***Source***	**S.G.**	***lb/yd³ (SSD)***	
Cement	*Kerneos Calcium Aluminate Cement - Norfolk, VA*	2.95	703	703
Coarse Aggregate	*Hanson Thornton Quarry - Thornton, IL*	2.71	1660	1660
Fine Aggregate	*Meyer Material Co. - Algonquin, IL*	2.67	1316	1316
Water	*Potable*	1.00	113	0
Chemical Admixtures			***fl. oz./cwt***	
Accelerator	*GCX-500 Accelerator*		29.7	59.3
HRWRA	*GRT Polychem SPC*		11.8	N/A
Latex	*BASF Styrofan 1186*		N/A	469.8
AEA	*GRT Polychem AE*		0.7	N/A
w/cm (including water in admixtures)			**0.19**	**0.20**

Table 3-2 – Large Scale Laboratory Placement – Fresh Properties

	Mix ID:	**CAC**	**LCAC**
		Measured Fresh Properties	
Air Content, %		6.2	3.4%
Slump, in.		9.75	8.25
Density (unit weight), lb/ft^3		142.3	145.3

Two curing regimens were implemented in order to investigate the effect of CAC conversion on concrete properties. After casting, all specimens were covered with moist burlap and left undisturbed at standard laboratory conditions for 24 hours. Upon demolding, samples labeled “standard” were cured at 73.4 ± 3.6°F and >95% RH. Samples identified “hot” were submerged in a heated water bath (122°F) for 7 days, and kept in a moisture room (73.4 ± 3.6°F and >95% RH) thereafter.

3.1.1.2 **Compressive Strength**

Compressive strength testing in accordance with ASTM C39[2] was performed at 2, 3, 4, 5, 6, 8, and 24 hours to characterize early-age strength development. As shown in Figure 3-1, both the CAC and LCAC concrete mixtures exhibited rapid strength gain. Measured compressive strengths of both mixtures exceeded 4,000 psi in 4 hours. The CAC mixture showed greater compressive strength at all ages, primarily due to a lower water content in the mixture (the CAC mixture had a w/cm of 0.18 whereas LCAC had a w/cm of 0.19).

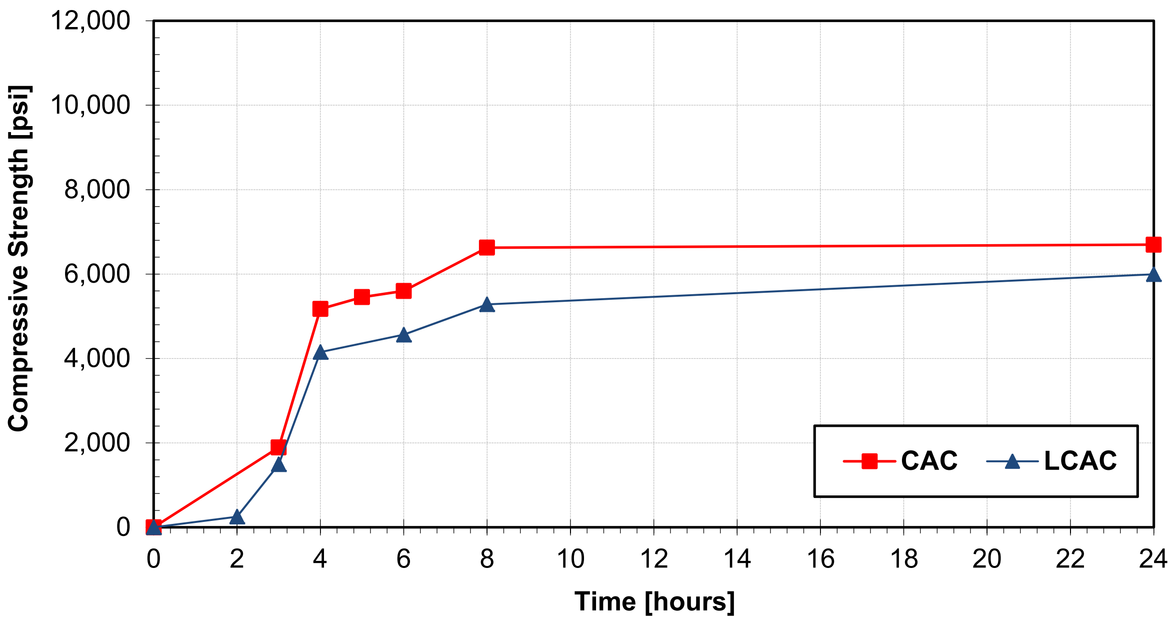


Figure 3-1 – Early-Age Strength Development for CAC and LCAC

In order investigate strength loss due to CAC conversion strength was also determined at 2, 3, 4, 5, 6, 7, 14, 28, and 56 days. The expected strength reduction associated with the CAC hydrates conversion process was observed at 3 days for both mixtures as shown in Figure 3-2 and Figure 3-3. At three days of age, compressive strength loss of 44% was observed in the case of the CAC mixture while only 14% lost was observed for the LCAC.

---

[2]ASTM C39/C39M-16a Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

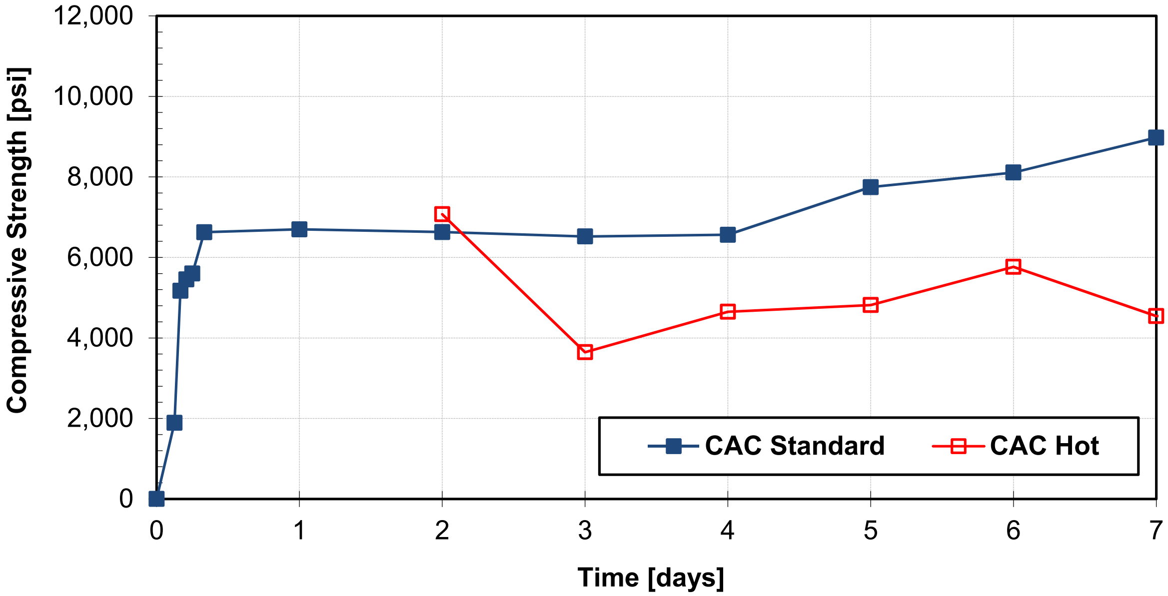


Figure 3-2 – Short-term CAC Strength Development and Conversion

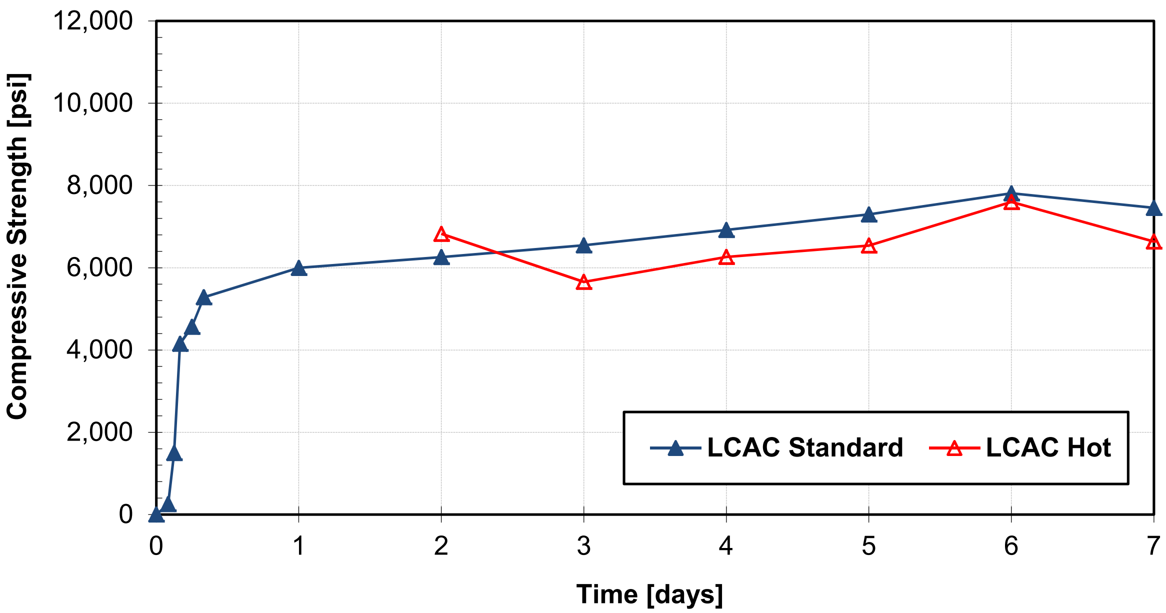


Figure 3-3 – Short-term LCAC Strength Development and Conversion

Long-term compressive strength development is shown in Figure 3-4 and Figure 3-5. Despite the observed strength loss at 3 days, measured average compressive strengths of standard and hot cured LCAC samples are almost identical at 14 days and beyond. The gap between converted and non-converted samples in term of compressive strength was reduced at 14 days, however, the compressive strength of converted CAC mixture remained at approximately 70% of the non-converted (standard cured) CAC mixture strength at 14 days and beyond.

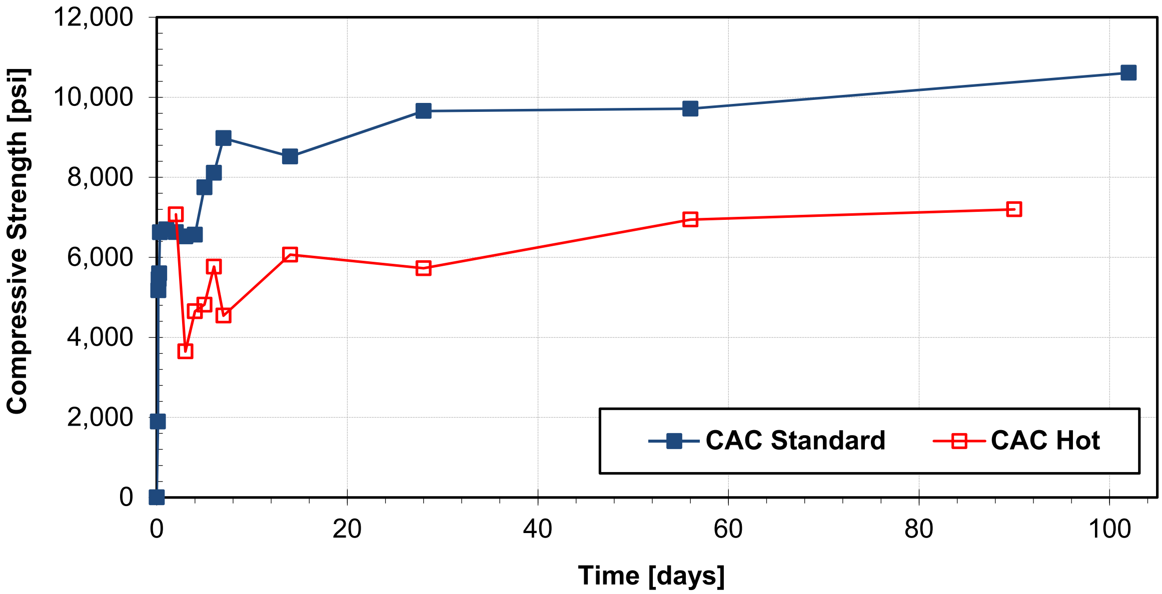


Figure 3-4 – Long-term CAC Strength Development and Conversion

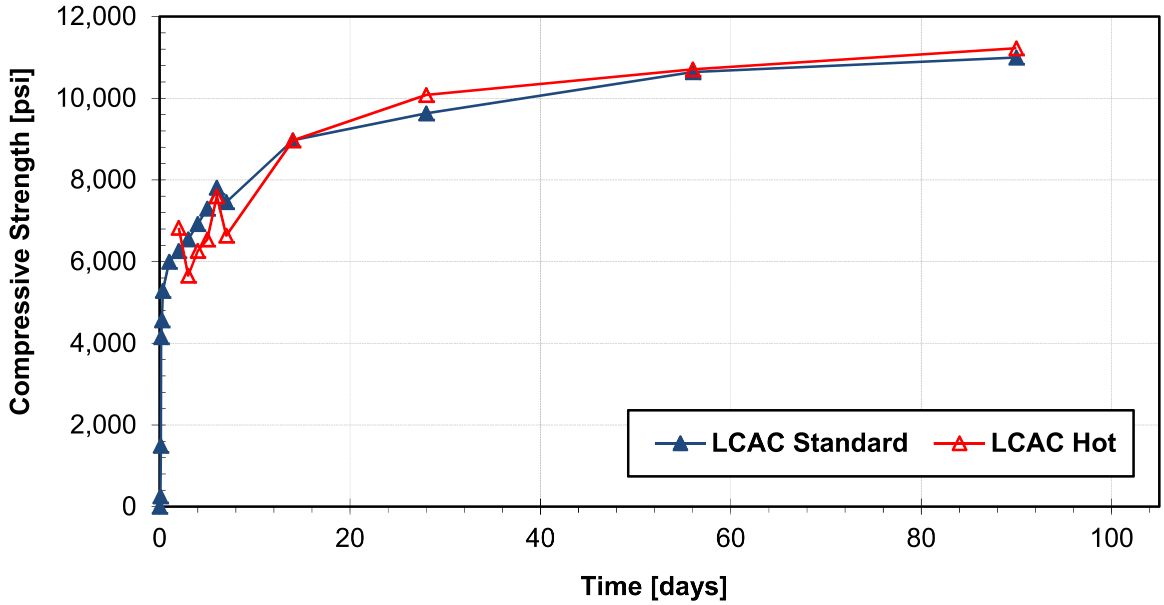


Figure 3-5 – Long-term LCAC Strength Development and Conversion

The results clearly show that the conversion can cause loss of compressive strength. However, in case of the LCAC mixture, such behavior was observed only during the first 14 days of age, as opposed to the permanent strength loss observed for the CAC mixture. The long-term mechanical performance of LCAC can be attributed to higher degree of hydration as well as polymer coagulation process (Ukrainczyk & Rogina, 2013). In a standard CAC concrete mixture, the process of conversion leads to a formation of hydration products with smaller volume compared to the volume of non-converted compounds, resulting in an increased porosity and subsequent reduced compressive strength. Findings of this study suggested that the effect of CAC conversion can be effectively mitigated by using latex as a concrete-modifying admixture.

Despite the conversion process, compressive strength of CAC and LCAC mixtures did not drop below 3,500 psi, therefore both mixtures would be suitable for most rapid repair applications. In addition, data scatter in the results is apparent. The scatter is caused by sample fabrication and temperature sensitivity, which is expected to vary more for high early strength materials than for standard strength concretes. Individual test reports for compressive strength test results are attached in Appendix C - ASTM C39 Compressive Strength.

3.1.1.3 **Heat of Hydration**

Adiabatic temperature rise (ATR) cubes were fabricated for each mixture. The cubes were 2x2x2 ft. with three layers of extruded polystyrene insulation (R value of 10) on all sides. Thermocouples (Type K) were installed inside the cubes to monitor and record the temperature history. Results of the ATR temperature monitoring are shown in Figure 3-6. Recorded peak temperature was 201°F and 186°F for the CAC and LCAC mixtures, respectively. The difference between recorded temperatures for CAC and LCAC showed a slightly decreasing trend over the time as the temperature difference at 144 hours was approximately 10°F.

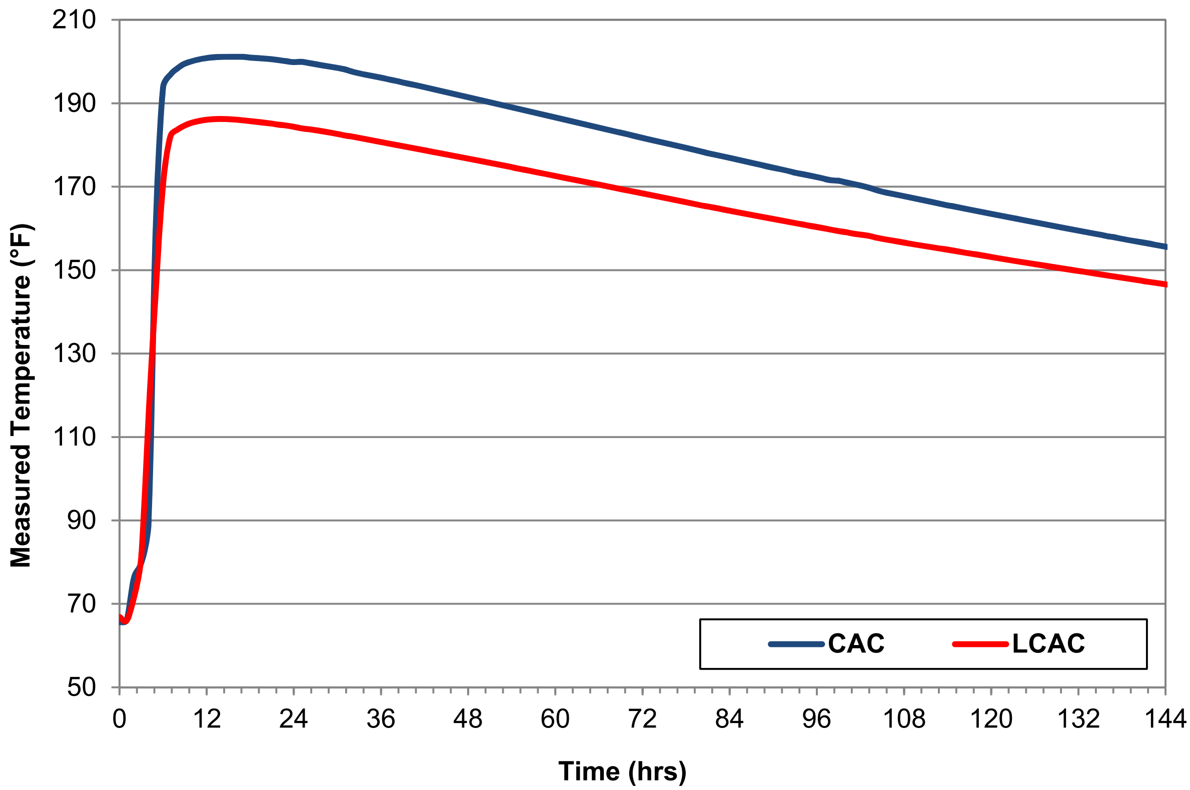


Figure 3-6 – CAC and LCAC Adiabatic Temperature Rise

3.1.1.4 **Surface Resistivity**

Surface resistivity measurements were completed in general accordance with AASHTO TP-95[3]. Resistivity measurements were performed on a set of specimens that was cured identically to specimens used for compressive strength testing (hot and standard moist curing).

Surface resistivity measurement results at early-age are shown in Figure 3-7. Drop in the surface resistivity of heat cured specimens can be observed at 1 day for CAC and 2 days for LCAC. This correlates to the compressive strength behavior observed on these concrete mixtures which is attributed to the conversion process in CAC. This observation suggests that the conversion process can be detected using surface resistivity measurements.

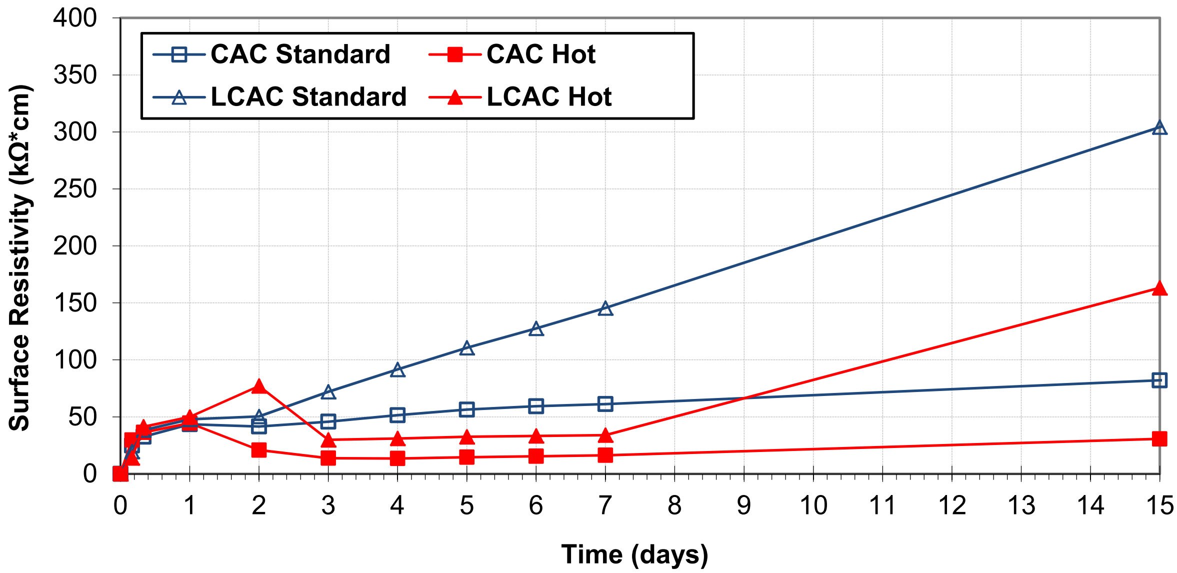


Figure 3-7 – Surface Resistivity, Early-Age

The evolution of surface resistivity in a long-term timeframe is shown Figure 3-8 . After 7 days, the surface resistivity of converted specimens began to increase. The rate of increase of the LCAC specimens showed similar slope to standard cured LCAC specimens. At 90 days, hot cured samples exhibited approximately 12% lower surface resistivity than standard cure specimens. For the CAC mixture, standard cured specimens reached a peak surface resistivity

[3] AASHTO TP 95 - Standard Method of Test for Surface Resistivity of Concrete’s Ability to Resist Chloride Ion Penetration

at 14 days and then began decreasing whereas an increase in resistivity was observed for hot cured samples beyond 14 days. At 90 days, the surface resistivity of both standard and hot cured CAC samples converged. The surface resistivity of CAC specimens was significantly lower than resistivity of LCAC specimens, primarily due to the lower porosity of cement paste enhanced by latex. Complete results of surface resistivity measurements are included in Appendix D - AASHTO TP-95 Surface Resistivity.

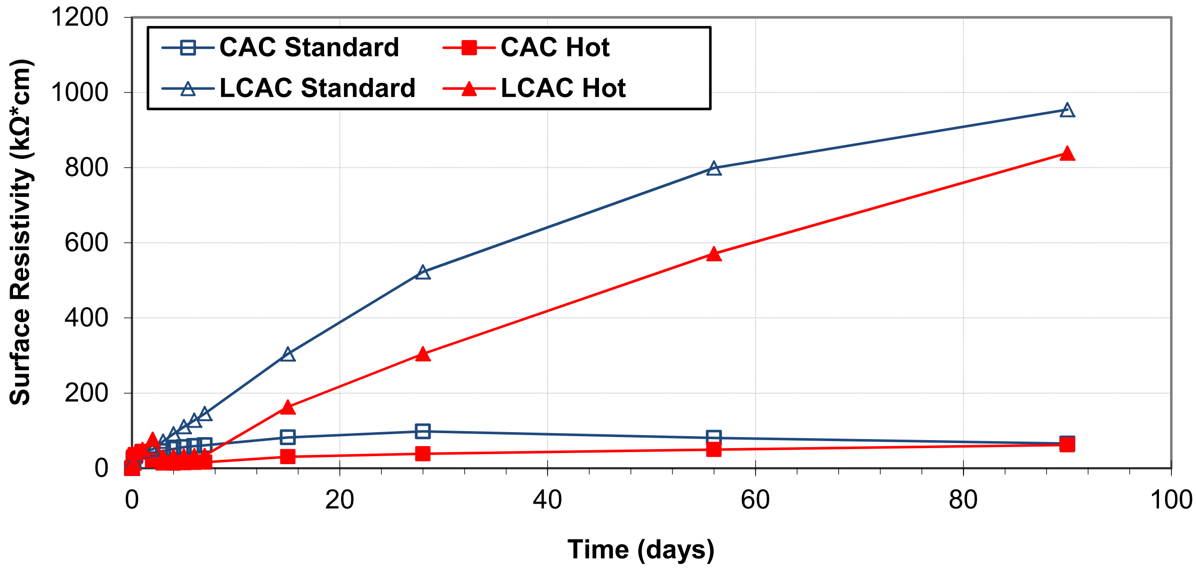


Figure 3-8 – Surface Resistivity, Long-Term

3.1.1.5 **Drying Shrinkage**

Drying shrinkage was evaluated using both unrestrained and restrained shrinkage tests. Drying shrinkage testing was conducted in general accordance with ASTM C157[4] and results are shown in Figure 3-9. Samples were subjected to four different curing regimes prior to being testing for drying shrinkage: (1) 4 hours of moist curing under wet burlap at 73°F, 24 hours of moist curing under wet burlap at 73°F, 7 days of curing in limewater at 73°F (only for the CAC mixture), and 7 days of curing in limewater at 122°F. As expected, the overall magnitude of drying shrinkage decreased with an increase in the curing time. With the prolonged curing time,

[4] ASTM C157/C157M-08(2014)e1 Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

the addition of latex to the mixture showed promising results. The length change of 7-day hot cured LCAC specimen after 28 days of drying was approximately 40% lower than that CAC sample cured under same conditions.

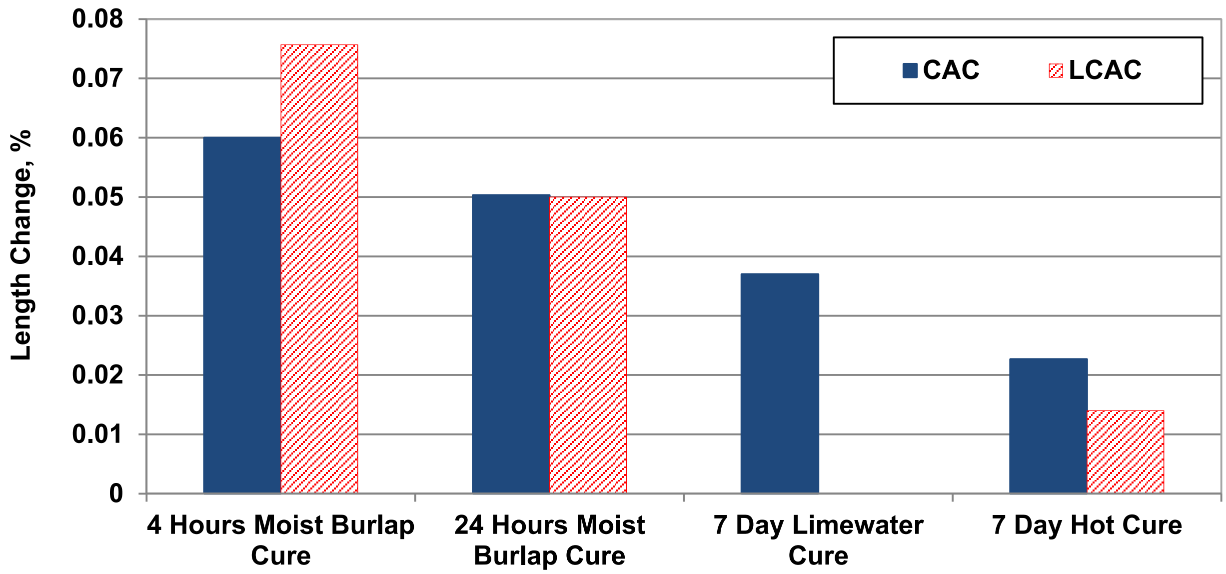


Figure 3-9 – Drying Shrinkage – CAC vs. LCAC3 3 - Volume Change Test Results

Restrained shrinkage testing was conducted according to ASTM C1581[5]. One set for each mixture (three rings) was tested. Samples were covered with moist burlap at 73.4°F for 24 hours prior to drying at 73.4°F and 50% RH. The CAC samples had an average time to cracking of 4.2 days with individual results ranging from 3.5 to 5.5 days. The LCAC samples had an average time to cracking of 2.3 days with individual results ranging from 1.9 to 2.5 days. Individual test reports for both C157 and C1581 tests are included in Appendix E - ASTM C157 Drying Shrinkage.

[5] ASTM C1581/C1581M-16 Standard Test Method for Determining the Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage

3.1.1.6 **Durability**

Durability of CAC-based mixtures was evaluated on the basis of five different test methods: (1) abrasion resistance, (2) rapid chloride penetrability, (3) chloride diffusivity, (4) freeze-thaw durability, and (5) scaling resistance.

3.1.1.6.1 Abrasion Resistance

Abrasion resistance testing was performed according to ASTM C779[6]. Testing results are shown in Figure 3-10. It was hypothesized that the abrasion resistance of CAC-based mixtures that underwent the conversion process could be negatively affected. However, both CAC and LCAC mixtures performed well in the test. Force-converted (hot cured) samples showed similar of better abrasion resistance compared to their standard-cured companions. The maximum observed depth of wear of 0.039 inches at 60 minutes was recorded for the standard-cured LCAC mixture. Test reports are attached in Appendix I - ASTM C779 Abrasion Resistance.

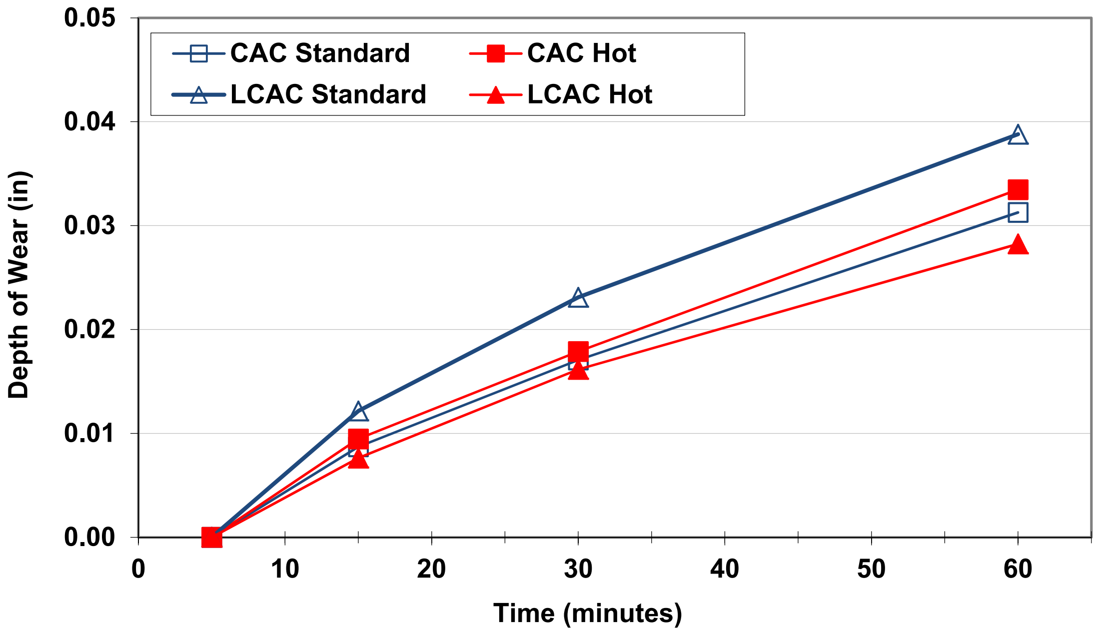


Figure 3-10 – Abrasion Resistance Test Results

---

[6] ASTM C779M-12 Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces

3.1.1.6.2 Rapid Chloride Penetrability

Rapid Chloride Penetrability was tested according to ASTM C1202[7] and results are shown in Figure 3-11. As expected, the LCAC mixture exhibited lower chloride penetrability than the CAC mixture due to the densifying effect of the latex admixture used in the LCAC mixture. Hot-cured samples exhibited significantly higher permeability than the companion specimens cured under standard conditions. This confirms the fact that the conversion process increases porosity of the cement matrix, hence increasing the overall permeability of the concrete system. However, all of the tested samples but one had "*Very Low Chloride Permeability*" as per ASTM C1202 classification. Test reports are attached in Appendix J - ASTM C1202 Rapid Chloride Penetrability.

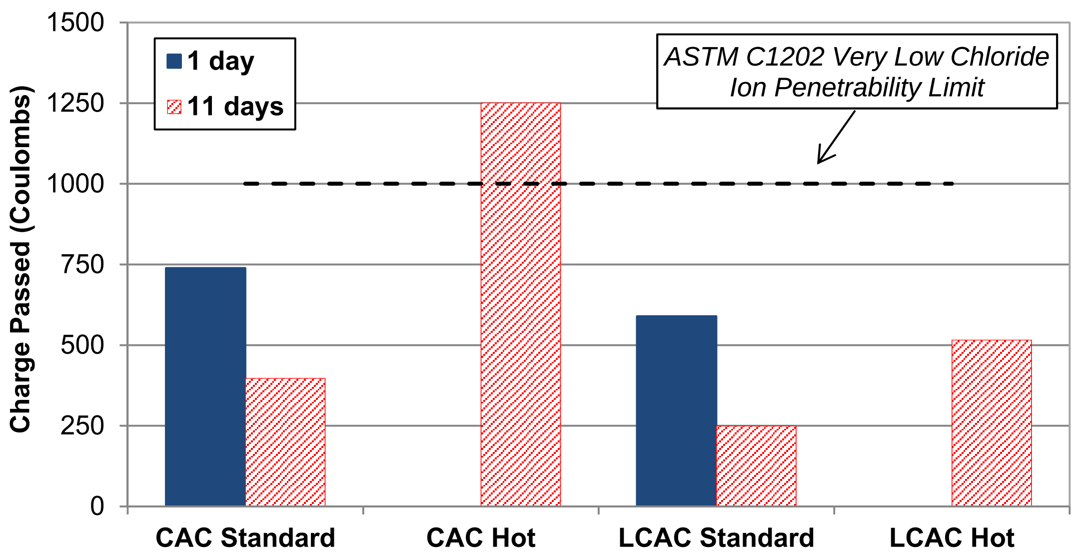


Figure 3-11 – Rapid Chloride Permeability Results

3.1.1.6.3 Chloride Diffusivity

Chloride diffusion was tested in general accordance with ASTM C1556[8]. Calculated diffusion coefficients and surface chloride contents are shown in Figure 3-11and Figure 3-12,

---

[7] ASTM C1202-12 Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

[8] ASTM C1556- "-11a(2016) Standard Test Method for Determining the Apparent Chloride Diffusion Coefficient of Cementitious Mixtures by Bulk Diffusion"

respectively. The process of conversion and its effect on increased porosity of the cement matrix resulted in higher diffusion rates. Both hot-cured CAC and LCAC mixtures exhibited higher diffusion coefficient and simultaneously lower surface chloride concentration that the standard-cured specimens. Test reports are attached in ASTM C1556 Chloride Diffusion Coefficient.

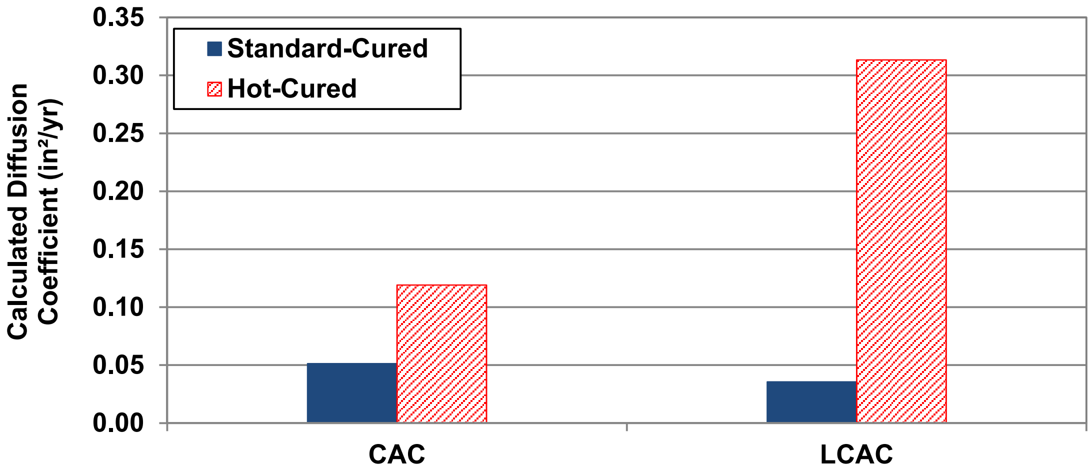


Figure 3-12 – Chloride Diffusivity Results

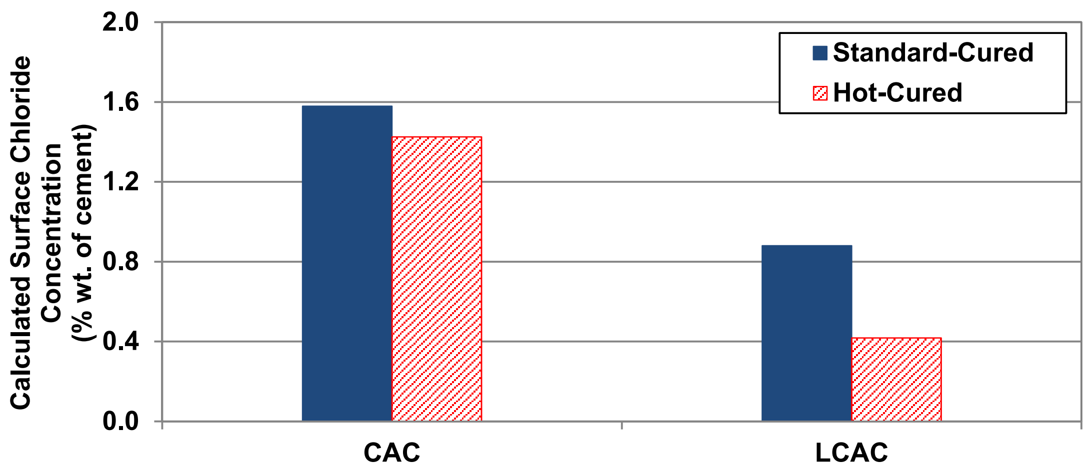


Figure 3-13 – Surface Chloride Content Results

3.1.1.6.4 Freeze-Thaw Durability

Freeze-thaw testing was performed in general accordance with ASTM C666[9]. The CAC mixture was designed as an air-entrained concrete. A synthetic air entraining agent was used to produce concrete with 6.2% of air voids (measured in the fresh state according ASTM C231[10]). The LCAC concrete mixture was not purposefully air-entrained; however, latex is known to generate air voids in concrete mixtures. The LCAC was measured to have the plastic air content of 3.4%.

Several sets of samples with different curing history were used for the F-T testing. First set of CAC and LCAC test specimens was cured in molds under wet burlap at 73°F for 24 hours. The second set was cured in hot water at 122°F for 7 days in order to force the CAC conversion. Additionally, one set of CAC samples was cured in a moisture room at 73°F and 100% RH and one set of LCAC samples was cured in laboratory environment at 73°F and 50% RH.

Measured relative dynamic modulus values of all six F-T sets are shown in Figure 3-14. It is apparent that all samples had relative dynamic modulus values greater than 95% after 300 cycles. Therefore, all mixtures can be considered freeze-thaw durable.

Test reports are attached in Appendix G - ASTM C666 Freeze-Thaw Resistance.

[9] ASTM C666/C666M-15 Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
[10] ASTM C231 / C231M-14, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

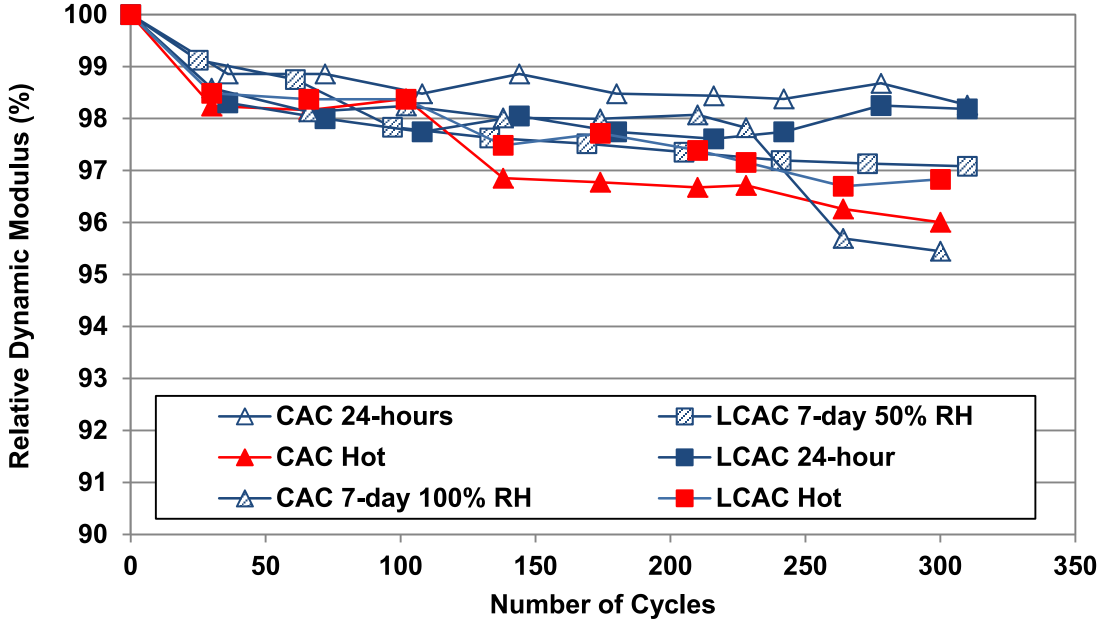


Figure 3-14 – F-T Testing - Relative Dynamic Modulus Results

3.1.1.6.5 Scaling Resistance

Salt scaling testing was performed in general accordance with ASTM C672[11]. The same curing conditions that were used for freeze-thaw testing were utilized for the scaling resistance tests (24 hours in the mold, 7 days in 100% RH/50% RH, and 7 days at 122°F). The cumulative mass loss for each tested sample set is show in Figure 3-15. It is apparent from the presented results that the CAC and LCAC mixtures performed very similarly with one exception; the hot-cured CAC mixture exhibited much significant loss that the rest of the test set. This mixture also received the highest average visual ranking of 3.5 (measured on a scale from 0 to 5). Test reports are attached in Appendix H - ASTM C672 Salt Scaling.

[11] ASTM C672/C672M-12 Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals

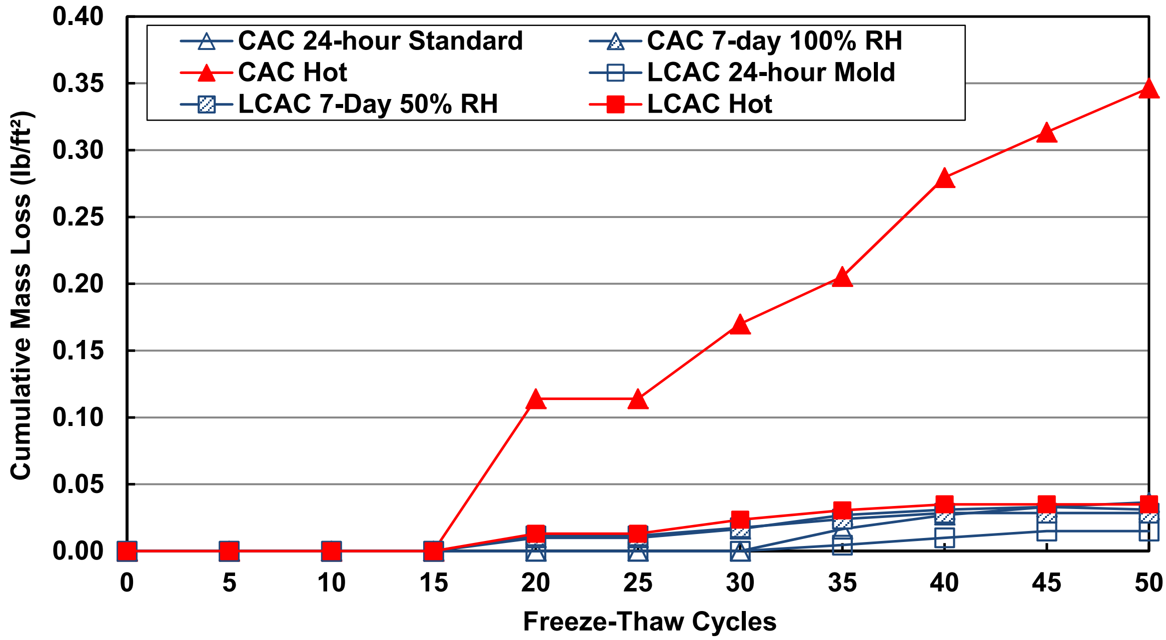


Figure 3-15 – Scaling Resistance Results

3.1.2 SHRINKAGE STUDY

A CAC shrinkage study was carried out in two phases:

A series of CAC mortar batches with was made and shrinkage was evaluated on the basis of ASTM C157. Initially, a series of concrete mixtures with no latex or accelerator was made. Fabricated samples were cured at three different temperatures (73°F, 86°F, and 100°F) and for different varying periods of time (ranging from 8 hours to 24 hours). Additionally, a set of batches utilizing a shrinkage-reducing admixture (SRA) was made.

Three CAC-based concrete mixtures were fabricated in order to investigate the effect of latex and SRA on drying shrinkage of CAC. Shrinkage characteristics evaluated according to C157 and C1581.

3.1.2.1 **Mortar Shrinkage Study**

Two sets (Trial 1 and Trial 2) of CAC mortar mixtures were prepared using standard proportions adopted from ASTM C1260[12] (1 part of cement to 2.25 parts of aggregate by mass; 0.47 w/c). Standard C157 specimens (1x1x11.25in. bars) were fabricated and cured at three temperatures for up to four different periods of time, as shown in Table 3-3. Upon initial curing, specimens were stored in a drying environment (73°F and 50% RH) for the remainder of the testing.

Table 3-3 – Mortar Shrinkage Study - Curing

Temperature	Duration			
	8 hrs	*10 hrs*	*12 hrs*	*24 hrs*
73°F	x	--	--	x
86°F	x	x	x	x
100°F	x	--	x	x

Moreover, a series of three batches utilizing the same mix design was prepared with a partial (1-3 gallons per cubic yard) water replacement by a shrinkage reducing admixture. Replacement rates were selected to compare to the rates that are commonly used in portland cement concrete mixtures.

Experiments in this part of the study were carried on mortar; hence the measured shrinkage values are not directly comparable to the shrinkage characteristics of concrete. Also, the w/c ratio of 0.47 exceeds values typically used with a CAC concrete system.

Comparison of average length change measurements obtained according to ASTM C157 for the two performed trials is shown in Figure 3-16. The first and second trials showed similar results for the samples cured at 73°F and 100°F, however, significant differences between the two trials were observed for the samples cured at 86°F. However, the standard deviation between three samples for the 86°F-cured samples was in some case greater than the allowed value per the ASTM standard (0.0084%). This indicated relatively high variability of the ASTM C157 results, especially at the 86°F curing conditions. Therefore, the 86°F-cured samples were excluded from the data set in order to avoid any misinterpretation of the results.

[12] ASTM C1260 Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)

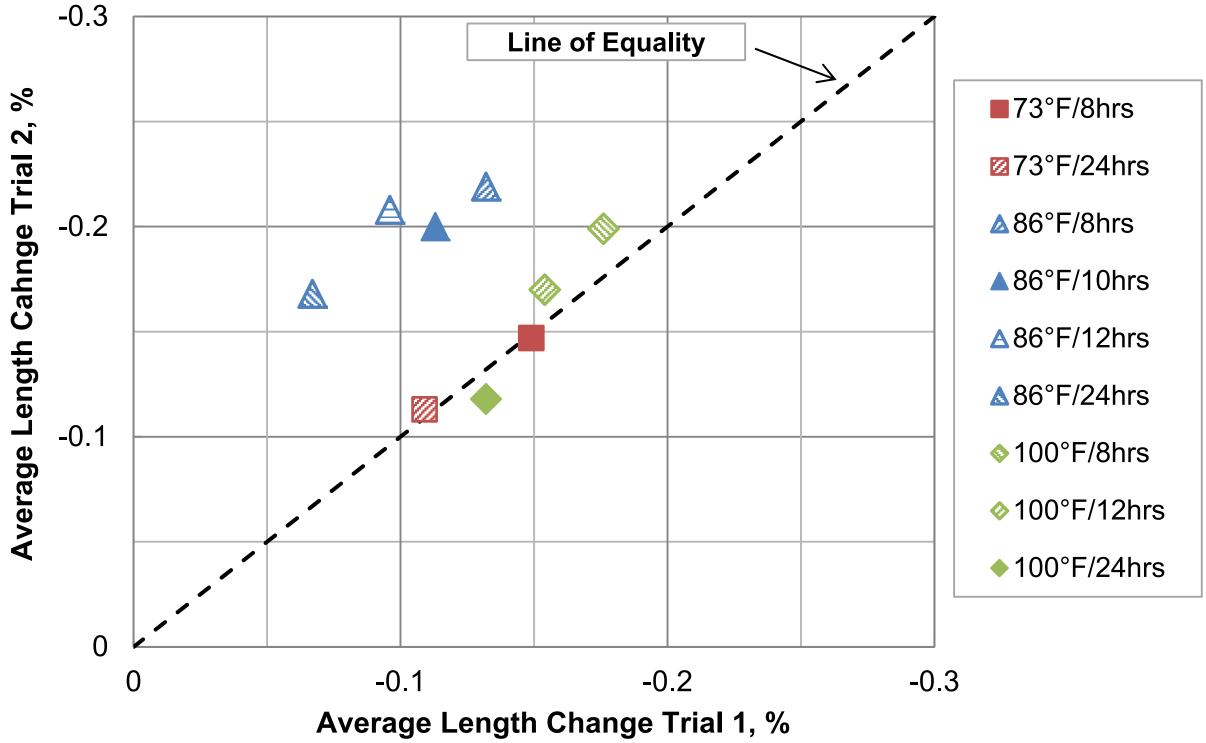


Figure 3-16 – Mortar Shrinkage Study – Trial 1 and Trial 2 comparison

Complete results for both trials are included shown in Figure 3-17 and Figure 3-18. The results showed that the measured average length change decreased with increased curing time. The 73°F-cured samples exhibited shrinkage reduction from 0.148% to 0.111% (25% less shrinkage) when curing was increased from 8 hours to 24 hours. For the same increase in curing time, the 100°F-cured samples exhibited an increase from 0.188% to 0.125% (33% reduction of shrinkage).

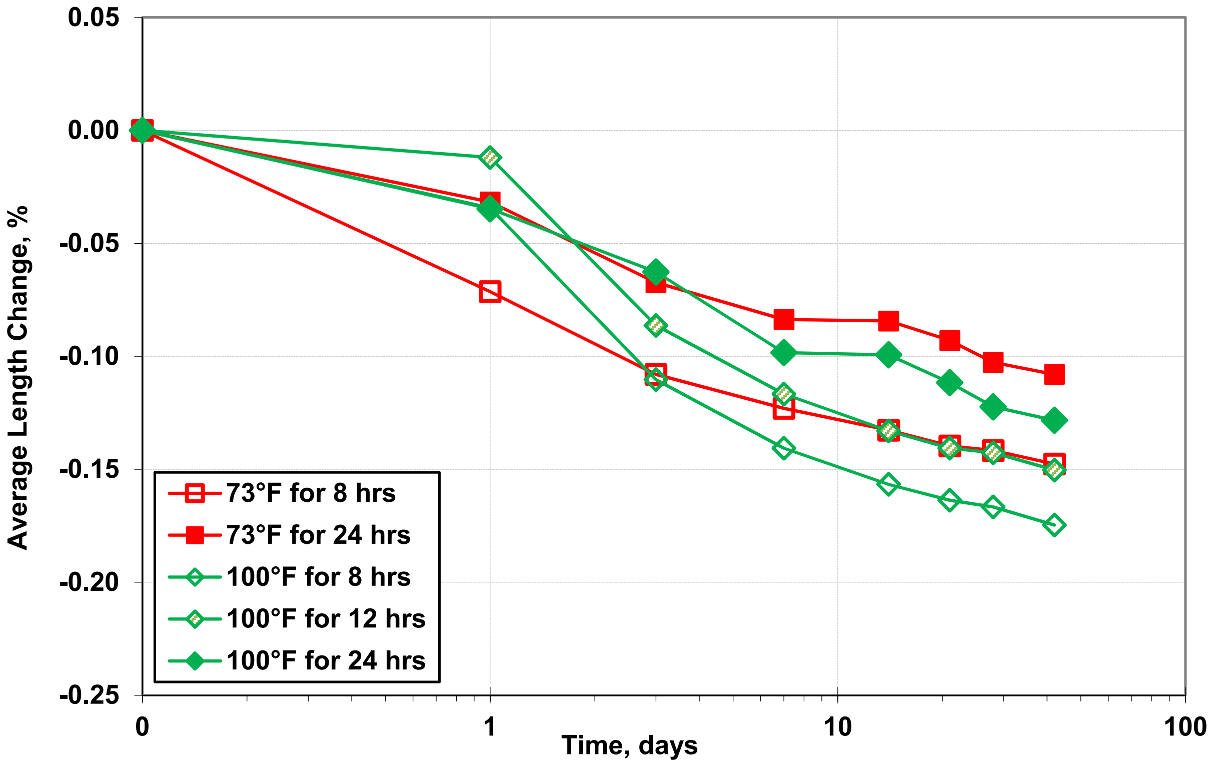


Figure 3-17 – Mortar Bar Shrinkage Study (First Trial)

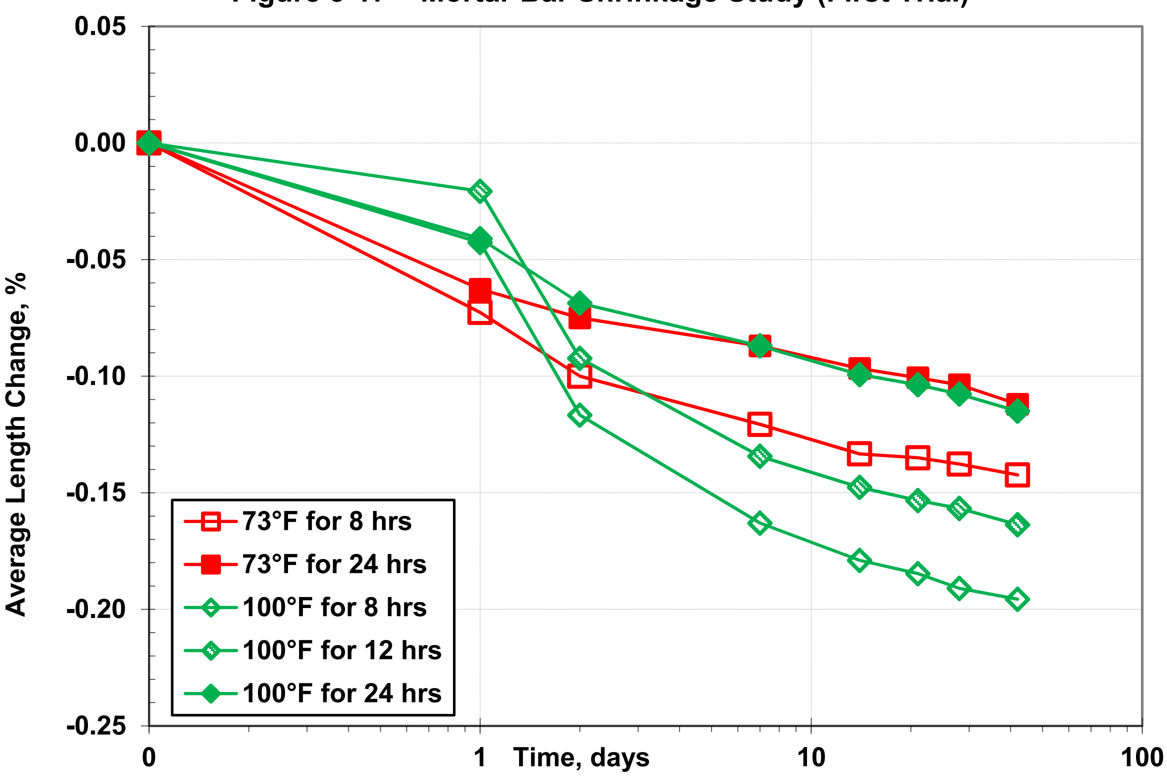


Figure 3-18 – Mortar Bar Shrinkage Study (Second Trial)

www.CTLGroup.com

Test results obtained from samples fabricated with partial replacement of water with SRA are shown Figure 3-19. The addition of SRA into the CAC-based system resulted in a 10-15% decrease in the average length change due to drying shrinkage and the effect of SRA dosage on the overall reduction of shrinkage was very limited.

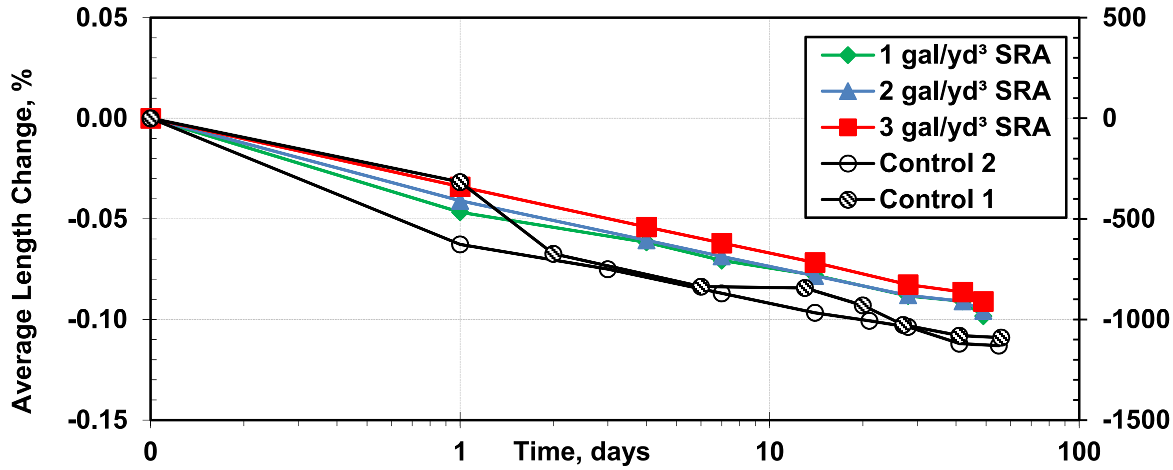


Figure 3-19 – Mortar Bar Shrinkage Study – SRA

In portland cement systems, dosages of SRA in the range used in this study would be expected to result in much higher shrinkage reductions. It is common to achieve up to 50% shrinkage reduction by using SRA. Additionally, the shrinkage reduction is typically very sensitive to the SRA dosage rate. Results suggested that the effectiveness of SRA in CAC-based mortar (and concrete) mixtures is reduced. This could be attributed to the combination of chemical shrinkage, autogenous shrinkage and drying shrinkage occurring in CAC mixtures compared to forces exerted by capillary pores in ordinary portland cement concrete mixtures (Adams, 2015). Individual test reports are included in Appendix E - ASTM C157 Drying Shrinkage.

3.1.2.2 **Concrete Shrinkage Study**

A series of laboratory CAC concrete mixtures was fabricated to investigate the effect of latex and shrinkage-reducing admixtures on shrinkage characteristics of CAC-based concrete. Specimens for compressive strength, drying shrinkage test and restrained shrinkage test (the ring test) were fabricated. Mixture proportions are shown in Table 3-4. As opposed to the large placement study, accelerator was not utilized in the concrete mixture. The control mixture (CAC) and mixture with SRA (CAC-SRA) had identical w/cm ratios whereas the latex mixture (LCAC) had w/cm of 0.20. The LCAC mixture was fabricated using only 28 lb. of water per cubic yard, however, taking into account the water contained in admixtures (the latex admixture contains 52% of water, i.e. 112 lb/yd^3), the total water content was 140 lb/yd^3.

Table 3-4 – Concrete Shrinkage Study - Mixture Proportions

	Mix ID:	**CAC**	**LCAC**	**CAC-SRA**
Material	***Source***		***lb/yd³ (SSD)***	
Cement	*Kerneos Calcium Aluminate Cement*	702	703	702
Coarse Aggregate	*Fox Valley, IL CM-11, Crushed Limestone*	1659	1788	1608
Fine Aggregate	*Meyer Material Co. Algonquin, IL*	1302	1329	1262
Water	*Potable, Skokie, IL*	262	28	262
Chemical Admixtures			***fl. oz./cwt***	
Accelerator	*GCX-500 Accelerator*	0.0	0.0	0.0
HRWR	*MasterGlenium 7500*	11.8	0.0	11.8
Latex Modifier	*Styrofan 1186 (52% water)*	0.0	469.8	0.0
AEA	*MasterAir AE 200*	3.6	0.0	3.6
SRA	*Masterlife SRA 20*	0.0	0.0	36.4
w/cm (accounting for water in admixtures)		**0.38**	**0.20**	**0.38**

Measured fresh properties are shown in Table 3-5. All three mixes had similar workability with slump between 8.00 and 9.50 inches.

Table 3-5 – Concrete Shrinkage Study – Fresh Properties

	CAC	**LCAC**	**CAC-SRA**
Slump, in., ASTM C143.	8.00	9.50	8.00
Air Content, %, ASTM C231%	6	3.4	5.1
Density (unit weight), lb/ft³, ASTM C138	145.2	151.7	148.7

3.1.2.2.1 Compressive Strength

The compressive strength was determined at 1, 3, 5, 7, 14 and 28 days for all mixtures, as shown in Figure 3-20. All three mixtures had compressive strength greater than 4,000 psi at 24 hours. Despite having lower w/cm than the other two mixtures in the set, the LCAC mixture did not exhibited the highest compressive strength at 28 days. Individual test reports are included in Appendix C - ASTM C39 Compressive Strength.

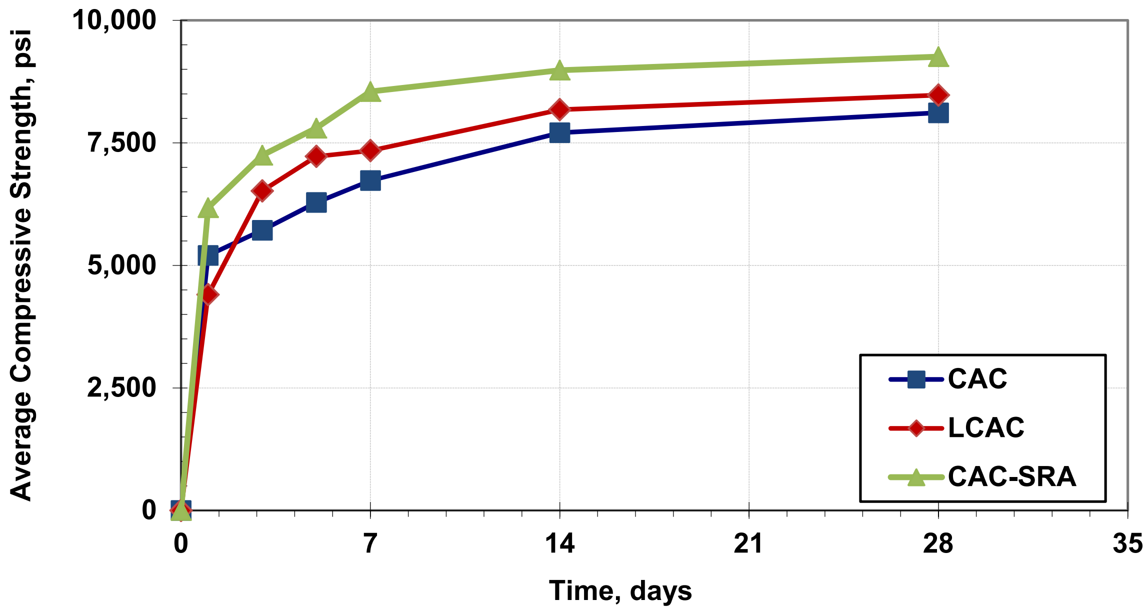


Figure 3-20 – Concrete Shrinkage Study – Compressive Strength Development

3.1.2.2.2 Drying Shrinkage and Restrained Shrinkage

Two curing regimens were used for samples fabricated for drying shrinkage tests:

Standard curing: samples were covered with plastic sheets and moist burlap (with the exception of LCAC that was covered in plastic only) and kept at 73°F73F for 24 hours. Afterwards, specimens were kept at 73°F73F and 50% RH for the remainder of the testing.

Hot curing: samples were covered in plastic sheet and moist burlap (with the exception of LCAC that was covered in plastic only) and kept at 100°F for 24 hours. Afterwards, specimens were kept at 73°F73F and 50% RH for the remainder of the testing.

Drying shrinkage results are shown in Figure 3-21. It is apparent that the presence SRA or latex in the system improved overall performance of CAC-based mixtures. The addition of latex reduced shrinkage by 3% and 11% for standard and hot curing conditions, respectively. The presence of SRA led to a decrease of 11% and 42% for standard and hot-cured samples, respectively. There was no particular relationship observed between the curing regimen and the length change of testes specimens. The hot-cured CAC-SRA mixture exhibited less shrinkage than the companion sample that was cured under standard conditions. On the contrary, the CAC hot-cured mixture experienced greater amount of drying shrinkage compared to the standard-cured companion. Finally, there was significant difference measured in the length change between standard and hot-cured LCAC specimens.

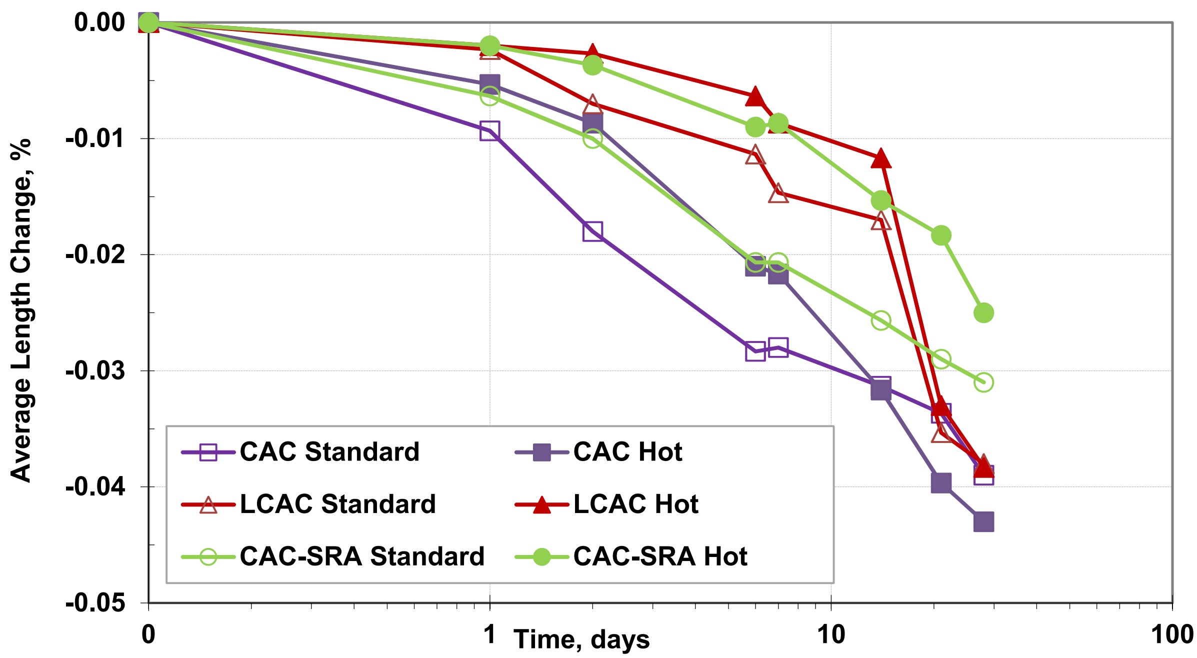


Figure 3-21 – Concrete Shrinkage Study – Drying Shrinkage Test Results

The resistance to cracking of concrete samples subjected to restrained shrinkage testing in accordance with ASTM C1581 is shown in Figure 3-22. Please note that the full circle indicates formation of a crack. It is apparent that both CAC-SRA and LCAC mixtures showed improved resistance to cracking under restrained shrinkage. The average recorded time to cracking was 2.3 days and 6.1 days for the CAC and CAC-SRA mixes, respectively. For the LCAC mixture, one sample remained intact through testing (time to cracking greater than 28 days) and the other two samples failed at ages of 11 and 13 days. Individual test reports are attached in Appendix E - ASTM C157 Drying Shrinkage and Appendix F - ASTM C1581 Restrained Drying Shrinkage.

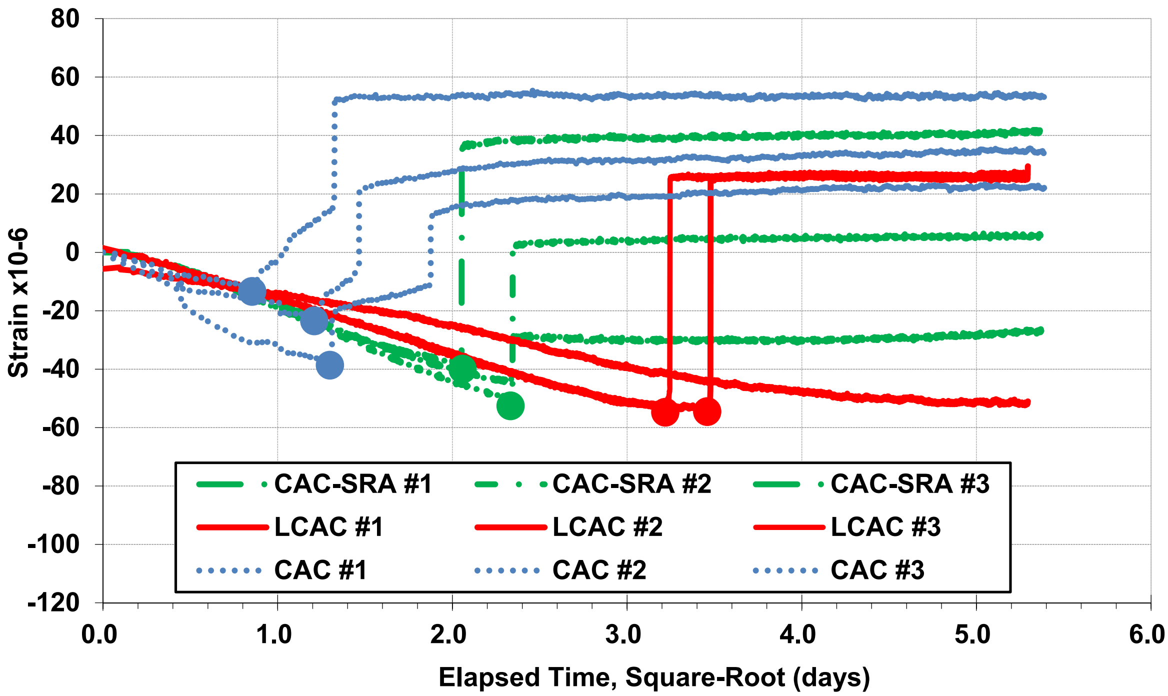


Figure 3-22 – Concrete Shrinkage Study – Restrained Shrinkage Test Results

3.2 FIELD IMPLEMENTATION AND VALIDATION

CTLGroup observed and monitored three field placements of CAC patch materials on Tollway pavements in October and December of 2015. The first placement was a full-depth bridge deck patch on I-294 over North Avenue. The second placement took place on I-88 at Toll plaza #61. This repair consisted of two sub-repairs: (1) one full lane was patched with CAC with a latex-modifying admixture and an accelerator, and (2) pavement shoulder was patched with non-accelerated latex-modified CAC. The third placement was a full depth patch on I-294 at Lake Cook Road. This patch consisted of two lanes placed at once with a contraction joint in the middle.

CTLGroup instrumented each repair with thermocouples to monitor the temperature profile in the patch. For all three patches the testing laboratory fabricated 6x12-inch cylinders for strength verification. The samples were stored in a cooler prior to testing. See Appendix M - Field Patches Reports for the full report on this phase of the study.

3.2.1 FULL-DEPTH BRIDGE REPAIR (I-294 OVER NORTH AVENUE)

October 18, 2015

The first patch was located on a bridge deck on I-294 over North Avenue. The patched area, shown in Figure 3-23, measured 5 by 5 feet and was 8 inches thick. The bridge deck was reinforced in both directions with bars of approximately 0.75-in. in diameter. The transverse reinforcement included a lap splice in the middle of the top layer of reinforcement. The transverse reinforcement spacing (center-to-center) was approximately 6 and 9 inches for the top and bottom layer, respectively. The longitudinal reinforcement was spaced in 12-inch intervals (center-to-center) in both top and bottom layers. Vertically, the reinforcement layers were spaced 6 in. apart.

Figure 3-23 – I-294/North Avenue Repair Site

Thermocouples were placed in three locations: the center, the middle of an edge, and a corner. At the center location, four thermocouples were installed: (1) near the formwork on the bottom, (2) at mid-depth, (3) at the level of top layer of reinforcement (approximately 6 inches from the bottom surface and 2 inches from the top surface), and (4) near the top surface of the patch. For two thermocouples were installed at both the corner and middle-edge location: (1) at mid-depth and (2) at the top surface.

A second patch area, measuring approximately 2 x 2 ft., was adjacent to the instrumented repair. It was a partial-depth patch and was not instrumented. However, the repair was observed for cracking.

The CAC mixture for this placement contained a latex-modifying admixture and an accelerator. No additional water was added. Concrete placement began at 6:25 AM with placement and finishing completed by 6:35 AM.

CTLGroup returned to the patch after approximately 36 hours to document the condition of the patches and remove the instrumentation. Cracking was observed in both directions of the patch, with cracks ranging from 0.25 to 0.50 mm of width. One crack was observed forming through along center axis of the patch in both directions, as shown in Figure 3-24.

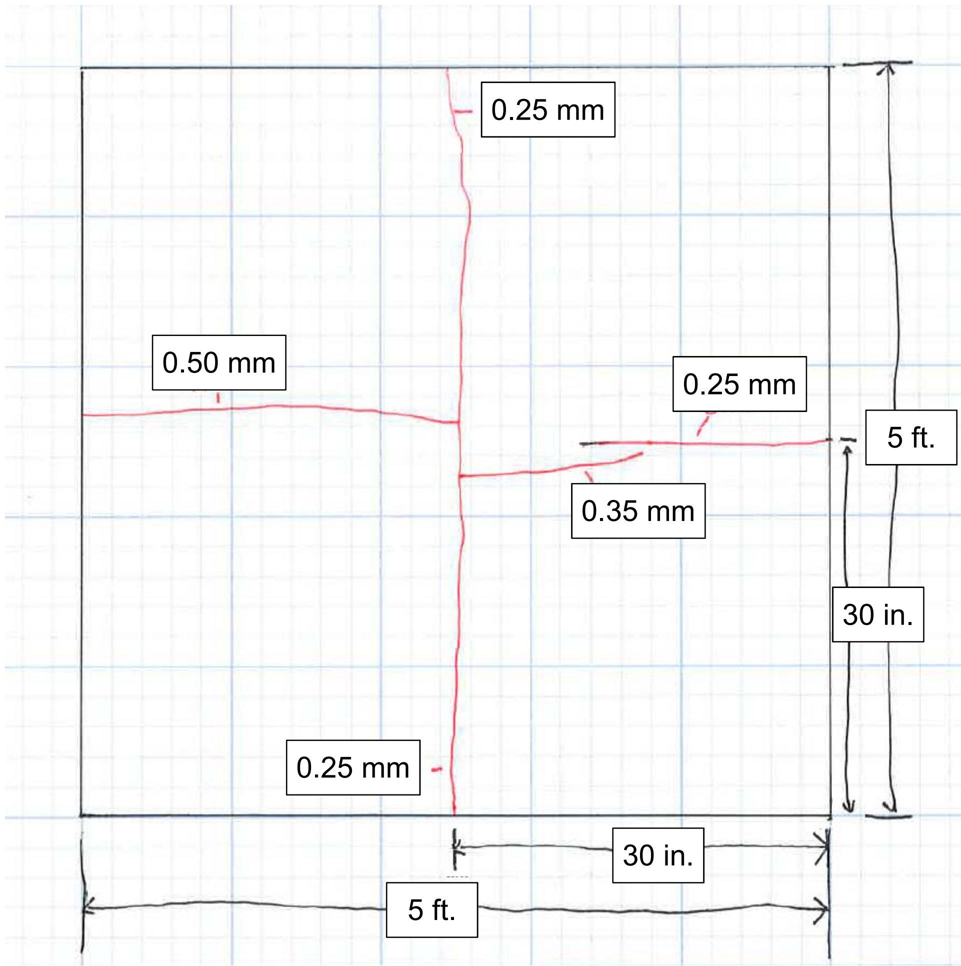


Figure 3-24 – I-294/North Avenue Repair – Crack Map at 36 hours

Recorded temperature profiles are shown in Figure 3-25 and Figure 3-26. The presented data indicate that the maximum temperature in the concrete occurred approximately 6 hours after the placement and the temperatures began decreasing as soon as the insulation was removed. At 48 hours, recorded temperature values are similar to the ambient temperature, thereby indicating the bulk of the chemical reaction was complete. As expected, the temperatures in the corner and edge locations were lower than at the center. Additionally, the corner location experienced the lowest temperatures. However, the temperature difference between the surface and mid-depth location was greater for both of these locations, compared to the data for the center location.

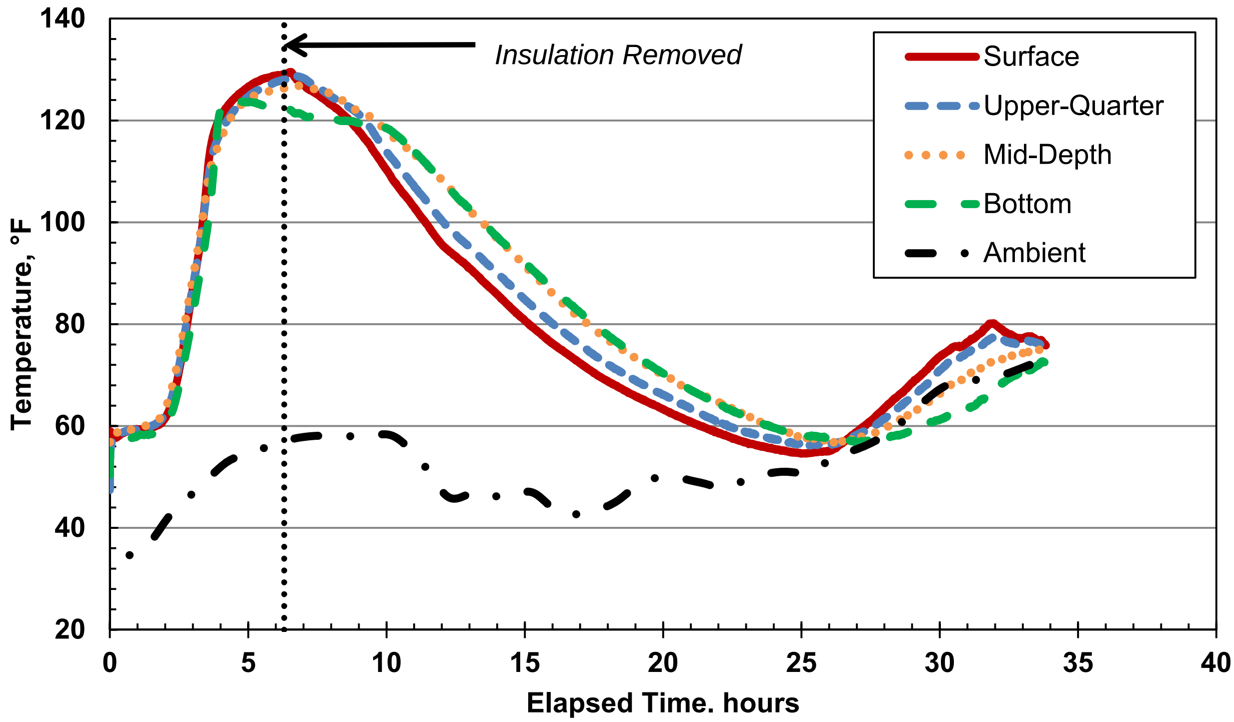


Figure 3-25 – Bridge Deck Patch Center Temperatures

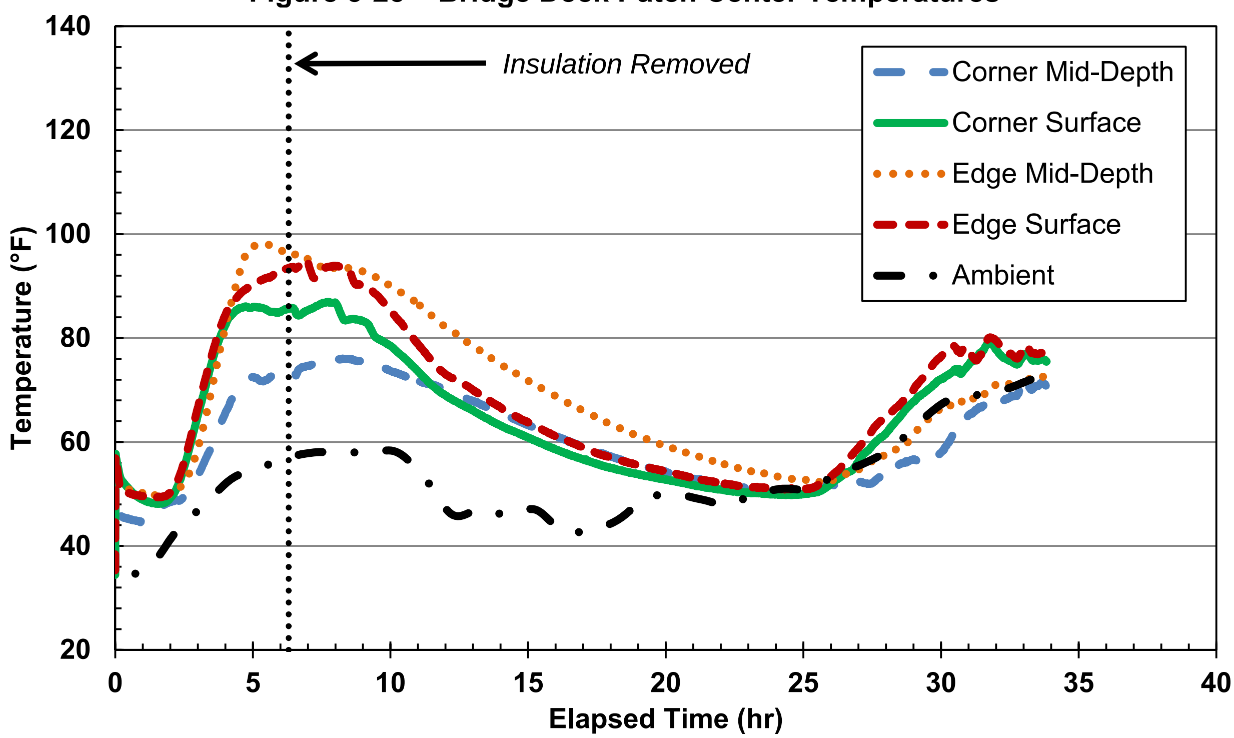


Figure 3-26 – Bridge Deck Patch Corner and Edge Temperatures

3.2.2 **I-88 WESTBOUND, TOLL PLAZA 61**

October 30, 2015

CTLGroup observed placement of a latex-modified CAC (LCAC) full-depth pavement patch that was approximately 12.25x25.5ft. and 14in. thick. The patch was divided into two placements: (1) the interior patch (traffic lane) was placed with LCAC concrete with accelerator, and (2) the outside patch (shoulder) was placed with LCAC with no accelerator. No additional water was added to either batch. CTLGroup installed thermocouples at the center of the accelerated (traffic lane) patch, and at the center and the middle of the outside edge of the non-accelerated (shoulder) patch.

Four thermocouples were placed at each instrumented location: (1) 1 in. below the surface, (2) 4 in. below the surface, (3) 8 in. (7 in. for the outside edge location) below the surface (mid-depth), and (4) 1 in. above the subgrade.

Concrete placement began at 3:00 AM and concluded by 3:45 AM in the accelerated patch. The bulkhead separating the driving lane patch from the shoulder patch was removed at 4:00 AM and concrete placement began at 4:15 AM in the non-accelerated patch. Placement concluded by 4:45 AM. Sensors were removed after approximately 48 hours.

Upon return on the site approximately 48 hours after the placement, several small cracks were found on the surface of the non-accelerated portion of the patch. These cracks likely formed due to early age thermal stresses. Additionally, a longitudinal crack at the interface between the accelerated portion and the non-accelerated portion of the repair was observed. It was hypothesized that the early age thermal expansion of the accelerated part of the repair induced stresses greater than early age strength of the non-accelerated portion, ultimately leading to the crack formation in the non-accelerated part of the patch. It is not anticipated that future patches will involve simultaneous placement of two different mixtures, thus this particular cracking mode is not likely to be repeated.

As shown in Figure 3-27, the accelerated LCAC reached peak temperatures between 5 and 6 hours after placement with a maximum temperature of 119°F at the upper-quarter sensor location. The maximum temperature in the non-accelerated CAC patch occurred 35-37 hours after placement with a maximum temperature of 88°F at the patch center and 94°F at the patch edge, as shown in Figure 3-28 and Figure 3-29.

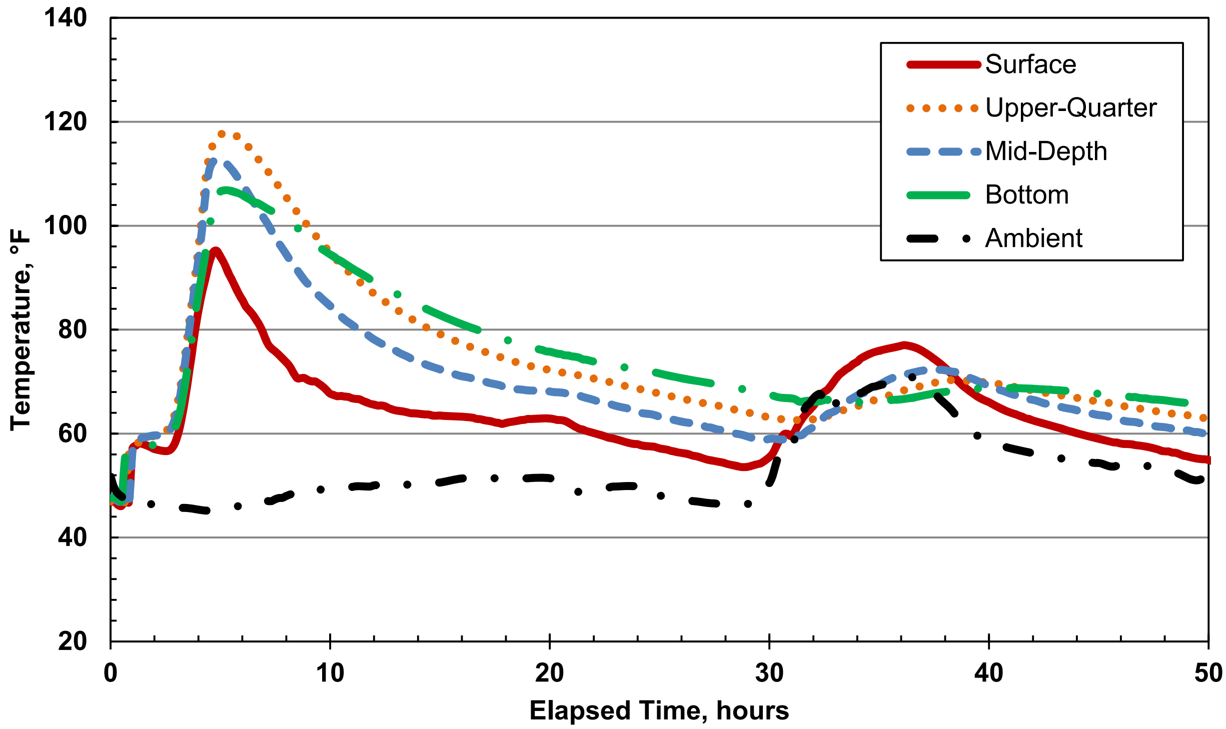


Figure 3-27 – I-88 Patch, Accelerated LCAC

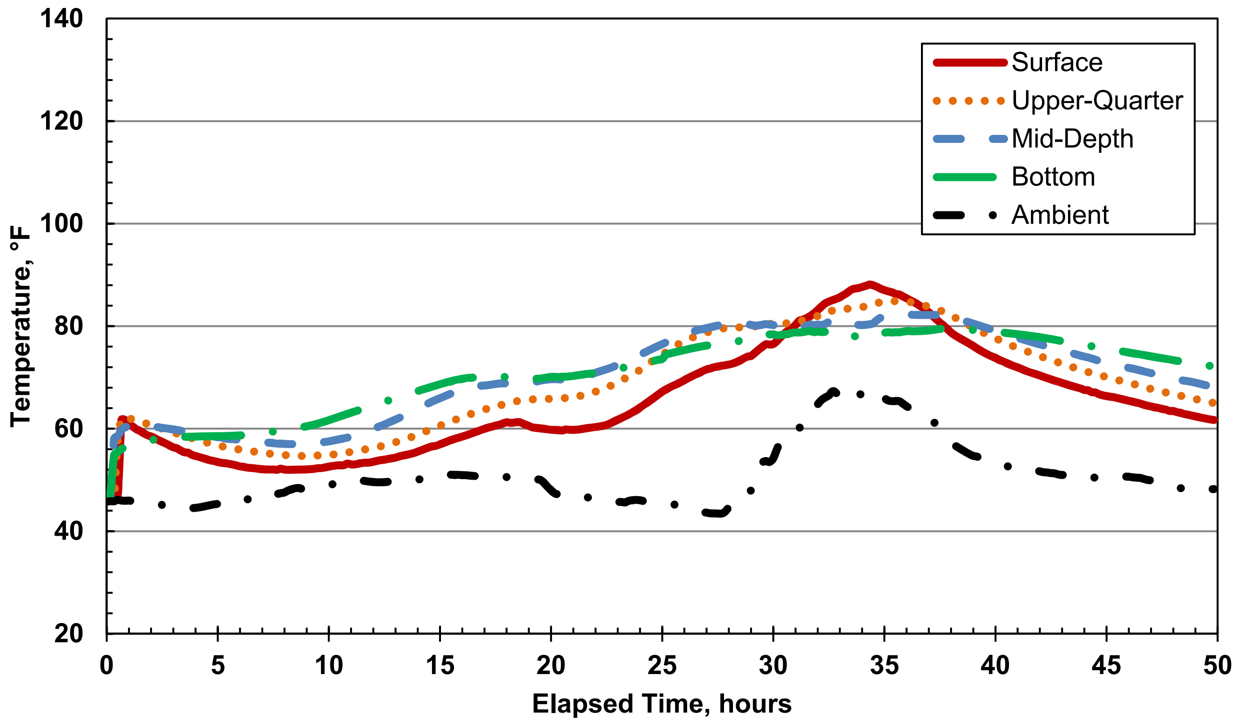


Figure 3-28 – I-88 Patch, Non-Accelerated LCAC (Center Location)

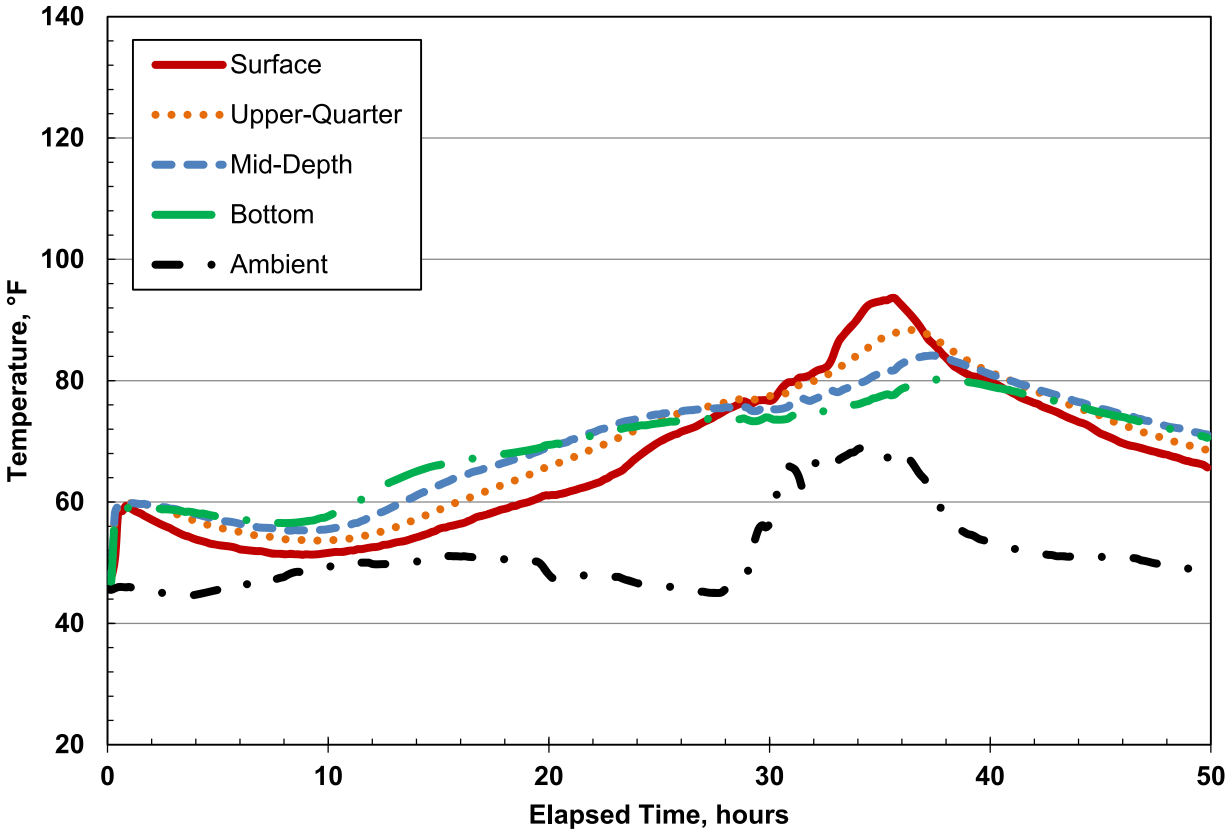


Figure 3-29 – I-88 Patch, Non-Accelerated LCAC (Edge Location)

3.2.3 I-294 SOUTHBOUND UNDER LAKE COOK Road

December 6, 2015

CTLGroup was present onsite for the third patch placement in the outside two lanes of southbound I-294 immediately below the Lake Cook Road Bridge. The patch measured 25 x 13 ft. and was 12 in. thick. Epoxy coated dowel bars were installed to facilitate the load transfer between transverse joints and epoxy coated tie bars were placed in steel baskets at the location of the planned longitudinal joint. Thermocouples were installed in three locations: (1) the center of the patch, (2) the middle of the long edge of the patch, and (3) corner of the repair area. There were four thermocouples installed at each location: (1) at the bottom of the patch near the subgrade, (2) at the mid-depth location approximately 6in. above the subgrade, (3) at the upper-quarter location approximately 3 in. below the surface, and (4) near the top surface. The overview of the repair area is shown in Figure 3-30.

Figure 3-30 – I-294 Patch, Repair Area

The LCAC mixture with accelerator was used for this placement. No additional water was added. Two volumetric concrete trucks were deployed for this placement and total of 9 cubic yards of concrete were used. Concrete from the first truck was placed in the patch at 1:20 AM, and at 1:58 AM from the second truck. The patch was complete at 2:23 AM. Measured plastic air content was 4.9% and 3.8% for concrete sampled from the first and second truck, respectively. The measured temperature was 58°F and 56°F for the first and second truck, respectively. Upon completion of the placement, one layer of plastic sheeting was placed over the patch.

Cylinder specimens were fabricated by 2:35 AM. Cylinders were tested for compressive strength by the contractor at 6:38 AM (4 hours). The reported compressive strengths were 2,810 psi and 2,850 psi for the concrete sample from the first and second truck, respectively.

The plastic sheet was removed from the patch at 7:05 AM. CTLGroup disconnected the thermocouples at 7:07 AM.

At the time the instrumentation was disconnected, concrete temperatures at the center of the patch were still rising, as shown in Figure 3-31. The temperatures at the corner and edge installations peaked at an elapsed time of approximately 4 hours, as shown in Figure 3-32 and Figure 3-33. In all three locations, the temperature of the concrete was 40 to 60 degrees higher than the ambient temperature at the time the sensors disconnection.

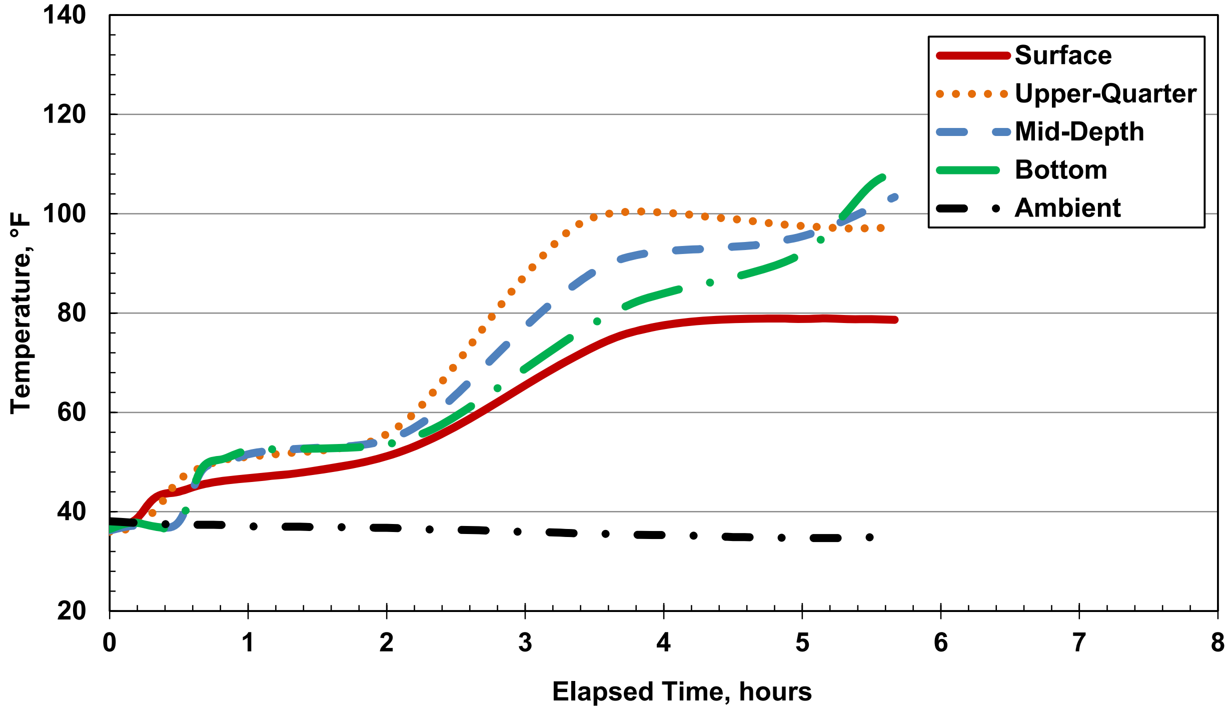


Figure 3-31 – I-294 Patch, Temperatures Center

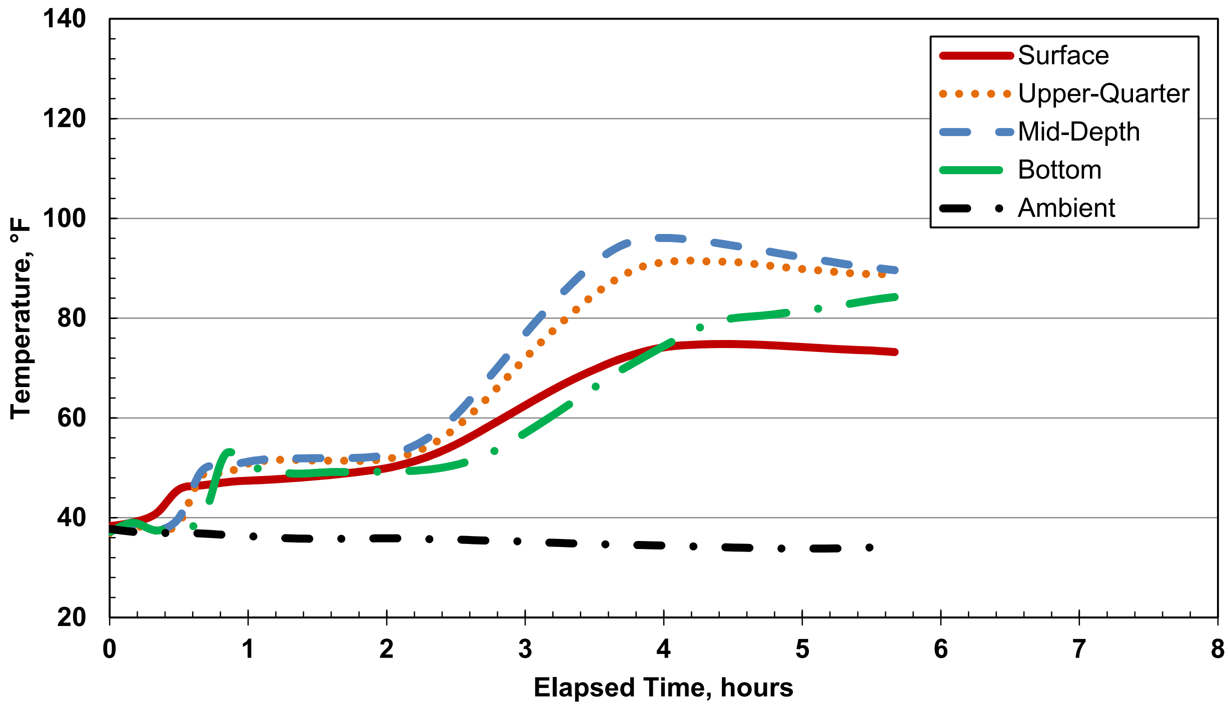


Figure 3-32 – I-294 Patch, Temperatures Edge

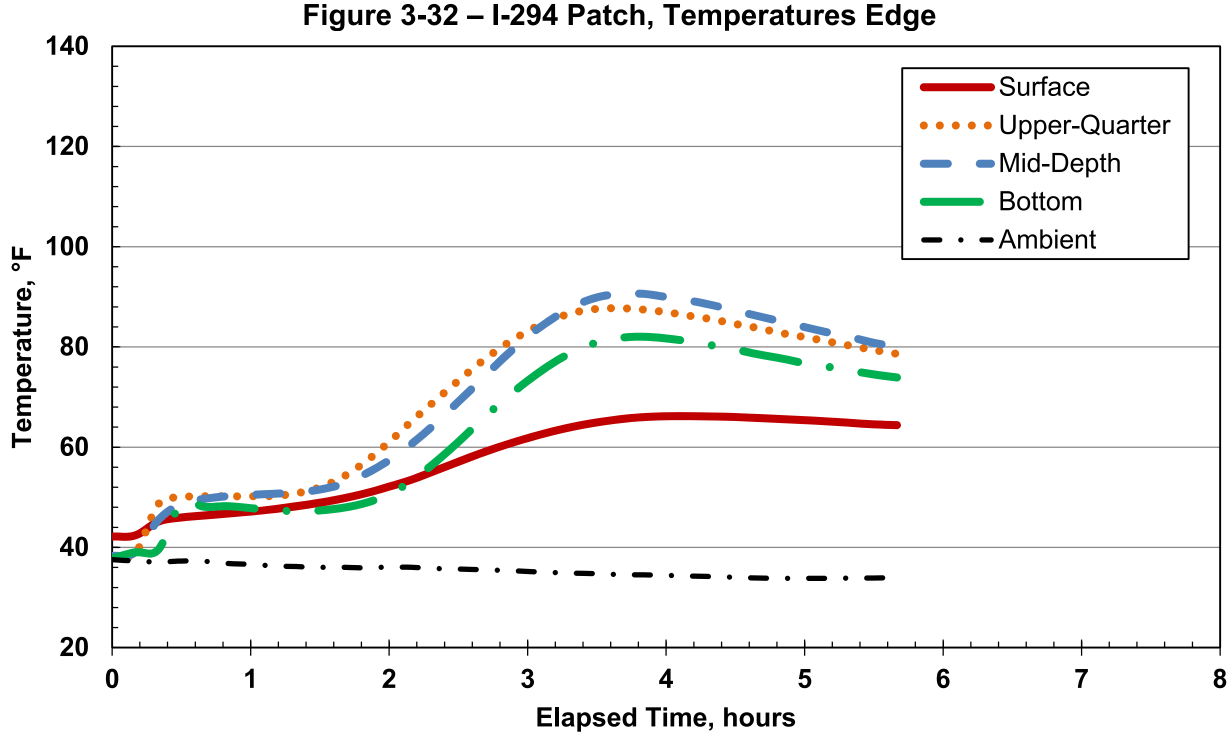


Figure 3-33 – I-294 Patch, Temperatures Corner

3.3 DISCUSSION AND SUMMARY

3.3.1 COMPRESSIVE STRENGTH

The compressive strength of concrete samples fabricated with an ordinary CAC or a latex-modified CAC concrete mixture was investigated. During the first 24 hours, compressive strength of both mixtures was comparable based on their corresponding water-to-cementitious (w/cm) ratio 0.18 and 0.19, respectively.

The compressive strength test results showed that a strong dependency on curing temperature conditions exists for CAC concrete mixtures. CAC concrete samples cured at standard conditions for 7 days showed higher compressive strength compared to those cured at 100°F. In the case of latex-modified CAC mixtures, compressive strength test results did not show a correlation to temperature curing conditions. In the case of CAC mixtures, the loss in compressive strength when cured at higher temperature conditions is attributed to the conversion process. For latex-modified CAC mixtures, no significant reduction in compressive strength was observed regardless of the possible occurrence of conversion.

3.3.2 HEAT OF HYDRATION

Test results showed that the addition of latex to CAC-based concrete can reduce the heat of hydration. For the investigated mixtures, the heat of hydration of the LCAC mixture was approximately 90% of the CAC mixture.

3.3.3 SURFACE RESISTIVITY

The surface resistivity results indicated that the CAC conversion can be successfully tracked using this method. Compressive strength and surface resistivity measurements showed good correlation throughout the study. The measured surface resistivity values of LCAC mixtures were lower than those of the CAC, primarily due to the lower internal porosity of cement-based system fabricated with the addition of latex.

3.3.4 SHRINKAGE

Test results of drying shrinkage of CAC and latex-modified CAC concrete specimens showed a dependency on the temperature conditions during curing. For samples cured in high temperature conditions, the length of the samples prior to the curing process were significantly greater compared to the other curing conditions. This suggests that other mechanisms of shrinkage, i.e. chemical and/or autogenous, may occur during the curing process. Samples cured in accelerated conditions showed lower values of drying shrinkage, which are typical for mature concrete systems. With respect to restrained shrinkage, test results showed poor performance for both CAC and latex-modified CAC concrete mixtures.

3.3.5 DURABILITY

The abrasion resistance was investigated. No significant difference in abrasion resistivity of CAC and LCAC mixtures was determined. Furthermore, the test results indicated that the conversion process had no effect on abrasion performance of CAC concrete mixtures.

The chloride penetrability of CAC and latex-modified CAC concrete was evaluated at 1 and 11 days of age for standard and elevated temperature curing conditions. It was shown that latex-modified CAC concrete exhibited lower charge passing results compared to ordinary CAC concrete samples. In general, the chloride penetration was found to be very low except for CAC concrete cured in elevated temperature conditions in which the chloride penetrability was found to be slightly higher. As reported elsewhere, connectivity and structure of the pore system in CAC concrete is responsible for the low passing of electrical charge.

Chloride ingress in CAC and latex-modified CAC concrete samples subject to diffusion testing was low. The calculated diffusion coefficient of chlorides in CAC and latex-modified CAC concrete mixtures was found to be low except for latex-modified CAC concrete samples cured at elevated temperature conditions. In this case, a higher diffusion coefficient is attributed to the effect of the conversion process.

The calculated surface chloride concentration for CAC was found to be higher than latex-modified CAC samples regardless of the curing condition. Results correlate well with the expected low permeability of CAC and latex-modified CAC.

Both ordinary CAC and latex-modified CAC mixtures showed superior freeze-thaw durability performance as the relative dynamic modulus measured after 300 cycles were greater than 95%. It was also found out that the curing temperature, and subsequently the conversion process, did not have any effect of the F-T performance of investigated mixtures.

The results of the scaling resistance testing revealed that the conversion process of CAC mixtures can cause a significant surface scaling. The hot-cured CAC samples exhibited approximately seven times greater mass loss over the course of the test than the standard temperature-cured CAC test companions. However, the addition of the latex to the concrete mixture was an efficient measure to completely mitigate this issue.

4. PHASE III (2016)

Phases I and II of this research program showed that the volumetric stability of CAC-based repair materials is a major concern. In order to address this issue, a laboratory program focused on shrinkage mitigation strategies for CAC was developed. Three rounds of laboratory trials were conducted, primarily focusing on the effectiveness of shrinkage-reducing admixtures, latex, and saturated lightweight aggregate on CAC volumetric change. Additionally, the effect of water-reducing and accelerating admixtures on CAC concrete properties was evaluated.

4.1 LABORATORY TRIALS – ROUND I

The first round of laboratory trials was conducted to investigate the relationship between the compressive strength development and usage of chemical admixtures. Additionally, a visual evaluation of concrete workability was conducted to assess the effect of used admixtures on concrete fresh properties.

The mixture proportions utilized in the first round of lab trials are shown in Table 4-1. A constant dosage of latex and HRWR was used throughout the whole round of testing. Accelerating and set-retarding admixtures were also incorporated into the testing matrix. Following the industry practice, all mixing water was provided through the addition of chemical admixtures (both latex and accelerator contained more than 50% of water) and no additional water was added during the mixing process.

Table 4-1 – Lab Trials – Round I - Mixture Proportions

Mix ID:	LCAC	LCAC-A	LCAC-AD
Date Fabricated:	1/21/2016	1/21/2016	1/21/2016
		lb/yd³ (SSD)	
Cement - Kerneos CAC	700	700	700
CA - CM-13, Lafarge, Fox River	1,660	1,660	1,660
FA - FM-02, Meyer Material Co.	1,316	1,316	1,316
Chemical Admixtures		*fl. oz./cwt*	
HRWR - BASF Glenium 7500	27.9	27.9	27.9
Latex - Styrofan 1186 (52% water content)	405.0	405.0	405.0
Accelerator - GCX-500 (1:1 solution with water)	--	29.8	29.8
Retarder - MasterSet Delvo	--	--	15.0
w/cm (accounting for water in admixtures)	0.15	0.17	0.17

The mixture with SRA exhibited the best workability for the longest period of time. High-range water reducer was added initially to increase slump but it was very quickly determined it had little impact on the workability of the concrete. It was added to all subsequent mixtures for consistency.

Results of compressive strength testing are shown in Table 4-2. Two curing environments were utilized for curing of compressive strength samples: standard laboratory (73°F) and a cold room conditions (43°F). Several values of 0 psi were recorded; these values indicate the ability to easily scratch the finished surface of compressive strength cylinders. As expected, the mixture without accelerator (LCAC) showed the slowest strength gain, followed by the mixture containing both the accelerator and set-retarder (LCAC-AD). The fastest strength development was recorded for the mixture containing only the accelerator (LCAC-A), reaching approximately 4,500 psi at 8 hours in a cold environment. However, none of the mixtures had early age compressive strengths that meet the requirements for CAC rapid repair materials.

Table 4-2 – Lab Trials – Round I - Compressive Strength

Curing:		**Mold, 73°F**			**Mold, 43°F**	
Mix ID:	**LCAC**	**LCAC-A**	**LCAC-AD**	**LCAC**	**LCAC-A**	**LCAC-AD**
Age	**Compressive Strength, psi**					
4 hours	0	0	0	--	--	--
5 hours	--	--	--	--	--	--
6 hours	0	830	80	--	--	--
8 hours	--	--	--	0	4,520	0
10 hours	--	--	--	--	--	--
23-24 hours	120	8,080	6,620	0	--	--
29-32 hours	770	--	--	600	8,600	3,270
48 hours	--	--	--	7,790	--	6,770

4.2 LABORATORY TRIALS – ROUND II

Mixture proportions used in the second round of laboratory trials are shown in Table 4-3. Latex dosages varied within the range of values identified by the concrete producer as values that are routinely used in the field. Two dosages of accelerator were used to further investigate the effect of accelerator on concrete properties.

Table 4-3 – Lab Trials – Round II - Mixture Proportions

Mix ID:	LCAC-ASRA	LCAC-ASRA(1-4)	LCAC-ASRA(A)	LCAC-ASRA(B)	LCAC-ASRA(C)	LCAC-ASRA2
Date Fabricated:	2/19/2016	2/19/2016	2/26/2016	2/26/2016	2/26/2016	3/8/2016
	lb/yd³ (SSD)					
Cement - Kerneos CAC	700	700	700	700	700	700
CA - CM-13, Lafarge, Fox River	1,660	1,660	1,660	1,660	1,660	1,660
FA - FM-02, Meyer Material Co.	1,316	1,316	1,316	1,316	1,316	1,316
Potable Water, Skokie, IL	--	--	39	39	55	98
	fl. oz./cwt					
HRWR - BASF Glenium 7500	28	52	--	--	--	--
Latex - Styrofan 1186 (52% water)	405	494	494	306	405	310
Accelerator - GCX-500 (1:1 in water)	29.8	29.8	29.8	29.8	59.6	59.6
SRA, BASF MasterLife SRA	36.3	36.3	36.3	29.8	59.6	36.3
w/cm (incl. water in admixtures)	0.17	0.21	0.24	0.28	0.25	0.27

4.2.1 COMPRESSIVE STRENGTH

Compressive strength samples were cured in three different environments: in a cold room at 43°F, in a standard laboratory environment at 73°F, and in a hot tank at 122°F. Compressive strength results for all three curing conditions are shown in Table 4-4, Table 4-5, and Table 4-6. It was observed that cylinders cured at 43°F had the lowest early age strength out of the testing set. However, compared to the specimens cured at the standard conditions, the cold-cured cylinders exhibited slightly greater compressive strength at 28 day. The elevated temperature-cured samples, which went through conversion, exhibited satisfactory compressive strength (greater than 5,000 psi) at 28 days.

Table 4-4 – Lab Trials – Round II – Compressive Strength (73°F)

Compressive Strength, psi (Standard, 73°F/50% RH)						
Mix ID	**LCAC-ASRA**	**LCAC-ASRA (1-4)**	**LCAC-ASRA(A)**	**LCAC-ASRA(B)**	**LCAC-ASRA(C)**	**LCAC-ASRA2**
2 hours	--	--	--	--	--	220
3 hours	--	--	--	--	--	1,120
4 hours	580	--	710	700	740	2,130
5 hours	--	770	--	--	--	--
6 hours	3,560	2,130	2,100	2,390	3,040	2,670
8 hours	--	3,050	3,220	3,600	3,910	3,010
10 hours	--	--	3,770	--	--	3,940
24 hours	--	4,670	3,900	4,770	4,810	4,360
3 days	--	5,570	--	--	--	--
7 days	--	6,820	--	--	--	6,230
14 days	--	7,890	--	--	--	--
28 days	--	8,900	--	--	--	7,890

Table 4-5 – Lab Trials – Round II – Compressive Strength (43°F)

Compressive Strength, psi (Cold room, 43°F)						
Mix ID	**LCAC-ASRA**	**LCAC-ASRA (1-4)**	**LCAC-ASRA(A)**	**LCAC-ASRA(B)**	**LCAC-ASRA(C)**	**LCAC-ASRA2**
2 hours	--	--	--	--	--	200
3 hours	--	--	--	--	--	760
4 hours	--	--	--	--	--	1,750
6 hours	--	--	330	1,450	2,820	2,940
8 hours	--	--	1,880	3,910	4,300	3,290
10 hours	--	--	3,460	4,260	4,540	4,190
22 hours	4,150	--	--	--	--	--
24 hours	--	--	4,610	5,150	5,340	4,580
31 hours	4,100	--	--	--	--	--
3 days	--	4,530	--	--	--	--
7 days	--	--	--	--	--	5,780
28 days	--	--	--	--	--	6,590

Table 4-6 – Lab Trials – Round II – Compressive Strength (122°F)

Compressive Strength, psi (Hot tank, Limewater, 122°F)						
Mix ID	**LCAC-ASRA**	**LCAC-ASRA (1-4)**	**LCAC-ASRA(A)**	**LCAC-ASRA(B)**	**LCAC-ASRA(C)**	**LCAC-ASRA2**
24 hours	--	--	--	--	--	3,750
7 day	--	5,540	--	--	--	4,310
28 day	--	5,040	--	--	--	5,500

4.2.2 OTHER PERFORMANCE TESTING

Two round II mixtures, LCAC-ASRA(1-4) (fabricated on February 19, 2016) and LCAC-ASRA2 (fabricated on March 8, 2016) were subjected to an extended testing program in order to evaluate the performance characteristics of latex-modified CAC-based concrete. The mixtures were tested for setting time, drying shrinkage, restrained shrinkage cracking, rapid chloride penetrability, freeze thaw resistance, and resistance to salt scaling.

4.2.2.1 Setting Time

The setting time was measured according to ASTM C403[13] and the results are shown in Table 4-7. LCAC-ASRA(1-4) reached the initial set 140 minutes and the final set 165 minutes after water addition, whereas LCAC-ASRA2 reached the initial and the final set 10 minutes and 30 minutes after water addition, respectively. The significant difference observed in both initial and final setting times is to be contributed to dosages of chemical admixtures. The LCAC-ASRA2 mixture was designed to have twice as much accelerator as LCAC-ASRA(1-4). Additionally, LCAC-ASRA(1-4) utilized high-range water reducing admixture. Both of these mixture design parameters inevitable led to the increased setting time of the LCAC-ASRA(1-4) mixture.

Table 4-7 – Round II – Performance Testing – Time of Setting

Test Method, ASTM standard	Measured Property	LCAC-ASRA (1-4)	LCAC-ASRA2
Time of Setting, ASTM C403	Time of Setting, minutes	Initial: 140 Final: 165	Initial: 10 Final: 30

[13] ASTM C403/C403M-08 Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance

4.2.2.2 **Shrinkage**

Drying shrinkage was determined according to ASTM C157.[14] Both mixtures exhibited similar shrinkage behavior, as shown in Table 4-8. The LCAC-ASRA(1-4) mixture and the LCAC-ASRA2 mixture shrank by 0.050% and 0.047% after 28 days of drying, respectively. Although the results showed less overall shrinkage compared to values to values obtained for mixtures fabricated the Phase II of this study (see Section 3.1.1), the level of drying shrinkage for these mixture was still excessive.

Table 4-8 – Round II – Performance Testing – Shrinkage

Test Method, ASTM standard	Measured Property	LCAC-ASRA (1-4)	LCAC-ASRA2
Drying Shrinkage, ASTM C157	Length Change, %	-0.050	-0.047
Restrained Drying Shrinkage, ASTM C1581	Age at Cracking, days	7.1	4.7

The restrained drying shrinkage was determined according to ASTM C1581[15]. The measured average time to cracking was 7.1 days and 4.7 days for the LCAC-ASRA(1-4) and LCAC-ASRA2 mixtures, respectively. The different dosage of accelerator and high-range water reducer is believed to be responsible for the difference in the measured time to cracking of the two concrete mixtures.

4.2.2.3 **Durability Tests**

Rapid chloride penetrability was determined according to ASTM C1202[16]. Results are shown in Table 4-9. Specimens for rapid chloride penetrability tests were cured in two different regimens: (1) in a limewater bath at 73°F for 28 days (standard curing), and (2) for 7 or 14 days in limewater at 73°F and additional 21 days in a limewater bath at 100°F (accelerated curing). Accelerated test samples were expected to undergo the CAC conversion process due to the elevated curing temperature. Based on the test method classification, results for the LCAC-

[14] ASTM C157/C157M-08 Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
[15] ASTM C1581/C1581M-16 Standard Test Method for Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage
[16] ASTM C1202-12 Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

ASRA(1-4) mixture indicated “negligible chloride penetrability” whereas the LCAC-ASRA2 mixture was classified as a “very low chloride penetrability” mixture. The higher dosage of latex combined with lower water content was responsible for the superior performance of the LCAC-ASRA(1-4) mixture. As expected, the measured passed charge values for the samples that underwent forced conversion (accelerated-cured samples) were higher than the samples cured at standard temperature, primarily due to an increase in the overall porosity of the cement matrix. The measured difference between hot and standard-cured specimens was approximately 60 coulombs.

Table 4-9 – Round II – Durability Testing – Rapid Chloride Penetrability

Test Method, ASTM standard	Measured Property	Curing	LCAC-ASRA (1-4)	LCAC-ASRA2
Rapid Chloride Penetrability, ASTM C1202	Charge Passed, Coulombs	LW: 73°F/28 days	90	296
		LW: 73°F/7 days; LW: 100°F/21 days	149	--
		LW: 73°F/14 days; LW: 100°F/21 days	--	359

Freeze-thaw resistance was determined according to ASTM C666[17] and the test results are shown in Table 4-10. In order to evaluate the effect of the conversion process of the F-T durability, two curing conditions were deployed: (1) standard curing in limewater bath at 73°F and (2) accelerated curing in limewater at 122°F. All samples were cured for the period of 14 days after fabrication. Test results indicated that both mixtures had superior resistance to freeze-thaw cycles. Measured values of relative dynamic modules (RDM) were 95% for both mixtures, which correlated well with recorder negligible mass and length change values. No change in F-T durability was observed in regard with the force CAC conversion.

[17] ASTM C666/C666M-15 Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing

Table 4-10 – Round II – Durability Testing – Freeze-Thaw Resistance

Test Method, ASTM standard	Measured Property	Curing	LCAC-ASRA (1-4)	LCAC-ASRA2
Freeze Thaw Resistance, ASTM C666	Length Change, %	LW: 73°F/14 days	0.019	0.018
	Mass Change, %		0.06	-0.04
	RDM, %		95	95
	Length Change, %	LW: 122°F/14 days	0.018	0.018
	Mass Change, %		0.01	-0.04
	RDM, %		95	95

Salt scaling was assessed in accordance with ASTM C672[18] and the results are summarized in Table 4-11. The results showed that both investigated mixtures had a high resistance to salt scaling as mass loss values and visual scale ratings were all zero after 50 cycles.

Table 4-11 – Round II – Durability Testing – Salt Scaling

Test Method, ASTM standard	Measured Property	Curing	LCAC-ASRA (1-4)	LCAC-ASRA2
Scaling Resistance, ASTM C672	Cumulative Mass Loss, lb/ft²	73°F/50% RH 14 days; LW: 100°F/14 days	0.00	0.00
	Visual Scale Rating		0	0

*LW = saturated limewater solution bath

4.3 LABORATORY TRIALS – ROUND III

Saturated lightweight aggregate has been used successfully used in portland cement concrete as a means of reducing shrinkage and increasing durability (Henkensiefken, Bentz, Nantung, & Weiss, 2009). As the earlier laboratory trials revealed that the use of shrinkage-modifying admixture does not help to reduce shrinkage cracking potential (see Section 4.2.2.2), it was decided to explore the use of saturated lightweight aggregate (ALW) for shrinkage mitigation. To this extent, no literature reporting the use of saturated lightweight aggregates for internal curing of CAC-based system was found.

18 ASTM C672/C672M-12 Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals

Internal curing using saturated lightweight aggregate is a technique frequently used to produce a crack-free concrete with dense microstructure. Especially for concrete mixtures with relatively low w/cm, majority of the mixing water is quickly bonded in the hydration process. After the final set, capillaries and void spaces filled with vapor are formed in the paste microstructure due the continued hydration process and subsequent volume reduction. A surface tension develops inside the voids, causing shrinkage of the whole system. The slowly-released water from saturated light-weight aggregates is known to help mitigate the effects of autogenous shrinkage in the system by providing additional water to fill the capillary voids, thereby reducing the shrinkage effect caused by the presence of surface tension inside the voids.

Five mixtures with using saturated lightweight aggregates were fabricated, as shown in Table 4-12. Both cement and coarse aggregate contents remained the same as in the Round II of laboratory trials. For the first mixture (ALW), the saturated lightweight aggregate replaced 43% (by volume) of the traditional fine aggregate in the mixture. For the remainder of the mixture set, fine aggregate was completely replaced by the saturated lightweight aggregate.

Table 4-12 – Round III – Mixture Proportions

Mix ID:	**ALW**	**ALW2**	**ALW3**	**ALW4**	**ALW5**
Date Fabricated:	6/3/2016	8/30/2016	8/30/2016	9/2/2016	9/2/2016
			lb/yd³ (SSD)		
Cement - Kerneos CAC	700	700	700	700	750
CA - CM-13, Lafarge, Fox River	1660	1660	1550	1450	1450
FA - FM-02, Meyer Material Co.	738	--	--	--	--
LWA - Lafarge, South Chicago, #444	470	935	1131	1063	1063
Potable Water, Skokie, IL	51	225	195	195	179
Chemical Admixtures			*fl. oz./cwt*		
Latex - Styrofan 1186 (52% water content)	493.7	493.7	493.7	493.7	493.7
Accelerator - GCX-500 (1:1 in water)	29.8	29.8	29.8	29.8	29.8
w/cm (accounting for water in admixtures)	0.26	0.51	0.46	0.46	0.42

Drying shrinkage (ASTM C157[19]) and restrained drying shrinkage (ASTM C1581[20]) were evaluated for the ALW mixture. The average length change after 28 days of drying was 0.055%; the measured value of drying shrinkage was similar to 0.050% and 0.047%, previously measured for mixtures containing shrinkage-reducing admixture. However, the use of saturated lightweight aggregates drastically improved performance of the CAC mixture in the restrained drying shrinkage test. Rings fabricated for the ALW mixture exhibited partial cracking in one specimen starting at 8.3 days but the other two remain intact and without any visible cracking for more than 100 days. This result compares favorably with previously fabricated mixtures with the shrinkage-reducing admixture that exhibited cracking at 7.1 and 4.7 days, the restrained cracking test results supported the initial hypothesis that the saturated lightweight aggregate has the potential to significantly reduce the shrinkage cracking potential of CAC-based systems.

In the light of the initial mixture performance, the rest of the trial set was designed using the saturated lightweight aggregate only and completely omitting fine aggregate previously utilized throughout the study. The goal of this portion of the trials was to modify the mixture proportions so to reach the required strength of 2,500 psi in 4 hours while maintaining a sufficient workability of the mixture. All mixtures fabricated in this phase of the research program were tested for compressive strength according to ASTM C39[21]. As shown in Table 4-13, the ALW4 mixture had strength of 2,230 psi in 4 hours when cured at standard conditions (73°F/50% RH).

Table 4-13 – Round III – Compressive Strength

Standard, 73°F/50% RH					
Mix ID	**ALW**	**ALW2**	**ALW3**	**ALW4**	**ALW5**
3 hours	460	--	--	--	--
4 hours	3,290	1,820	1,620	2,230	1,990
5 hours	4,240	--	--	--	--
24 hours	5,440	2,300	2,120	2,920	2,670
2 days	--	2,780	2,610	--	--
4 days	--	--	--	3,540	3,360
7 days	--	3,560	3,340	3,890	3,700

19 ASTM C157 / C157M-08(2014)e1, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

20 ASTM C1581/C1581M-16 Standard Test Method for Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage,

21 ASTM C39/C39M-16b Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Water-to-cement ratio is one of the crucial factors affecting both the ultimate compressive strength as well as the strength development. When saturated-lightweight aggregated is used, it is necessary to accurately determine its absorption capacity and to evaluate its moisture condition. For purposes of this study, absorption properties and moisture characteristics of the lightweight aggregate were assessed according to ASTM C1761[22] and ITM222-15T[23]. The lightweight aggregate was soaked in water for 24 hours, followed by a 24-hour period of draining, in order to achieve good level of saturation of the lightweight aggregate particles.

22 ASTM C1761/C1761M-15 Standard Specification for Lightweight Aggregate for Internal Curing of Concrete
23 Indiana Department of Transportation(2015), ITM 222-15T Specific Gravity Factor and Absorption of Lightweight Fine Aggregate

4.4 LABORATORY TRIALS – ROUND IV

The final round of laboratory trials was designed to verify field performance of the mixture. A modification of the ALW4 mixture fabricated during the Round III of the trials (see Section 4.3) was designed to be used in a full-scale field trial, as shown in Table 4-14.

Table 4-14 – Round IV – Mixture Proportions

Mix ID:	**ALW4-T**
Date Fabricated:	9/6/2016
Materials	***lb/yd³ (SSD)***
Cement - Kerneos CAC	700
CA - CM-13, Lafarge, Fox River	1480
FA - FM-02, Meyer Material Co.	--
LWA - Lafarge, South Chicago, #444	961
Potable Water, Skokie, IL	47
Chemical Admixtures	***fl. oz./cwt***
Latex - Styrofan 1186 (52% water content)	508.3
Accelerator - GCX-500 (1:1 with water)	20.0
w/cm (incl. water in admixtures)	***0.25***

The trial was conducted at the CTLGroup facilities in Skokie, IL on September 6, 2016. A volumetric mixing truck was provided by Henry Frerk Sons (HFS) in order to simulate true field placement conditions. The recorded air temperature during the placement was 80°F at the beginning of the trial and 90°F upon fabrication of all test samples.

Lightweight aggregates were conditioned by HFS according to instructions of CTLGroup experts. The moisture content of the aggregate was measured prior to the mixing by CTLGroup technicians and according to both ASTM C1761[24] and ITM222-15T[25]. It was determined the total moisture of the lightweight aggregate was 18.24% and 17.76% based on ASTM C1761 and

24 ASTM C1761/C1761M-15 Standard Specification for Lightweight Aggregate for Internal Curing of Concrete
25 Indiana Department of Transportation(2015), ITM 222-15T Specific Gravity Factor and Absorption of Lightweight Fine Aggregate

ITM222-15T, respectively. The surface moisture content (free water) was 3.84% (ASTM C1761) and 3.36% (ITM222-15T). The value of 3.84% obtained using the current ASTM standard for used for further mixture proportions adjustments.

4.4.1 COMPRESSIVE STRENGTH

Compressive strength samples were cured in two different environments: (1) in a cold room at 43°F and (2) in a standard laboratory environment at 73°F. Compressive strength results for both curing conditions are shown in Table 4-15. Both standard and cold-cured samples exceed 2,500 psi in 4 hours, thereby meeting the requirements of a rapid repair material.

Table 4-15 – Round IV – Compressive Strength

ALW4-T	Compressive Strength, psi	
Curing	**Standard (73°F)**	**Cold (43°F)**
4 hours	3,800	3,600
5 hours	4,160	4,540
6 hours	4,530	4,880
24 hours	5,120	--
4 days	5,890	--
7 days	6,290	--
14 days	6,980	--
28 days	7,640	--

4.4.2 OTHER PERFORMANCE TESTING

4.4.2.1 Shrinkage

Both drying shrinkage (ASTM C 157) and restrained drying shrinkage (ASTM C1581) were evaluated. The results of ASTM C157 test are shown in Figure 4-1. During the first two weeks of drying, the overall length change was recorded to be much smaller than during previous phases of this research program. However, a sudden increase of the shrinkage rate was recorded between 14 and 21 days of drying. This suggests that the shrinkage mechanism is dependent on the internal relative humidity of the CAC-system and the hydration characteristics of the mixture. Although the magnitude of the shrinkage reached similar values as in previous phases of the study after 28 days of drying, the results show that the saturated lightweight aggregate is a very promising way to mitigate the shrinkage issues of CAC systems.

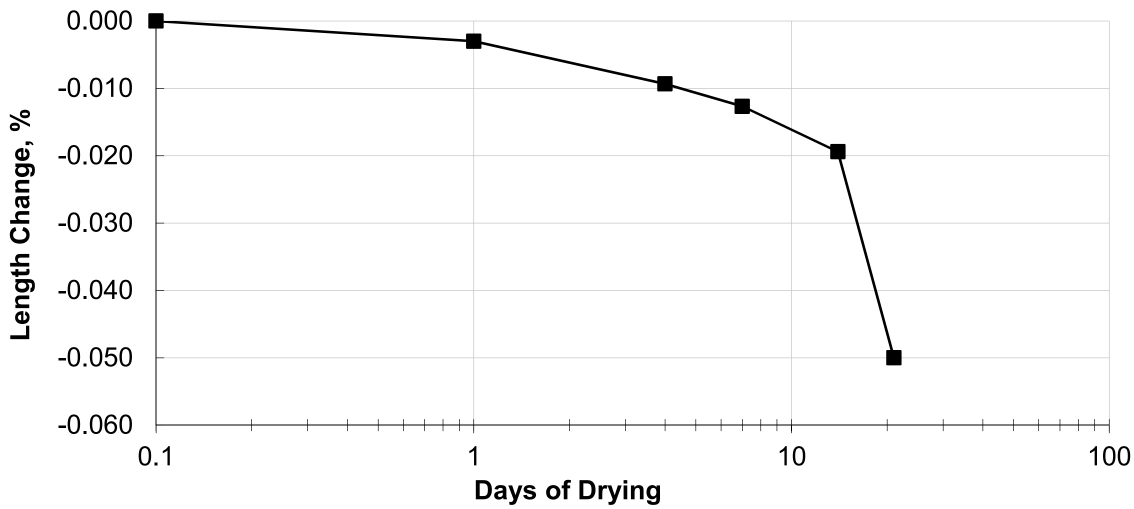


Figure 4-1 – Drying shrinkage results – ALW4-T

The use of saturated lightweight aggregate also significantly improved the performance of a LCAC system in the restrained drying shrinkage test. None of the three test rings fully cracked during the first 28 days of the test. Several small, partial cracks were detected on the rings throughout the testing but none of them resulted in a full-depth crack that can be normally observed on ASTM C1581 test specimens. The strain profile is shown in Figure 4-2.

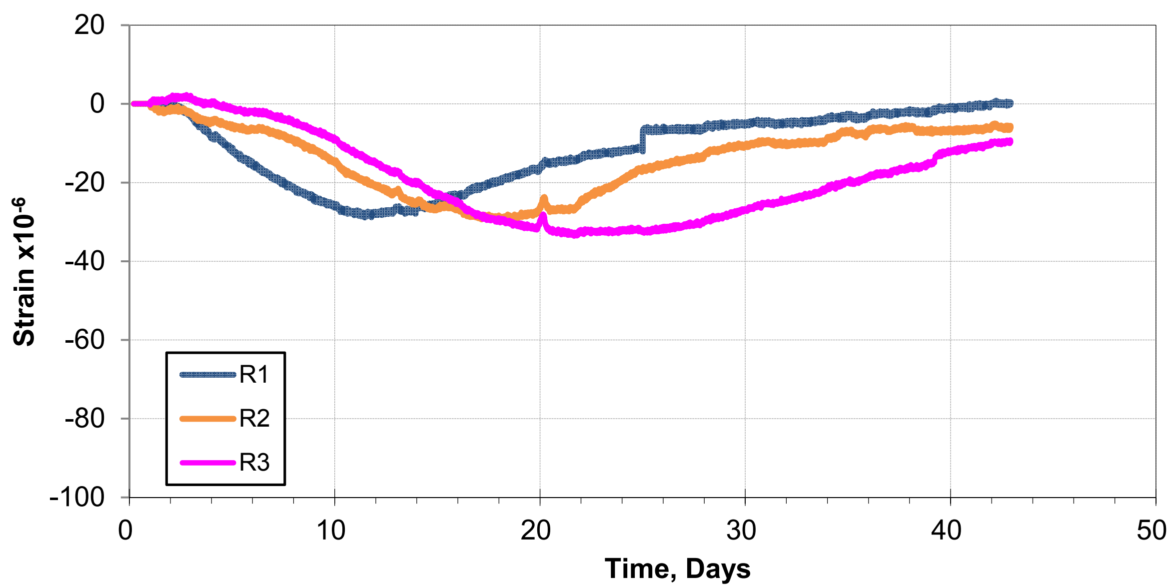


Figure 4-2 – Restrained shrinkage results – ALW4-T

4.4.2.2 **Rapid Chloride Ion Penetrability**

Both hot and standard cured samples were tested according to the ASTM C1202 test method for chloride ion penetrability. The total passed charge for both test allowed the CAC mixture to be classified as having “Very Low” chloride ion penetrability. Due to the forces conversion process, the hot-cured sample showed higher permeability than the standard-cured companion. However, none of the tested specimens allowed for more than 500 coulombs to pass through during the test.

4.4.2.3 **Durability Tests**

Resistance to freezing and thawing and salt scaling resistance were tested according to ASTM C666 and ASTM C672, respectively. The results are shown in Table 4-16. The mixture performed extremely well in both tests; the Relative Dynamic Modulus after 300 freeze-thaw cycles was 94% and no scaling due to deicer salts was observed after 50 freeze-thaw cycles.

Table 4-16 – Round IV – Durability

Test Method	***Measured Performance***	***Curing***	***Result***
Freeze Thaw Resistance, ASTM C666	RDM, %	Limewater bath 73°F, 14 days	94
Scaling Resistance, ASTM C672	Visual Scale Rating	73°F/50% RH, 14 days	0

4.5 SPECIFICATION DEVELOPMENT

A performance-related special provision for calcium aluminate cement concrete was developed for the Illinois Tollway (Tollway) based on this research program. The specification combines both prescriptive and performance tools to ensure that a high-quality patching material is used Tollway's projects.

The provision was developed taking into account the main conclusions of this research program. In order to ensure rapid early-age strength development, the minimum of 700 lbs. per cubic yard of CAC is required while the maximum w/cm is set to 0.35. The use of both latex and saturated lightweight aggregate is required to ensure volumetric stability and to prevent early-age cracking. Time to cracking determined according to ASTM C1581 should not be less than 14 days, and the minimum compressive strength should be 2500 psi in 4 hours when applied to pavement repairs of 4000 psi in 6 hours when applied to bridge deck repairs. The full document is attached to this report in Appendix N.

4.6 FIELD TRIALS

A field trial was conducted on the morning of September 25, 2016 by placing a mixture containing saturated lightweight aggregate. Two patches were placed in continuously reinforced concrete as part of the bridge structure and approach over North River Road in the open road toll lanes of east bound Interstate 90. The final proportions are included in Table 4-17.

Table 4-17 – Field Trials 2016 - Mixture Proportions

Mix ID:	**ALW4-Field**
Date Fabricated:	9/25/2016
Material	
Kerneos Calcium Aluminate Cement Norfolk, VA	700
LaFarge Fox River, Elgin, IL (3210501)	1480
Meyer Material Co. McHenry IL	--
Lafarge, South Chicago, #444 Lightweight	1017
Potable Water, Skokie, IL	236
Chemical Admixtures	
Glenium 7500	--
Styrofan 1186	283.4
GCX-500 Accelerator2	29.9
MasterLife SRA	--
MasterSet Delvo	--
w/cm (accounting for water in admixtures)	0.45

4.6.1 AGGREGATE PREPARATION

The free moisture (above SSD) as measured by the tollway was 19.6% using the Indiana DOT centrifuge method[26]. The total moisture was 40.2% and the absorption of the aggregate was 17.2%. The contractor reported they prepared the aggregate by storing it in a material hauler with a running water hose from the time of receiving the material (~36 hours before placement)

26 Indiana Department of Transportation: Office of Materials Management ITM 222-15T “Specific Gravity Factor and Absorption of Lightweight Fine Aggregate”

until preparing the aggregate for placement in his volumetric batching truck (~2 hours before placement).

4.6.2 CONCRETE PLACEMENT

The batching truck arrived on site with water leaking from the bottom of the lightweight aggregate bin. The contractor cut back the latex dose to control the slump of the concrete. The latex dose, averaged for all material placed, was 15.5 gallons/yd. The measured air content was 3.9% and the temperature of the concrete was 73°F. The ambient temperature at the time of placement was 68°F. The first patch location measured 5x26-feet by 13-14in. deep. The concrete for this patch was placed in 25 minutes. The contractor reported he increased the latex dose halfway through the placement to compensate for the change in workability of the material due to the gradient in aggregate moisture in the bin. The second patch location measured 6x12.5-feet by 13-14-inches deep. The concrete for the second patch was placed in 14 minutes. The contractor reported no adjustments were made to the mixture during placement. The 4 hour strength was 4,095 lb/in^2.

4.6.3 RESULTS

Developed specification, as discussed in Section 0, was used for this placement. The concrete producer did not meet the specification requirement in two areas; water content and latex content. Both deviations from the specification are related to the amount of free water in the aggregate. The specification called for a maximum of 256 lb of water per yd^3 and a minimum of 15% latex solids by weight of cement. The contractor added no additional water to the mixture so the deviation from the specification is directly related to the amount of free water on the saturated lightweight aggregate. To meet the specification requirement for latex content, given the chosen latex and cement content, the contractor would have needed to dose latex at ~ 26 gallons/yd^3. The contractor was informed the proper practice with lightweight aggregate is to stop wetting the aggregate 24 hours prior to use and allowing it to drain for the 24 hours before use.

4.7 VOLUMETRIC BATCHING TRUCK CALIBRATION

An on-site calibration of Henry Frerk Sons batching truck was performed in November 2016. Field report from the calibration is attached in Appendix O.

4.8 DISCUSSION AND SUMMARY

4.8.1 PERFORMANCE OF CHEMICAL ADMIXTURES

4.8.1.1 High-Range Water Reducer

A polycarboxylate-based high-range water reducer (HRWR) was utilized during the first two rounds of the laboratory trial. The HRWR was added in an attempt to improve workability but it was found that it did not impact the CAC-based material in that manner. Additionally, the use of polycarboxylate HRWR was found to significantly slow the hydration process and subsequently compressive strength gain development. None of the mixtures with HRWR exhibited compressive strengths greater than 1,000 psi at 4 hours. Moreover, the measured time of setting of the mixture with HRWR (140 minutes) was substantially greater than of the mixture without the admixture (10 minutes).

4.8.1.2 Shrinkage-Reducing Admixture

During the second round of the laboratory trials, the impact of shrinkage-reducing admixture performance of latex-modified concrete was evaluated. The two mixtures with SRA showed no improvement in the ASTM C157 drying shrinkage test performance over the mixtures fabricated in the Phase II of this research program (see Section 3.1.2). Similarly, with cracking ages of seven and five days, no performance enhancement was observed for the ASTM C1581 restrained drying shrinkage test. The results of this round of testing only confirmed the observations made during the Phase II of the study suggesting that the traditional shrinkage-reducing admixtures are not effective with calcium aluminate cement-based systems. Lastly, all mixtures with SRA experienced much slower strength development (only one of the six mixtures containing SRA gained more than 1,000 psi at 4 hours), as well as lower ultimate compressive strength than mixtures without the admixture. The results of this research study suggest that the use of shrinkage-reducing admixtures is not feasible in CAC concretes.

4.8.1.3 Latex

The impact of latex admixture on compressive strength development was evaluated. The results suggested that an increase in the latex dosage can negatively affect both early and ultimate compressive strengths.

4.8.1.4 **Accelerating Admixture**

The accelerating admixture used in this study was used in 1:1 solution with water. An increase in the accelerator dosage leads to a rapid compressive strength gain. However, at the same time, the time to cracking measure in accordance with ASTM C1581 was reduced by approximately 3 days, indicating that an excessive accelerator dosage can promote the drying shrinkage causing volumetric instability of CAC-based systems.

4.8.2 **SATURATED LIGHTWEIGHT AGGREGATE**

The use of saturated lightweight aggregate has shown a significant reduction in the volumetric changes of CAC and latex-modified CAC concrete. Compared to shrinkage-reducing chemical admixtures, the reduction in volumetric changes when using lightweight aggregates for shrinkage mitigation is outstanding. Results of unrestrained and restrained shrinkage have shown significant improvement on the time to cracking in accordance with ASTM C1581 and drying shrinkage in accordance with ASTM C157.

In both cases, the increased shrinkage mitigation is attributed to the increase in relative humidity in the samples due to the presence of the saturated lightweight. As shown in the ASTM C157 test report for mixture ALW4-T 9/6/16, drying shrinkage per ASTM C157 was significantly low during the first 14 days of drying. The drying shrinkage observed past 14 days show a significant increase that suggests that the relative humidity in the samples could start to decrease. These results suggested that volumetric changes in CAC concrete can be significantly mitigated with the use of saturated lightweight aggregates.

5. CONCLUSIONS

A study of the performance of calcium aluminate cement-based concrete for rapid repair applications has provided valuable insight and new direction for patching applications for highway pavements and bridge decks.

- Review of literature and field performance of CAC concrete repairs showed that the process of conversion and volumetric instability are the main challenges for the use CAC concrete. Additionally, the literature review revealed that the early-age shrinkage mechanism in CAC based systems is not well understood.

- Laboratory testing of CAC and latex-modified CAC concrete samples showed that the curing temperature has a significant influence on its mechanical and durability properties. Performance of CAC and latex-modified CAC concrete samples was observed in abrasion, chloride ingress, chloride penetrability, scaling, and freeze-thaw testing.

- Volumetric stability of CAC and latex-modified CAC concrete was significant regardless of the curing conditions and the use of shrinkage-reducing admixtures. The effectiveness of shrinkage reducing admixtures in CAC and latex-modified CAC concrete was not as significant as with portland cement based systems, although some benefit was observed. The slight improvement in performance may be attributed to a reduced hydration rate in the presence of SRA and not the capillary tension mechanism. Additionally, the use of SRA leads to a reduction of both early and ultimate compressive strengths.

- Polycarboxylate-based high-range water reducing admixtures showed significant retarding effects and reduction in compressive strength without improving workability of CAC and latex-modified CAC mixtures.

- The initial workability of CAC and latex-modified CAC mixtures was strongly dependent water (w/c) and latex content. The duration of working time was strongly dependent on temperature and dosage of accelerator. Careful metering of the accelerator dosage, based on ambient temperature during placement, is needed to ensure workability is sufficient for placement. Results also indicate that volume change and cracking tendency increase as accelerator dosage increases. Therefore, a minimum amount of accelerator should be used, optimized to achieve early strength without compromising workability or increasing cracking risk.

- Saturated lightweight aggregate mitigated the early volume instability of CAC and increased the time to cracking. Later age volume change did not improve significantly, indicating the volume change mechanism was delayed. Results suggest that volume change correlates to internal relative humidity but in a manner that differs from portland cement based systems. Further research is needed in this area, both to understand the shrinkage mechanism of CAC-based concrete and to further mitigate the potential for long term cracking.

- The use of latex in CAC-based concrete enhanced its long-term durability, especially considering mixtures cured at elevated temperatures that underwent the conversion process. Specifically for the converted CAC mixtures, latex addition significantly reduced chloride penetrability, and improved performance of these mixtures in freeze-thaw and scaling tests, when compared to hot-cured (converted) CAC mixtures without latex. Additionally, compressive strength of latex-modified CAC mixtures did not decrease due to the conversion process, as opposed to no-latex CAC mixtures that exhibited a significant drop in both short-term and long-term compressive strength values. Therefore, latex is recommended to be used in CAC-based concrete mixtures to ensure that required durability performance and mechanical properties are achieved.

6. REFERENCES

Alonso, M. V. (2011). Compatibility between PCE admixtures and calcium aluminate cement. *13th International Congress on the Chemisty of Cement* (pp. 1-7). Madrid: BRE Press.

American Concrete Pavement Association. (1998). *Concrete Paving Technology: Guidelines for Partial-Depth Spall Repair.* Skokie, IL: American Concrete Pavement Association.

ASTM C 1600. (2011). *Standard Specification for Rapid Hardening Cement.* West Conshohocken, PA: ASTM International.

Banfill, P. G., & Gill, S. M. (1993). Superplasticizers for Ciment Fondu. Part 1: Effects on rheological properties of fresh paste and mortar. *Advances in Cement Research 5(20)*, 131-138.

Barborak, R. (2010). *Calcium Aluminate Cement Concrete (Class CAC Concrete) TxDOT Special Specification SS-4491 Tip Sheet.* Austin, TX: TxDOT Construction and Bridge Divisions.

Barborak, R. (2010). *TxDOT SS-4491 Class CAC Concrete.* Austin, Texas: Texas Department of Transportation.

Barenberg, E. (1980). Rehabilitation of Concrete Pavements by Using Portland Cement Concrete. *Transportation Research Board*, 29-34.

Bushnell-Watson, S. M., & Sharp, J. H. (1986). The Effect of Temperature Upon the Setting Behavior of Refractory Calcium Aluminate Cements. *Cement and Concrete Research*, 875-884.

Campas, S. a. (1998). Calcium Aluminate Cements. In Hewlett, *Lea's Chemistry of Cement and Concrete - 4th Edition* (pp. 711-770). Woburn: Butterworth-Heinemann.

Crammond, N. (1990). Long-term performance of high alumina cement in sulfate-bearing enviroments. *In R. Mangabhai, Calcium aluminate cements*, 208-221.

Dunster, A. M., & Sergi, G. (2008). Carbonation and Reinformcement Corrosion in CAC Concrete. *Calcium Alumiante Cements: Proceedings of the Centenary Conference 2008* (pp. 221-248). Avignon: BRE Press.

Dunster, A., & Holton, I. (2001). A Laboratory Study of the Resistance of CAC Concretes to Chemcial Attack by Sulphate and Alkali Carbonate Solutions. *Calcium Aluminate Cements 2001* (pp. 333-349). Edinburgh: IOM Communications.

Fryda, H. G. (2000). Interaction of Superplasticizers with Calcium Aluminate Cements. *American Concrete Institute - Special Publication SP 195-7*, 91-101.

Gosselin, C., & Scrivener, K. L. (2008). Microstructure Development of Calcium Aluminate Cements Accelerated by Lithium Sulphate. *Calcium Aluminate Cements: Proceedings of the Centenary Conference* (pp. 109-122). Avignon: IHS BRE Press.

Jolin, M., & Gagnon, F. (2008). De-icer Salt Scaling resistance of CAC Concretes Exposed to Various De-icer Salts. *Calcium Aluminate Cements: Proceedings of the Centenary Conference 2008* (pp. 259-266). Avignon: BRE Press.

Mammoliti, L., Bergsma, B. P., & Hansson, C. M. (2008). Corrosion of Rebar in Pore Solutions Simulating Calcium Aluminate Cement. *Calcium Aluminate Cement Proceedings of the Centenary Confernce 2008* (pp. 235-247). Avignon: BRE Press.

Muller. (2010). *Thesis: Conversion & résistance en compression des ciments cT a lu m in a tes de calcium.* Quebec City, Canada: Laval University.

Robson, T. (1962). *High-Alumina Cements and Concretes.* New York: Contractors Record Limited.

Rodger, S. A., & Double, D. (1984). The Chemical Hydration of High-Alumina Cement in the Presence of Accelerating and Retarding Admixtures. *Cement and Concrete Research*, 73-82.

Scrivener. (2003). Calcium Aluminate Cements. In J. a. Newman, *Advanced Concrete Technology* (pp. 2/1-2/30). Oxford: Butterworth-Heinemann.

Scrivener, K. L., & Capmas, A. (1998). Chapter 13 - Calcium Aluminate Cements. In P. C. Hewlett, *Lea's Chemistry of Cement and Concrete - 4th Edition* (pp. 713-782). Woburn: Butterworth-Heinemann.

State of California Deparment of Transportation. (2008). Isolated Partial Depth Concrete Repair. In S. o. (Caltrans), *Maintenance Technical Advisory Guide Volume II - Rigid Pavement Preservation Second Edition* (pp. 7-1 - 7-20). Sacrmento, CA: State of California Deparment of Transportation.

Thomas, M., Yi, H., & Dhole, R. (2008). Durability of CAC Concrete Exposed to Seawater and De-icing Salts. *Calcium Aluminate Cements: Proceedings of the Centenary Conference 2008* (pp. 249-258). Avignon: BRE Press.

Touche, M. (1926). Note sur l' emploi du ciment, Fondu sur la Ligne de Nice a Com.

Ukrainczyk, N., & Rogina, A. (2013). Styrene-butadiene latex modified calcium aluminate cement mortar. *Cement and Concrete Composities*, 16-23.

DO NOT PRINT! FOR TABLE OF CONTENTS ONLY

APPENDIX A

ASTM C192 MIXTURE SUMMARIES

Client:	**Illinois Tollway**	CTLGroup Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technicians:	**N/A**
Report Date:	**8/19/2015**	Approved:	**J. Gajda**

ASTM C 192 Mixture Summary

		Mix ID:	CAC		LCAC	
		Date Fabricated:	*6/26/2014*		*6/26/2014*	
Material	*Source*	S.G.	lb/yd³ (SSD)		lb/yd³ (SSD)	
Cement	*Kerneos Calcium Aluminate Cement Norfolk, VA*	2.95	703		703	
Coarse Aggregate	*Hanson Thorton Quarry Thorton, IL*	2.71	1660		1660	
Fine Aggregate	*Meyer Material Co. Algonquin, IL*	2.67	1316		1316	
Fiber	*N/A*	2.63	0		0	
Water	*Potable*	1.00	113		0	
Chemical Admixtures			fl. oz./cwt (100 lbs of cementitious material)			
Accelerator	*GCX-500 Accelerator*		29.7		59.3	
HRWRA	*GRT Polychem SPC*		11.8		N/A	
Latex	*Styrofan 1186*		N/A		469.8	
AEA	*GRT Polychem AE*		0.7		N/A	
w/cm (including water in admixtures)			0.19		0.20	
			Measured Fresh Properties			
Air Content, %			6.20		3.40	
Slump, in.			9.75		8.25	
Temperature, °F						
Density (unit weight), lb/ft^3			142.3		145.3	

Test	**Test Method**	**Age**	**Test Result**			
Compressive Strength, psi	ASTM C39	**Curing**	**Ambient**	**Heat Cured**	**Ambient**	**Heat Cured**
		2 hour	N/A	N/A	250	N/A
		3 hour	1,890	N/A	1,490	N/A
		4 hour	5,170	N/A	4,150	N/A
		5 hour	5,450	N/A	N/A	N/A
		6 hour	5,600	N/A	4,560	N/A
		8 hour	6,630	N/A	5,280	N/A
		24 hour	6,700	N/A	6,000	N/A
		2 day	6,630	7,070	6,260	6,830
		3 day	6,520	3,650	6,550	5,660
		4 day	6,560	4,650	6,920	6,260
		5 day	7,750	4,820	7,300	6,540
		6 day	8,110	5,770	7,810	7,600
		7 day	8,970	4,540	7,460	6,640
		14 day	8,520	6,070	8,980	8,970
		28 day	9,660	5,730	9,630	10,080
		56 day	9,710	6,940	10,640	10,710
		90 day	N/A	7,200	11,000	11,220
		102 day	10,610	N/A	N/A	N/A

Test	**Test Method**	**Age**	**Test Result**			
Surface Resistivity, kΩ*cm	AASHTO, TP-95	**Curing**	**Ambient**	**Heat Cured**	**Ambient**	**Heat Cured**
		4 hour	25	N/A	20	N/A
		8 hour	33	N/A	38	N/A
		1 day	44	N/A	48	N/A
		2 day	42	21	50	77
		3 day	46	14	72	30
		4 day	51	13	92	31
		5 day	56	15	111	33
		6 day	59	15	128	33
		7 day	61	16	145	34
		14 day	82	31	304	163
		28 day	98	39	523	305
		56 day	81	50	799	571
		90 day	66	62	954	839

Test	**Test Method**	**Age**	**Test Result**			
Drying Shrinkage, %	ASTM C157	**Curing**	**Ambient**	**Heat Cured**	**Ambient**	**Heat Cured**
		4 hours	0.060	N/A	0.076	N/A
		24 hours	0.050	N/A	0.050	N/A
		7 days	0.037	0.023	N/A	0.014

Notes:

1. This report may not be reproduced except in its entirety

Client:	**Illinois Tollway**	CTLGroup Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technicians:	**N/A**
Report Date:	**8/19/2015**	Approved:	**J. Gajda**

ASTM C 192 Mixture Summary

			CAC	LCAC
		Mix ID:	CAC	LCAC
		Date Fabricated:	*6/26/2014*	*6/26/2014*
Material	*Source*	S.G.	lb/yd³ (SSD)	lb/yd³ (SSD)
Cement	*Kerneos Calcium Aluminate Cement Norfolk, VA*	2.95	703	703
Coarse Aggregate	*Hanson Thorton Quarry Thorton, IL*	2.71	1660	1660
Fine Aggregate	*Meyer Material Co. Algonquin, IL*	2.67	1316	1316
Fiber	*N/A*	2.63	0	0
Water	*Potable*	1.00	113	0
Chemical Admixtures			fl. oz./cwt (100 lbs of cementitious material)	
Accelerator	*GCX-500 Accelerator*		29.7	59.3
HRWRA	*GRT Polychem SPC*		11.8	N/A
Latex	*Styrofan 1186*		N/A	469.8
AEA	*GRT Polychem AE*		0.7	N/A
w/cm (including water in admixtures)			0.19	0.20
			Measured Fresh Properties	
Air Content, %			6.20	3.40
Slump, in.			9.75	8.25
Temperature, °F				
Density (unit weight), lb/ft³			142.3	145.3

Test	Test Method		Age	Test Result			
Age at Cracking, days	ASTM C1581		**Curing**	**Ambient**	**Heat Cured**	**Ambient**	**Heat Cured**
			1 day	4.2	N/A	2.3	N/A
Test	**Test Method**		**Age**	**Test Result**			
Abrasion Resistance, inches	ASTM C779		**Curing**	**Ambient**	**Heat Cured**	**Ambient**	**Heat Cured**
				0.031	0.033	0.039	0.028
Test	**Test Method**		**Age**	**Test Result**			
Rapid Chloride Penetrability, coulombs	ASTM C1202		**Curing**	**Ambient**	**Heat Cured**	**Ambient**	**Heat Cured**
			1 day	739	N/A	590	N/A
			11 day	398	1,252	250	516
Test	**Test Method**		**Age**	**Test Result**			
Chloride Diffusion	ASTM C1556		**Curing**	**Ambient**	**Heat Cured**	**Ambient**	**Heat Cured**
		Surface Chloride Content, C_s, *%*	24 hours	0.00	N/A	0.08	N/A
		Calculated Diffusion Coefficient, D_a, *m²/s (x10^{-12})*	24 hours	1.87	N/A	0.99	N/A
		Calculated Diffusion Coefficient, D_a, *in²/yr*	24 hours	1.65	N/A	0.77	N/A
		Surface Chloride Content, C_s, *%*	7 days	0.00	0.00	0.05	0.12
		Calculated Diffusion Coefficient, D_a, *m²/s (x10^{-12})*	7 days	1.58	1.42	0.88	0.42
		Calculated Diffusion Coefficient, D_a, *in²/yr*	7 days	1.05	2.44	0.73	6.41
Test	**Test Method**		**Age**	**Test Result**			
Freeze Thaw Resistance	ASTM C666		**Curing**	**Ambient**	**Heat Cured**	**Ambient**	**Heat Cured**
		Length Change, %	24 hours	0.02	N/A	0.02	N/A
		Mass Change, %	24 hours	0.21	N/A	0.08	N/A
		Relative Dynamic Modulus, RDM	24 hours	98	N/A	98	N/A
		Length Change, %	7 days	0.01	0.02	0.02	0.01
		Mass Change, %	7 days	0.11	-2.41	0.00	-0.20
		Relative Dynamic Modulus, RDM	7 days	95	96	97	97
Test	**Test Method**		**Age**	**Test Result**			
Scaling Resistance	ASTM C672		**Curing**	**Ambient**	**Heat Cured**	**Ambient**	**Heat Cured**
		Cumulative Mass loss, lb/ft² (after 50 cycles)	1 day	0.04	N/A	0.02	N/A
		Visual Scale Rating (after 50 cycles)	1 day	1.50	N/A	1.00	N/A
		Cumulative Mass loss, lb/ft² (after 50 cycles)	7 day	0.03	0.35	0.03	0.04
		Visual Scale Rating (after 50 cycles)	7 day	1.00	3.50	1.00	1.00

Notes:

1. This report may not be reproduced except in its entirety

Client:	**Illinois Tollway**	CTLGroup Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technicians:	**BS/MK/GN**
Report Date:	**October 11, 2016**	Approved:	**B. Birch**

ASTM C 192 Mixture Summary

		Mix ID:	CAC	LCAC	CAC-SRA
		Date Fabricated:	*9/10/2014*	*9/11/2014*	*9/10/2014*
Material	*Source*	S.G		*lb/yd³ (SSD)*	
Cement	*Kerneos Calcium Aluminate Cement*	2.95	702	703	702
Coarse Aggregate	*Fox Valley, IL CM-11*	2.73	1659	1788	1608
Fine Aggregate	*Meyer Material Co. Algonquin, IL*	2.67	1302	1329	1262
Water	*Potable*	1.00	262	28	262
				fl. oz./cwt (100 lbs of cementitious material)	
Accelerator	*GCX-500 Accelerator*		0.0	0.0	0.0
HRWRA	*MasterGlenium® 7500*		11.8	0.0	11.8
Latex Modifier	*Styrofan 1186*		0.0	469.8	0.0
AEA	*MasterAir AE 200*		3.6	0.0	3.6
SRA	*Masterlife SRA 20*		0.0	0.0	36.4
w/cm (accounting for water in admixtures)			0.38	0.20	0.38
				Measured Fresh Properties	
Air Content, %			6.0%	3.4%	5.1%
Slump, in.			8.00	9.50	8.00
Density (unit weight), lb/ft^3			145.2	151.7	148.7
Test	**Test Method**	**Age**			
Compressive Strength, psi	ASTM C39	1 day	5,203	4,403	6,177
		3 day	5,717	6,520	7,247
		5 day	6,283	7,223	7,800
		7 day	6,730	7,340	8,547
		14 day	7,707	8,177	8,983
		28 day	8,113	8,473	9,257

Test	**Test Method**							
Drying Shrinkage, %	ASTM C157	**Curing**	**Heat-Cured**	**Ambient**	**Heat-Cured**	**Ambient**	**Heat Cured**	**Ambient**
		1 day	-0.049	-0.041	-0.039	-0.039	-0.027	-0.032
Test	**Test Method**							
Age at Cracking, days	ASTM C1581		--	2.3	--	N/A (Note 2)	--	6.1

Notes:

1. This report may not be reproduced except in its entirety

2. One sample for ASTM C1581 never cracked. The other two samples cracked at ages of 11.55 and 13.10 days.

CTLGROUP

Client:	**Illinois Tollway**	CTLGroup Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technicians:	**WD, JP**
Report Date:	**October 7, 2016**	Approved:	**B. Birch**

ASTM C 192 Mixture Summary

			Mix ID:	**LCAC**	**LCAC-A**	**LCAC-AD**
			Date Fabricated:	1/21/2016	1/21/2016	1/21/2016
Material	*Source*		*S.G*		*lb/yd³ (SSD)*	
Cement	*Kerneos Calcium Aluminate Cement Norfolk, VA*		*2.95*	700	700	700
Coarse Aggregate	*LaFarge Fox River, Elgin, IL (3210501)*		*2.71*	1,660	1660	1660
Fine Aggregate	*Meyer Material Co. McHenry IL*		*2.67*	1,316	1316	1316
Ligth Weight Fine Aggregate	*Lafarge, South Chicago, #444 Lightweight*		*2.24*	--	--	--
Water	*Potable Water, Skokie, IL*		*1.00*	--	--	--
			S.G		*fl. oz./cwt (100 lbs of cementitious material)*	
HRWRA	*Glenium 7500*		*1.11*	27.9	27.9	27.9
Latex Modifier	*Styrofan 1186*		*1.02*	405.0	405.0	405.0
Accelerator	*GCX-500 Accelerator* [2]		*1.01*	--	29.8	29.8
Hydration Controller	*MasterSet Delvo*		*1.07*	--	--	15.0
Accelerator solids / cement by weight				--	0.0208%	0.0208%
w/cm (accounting for water in admixtures)				0.15	0.17	0.17
Test Method, Standard	**Measured Property**	**Curing Environment**	**Age**		**Test Result**	
Compressive Strength	Compressive Strength, psi		4 hrs	0	0	0
ASTM C39			5 hrs	--	--	--
		Concrete laboratory	6 hrs	0	830	80
		Mold, 73°F	23 hrs	120	--	--
			24 hrs	--	8,080	6,620
			31 hrs	770	--	--
			8 hrs	0	4,520	0
			22 hrs	0	--	--
		Cold room	29 hrs	--	--	3,270
		Mold, 42.5°F	31 hrs	600	--	--
			32 hrs	--	8,600	--
			2 days	7,790	--	6,770
Hardened Air Void Analysis	Air Void Content, %	Drying room		1.8	1.4	2.3
ASTM C457	Spacing Factor, in.	73°F, 50% RH	7 days	0.020	0.015	0.023
	Specific Surface, 1/in			390	537	310

Notes:
1. This report may not be reproduced except in its entirety
2. GCX-500 Accelerator was diluted 1:1 with tap water, as per Henry Frerk Sons field placements. The dose reported is of the diluted admixture.

Client: **Illinois Tollway**
Project: **Calcium Aluminate Cement Project**
Contact: **Steve Gillen**
Report Date: **October 7, 2016**

CTLGroup Project No: **057177**
CTLGroup Project Mgr.: **M. D'Ambrosia**
Technicians: **WD, JP**
Approved: **B. Birch**

ASTM C 192 Mixture Summary

			Mix ID:	**ASRA**	**ASRA (Mix 1 - Mix 5)**	**ASRA (Mix A)**	**ASRA (Mix B)**	**ASRA (Mix C)**	**ASRA2**
			Date Fabricated:	2/19/2016	2/19/2016	2/26/2016	2/26/2016	2/26/2016	3/8/2016
Material	*Source*		*S.G*			*lb/yd³ (SSD)*			
Cement	*Kerneos Calcium Aluminate Cement Norfolk, VA*		*2.95*	700	700	700	700	700	700
Coarse Aggregate	*LaFarge Fox River, Elgin, IL (3210501)*		*2.71*	1660	1660	1660	1660	1660	1660
Fine Aggregate	*Meyer Material Co. McHenry IL*		*2.67*	1316	1316	1316	1316	1316	1316
Ligth Weight Fine Aggregate	*Lafarge, South Chicago, #444 Lightweight*		*2.24*	--	--	--	--	--	--
Water	*Potable Water, Skokie, IL*		*1.00*	--	--	39	39	55	98
			S.G			*fl. oz./cwt (100 lbs of cementitious material)*			
HRWRA	*Glenium 7500*		*1.11*	27.9	51.9	--	--	--	--
Latex Modifier	*Styrofan 1186*		*1.02*	405.0	493.7	493.7	306.3	405.0	310.0
Accelerator	*GCX-500 Accelerator* [2]		*1.01*	29.8	29.8	29.8	29.8	59.6	59.6
Shrinkage Reducer	*MasterLife SRA*		*1.07*	36.3	36.3	36.3	36.3	36.3	36.3
Hydration Controller	*MasterSet Delvo*		*1.07*	--	--	--	--	--	--
Accelerator solids / cement by weight				0.0208%	0.0200%	0.0200%	0.0200%	0.0400%	0.0415%
				120	145	168	197	172	192
w/cm (accounting for water in admixtures)				0.17	0.21	0.24	0.28	0.25	0.27
Test Method, Standard	**Measured Property**	**Curing Environment**	**Age**			**Test Result**			
Compressive Strength ASTM C39	Compressive Strength, psi	Concrete laboratory Mold, 73°F	2 hrs	--	--	--	--	--	220
			3 hrs	--	--	--	--	--	1,120
			4 hrs	580	--	710	700	740	2,130
			5 hrs	--	770	--	--	--	--
			6 hrs	3,560	2,130	2,100	2,390	3,040	2,670
			8 hrs	--	3,050	3,220	3,600	3,910	3,010
			10 hrs	--	--	3,770	--	--	3,940
			24 hrs	--	4,670	3,900	4,770	4,810	4,360
		Drying room 73°F, 50% RH	2 days	--	--	--	--	--	--
			3 days	--	5,570	--	--	--	--
			4 days	--	--	--	--	--	--
			7 days	--	6,820	--	--	--	6,230
			14 days	--	7,890	--	--	--	--
			28 days	--	8,900	--	--	--	7,890
		Cold room Mold, 42.5°F	2 hrs	--	--	--	--	--	200
			3 hrs	--	--	--	--	--	760
			4 hrs	--	--	--	--	--	1,750
			6 hrs	--	--	330	1,450	2,820	2,940
			8 hrs	--	--	1,880	3,910	4,300	3,290
			10 hrs	--	--	3,460	4,260	4,540	4,190
			22 hrs	4,150	--	--	--	--	--
			24 hrs	--	--	4,610	5,150	5,340	4,580
			31 hrs	4,100	--	--	--	--	--
			3 days	--	4,530	--	--	--	--
			7 days	--	--	--	--	--	5,780
			28 days	--	--	--	--	--	6,590
		Hot tank, Limewater, Mold, 122°F	24 hr	--	--	--	--	--	3,750
			7 day	--	5,540	--	--	--	4,310
			28 day	--	5,040	--	--	--	5,500
Time of Setting, ASTM C403	Time of Setting, minutes	N/A	N/A	--	Initial: 140	--	--	--	Initial: 10
		N/A	N/A	--	Final: 165				Final: 30
Drying Shrinkage, ASTM C157	Length Change, %	Limewater bath 73°F/7 days	28 days	--	-0.050	--	--	--	-0.047
Restrained Drying Shrinkage, ASTM C1581	Age at Cracking, days	Mold, 73.4°F/50% RH - 8hrs	N/A	--	7.1	--	--	--	--
		Mold, 73.4°F/50% RH - 24hrs	N/A	--	--	--	--	--	4.7
Rapid Chloride Penetrability, ASTM C1202	Charge Passed, Coulombs	Limewater bath 73°F/28 days	28 days	--	90	--	--	--	296
		Limewater bath 73°F/7 days; 100°F/21 days	28 days	--	149	--	--	--	--
		Limewater bath 73°F/14 days; 100°F/21 days	28 days	--	--	--	--	--	359
Hardened Air Void Analysis ASTM C457	Air Void Content, %	Drying room 73°F, 50% RH	7 days	2.2	--	--	--	--	--
	Spacing Factor, in.			0.028	--	--	--	--	--
	Specific Surface, 1/in			248	--	--	--	--	--
Freeze Thaw Resistance, ASTM C666	Length Change, %	Limewater bath 73°F/14 days	N/A		0.019				0.018
	Mass Change, %			--	0.06	--	--	--	-0.04
	RDM, %				95				95
	Length Change, %	Limewater bath 122°F/14 days	N/A		0.018				0.018
	Mass Change, %			--	0.01	--	--	--	-0.04
	RDM, %				95				95
Scaling Resistance , ASTM C672	Cumulative Mass Loss, lb/ft²	73°F/50% RH 14 days, Limewater bath - 100°F/14	N/A	--	0.00	--	--	--	0.00
	Visual Scale Rating			--	0	--	--	--	0

Notes:
1. This report may not be reproduced except in its entirety
2. GCX-500 Accelerator was diluted 1:1 with tap water, as per Henry Frerk Sons field placements. The dose reported is of the diluted admixture.

Client: **Illinois Tollway**
Project: **Calcium Aluminate Cement Project**
Contact: **Steve Gillen**
Report Date: **October 7, 2016**

CTLGroup Project No: **057177**
CTLGroup Project Mgr.: **M. D'Ambrosia**
Technicians: **WD, JP**
Approved: **B. Birch**

ASTM C 192 Mixture Summary

			Mix ID:	**ALW**	**ALW2**	**ALW3**	**ALW4**	**ALW5**	**ALW4-T**	**ALW4-Field**
			Date Fabricated:	6/3/2016	8/30/2016	8/30/2016	9/2/2016	9/2/2016	9/6/2016	9/25/2016
Material	*Source*		*S.G*				*lb/yd³ (SSD)*			
Cement	*Kerneos Calcium Aluminate Cement Norfolk, VA*		*2.95*	700	700	700	700	750	700	700
Coarse Aggregate	*LaFarge Fox River, Elgin, IL (3210501)*		*2.71*	1660	1660	1550	1450	1450	1480	1480
Fine Aggregate	*Meyer Material Co. McHenry IL*		*2.67*	738	--	--	--	--	--	--
Ligth Weight Fine Aggregate	*Lafarge, South Chicago, #444 Lightweight*		*2.24*	470	935	1131	1063	1063	961	1017
Water	*Potable Water, Skokie, IL*		*1.00*	51	225	195	195	179	47	236
			S.G			*fl. oz./cwt (100 lbs of cementitious material)*				
HRWRA	*Glenium 7500*		*1.11*	--	--	--	--	--	--	--
Latex Modifier	*Styrofan 1186*		*1.02*	493.7	493.7	493.7	493.7	493.7	508.3	283.4
Accelerator	*GCX-500 Accelerator* [2]		*1.01*	29.8	29.8	29.8	29.8	29.8	20.0	29.9
Shrinkage Reducer	*MasterLife SRA*		*1.07*	--	--	--	--	--	--	--
Hydration Controller	*MasterSet Delvo*		*1.07*	--	--	--	--	--	--	--
Accelerator solids / cement by weight				0.0208%	0.0208%	0.0208%	0.0208%	0.0208%	0.0139%	0.0208%
				180	354	324	324	317	176	
w/cm (accounting for water in admixtures)				0.26	0.51	0.46	0.46	0.42	0.25	0.45
Test Method, Standard	**Measured Property**	**Curing Environment**	**Age**				**Test Result**			
Compressive Strength[3] ASTM C39	Compressive Strength, psi	Concrete laboratory Mold, 73°F	3 hrs	460	--	--	--	--	--	--
			4 hrs	3,290	1,820	1,620	2,230	1,990	3,800	4,095
			5 hrs	4,240	--	--	--	--	4,160	--
			6 hrs	--	--	--	--	--	4,530	--
			24 hrs	5,440	2,300	2,120	2,920	2,670	5,120	--
		Drying room 73°F, 50% RH	2 days	--	2,780	2,610	--	--	--	--
			4 days	--	--	--	3,540	3,360	5,890	--
			7 days	--	3,560	3,340	3,890	3,700	6,290	--
			14 days	--	--	--	--	--	6,980	--
			28 days	--	--	--	--	--	7,640	--
		Cold room Mold, 42.5°F	4 hrs	--	--	--	--	--	3,600	--
			5 hrs	--	--	--	--	--	4,540	--
			6 hrs	--	--	--	--	--	4,880	--
Drying Shrinkage, ASTM C157	Length Change, %	Limewater bath 73°F/7 days	28 days	-0.055	--	--	--	--	-0.051 @ 21 days	--
Restrained Drying Shrinkage, ASTM C1581	Age at Cracking, days	Mold, 73.4°F/50% RH - 8hrs	N/A	--	--	--	--	--	--	--
		Mold, 73.4°F/50% RH - 24hrs	N/A	>28.1	--	--	--	--	>31	--
Rapid Chloride Penetrability, ASTM C1202	Charge Passed, Coulombs	Limewater bath 73°F/28 days	28 days	--	--	--	--	--	330	--
		Limewater bath 73°F/7 days; 100°F/21 days	28 days	--	--	--	--	--	497	--
Hardened Air Void Analysis ASTM C457	Air Void Content, %	Drying room 73°F, 50% RH	7 days	--	--	--	--	--	3.3	--
	Spacing Factor, in.			--	--	--	--	--	0.011	--
	Specific Surface, 1/in			--	--	--	--	--	627	--
Freeze Thaw Resistance, ASTM C666	Length Change, % Mass Change, % RDM, %	Limewater bath 73°F/14 days	N/A	--	--	--	--	--	0.005 @ 72 0.05 @ 72 97 @ 72	--
Scaling Resistance, ASTM C672	Cumulative Mass Loss, lb/ft² Visual Scale Rating	73°F/50% RH 14 days, Limewater bath - 100°F/14	N/A	--	--	--	--	--	0 @ 0 cycles *Due 12/13/16*	--

Notes:
1. This report may not be reproduced except in its entirety
2. GCX-500 Accelerator was diluted 1:1 with tap water, as per Henry Frerk Sons field placements. The dose reported is of the diluted admixture.
3. ALW4-Field ASTM C39 test performed by others and reported to CTLGroup.

Client:	**Illinois Tollway**
Project:	**Calcium Aluminate Cement Project**
Contact:	**Steve Gillen**
Report Date:	**October 7, 2016**
CTLGroup Project No:	**057177**
CTLGroup Project Mgr.:	**M. D'Ambrosia**
Technicians:	**WD, JP**
Approved:	**B. Birch**

ASTM C 192 Mixture Summary

			Mix ID:	**LCAC**	**LCAC-A**	**LCAC-AD**
			Date Fabricated:	1/21/2016	1/21/2016	1/21/2016
Material	*Source*		*S.G*		*lb/yd³ (SSD)*	
Cement	*Kerneos Calcium Aluminate Cement Norfolk, VA*		*2.95*	700	700	700
Coarse Aggregate	*LaFarge Fox River, Elgin, IL (3210501)*		*2.71*	1,660	1660	1660
Fine Aggregate	*Meyer Material Co. McHenry IL*		*2.67*	1,316	1316	1316
Ligth Weight Fine Aggregate	*Lafarge, South Chicago, #444 Lightweight*		*2.24*	--	--	--
Water	*Potable Water, Skokie, IL*		*1.00*	--	--	--
			S.G	*fl. oz./cwt (100 lbs of cementitious material)*		
HRWRA	*Glenium 7500*		*1.11*	27.9	27.9	27.9
Latex Modifier	*Styrofan 1186*		*1.02*	405.0	405.0	405.0
Accelerator	*GCX-500 Accelerator* [2]		*1.01*	--	29.8	29.8
Hydration Controller	*MasterSet Delvo*		*1.07*	--	--	15.0
Accelerator solids / cement by weight				--	0.0208%	0.0208%
w/cm (accounting for water in admixtures)				0.15	0.17	0.17
Test Method, Standard	**Measured Property**	**Curing Environment**	**Age**		**Test Result**	
Compressive Strength ASTM C39	Compressive Strength, psi	Concrete laboratory Mold, 73°F	4 hrs	0	0	0
			5 hrs	--	--	--
			6 hrs	0	830	80
			23 hrs	120	--	--
			24 hrs	--	8,080	6,620
			31 hrs	770	--	--
		Cold room Mold, 42.5°F	8 hrs	0	4,520	0
			22 hrs	0	--	--
			29 hrs	--	--	3,270
			31 hrs	600	--	--
			32 hrs	--	8,600	--
			2 days	7,790	--	6,770
Hardened Air Void Analysis ASTM C457	Air Void Content, %	Drying room 73°F, 50% RH	7 days	1.8	1.4	2.3
	Spacing Factor, in.			0.020	0.015	0.023
	Specific Surface, 1/in			390	537	310

Notes:
1. This report may not be reproduced except in its entirety
2. GCX-500 Accelerator was diluted 1:1 with tap water, as per Henry Frerk Sons field placements. The dose reported is of the diluted admixture.

CTLGROUP

Client: **Illinois Tollway**
Project: **Calcium Aluminate Cement Project**
Contact: **Steve Gillen**
Report Date: **October 7, 2016**

CTLGroup Project No: **057177**
CTLGroup Project Mgr.: **M. D'Ambrosia**
Technicians: **WD, JP**
Approved: **B. Birch**

ASTM C 192 Mixture Summary

			Mix ID:	**ASRA**	**ASRA (Mix 1 - Mix 5)**	**ASRA (Mix A)**	**ASRA (Mix B)**	**ASRA (Mix C)**	**ASRA2**
			Date	2/19/2016	2/19/2016	2/26/2016	2/26/2016	2/26/2016	3/8/2016
Material	*Source*		*S.G*	*lb/yd³ (SSD)*					
Cement	*Kerneos Calcium Aluminate Cement Norfolk, VA*		*2.95*	700	700	700	700	700	700
Coarse Aggregate	*LaFarge Fox River, Elgin, IL (3210501)*		*2.71*	1660	1660	1660	1660	1660	1660
Fine Aggregate	*Meyer Material Co. McHenry IL*		*2.67*	1316	1316	1316	1316	1316	1316
Ligth Weight Fine Aggregate	*Lafarge, South Chicago, #444 Lightweight*		*2.24*	--	--	--	--	--	--
Water	*Potable Water, Skokie, IL*		*1.00*	--	--	39	39	55	98
			S.G	*fl. oz./cwt (100 lbs of cementitious material)*					
HRWRA	*Glenium 7500*		*1.11*	27.9	51.9	--	--	--	--
Latex Modifier	*Styrofan 1186*		*1.02*	405.0	493.7	493.7	306.3	405.0	310.0
Accelerator	*GCX-500 Accelerator* [2]		*1.01*	29.8	29.8	29.8	29.8	59.6	59.6
Shrinkage Reducer	*MasterLife SRA*		*1.07*	36.3	36.3	36.3	29.8	59.6	36.3
Hydration Controller	*MasterSet Delvo*		*1.07*	--	--	--	--	--	--
Accelerator solids / cement by weight				0.0208%	0.0200%	0.0200%	0.0200%	0.0400%	0.0415%
				120	145	168	197	172	192
w/cm (accounting for water in admixtures)				0.17	0.21	0.24	0.28	0.25	0.27
Test Method, Standard	**Measured Property**	**Curing Environment**	**Age**	**Test Result**					
Compressive Strength ASTM C39	Compressive Strength, psi	Concrete laboratory Mold, 73°F	2 hrs	--	--	--	--	--	220
			3 hrs	--	--	--	--	--	1,120
			4 hrs	580	--	710	700	740	2,130
			5 hrs	--	770	--	--	--	--
			6 hrs	3,560	2,130	2,100	2,390	3,040	2,670
			8 hrs	--	3,050	3,220	3,600	3,910	3,010
			10 hrs	--	--	3,770	--	--	3,940
			24 hrs	--	4,670	3,900	4,770	4,810	4,360
		Drying room 73°F, 50% RH	2 days	--	--	--	--	--	--
			3 days	--	5,570	--	--	--	--
			4 days	--	--	--	--	--	--
			7 days	--	6,820	--	--	--	6,230
			14 days	--	7,890	--	--	--	--
			28 days	--	8,900	--	--	--	7,890
		Cold room Mold, 42.5°F	2 hrs	--	--	--	--	--	200
			3 hrs	--	--	--	--	--	760
			4 hrs	--	--	--	--	--	1,750
			6 hrs	--	--	330	1,450	2,820	2,940
			8 hrs	--	--	1,880	3,910	4,300	3,290
			10 hrs	--	--	3,460	4,260	4,540	4,190
			22 hrs	4,150	--	--	--	--	--
			24 hrs	--	--	4,610	5,150	5,340	4,580
			31 hrs	4,100	--	--	--	--	--
			3 days	--	4,530	--	--	--	--
			7 days	--	--	--	--	--	5,780
			28 days	--	--	--	--	--	6,590
		Hot tank, Limewater, Mold, 122°F	24 hr	--	--	--	--	--	3,750
			7 day	--	5,540	--	--	--	4,310
			28 day	--	5,040	--	--	--	5,500
Time of Setting, ASTM C403	Time of Setting, minutes	N/A	N/A	--	Initial: 140	--	--	--	Initial: 10
		N/A	N/A	--	Final: 165				Final: 30
Drying Shrinkage, ASTM C157	Length Change, %	Limewater bath 73°F/7 days	28 days	--	-0.050	--	--	--	-0.047
Restrained Drying Shrinkage, ASTM C1581	Age at Cracking, days	Mold, 73.4°F/50% RH - 8hrs	N/A	--	7.1	--	--	--	--
		Mold, 73.4°F/50% RH - 24hrs	N/A	--	--	--	--	--	4.7
Rapid Chloride Penetrability, ASTM C1202	Charge Passed, Coulombs	Limewater bath 73°F/28 days	28 days	--	90	--	--	--	296
		Limewater bath 73°F/7 days; 100°F/21 days	28 days	--	149	--	--	--	--
		Limewater bath 73°F/14 days; 100°F/21 days	28 days	--	--	--	--	--	359
Hardened Air Void Analysis ASTM C457	Air Void Content, %	Drying room 73°F, 50% RH	7 days	2.2	--	--	--	--	--
	Spacing Factor, in.			0.028	--	--	--	--	--
	Specific Surface, 1/in			248	--	--	--	--	--
Freeze Thaw Resistance, ASTM C666	Length Change, %	Limewater bath 73°F/14 days	N/A	--	0.019	--	--	--	0.018
	Mass Change, %				0.06				-0.04
	RDM, %				95				95
	Length Change, %	Limewater bath 122°F/14 days	N/A	--	0.018	--	--	--	0.018
	Mass Change, %				0.01				-0.04
	RDM, %				95				95
Scaling Resistance , ASTM C672	Cumulative Mass Loss, lb/ft²	73°F/50% RH 14 days, Limewater bath - 100°F/14	N/A	--	0.00	--	--	--	0.00
	Visual Scale Rating			--	0	--	--	--	0

Notes:
1. This report may not be reproduced except in its entirety
2. GCX-500 Accelerator was diluted 1:1 with tap water, as per Henry Frerk Sons field placements. The dose reported is of the diluted admixture.

CTLGroup

Client:	**Illinois Tollway**	CTLGroup Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technicians:	**WD, JP**
Report Date:	**January 15, 2017**	Approved:	**B, Birch**

ASTM C 192 Mixture Summary

			Mix ID:	**ALW**	**ALW2**	**ALW3**	**ALW4**	**ALW5**	**ALW4-T**	**ALW4-Field**
			Date Fabricated:	6/3/2016	8/30/2016	8/30/2016	9/2/2016	9/2/2016	9/6/2016	9/25/2016
Material	*Source*		*S.G*				*lb/yd³ (SSD)*			
Cement	*Kerneos Calcium Aluminate Cement Norfolk, VA*		*2.95*	700	700	700	700	750	700	700
Coarse Aggregate	*LaFarge Fox River, Elgin, IL (3210501)*		*2.71*	1660	1660	1550	1450	1450	1480	1480
Fine Aggregate	*Meyer Material Co. McHenry IL*		*2.67*	738	--	--	--	--	--	--
Ligth Weight Fine Aggregate	*Lafarge, South Chicago, #444 Lightweight*		*2.24*	470	935	1131	1063	1063	961	1017
Water	*Potable Water, Skokie, IL*		*1.00*	51	225	195	195	179	47	236
			S.G				*fl. oz./cwt (100 lbs of cementitious material)*			
HRWRA	*Glenium 7500*		*1.11*	--	--	--	--	--	--	--
Latex Modifier	*Styrofan 1186*		*1.02*	493.7	493.7	493.7	493.7	493.7	508.3	283.4
Accelerator	*GCX-500 Accelerator* [2]		*1.01*	29.8	29.8	29.8	29.8	29.8	20.0	29.9
Shrinkage Reducer	*MasterLife SRA*		*1.07*	--	--	--	--	--	--	--
Hydration Controller	*MasterSet Delvo*		*1.07*	--	--	--	--	--	--	--
Accelerator solids / cement by weight				0.0208%	0.0208%	0.0208%	0.0208%	0.0208%	0.0139%	0.0208%
				180	354	324	324	317	176	
w/cm (accounting for water in admixtures)				0.26	0.51	0.46	0.46	0.42	0.25	0.45
Test Method, Standard	**Measured Property**	**Curing Environment**	**Age**				**Test Result**			
ASTM C39		Concrete laboratory Mold, 73°F	3 hrs	460	--	--	--	--	--	--
			4 hrs	3,290	1,820	1,620	2,230	1,990	3,800	4,095
			5 hrs	4,240	--	--	--	--	4,160	--
			6 hrs	--	--	--	--	--	4,530	--
			8 hrs	--	--	--	--	--	--	--
			23 hrs	--	--	--	--	--	--	--
			24 hrs	5,440	2,300	2,120	2,920	2,670	5,120	--
		Drying room 73°F, 50% RH	2 days	--	2,780	2,610	--	--	--	--
			4 days	--	--	--	3,540	3,360	5,890	--
			7 days	--	3,560	3,340	3,890	3,700	6,290	--
			14 days	--	--	--	--	--	6,980	--
			28 days	--	--	--	--	--	7,640	--
		Cold room Mold, 42.5°F	4 hrs	--	--	--	--	--	3,600	--
			5 hrs	--	--	--	--	--	4,540	--
			6 hrs	--	--	--	--	--	4,880	--
Drying Shrinkage, ASTM C157	Length Change, %	Limewater bath 73°F/7 days	28 days	-0.055	--	--	--	--	-0.063 @ 28 days	--
Restrained Drying Shrinkage, ASTM C1581	Age at Cracking, days	Mold, 73.4°F/50% RH - 24hrs	N/A	>28.1	--	--	--	--	>28	--
Rapid Chloride Penetrability, ASTM C1202	Charge Passed, Coulombs	Limewater bath 73°F/28 days	28 days	--	--	--	--	--	330	--
		Limewater bath 73°F/7 days; 100°F/21 days	28 days	--	--	--	--	--	497	--
		Limewater bath 73°F/14 days; 100°F/21 days	28 days	--	--	--	--	--	--	--
Hardened Air Void Analysis ASTM C457	Air Void Content, %	Drying room 73°F, 50% RH	7 days	--	--	--	--	--	3.3	--
	Spacing Factor, in.			--	--	--	--	--	0.011	--
	Specific Surface, 1/in			--	--	--	--	--	627	--
Freeze Thaw Resistance, ASTM C666	Length Change, %	Limewater bath 73°F/14 days	N/A						0.024 @ 300 cycles	
	Mass Change, %			--	--	--	--	--	0.11 @ 300 cycles	--
	RDM, %								94 @ 300 cycles	
Scaling Resistance of Concrete Surfaces Exposed to Deicing	Cumulative Mass Loss, lb/ft²	73°F/50% RH 14 days, Limewater bath - 100°F/14	N/A	--	--	--	--	--	0.00 @ 35 cycles	--
	Visual Scale Rating								0 @ 35 cycles	

Notes:
1. This report may not be reproduced except in its entirety
2. GCX-500 Accelerator was diluted 1:1 with tap water, as per Henry Frerk Sons field placements. The dose reported is of the diluted admixture.
3. ALW4-Field ASTM C39 test performed by others and reported to CTLGroup.

APPENDIX B

ASTM C403 TIME OF SETTING

TEST RESULTS

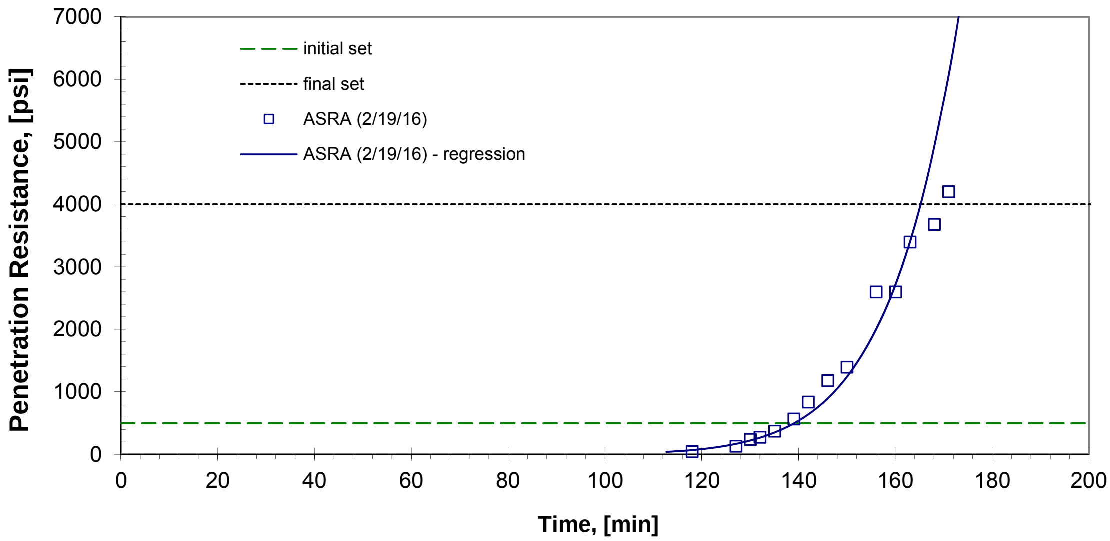
Client:	**Illinois Tollway**	CTLGroup Project No.:	**057177**
Project:	**Research and Development of CAC**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**J. Pycz**
Report Date:	**February 19, 2016**	Approved by:	**M. Salguero**

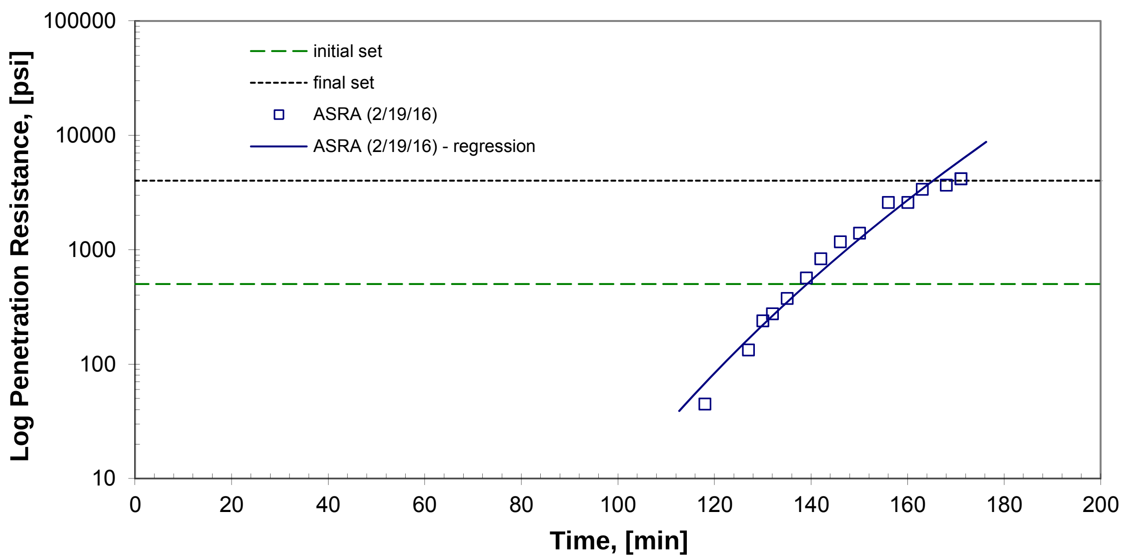
ASTM C403 / C403M - 08
Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance

Mix ID: **ASRA (2/19/16)**

Initial mortar temperature: **74.3**

	[h:m]	[min]
initial set:	2:20	140
final set:	2:45	165





Notes:
1. The sample was stored in a laboratory environment (~73°F) during testing.
2. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTLGroup Project No.:	**057177**
Project:	**Research and Development of CAC**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**J. Pycz**
Report Date:	**March 8, 2016**	Approved by:	

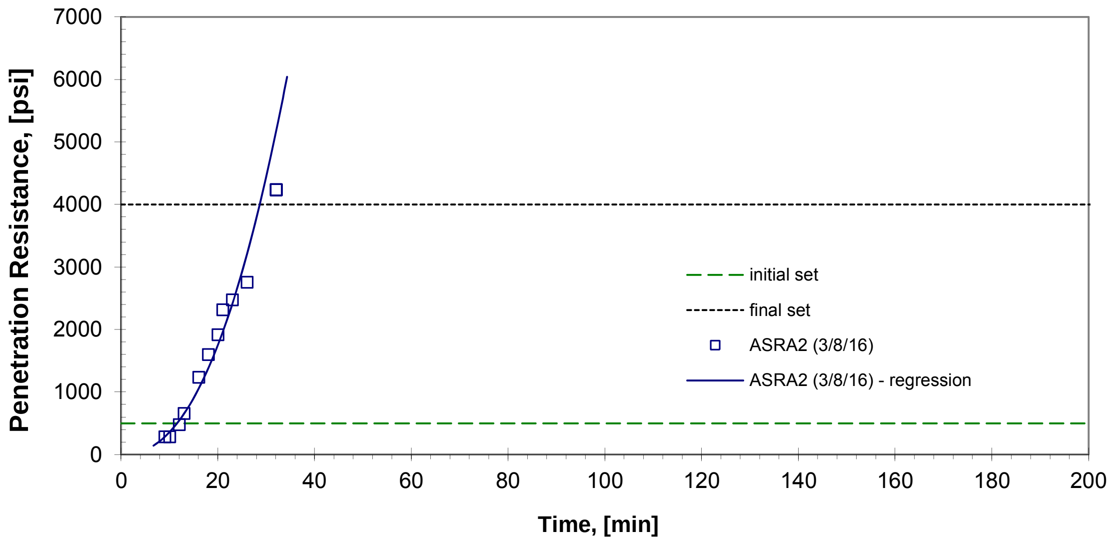
ASTM C403 / C403M - 08

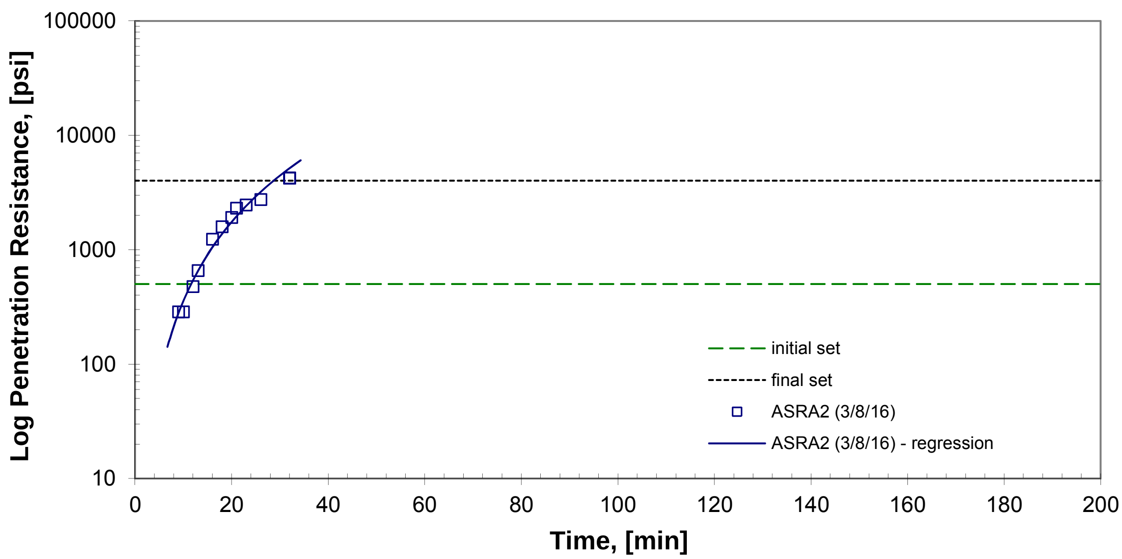
Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance

Mix ID: **ASRA2 (3/8/16)**

Initial mortar temperature: **73.5**

	[h:m]	[min]
initial set:	0:10	10
final set:	0:30	30





Notes:

1. The sample was stored in a laboratory environment (~73°F) during testing.
2. This report may not be reproduced except in its entirety.

APPENDIX C

ASTM C39 COMPRESSIVE STRENGTH

TEST RESULTS

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	6/26/14 11:10	6/26/14 11:14	6/26/14 11:19
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	3	3	3
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.01	4.01	4.03
Diameter 2, in.	4.00	4.00	4.01
Length(without caps), in.	7.92	8.00	7.98
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.00	4.02
Length / Diameter (L/D)	1.97	2.00	1.98
Cross-Sectional Area, in^2	12.63	12.57	12.69

Compressive Strength and Fracture Pattern

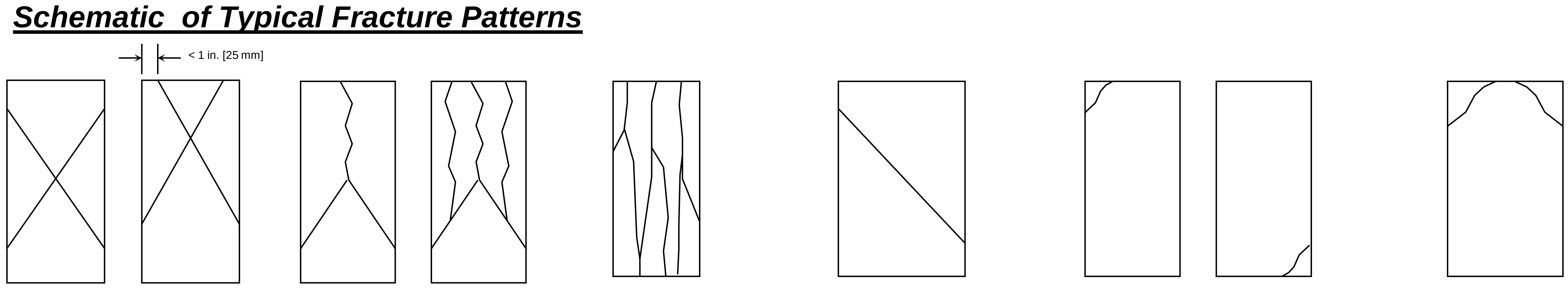
Maximum Load, lb	22,859	23,967	24,876
Compressive Strength, psi	1,810	1,910	1,960
Fracture Pattern	Type 3	Type 6	Type 3

Average Compressive Strength, psi	1,893

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	6/26/14 12:12	6/26/14 12:16	6/26/14 12:19
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	4	4	4
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.02	4.00	4.04
Diameter 2, in.	4.01	3.99	4.02
Length(without caps), in.	8.04	8.00	8.03
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	3.99	4.03
Length / Diameter (L/D)	2.00	2.01	1.99
Cross-Sectional Area, in^2	12.69	12.50	12.76

Compressive Strength and Fracture Pattern

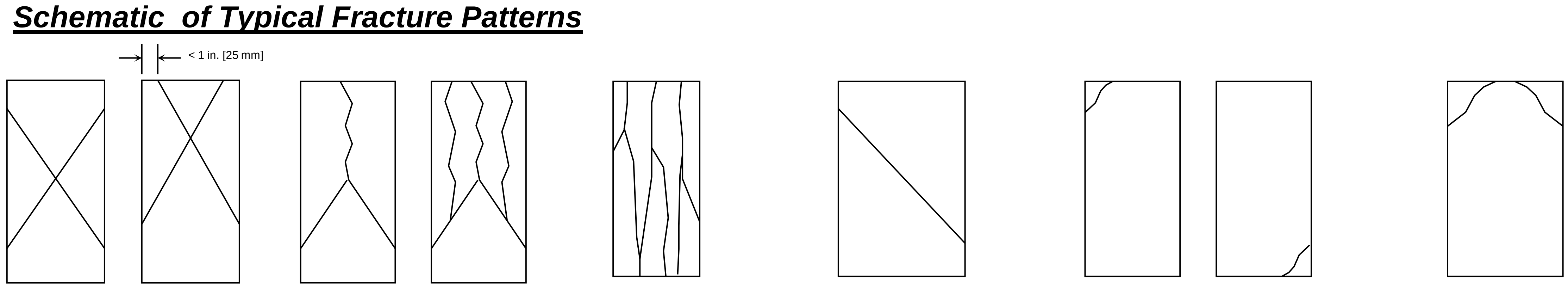
Maximum Load, lb	66,635	63,928	65,879
Compressive Strength, psi	5,250	5,110	5,160
Fracture Pattern	Type 5	Type 6	Type 5

Average Compressive Strength, psi	5,173

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	6/26/14 13:15	6/26/14 13:18	6/26/14 13:21
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	5	5	5
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.00	4.03
Diameter 2, in.	4.02	4.00	4.02
Length(without caps), in.	8.05	8.01	8.03
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.03	4.00	4.02
Length / Diameter (L/D)	2.00	2.00	2.00
Cross-Sectional Area, in^2	12.76	12.57	12.69

Compressive Strength and Fracture Pattern

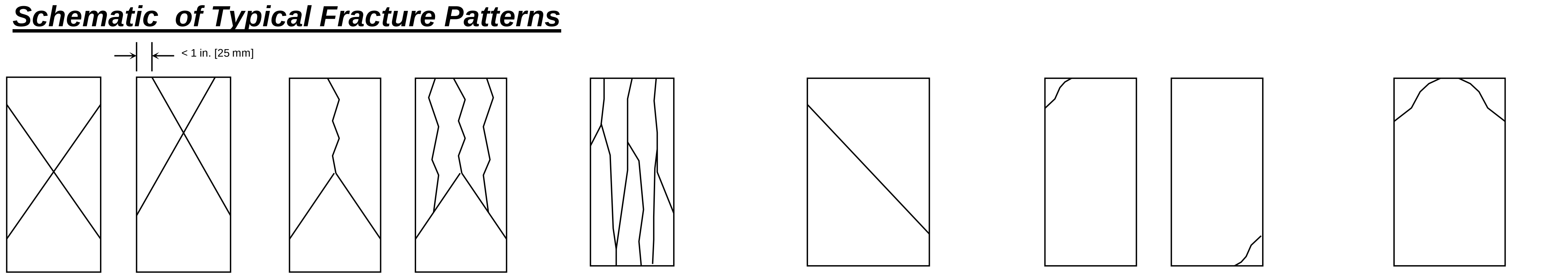
Maximum Load, lb	68,888	67,579	70,834
Compressive Strength, psi	5,400	5,380	5,580
Fracture Pattern	Type 6	Type 5	Type 5

Average Compressive Strength, psi	5,453

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	6/26/14 14:15	6/26/14 14:18	6/26/14 14:21
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	6	6	6
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.01
Diameter 2, in.	4.00	4.02	4.00
Length(without caps), in.	8.01	8.00	8.05
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.02	4.01
Length / Diameter (L/D)	2.00	1.99	2.01
Cross-Sectional Area, in^2	12.57	12.69	12.63

Compressive Strength and Fracture Pattern

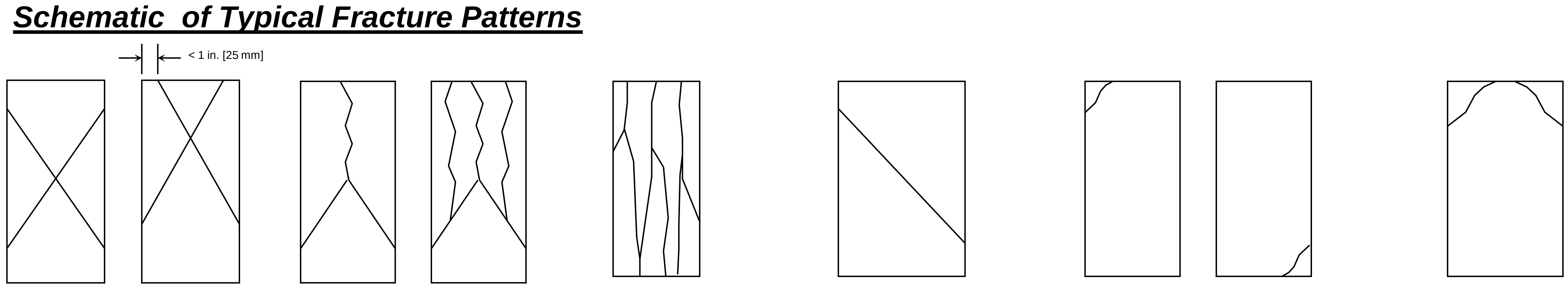
Maximum Load, lb	70,968	69,992	71,126
Compressive Strength, psi	5,650	5,520	5,630
Fracture Pattern	Type 5	Type 5	Type 5

Average Compressive Strength, psi	5,600

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	6/26/14 16:12	6/26/14 16:16	6/26/14 16:19
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	8	8	8
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.02	4.00	4.03
Diameter 2, in.	4.00	3.99	4.02
Length(without caps), in.	8.07	8.01	8.03
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.00	4.03
Length / Diameter (L/D)	2.01	2.00	1.99
Cross-Sectional Area, in^2	12.63	12.57	12.76

Compressive Strength and Fracture Pattern

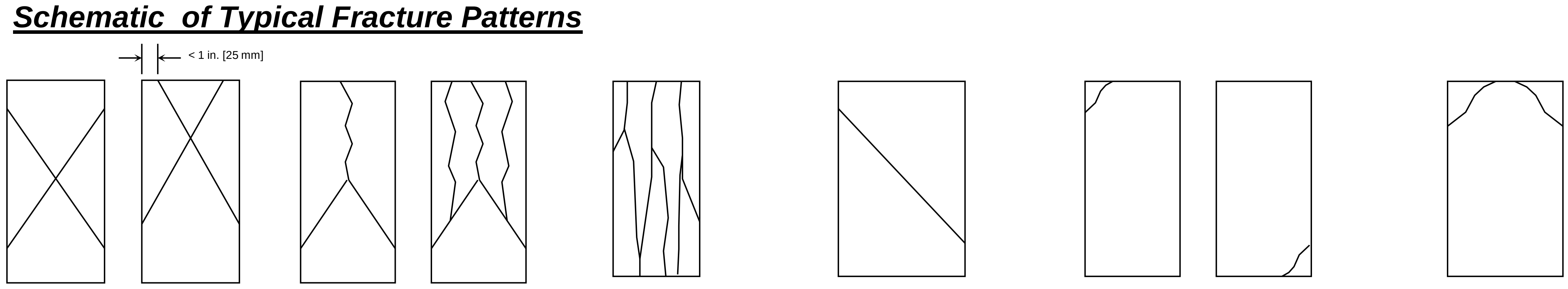
Maximum Load, lb	84,173	85,168	82,168
Compressive Strength, psi	6,660	6,780	6,440
Fracture Pattern	Type 3	Type 3	Type 6

Average Compressive Strength, psi	6,627

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	6/26/14 8:00	6/26/14 8:05	6/26/14 8:09
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	1	1	1
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.00	4.02
Diameter 2, in.	4.01	3.99	4.02
Length(without caps), in.	7.88	7.86	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.00	4.02
Length / Diameter (L/D)	1.96	1.97	1.96
Cross-Sectional Area, in^2	12.69	12.57	12.69

Compressive Strength and Fracture Pattern

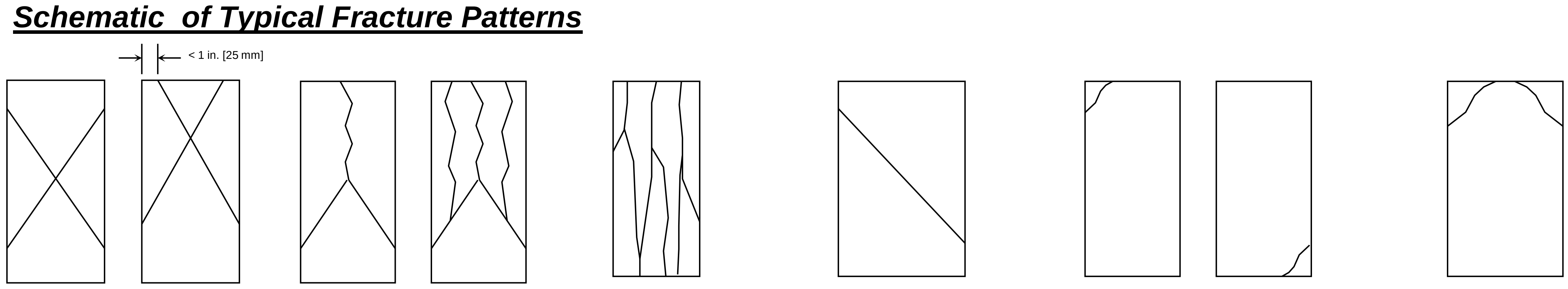
Maximum Load, lb	85,406	84,929	83,786
Compressive Strength, psi	6,730	6,760	6,600
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,697

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	6/28/14 9:00	6/28/14 9:00	6/28/14 9:00
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	2	2	2
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.03	4.01
Diameter 2, in.	3.99	4.01	4.00
Length(without caps), in.	7.90	7.88	7.90
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.02	4.01
Length / Diameter (L/D)	1.98	1.96	1.97
Cross-Sectional Area, in^2	12.57	12.69	12.63

Compressive Strength and Fracture Pattern

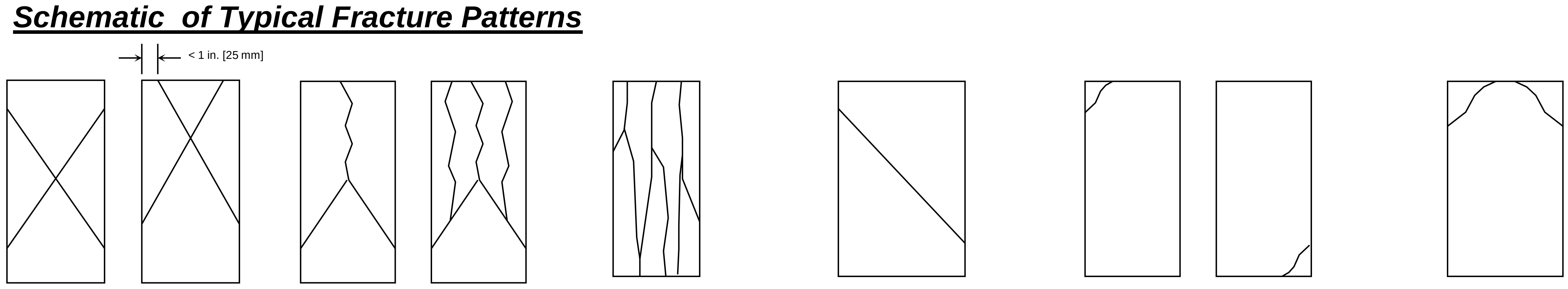
Maximum Load, lb	83,686	84,920	82,623
Compressive Strength, psi	6,660	6,690	6,540
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,630

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	6/29/14 7:45	6/29/14 7:49	6/29/14 7:54
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	3	3	3
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.00	4.00
Diameter 2, in.	3.99	4.01	4.01
Length(without caps), in.	7.84	7.86	7.83
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.01	4.00
Length / Diameter (L/D)	1.95	1.96	1.96
Cross-Sectional Area, in^2	12.63	12.63	12.57

Compressive Strength and Fracture Pattern

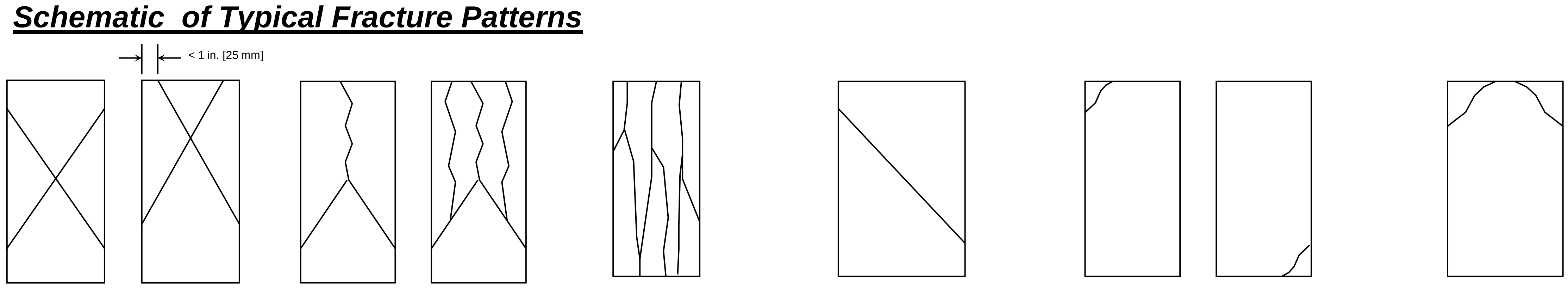
Maximum Load, lb	71,226	88,994	86,379
Compressive Strength, psi	5,640	7,050	6,870
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,520

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	6/30/14 8:30	6/30/14 8:30	6/30/14 8:30
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	4	4	4
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.01	4.01
Diameter 2, in.	3.99	4.01	4.00
Length(without caps), in.	7.90	7.88	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.01	4.01
Length / Diameter (L/D)	1.98	1.96	1.97
Cross-Sectional Area, in^2	12.57	12.63	12.63

Compressive Strength and Fracture Pattern

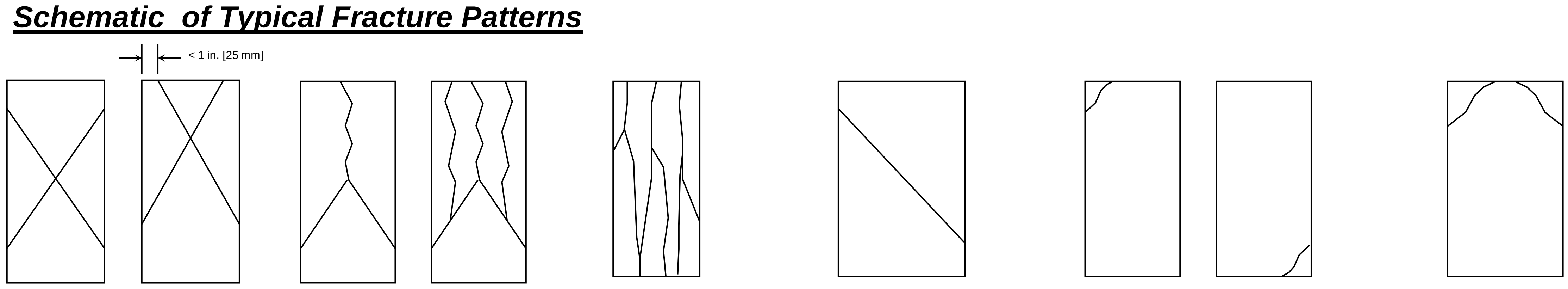
Maximum Load, lb	81,926	83,637	82,724
Compressive Strength, psi	6,520	6,620	6,550
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,563

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	7/1/14 10:30	7/1/14 10:35	7/1/14 10:42
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	5	5	5
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.01	4.03
Diameter 2, in.	4.01	3.99	4.01
Length(without caps), in.	7.87	7.89	7.87
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.00	4.02
Length / Diameter (L/D)	1.96	1.97	1.96
Cross-Sectional Area, in^2	12.69	12.57	12.69

Compressive Strength and Fracture Pattern

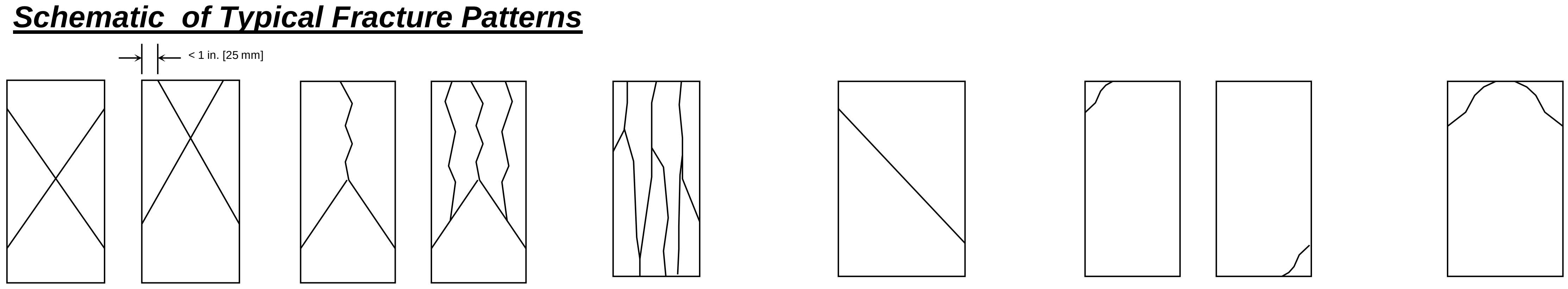
Maximum Load, lb	96,802	99,345	97,841
Compressive Strength, psi	7,630	7,900	7,710
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	7,747

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	7/2/14 15:41	7/2/14 15:44	7/2/14 15:48
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	6	6	6
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground & Sulfur	Ground & Sulfur	Ground & Sulfur

Concrete Dimensions

Diameter 1, in.	4.06	3.96	4.03
Diameter 2, in.	4.00	4.01	4.01
Length(without caps), in.	7.86	7.96	7.79
Length(with caps), in.	8.03	8.13	7.94
Average Diameter, in.	4.03	3.98	4.02
Length / Diameter (L/D)	1.99	2.04	1.97
Cross-Sectional Area, in^2	12.76	12.44	12.69

Compressive Strength and Fracture Pattern

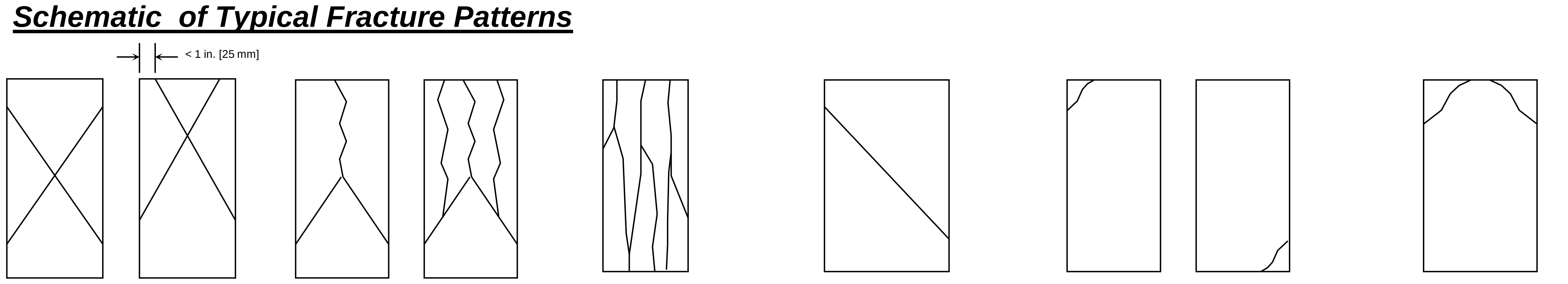
Maximum Load, lb	99,752	103,316	104,018
Compressive Strength, psi	7,820	8,310	8,200
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	8,110

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	7/3/14 10:00	7/3/14 10:06	7/3/14 10:12
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	7	7	7
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.00	4.03
Diameter 2, in.	4.00	3.99	4.03
Length(without caps), in.	7.87	7.90	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.00	4.03
Length / Diameter (L/D)	1.96	1.98	1.95
Cross-Sectional Area, in^2	12.63	12.57	12.76

Compressive Strength and Fracture Pattern

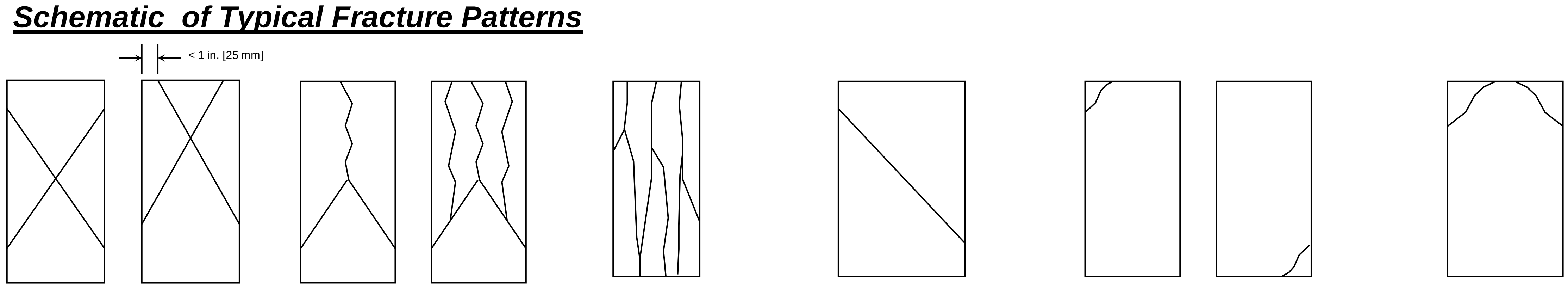
Maximum Load, lb	112,961	114,567	113,281
Compressive Strength, psi	8,940	9,110	8,880
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	8,977

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	7/10/14 9:03	7/10/14 9:09	7/10/14 9:14
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	14	14	14
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.01	4.01
Diameter 2, in.	4.01	3.99	4.01
Length(without caps), in.	7.88	7.91	7.90
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.00	4.01
Length / Diameter (L/D)	1.96	1.98	1.97
Cross-Sectional Area, in^2	12.69	12.57	12.63

Compressive Strength and Fracture Pattern

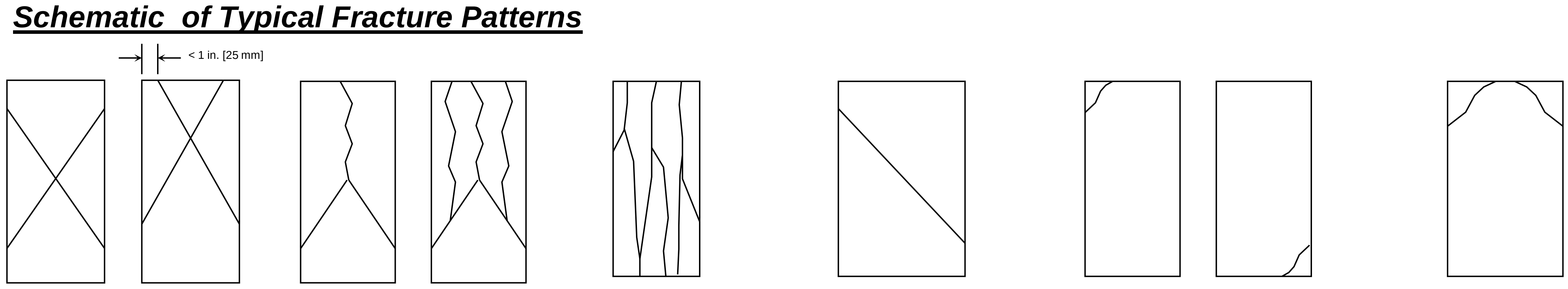
Maximum Load, lb	108,764	107,074	106,921
Compressive Strength, psi	8,570	8,520	8,470
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	8,520

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

CTLGroup

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

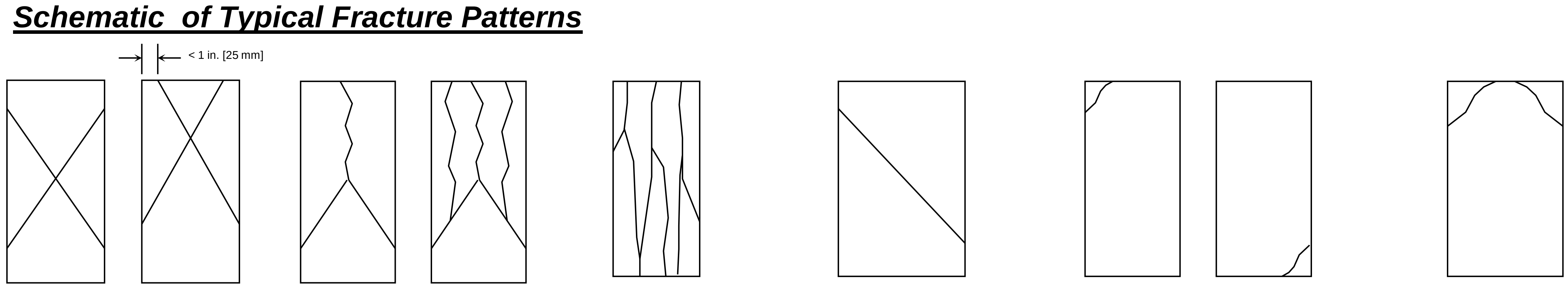
Specimen Identification			
CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	7/24/14 11:36	7/24/14 11:44	7/24/14 11:53
Loading Rate, psi/sec	35	35	35
Concrete Description			
Concrete Age at Test, days	28	28	28
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground	Ground	Ground
Concrete Dimensions			
Diameter 1, in.	4.00	4.03	4.02
Diameter 2, in.	3.99	4.02	4.01
Length(without caps), in.	7.90	7.92	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.02	4.02
Length / Diameter (L/D)	1.97	1.97	1.96
Cross-Sectional Area, in^2	12.57	12.69	12.69
Compressive Strength and Fracture Pattern			
Maximum Load, lb	120,830	121,826	123,868
Compressive Strength, psi	9,610	9,600	9,760
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	9,657

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	8/21/14 11:46	8/21/14 11:53	8/21/14 12:04
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	56	56	56
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.01	4.02
Diameter 2, in.	4.02	4.01	4.01
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.03	8.06	8.05
Average Diameter, in.	4.02	4.01	4.02
Length / Diameter (L/D)	2.00	2.01	2.00
Cross-Sectional Area, in^2	12.69	12.63	12.69

Compressive Strength and Fracture Pattern

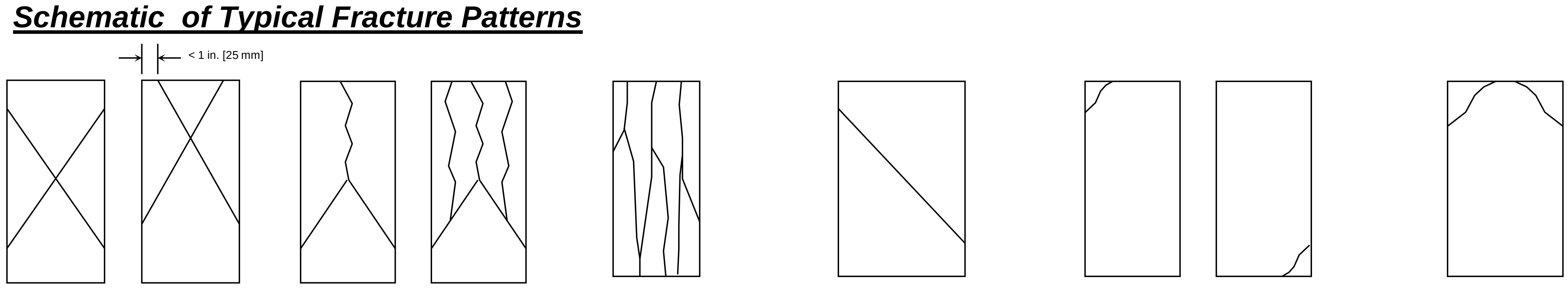
Maximum Load, lb	124,582	121,797	122,787
Compressive Strength, psi	9,820	9,640	9,680
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	9,713

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	9/24/14 15:20	9/24/14 15:27	9/24/14 15:34
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	90	90	90
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground & Sulfur	Ground & Sulfur	Ground & Sulfur

Concrete Dimensions

Diameter 1, in.	4.01	4.02	4.01
Diameter 2, in.	3.99	4.02	4.01
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.17	8.19	8.18
Average Diameter, in.	4.00	4.02	4.01
Length / Diameter (L/D)	2.04	2.04	2.04
Cross-Sectional Area, in^2	12.57	12.69	12.63

Compressive Strength and Fracture Pattern

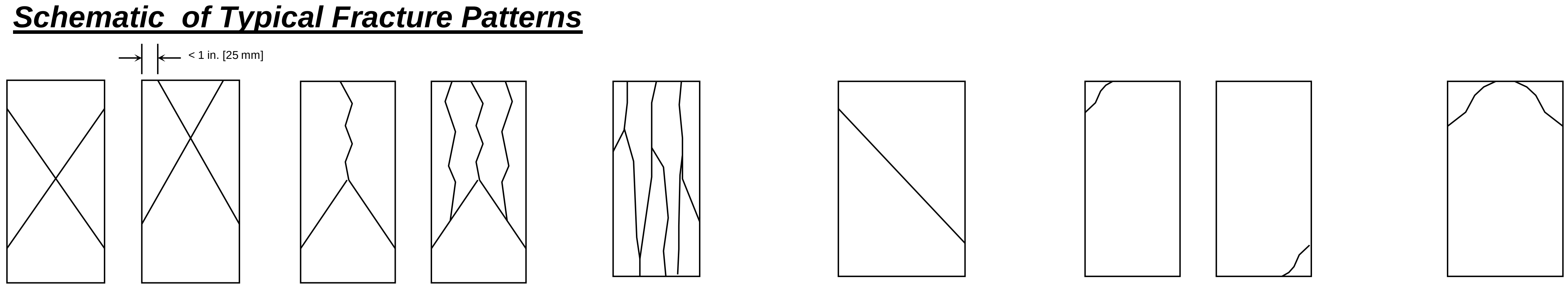
Maximum Load, lb	103,926	105,519	102,157
Compressive Strength, psi	8,270	8,320	8,090
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	8,227

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	10/6/14 13:30	10/6/14 13:45	10/6/14 14:00
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	102	102	102
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground & Sulfur	Ground & Sulfur	Ground & Sulfur

Concrete Dimensions

Diameter 1, in.	4.03	4.02	4.03
Diameter 2, in.	4.01	4.00	4.03
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.08	8.07	8.08
Average Diameter, in.	4.02	4.01	4.03
Length / Diameter (L/D)	2.01	2.01	2.01
Cross-Sectional Area, in^2	12.69	12.63	12.76

Compressive Strength and Fracture Pattern

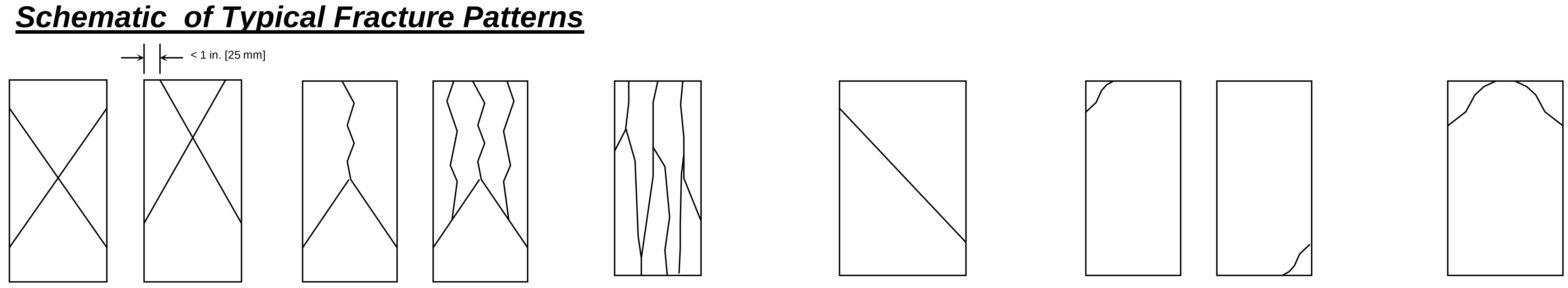
Maximum Load, lb	132,297	149,681	121,815
Compressive Strength, psi	10,430	11,850	9,550
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	10,610

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC Hot	CAC Hot	CAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	6/28/14 9:30	6/28/14 9:30	6/28/14 9:30
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	2	2	2
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Water tank at 122°F	Water tank at 122°F	Water tank at 122°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.01
Diameter 2, in.	4.00	4.03	4.00
Length(without caps), in.	7.88	7.87	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.03	4.01
Length / Diameter (L/D)	1.97	1.95	1.97
Cross-Sectional Area, in^2	12.57	12.76	12.63

Compressive Strength and Fracture Pattern

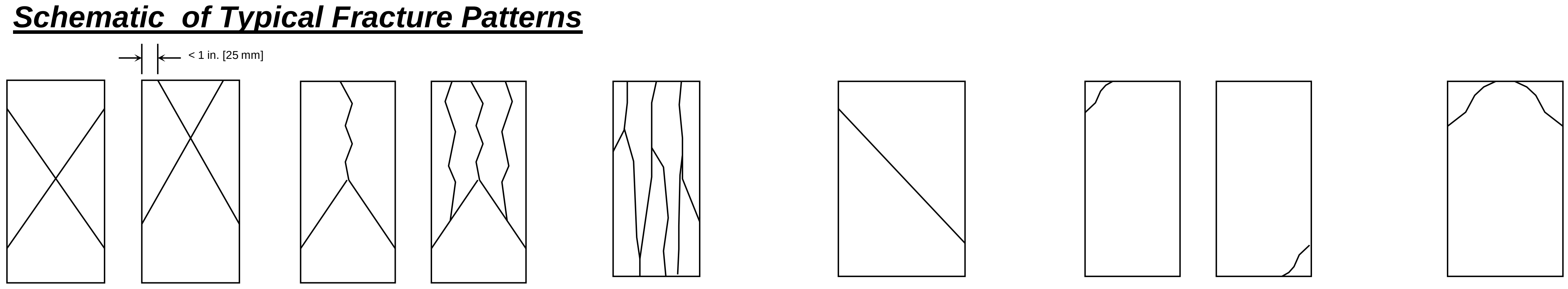
Maximum Load, lb	89,945	89,833	88,684
Compressive Strength, psi	7,160	7,040	7,020
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	7,073

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC Hot	CAC Hot	CAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	6/29/14 8:12	6/29/14 8:14	6/29/14 8:17
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	3	3	3
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Water tank at 122°F	Water tank at 122°F	Water tank at 122°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.02	4.01
Diameter 2, in.	4.00	3.99	4.01
Length(without caps), in.	7.85	7.88	7.92
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.01	4.01
Length / Diameter (L/D)	1.96	1.97	1.98
Cross-Sectional Area, in^2	12.57	12.63	12.63

Compressive Strength and Fracture Pattern

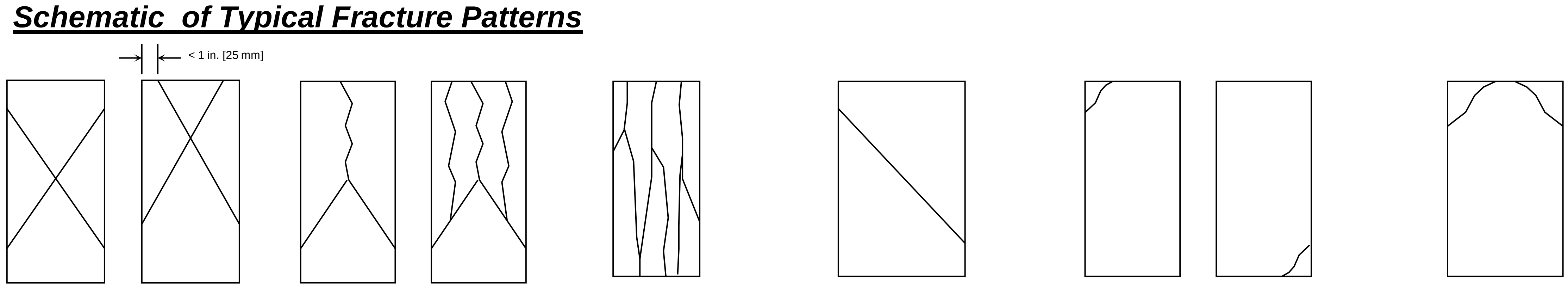
Maximum Load, lb	50,545	37,986	49,365
Compressive Strength, psi	4,020	3,010	3,910
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	3,647

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC Hot	CAC Hot	CAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	6/30/14 9:30	6/30/14 9:30	6/30/14 9:30
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	4	4	4
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Water tank at 122°F	Water tank at 122°F	Water tank at 122°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.01	4.03
Diameter 2, in.	4.02	4.00	4.02
Length(without caps), in.	7.91	7.88	7.87
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.03	4.00	4.02
Length / Diameter (L/D)	1.96	1.97	1.96
Cross-Sectional Area, in^2	12.76	12.57	12.69

Compressive Strength and Fracture Pattern

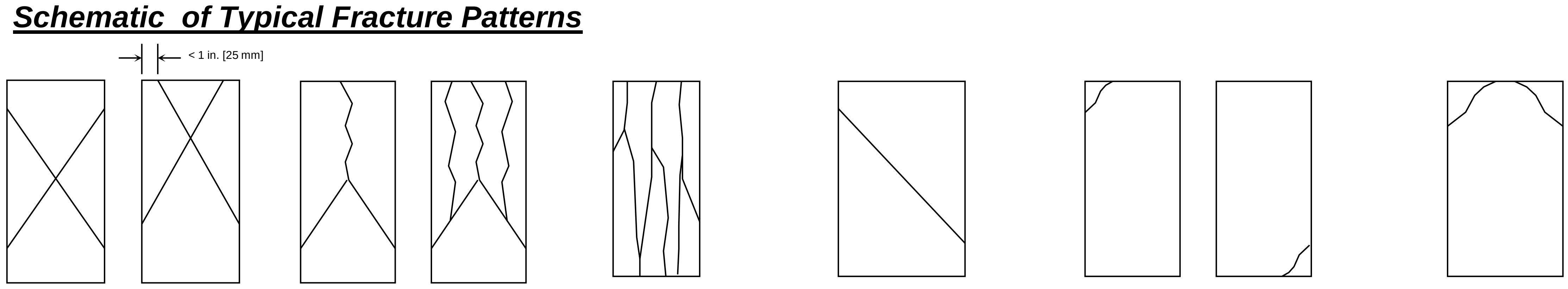
Maximum Load, lb	59,031	59,230	58,454
Compressive Strength, psi	4,630	4,710	4,610
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	4,650

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC Hot	CAC Hot	CAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	7/1/14 11:09	7/1/14 11:16	7/1/14 11:22
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	5	5	5
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Water tank at 122°F	Water tank at 122°F	Water tank at 122°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.01	4.03
Diameter 2, in.	4.02	4.00	4.02
Length(without caps), in.	7.88	7.91	7.92
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.03	4.01	4.02
Length / Diameter (L/D)	1.95	1.97	1.97
Cross-Sectional Area, in^2	12.76	12.63	12.69

Compressive Strength and Fracture Pattern

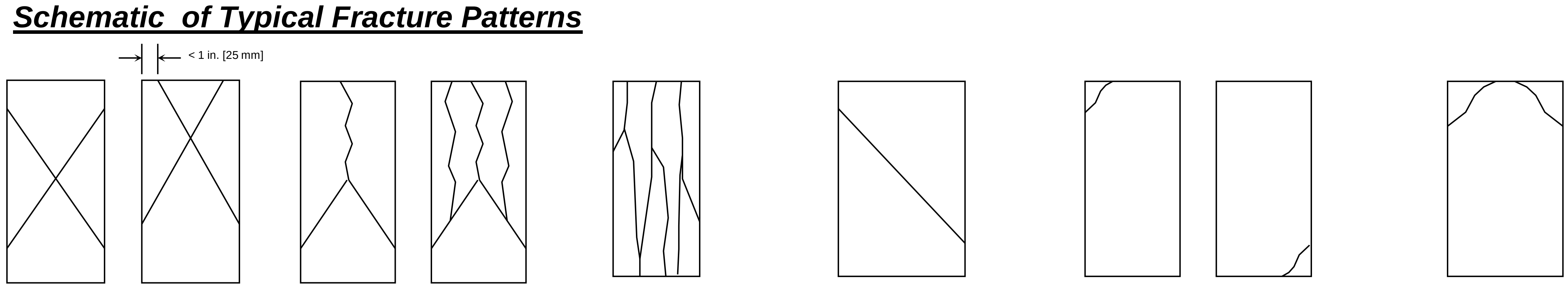
Maximum Load, lb	60,983	60,397	62,086
Compressive Strength, psi	4,780	4,780	4,890
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	4,817

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC Hot	CAC Hot	CAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	7/2/14 15:54	7/2/14 15:59	7/2/14 16:04
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	6	6	6
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Water tank at 122°F	Water tank at 122°F	Water tank at 122°F
Cylinder End Preparation	Ground & Sulfur	Ground & Sulfur	Ground & Sulfur

Concrete Dimensions

Diameter 1, in.	3.99	4.00	4.01
Diameter 2, in.	4.02	4.02	4.01
Length(without caps), in.	7.67	7.70	7.88
Length(with caps), in.	7.81	7.86	8.05
Average Diameter, in.	4.01	4.01	4.01
Length / Diameter (L/D)	1.95	1.96	2.01
Cross-Sectional Area, in^2	12.63	12.63	12.63

Compressive Strength and Fracture Pattern

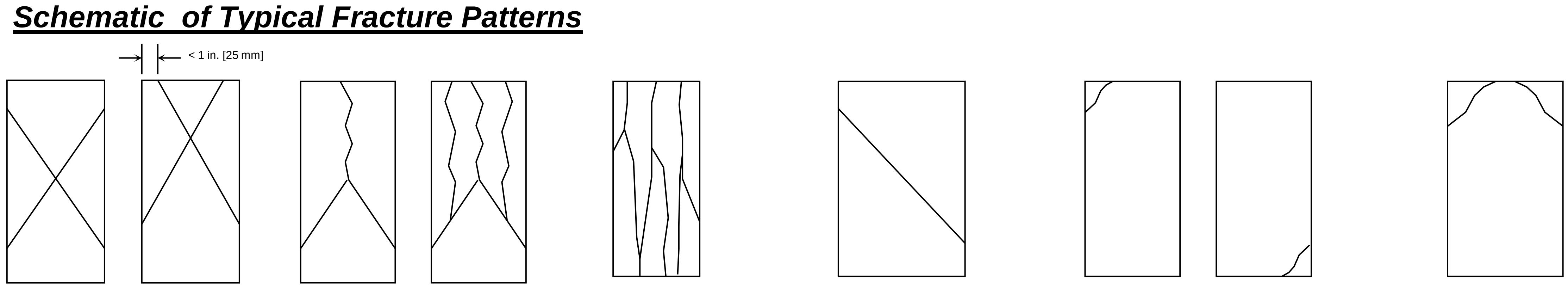
Maximum Load, lb	74,344	73,154	70,919
Compressive Strength, psi	5,890	5,790	5,620
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	5,767

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC Hot	CAC Hot	CAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	7/3/14 10:53	7/3/14 11:00	7/3/14 11:05
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	7	7	7
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Water tank at 122°F	Water tank at 122°F	Water tank at 122°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.01	4.02
Diameter 2, in.	4.02	4.00	4.02
Length(without caps), in.	7.91	7.89	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.03	4.01	4.02
Length / Diameter (L/D)	1.96	1.97	1.96
Cross-Sectional Area, in^2	12.76	12.63	12.69

Compressive Strength and Fracture Pattern

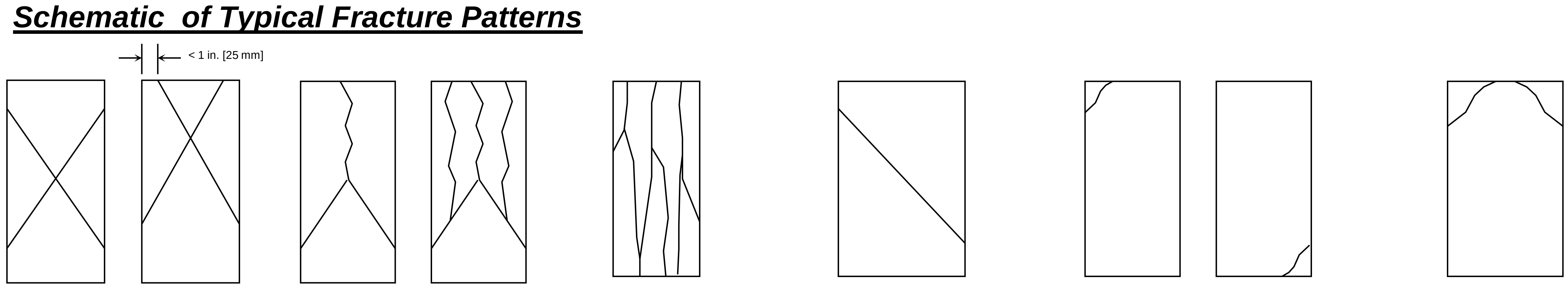
Maximum Load, lb	57,395	59,662	55,987
Compressive Strength, psi	4,500	4,720	4,410
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	4,543

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC Hot	CAC Hot	CAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	7/10/14 8:43	7/10/14 8:50	7/10/14 8:57
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	14	14	14
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100% [2]	74° / 100% [2]	74° / 100% [2]
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.01	4.02
Diameter 2, in.	3.98	4.00	4.01
Length(without caps), in.	7.87	7.89	7.86
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	3.99	4.01	4.01
Length / Diameter (L/D)	1.97	1.97	1.96
Cross-Sectional Area, in^2	12.50	12.63	12.63

Compressive Strength and Fracture Pattern

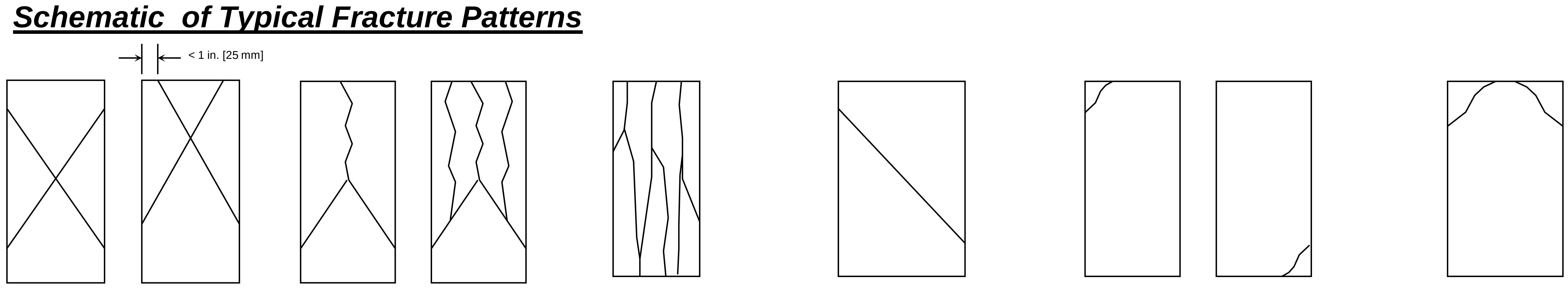
Maximum Load, lb	78,973	73,998	76,081
Compressive Strength, psi	6,320	5,860	6,020
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,067

Report Notes

1. This report may not be reproduced except in its entirety.
2. After initial cure, specimens were cured in a water tank at 122°F until and age of 7 days and then transferred to a moist room

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC Hot	CAC Hot	CAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	7/24/14 11:10	7/24/14 11:16	7/24/14 11:24
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	28	28	28
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100% [2]	74° / 100% [2]	74° / 100% [2]
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.02
Diameter 2, in.	4.00	4.03	4.01
Length(without caps), in.	7.91	7.88	7.90
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.03	4.02
Length / Diameter (L/D)	1.97	1.96	1.96
Cross-Sectional Area, in^2	12.63	12.76	12.69

Compressive Strength and Fracture Pattern

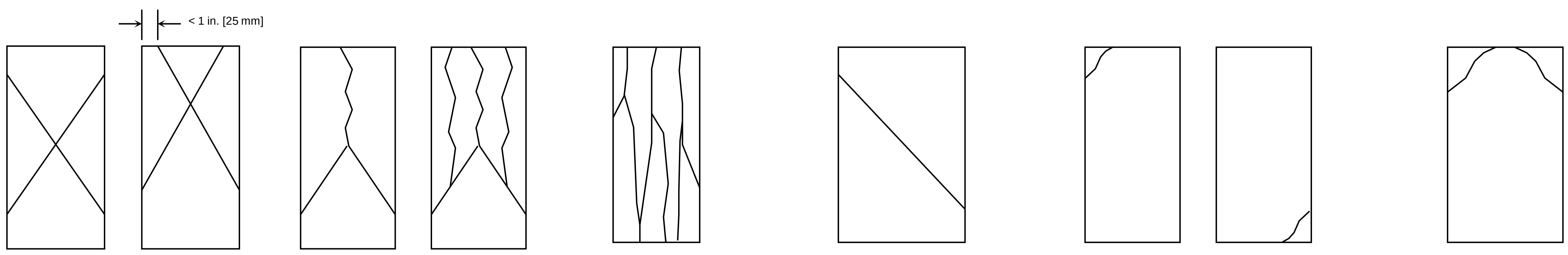
Maximum Load, lb	71,804	72,168	74,008
Compressive Strength, psi	5,690	5,660	5,830
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	5,727

Report Notes

1. This report may not be reproduced except in its entirety.
2. After initial cure, specimens were cured in 122°F water until and age of 7 days and then transferred to a moist room at 23.0 ±

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

CTLGROUP

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC Hot	CAC Hot	CAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	8/21/14 11:28	8/21/14 11:36	8/21/14 11:40
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	56	56	56
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100% [2]	74° / 100% [2]	74° / 100% [2]
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.02	4.02
Diameter 2, in.	4.03	4.03	4.01
Length(without caps), in.	8.05	8.07	8.07
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.03	4.03	4.01
Length / Diameter (L/D)	2.00	2.00	2.01
Cross-Sectional Area, in^2	12.76	12.76	12.63

Compressive Strength and Fracture Pattern

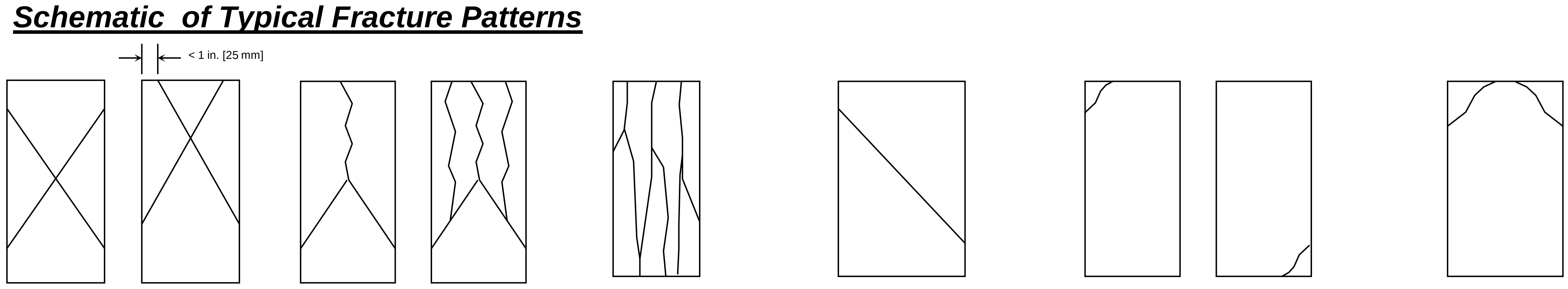
Maximum Load, lb	89,761	87,098	88,006
Compressive Strength, psi	7,030	6,830	6,970
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,943

Report Notes

1. This report may not be reproduced except in its entirety.
2. After initial cure, specimens were cured in 122°F water until and age of 7 days and then transferred to a moist room at 23.0 ±

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC Hot	CAC Hot	CAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:12	6/26/14 8:12	6/26/14 8:12
Test Date / Time	9/24/14 15:00	9/24/14 15:06	9/24/14 15:12
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	90	90	90
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100% [2]	74° / 100% [2]	74° / 100% [2]
Cylinder End Preparation	Ground & Sulfur	Ground & Sulfur	Ground & Sulfur

Concrete Dimensions

Diameter 1, in.	4.02	4.04	4.03
Diameter 2, in.	4.02	4.03	4.01
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.17	8.18	8.16
Average Diameter, in.	4.02	4.03	4.02
Length / Diameter (L/D)	2.03	2.03	2.03
Cross-Sectional Area, in^2	12.69	12.76	12.69

Compressive Strength and Fracture Pattern

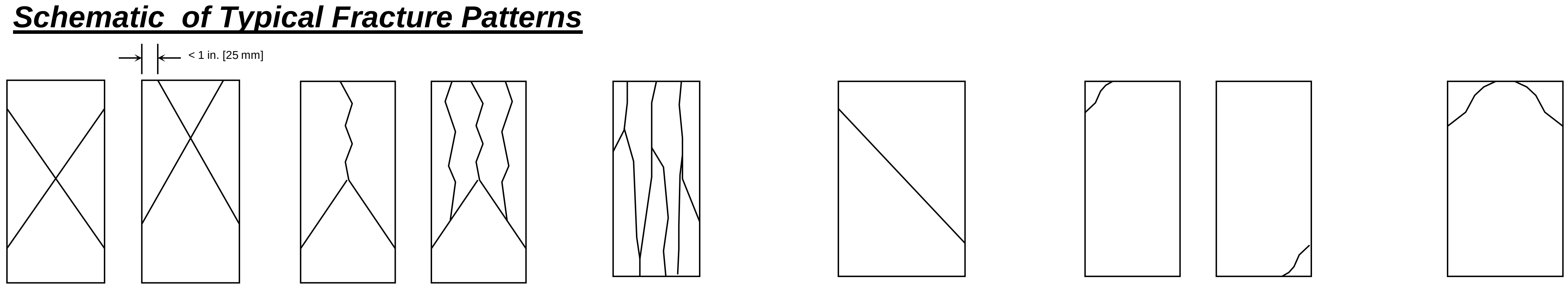
Maximum Load, lb	91,686	92,084	90,774
Compressive Strength, psi	7,230	7,220	7,150
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	7,200

Report Notes

1. This report may not be reproduced except in its entirety.
2. After initial cure, specimens were cured in 122°F water until and age of 7 days and then transferred to a moist room at 23.0 ±

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	6/26/14 10:43	6/26/14 10:47	6/26/14 10:50
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	2	2	2
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.02
Diameter 2, in.	3.99	4.02	4.00
Length(without caps), in.	8.03	8.01	8.04
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.02	4.01
Length / Diameter (L/D)	2.01	1.99	2.00
Cross-Sectional Area, in^2	12.57	12.69	12.63

Compressive Strength and Fracture Pattern

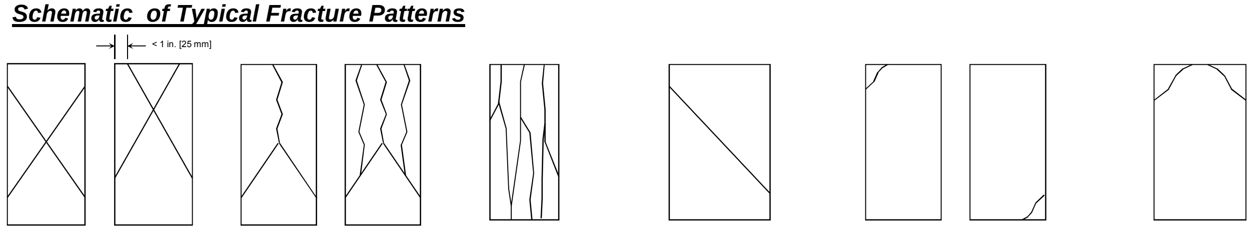
Maximum Load, lb	2,723	3,349	3,487
Compressive Strength, psi	220	260	280
Fracture Pattern	Type 3	Type 3	Type 3

Average Compressive Strength, psi	253

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	6/26/14 11:43	6/26/14 11:47	6/26/14 11:51
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	3	3	2
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.00	4.03	4.02
Diameter 2, in.	3.99	4.01	4.01
Length(without caps), in.	8.02	8.01	8.02
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.02	4.01
Length / Diameter (L/D)	2.01	1.99	2.00
Cross-Sectional Area, in^2	12.57	12.69	12.63

Compressive Strength and Fracture Pattern

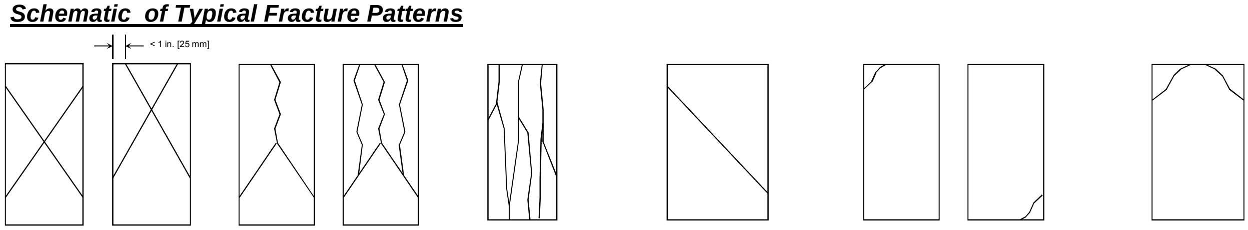
Maximum Load, lb	18,613	19,621	18,353
Compressive Strength, psi	1,480	1,550	1,450
Fracture Pattern	Type 3	Type 3	Type 3

Average Compressive Strength, psi	1,493

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	6/26/14 12:45	6/26/14 12:48	6/26/14 12:51
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	4	4	2
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.00	4.01
Diameter 2, in.	4.00	4.00	4.00
Length(without caps), in.	8.07	8.01	8.02
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.00	4.00
Length / Diameter (L/D)	2.01	2.00	2.00
Cross-Sectional Area, in^2	12.69	12.57	12.57

Compressive Strength and Fracture Pattern

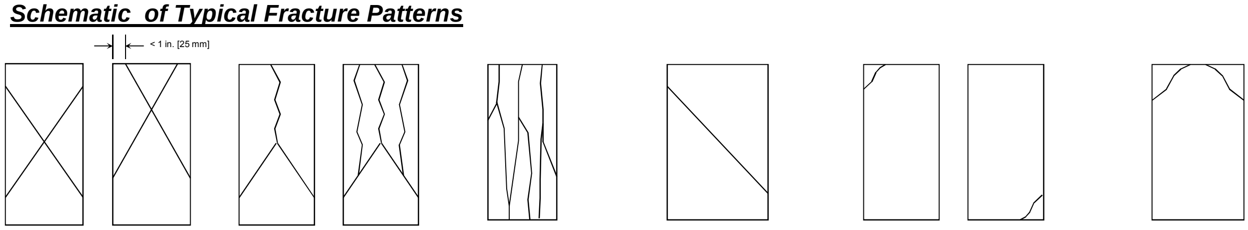
Maximum Load, lb	51,139	53,668	52,297
Compressive Strength, psi	4,030	4,270	4,160
Fracture Pattern	Type 2	Type 5	Type 5

Average Compressive Strength, psi	4,153

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	6/26/14 14:42	6/26/14 14:46	6/26/14 14:49
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	6	6	2
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.02	4.01	4.04
Diameter 2, in.	4.01	4.00	4.03
Length(without caps), in.	8.04	8.01	8.03
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.00	4.03
Length / Diameter (L/D)	2.01	2.00	1.99
Cross-Sectional Area, in^2	12.63	12.57	12.76

Compressive Strength and Fracture Pattern

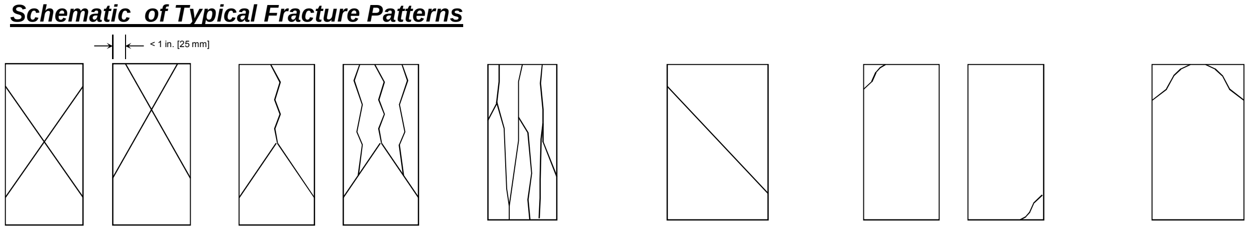
Maximum Load, lb	56,433	58,992	57,776
Compressive Strength, psi	4,470	4,690	4,530
Fracture Pattern	Type 5	Type 5	Type 5

Average Compressive Strength, psi	4,563

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	6/26/14 16:42	6/26/14 16:45	6/26/14 16:49
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	8	8	2
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.02	4.03	4.02
Diameter 2, in.	4.01	4.02	4.01
Length(without caps), in.	8.06	8.03	8.04
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.03	4.02
Length / Diameter (L/D)	2.01	1.99	2.00
Cross-Sectional Area, in^2	12.63	12.76	12.69

Compressive Strength and Fracture Pattern

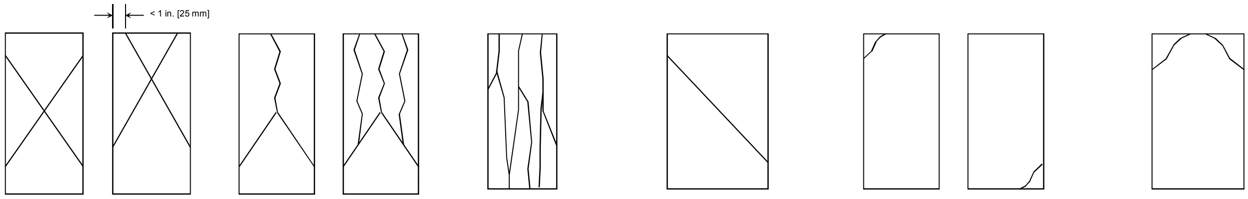
Maximum Load, lb	65,373	67,879	67,832
Compressive Strength, psi	5,180	5,320	5,350
Fracture Pattern	Type 6	Type 5	Type 6

Average Compressive Strength, psi	5,283

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	6/26/14 8:30	6/26/14 8:35	6/26/14 8:39
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	1	1	2
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.04	4.02	4.02
Diameter 2, in.	4.03	4.01	4.02
Length(without caps), in.	7.90	7.87	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.03	4.01	4.02
Length / Diameter (L/D)	1.96	1.96	1.96
Cross-Sectional Area, in^2	12.76	12.63	12.69

Compressive Strength and Fracture Pattern

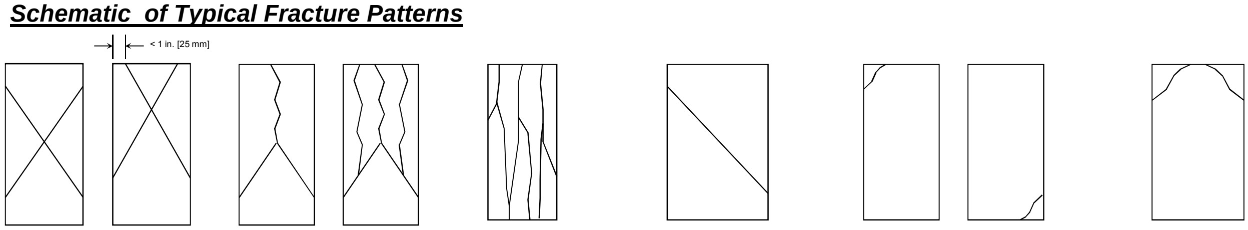
Maximum Load, lb	77,372	75,617	75,326
Compressive Strength, psi	6,060	5,990	5,940
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	5,997

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	6/28/14 10:00	6/28/14 10:00	6/28/14 10:00
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	2	2	2
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.02	4.02
Diameter 2, in.	4.00	4.00	4.01
Length(without caps), in.	7.87	7.87	7.92
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.01	4.01
Length / Diameter (L/D)	1.97	1.96	1.97
Cross-Sectional Area, in^2	12.57	12.63	12.63

Compressive Strength and Fracture Pattern

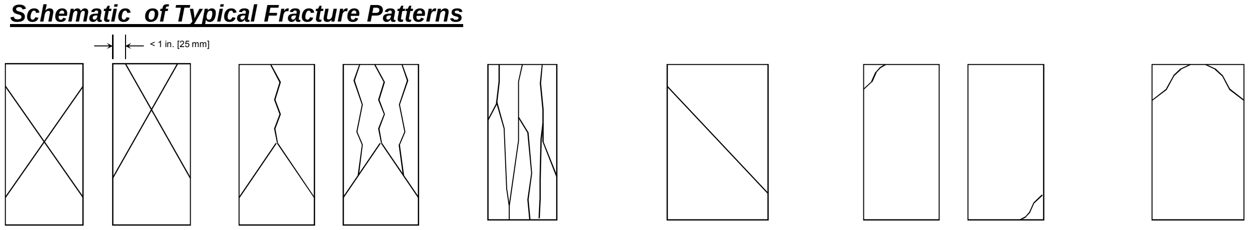
Maximum Load, lb	77,112	80,906	78,783
Compressive Strength, psi	6,130	6,410	6,240
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,260

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	6/29/14 7:33	6/29/14 7:36	6/29/14 7:40
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	3	3	3
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	3.99	4.00
Diameter 2, in.	4.00	4.02	4.00
Length(without caps), in.	7.96	7.90	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.00	4.00
Length / Diameter (L/D)	1.99	1.98	1.97
Cross-Sectional Area, in^2	12.57	12.57	12.57

Compressive Strength and Fracture Pattern

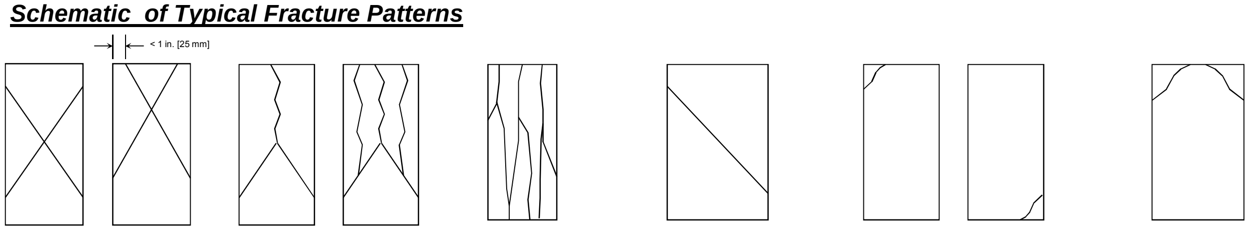
Maximum Load, lb	84,624	80,504	81,870
Compressive Strength, psi	6,730	6,400	6,510
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,547

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	6/30/14 9:00	6/30/14 9:00	6/30/14 9:00
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	4	4	4
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.02
Diameter 2, in.	3.99	4.02	4.01
Length(without caps), in.	7.91	7.89	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.03	4.02
Length / Diameter (L/D)	1.98	1.96	1.96
Cross-Sectional Area, in^2	12.57	12.76	12.69

Compressive Strength and Fracture Pattern

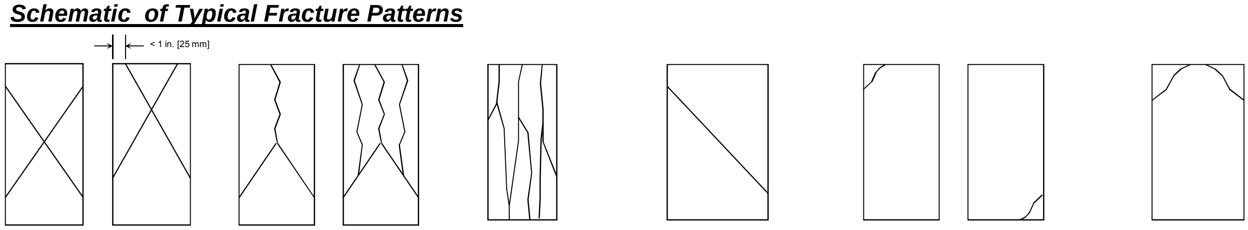
Maximum Load, lb	88,012	87,475	87,546
Compressive Strength, psi	7,000	6,860	6,900
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,920

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	7/1/14 10:50	7/1/14 10:56	7/1/14 11:03
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	5	5	5
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.02	4.01
Diameter 2, in.	4.00	4.01	4.00
Length(without caps), in.	7.91	7.87	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.01	4.00
Length / Diameter (L/D)	1.98	1.96	1.97
Cross-Sectional Area, in^2	12.57	12.63	12.57

Compressive Strength and Fracture Pattern

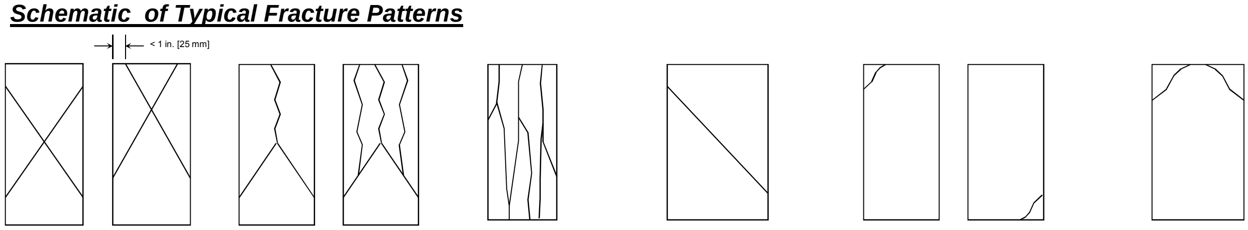
Maximum Load, lb	90,825	93,050	91,580
Compressive Strength, psi	7,230	7,370	7,290
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	7,297

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	7/2/14 15:05	7/2/14 15:12	7/2/14 15:18
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	6	6	6
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Ground & Sulfur	Ground & Sulfur	Ground & Sulfur

Concrete Dimensions

Diameter 1, in.	4.01	4.00	3.99
Diameter 2, in.	3.99	4.03	4.00
Length(without caps), in.	7.84	7.68	7.75
Length(with caps), in.	8.04	7.84	7.92
Average Diameter, in.	4.00	4.01	3.99
Length / Diameter (L/D)	2.01	1.96	1.98
Cross-Sectional Area, in^2	12.57	12.63	12.50

Compressive Strength and Fracture Pattern

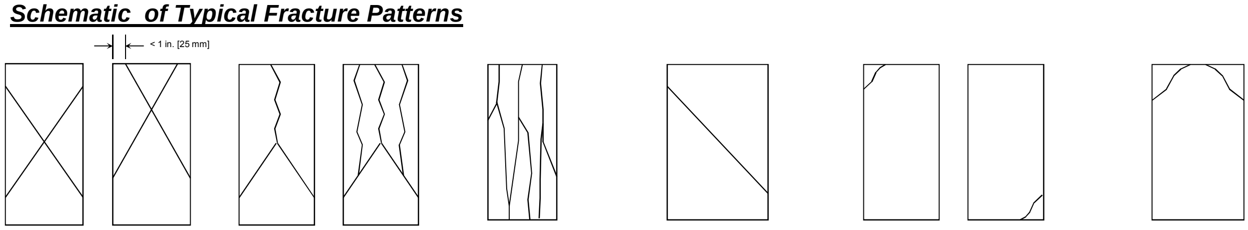
Maximum Load, lb	105,251	97,097	92,177
Compressive Strength, psi	8,370	7,690	7,370
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	7,810

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	7/3/14 10:17	7/3/14 10:23	7/3/14 10:29
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	7	7	7
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.01	4.02
Diameter 2, in.	4.01	4.00	4.01
Length(without caps), in.	7.89	7.89	7.90
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.00	4.01
Length / Diameter (L/D)	1.96	1.97	1.97
Cross-Sectional Area, in^2	12.69	12.57	12.63

Compressive Strength and Fracture Pattern

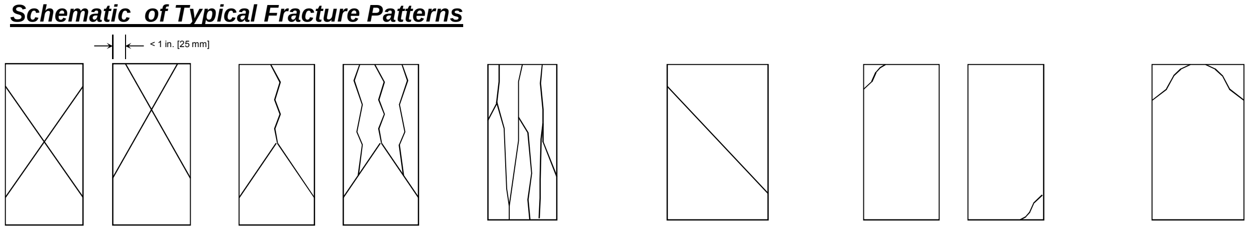
Maximum Load, lb	93,716	96,145	92,633
Compressive Strength, psi	7,390	7,650	7,330
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	7,457

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	7/10/14 8:23	7/10/14 8:30	7/10/14 8:36
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	14	14	14
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.01	4.02
Diameter 2, in.	3.98	3.99	4.01
Length(without caps), in.	7.90	7.88	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	3.99	4.00	4.02
Length / Diameter (L/D)	1.98	1.97	1.96
Cross-Sectional Area, in^2	12.50	12.57	12.69

Compressive Strength and Fracture Pattern

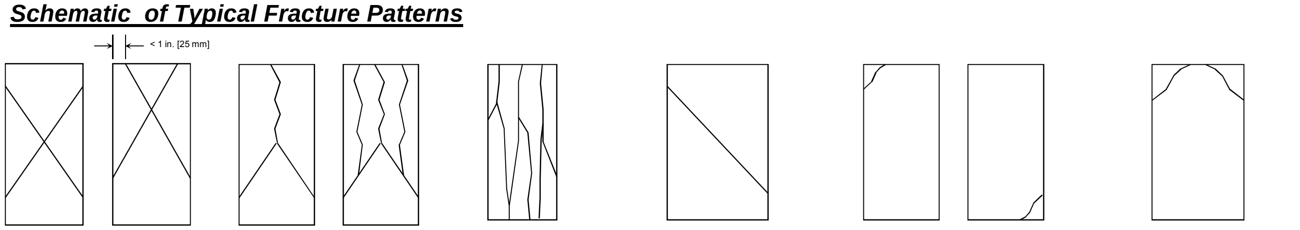
Maximum Load, lb	113,273	111,884	113,703
Compressive Strength, psi	9,060	8,900	8,960
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	8,973

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	7/24/14 10:46	7/24/14 10:54	7/24/14 11:00
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	28	28	28
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.04	4.01	4.03
Diameter 2, in.	4.03	4.00	4.02
Length(without caps), in.	7.90	7.88	7.90
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.03	4.01	4.02
Length / Diameter (L/D)	1.96	1.97	1.96
Cross-Sectional Area, in^2	12.76	12.63	12.69

Compressive Strength and Fracture Pattern

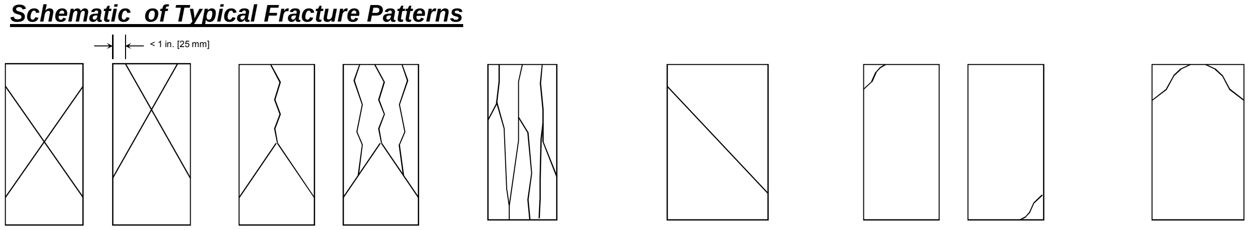
Maximum Load, lb	121,869	123,342	121,500
Compressive Strength, psi	9,550	9,770	9,570
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	9,630

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	8/21/14 10:30	8/21/14 10:40	8/21/14 10:49
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	56	56	56
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.03	4.02
Diameter 2, in.	4.01	4.03	4.02
Length(without caps), in.	8.06	8.04	8.05
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.03	4.02
Length / Diameter (L/D)	2.01	1.99	2.00
Cross-Sectional Area, in^2	12.63	12.76	12.69

Compressive Strength and Fracture Pattern

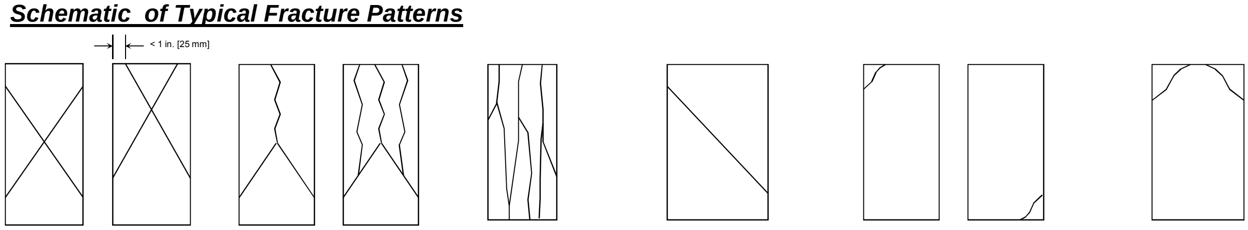
Maximum Load, lb	136,359	132,717	136,081
Compressive Strength, psi	10,800	10,400	10,720
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	10,640

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	9/24/14 14:20	9/24/14 14:30	9/24/14 14:40
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	90	90	90
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Ground & Sulfur	Ground & Sulfur	Ground & Sulfur

Concrete Dimensions

Diameter 1, in.	4.00	4.03	4.03
Diameter 2, in.	3.99	4.02	4.01
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.17	8.19	8.17
Average Diameter, in.	3.99	4.02	4.02
Length / Diameter (L/D)	2.05	2.04	2.03
Cross-Sectional Area, in^2	12.50	12.69	12.69

Compressive Strength and Fracture Pattern

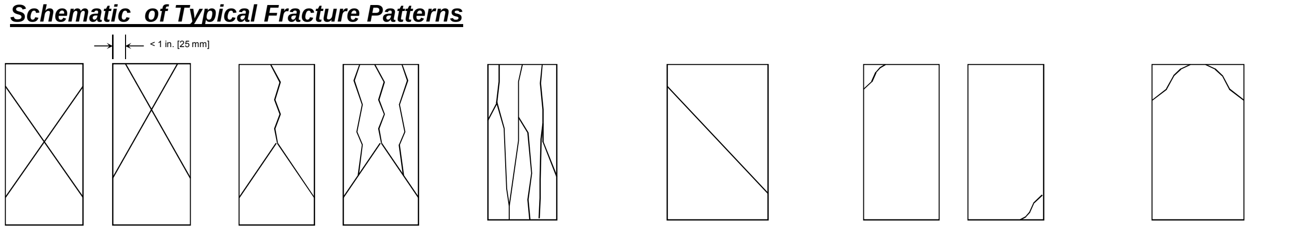
Maximum Load, lb	137,692	139,871	138,903
Compressive Strength, psi	11,020	11,020	10,950
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	10,997

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC Hot	LCAC Hot	LCAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	6/28/14 10:30	6/28/14 10:30	6/28/14 10:30
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	2	2	2
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Water tank at 122°F	Water tank at 122°F	Water tank at 122°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.01	4.02
Diameter 2, in.	4.02	3.99	4.00
Length(without caps), in.	7.90	7.87	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.03	4.00	4.01
Length / Diameter (L/D)	1.96	1.97	1.97
Cross-Sectional Area, in^2	12.76	12.57	12.63

Compressive Strength and Fracture Pattern

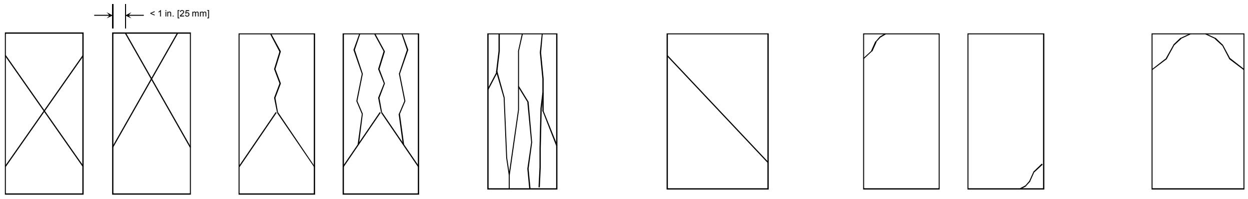
Maximum Load, lb	87,140	85,318	86,627
Compressive Strength, psi	6,830	6,790	6,860
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,827

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC Hot	LCAC Hot	LCAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	6/29/14 7:58	6/29/14 8:05	6/29/14 8:10
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	3	3	3
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Water tank at 122°F	Water tank at 122°F	Water tank at 122°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.00	4.00
Diameter 2, in.	4.00	4.01	4.01
Length(without caps), in.	7.94	7.95	7.93
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.01	4.00
Length / Diameter (L/D)	1.98	1.98	1.98
Cross-Sectional Area, in^2	12.63	12.63	12.57

Compressive Strength and Fracture Pattern

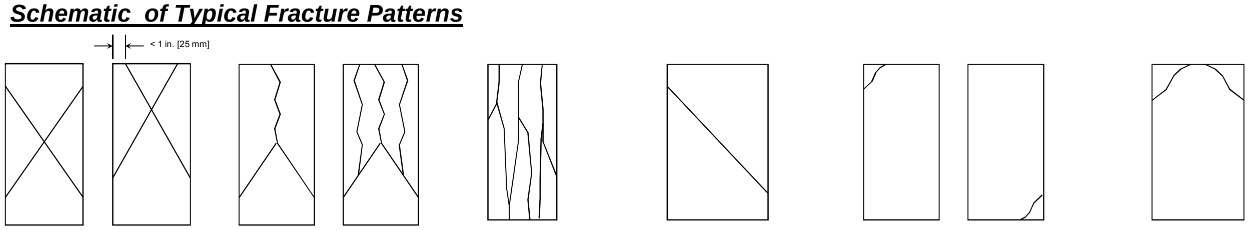
Maximum Load, lb	69,168	74,096	70,649
Compressive Strength, psi	5,480	5,870	5,620
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	5,657

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

CTLGROUP

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC Hot	LCAC Hot	LCAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	6/30/14 10:00	6/30/14 10:00	6/30/14 10:00
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	4	4	4
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Water tank at 122°F	Water tank at 122°F	Water tank at 122°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.02	4.01
Diameter 2, in.	3.99	4.01	4.00
Length(without caps), in.	7.87	7.89	7.90
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	3.99	4.02	4.01
Length / Diameter (L/D)	1.97	1.96	1.97
Cross-Sectional Area, in^2	12.50	12.69	12.63

Compressive Strength and Fracture Pattern

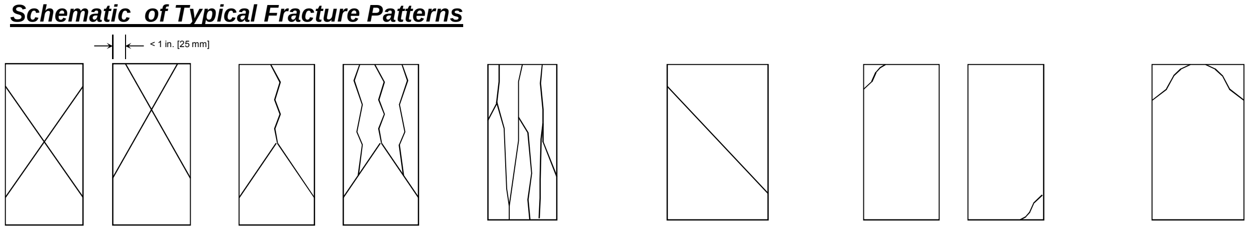
Maximum Load, lb	79,252	76,286	81,304
Compressive Strength, psi	6,340	6,010	6,440
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,263

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC Hot	LCAC Hot	LCAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	7/1/14 11:30	7/1/14 11:36	7/1/14 11:43
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	5	5	5
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Water tank at 122°F	Water tank at 122°F	Water tank at 122°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.01	4.03
Diameter 2, in.	4.00	3.99	4.02
Length(without caps), in.	7.89	7.87	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.00	4.02
Length / Diameter (L/D)	1.97	1.97	1.96
Cross-Sectional Area, in^2	12.63	12.57	12.69

Compressive Strength and Fracture Pattern

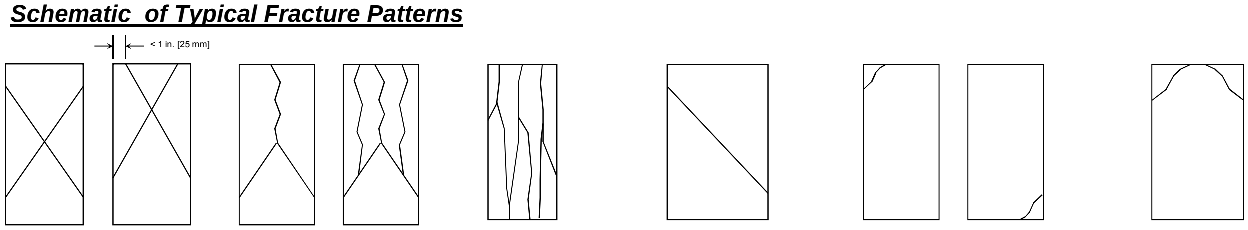
Maximum Load, lb	81,419	84,105	82,283
Compressive Strength, psi	6,450	6,690	6,480
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,540

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

CTLGroup

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC Hot	LCAC Hot	LCAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	7/2/14 15:28	7/2/14 15:32	7/2/14 15:35
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	6	6	6
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Water tank at 122°F	Water tank at 122°F	Water tank at 122°F
Cylinder End Preparation	Ground & Sulfur	Ground & Sulfur	Ground & Sulfur

Concrete Dimensions

Diameter 1, in.	4.00	4.02	3.99
Diameter 2, in.	4.04	3.98	4.02
Length(without caps), in.	7.88	7.81	7.87
Length(with caps), in.	8.04	7.97	8.04
Average Diameter, in.	4.02	4.00	4.00
Length / Diameter (L/D)	2.00	1.99	2.01
Cross-Sectional Area, in^2	12.69	12.57	12.57

Compressive Strength and Fracture Pattern

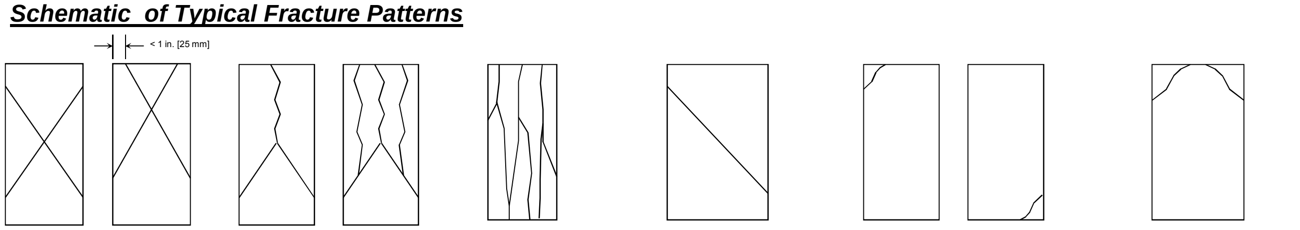
Maximum Load, lb	95,828	95,805	95,888
Compressive Strength, psi	7,550	7,620	7,630
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	7,600

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC Hot	LCAC Hot	LCAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	7/3/14 10:36	7/3/14 10:41	7/3/14 10:47
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	7	7	7
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Water tank at 122°F	Water tank at 122°F	Water tank at 122°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.03	4.02
Diameter 2, in.	3.99	4.02	4.01
Length(without caps), in.	7.87	7.90	7.87
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.03	4.02
Length / Diameter (L/D)	1.97	1.96	1.96
Cross-Sectional Area, in^2	12.57	12.76	12.69

Compressive Strength and Fracture Pattern

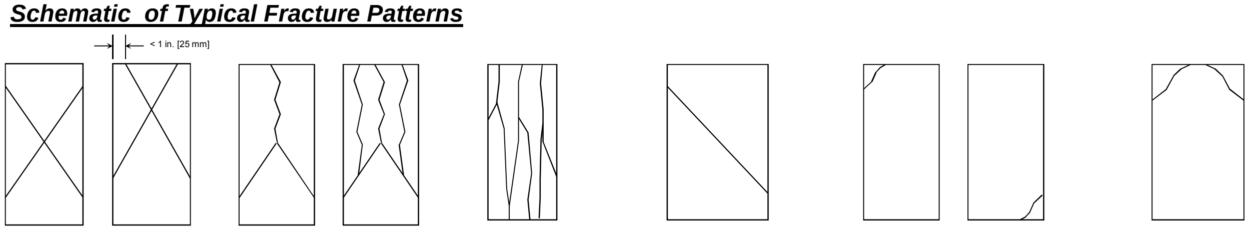
Maximum Load, lb	83,691	82,632	85,861
Compressive Strength, psi	6,660	6,480	6,770
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,637

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC Hot	LCAC Hot	LCAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	7/10/14 8:00	7/10/14 8:07	7/10/14 8:15
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	14	14	14
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50% [2]	74° / 50% [2]	74° / 50% [2]
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.01	4.01
Diameter 2, in.	4.02	4.00	4.01
Length(without caps), in.	7.88	7.87	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.00	4.01
Length / Diameter (L/D)	1.96	1.97	1.97
Cross-Sectional Area, in^2	12.69	12.57	12.63

Compressive Strength and Fracture Pattern

Maximum Load, lb	112,368	114,196	113,285
Compressive Strength, psi	8,850	9,080	8,970
Fracture Pattern	Type 1	Type 1	Type 1

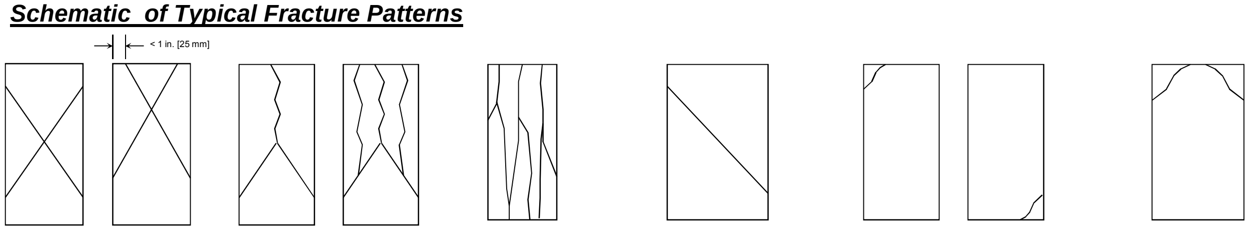
Average Compressive Strength, psi	8,967

Report Notes

1. This report may not be reproduced except in its entirety.

2. After initial cure, specimens were cured in 122°F water until and age of 7 days and then transferred to an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity until test preparations.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC Hot	LCAC Hot	LCAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	7/24/14 10:21	7/24/14 10:29	7/24/14 10:37
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	28	28	28
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50% [2]	74° / 50% [2]	74° / 50% [2]
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.01	4.02
Diameter 2, in.	4.00	3.99	4.02
Length(without caps), in.	7.90	7.88	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.00	4.02
Length / Diameter (L/D)	1.97	1.97	1.96
Cross-Sectional Area, in^2	12.63	12.57	12.69

Compressive Strength and Fracture Pattern

Maximum Load, lb	128,121	126,728	127,106
Compressive Strength, psi	10,140	10,080	10,020
Fracture Pattern	Type 1	Type 1	Type 1

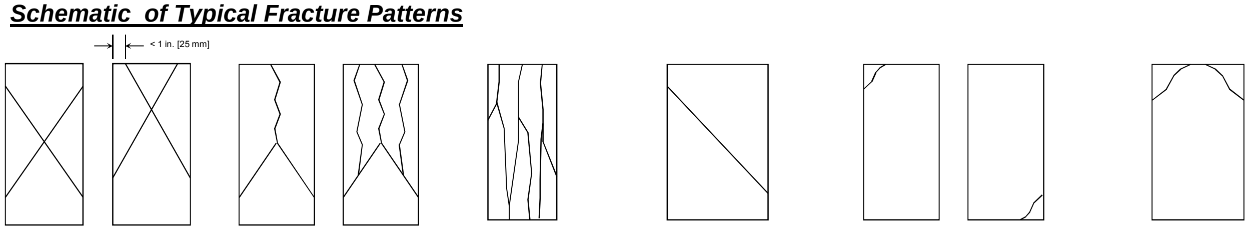
Average Compressive Strength, psi	10,080

Report Notes

1. This report may not be reproduced except in its entirety.

2. After initial cure, specimens were cured in 122°F water until and age of 7 days and then transferred to an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity until test preparations.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC Hot	LCAC Hot	LCAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	8/21/14 10:57	8/21/14 11:06	8/21/14 11:14
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	56	56	56
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50% [2]	74° / 50% [2]	74° / 50% [2]
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.00	4.01
Diameter 2, in.	4.01	3.99	4.00
Length(without caps), in.	8.07	8.04	8.06
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.00	4.01
Length / Diameter (L/D)	2.01	2.01	2.01
Cross-Sectional Area, in^2	12.69	12.57	12.63

Compressive Strength and Fracture Pattern

Maximum Load, lb	136,501	133,624	135,563
Compressive Strength, psi	10,760	10,630	10,730
Fracture Pattern	Type 1	Type 1	Type 1

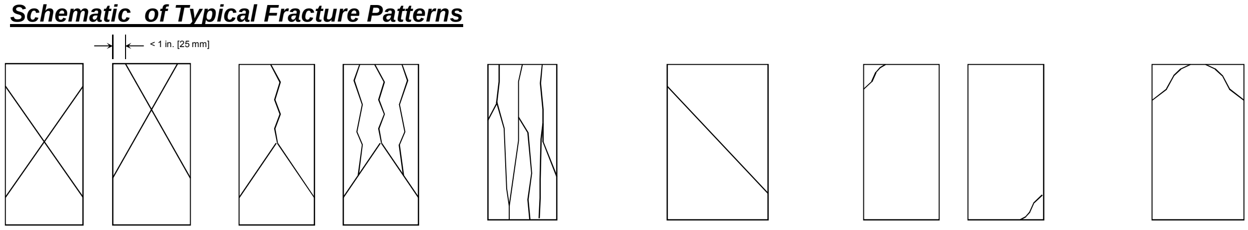
Average Compressive Strength, psi	10,707

Report Notes

1. This report may not be reproduced except in its entirety.

2. After initial cure, specimens were cured in 122°F water until and age of 7 days and then transferred to an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity until test preparations.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC Hot	LCAC Hot	LCAC Hot
Client Identification	N/A	N/A	N/A
Casting Date	6/26/14 8:42	6/26/14 8:42	6/26/14 8:42
Test Date / Time	9/24/14 13:45	9/24/14 13:55	9/24/14 14:08
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	90	90	90
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50% [2]	74° / 50% [2]	74° / 50% [2]
Cylinder End Preparation	Ground & Sulfur	Ground & Sulfur	Ground & Sulfur

Concrete Dimensions

Diameter 1, in.	4.03	4.01	4.03
Diameter 2, in.	4.02	4.00	4.03
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.16	8.18	8.17
Average Diameter, in.	4.02	4.01	4.03
Length / Diameter (L/D)	2.03	2.04	2.03
Cross-Sectional Area, in^2	12.69	12.63	12.76

Compressive Strength and Fracture Pattern

Maximum Load, lb	139,947	144,467	142,914
Compressive Strength, psi	11,030	11,440	11,200
Fracture Pattern	Type 1	Type 1	Type 1

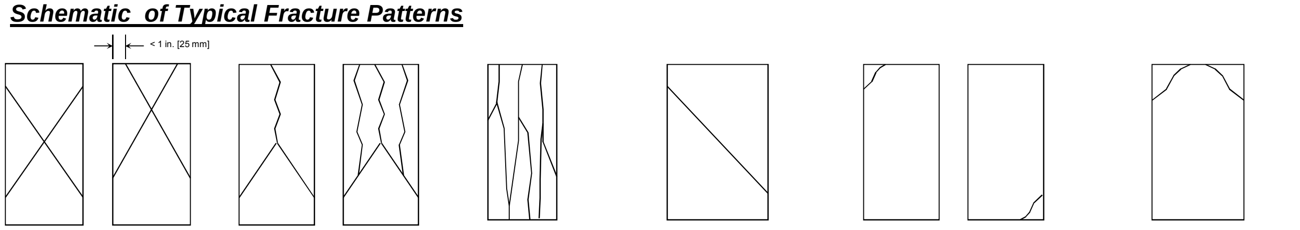
Average Compressive Strength, psi	11,223

Report Notes

1. This report may not be reproduced except in its entirety.

2. After initial cure, specimens were cured in 122°F water until and age of 7 days and then transferred to an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity until test preparations.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-

Type 3
Columnar vertical cracking through both ends, no well-

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	9/10/14 8:25	9/10/14 8:25	9/10/14 8:25
Test Date / Time	9/11/14 8:05	9/11/14 8:10	9/11/14 8:14
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	1	1	1
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.01	4.03
Diameter 2, in.	4.02	4.00	4.02
Length(without caps), in.	8.03	8.02	8.05
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.03	4.01	4.02
Length / Diameter (L/D)	1.99	2.00	2.00
Cross-Sectional Area, in^2	12.76	12.63	12.69

Compressive Strength and Fracture Pattern

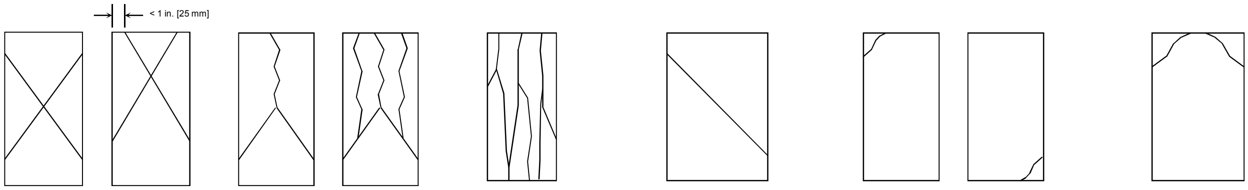
Maximum Load, lb	64,549	65,892	67,616
Compressive Strength, psi	5,060	5,220	5,330
Fracture Pattern	Type 3	Type 3	Type 3

Average Compressive Strength, psi	5,203

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	9/10/14 8:25	9/10/14 8:25	9/10/14 8:25
Test Date / Time	9/13/14 9:30	9/13/14 9:36	9/13/14 9:43
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	3	3	3
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Sulfur	Sulfur	Sulfur

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.02
Diameter 2, in.	4.00	4.02	4.02
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.23	8.20	8.22
Average Diameter, in.	4.01	4.03	4.02
Length / Diameter (L/D)	2.05	2.03	2.05
Cross-Sectional Area, in^2	12.63	12.76	12.69

Compressive Strength and Fracture Pattern

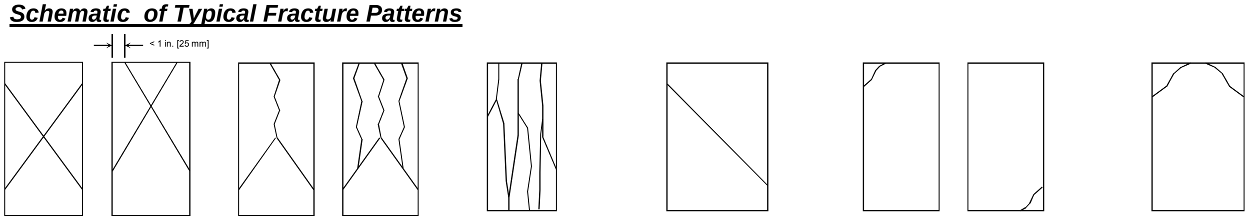
Maximum Load, lb	73,824	70,723	73,064
Compressive Strength, psi	5,850	5,540	5,760
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	5,717

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	9/10/14 8:25	9/10/14 8:25	9/10/14 8:25
Test Date / Time	9/15/14 13:30	9/15/14 13:33	9/15/14 13:38
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	5	5	5
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Sulfur	Sulfur	Sulfur

Concrete Dimensions

Diameter 1, in.	4.00	4.02	4.01
Diameter 2, in.	3.99	4.02	4.01
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.23	8.21	8.22
Average Diameter, in.	4.00	4.02	4.01
Length / Diameter (L/D)	2.06	2.04	2.05
Cross-Sectional Area, in^2	12.57	12.69	12.63

Compressive Strength and Fracture Pattern

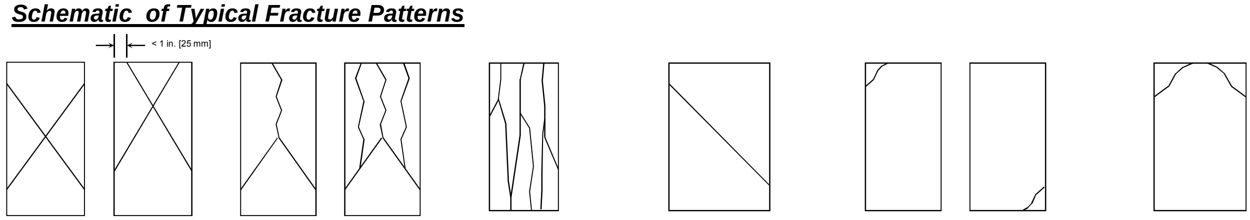
Maximum Load, lb	80,590	79,391	78,049
Compressive Strength, psi	6,410	6,260	6,180
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,283

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	9/10/14 8:25	9/10/14 8:25	9/10/14 8:25
Test Date / Time	9/17/14 14:05	9/17/14 14:09	9/17/14 14:12
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	7	7	7
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.03	4.01
Diameter 2, in.	4.00	4.03	4.01
Length(without caps), in.	8.16	8.18	8.16
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.03	4.01
Length / Diameter (L/D)	2.03	2.03	2.04
Cross-Sectional Area, in^2	12.63	12.76	12.63

Compressive Strength and Fracture Pattern

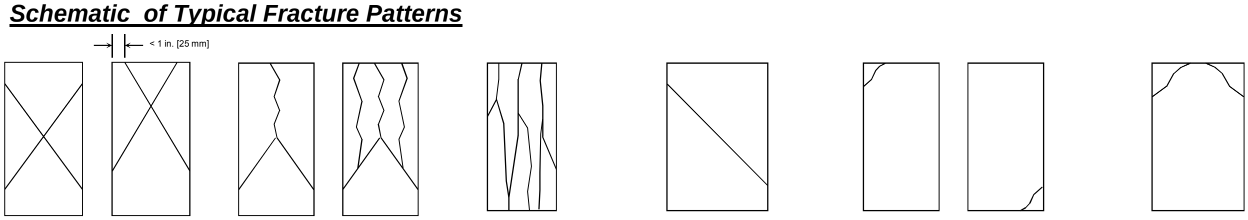
Maximum Load, lb	86,160	84,886	84,856
Compressive Strength, psi	6,820	6,650	6,720
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,730

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	9/10/14 8:25	9/10/14 8:25	9/10/14 8:25
Test Date / Time	9/24/14 11:20	9/24/14 11:26	9/24/14 11:32
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	14	14	14
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground & Sulfur	Ground & Sulfur	Ground & Sulfur

Concrete Dimensions

Diameter 1, in.	4.00	4.02	4.01
Diameter 2, in.	3.99	4.01	4.00
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.17	8.15	8.18
Average Diameter, in.	4.00	4.01	4.01
Length / Diameter (L/D)	2.04	2.03	2.04
Cross-Sectional Area, in^2	12.57	12.63	12.63

Compressive Strength and Fracture Pattern

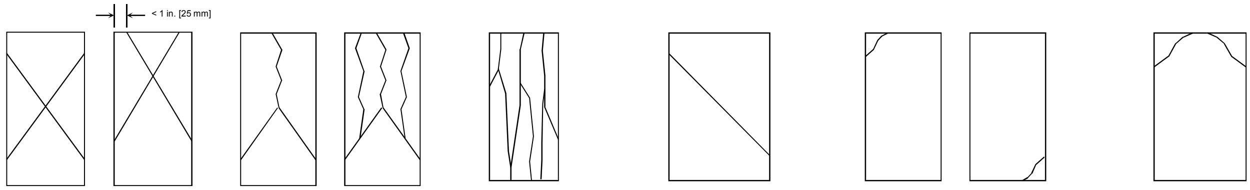
Maximum Load, lb	98,685	96,904	95,989
Compressive Strength, psi	7,850	7,670	7,600
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	7,707

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC	CAC	CAC
Client Identification	N/A	N/A	N/A
Casting Date	9/10/14 8:25	9/10/14 8:25	9/10/14 8:25
Test Date / Time	10/8/14 17:10	10/8/14 17:15	10/8/14 17:20
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	28	28	28
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground & Sulfur	Ground & Sulfur	Ground & Sulfur

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.03
Diameter 2, in.	4.00	4.02	4.02
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.10	8.11	8.08
Average Diameter, in.	4.01	4.02	4.02
Length / Diameter (L/D)	2.02	2.02	2.01
Cross-Sectional Area, in^2	12.63	12.69	12.69

Compressive Strength and Fracture Pattern

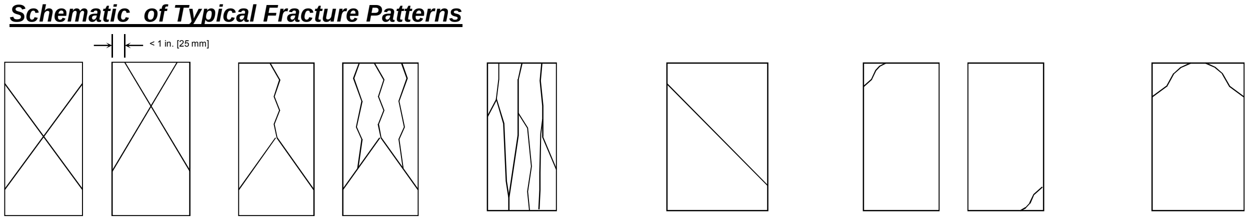
Maximum Load, lb	101,841	102,398	104,212
Compressive Strength, psi	8,060	8,070	8,210
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	8,113

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC-SRA	CAC-SRA	CAC-SRA
Client Identification	N/A	N/A	N/A
Casting Date	9/10/14 13:27	9/10/14 13:27	9/10/14 13:27
Test Date / Time	9/11/14 13:05	9/11/14 13:09	9/11/14 13:12
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	1	1	1
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.03
Diameter 2, in.	4.00	4.02	4.02
Length(without caps), in.	8.04	8.01	8.03
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.03	4.02
Length / Diameter (L/D)	2.01	1.99	2.00
Cross-Sectional Area, in^2	12.57	12.76	12.69

Compressive Strength and Fracture Pattern

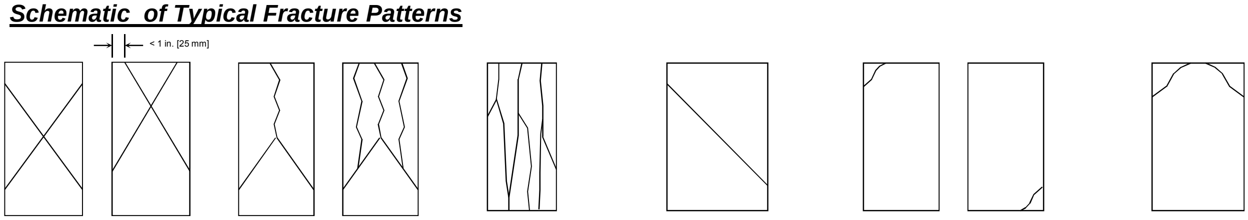
Maximum Load, lb	79,342	76,898	78,588
Compressive Strength, psi	6,310	6,030	6,190
Fracture Pattern	Type 5	Type 5	Type 3

Average Compressive Strength, psi	6,177

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC-SRA	CAC-SRA	CAC-SRA
Client Identification	N/A	N/A	N/A
Casting Date	9/10/14 13:27	9/10/14 13:27	9/10/14 13:27
Test Date / Time	9/13/14 10:30	9/13/14 10:36	9/13/14 10:42
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	3	3	3
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Sulfur	Sulfur	Sulfur

Concrete Dimensions

Diameter 1, in.	4.00	4.01	4.03
Diameter 2, in.	3.99	4.00	4.03
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.23	8.20	8.23
Average Diameter, in.	4.00	4.01	4.03
Length / Diameter (L/D)	2.06	2.04	2.04
Cross-Sectional Area, in^2	12.57	12.63	12.76

Compressive Strength and Fracture Pattern

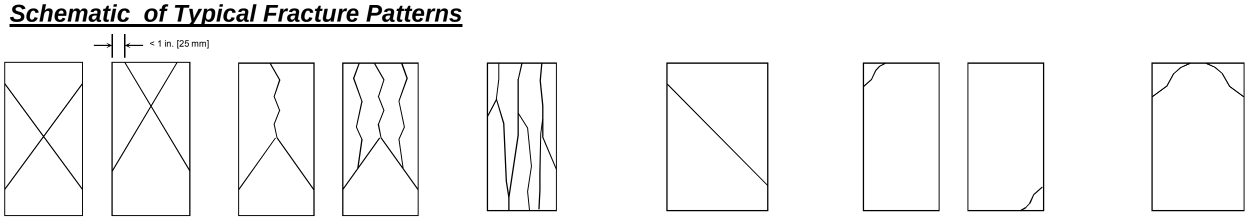
Maximum Load, lb	90,026	93,335	91,686
Compressive Strength, psi	7,160	7,390	7,190
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	7,247

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC-SRA	CAC-SRA	CAC-SRA
Client Identification	N/A	N/A	N/A
Casting Date	9/10/14 13:27	9/10/14 13:27	9/10/14 13:27
Test Date / Time	9/15/14 14:30	9/15/14 14:33	9/15/14 14:38
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	5	5	5
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Sulfur	Sulfur	Sulfur

Concrete Dimensions

Diameter 1, in.	4.03	4.01	4.03
Diameter 2, in.	4.02	4.00	4.02
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.20	8.23	8.20
Average Diameter, in.	4.03	4.01	4.03
Length / Diameter (L/D)	2.03	2.05	2.03
Cross-Sectional Area, in^2	12.76	12.63	12.76

Compressive Strength and Fracture Pattern

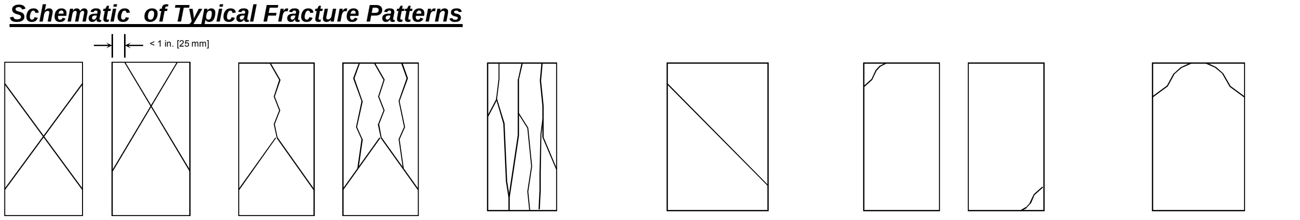
Maximum Load, lb	100,001	98,239	99,333
Compressive Strength, psi	7,840	7,780	7,780
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	7,800

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC-SRA	CAC-SRA	CAC-SRA
Client Identification	N/A	N/A	N/A
Casting Date	9/10/14 13:27	9/10/14 13:27	9/10/14 13:27
Test Date / Time	9/17/14 14:40	9/17/14 14:40	9/17/14 14:44
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	7	7	7
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.02	4.01
Diameter 2, in.	4.01	4.02	3.99
Length(without caps), in.	8.17	8.18	8.15
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.02	4.00
Length / Diameter (L/D)	2.04	2.03	2.04
Cross-Sectional Area, in^2	12.57	12.69	12.57

Compressive Strength and Fracture Pattern

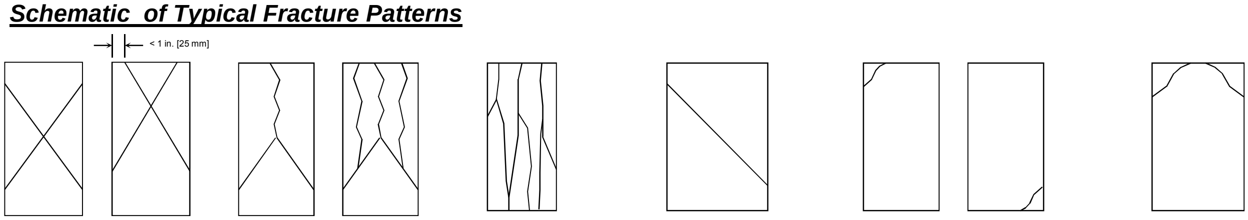
Maximum Load, lb	109,173	106,124	107,928
Compressive Strength, psi	8,690	8,360	8,590
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	8,547

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC-SRA	CAC-SRA	CAC-SRA
Client Identification	N/A	N/A	N/A
Casting Date	9/10/14 13:27	9/10/14 13:27	9/10/14 13:27
Test Date / Time	9/24/14 11:00	9/24/14 11:06	9/24/14 11:12
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	14	14	14
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground & Sulfur	Ground & Sulfur	Ground & Sulfur

Concrete Dimensions

Diameter 1, in.	4.03	4.00	4.02
Diameter 2, in.	4.02	3.99	4.02
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.17	8.19	8.18
Average Diameter, in.	4.03	4.00	4.02
Length / Diameter (L/D)	2.03	2.05	2.03
Cross-Sectional Area, in^2	12.76	12.57	12.69

Compressive Strength and Fracture Pattern

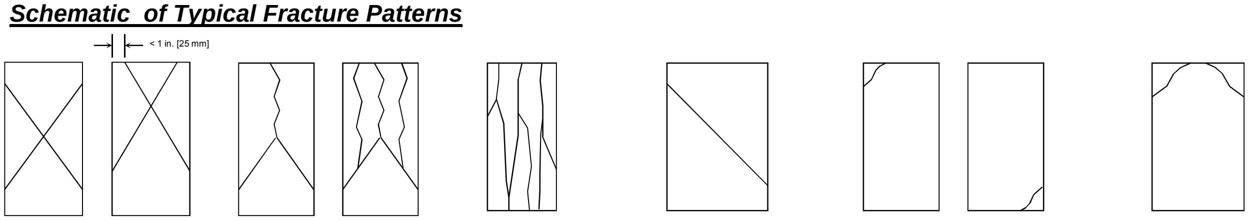
Maximum Load, lb	114,921	112,267	114,372
Compressive Strength, psi	9,010	8,930	9,010
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	8,983

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client: **Illinois Tollway**
Project: **Calcium Aluminate Cement Project**
Contact: **Steve Gillen**
Date Reported: **February 12, 2015**

CTL Project No.: **057177**
CTL Project Mgr.: **M. D'Ambrosia**
Technician: **W. Demharter**
Approved by: **B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	CAC-SRA	CAC-SRA	CAC-SRA
Client Identification	N/A	N/A	N/A
Casting Date	9/10/14 13:27	9/10/14 13:27	9/10/14 13:27
Test Date / Time	10/8/14 16:46	10/8/14 16:54	10/8/14 17:00
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	28	28	28
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	74° / 100%	74° / 100%	74° / 100%
Cylinder End Preparation	Ground & Sulfur	Ground & Sulfur	Ground & Sulfur

Concrete Dimensions

Diameter 1, in.	4.00	4.03	4.02
Diameter 2, in.	4.01	4.03	4.02
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.10	8.09	8.07
Average Diameter, in.	4.01	4.03	4.02
Length / Diameter (L/D)	2.02	2.01	2.01
Cross-Sectional Area, in^2	12.63	12.76	12.69

Compressive Strength and Fracture Pattern

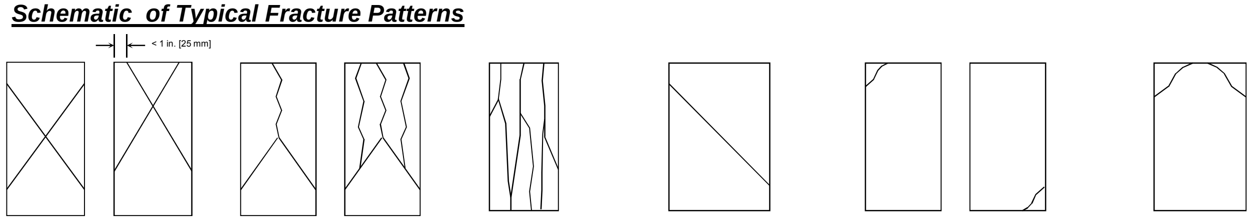
Maximum Load, lb	116,621	118,186	117,816
Compressive Strength, psi	9,230	9,260	9,280
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	9,257

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

CTLGroup

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	9/11/14 11:34	9/11/14 11:34	9/11/14 11:34
Test Date / Time	9/12/14 10:30	9/12/201410:33	9/12/14 10:37
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	1	1	1
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	Mold	Mold	Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.02
Diameter 2, in.	4.00	4.02	4.01
Length(without caps), in.	8.06	8.02	8.03
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.03	4.02
Length / Diameter (L/D)	2.01	1.99	2.00
Cross-Sectional Area, in^2	12.63	12.76	12.69

Compressive Strength and Fracture Pattern

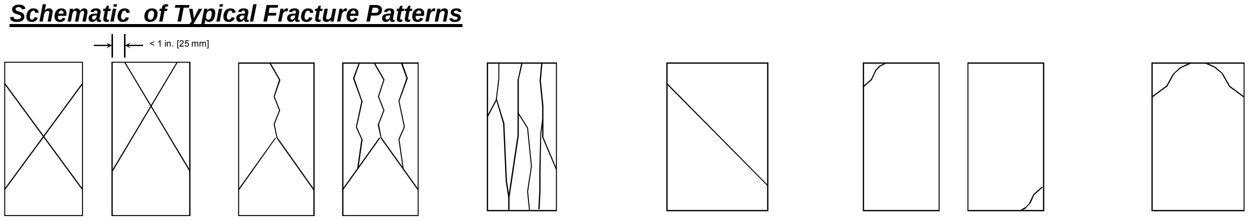
Maximum Load, lb	55,081	55,385	57,205
Compressive Strength, psi	4,360	4,340	4,510
Fracture Pattern	Type 3	Type 2	Type 2

Average Compressive Strength, psi	4,403

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

CTLGroup

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**G. Neiweem**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	9/11/14 11:34	9/11/14 11:34	9/11/14 11:34
Test Date / Time	9/14/14 13:10	9/14/14 13:15	9/14/14 13:20
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	3	3	3
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Sulfur	Sulfur	Sulfur

Concrete Dimensions

Diameter 1, in.	4.00	4.01	4.02
Diameter 2, in.	4.01	4.00	4.01
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.25	8.18	8.24
Average Diameter, in.	4.00	4.00	4.01
Length / Diameter (L/D)	2.06	2.05	2.06
Cross-Sectional Area, in^2	12.57	12.57	12.63

Compressive Strength and Fracture Pattern

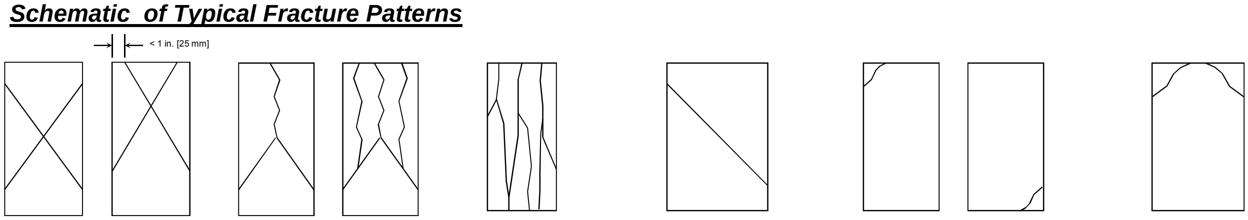
Maximum Load, lb	81,407	81,203	83,555
Compressive Strength, psi	6,480	6,460	6,620
Fracture Pattern	Type 2	Type 1	Type 2

Average Compressive Strength, psi	6,520

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	9/11/14 11:34	9/11/14 11:34	9/11/14 11:34
Test Date / Time	9/16/14 16:30	9/16/14 16:34	9/16/14 16:39
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	5	5	5
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Sulfur	Sulfur	Sulfur

Concrete Dimensions

Diameter 1, in.	4.01	4.02	4.02
Diameter 2, in.	4.00	4.01	4.00
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.19	8.20	8.23
Average Diameter, in.	4.01	4.01	4.01
Length / Diameter (L/D)	2.04	2.05	2.05
Cross-Sectional Area, in^2	12.63	12.63	12.63

Compressive Strength and Fracture Pattern

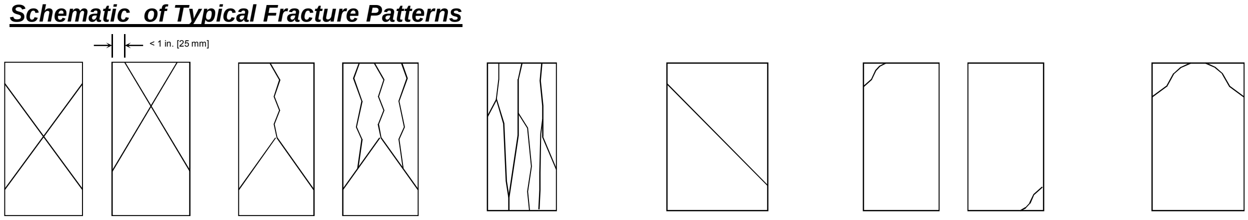
Maximum Load, lb	91,113	90,593	92,024
Compressive Strength, psi	7,210	7,170	7,290
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	7,223

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**B. Szczerowski**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	9/11/14 11:34	9/11/14 11:34	9/11/14 11:34
Test Date / Time	9/18/14 9:48	9/18/14 9:51	9/18/14 9:54
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	7	7	7
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Sulfur	Sulfur	Sulfur

Concrete Dimensions

Diameter 1, in.	4.00	4.00	4.00
Diameter 2, in.	4.00	4.01	4.00
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.19	8.22	8.24
Average Diameter, in.	4.00	4.01	4.00
Length / Diameter (L/D)	2.05	2.05	2.06
Cross-Sectional Area, in^2	12.57	12.63	12.57

Compressive Strength and Fracture Pattern

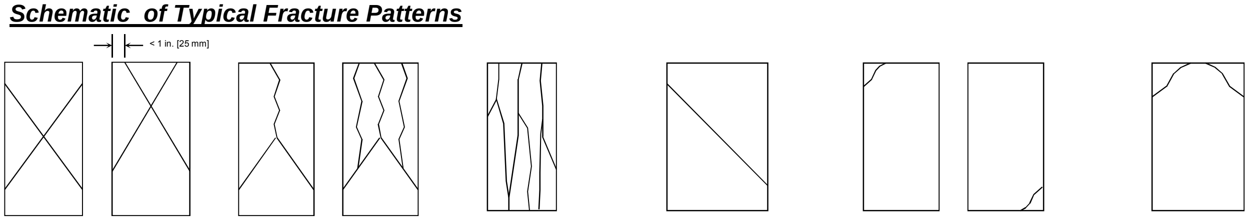
Maximum Load, lb	91,156	93,863	92,206
Compressive Strength, psi	7,250	7,430	7,340
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	7,340

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	9/11/14 11:34	9/11/14 11:34	9/11/14 11:34
Test Date / Time	9/25/14 11:51	9/25/14 11:22	9/25/14 11:30
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	14	14	14
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Ground & Sulfur	Ground & Sulfur	Ground & Sulfur

Concrete Dimensions

Diameter 1, in.	4.00	4.03	4.02
Diameter 2, in.	3.99	4.02	4.01
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.13	8.15	8.14
Average Diameter, in.	4.00	4.02	4.01
Length / Diameter (L/D)	2.03	2.03	2.03
Cross-Sectional Area, in^2	12.57	12.69	12.63

Compressive Strength and Fracture Pattern

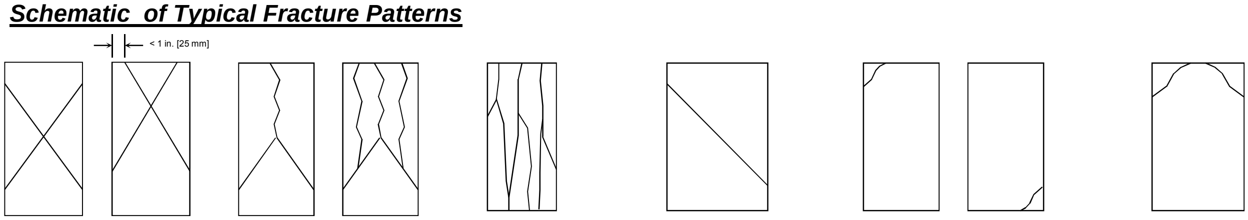
Maximum Load, lb	102,754	104,743	102,442
Compressive Strength, psi	8,170	8,250	8,110
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	8,177

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**B. Szczerowski**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC	LCAC	LCAC
Client Identification	N/A	N/A	N/A
Casting Date	9/11/14 11:34	9/11/14 11:34	9/11/14 11:34
Test Date / Time	10/9/14 8:18	10/9/14 8:18	10/9/14 8:18
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	28	28	28
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	74° / 50%	74° / 50%	74° / 50%
Cylinder End Preparation	Sulfur	Sulfur	Sulfur

Concrete Dimensions

Diameter 1, in.	4.01	4.02	3.99
Diameter 2, in.	4.00	3.98	4.01
Length(without caps), in.	N/A	N/A	N/A
Length(with caps), in.	8.13	8.22	8.24
Average Diameter, in.	4.00	4.00	4.00
Length / Diameter (L/D)	2.03	2.06	2.06
Cross-Sectional Area, in^2	12.57	12.57	12.57

Compressive Strength and Fracture Pattern

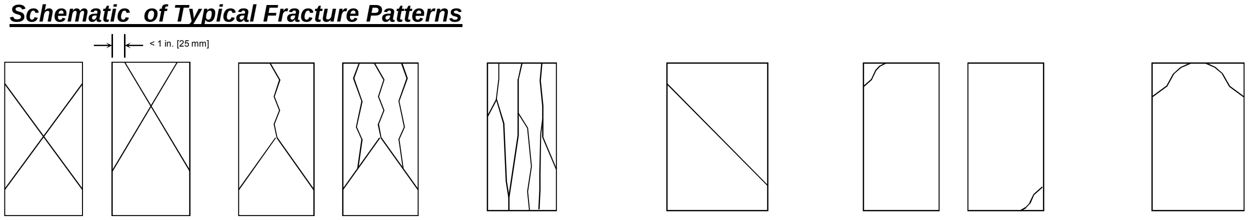
Maximum Load, lb	107,722	106,283	105,489
Compressive Strength, psi	8,570	8,460	8,390
Fracture Pattern	Type 4	Type 4	Type 1

Average Compressive Strength, psi	8,473

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 22, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC (lab)	LCAC (lab)
Client Identification	N/A	N/A
Casting Date	1/21/2016	1/21/2016
Test Date / Time	1/22/2016	1/22/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	23	23
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.02	4.03
Diameter 2, in.	4.00	4.03
Length(without caps), in.	8.02	8.01
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.03
Length / Diameter (L/D)	2.00	1.99
Cross-Sectional Area, in^2	12.63	12.76

Compressive Strength and Fracture Pattern

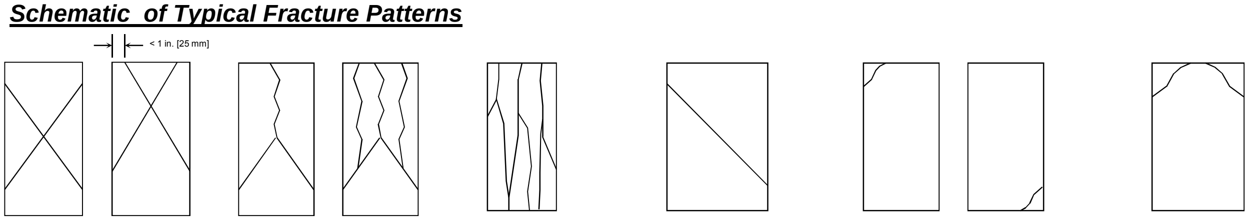
Maximum Load, lb	1,465	1,603
Compressive Strength, psi	120	130
Fracture Pattern	Type 3	Type 3

Average Compressive Strength, psi	120

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 22, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

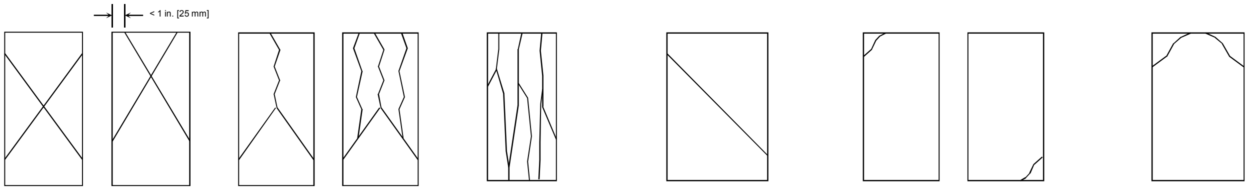
Specimen Identification		
CTLGroup Identification	LCAC (lab)	LCAC (lab)
Client Identification	N/A	N/A
Casting Date	1/21/2016	1/21/2016
Test Date / Time	1/22/2016	1/22/2016
Loading Rate, psi/sec	35	35
Concrete Description		
Concrete Age at Test, hours	31	31
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene
Concrete Dimensions		
Diameter 1, in.	4.00	4.02
Diameter 2, in.	4.02	4.01
Length(without caps), in.	8.02	8.00
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.01
Length / Diameter (L/D)	2.00	2.00
Cross-Sectional Area, in^2	12.63	12.63
Compressive Strength and Fracture Pattern		
Maximum Load, lb	9,487	9,915
Compressive Strength, psi	750	790
Fracture Pattern	Type 3	Type 3

Average Compressive Strength, psi	770

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 22, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

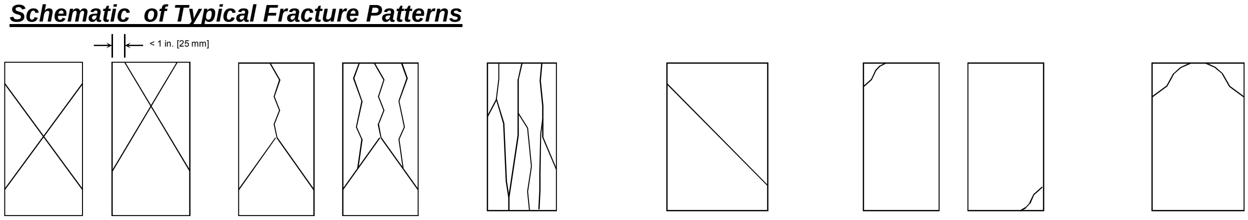
Specimen Identification		
CTLGroup Identification	LCAC (cold)	LCAC (cold)
Client Identification	N/A	N/A
Casting Date	1/21/2016	1/21/2016
Test Date / Time	1/22/2016	1/22/2016
Loading Rate, psi/sec	35	35
Concrete Description		
Concrete Age at Test, hours	31	31
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Neoprene	Neoprene
Concrete Dimensions		
Diameter 1, in.	4.02	4.04
Diameter 2, in.	4.01	4.02
Length(without caps), in.	8.02	8.03
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.03
Length / Diameter (L/D)	2.00	1.99
Cross-Sectional Area, in^2	12.69	12.76
Compressive Strength and Fracture Pattern		
Maximum Load, lb	8,196	7,091
Compressive Strength, psi	650	560
Fracture Pattern	Type 3	Type 3

Average Compressive Strength, psi	600

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 23, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC (cold)	LCAC (cold)
Client Identification	N/A	N/A
Casting Date	1/21/2016	1/21/2016
Test Date / Time	1/23/2016	1/23/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, days	2	2
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.01
Diameter 2, in.	4.02	4.00
Length(without caps), in.	7.93	7.91
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.03	4.01
Length / Diameter (L/D)	1.97	1.97
Cross-Sectional Area, in^2	12.76	12.63

Compressive Strength and Fracture Pattern

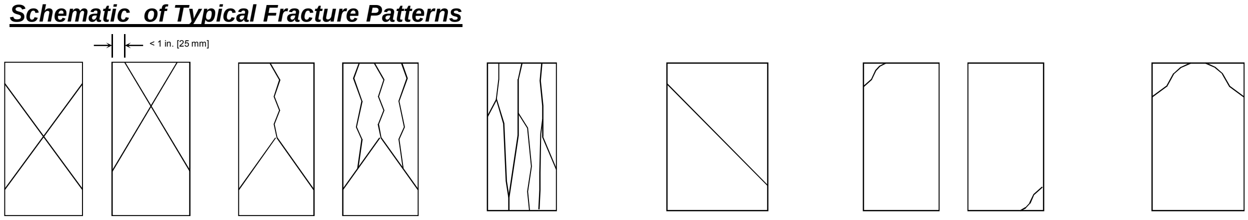
Maximum Load, lb	97,129	100,632
Compressive Strength, psi	7,610	7,970
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	7,790

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 21, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC-A (lab)	LCAC-A (lab)
Client Identification	N/A	N/A
Casting Date	1/21/16 9:01	1/21/16 9:01
Test Date / Time	1/21/16 15:00	1/21/16 15:00
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	6	6
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.00	4.02
Diameter 2, in.	4.00	4.01
Length(without caps), in.	8.01	8.02
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.00	4.02
Length / Diameter (L/D)	2.00	1.99
Cross-Sectional Area, in^2	12.57	12.69

Compressive Strength and Fracture Pattern

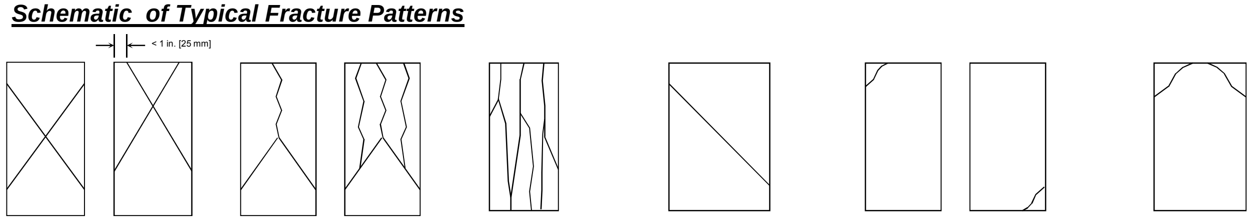
Maximum Load, lb	10,267	10,622
Compressive Strength, psi	820	840
Fracture Pattern	Type 3	Type 3

Average Compressive Strength, psi	830

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 22, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC-A (lab)	LCAC-A (lab)
Client Identification	N/A	N/A
Casting Date	1/21/16 9:01	1/21/16 9:01
Test Date / Time	1/22/16 10:00	1/22/16 10:00
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	25	25
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.01
Diameter 2, in.	4.01	3.99
Length(without caps), in.	7.99	7.97
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.00
Length / Diameter (L/D)	1.99	1.99
Cross-Sectional Area, in^2	12.63	12.57

Compressive Strength and Fracture Pattern

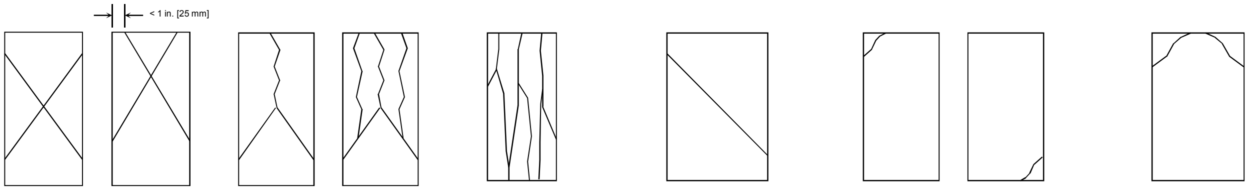
Maximum Load, lb	101,384	102,160
Compressive Strength, psi	8,030	8,130
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	8,080

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 21, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC-A (cold)	LCAC-A (cold)
Client Identification	N/A	N/A
Casting Date	1/21/16 9:01	1/21/16 9:01
Test Date / Time	1/21/16 17:04	1/21/16 17:04
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	8	8
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.00	4.02
Diameter 2, in.	4.00	4.02
Length(without caps), in.	8.02	8.00
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.00	4.02
Length / Diameter (L/D)	2.01	1.99
Cross-Sectional Area, in^2	12.57	12.69

Compressive Strength and Fracture Pattern

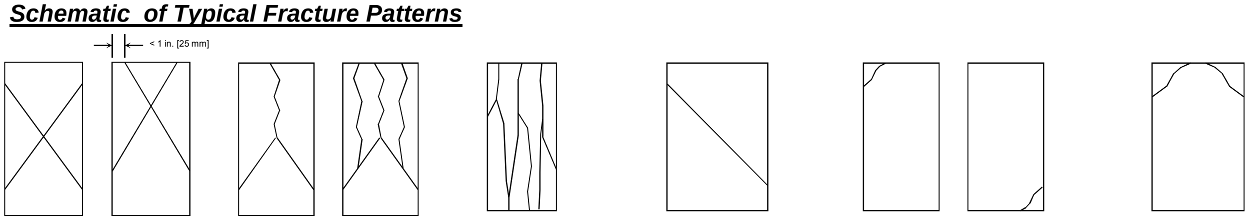
Maximum Load, lb	58,219	56,011
Compressive Strength, psi	4,630	4,410
Fracture Pattern	Type 3	Type 3

Average Compressive Strength, psi	4,520

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 22, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC-A (cold)	LCAC-A (cold)
Client Identification	N/A	N/A
Casting Date	1/21/16 9:01	1/21/16 9:01
Test Date / Time	1/22/16 17:15	1/22/16 17:15
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	32	32
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.02
Diameter 2, in.	3.99	4.02
Length(without caps), in.	7.92	7.90
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.00	4.02
Length / Diameter (L/D)	1.98	1.97
Cross-Sectional Area, in^2	12.57	12.69

Compressive Strength and Fracture Pattern

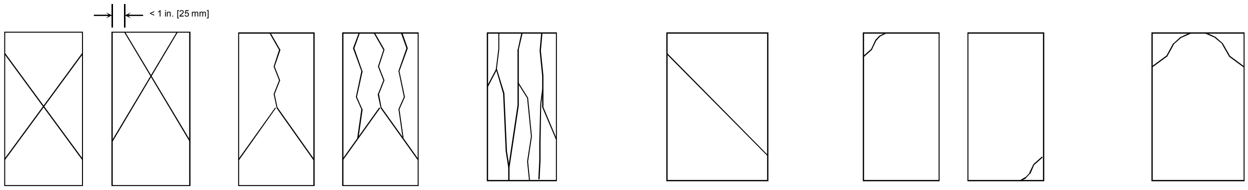
Maximum Load, lb	107,309	109,996
Compressive Strength, psi	8,540	8,670
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	8,600

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 21, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC-AD (lab)	LCAC-AD (lab)
Client Identification	N/A	N/A
Casting Date	1/21/2016	1/21/2016
Test Date / Time	1/21/2016	1/21/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	6	6
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.02	4.00
Diameter 2, in.	4.01	4.00
Length(without caps), in.	8.02	8.01
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.00
Length / Diameter (L/D)	1.99	2.00
Cross-Sectional Area, in^2	12.69	12.57

Compressive Strength and Fracture Pattern

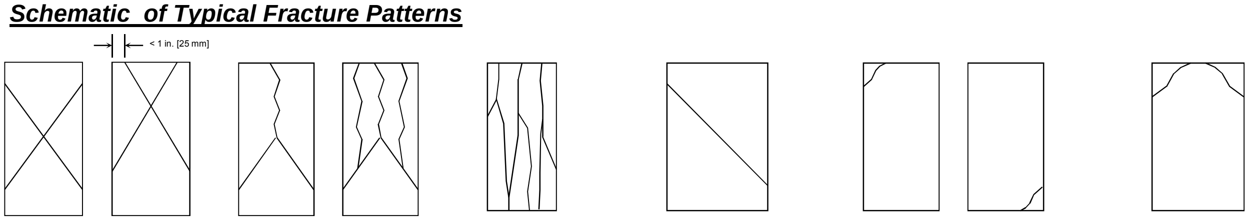
Maximum Load, lb	926	1,019
Compressive Strength, psi	70	80
Fracture Pattern	Type 3	Type 3

Average Compressive Strength, psi	80

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 22, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC-AD (lab)	LCAC-AD (lab)
Client Identification	N/A	N/A
Casting Date	1/21/2016	1/21/2016
Test Date / Time	1/22/2016	1/22/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	25	25
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.00
Diameter 2, in.	4.02	3.99
Length(without caps), in.	7.91	7.88
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.00
Length / Diameter (L/D)	1.97	1.97
Cross-Sectional Area, in^2	12.69	12.57

Compressive Strength and Fracture Pattern

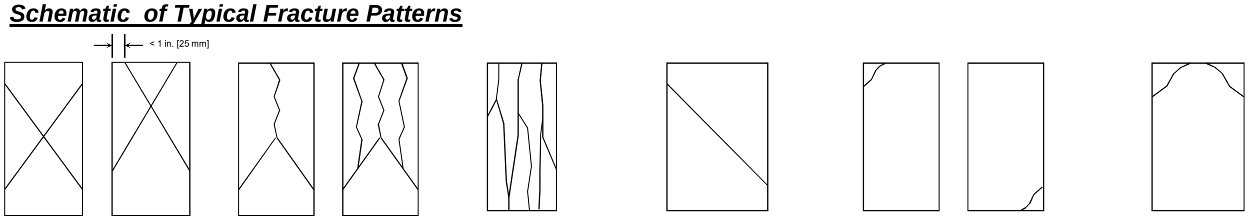
Maximum Load, lb	82,303	84,991
Compressive Strength, psi	6,490	6,760
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	6,620

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 22, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC-AD (cold)	LCAC-AD (cold)
Client Identification	N/A	N/A
Casting Date	1/21/2016	1/21/2016
Test Date / Time	1/22/2016	1/22/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	30	30
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.02	4.00
Diameter 2, in.	4.00	3.99
Length(without caps), in.	8.03	8.01
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.00
Length / Diameter (L/D)	2.00	2.00
Cross-Sectional Area, in^2	12.63	12.57

Compressive Strength and Fracture Pattern

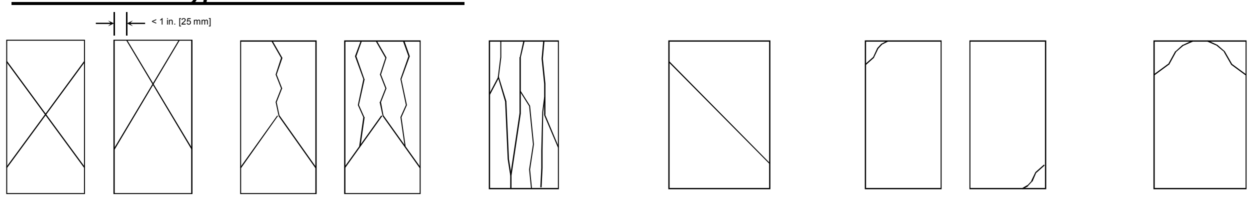
Maximum Load, lb	42,368	39,928
Compressive Strength, psi	3,350	3,180
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	3,270

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 23, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	LCAC-AD (cold)	LCAC-AD (cold)
Client Identification	N/A	N/A
Casting Date	1/21/2016	1/21/2016
Test Date / Time	1/23/2016	1/23/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	48	48
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03
Diameter 2, in.	4.00	4.03
Length(without caps), in.	7.91	7.93
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.03
Length / Diameter (L/D)	1.97	1.97
Cross-Sectional Area, in^2	12.63	12.76

Compressive Strength and Fracture Pattern

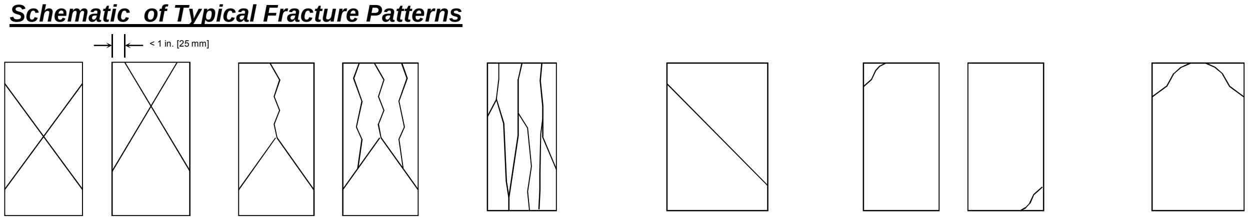
Maximum Load, lb	85,727	86,060
Compressive Strength, psi	6,790	6,740
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	6,770

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 21, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA (lab)	ASRA (lab)
Client Identification	N/A	N/A
Casting Date	1/21/2016	1/21/2016
Test Date / Time	1/21/2016	1/21/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	4	4
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.00	4.01
Diameter 2, in.	3.99	4.00
Length(without caps), in.	8.03	8.01
Length(with caps), in.	N/A	N/A
Average Diameter, in.	3.99	4.01
Length / Diameter (L/D)	2.01	2.00
Cross-Sectional Area, in^2	12.50	12.63

Compressive Strength and Fracture Pattern

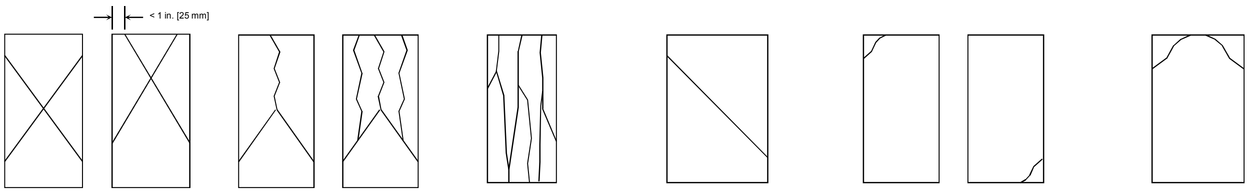
Maximum Load, lb	6,955	7,575
Compressive Strength, psi	560	600
Fracture Pattern	Type 3	Type 3

Average Compressive Strength, psi	580

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 21, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA (lab)	ASRA (lab)
Client Identification	N/A	N/A
Casting Date	1/21/2016	1/21/2016
Test Date / Time	1/21/2016	1/21/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	6	6
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.01	4.04
Diameter 2, in.	4.00	4.02
Length(without caps), in.	8.01	8.02
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.03
Length / Diameter (L/D)	2.00	1.99
Cross-Sectional Area, in^2	12.63	12.76

Compressive Strength and Fracture Pattern

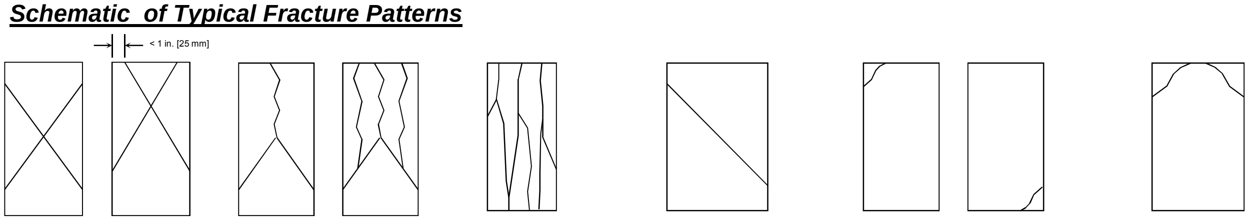
Maximum Load, lb	44,302	46,130
Compressive Strength, psi	3,510	3,620
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	3,560

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 22, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA (cold)	ASRA (cold)
Client Identification	N/A	N/A
Casting Date	1/21/2016	1/21/2016
Test Date / Time	1/22/2016	1/22/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	22	22
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.02	4.03
Diameter 2, in.	4.01	4.02
Length(without caps), in.	8.00	8.01
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.03
Length / Diameter (L/D)	2.00	1.99
Cross-Sectional Area, in^2	12.63	12.76

Compressive Strength and Fracture Pattern

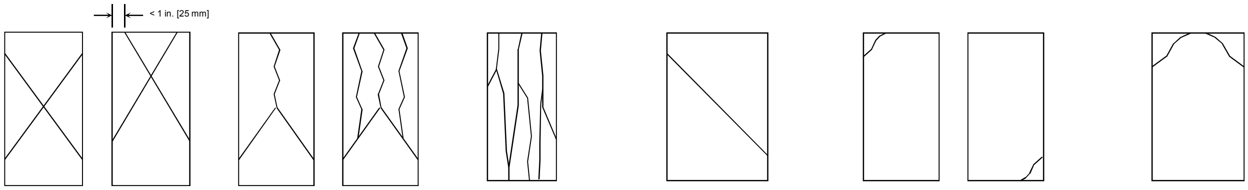
Maximum Load, lb	54,169	51,229
Compressive Strength, psi	4,290	4,010
Fracture Pattern	Type 6	Type 3

Average Compressive Strength, psi	4,150

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**January 22, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA (cold)	ASRA (cold)
Client Identification	N/A	N/A
Casting Date	1/21/2016	1/21/2016
Test Date / Time	1/22/2016	1/22/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	31	31
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.02
Diameter 2, in.	4.02	4.02
Length(without caps), in.	8.00	8.02
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.03	4.02
Length / Diameter (L/D)	1.99	2.00
Cross-Sectional Area, in^2	12.76	12.69

Compressive Strength and Fracture Pattern

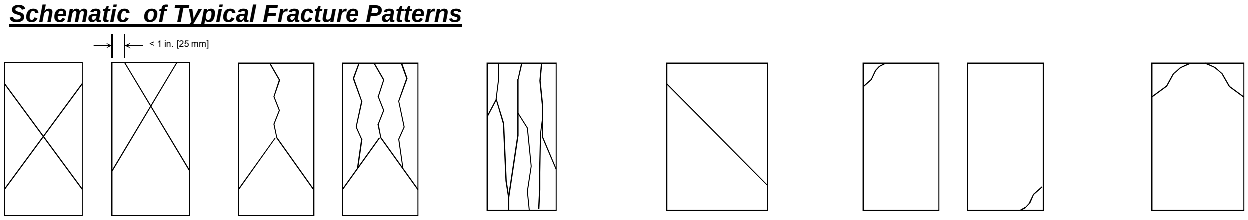
Maximum Load, lb	50,186	54,209
Compressive Strength, psi	3,930	4,270
Fracture Pattern	Type 3	Type 3

Average Compressive Strength, psi	4,100

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 22, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix 1 (lab)
Client Identification	N/A
Casting Date	2/19/2016
Test Date / Time	2/19/2016
Loading Rate, psi/sec	35

Concrete Description

Concrete Age at Test, hours	5
Moisture Condition at Test	Mold
Curing Conditions (Temp/RH)	73°F / Mold
Cylinder End Preparation	Neoprene

Concrete Dimensions

Diameter 1, in.	4.03
Diameter 2, in.	4.02
Length(without caps), in.	8.00
Length(with caps), in.	N/A
Average Diameter, in.	4.03
Length / Diameter (L/D)	1.99
Cross-Sectional Area, in^2	12.76

Compressive Strength and Fracture Pattern

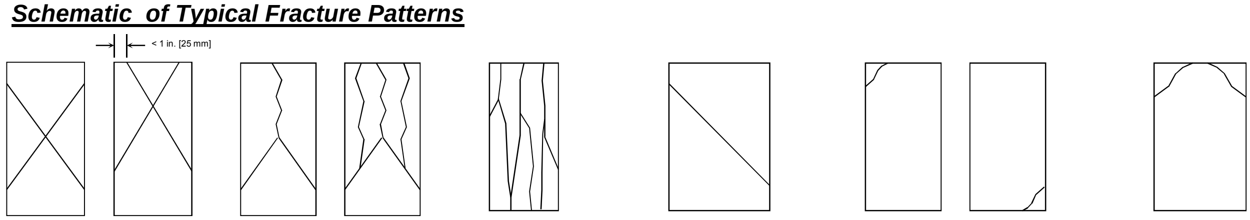
Maximum Load, lb	9,800
Compressive Strength, psi	770
Fracture Pattern	Type 3

Average Compressive Strength, psi	770

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 22, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix 1 (lab)	ASRA Mix 1 (lab)	ASRA Mix 1 (lab)
Client Identification	N/A	N/A	N/A
Casting Date	2/19/2016	2/19/2016	2/19/2016
Test Date / Time	2/19/2016	2/19/2016	2/19/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	6	6	6
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.02	4.01	4.03
Diameter 2, in.	4.01	4.00	4.02
Length(without caps), in.	8.02	8.00	8.01
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.00	4.03
Length / Diameter (L/D)	2.00	2.00	1.99
Cross-Sectional Area, in^2	12.63	12.57	12.76

Compressive Strength and Fracture Pattern

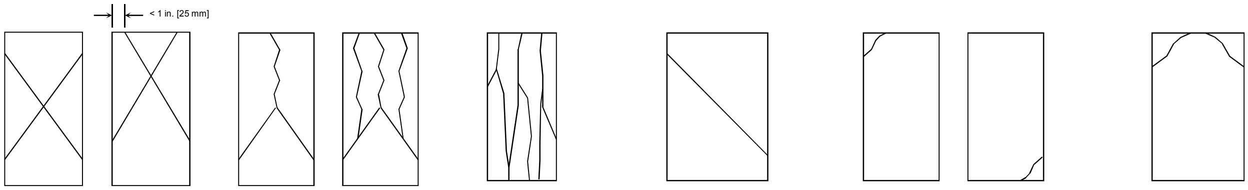
Maximum Load, lb	28,928	25,752	26,307
Compressive Strength, psi	2,290	2,050	2,060
Fracture Pattern	Type 3	Type 3	Type 3

Average Compressive Strength, psi	2,130

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 22, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix 1 (lab)	ASRA Mix 1 (lab)	ASRA Mix 1 (lab)
Client Identification	N/A	N/A	N/A
Casting Date	2/19/2016	2/19/2016	2/19/2016
Test Date / Time	2/19/2016	2/19/2016	2/19/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	8	8	8
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.00	4.03
Diameter 2, in.	4.03	4.02	4.02
Length(without caps), in.	8.00	8.03	8.01
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.03	4.01	4.02
Length / Diameter (L/D)	1.99	2.00	1.99
Cross-Sectional Area, in^2	12.76	12.63	12.69

Compressive Strength and Fracture Pattern

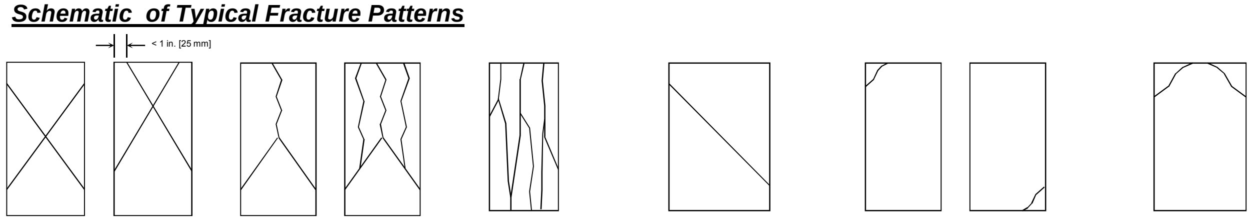
Maximum Load, lb	38,677	38,360	38,999
Compressive Strength, psi	3,030	3,040	3,070
Fracture Pattern	Type 3	Type 3	Type 3

Average Compressive Strength, psi	3,050

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 22, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix 1 (lab)	ASRA Mix 1 (lab)	ASRA Mix 1 (lab)
Client Identification	N/A	N/A	N/A
Casting Date	2/19/2016	2/19/2016	2/19/2016
Test Date / Time	2/20/2016	2/20/2016	2/20/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	24	24	24
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.01	4.02
Diameter 2, in.	4.00	4.00	4.02
Length(without caps), in.	7.94	7.92	7.92
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.00	4.02
Length / Diameter (L/D)	1.98	1.98	1.97
Cross-Sectional Area, in^2	12.63	12.57	12.69

Compressive Strength and Fracture Pattern

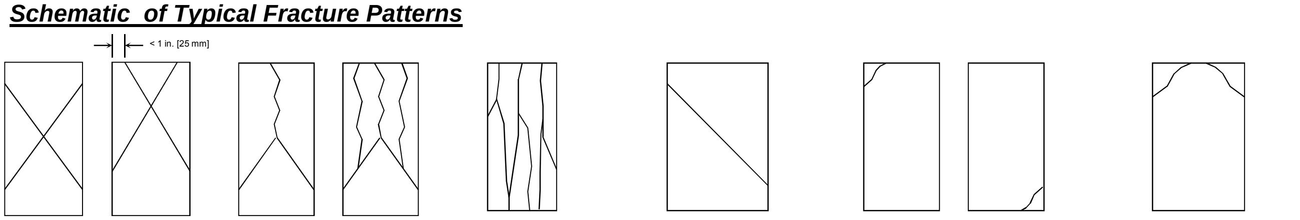
Maximum Load, lb	59,822	58,157	58,779
Compressive Strength, psi	4,740	4,630	4,630
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	4,670

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix 1 (cold)	ASRA Mix 1 (cold)	ASRA Mix 1 (cold)
Client Identification	N/A	N/A	N/A
Casting Date	2/19/2016	2/19/2016	2/19/2016
Test Date / Time	2/22/2016	2/22/2016	2/22/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	3	3	3
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.02	4.01
Diameter 2, in.	4.01	4.01	4.02
Length(without caps), in.	7.89	7.87	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.02	4.01
Length / Diameter (L/D)	1.97	1.96	1.97
Cross-Sectional Area, in^2	12.63	12.69	12.63

Compressive Strength and Fracture Pattern

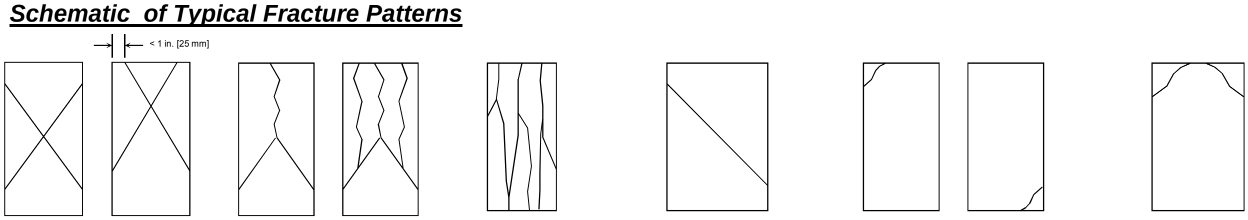
Maximum Load, lb	57,210	58,281	56,549
Compressive Strength, psi	4,530	4,590	4,480
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	4,530

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 22, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix 2 (lab)
Client Identification	N/A
Casting Date	2/19/2016
Test Date / Time	2/19/2016
Loading Rate, psi/sec	35

Concrete Description

Concrete Age at Test, hours	3.3
Moisture Condition at Test	Mold
Curing Conditions (Temp/RH)	73°F / Mold
Cylinder End Preparation	Neoprene

Concrete Dimensions

Diameter 1, in.	4.01
Diameter 2, in.	4.00
Length(without caps), in.	8.02
Length(with caps), in.	N/A
Average Diameter, in.	4.01
Length / Diameter (L/D)	2.00
Cross-Sectional Area, in^2	12.63

Compressive Strength and Fracture Pattern

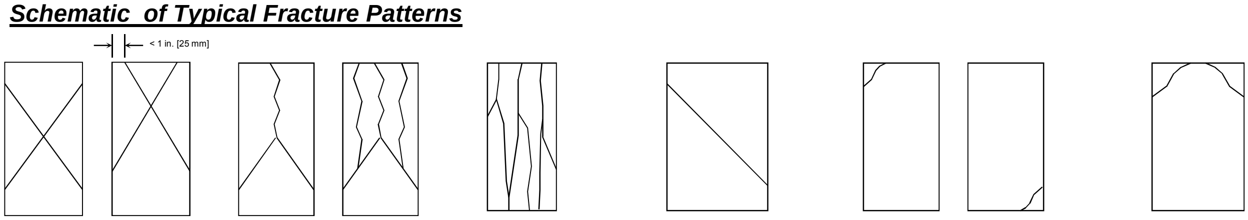
Maximum Load, lb	653
Compressive Strength, psi	50
Fracture Pattern	Type 3

Average Compressive Strength, psi	50

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix 4	ASRA Mix 4	ASRA Mix 4
Client Identification	N/A	N/A	N/A
Casting Date	2/19/2016	2/19/2016	2/19/2016
Test Date / Time	2/22/2016	2/22/2016	2/22/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	3	3	3
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.03	4.02
Diameter 2, in.	3.99	4.01	4.01
Length(without caps), in.	7.89	7.86	7.87
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.02	4.01
Length / Diameter (L/D)	1.97	1.96	1.96
Cross-Sectional Area, in^2	12.57	12.69	12.63

Compressive Strength and Fracture Pattern

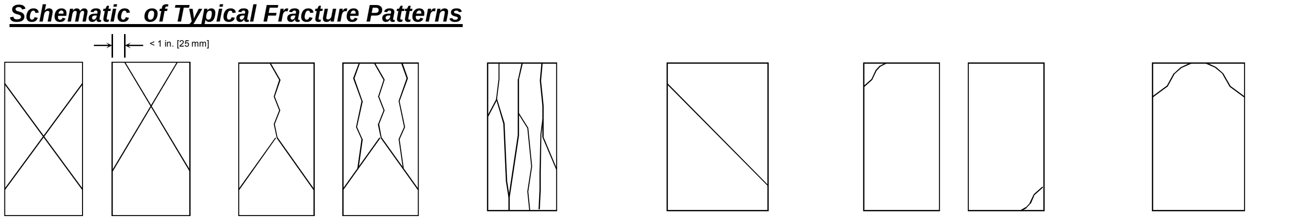
Maximum Load, lb	71,191	69,746	70,260
Compressive Strength, psi	5,660	5,500	5,560
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	5,570

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix 4	ASRA Mix 4	ASRA Mix 4
Client Identification	N/A	N/A	N/A
Casting Date	2/19/2016	2/19/2016	2/19/2016
Test Date / Time	2/26/2016	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	7	7	7
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.01	4.03
Diameter 2, in.	4.02	4.01	4.02
Length(without caps), in.	7.87	7.89	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.03	4.01	4.02
Length / Diameter (L/D)	1.95	1.97	1.96
Cross-Sectional Area, in^2	12.76	12.63	12.69

Compressive Strength and Fracture Pattern

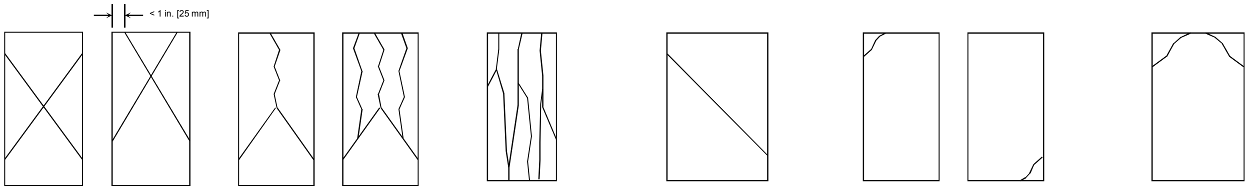
Maximum Load, lb	87,002	86,871	85,866
Compressive Strength, psi	6,820	6,880	6,770
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,820

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 5, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix 4	ASRA Mix 4	ASRA Mix 4
Client Identification	N/A	N/A	N/A
Casting Date	2/19/2016	2/19/2016	2/19/2016
Test Date / Time	3/4/2016	3/4/2016	3/4/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	14	14	14
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.02
Diameter 2, in.	4.00	4.02	4.02
Length(without caps), in.	7.86	7.88	7.87
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.03	4.02
Length / Diameter (L/D)	1.96	1.96	1.96
Cross-Sectional Area, in^2	12.63	12.76	12.69

Compressive Strength and Fracture Pattern

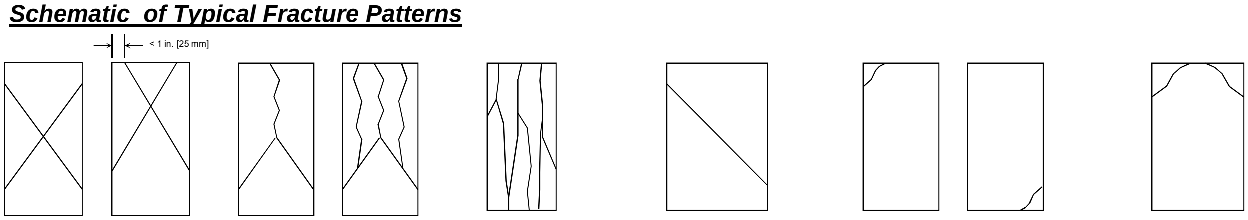
Maximum Load, lb	99,260	99,842	101,262
Compressive Strength, psi	7,860	7,820	7,980
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	7,890

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 5, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix 4	ASRA Mix 4	ASRA Mix 4
Client Identification	N/A	N/A	N/A
Casting Date	2/19/2016	2/19/2016	2/19/2016
Test Date / Time	3/18/2016	3/18/2016	3/18/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	28	28	28
Moisture Condition at Test	Moist	Moist	Moist
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.00	4.02
Diameter 2, in.	4.01	4.01	4.01
Length(without caps), in.	7.88	7.90	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.00	4.02
Length / Diameter (L/D)	1.96	1.98	1.96
Cross-Sectional Area, in^2	12.69	12.57	12.69

Compressive Strength and Fracture Pattern

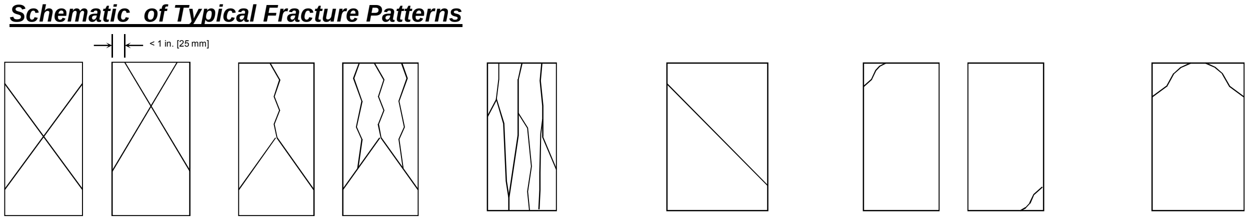
Maximum Load, lb	111,605	112,828	113,362
Compressive Strength, psi	8,790	8,980	8,930
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	8,900

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1 Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2 Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3 Columnar vertical cracking through both ends, no well-formed cones

Type 4 Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5 Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6 Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix 4 (hot)	ASRA Mix 4 (hot)	ASRA Mix 4 (hot)
Client Identification	N/A	N/A	N/A
Casting Date	2/19/16 11:05	2/19/16 11:05	2/19/16 11:05
Test Date / Time	2/26/16 9:00	2/26/16 9:00	2/26/16 9:00
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	7	7	7
Moisture Condition at Test	SSD	SSD	SSD
Curing Conditions (Temp/RH)	Limewater / 122°F	Limewater / 122°F	Limewater / 122°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.04	4.00
Diameter 2, in.	4.01	4.03	4.00
Length(without caps), in.	7.88	7.86	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.03	4.00
Length / Diameter (L/D)	1.96	1.95	1.97
Cross-Sectional Area, in^2	12.63	12.76	12.57

Compressive Strength and Fracture Pattern

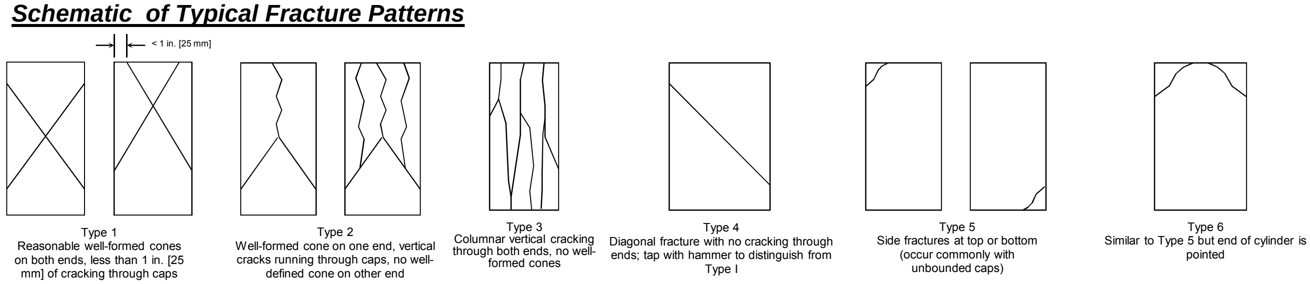
Maximum Load, lb	70,774	70,833	68,601
Compressive Strength, psi	5,600	5,550	5,460
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	5,540

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 5, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix 4 (hot)	ASRA Mix 4 (hot)
Client Identification	N/A	N/A
Casting Date	2/19/16 11:05	2/19/16 11:05
Test Date / Time	3/18/16 9:50	3/18/16 9:50
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, days	28	28
Moisture Condition at Test	SSD	SSD
Curing Conditions (Temp/RH)	Limewater / 122°F	Limewater / 122°F
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.01
Diameter 2, in.	4.02	4.00
Length(without caps), in.	7.88	7.89
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.01
Length / Diameter (L/D)	1.96	1.97
Cross-Sectional Area, in^2	12.69	12.63

Compressive Strength and Fracture Pattern

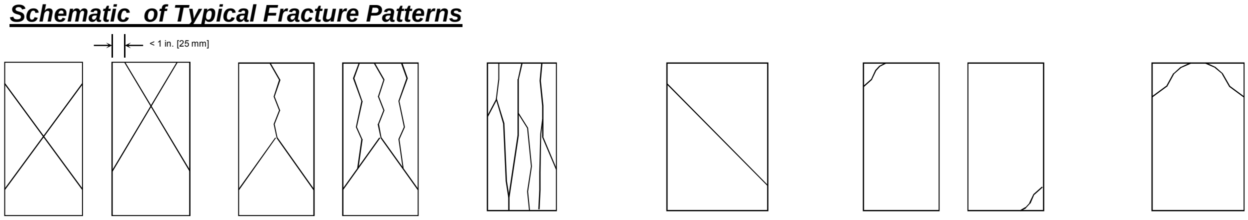
Maximum Load, lb	62,730	64,921
Compressive Strength, psi	4,940	5,140
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	5,040

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix A (lab)	ASRA Mix A (lab)
Client Identification	N/A	N/A
Casting Date	8:34:00 AM	8:34:00 AM
Test Date / Time	12:30:00 PM	12:30:00 PM
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	4	4
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.02	4.02
Diameter 2, in.	4.01	4.01
Length(without caps), in.	8.01	8.02
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.01
Length / Diameter (L/D)	2.00	2.00
Cross-Sectional Area, in^2	12.63	12.63

Compressive Strength and Fracture Pattern

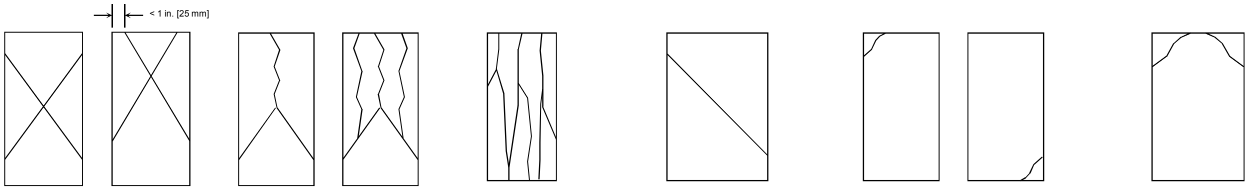
Maximum Load, lb	8,196	9,621
Compressive Strength, psi	650	760
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	710

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix A (lab)	ASRA Mix A (lab)
Client Identification	N/A	N/A
Casting Date	8:34:00 AM	8:34:00 AM
Test Date / Time	2:30:00 PM	2:30:00 PM
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	6	6
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.00	4.03
Diameter 2, in.	4.02	4.03
Length(without caps), in.	8.01	8.03
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.03
Length / Diameter (L/D)	2.00	1.99
Cross-Sectional Area, in^2	12.63	12.76

Compressive Strength and Fracture Pattern

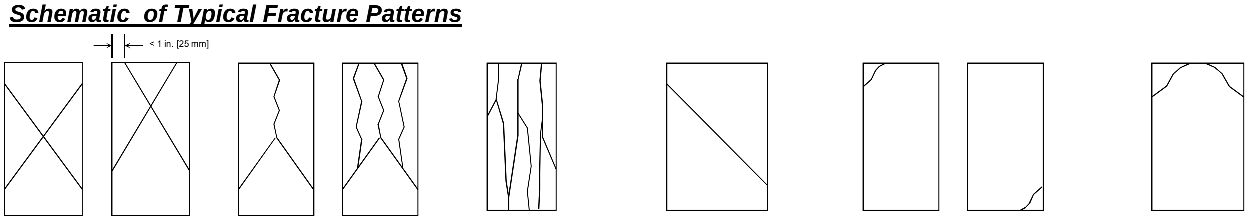
Maximum Load, lb	27,244	26,018
Compressive Strength, psi	2,160	2,040
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	2,100

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix A (lab)	ASRA Mix A (lab)
Client Identification	N/A	N/A
Casting Date	8:34:00 AM	8:34:00 AM
Test Date / Time	4:30:00 PM	4:30:00 PM
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	8	8
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.00
Diameter 2, in.	4.01	3.99
Length(without caps), in.	8.01	8.02
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.00
Length / Diameter (L/D)	1.99	2.00
Cross-Sectional Area, in^2	12.69	12.57

Compressive Strength and Fracture Pattern

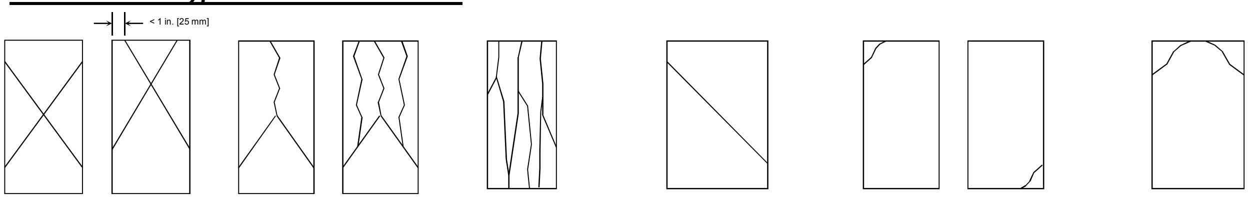
Maximum Load, lb	40,116	41,264
Compressive Strength, psi	3,160	3,280
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	3,220

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix A (lab)	ASRA Mix A (lab)	ASRA Mix A (lab)
Client Identification	N/A	N/A	N/A
Casting Date	8:34:00 AM	8:34:00 AM	2/26/2016
Test Date / Time	6:30:00 PM	6:50:00 PM	2/26/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	9.9	10.3	10.6
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.01	4.02
Diameter 2, in.	4.01	4.01	4.01
Length(without caps), in.	8.00	7.99	8.03
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.01	4.02
Length / Diameter (L/D)	1.99	1.99	2.00
Cross-Sectional Area, in^2	12.69	12.63	12.69

Compressive Strength and Fracture Pattern

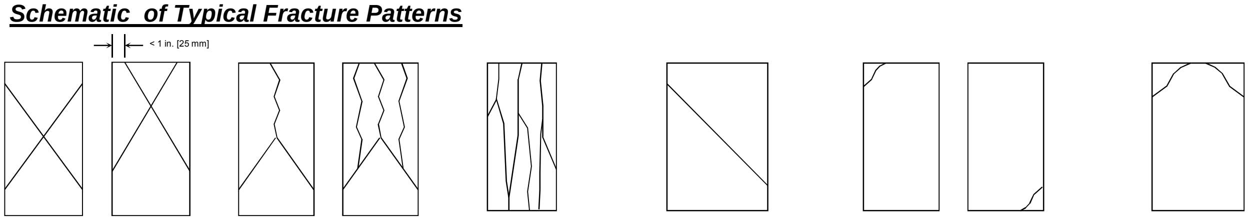
Maximum Load, lb	44,297	48,006	51,119
Compressive Strength, psi	3,490	3,800	4,030
Fracture Pattern	Type 3	Type 6	Type 6

Average Compressive Strength, psi	3,770

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix A (lab)	ASRA Mix A (lab)
Client Identification	N/A	N/A
Casting Date	8:34:00 AM	8:34:00 AM
Test Date / Time	8:45:00 AM	8:45:00 AM
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	24	24
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.02
Diameter 2, in.	4.02	4.01
Length(without caps), in.	7.87	7.89
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.01
Length / Diameter (L/D)	1.96	1.97
Cross-Sectional Area, in^2	12.69	12.63

Compressive Strength and Fracture Pattern

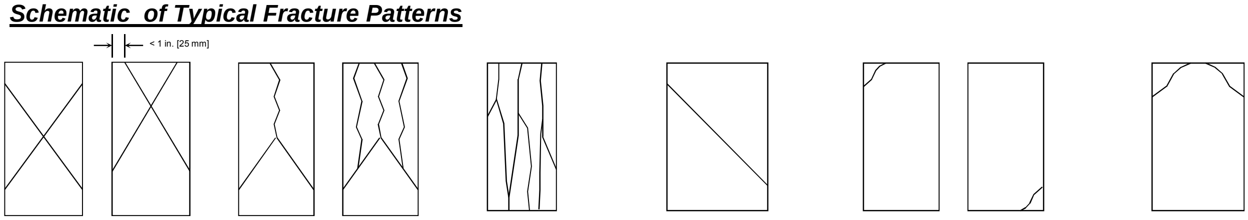
Maximum Load, lb	47,902	50,911
Compressive Strength, psi	3,770	4,030
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	3,900

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1 Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2 Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3 Columnar vertical cracking through both ends, no well-formed cones

Type 4 Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5 Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6 Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix A (cold)	ASRA Mix A (cold)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	6	6
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.01	4.03
Diameter 2, in.	4.00	4.02
Length(without caps), in.	8.01	8.02
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.03
Length / Diameter (L/D)	2.00	1.99
Cross-Sectional Area, in^2	12.63	12.76

Compressive Strength and Fracture Pattern

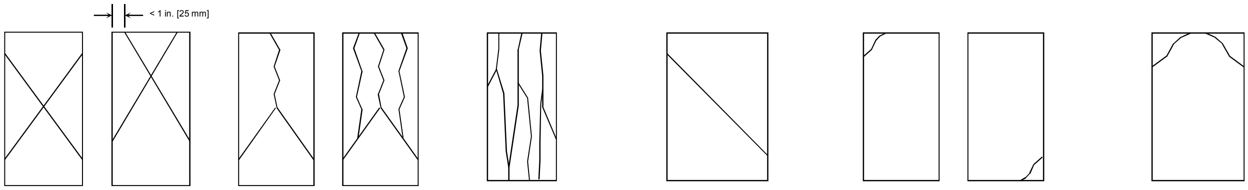
Maximum Load, lb	4,334	3,980
Compressive Strength, psi	340	310
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	330

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix A (cold)	ASRA Mix A (cold)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	8	8
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.01	4.03
Diameter 2, in.	4.03	4.02
Length(without caps), in.	8.03	8.02
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.02
Length / Diameter (L/D)	2.00	2.00
Cross-Sectional Area, in^2	12.69	12.69

Compressive Strength and Fracture Pattern

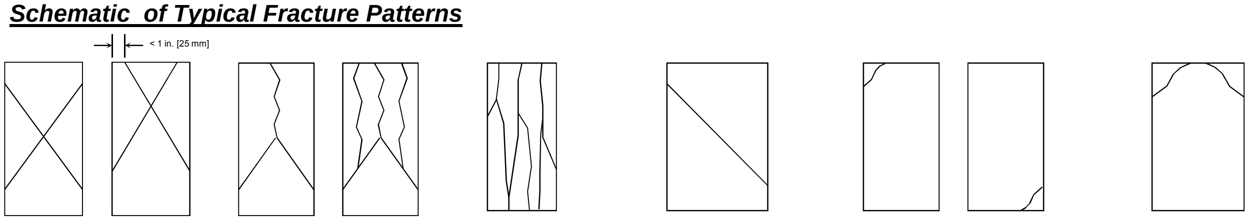
Maximum Load, lb	22,486	25,291
Compressive Strength, psi	1,770	1,990
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	1,880

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix A (cold)	ASRA Mix A (cold)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	10	10
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.01	4.03
Diameter 2, in.	4.02	4.02
Length(without caps), in.	8.01	8.00
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.02
Length / Diameter (L/D)	2.00	1.99
Cross-Sectional Area, in^2	12.63	12.69

Compressive Strength and Fracture Pattern

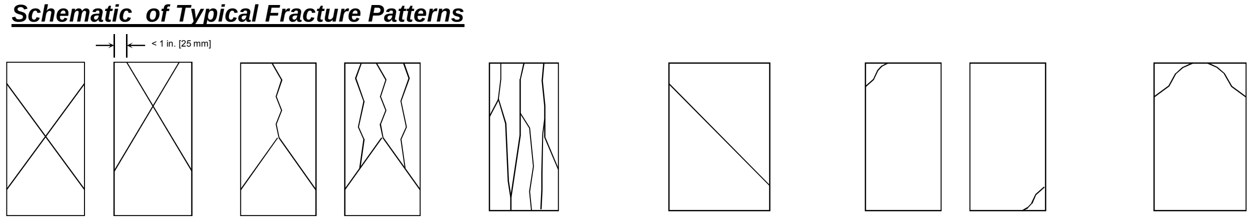
Maximum Load, lb	45,289	42,256
Compressive Strength, psi	3,590	3,330
Fracture Pattern	Type 3	Type 3

Average Compressive Strength, psi	3,460

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix A (cold)	ASRA Mix A (cold)	ASRA Mix A (cold)
Client Identification	N/A	N/A	N/A
Casting Date	2/26/2016	2/26/2016	2/26/2016
Test Date / Time	2/27/2016	2/27/2016	2/27/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	24	24	24
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.01	4.03
Diameter 2, in.	4.03	4.00	4.03
Length(without caps), in.	7.86	7.89	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.03	4.01	4.03
Length / Diameter (L/D)	1.95	1.97	1.96
Cross-Sectional Area, in^2	12.76	12.63	12.76

Compressive Strength and Fracture Pattern

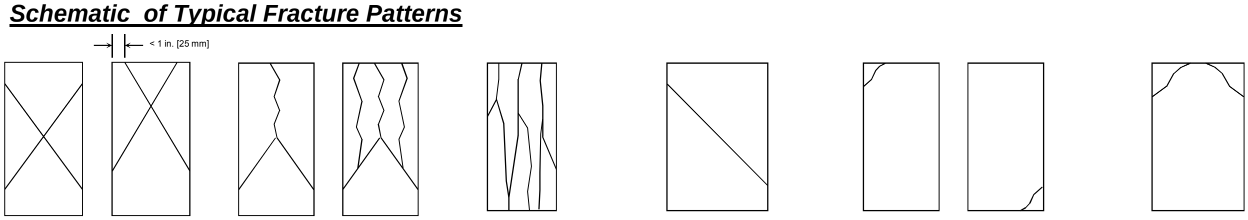
Maximum Load, lb	57,590	59,407	58,721
Compressive Strength, psi	4,510	4,700	4,600
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	4,610

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix B (lab)	ASRA Mix B (lab)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	4	4
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.01
Diameter 2, in.	4.02	4.01
Length(without caps), in.	8.00	8.01
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.01
Length / Diameter (L/D)	1.99	2.00
Cross-Sectional Area, in^2	12.69	12.63

Compressive Strength and Fracture Pattern

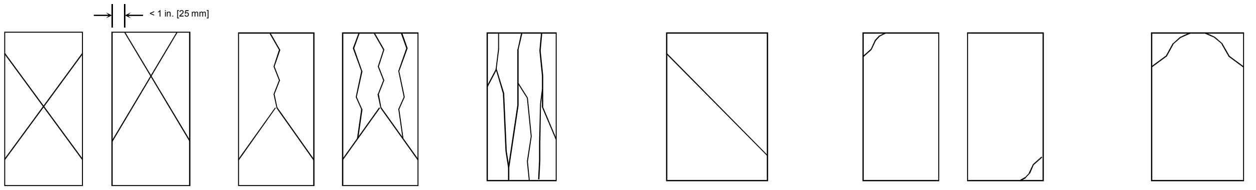
Maximum Load, lb	8,498	9,189
Compressive Strength, psi	670	730
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	700

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix B (lab)	ASRA Mix B (lab)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	6	6
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.00	4.02
Diameter 2, in.	3.99	4.01
Length(without caps), in.	8.01	8.02
Length(with caps), in.	N/A	N/A
Average Diameter, in.	3.99	4.01
Length / Diameter (L/D)	2.01	2.00
Cross-Sectional Area, in^2	12.50	12.63

Compressive Strength and Fracture Pattern

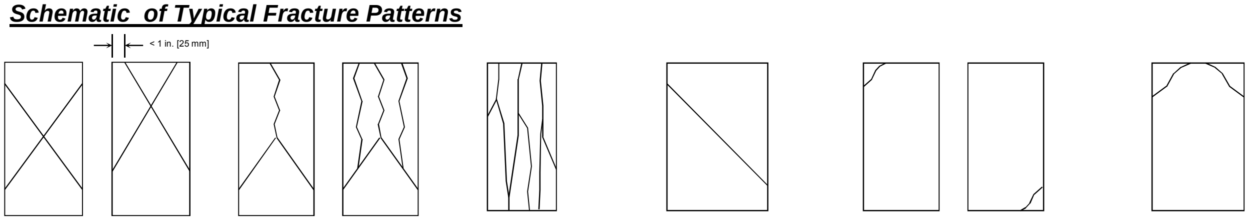
Maximum Load, lb	31,008	29,069
Compressive Strength, psi	2,480	2,300
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	2,390

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix B (lab)	ASRA Mix B (lab)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	8	8
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.02	4.02
Diameter 2, in.	4.01	4.00
Length(without caps), in.	8.00	8.03
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.01
Length / Diameter (L/D)	1.99	2.00
Cross-Sectional Area, in^2	12.69	12.63

Compressive Strength and Fracture Pattern

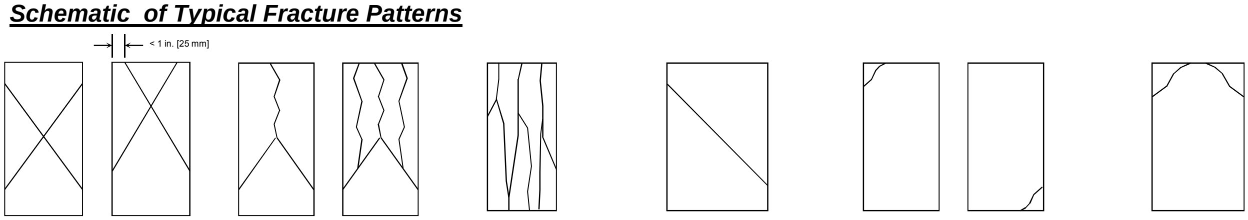
Maximum Load, lb	46,146	44,929
Compressive Strength, psi	3,640	3,560
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	3,600

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix B (lab)	ASRA Mix B (lab)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/27/2016	2/27/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	24	24
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.01
Diameter 2, in.	4.02	4.00
Length(without caps), in.	7.90	7.87
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.03	4.01
Length / Diameter (L/D)	1.96	1.96
Cross-Sectional Area, in^2	12.76	12.63

Compressive Strength and Fracture Pattern

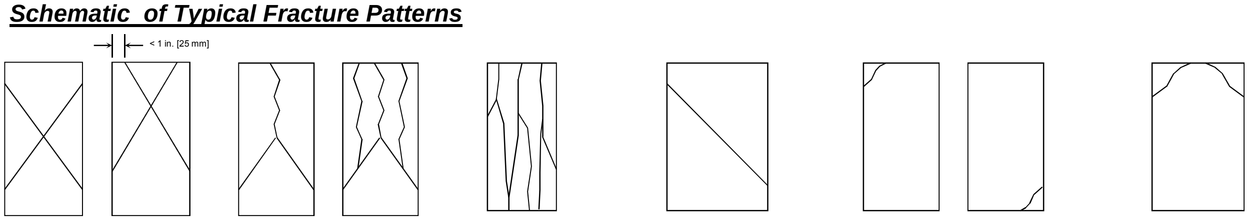
Maximum Load, lb	61,321	59,829
Compressive Strength, psi	4,810	4,740
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	4,770

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1 — Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2 — Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3 — Columnar vertical cracking through both ends, no well-formed cones

Type 4 — Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5 — Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6 — Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix B (cold)	ASRA Mix B (cold)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	6	6
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.01
Diameter 2, in.	4.01	4.01
Length(without caps), in.	8.00	8.02
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.01
Length / Diameter (L/D)	1.99	2.00
Cross-Sectional Area, in^2	12.69	12.63

Compressive Strength and Fracture Pattern

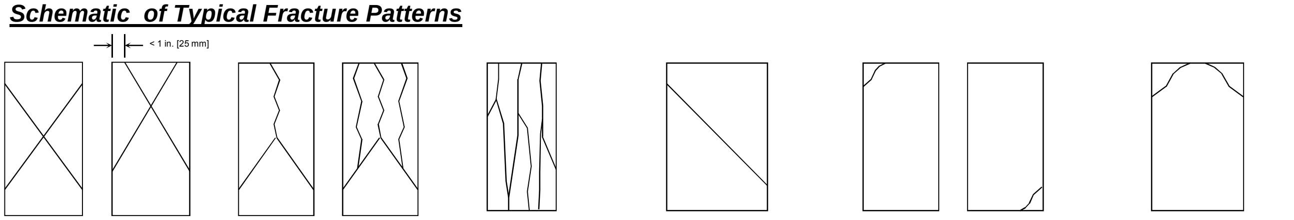
Maximum Load, lb	16,929	19,852
Compressive Strength, psi	1,330	1,570
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	1,450

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix B (cold)	ASRA Mix B (cold)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	8	8
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.01
Diameter 2, in.	4.02	4.00
Length(without caps), in.	8.02	8.00
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.03	4.00
Length / Diameter (L/D)	1.99	2.00
Cross-Sectional Area, in^2	12.76	12.57

Compressive Strength and Fracture Pattern

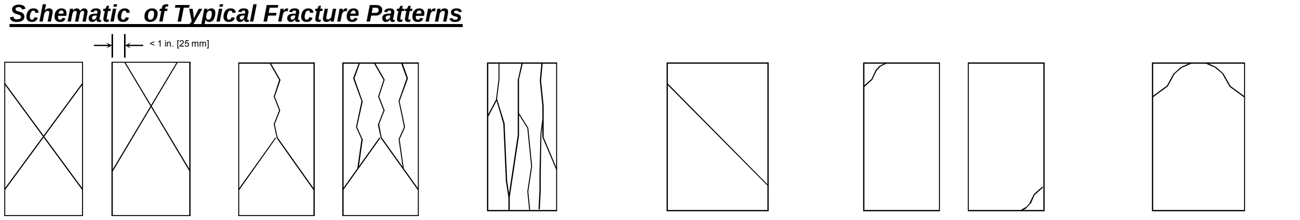
Maximum Load, lb	50,957	47,986
Compressive Strength, psi	3,990	3,820
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	3,910

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix B (cold)	ASRA Mix B (cold)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	10	10
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.02
Diameter 2, in.	4.02	4.00
Length(without caps), in.	8.02	8.00
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.03	4.01
Length / Diameter (L/D)	1.99	2.00
Cross-Sectional Area, in^2	12.76	12.63

Compressive Strength and Fracture Pattern

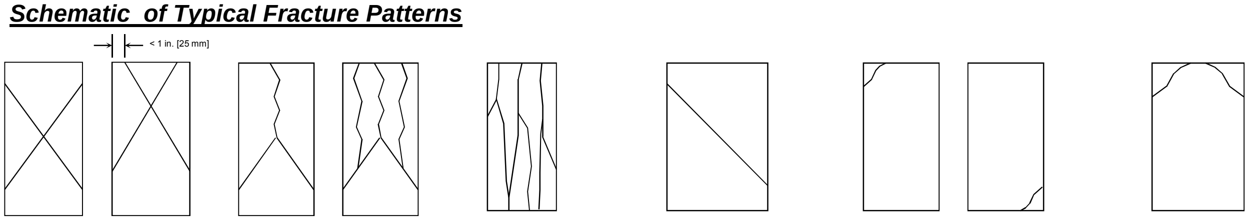
Maximum Load, lb	52,296	55,929
Compressive Strength, psi	4,100	4,430
Fracture Pattern	Type 3	Type 6

Average Compressive Strength, psi	4,260

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix B (cold)	ASRA Mix B (cold)	ASRA Mix B (cold)
Client Identification	N/A	N/A	N/A
Casting Date	2/26/2016	2/26/2016	2/26/2016
Test Date / Time	2/27/2016	2/27/2016	2/27/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	24	24	24
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.02
Diameter 2, in.	3.99	4.03	4.02
Length(without caps), in.	7.88	7.90	7.91
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.03	4.02
Length / Diameter (L/D)	1.97	1.96	1.97
Cross-Sectional Area, in^2	12.57	12.76	12.69

Compressive Strength and Fracture Pattern

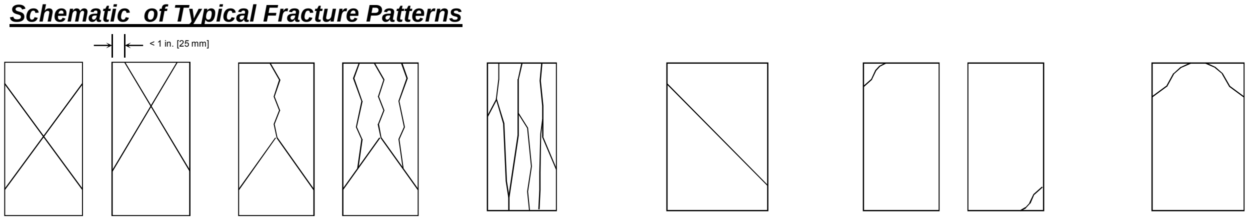
Maximum Load, lb	66,167	64,292	65,259
Compressive Strength, psi	5,260	5,040	5,140
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	5,150

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client: **Illinois Tollway**
Project: **Calcium Aluminate Cement Project**
Contact: **Steve Gillen**
Date Reported: **March 1, 2016**

CTL Project No.: **057177**
CTL Project Mgr.: **M. D'Ambrosia**
Technician: **W. Demharter**
Approved by: **B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix C (lab)	ASRA Mix C (lab)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	4	4
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.01	4.03
Diameter 2, in.	4.00	4.01
Length(without caps), in.	8.03	8.01
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.00	4.02
Length / Diameter (L/D)	2.01	1.99
Cross-Sectional Area, in^2	12.57	12.69

Compressive Strength and Fracture Pattern

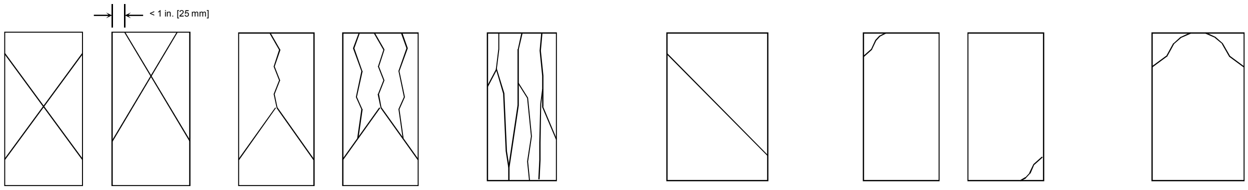
Maximum Load, lb	10,296	8,422
Compressive Strength, psi	820	660
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	740

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix C (lab)	ASRA Mix C (lab)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	6	6
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.02	4.02
Diameter 2, in.	4.01	4.00
Length(without caps), in.	8.03	8.01
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.01
Length / Diameter (L/D)	2.00	2.00
Cross-Sectional Area, in^2	12.69	12.63

Compressive Strength and Fracture Pattern

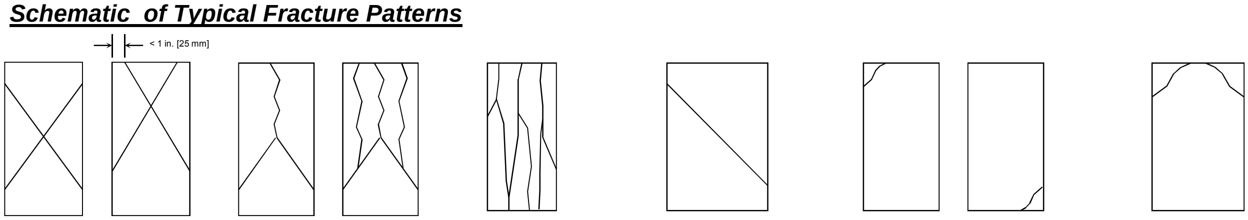
Maximum Load, lb	37,940	38,994
Compressive Strength, psi	2,990	3,090
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	3,040

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

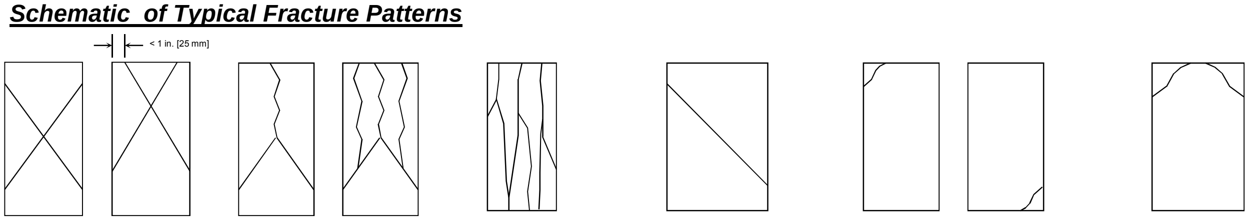
Specimen Identification		
CTLGroup Identification	ASRA Mix C (lab)	ASRA Mix C (lab)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35
Concrete Description		
Concrete Age at Test, hours	8	8
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene
Concrete Dimensions		
Diameter 1, in.	4.02	4.01
Diameter 2, in.	4.01	4.02
Length(without caps), in.	8.00	8.03
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.01
Length / Diameter (L/D)	1.99	2.00
Cross-Sectional Area, in^2	12.69	12.63
Compressive Strength and Fracture Pattern		
Maximum Load, lb	48,902	49,991
Compressive Strength, psi	3,850	3,960
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	3,910

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix C (lab)	ASRA Mix C (lab)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/27/2016	2/27/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	24	24
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03
Diameter 2, in.	4.01	4.02
Length(without caps), in.	7.88	7.90
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.03
Length / Diameter (L/D)	1.96	1.96
Cross-Sectional Area, in^2	12.63	12.76

Compressive Strength and Fracture Pattern

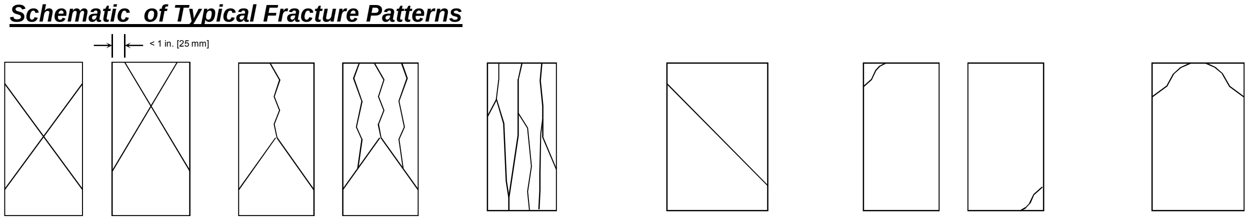
Maximum Load, lb	61,996	60,224
Compressive Strength, psi	4,910	4,720
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	4,810

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix C (cold)	ASRA Mix C (cold)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	6	6
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.00	4.03
Diameter 2, in.	4.02	4.03
Length(without caps), in.	8.00	8.01
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.03
Length / Diameter (L/D)	2.00	1.99
Cross-Sectional Area, in^2	12.63	12.76

Compressive Strength and Fracture Pattern

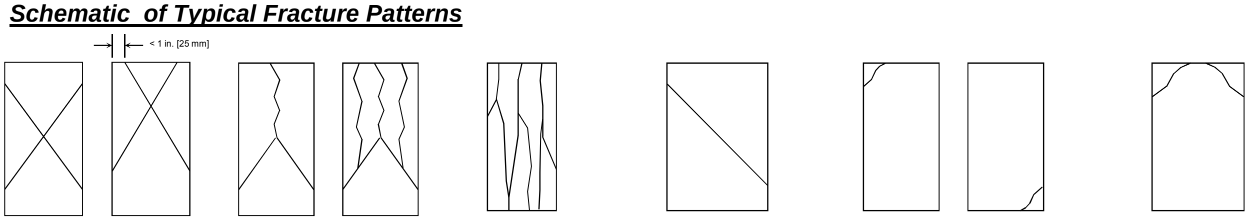
Maximum Load, lb	35,294	36,239
Compressive Strength, psi	2,790	2,840
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	2,820

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix C (cold)	ASRA Mix C (cold)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	8	8
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.02
Diameter 2, in.	4.02	4.01
Length(without caps), in.	8.01	8.03
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.03	4.02
Length / Diameter (L/D)	1.99	2.00
Cross-Sectional Area, in^2	12.76	12.69

Compressive Strength and Fracture Pattern

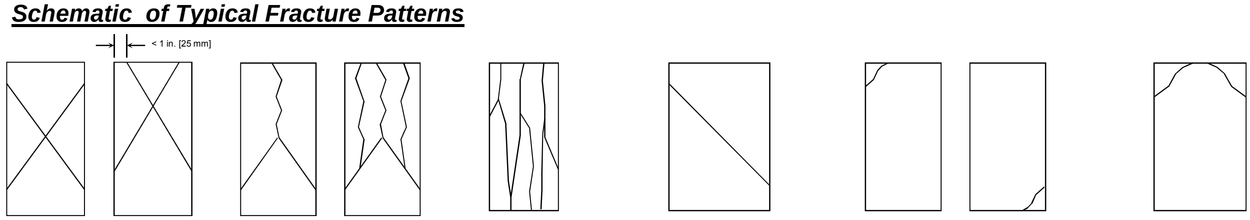
Maximum Load, lb	56,129	53,224
Compressive Strength, psi	4,400	4,190
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	4,300

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix C (cold)	ASRA Mix C (cold)
Client Identification	N/A	N/A
Casting Date	2/26/2016	2/26/2016
Test Date / Time	2/26/2016	2/26/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	10	10
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.04	4.01
Diameter 2, in.	4.02	4.02
Length(without caps), in.	8.03	8.01
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.03	4.01
Length / Diameter (L/D)	1.99	2.00
Cross-Sectional Area, in^2	12.76	12.63

Compressive Strength and Fracture Pattern

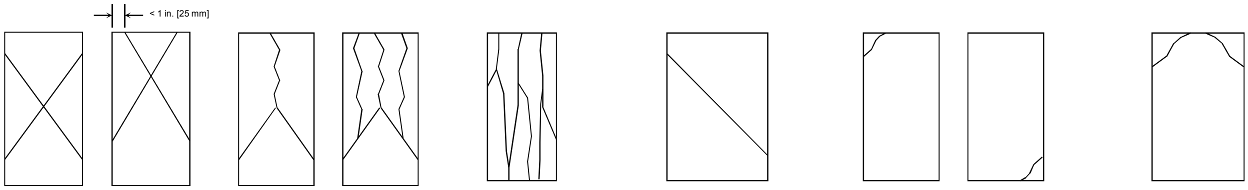
Maximum Load, lb	57,014	58,226
Compressive Strength, psi	4,470	4,610
Fracture Pattern	Type 6	Type 3

Average Compressive Strength, psi	4,540

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA Mix C (cold)	ASRA Mix C (cold)	ASRA Mix C (cold)
Client Identification	N/A	N/A	N/A
Casting Date	2/26/2016	2/26/2016	2/26/2016
Test Date / Time	2/27/2016	2/27/2016	2/27/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	24	24	24
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.03
Diameter 2, in.	4.02	4.02	4.02
Length(without caps), in.	7.87	7.89	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.02	4.02
Length / Diameter (L/D)	1.96	1.96	1.96
Cross-Sectional Area, in^2	12.69	12.69	12.69

Compressive Strength and Fracture Pattern

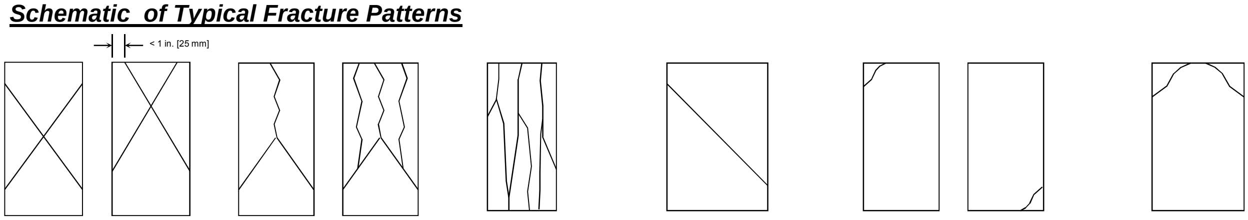
Maximum Load, lb	68,661	66,924	67,742
Compressive Strength, psi	5,410	5,270	5,340
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	5,340

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (lab)
Client Identification	N/A
Casting Date	3/8/2016
Test Date / Time	3/8/2016
Loading Rate, psi/sec	35

Concrete Description

Concrete Age at Test, hours	2
Moisture Condition at Test	Mold
Curing Conditions (Temp/RH)	73°F / Mold
Cylinder End Preparation	neoprene

Concrete Dimensions

Diameter 1, in.	4.03
Diameter 2, in.	4.01
Length(without caps), in.	8.00
Length(with caps), in.	N/A
Average Diameter, in.	4.02
Length / Diameter (L/D)	1.99
Cross-Sectional Area, in^2	12.69

Compressive Strength and Fracture Pattern

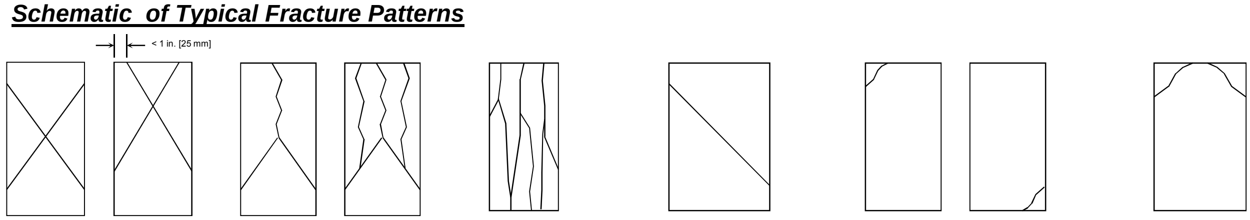
Maximum Load, lb	2,812
Compressive Strength, psi	220
Fracture Pattern	Type 3

Average Compressive Strength, psi	220

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (lab)
Client Identification	N/A
Casting Date	3/8/2016
Test Date / Time	3/8/2016
Loading Rate, psi/sec	35

Concrete Description

Concrete Age at Test, hours	3
Moisture Condition at Test	Mold
Curing Conditions (Temp/RH)	73°F / Mold
Cylinder End Preparation	neoprene

Concrete Dimensions

Diameter 1, in.	4.02
Diameter 2, in.	4.01
Length(without caps), in.	8.02
Length(with caps), in.	N/A
Average Diameter, in.	4.02
Length / Diameter (L/D)	2.00
Cross-Sectional Area, in^2	12.69

Compressive Strength and Fracture Pattern

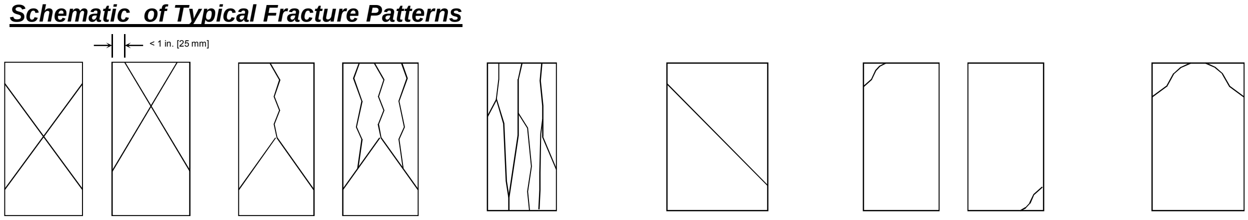
Maximum Load, lb	14,185
Compressive Strength, psi	1,120
Fracture Pattern	Type 6

Average Compressive Strength, psi	1,120

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (lab)	ASRA2 (lab)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	3/8/2016	3/8/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	4	4
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	neoprene	neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.01
Diameter 2, in.	4.02	3.99
Length(without caps), in.	8.00	8.03
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.03	4.00
Length / Diameter (L/D)	1.99	2.01
Cross-Sectional Area, in^2	12.76	12.57

Compressive Strength and Fracture Pattern

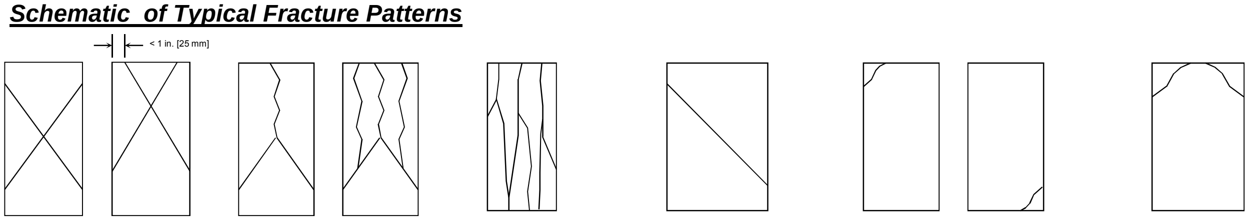
Maximum Load, lb	27,616	26,377
Compressive Strength, psi	2,160	2,100
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	2,130

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (lab)	ASRA2 (lab)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	3/8/2016	3/8/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	6	6
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	neoprene	neoprene

Concrete Dimensions

Diameter 1, in.	4.02	4.03
Diameter 2, in.	4.03	4.01
Length(without caps), in.	8.00	8.01
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.03	4.02
Length / Diameter (L/D)	1.98	1.99
Cross-Sectional Area, in^2	12.76	12.69

Compressive Strength and Fracture Pattern

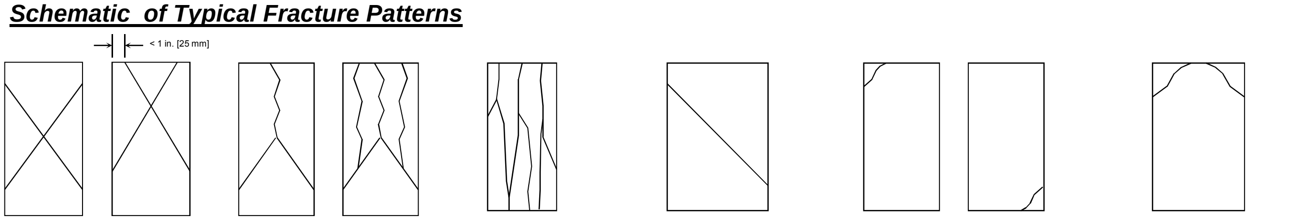
Maximum Load, lb	34,655	33,291
Compressive Strength, psi	2,720	2,620
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	2,670

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (lab)	ASRA2 (lab)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	3/8/2016	3/8/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	8	8
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	neoprene	neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.01
Diameter 2, in.	4.02	4.00
Length(without caps), in.	8.03	8.01
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.00
Length / Diameter (L/D)	2.00	2.00
Cross-Sectional Area, in^2	12.69	12.57

Compressive Strength and Fracture Pattern

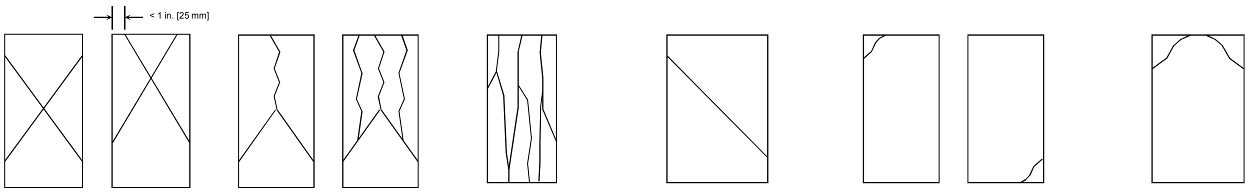
Maximum Load, lb	38,894	37,125
Compressive Strength, psi	3,060	2,950
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	3,010

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (lab)	ASRA2 (lab)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	3/8/2016	3/8/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	10	10
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	ground	ground

Concrete Dimensions

Diameter 1, in.	4.00	4.03
Diameter 2, in.	4.00	4.02
Length(without caps), in.	7.90	7.87
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.00	4.02
Length / Diameter (L/D)	1.98	1.96
Cross-Sectional Area, in^2	12.57	12.69

Compressive Strength and Fracture Pattern

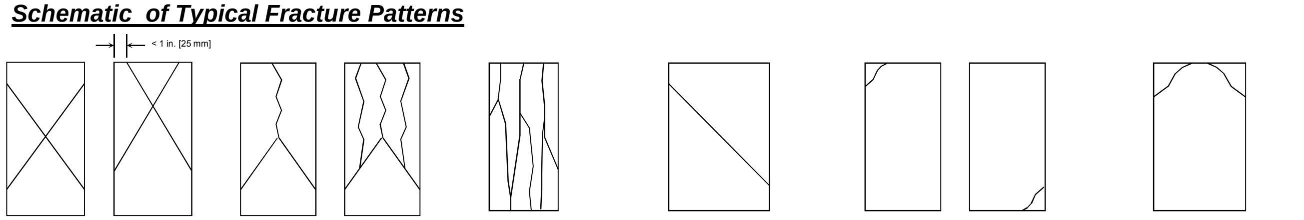
Maximum Load, lb	49,233	50,168
Compressive Strength, psi	3,920	3,950
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	3,940

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (lab)	ASRA2 (lab)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	3/9/2016	3/9/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, days	1	1
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	ground	ground

Concrete Dimensions

Diameter 1, in.	4.02	4.01
Diameter 2, in.	4.03	4.00
Length(without caps), in.	7.86	7.88
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.01
Length / Diameter (L/D)	1.96	1.97
Cross-Sectional Area, in^2	12.69	12.63

Compressive Strength and Fracture Pattern

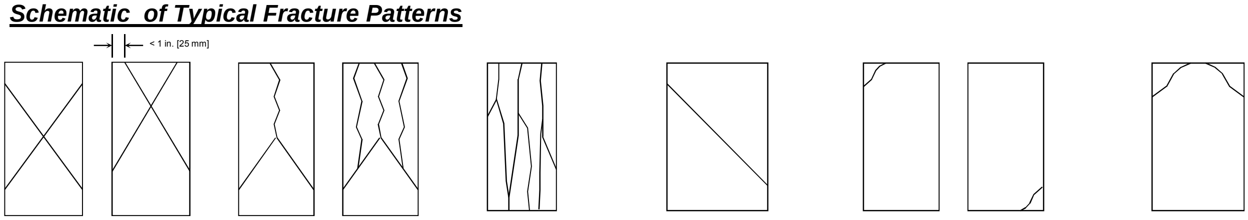
Maximum Load, lb	55,327	54,971
Compressive Strength, psi	4,360	4,350
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	4,360

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 15, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (lab)	ASRA2 (lab)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	3/15/2016	3/15/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, days	7	7
Moisture Condition at Test	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.03
Diameter 2, in.	4.00	4.02
Length(without caps), in.	7.89	7.88
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.00	4.02
Length / Diameter (L/D)	1.97	1.96
Cross-Sectional Area, in^2	12.57	12.69

Compressive Strength and Fracture Pattern

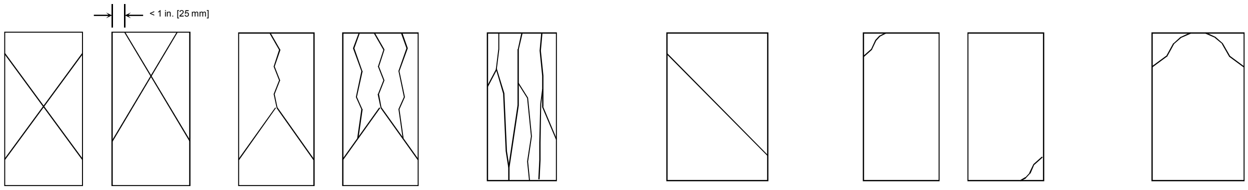
Maximum Load, lb	79,186	78,254
Compressive Strength, psi	6,300	6,170
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	6,230

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**April 6, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (lab)	ASRA2 (lab)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	4/5/2016	4/5/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, days	28	28
Moisture Condition at Test	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.03
Diameter 2, in.	4.02	4.02
Length(without caps), in.	7.90	7.88
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.02
Length / Diameter (L/D)	1.97	1.96
Cross-Sectional Area, in^2	12.69	12.69

Compressive Strength and Fracture Pattern

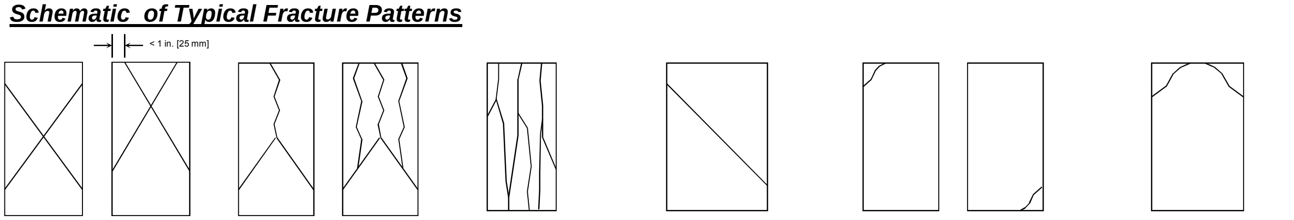
Maximum Load, lb	100,150	99,989
Compressive Strength, psi	7,890	7,880
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	7,890

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (cold)
Client Identification	N/A
Casting Date	3/8/2016
Test Date / Time	3/8/2016
Loading Rate, psi/sec	35

Concrete Description

Concrete Age at Test, hours	2
Moisture Condition at Test	Mold
Curing Conditions (Temp/RH)	Mold / 45°F
Cylinder End Preparation	neoprene

Concrete Dimensions

Diameter 1, in.	4.02
Diameter 2, in.	4.01
Length(without caps), in.	8.02
Length(with caps), in.	N/A
Average Diameter, in.	4.02
Length / Diameter (L/D)	1.99
Cross-Sectional Area, in^2	12.69

Compressive Strength and Fracture Pattern

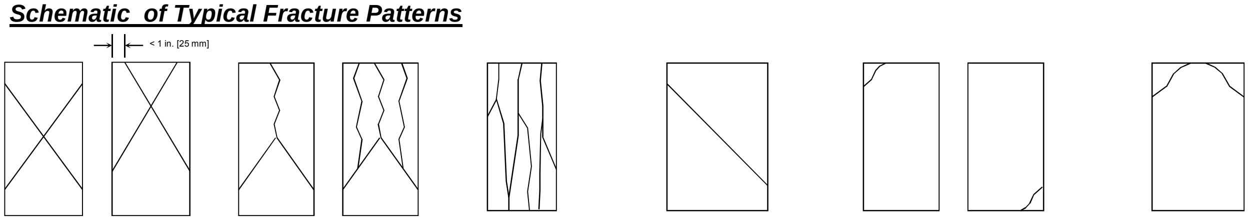
Maximum Load, lb	2,486
Compressive Strength, psi	200
Fracture Pattern	Type 3

Average Compressive Strength, psi	200

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (cold)
Client Identification	N/A
Casting Date	3/8/2016
Test Date / Time	3/8/2016
Loading Rate, psi/sec	35

Concrete Description

Concrete Age at Test, hours	3
Moisture Condition at Test	Mold
Curing Conditions (Temp/RH)	Mold / 45°F
Cylinder End Preparation	neoprene

Concrete Dimensions

Diameter 1, in.	4.03
Diameter 2, in.	4.02
Length(without caps), in.	8.02
Length(with caps), in.	N/A
Average Diameter, in.	4.03
Length / Diameter (L/D)	1.99
Cross-Sectional Area, in^2	12.76

Compressive Strength and Fracture Pattern

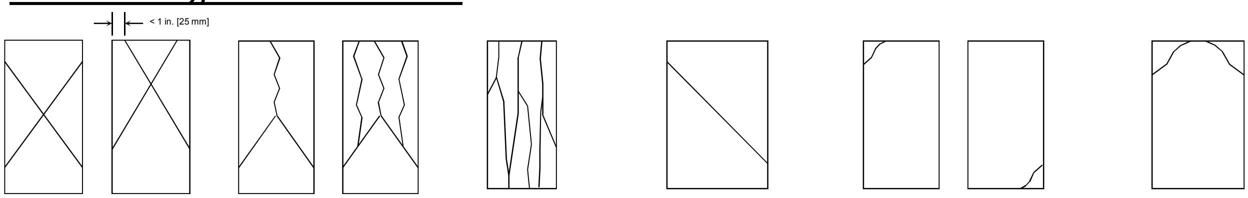
Maximum Load, lb	9,753
Compressive Strength, psi	760
Fracture Pattern	Type 3

Average Compressive Strength, psi	760

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (cold)	ASRA2 (cold)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	3/8/2016	3/8/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	4	4
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	neoprene	neoprene

Concrete Dimensions

Diameter 1, in.	4.00	4.03
Diameter 2, in.	4.01	4.01
Length(without caps), in.	8.01	8.03
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.02
Length / Diameter (L/D)	2.00	2.00
Cross-Sectional Area, in^2	12.63	12.69

Compressive Strength and Fracture Pattern

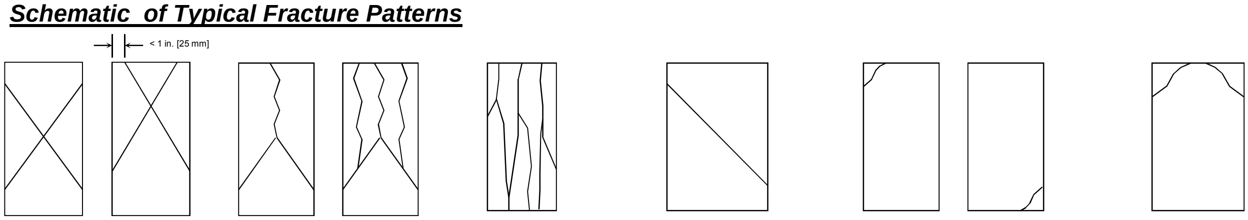
Maximum Load, lb	23,038	21,235
Compressive Strength, psi	1,820	1,670
Fracture Pattern	Type 6	Type 6

Average Compressive Strength, psi	1,750

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (cold)	ASRA2 (cold)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	3/8/2016	3/8/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	6	6
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	neoprene	neoprene

Concrete Dimensions

Diameter 1, in.	4.00	4.03
Diameter 2, in.	3.99	4.04
Length(without caps), in.	8.02	8.00
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.00	4.03
Length / Diameter (L/D)	2.00	1.99
Cross-Sectional Area, in^2	12.57	12.76

Compressive Strength and Fracture Pattern

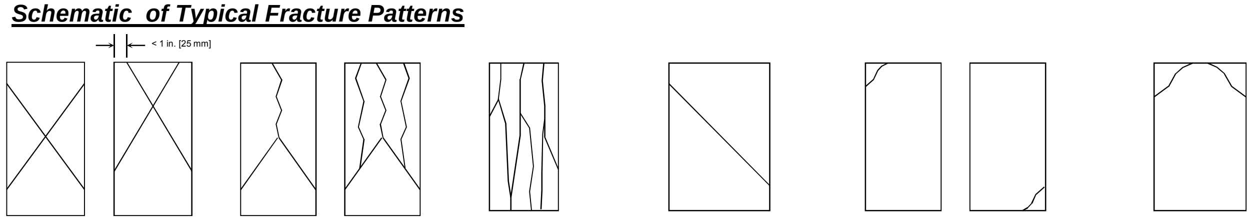
Maximum Load, lb	37,488	37,069
Compressive Strength, psi	2,980	2,910
Fracture Pattern	Type 6	Type 3

Average Compressive Strength, psi	2,940

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (cold)	ASRA2 (cold)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	3/8/2016	3/8/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	8	8
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	neoprene	neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.00
Diameter 2, in.	4.02	3.99
Length(without caps), in.	8.02	8.00
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.03	4.00
Length / Diameter (L/D)	1.99	2.00
Cross-Sectional Area, in^2	12.76	12.57

Compressive Strength and Fracture Pattern

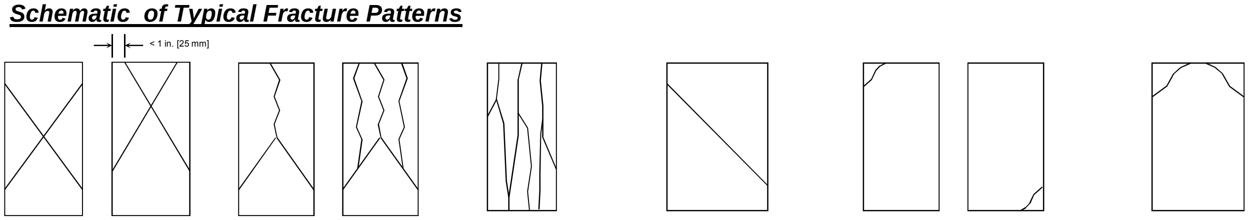
Maximum Load, lb	41,946	41,334
Compressive Strength, psi	3,290	3,290
Fracture Pattern	Type 3	Type 6

Average Compressive Strength, psi	3,290

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (cold)	ASRA2 (cold)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	3/8/2016	3/8/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	10	10
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	ground	ground

Concrete Dimensions

Diameter 1, in.	4.02	4.00
Diameter 2, in.	4.02	3.99
Length(without caps), in.	7.89	7.86
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.00
Length / Diameter (L/D)	1.96	1.97
Cross-Sectional Area, in^2	12.69	12.57

Compressive Strength and Fracture Pattern

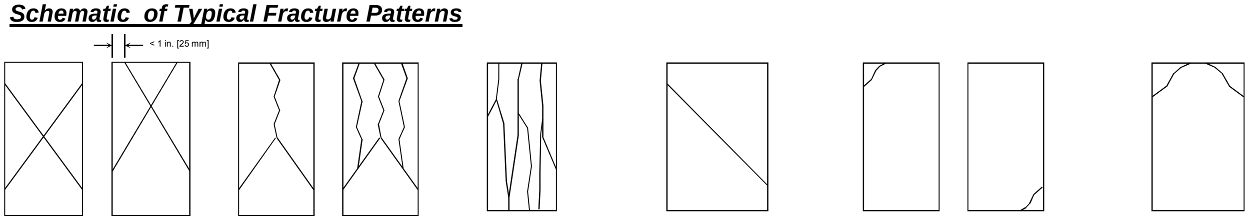
Maximum Load, lb	52,466	53,321
Compressive Strength, psi	4,130	4,240
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	4,190

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (cold)	ASRA2 (cold)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	3/9/2016	3/9/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, days	1	1
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	ground	ground

Concrete Dimensions

Diameter 1, in.	4.03	4.00
Diameter 2, in.	4.02	4.00
Length(without caps), in.	7.89	7.88
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.03	4.00
Length / Diameter (L/D)	1.96	1.97
Cross-Sectional Area, in^2	12.76	12.57

Compressive Strength and Fracture Pattern

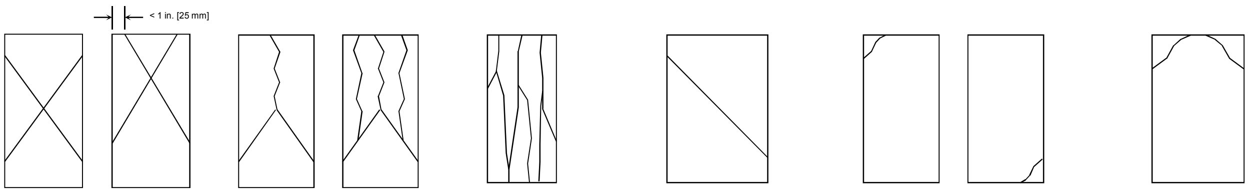
Maximum Load, lb	58,851	57,116
Compressive Strength, psi	4,610	4,540
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	4,580

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 15, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (cold)
Client Identification	N/A
Casting Date	3/8/2016
Test Date / Time	3/15/2016
Loading Rate, psi/sec	35

Concrete Description

Concrete Age at Test, days	7
Moisture Condition at Test	Mold
Curing Conditions (Temp/RH)	Mold / 45°F
Cylinder End Preparation	Ground

Concrete Dimensions

Diameter 1, in.	4.02
Diameter 2, in.	4.01
Length(without caps), in.	7.88
Length(with caps), in.	N/A
Average Diameter, in.	4.02
Length / Diameter (L/D)	1.96
Cross-Sectional Area, in^2	12.69

Compressive Strength and Fracture Pattern

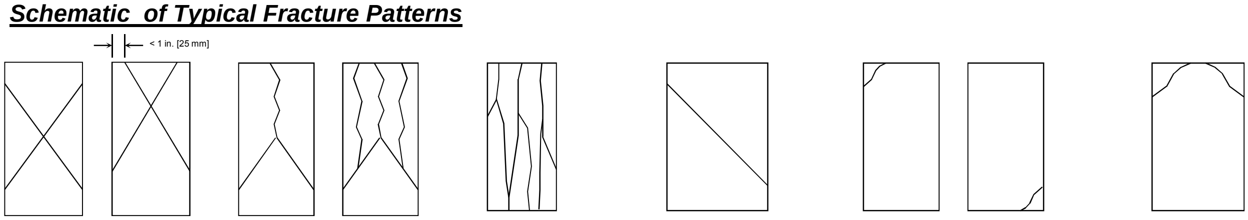
Maximum Load, lb	73,378
Compressive Strength, psi	5,780
Fracture Pattern	Type 1

Average Compressive Strength, psi	5,780

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**April 6, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (cold)
Client Identification	N/A
Casting Date	3/8/2016
Test Date / Time	4/5/2016
Loading Rate, psi/sec	35

Concrete Description

Concrete Age at Test, days	28
Moisture Condition at Test	Mold
Curing Conditions (Temp/RH)	Mold / 45°F
Cylinder End Preparation	Ground

Concrete Dimensions

Diameter 1, in.	4.01
Diameter 2, in.	4.01
Length(without caps), in.	7.88
Length(with caps), in.	N/A
Average Diameter, in.	4.01
Length / Diameter (L/D)	1.96
Cross-Sectional Area, in^2	12.63

Compressive Strength and Fracture Pattern

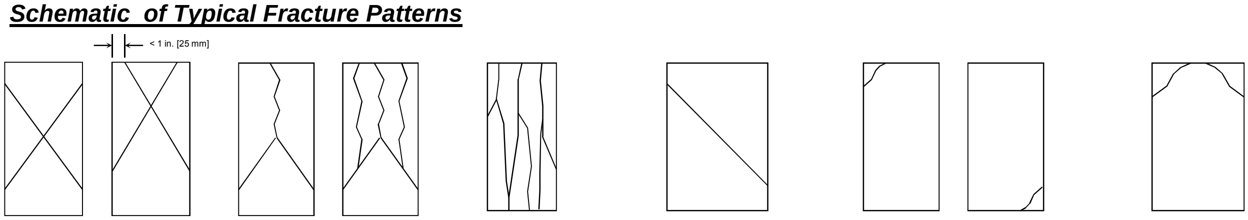
Maximum Load, lb	83,278
Compressive Strength, psi	6,590
Fracture Pattern	Type 1

Average Compressive Strength, psi	6,590

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 8, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (hot)	ASRA2 (hot)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	3/9/2016	3/9/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, days	1	1
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	In Mold/LW at 122°F	In Mold/LW at 122°F
Cylinder End Preparation	ground	ground

Concrete Dimensions

Diameter 1, in.	4.02	4.03
Diameter 2, in.	4.02	4.02
Length(without caps), in.	7.87	7.90
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.02
Length / Diameter (L/D)	1.96	1.97
Cross-Sectional Area, in^2	12.69	12.69

Compressive Strength and Fracture Pattern

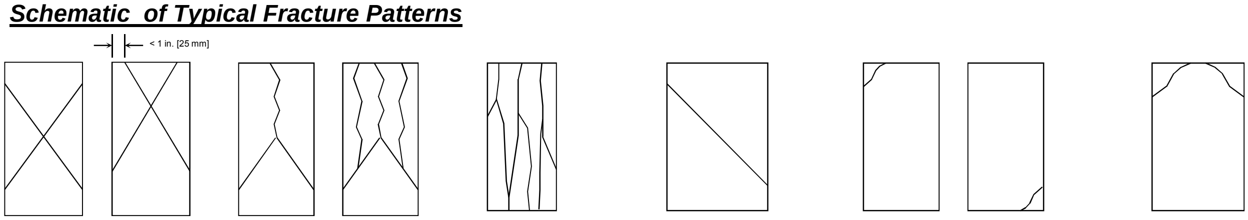
Maximum Load, lb	48,320	46,827
Compressive Strength, psi	3,810	3,690
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	3,750

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**March 15, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (hot)	ASRA2 (hot)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	3/15/2016	3/15/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, days	7	7
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	In Mold/LW at 122°F	In Mold/LW at 122°F
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.00
Diameter 2, in.	4.01	3.99
Length(without caps), in.	7.86	7.89
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.00
Length / Diameter (L/D)	1.96	1.97
Cross-Sectional Area, in^2	12.69	12.57

Compressive Strength and Fracture Pattern

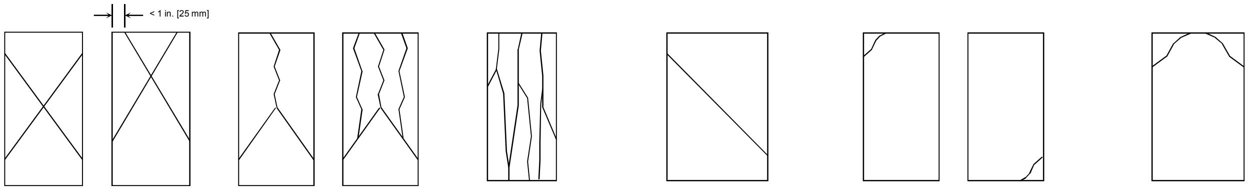
Maximum Load, lb	53,355	55,430
Compressive Strength, psi	4,200	4,410
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	4,310

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**April 6, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ASRA2 (hot)	ASRA2 (hot)
Client Identification	N/A	N/A
Casting Date	3/8/2016	3/8/2016
Test Date / Time	4/5/2016	4/5/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, days	28	28
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	In Mold/LW at 122°F	In Mold/LW at 122°F
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03
Diameter 2, in.	4.00	4.02
Length(without caps), in.	7.90	7.87
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.00	4.02
Length / Diameter (L/D)	1.97	1.96
Cross-Sectional Area, in^2	12.57	12.69

Compressive Strength and Fracture Pattern

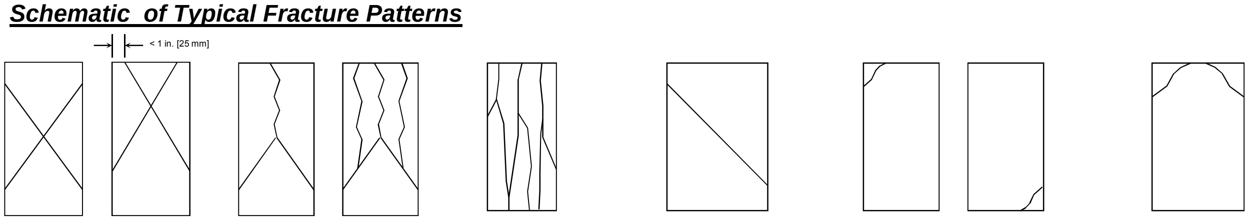
Maximum Load, lb	69,107	69,730
Compressive Strength, psi	5,500	5,490
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	5,500

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**June 3, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW (lab)	ALW (lab)
Client Identification	N/A	N/A
Casting Date	6/3/2016	6/3/2016
Test Date / Time	6/3/2016	6/3/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	3	3
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Neoprene	Neoprene

Concrete Dimensions

Diameter 1, in.	4.03	4.01
Diameter 2, in.	4.01	4.00
Length(without caps), in.	8.02	8.01
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.01
Length / Diameter (L/D)	2.00	2.00
Cross-Sectional Area, in^2	12.69	12.63

Compressive Strength and Fracture Pattern

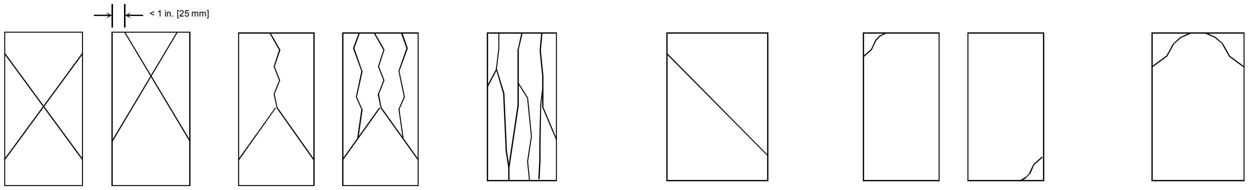
Maximum Load, lb	5,602	6,002
Compressive Strength, psi	440	480
Fracture Pattern	Type 3	Type 3

Average Compressive Strength, psi	460

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**June 3, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW (lab)	ALW (lab)
Client Identification	N/A	N/A
Casting Date	6/3/2016	6/3/2016
Test Date / Time	6/3/2016	6/3/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	4	4
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.03
Diameter 2, in.	4.02	4.01
Length(without caps), in.	7.86	7.88
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.02
Length / Diameter (L/D)	1.96	1.96
Cross-Sectional Area, in^2	12.69	12.69

Compressive Strength and Fracture Pattern

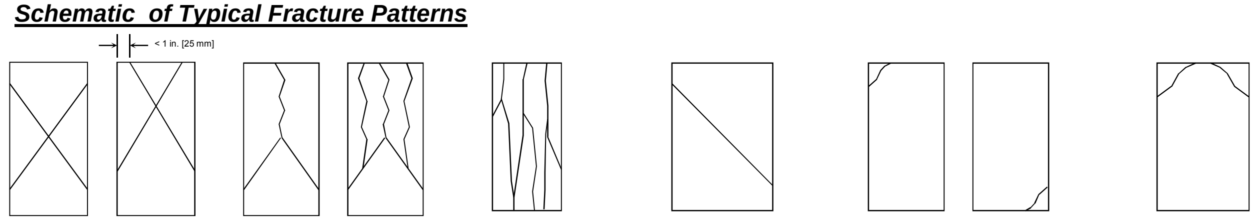
Maximum Load, lb	42,817	40,558
Compressive Strength, psi	3,370	3,200
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	3,290

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**June 3, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22

Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW (lab)	ALW (lab)
Client Identification	N/A	N/A
Casting Date	6/3/2016	6/3/2016
Test Date / Time	6/3/2016	6/3/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	5	5
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.01
Diameter 2, in.	4.03	4.01
Length(without caps), in.	7.89	7.88
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.03	4.01
Length / Diameter (L/D)	1.96	1.96
Cross-Sectional Area, in^2	12.76	12.63

Compressive Strength and Fracture Pattern

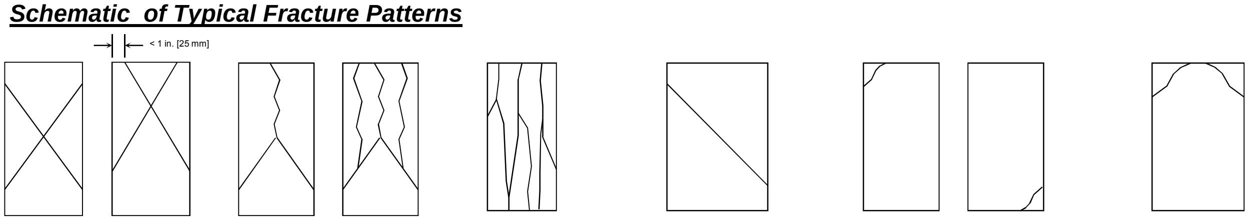
Maximum Load, lb	53,299	54,247
Compressive Strength, psi	4,180	4,300
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	4,240

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**June 6, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW (lab)	ALW (lab)
Client Identification	N/A	N/A
Casting Date	6/3/2016	6/3/2016
Test Date / Time	6/4/2016	6/4/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	24	24
Moisture Condition at Test	Moist	Moist
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.01
Diameter 2, in.	4.01	4.00
Length(without caps), in.	7.87	7.88
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.00
Length / Diameter (L/D)	1.96	1.97
Cross-Sectional Area, in^2	12.63	12.57

Compressive Strength and Fracture Pattern

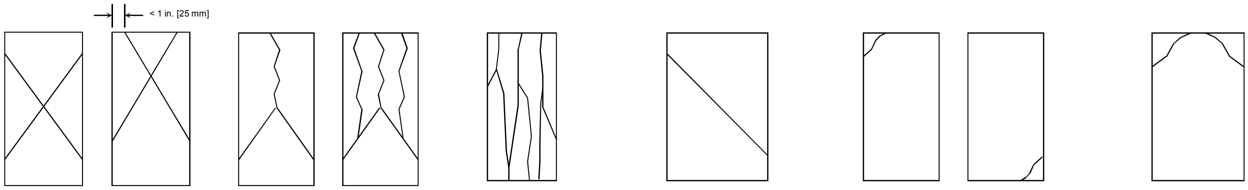
Maximum Load, lb	68,821	68,158
Compressive Strength, psi	5,450	5,420
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	5,440

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 30, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW2 (lab)	ALW2 (lab)
Client Identification	N/A	N/A
Casting Date	8/30/2016	8/30/2016
Test Date / Time	8/30/2016	8/30/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	4	4
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.03
Diameter 2, in.	4.02	4.02
Length(without caps), in.	7.86	7.89
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.02	4.03
Length / Diameter (L/D)	1.96	1.96
Cross-Sectional Area, in^2	12.69	12.76

Compressive Strength and Fracture Pattern

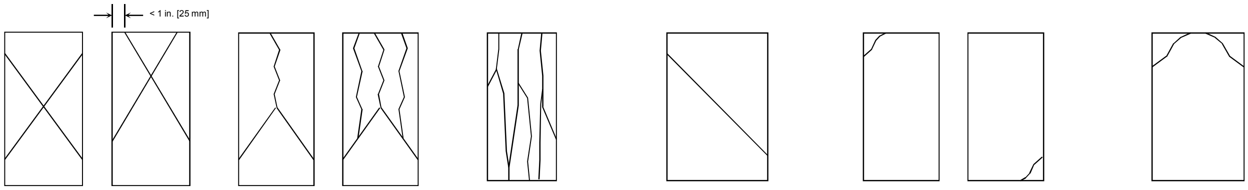
Maximum Load, lb	22,879	23,558
Compressive Strength, psi	1,800	1,850
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	1,820

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 31, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW2 (lab)	ALW2 (lab)
Client Identification	N/A	N/A
Casting Date	8/30/2016	8/30/2016
Test Date / Time	8/31/2016	8/31/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	24	24
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.03
Diameter 2, in.	4.00	4.02
Length(without caps), in.	7.86	7.88
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.02
Length / Diameter (L/D)	1.96	1.96
Cross-Sectional Area, in^2	12.63	12.69

Compressive Strength and Fracture Pattern

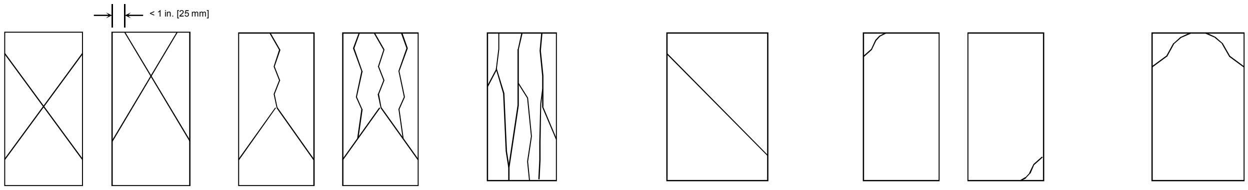
Maximum Load, lb	28,769	29,448
Compressive Strength, psi	2,280	2,320
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	2,300

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW2 (lab)	ALW2 (lab)
Client Identification	N/A	N/A
Casting Date	8/30/2016	8/30/2016
Test Date / Time	9/1/2016	9/1/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, days	2	2
Moisture Condition at Test	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.00
Diameter 2, in.	4.00	4.00
Length(without caps), in.	7.68	7.68
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.00
Length / Diameter (L/D)	1.91	1.92
Cross-Sectional Area, in^2	12.63	12.57

Compressive Strength and Fracture Pattern

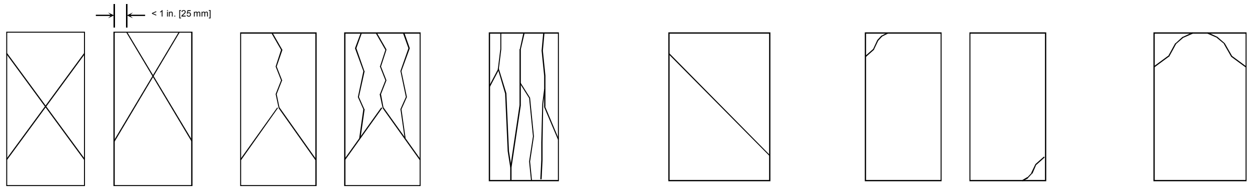
Maximum Load, lb	34,103	36,020
Compressive Strength, psi	2,700	2,870
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	2,780

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 7, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW2 (lab)	ALW2 (lab)	LCAC-ALW2
Client Identification	N/A	N/A	N/A
Casting Date	8/30/2016	8/30/2016	8/30/16 10:00
Test Date / Time	9/6/2016	9/6/2016	9/6/16 10:35
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	7	7	7
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.01	4.03
Diameter 2, in.	4.02	4.00	4.02
Length(without caps), in.	7.85	7.90	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.01	4.03
Length / Diameter (L/D)	1.95	1.97	1.96
Cross-Sectional Area, in^2	12.69	12.63	12.76

Compressive Strength and Fracture Pattern

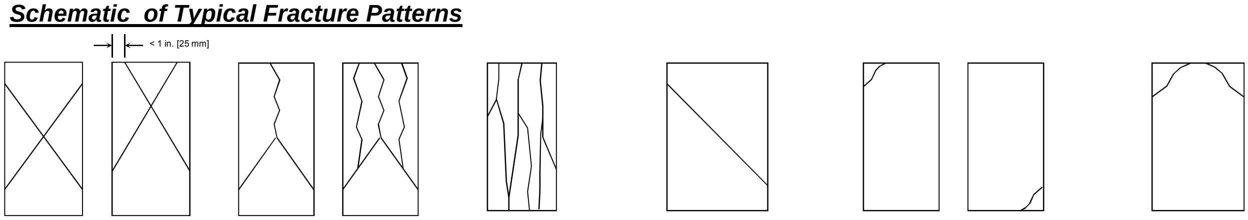
Maximum Load, lb	44,894	44,632	45,955
Compressive Strength, psi	3,540	3,530	3,600
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	3,560

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1 Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2 Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3 Columnar vertical cracking through both ends, no well-formed cones

Type 4 Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5 Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6 Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 30, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW3 (lab)	ALW3 (lab)
Client Identification	N/A	N/A
Casting Date	8/30/2016	8/30/2016
Test Date / Time	8/30/2016	8/30/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	4	4
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.02
Diameter 2, in.	4.02	4.03
Length(without caps), in.	7.85	7.89
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.03
Length / Diameter (L/D)	1.96	1.96
Cross-Sectional Area, in^2	12.63	12.76

Compressive Strength and Fracture Pattern

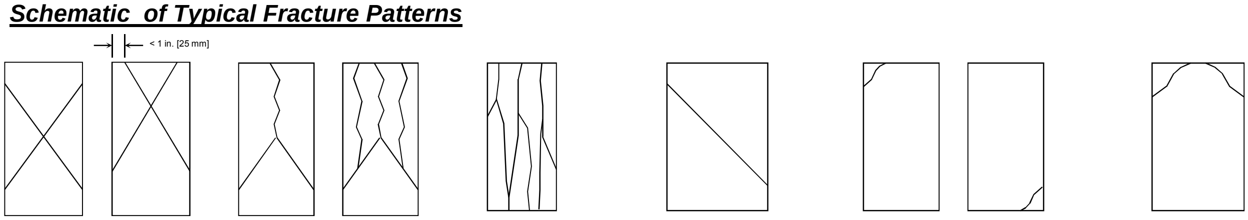
Maximum Load, lb	20,122	20,986
Compressive Strength, psi	1,590	1,640
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	1,620

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 31, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW3 (lab)	ALW3 (lab)
Client Identification	N/A	N/A
Casting Date	8/30/2016	8/30/2016
Test Date / Time	8/31/2016	8/31/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, hours	24	24
Moisture Condition at Test	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.01
Diameter 2, in.	3.99	4.00
Length(without caps), in.	7.89	7.87
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.00	4.01
Length / Diameter (L/D)	1.97	1.96
Cross-Sectional Area, in^2	12.57	12.63

Compressive Strength and Fracture Pattern

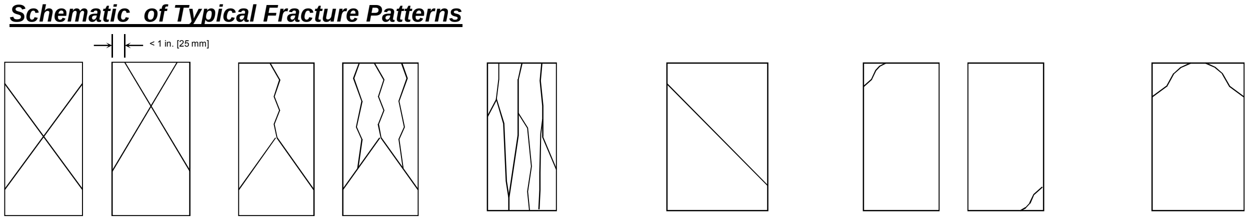
Maximum Load, lb	26,298	27,141
Compressive Strength, psi	2,090	2,150
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	2,120

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 1, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW3 (lab)	ALW3 (lab)
Client Identification	N/A	N/A
Casting Date	8/30/2016	8/30/2016
Test Date / Time	9/1/2016	9/1/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, days	2	2
Moisture Condition at Test	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.00
Diameter 2, in.	4.00	4.00
Length(without caps), in.	7.78	7.78
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.00	4.00
Length / Diameter (L/D)	1.94	1.94
Cross-Sectional Area, in^2	12.57	12.57

Compressive Strength and Fracture Pattern

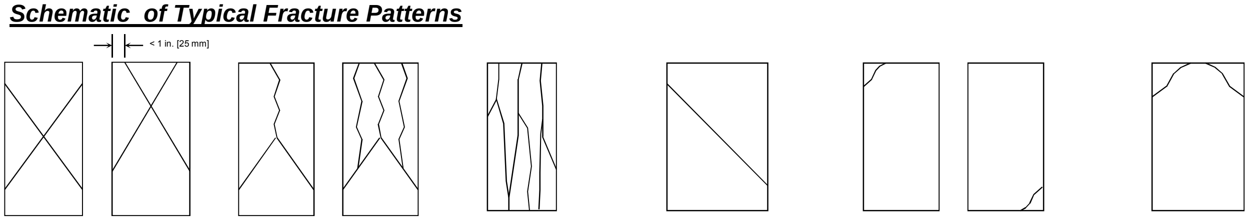
Maximum Load, lb	31,574	34,130
Compressive Strength, psi	2,510	2,720
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	2,610

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 7, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW3 (lab)	ALW3 (lab)	ALW3 (lab)
Client Identification	N/A	N/A	N/A
Casting Date	8/30/2016	8/30/2016	8/30/16 10:00
Test Date / Time	9/6/2016	9/6/2016	9/6/16 10:25
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	7	7	7
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.02	4.02
Diameter 2, in.	4.02	4.02	4.03
Length(without caps), in.	7.89	7.90	7.86
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.02	4.02
Length / Diameter (L/D)	1.97	1.97	1.96
Cross-Sectional Area, in^2	12.63	12.69	12.69

Compressive Strength and Fracture Pattern

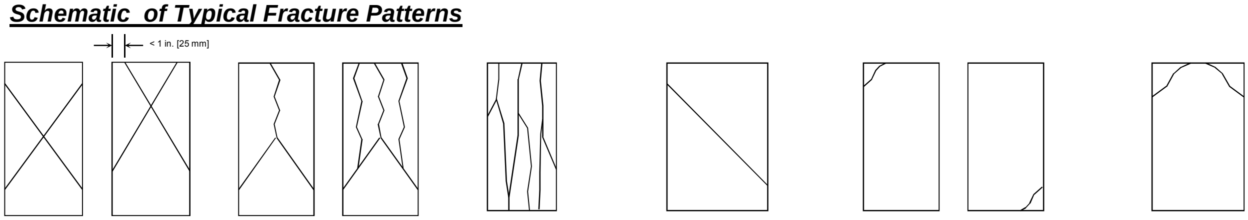
Maximum Load, lb	42,360	41,943	42,525
Compressive Strength, psi	3,350	3,310	3,350
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	3,340

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 2, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW4 (lab)	ALW4 (lab)	ALW4 (lab)
Client Identification	N/A	N/A	N/A
Casting Date	9/2/2016	9/2/2016	9/2/2016
Test Date / Time	9/2/2016	9/2/2016	9/2/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	4	4	4
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.03	4.01
Diameter 2, in.	4.03	4.03	4.00
Length(without caps), in.	7.86	7.89	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.03	4.01
Length / Diameter (L/D)	1.96	1.96	1.96
Cross-Sectional Area, in^2	12.69	12.76	12.63

Compressive Strength and Fracture Pattern

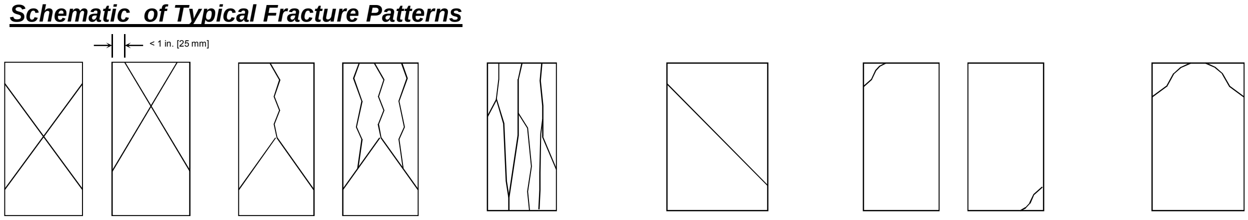
Maximum Load, lb	27,699	28,721	28,525
Compressive Strength, psi	2,180	2,250	2,260
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	2,230

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 2, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW4 (lab)	ALW4 (lab)	ALW4 (lab)
Client Identification	N/A	N/A	N/A
Casting Date	9/2/2016	9/2/2016	9/2/2016
Test Date / Time	9/3/2016	9/3/2016	9/3/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	24	24	24
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.03	4.03
Diameter 2, in.	4.02	4.02	4.02
Length(without caps), in.	7.89	7.89	7.87
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.03	4.02
Length / Diameter (L/D)	1.96	1.96	1.96
Cross-Sectional Area, in^2	12.69	12.76	12.69

Compressive Strength and Fracture Pattern

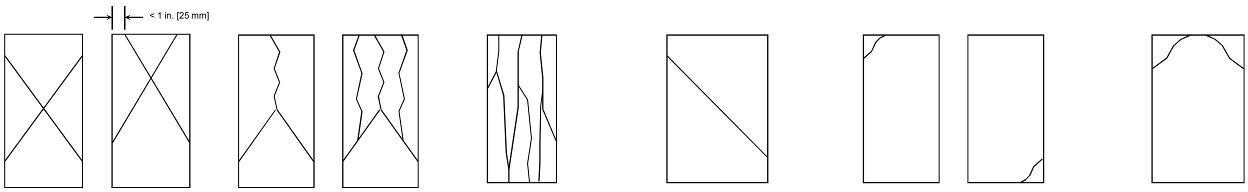
Maximum Load, lb	37,528	37,590	36,286
Compressive Strength, psi	2,960	2,950	2,860
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	2,920

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 7, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW4 (lab)	ALW4 (lab)	ALW4 (lab)
Client Identification	N/A	N/A	N/A
Casting Date	9/2/2016	9/2/2016	9/2/2016
Test Date / Time	9/6/2016	9/6/2016	9/6/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	4	4	4
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.02
Diameter 2, in.	4.00	4.02	4.00
Length(without caps), in.	7.87	7.88	7.87
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.02	4.01
Length / Diameter (L/D)	1.96	1.96	1.96
Cross-Sectional Area, in^2	12.63	12.69	12.63

Compressive Strength and Fracture Pattern

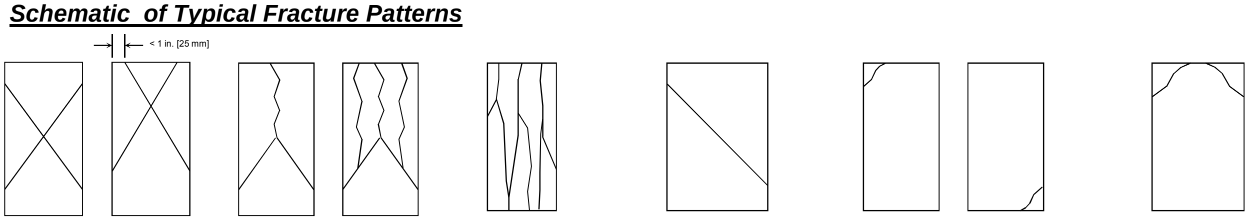
Maximum Load, lb	44,050	44,686	45,452
Compressive Strength, psi	3,490	3,520	3,600
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	3,540

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 9, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW4 (lab)	ALW4 (lab)	ALW4 (lab)
Client Identification	N/A	N/A	N/A
Casting Date	9/2/2016	9/2/2016	9/2/2016
Test Date / Time	9/9/2016	9/9/2016	9/9/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	7	7	7
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.03	4.03
Diameter 2, in.	4.01	4.01	4.02
Length(without caps), in.	7.86	7.90	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.02	4.03
Length / Diameter (L/D)	1.96	1.96	1.96
Cross-Sectional Area, in^2	12.63	12.69	12.76

Compressive Strength and Fracture Pattern

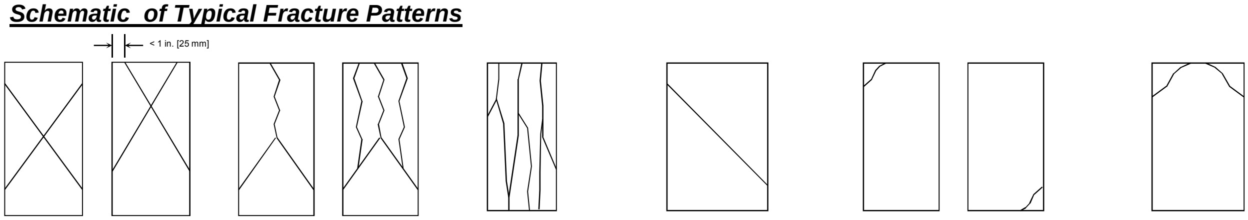
Maximum Load, lb	50,340	48,786	49,132
Compressive Strength, psi	3,990	3,840	3,850
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	3,890

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 2, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW5 (lab)	ALW5 (lab)	ALW5 (lab)
Client Identification	N/A	N/A	N/A
Casting Date	9/2/2016	9/2/2016	9/2/2016
Test Date / Time	9/2/2016	9/2/2016	9/2/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	4	4	4
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.01	4.01
Diameter 2, in.	4.00	4.01	4.02
Length(without caps), in.	7.86	7.88	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.01	4.02
Length / Diameter (L/D)	1.96	1.96	1.96
Cross-Sectional Area, in^2	12.57	12.63	12.69

Compressive Strength and Fracture Pattern

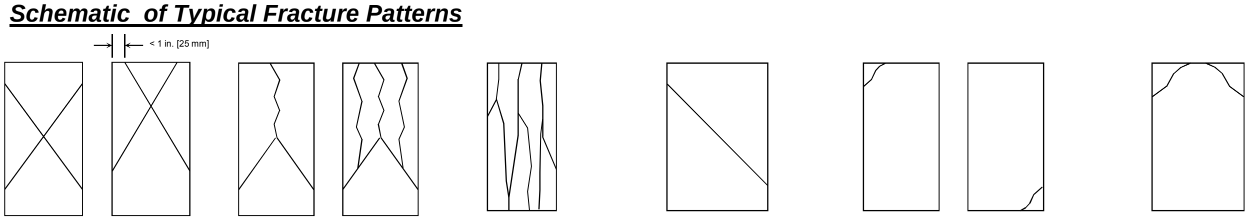
Maximum Load, lb	26,025	25,186	24,141
Compressive Strength, psi	2,070	1,990	1,900
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	1,990

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 2, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW5 (lab)	ALW5 (lab)	ALW5 (lab)
Client Identification	N/A	N/A	N/A
Casting Date	9/2/2016	9/2/2016	9/2/2016
Test Date / Time	9/3/2016	9/3/2016	9/3/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	24	24	24
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.02
Diameter 2, in.	4.00	4.02	4.01
Length(without caps), in.	7.90	7.88	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.03	4.01
Length / Diameter (L/D)	1.98	1.95	1.97
Cross-Sectional Area, in^2	12.57	12.76	12.63

Compressive Strength and Fracture Pattern

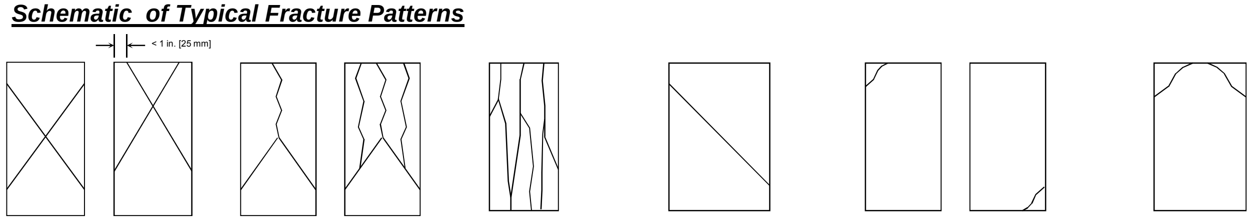
Maximum Load, lb	33,293	34,199	34,036
Compressive Strength, psi	2,650	2,680	2,690
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	2,670

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 7, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW5 (lab)	ALW5 (lab)	ALW5 (lab)
Client Identification	N/A	N/A	N/A
Casting Date	9/2/2016	9/2/2016	9/2/2016
Test Date / Time	9/6/2016	9/6/2016	9/6/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	4	4	4
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.03	4.02
Diameter 2, in.	4.00	4.03	4.01
Length(without caps), in.	7.85	7.89	7.87
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.03	4.01
Length / Diameter (L/D)	1.96	1.96	1.96
Cross-Sectional Area, in^2	12.57	12.76	12.63

Compressive Strength and Fracture Pattern

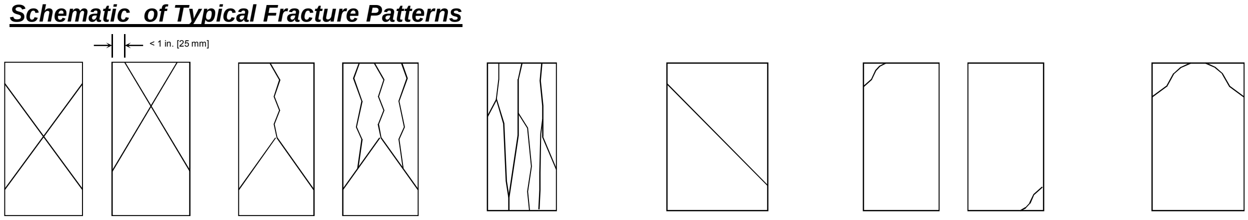
Maximum Load, lb	42,792	42,166	42,399
Compressive Strength, psi	3,400	3,300	3,360
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	3,360

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 9, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW5 (lab)	ALW5 (lab)	ALW5 (lab)
Client Identification	N/A	N/A	N/A
Casting Date	9/2/2016	9/2/2016	9/2/2016
Test Date / Time	9/9/2016	9/9/2016	9/9/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	7	7	7
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.02	4.01
Diameter 2, in.	3.99	4.03	4.02
Length(without caps), in.	7.90	7.87	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.02	4.01
Length / Diameter (L/D)	1.98	1.96	1.97
Cross-Sectional Area, in^2	12.57	12.69	12.63

Compressive Strength and Fracture Pattern

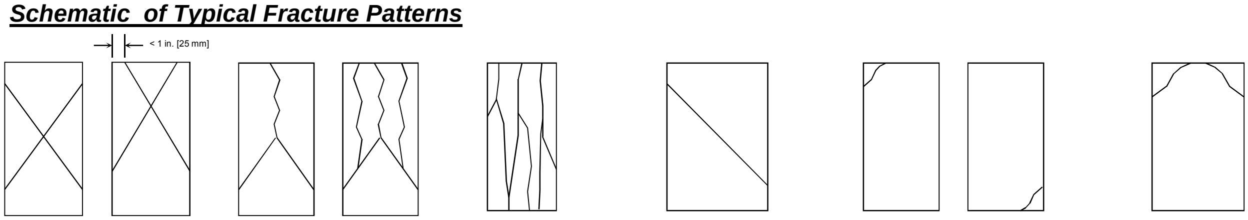
Maximum Load, lb	46,111	47,299	46,792
Compressive Strength, psi	3,670	3,730	3,700
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	3,700

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 6, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW4-T (cold)	ALW4-T (cold)	ALW4-T (cold)
Client Identification	N/A	N/A	N/A
Casting Date	9/6/16 11:20	9/6/16 11:20	9/6/16 11:20
Test Date / Time	9/6/16 15:41	9/6/16 15:44	9/6/16 15:50
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	4	4	5
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.01	4.01
Diameter 2, in.	4.00	4.01	4.02
Length(without caps), in.	7.86	7.88	7.89
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.01	4.02
Length / Diameter (L/D)	1.96	1.96	1.96
Cross-Sectional Area, in^2	12.57	12.63	12.69

Compressive Strength and Fracture Pattern

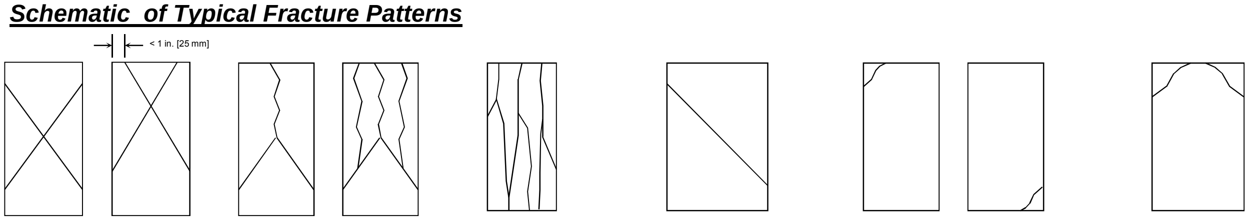
Maximum Load, lb	45,688	45,882	44,997
Compressive Strength, psi	3,630	3,630	3,550
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	3,600

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client: **Illinois Tollway**
Project: **Calcium Aluminate Cement Project**
Contact: **Steve Gillen**
Date Reported: **September 6, 2016**

CTL Project No.: **057177**
CTL Project Mgr.: **M. D'Ambrosia**
Technician: **W. Demharter**
Approved by: **B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW4-T (cold)	ALW4-T (cold)	ALW4-T (cold)
Client Identification	N/A	N/A	N/A
Casting Date	9/6/16 11:20	9/6/16 11:20	9/6/16 11:20
Test Date / Time	9/6/16 16:23	9/6/16 16:28	9/6/16 16:35
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	5	5	5
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.00	4.01
Diameter 2, in.	4.02	3.99	4.01
Length(without caps), in.	7.88	7.86	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.03	4.00	4.01
Length / Diameter (L/D)	1.96	1.97	1.96
Cross-Sectional Area, in^2	12.76	12.57	12.63

Compressive Strength and Fracture Pattern

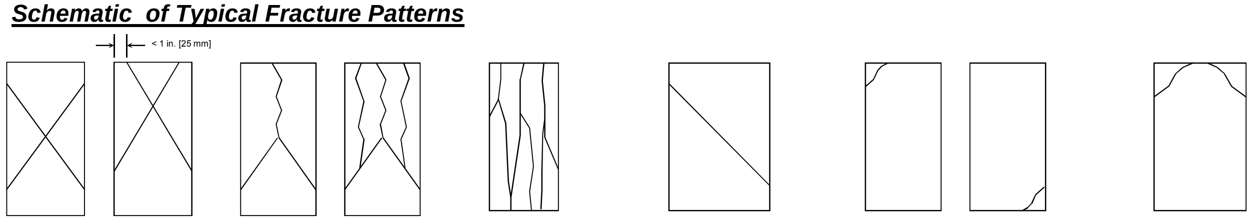
Maximum Load, lb	59,129	56,649	56,508
Compressive Strength, psi	4,630	4,510	4,470
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	4,540

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 6, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW4-T (cold)	ALW4-T (cold)	ALW4-T (cold)
Client Identification	N/A	N/A	N/A
Casting Date	9/6/16 11:20	9/6/16 11:20	9/6/16 11:20
Test Date / Time	9/6/16 17:26	9/6/16 17:30	9/6/16 17:35
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	6	6	6
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	Mold / 45°F	Mold / 45°F	Mold / 45°F
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.00	4.02	4.02
Diameter 2, in.	4.00	4.01	4.01
Length(without caps), in.	7.87	7.86	7.85
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.00	4.02	4.01
Length / Diameter (L/D)	1.97	1.96	1.96
Cross-Sectional Area, in^2	12.57	12.69	12.63

Compressive Strength and Fracture Pattern

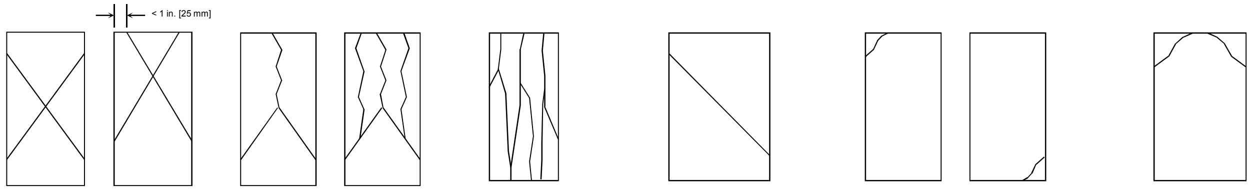
Maximum Load, lb	62,208	61,220	61,343
Compressive Strength, psi	4,950	4,820	4,860
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	4,880

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 6, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW4-T (lab)	ALW4-T (lab)	ALW4-T (lab)
Client Identification	N/A	N/A	N/A
Casting Date	9/6/16 11:20	9/6/16 11:20	9/6/16 11:20
Test Date / Time	9/6/16 15:18	9/6/16 15:20	9/6/16 15:24
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	4	4	4
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.03	4.01
Diameter 2, in.	4.01	4.02	4.00
Length(without caps), in.	7.86	7.89	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.03	4.01
Length / Diameter (L/D)	1.96	1.96	1.97
Cross-Sectional Area, in^2	12.69	12.76	12.63

Compressive Strength and Fracture Pattern

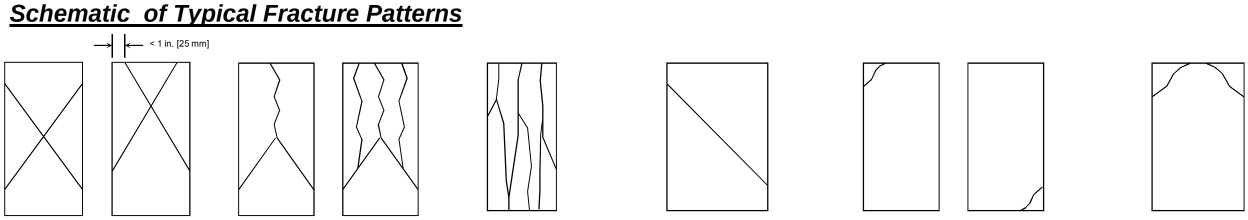
Maximum Load, lb	47,587	48,405	48,563
Compressive Strength, psi	3,750	3,790	3,850
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	3,800

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 6, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW4-T (lab)	ALW4-T (lab)	ALW4-T (lab)
Client Identification	N/A	N/A	N/A
Casting Date	9/6/16 11:20	9/6/16 11:20	9/6/16 11:20
Test Date / Time	9/6/16 16:10	9/6/16 16:13	9/6/16 16:18
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	5	5	5
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.02	4.03	4.04
Diameter 2, in.	4.01	4.02	4.03
Length(without caps), in.	7.85	7.88	7.87
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.03	4.03
Length / Diameter (L/D)	1.95	1.96	1.95
Cross-Sectional Area, in^2	12.69	12.76	12.76

Compressive Strength and Fracture Pattern

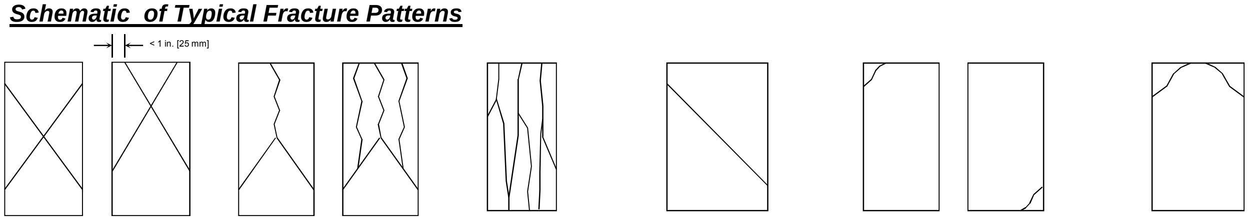
Maximum Load, lb	53,173	52,178	53,667
Compressive Strength, psi	4,190	4,090	4,210
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	4,160

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

CTLGroup

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 6, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW4-T (lab)	ALW4-T (lab)	ALW4-T (lab)
Client Identification	N/A	N/A	N/A
Casting Date	9/6/16 11:20	9/6/16 11:20	9/6/16 11:20
Test Date / Time	9/6/16 17:15	9/6/16 17:18	9/6/16 17:22
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	6	6	6
Moisture Condition at Test	Mold	Mold	Mold
Curing Conditions (Temp/RH)	73°F / Mold	73°F / Mold	73°F / Mold
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.02
Diameter 2, in.	4.01	4.03	4.01
Length(without caps), in.	7.87	7.90	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.03	4.02
Length / Diameter (L/D)	1.96	1.96	1.96
Cross-Sectional Area, in^2	12.63	12.76	12.69

Compressive Strength and Fracture Pattern

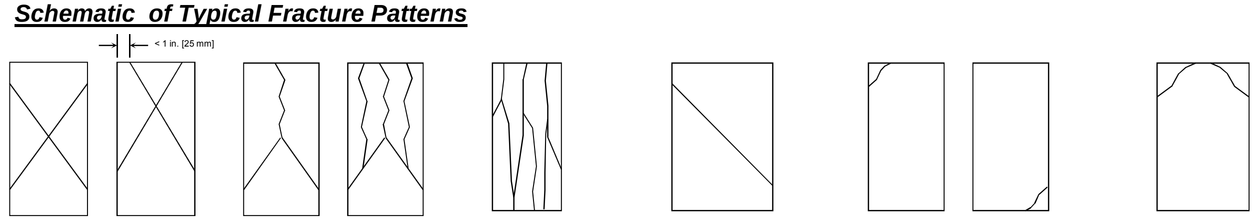
Maximum Load, lb	57,691	57,017	57,960
Compressive Strength, psi	4,570	4,470	4,570
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	4,530

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

CTLGroup

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 7, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW4-T (lab)	ALW4-T (lab)	ALW4-T (lab)
Client Identification	N/A	N/A	N/A
Casting Date	9/6/2016	9/6/2016	9/6/2016
Test Date / Time	9/7/2016	9/7/2016	9/7/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, hours	24	24	24
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.02
Diameter 2, in.	4.02	4.03	4.02
Length(without caps), in.	7.89	7.86	7.88
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.01	4.03	4.02
Length / Diameter (L/D)	1.97	1.95	1.96
Cross-Sectional Area, in^2	12.63	12.76	12.69

Compressive Strength and Fracture Pattern

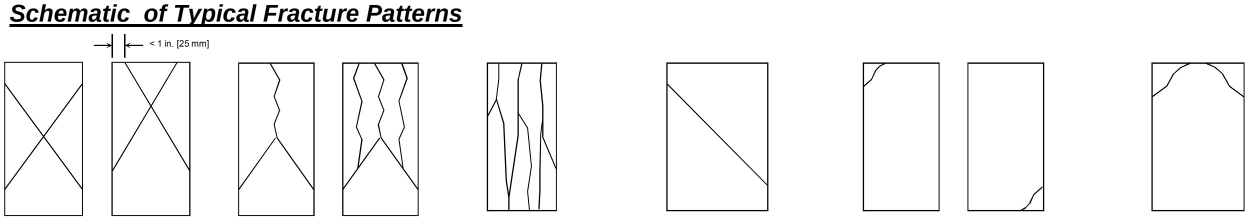
Maximum Load, lb	64,751	65,351	65,041
Compressive Strength, psi	5,130	5,120	5,130
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	5,120

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 10, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW4-T (lab)	ALW4-T (lab)
Client Identification	N/A	N/A
Casting Date	9/6/2016	9/6/2016
Test Date / Time	9/10/2016	9/10/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, days	4	4
Moisture Condition at Test	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03
Diameter 2, in.	4.00	4.02
Length(without caps), in.	7.86	7.89
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.01	4.02
Length / Diameter (L/D)	1.96	1.96
Cross-Sectional Area, in^2	12.63	12.69

Compressive Strength and Fracture Pattern

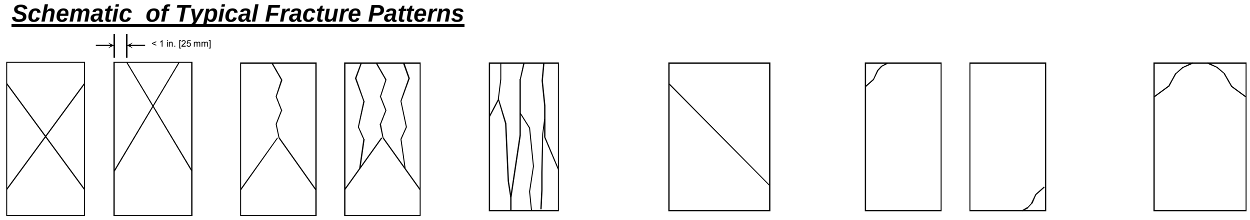
Maximum Load, lb	73,996	75,089
Compressive Strength, psi	5,860	5,920
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	5,890

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 13, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

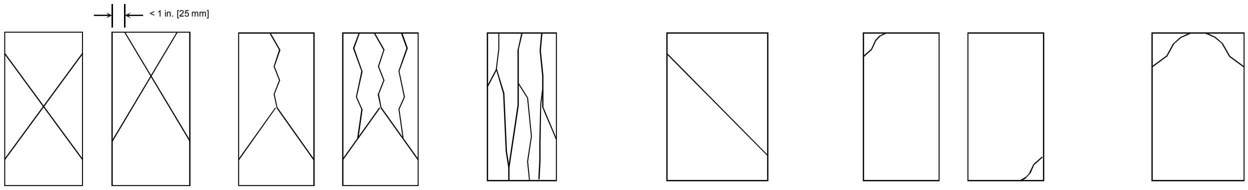
CTLGroup Identification	ALW4-T (lab)	ALW4-T (lab)	ALW4-T (lab)
Client Identification	N/A	N/A	N/A
Casting Date	9/6/2016	9/6/2016	9/6/2016
Test Date / Time	9/13/2016	9/13/2016	9/13/2016
Loading Rate, psi/sec	35	35	35
Concrete Description			
Concrete Age at Test, days	7	7	7
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground	Ground
Concrete Dimensions			
Diameter 1, in.	4.02	4.03	4.01
Diameter 2, in.	4.03	4.02	4.00
Length(without caps), in.	7.88	7.86	7.87
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	4.02	4.03	4.00
Length / Diameter (L/D)	1.96	1.95	1.97
Cross-Sectional Area, in^2	12.69	12.76	12.57
Compressive Strength and Fracture Pattern			
Maximum Load, lb	81,967	78,216	79,011
Compressive Strength, psi	6,460	6,130	6,290
Fracture Pattern	Type 1	Type 1	Type 1

Average Compressive Strength, psi	6,290

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**September 20, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW4-T (lab)	ALW4-T (lab)
Client Identification	N/A	N/A
Casting Date	9/6/2016	9/6/2016
Test Date / Time	9/20/2016	9/20/2016
Loading Rate, psi/sec	35	35

Concrete Description

Concrete Age at Test, days	14	14
Moisture Condition at Test	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.03	4.01
Diameter 2, in.	4.02	3.99
Length(without caps), in.	7.86	7.89
Length(with caps), in.	N/A	N/A
Average Diameter, in.	4.03	4.00
Length / Diameter (L/D)	1.95	1.97
Cross-Sectional Area, in^2	12.76	12.57

Compressive Strength and Fracture Pattern

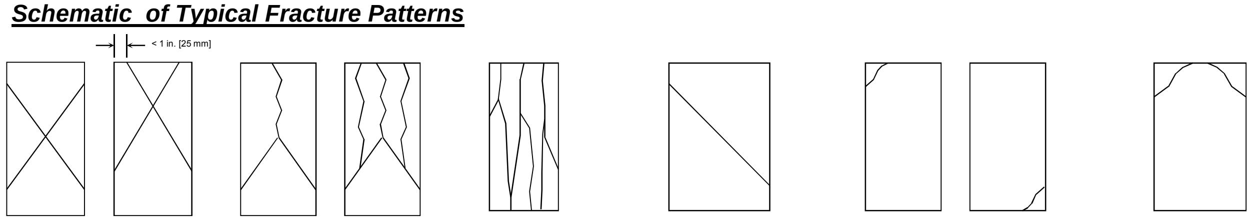
Maximum Load, lb	87,697	88,984
Compressive Strength, psi	6,870	7,080
Fracture Pattern	Type 1	Type 1

Average Compressive Strength, psi	6,980

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**October 4, 2016**	Approved by:	**B. Birch**

ASTM C39 and AASHTO T 22
Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

Specimen Identification

CTLGroup Identification	ALW4-T (lab)	ALW4-T (lab)	ALW4-T (lab)
Client Identification	N/A	N/A	N/A
Casting Date	9/6/2016	9/6/2016	9/6/2016
Test Date / Time	10/4/2016	10/4/2016	10/4/2016
Loading Rate, psi/sec	35	35	35

Concrete Description

Concrete Age at Test, days	28	28	28
Moisture Condition at Test	Dry	Dry	Dry
Curing Conditions (Temp/RH)	73°F / 50% RH	73°F / 50% RH	73°F / 50% RH
Cylinder End Preparation	Ground	Ground	Ground

Concrete Dimensions

Diameter 1, in.	4.01	4.03	4.03
Diameter 2, in.	3.98	3.99	3.99
Length(without caps), in.	7.84	7.83	7.83
Length(with caps), in.	N/A	N/A	N/A
Average Diameter, in.	3.99	4.01	4.01
Length / Diameter (L/D)	1.96	1.95	1.95
Cross-Sectional Area, in^2	12.50	12.63	12.63

Compressive Strength and Fracture Pattern

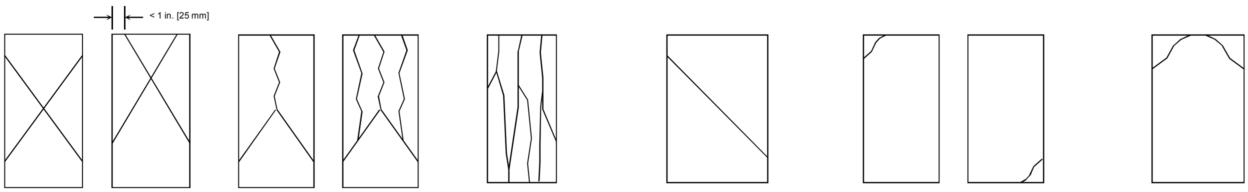
Maximum Load, lb	97,372	96,207	94,819
Compressive Strength, psi	7,790	7,620	7,510
Fracture Pattern	Type 4	Type 1	Type 4

Average Compressive Strength, psi	7,640

Report Notes

1. This report may not be reproduced except in its entirety.

Schematic of Typical Fracture Patterns



Type 1
Reasonable well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones

Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type I

Type 5
Side fractures at top or bottom (occur commonly with unbounded caps)

Type 6
Similar to Type 5 but end of cylinder is pointed

APPENDIX D

AASHTO TP-95 SURFACE RESISTIVITY TEST RESULTS

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (hours)	Surface Resistivity (kiloohm-cm)
CAC-C	6/26/2014	6/26/2014	4x8-in.	73° / 100%	4	24.2
CAC-D	6/26/2014	6/26/2014	4x8-in.	73° / 100%	4	25.5

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC-C	24.3	24.2	24.5	23.7	24.1	24.1	24.9	24.1	24.2
CAC-D	26.1	24.8	24.3	25.8	26.4	25.1	25.1	26.3	25.5
Set Average									24.9
Curing Condition Correction (× 1.0 for moist room)									24.9

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (hours)	Surface Resistivity (kiloohm-cm)
CAC-C	6/26/2014	6/26/2014	4x8-in.	73° / 100%	8	31.9
CAC-D	6/26/2014	6/26/2014	4x8-in.	73° / 100%	8	33.2

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC-C	31.6	31.5	31.9	32.9	31.0	31.3	32.3	32.7	31.9
CAC-D	33.3	34.1	32.9	32.7	33.1	34.3	32.6	32.7	33.2
Set Average									32.6
Curing Condition Correction (× 1.0 for moist room)									32.6

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC-C	6/26/2014	6/27/2014	4x8-in.	73° / 100%	1	42.4
CAC-D	6/26/2014	6/27/2014	4x8-in.	73° / 100%	1	44.6

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC-C	42.2	42.9	44.8	42.3	39.2	41.7	44.7	41.4	42.4
CAC-D	46.2	44.4	41.5	47.1	45.2	43.8	42.6	46.0	44.6
								Set Average	43.5
								Curing Condition Correction (× 1.0 for moist room)	43.5

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC-C	6/26/2014	6/28/2014	4x8-in.	73° / 100%	2	41.2
CAC-D	6/26/2014	6/28/2014	4x8-in.	73° / 100%	2	42.0

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC-C	41.3	41.7	41.3	40.6	40.9	41.0	41.5	41.0	41.2
CAC-D	47.1	39.8	39.7	43.5	42.5	39.7	40.0	43.7	42.0
Set Average									41.6
Curing Condition Correction (× 1.0 for moist room)									41.6

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC-C	6/26/2014	6/29/2014	4x8-in.	73° / 100%	3	45.5
CAC-D	6/26/2014	6/29/2014	4x8-in.	73° / 100%	3	46.0

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC-C	43.1	45.6	45.6	47.7	43.4	45.6	45.7	47.6	45.5
CAC-D	45.0	45.8	45.0	47.5	44.9	45.8	45.1	48.5	46.0
Set Average									45.7
Curing Condition Correction (× 1.0 for moist room)									45.7

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC-C	6/26/2014	6/30/2014	4x8-in.	73° / 100%	4	50.6
CAC-D	6/26/2014	6/30/2014	4x8-in.	73° / 100%	4	52.3

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC-C	47.3	50.8	50.4	53.4	48.3	50.0	50.6	53.8	50.6
CAC-D	52.7	52.5	51.4	52.2	52.6	51.3	52.9	53.0	52.3
Set Average									51.5
Curing Condition Correction (× 1.0 for moist room)									51.5

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

CTLGroup

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC-C	6/26/2014	7/1/2014	4x8-in.	73° / 100%	5	55.2
CAC-D	6/26/2014	7/1/2014	4x8-in.	73° / 100%	5	57.5

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC-C	50.6	54.7	55.5	58.9	53.1	55.4	55.3	58.3	55.2
CAC-D	59.2	55.4	56.5	57.8	57.3	56.1	58.7	59.0	57.5
Set Average									56.4
Curing Condition Correction (× 1.0 for moist room)									56.4

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC-C	6/26/2014	7/2/2014	4x8-in.	73° / 100%	6	57.8
CAC-D	6/26/2014	7/2/2014	4x8-in.	73° / 100%	6	60.7

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC-C	52.9	57.3	57.9	62.9	55.6	57.7	57.8	60.5	57.8
CAC-D	61.1	59.6	61.4	61.5	59.5	58.9	61.6	62.2	60.7
								Set Average	59.3
								Curing Condition Correction (× 1.0 for moist room)	59.3

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC-C	6/26/2014	7/3/2014	4x8-in.	73° / 100%	7	59.8
CAC-D	6/26/2014	7/3/2014	4x8-in.	73° / 100%	7	62.7

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC-C	55.9	58.2	60.6	63.0	58.6	58.8	60.9	62.2	59.8
CAC-D	61.6	61.7	63.5	64.0	61.5	61.5	63.8	63.6	62.7
Set Average									61.2
Curing Condition Correction (× 1.0 for moist room)									61.2

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC-C	6/26/2014	7/11/2014	4x8-in.	73° / 100%	15	80.9
CAC-D	6/26/2014	7/11/2014	4x8-in.	73° / 100%	15	83.2

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC-C	75.4	83.3	78.8	86.2	75.9	83.5	79.8	84.3	80.9
CAC-D	81.0	85.7	84.6	80.4	81.4	83.0	85.4	84.3	83.2
Set Average									82.1
Curing Condition Correction (× 1.0 for moist room)									82.1

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC-C	6/26/2014	7/24/2014	4x8-in.	73° / 100%	28	96.2
CAC-D	6/26/2014	7/24/2014	4x8-in.	73° / 100%	28	100.2

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC-C	92.0	98.1	96.2	98.6	92.4	98.9	94.8	98.2	96.2
CAC-D	96.5	96.7	106.1	101.3	98.1	98.1	104.3	100.3	100.2
Set Average									98.2
Curing Condition Correction (× 1.0 for moist room)									98.2

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC-C	6/26/2014	8/22/2014	4x8-in.	73° / 100%	57	77.8
CAC-D	6/26/2014	8/22/2014	4x8-in.	73° / 100%	57	84.0

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC-C	74.0	77.1	77.7	81.0	74.3	78.5	77.4	82.6	77.8
CAC-D	83.9	82.4	86.7	85.2	83.6	81.0	85.6	83.3	84.0
								Set Average	80.9
								Curing Condition Correction (× 1.0 for moist room)	80.9

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC-C	6/26/2014	9/24/2014	4x8-in.	73° / 100%	90	62.7
CAC-D	6/26/2014	9/24/2014	4x8-in.	73° / 100%	90	68.8

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC-C	63.8	63.4	60.5	63.3	59.7	64.3	62.0	64.5	62.7
CAC-D	69.5	67.5	67.3	74.0	66.8	67.8	69.5	68.3	68.8
Set Average									65.8
Curing Condition Correction (× 1.0 for moist room)									65.8

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (hours)	Surface Resistivity (kiloohm-cm)
CAC Hot-A	6/26/2014	6/26/2014	4x8-in.	122° / 100% [4]	4	32.4
CAC Hot-B	6/26/2014	6/26/2014	4x8-in.	122° / 100% [4]	4	26.9

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC Hot-A	32.5	32.7	33.3	31.1	32.3	32.2	33.5	31.7	32.4
CAC Hot-B	26.8	26.0	27.9	26.1	26.7	26.6	28.5	26.4	26.9
Set Average									29.6
Curing Condition Correction (× 1.0 for moist room)									29.6

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (hours)	Surface Resistivity (kiloohm-cm)
CAC Hot-A	6/26/2014	6/26/2014	4x8-in.	122° / 100% [4]	8	38.6
CAC Hot-B	6/26/2014	6/26/2014	4x8-in.	122° / 100% [4]	8	34.1

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC Hot-A	37.4	40.6	41.6	36.4	35.8	39.1	41.7	36.0	38.6
CAC Hot-B	32.0	34.2	35.6	33.7	33.0	34.6	34.9	34.5	34.1
Set Average									36.3
Curing Condition Correction (× 1.0 for moist room)									36.3

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC Hot-A	6/26/2014	6/27/2014	4x8-in.	122° / 100% [4]	1	45.3
CAC Hot-B	6/26/2014	6/27/2014	4x8-in.	122° / 100% [4]	1	43.7

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC Hot-A	43.7	46.2	49.1	43.7	41.8	45.5	49.1	43.0	45.3
CAC Hot-B	41.8	42.8	45.0	44.4	44.5	42.2	44.3	44.5	43.7
Set Average									44.5
Curing Condition Correction (× 1.0 for moist room)									44.5

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC Hot-A	6/26/2014	6/28/2014	4x8-in.	122° / 100% [4]	2	22.2
CAC Hot-B	6/26/2014	6/28/2014	4x8-in.	122° / 100% [4]	2	19.5

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC Hot-A	21.2	22.7	22.5	22.1	21.3	22.7	22.9	22.2	22.2
CAC Hot-B	19.3	19.2	20.0	18.9	19.4	19.8	20.2	18.8	19.5
Set Average									20.8
Curing Condition Correction (× 1.0 for moist room)									20.8

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC Hot-A	6/26/2014	6/29/2014	4x8-in.	122° / 100% [4]	3	13.7
CAC Hot-B	6/26/2014	6/29/2014	4x8-in.	122° / 100% [4]	3	13.8

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC Hot-A	13.2	13.5	14.0	13.9	13.3	13.7	13.9	13.9	13.7
CAC Hot-B	13.5	13.9	14.0	13.7	13.7	13.8	14.2	13.9	13.8
Set Average									13.8
Curing Condition Correction (× 1.0 for moist room)									13.8

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC Hot-A	6/26/2014	6/30/2014	4x8-in.	122° / 100% [4]	4	13.5
CAC Hot-B	6/26/2014	6/30/2014	4x8-in.	122° / 100% [4]	4	13.5

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC Hot-A	13.1	13.9	13.3	13.2	13.4	14.3	13.7	13.4	13.5
CAC Hot-B	13.0	13.5	14.0	13.2	13.1	13.3	14.0	13.5	13.5
Set Average									13.5
Curing Condition Correction (× 1.0 for moist room)									13.5

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11

Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC Hot-A	6/26/2014	7/1/2014	4x8-in.	122° / 100% [4]	5	14.6
CAC Hot-B	6/26/2014	7/1/2014	4x8-in.	122° / 100% [4]	5	14.6

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC Hot-A	14.5	13.8	14.9	14.3	14.6	14.8	14.9	14.8	14.6
CAC Hot-B	14.4	14.7	14.6	14.8	14.3	14.3	15.0	14.6	14.6
Set Average									14.6
Curing Condition Correction (× 1.0 for moist room)									14.6

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC Hot-A	6/26/2014	7/2/2014	4x8-in.	122° / 100% [4]	6	15.7
CAC Hot-B	6/26/2014	7/2/2014	4x8-in.	122° / 100% [4]	6	15.2

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC Hot-A	15.5	15.8	15.0	15.9	15.8	16.0	15.8	15.9	15.7
CAC Hot-B	15.2	15.2	15.4	14.7	15.1	15.2	15.5	15.2	15.2
								Set Average	15.5
								Curing Condition Correction (× 1.0 for moist room)	15.5

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC Hot-A	6/26/2014	7/3/2014	4x8-in.	122° / 100% [4]	7	16.7
CAC Hot-B	6/26/2014	7/3/2014	4x8-in.	122° / 100% [4]	7	15.9

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC Hot-A	16.8	16.8	16.4	16.0	16.4	17.0	16.9	16.9	16.7
CAC Hot-B	15.9	15.8	16.3	15.4	15.8	15.7	16.6	15.7	15.9
Set Average									16.3
Curing Condition Correction (× 1.0 for moist room)									16.3

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11

Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC Hot-A	6/26/2014	7/11/2014	4x8-in.	122° / 100% [4]	15	31.6
CAC Hot-B	6/26/2014	7/11/2014	4x8-in.	122° / 100% [4]	15	29.7

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC Hot-A	31.6	32.2	33.2	29.9	30.3	31.4	33.5	30.9	31.6
CAC Hot-B	29.6	29.3	30.5	28.7	29.6	31.1	29.4	29.6	29.7
Set Average									30.7
Curing Condition Correction (× 1.0 for moist room)									30.7

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC Hot-A	6/26/2014	7/24/2014	4x8-in.	122° / 100% [4]	28	39.3
CAC Hot-B	6/26/2014	7/24/2014	4x8-in.	122° / 100% [4]	28	37.7

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC Hot-A	38.2	39.3	39.7	40.6	38.2	39.2	38.8	40.4	39.3
CAC Hot-B	37.3	36.7	40.0	36.7	37.5	36.8	39.3	37.4	37.7
Set Average									38.5
Curing Condition Correction (× 1.0 for moist room)									38.5

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11

Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC Hot-A	6/26/2014	8/22/2014	4x8-in.	122° / 100% [4]	57	50.5
CAC Hot-B	6/26/2014	8/22/2014	4x8-in.	122° / 100% [4]	57	49.1

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC Hot-A	47.5	53.2	53.2	49.5	47.5	51.4	51.5	50.4	50.5
CAC Hot-B	48.0	47.6	50.7	49.3	48.6	47.6	51.8	49.2	49.1
Set Average									49.8
Curing Condition Correction (× 1.0 for moist room)									49.8

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
CAC Hot-A	6/26/2014	9/24/2014	4x8-in.	122° / 100% [4]	90	63.0
CAC Hot-B	6/26/2014	9/24/2014	4x8-in.	122° / 100% [4]	90	61.5

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
CAC Hot-A	60.1	62.3	62.6	67.3	61.2	63.0	62.2	65.4	63.0
CAC Hot-B	62.3	59.8	63.2	59.2	60.7	60.7	65.5	60.7	61.5
Set Average									62.3
Curing Condition Correction (× 1.0 for moist room)									62.3

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (hours)	Surface Resistivity (kiloohm-cm)
LCAC-C	6/26/2014	6/26/2014	4x8-in.	73° / 50%	4	18.7
LCAC-D	6/26/2014	6/26/2014	4x8-in.	73° / 50%	4	20.4

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC-C	20.3	17.8	17.8	18.5	20.0	18.6	18.2	18.7	18.7
LCAC-D	19.6	19.6	19.7	21.0	20.3	20.3	20.5	21.8	20.4
								Set Average	19.5
								Curing Condition Correction (× 1.0 for moist room) [5]	19.5

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (hours)	Surface Resistivity (kiloohm-cm)
LCAC-C	6/26/2014	6/26/2014	4x8-in.	73° / 50%	8	40.0
LCAC-D	6/26/2014	6/26/2014	4x8-in.	73° / 50%	8	36.7

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC-C	40.0	40.4	40.2	39.2	41.0	39.9	40.0	38.9	40.0
LCAC-D	37.2	36.3	36.3	36.8	38.0	35.7	35.9	37.1	36.7
Set Average									38.3
Curing Condition Correction (× 1.0 for moist room) [5]									38.3

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC-C	6/26/2014	6/27/2014	4x8-in.	73° / 50%	1	49.5
LCAC-D	6/26/2014	6/27/2014	4x8-in.	73° / 50%	1	46.1

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC-C	50.6	49.5	50.7	47.4	51.0	49.1	50.2	47.7	49.5
LCAC-D	46.8	45.8	45.5	46.4	46.9	45.2	45.9	45.9	46.1
Set Average									47.8
Curing Condition Correction (× 1.0 for moist room) [5]									47.8

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

CTLGROUP

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC-C	6/26/2014	6/28/2014	4x8-in.	73° / 50%	2	52.4
LCAC-D	6/26/2014	6/28/2014	4x8-in.	73° / 50%	2	48.2

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC-C	51.2	54.3	53.2	51.6	50.5	55.2	53.0	50.1	52.4
LCAC-D	49.6	50.2	46.5	45.9	50.0	49.5	46.3	47.5	48.2
								Set Average	50.3
								Curing Condition Correction (× 1.0 for moist room) [5]	50.3

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC-C	6/26/2014	6/29/2014	4x8-in.	73° / 50%	3	74.8
LCAC-D	6/26/2014	6/29/2014	4x8-in.	73° / 50%	3	69.2

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC-C	72.0	76.1	77.1	76.0	70.2	74.6	77.1	74.9	74.8
LCAC-D	71.5	69.9	65.5	70.9	71.2	69.6	65.4	69.9	69.2
								Set Average	72.0
								Curing Condition Correction (× 1.0 for moist room) [5]	72.0

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC-C	6/26/2014	6/30/2014	4x8-in.	73° / 50%	4	94.8
LCAC-D	6/26/2014	6/30/2014	4x8-in.	73° / 50%	4	88.3

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC-C	84.3	100.4	100.6	94.1	87.8	93.8	97.5	100.0	94.8
LCAC-D	92.6	90.0	84.3	90.8	91.2	85.4	83.9	88.5	88.3
								Set Average	91.6
								Curing Condition Correction (× 1.0 for moist room) [5]	91.6

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC-C	6/26/2014	7/1/2014	4x8-in.	73° / 50%	5	112.9
LCAC-D	6/26/2014	7/1/2014	4x8-in.	73° / 50%	5	108.2

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC-C	100.0	122.2	120.6	109.8	100.8	118.7	120.6	110.8	112.9
LCAC-D	115.9	107.7	100.2	109.7	114.0	109.1	103.9	105.4	108.2
Set Average									110.6
Curing Condition Correction (× 1.0 for moist room) [5]									110.6

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	Illinois Tollway	CTL Project No:	057177
Project:	Calcium Aluminate Cement Project	CTL Project Mgr.:	M. D'Ambrosia
Contact:	Steve Gillen	Analyst:	A. Bentivegna
Date Reported:	August 19, 2015	Approved:	B. Birch

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC-C	6/26/2014	7/2/2014	4x8-in.	73° / 50%	6	131.8
LCAC-D	6/26/2014	7/2/2014	4x8-in.	73° / 50%	6	123.5

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC-C	115.6	139.7	136.3	142.0	114.4	141.2	132.2	132.6	131.8
LCAC-D	133.7	113.3	116.3	130.0	131.3	118.4	119.5	125.2	123.5
								Set Average	127.6
								Curing Condition Correction (× 1.0 for moist room) [5]	127.6

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC-C	6/26/2014	7/3/2014	4x8-in.	73° / 50%	7	147.4
LCAC-D	6/26/2014	7/3/2014	4x8-in.	73° / 50%	7	143.6

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC-C	130.7	157.4	155.5	147.8	144.2	150.7	152.9	139.7	147.4
LCAC-D	150.0	144.0	142.9	141.1	150.9	141.9	136.6	141.5	143.6
Set Average									145.5
Curing Condition Correction (× 1.0 for moist room) [5]									145.5

Notes:
1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC-C	6/26/2014	7/10/2014	4x8-in.	73° / 50%	14	303.1
LCAC-D	6/26/2014	7/10/2014	4x8-in.	73° / 50%	14	305.3

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC-C	286.0	332.0	320.0	296.0	280.0	314.0	318.0	279.0	303.1
LCAC-D	325.0	308.0	281.0	313.0	318.0	309.0	283.0	305.0	305.3
Set Average									304.2
Curing Condition Correction (× 1.0 for moist room) [5]									304.2

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC-C	6/26/2014	7/24/2014	4x8-in.	73° / 50%	28	504.4
LCAC-D	6/26/2014	7/24/2014	4x8-in.	73° / 50%	28	540.9

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC-C	448.0	533.0	529.0	554.0	426.0	505.0	509.0	531.0	504.4
LCAC-D	570.0	513.0	507.0	562.0	584.0	503.0	525.0	563.0	540.9
Set Average									522.6
Curing Condition Correction (× 1.0 for moist room) [5]									522.6

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC-C	6/26/2014	8/21/2014	4x8-in.	73° / 50%	56	773.5
LCAC-D	6/26/2014	8/21/2014	4x8-in.	73° / 50%	56	824.5

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC-C	768.0	751.0	793.0	811.0	733.0	734.0	769.0	829.0	773.5
LCAC-D	820.0	816.0	835.0	806.0	819.0	837.0	816.0	847.0	824.5
Set Average									799.0
Curing Condition Correction (× 1.0 for moist room) [5]									799.0

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC-C	6/26/2014	9/24/2014	4x8-in.	73° / 50%	90	942.8
LCAC-D	6/26/2014	9/24/2014	4x8-in.	73° / 50%	90	965.9

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC-C	1035.0	835.0	1055.0	904.0	917.0	951.0	1031.0	814.0	942.8
LCAC-D	1018.0	940.0	1058.0	930.0	995.0	912.0	944.0	930.0	965.9
Set Average									954.3
Curing Condition Correction (× 1.0 for moist room) [5]									954.3

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (hours)	Surface Resistivity (kiloohm-cm)
LCAC Hot-A	6/26/2014	6/26/2014	4x8-in.	122° / 100% [4]	4	13.8
LCAC Hot-B	6/26/2014	6/26/2014	4x8-in.	122° / 100% [4]	4	14.2

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC Hot-A	13.5	14.0	13.3	13.6	13.9	14.3	13.6	13.9	13.8
LCAC Hot-B	14.0	14.4	13.2	14.7	14.3	14.7	13.4	14.9	14.2
Set Average									14.0
Curing Condition Correction (× 1.0 for moist room) [5]									14.0

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (hours)	Surface Resistivity (kiloohm-cm)
LCAC Hot-A	6/26/2014	6/26/2014	4x8-in.	122° / 100% [4]	8	44.9
LCAC Hot-B	6/26/2014	6/26/2014	4x8-in.	122° / 100% [4]	8	37.7

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC Hot-A	43.7	45.0	45.7	44.5	44.5	44.6	46.5	44.5	44.9
LCAC Hot-B	39.4	37.3	36.3	37.9	39.7	36.9	36.4	37.8	37.7
								Set Average	41.3
								Curing Condition Correction (× 1.0 for moist room) [5]	41.3

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC Hot-A	6/26/2014	6/27/2014	4x8-in.	122° / 100% [4]	1	55.0
LCAC Hot-B	6/26/2014	6/27/2014	4x8-in.	122° / 100% [4]	1	44.8

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC Hot-A	56.8	52.6	54.1	57.0	56.1	52.3	54.5	56.8	55.0
LCAC Hot-B	44.2	46.3	44.0	44.8	44.3	46.3	43.6	44.8	44.8
								Set Average	49.9
								Curing Condition Correction (× 1.0 for moist room) [5]	49.9

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC Hot-A	6/26/2014	6/28/2014	4x8-in.	122° / 100% [4]	2	77.6
LCAC Hot-B	6/26/2014	6/28/2014	4x8-in.	122° / 100% [4]	2	76.5

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC Hot-A	78.5	71.6	78.9	79.8	78.3	71.8	81.1	81.0	77.6
LCAC Hot-B	80.3	72.6	74.0	75.7	83.7	74.4	74.7	76.9	76.5
Set Average									77.1
Curing Condition Correction (× 1.0 for moist room) [5]									77.1

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC Hot-A	6/26/2014	6/29/2014	4x8-in.	122° / 100% [4]	3	28.1
LCAC Hot-B	6/26/2014	6/29/2014	4x8-in.	122° / 100% [4]	3	31.5

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC Hot-A	27.4	26.7	28.9	28.2	27.8	27.1	29.3	29.2	28.1
LCAC Hot-B	33.3	31.9	29.4	30.9	32.8	32.3	30.3	31.3	31.5
								Set Average	29.8
								Curing Condition Correction (× 1.0 for moist room) [5]	29.8

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC Hot-A	6/26/2014	6/30/2014	4x8-in.	122° / 100% [4]	4	29.6
LCAC Hot-B	6/26/2014	6/30/2014	4x8-in.	122° / 100% [4]	4	32.4

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC Hot-A	28.8	29.5	31.1	30.9	28.8	28.3	29.3	30.4	29.6
LCAC Hot-B	33.4	31.5	30.3	32.6	34.4	33.1	31.5	32.7	32.4
Set Average									31.0
Curing Condition Correction (× 1.0 for moist room) [5]									31.0

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

CTLGroup

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC Hot-A	6/26/2014	7/1/2014	4x8-in.	122° / 100% [4]	5	31.6
LCAC Hot-B	6/26/2014	7/1/2014	4x8-in.	122° / 100% [4]	5	33.4

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC Hot-A	32.0	30.1	31.3	30.9	32.8	31.3	32.6	31.5	31.6
LCAC Hot-B	35.6	32.2	31.2	32.7	37.1	33.6	31.6	33.5	33.4
Set Average									32.5
Curing Condition Correction (× 1.0 for moist room) [5]									32.5

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC Hot-A	6/26/2014	7/2/2014	4x8-in.	122° / 100% [4]	6	32.4
LCAC Hot-B	6/26/2014	7/2/2014	4x8-in.	122° / 100% [4]	6	34.2

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC Hot-A	32.2	30.8	34.3	32.1	31.5	31.6	34.5	32.5	32.4
LCAC Hot-B	34.7	33.9	33.3	34.0	35.1	34.5	33.5	34.2	34.2
Set Average									33.3
Curing Condition Correction (× 1.0 for moist room) [5]									33.3

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC Hot-A	6/26/2014	7/3/2014	4x8-in.	122° / 100% [4]	7	33.7
LCAC Hot-B	6/26/2014	7/3/2014	4x8-in.	122° / 100% [4]	7	34.3

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC Hot-A	34.2	33.4	34.0	33.4	33.3	32.0	35.2	33.7	33.7
LCAC Hot-B	34.8	35.4	32.7	33.0	35.9	35.2	33.3	33.9	34.3
Set Average									34.0
Curing Condition Correction (× 1.0 for moist room) [5]									34.0

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC Hot-A	6/26/2014	7/10/2014	4x8-in.	122° / 100% [4]	14	167.7
LCAC Hot-B	6/26/2014	7/10/2014	4x8-in.	122° / 100% [4]	14	158.7

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC Hot-A	180.0	155.1	167.2	164.6	175.8	155.0	171.5	172.5	167.7
LCAC Hot-B	163.1	157.4	170.7	163.7	157.4	158.0	136.5	163.0	158.7
Set Average									163.2
Curing Condition Correction (× 1.0 for moist room) [5]									163.2

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

CTLGroup

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC Hot-A	6/26/2014	7/24/2014	4x8-in.	122° / 100% [4]	28	321.3
LCAC Hot-B	6/26/2014	7/24/2014	4x8-in.	122° / 100% [4]	28	287.9

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC Hot-A	358.0	312.0	312.0	313.0	339.0	305.0	320.0	311.0	321.3
LCAC Hot-B	284.0	275.0	317.0	293.0	270.0	261.0	310.0	293.0	287.9
Set Average									304.6
Curing Condition Correction (× 1.0 for moist room) [5]									304.6

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC Hot-A	6/26/2014	8/21/2014	4x8-in.	122° / 100% [4]	56	626.3
LCAC Hot-B	6/26/2014	8/21/2014	4x8-in.	122° / 100% [4]	56	515.8

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC Hot-A	718.0	585.0	556.0	666.0	654.0	606.0	580.0	645.0	626.3
LCAC Hot-B	519.0	510.0	533.0	558.0	479.0	464.0	535.0	528.0	515.8
Set Average									571.0
Curing Condition Correction (× 1.0 for moist room) [5]									571.0

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

REPORT of ANALYSIS

AASHTO TP 95-11
Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Dimensions	Curing History (°F / RH)	Age at Test Date (days)	Surface Resistivity (kiloohm-cm)
LCAC Hot-A	6/26/2014	9/24/2014	4x8-in.	122° / 100% [4]	90	874.6
LCAC Hot-B	6/26/2014	9/24/2014	4x8-in.	122° / 100% [4]	90	802.8

Surface Resistivity (SR) Readings, kiloohm-cm

Sample ID	0°	90°	180°	270°	0°	90°	180°	270°	Average
LCAC Hot-A	1013.0	899.0	881.0	932.0	806.0	873.0	753.0	840.0	874.6
LCAC Hot-B	777.0	791.0	842.0	804.0	784.0	828.0	841.0	755.0	802.8
Set Average									838.7
Curing Condition Correction (× 1.0 for moist room) [5]									838.7

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. Specimens were 4x8-inch concrete cylinder.
4. Specimens were stored in a water tank at 50°C [122°F] until an age of 7 days and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity.
5. Specimens contain latex and therefore the curing was modified. A curing condition correction of 1.0 was used for comparison purposes.
6. This report may not be reproduced except in its entirety.

CTLGROUP

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**---**
Date Reported:	**Jul 28, 2016**	Approved:	**J. Pacheco**

REPORT of ANALYSIS

AASHTO TP-95

Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Concrete Mixture	Date of fabrication	Date of testing	Age	Curing condition	Dimensions
LCAC - ALW2 8/30/16	8/30/2016	8/31/2016	1	Moist Room	4x8"

	Surface resistivity (SR), kΩ-cm								
Sample	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**	**Average**
#1	14.1	13.3	12.9	14.0	14.0	12.5	13.1	12.8	13.3
#2	13.9	13.9	14.2	14.5	13.9	14.6	14.5	14.4	14.2
								Set average, kΩ-cm	13.8
								Curing condition correction (x 1.1 lime tank or 1.0 for moist room), kΩ-cm	13.8
								Chloride ion penetration	**Moderate**

Interpretation of results:

AASHTO TP 95-11, Table 1: Chloride Ion Penetration

Chloride Ion Penetration	100-mm x 200-mm (4-in. x 8-in.) Cylinder (kΩ-cm) a=1.5	150-mm x 300-mm (6-in. x 12-in.) Cylinder (kΩ-cm) a=1.5
High	<12	<9.5
Moderate	12-21	9.5-16.5
Low	21-37	16.5-29
Very Low	37-254	29-199
Negligible	>254	>199

Notes:

1. Specimens were reportedly fabricated by others on August 30, 2016 and delivered to CTLGroup on July 9, 2016.
2. Readings were carried out on SSD condition at 73°F.
3. Specimens were cured in limewater at 73°F prior to testing.
4. This analysis specifically represents the submitted samples.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**---**
Date Reported:	**Aug 16, 2016**	Approved:	**J. Pacheco**

REPORT of ANALYSIS

AASHTO TP-95

Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Concrete Mixture	Date of fabrication	Date of testing	Age	Curing condition	Dimensions
LCAC - ALW3 8/30/16	8/30/2016	8/31/2016	1	Moist Room	4x8"

	Surface resistivity (SR), kΩ-cm								
Sample	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**	**Average**
#1	14.1	13.3	12.9	13.2	13.7	13.5	12.4	13.3	13.3
#2	12.4	12.6	13.3	12.5	12.6	12.9	12.7	12.3	12.7
								Set average, kΩ-cm	13.0
								Curing condition correction (x 1.1 lime tank or 1.0 for moist room), kΩ-cm	13.0
								Chloride ion penetration	**Moderate**

Interpretation of results:

AASHTO TP 95-11, Table 1: Chloride Ion Penetration

Chloride Ion Penetration	100-mm x 200-mm (4-in. x 8-in.) Cylinder (kΩ-cm) a=1.5	150-mm x 300-mm (6-in. x 12-in.) Cylinder (kΩ-cm) a=1.5
High	<12	<9.5
Moderate	12-21	9.5-16.5
Low	21-37	16.5-29
Very Low	37-254	29-199
Negligible	>254	>199

Notes:

1. Specimens were reportedly fabricated by others on August 30, 2016 and delivered to CTLGroup on July 9, 2016.
2. Readings were carried out on SSD condition at 73°F.
3. Specimens were cured in limewater at 73°F prior to testing.
4. This analysis specifically represents the submitted samples.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**J. Vosahlik**
Date Reported:	**Sep 7, 2016**	Approved:	**J. Pacheco**

REPORT of ANALYSIS

AASHTO TP-95

Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Concrete Mixture	Date of fabrication	Date of testing	Age	Curing condition	Dimensions
ALW4-T	9/6/2016	9/7/2016	1	Drying Room	4x8"

	Surface resistivity (SR), kΩ-cm								
Sample	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**	**Average**
A	38.5	36.1	38.1	39.6	40.0	36.1	37.5	39.3	38.2
								Set average, kΩ-cm	38.2
								Chloride ion penetration	**Very Low**

Interpretation of results:

AASHTO TP 95-11, Table 1: Chloride Ion Penetration

Chloride Ion Penetration	100-mm x 200-mm (4-in. x 8-in.) Cylinder (kΩ-cm) a=1.5	150-mm x 300-mm (6-in. x 12-in.) Cylinder (kΩ-cm) a=1.5
High	<12	<9.5
Moderate	12-21	9.5-16.5
Low	21-37	16.5-29
Very Low	37-254	29-199
Negligible	>254	>199

Notes:

1. Specimen was fabricated by CLTGroup on September 6, 2016.
2. Readings were carried out on dry condition at 73°F.
3. Specimen was cured at 73°F/50% RH prior to testing.
4. This report may not be reproduced except in its entirety.

CTLGROUP

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**J. Vosahlik**
Date Reported:	**Sep 10, 2016**	Approved:	**J. Pacheco**

REPORT of ANALYSIS

AASHTO TP-95

Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Concrete Mixture	Date of fabrication	Date of testing	Age	Curing condition	Dimensions
ALW4-T	9/6/2016	9/10/2016	4	Drying Room	4x8"

	Surface resistivity (SR), kΩ-cm								
Sample	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**	**Average**
A	62.6	62.8	68.0	62.9	62.8	61.6	66.0	61.0	63.5
								Set average, kΩ-cm	63.5
								Chloride ion penetration	**Very Low**

Interpretation of results:

AASHTO TP 95-11, Table 1: Chloride Ion Penetration

Chloride Ion Penetration	100-mm x 200-mm (4-in. x 8-in.) Cylinder (kΩ-cm) a=1.5	150-mm x 300-mm (6-in. x 12-in.) Cylinder (kΩ-cm) a=1.5
High	<12	<9.5
Moderate	12-21	9.5-16.5
Low	21-37	16.5-29
Very Low	37-254	29-199
Negligible	>254	>199

Notes:

1. Specimen was fabricated by CLTGroup on September 6, 2016.
2. Readings were carried out on dry condition at 73°F.
3. Specimen was cured at 73°F/50% RH prior to testing.
4. This report may not be reproduced except in its entirety.

CTLGROUP

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**J. Vosahlik**
Date Reported:	**Sep 13, 2016**	Approved:	**J. Pacheco**

REPORT of ANALYSIS

AASHTO TP-95

Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Concrete Mixture	Date of fabrication	Date of testing	Age	Curing condition	Dimensions
ALW4-T	9/6/2016	9/13/2016	7	Drying Room	4x8"

	Surface resistivity (SR), kΩ-cm								
Sample	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**	**Average**
A	86.7	80.5	81.5	81.9	86.3	80.9	85.0	82.6	83.2
								Set average, kΩ-cm	83.2
								Chloride ion penetration	**Very Low**

Interpretation of results:

AASHTO TP 95-11, Table 1: Chloride Ion Penetration

Chloride Ion Penetration	100-mm x 200-mm (4-in. x 8-in.) Cylinder (kΩ-cm) a=1.5	150-mm x 300-mm (6-in. x 12-in.) Cylinder (kΩ-cm) a=1.5
High	<12	<9.5
Moderate	12-21	9.5-16.5
Low	21-37	16.5-29
Very Low	37-254	29-199
Negligible	>254	>199

Notes:

1. Specimen was fabricated by CLTGroup on September 6, 2016.
2. Readings were carried out on dry condition at 73°F.
3. Specimen was cured at 73°F/50% RH prior to testing.
4. This report may not be reproduced except in its entirety.

CTLGROUP

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**J. Vosahlik**
Date Reported:	**Sep 20, 2016**	Approved:	**J. Pacheco**

REPORT of ANALYSIS

AASHTO TP-95

Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Concrete Mixture	Date of fabrication	Date of testing	Age	Curing condition	Dimensions
ALW4-T	9/6/2016	9/20/2016	14	Drying Room	4x8"

	Surface resistivity (SR), kΩ-cm								
Sample	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**	**Average**
A	137.6	148.2	139.4	142.6	140.3	149.6	139.9	143.0	142.6
								Set average, kΩ-cm	142.6
								Chloride ion penetration	**Very Low**

Interpretation of results:

AASHTO TP 95-11, Table 1: Chloride Ion Penetration

Chloride Ion Penetration	100-mm x 200-mm (4-in. x 8-in.) Cylinder (kΩ-cm) a=1.5	150-mm x 300-mm (6-in. x 12-in.) Cylinder (kΩ-cm) a=1.5
High	<12	<9.5
Moderate	12-21	9.5-16.5
Low	21-37	16.5-29
Very Low	37-254	29-199
Negligible	>254	>199

Notes:

1. Specimen was fabricated by CLTGroup on September 6, 2016.
2. Readings were carried out on dry condition at 73°F.
3. Specimen was cured at 73°F/50% RH prior to testing.
4. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**J. Vosahlik**
Date Reported:	**Oct 4, 2016**	Approved:	**J. Pacheco**

REPORT of ANALYSIS

AASHTO TP-95

Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Concrete Mixture	Date of fabrication	Date of testing	Age	Curing condition	Dimensions
ALW4-T	9/6/2016	10/4/2016	28	Drying Room	4x8"

	Surface resistivity (SR), kΩ-cm								
Sample	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**	**Average**
A	216	192	195	193	207	219	207	175	200.5
								Set average, kΩ-cm	200.5
								Chloride ion penetration	**Very Low**

Interpretation of results:

AASHTO TP 95-11, Table 1: Chloride Ion Penetration

Chloride Ion Penetration	100-mm x 200-mm (4-in. x 8-in.) Cylinder (kΩ-cm) a=1.5	150-mm x 300-mm (6-in. x 12-in.) Cylinder (kΩ-cm) a=1.5
High	<12	<9.5
Moderate	12-21	9.5-16.5
Low	21-37	16.5-29
Very Low	37-254	29-199
Negligible	>254	>199

Notes:

1. Specimen was fabricated by CLTGroup on September 6, 2016.
2. Readings were carried out on dry condition at 73°F.
3. Specimen was cured at 73°F/50% RH prior to testing.
4. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**J. Vosahlik**
Date Reported:	**Oct 4, 2016**	Approved:	**J. Pacheco**

REPORT of ANALYSIS

AASHTO TP-95

Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration

Concrete Mixture	Date of fabrication	Date of testing	Age	Curing condition	Dimensions
ALW4-T	9/6/2016	10/4/2016	28	Limewater	4x8"

	Surface resistivity (SR), kΩ-cm								
Sample	**0°**	**90°**	**180°**	**270°**	**0°**	**90°**	**180°**	**270°**	**Average**
A	79.7	76.9	79.7	77.6	80.8	79.6	82.9	81.8	79.9
B	62.7	59.3	64.3	63.9	62.8	59.5	64.3	64.2	62.6
C	71.0	83.6	80.8	77.2	71.6	72.6	82.5	79.7	77.4
								Set average, kΩ-cm	73.3
								Curing condition correction (x 1.1 lime tank or 1.0 for moist room), kΩ-cm	80.6
								Chloride ion penetration	**Very Low**

Interpretation of results:

AASHTO TP 95-11, Table 1: Chloride Ion Penetration

Chloride Ion Penetration	100-mm x 200-mm (4-in. x 8-in.) Cylinder (kΩ-cm) a=1.5	150-mm x 300-mm (6-in. x 12-in.) Cylinder (kΩ-cm) a=1.5
High	<12	<9.5
Moderate	12-21	9.5-16.5
Low	21-37	16.5-29
Very Low	37-254	29-199
Negligible	>254	>199

Notes:

1. Specimen was fabricated by CLTGroup on September 6, 2016.
2. Readings were carried out on wet condition at 73°F.
3. Specimen was cured in limewater at 73°Fprior to testing.
4. This report may not be reproduced except in its entirety.

APPENDIX E

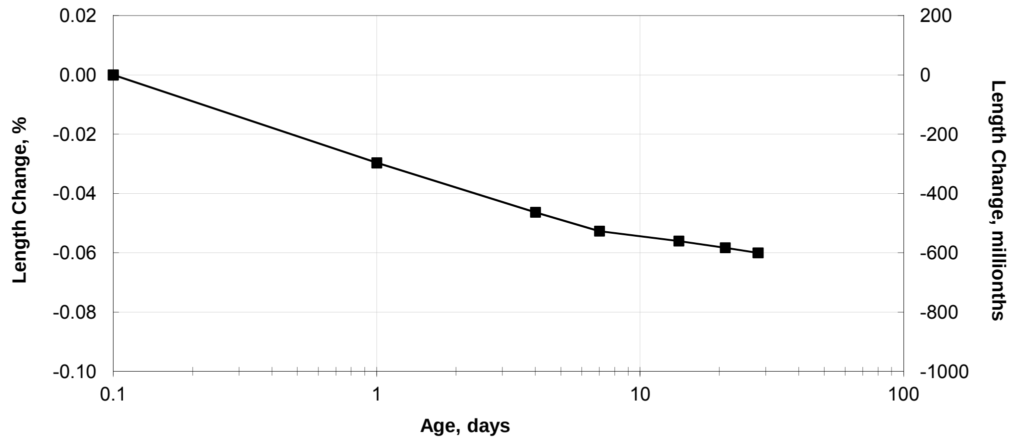
ASTM C157 DRYING SHRINKAGE

TEST RESULTS

Client:	**Illinois Tollway**	CTL Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

AASHTO T160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Mix ID: CAC - 4 Hours Moist Burlap Cure



				Specimen Length, in.			*Length Change, %*			**Average, %**	*Length Change, millionths*			**Average, millionths**
Date	Age, days	Days of Drying	Condition	A	B	C	A	B	C		A	B	C	
6/26/2014	0	0	Start dry	-0.0255	-0.0289	-0.0361	0.000	0.000	0.000	**0.000**	0	0	0	**0**
6/27/2014	1	1	dry	-0.0287	-0.0319	-0.0388	-0.032	-0.030	-0.027	**-0.030**	-320	-300	-270	**-297**
6/30/2014	4	4	dry	-0.0304	-0.0336	-0.0404	-0.049	-0.047	-0.043	**-0.046**	-490	-470	-430	**-463**
7/3/2014	7	7	dry	-0.0311	-0.0342	-0.0410	-0.056	-0.053	-0.049	**-0.053**	-560	-530	-490	**-527**
7/10/2014	14	14	dry	-0.0314	-0.0345	-0.0414	-0.059	-0.056	-0.053	**-0.056**	-590	-560	-530	**-560**
7/17/2014	21	21	dry	-0.0316	-0.0348	-0.0416	-0.061	-0.059	-0.055	**-0.058**	-610	-590	-550	**-583**
7/24/2014	28	28	dry	-0.0317	-0.0350	-0.0418	-0.062	-0.061	-0.057	**-0.060**	-620	-610	-570	**-600**

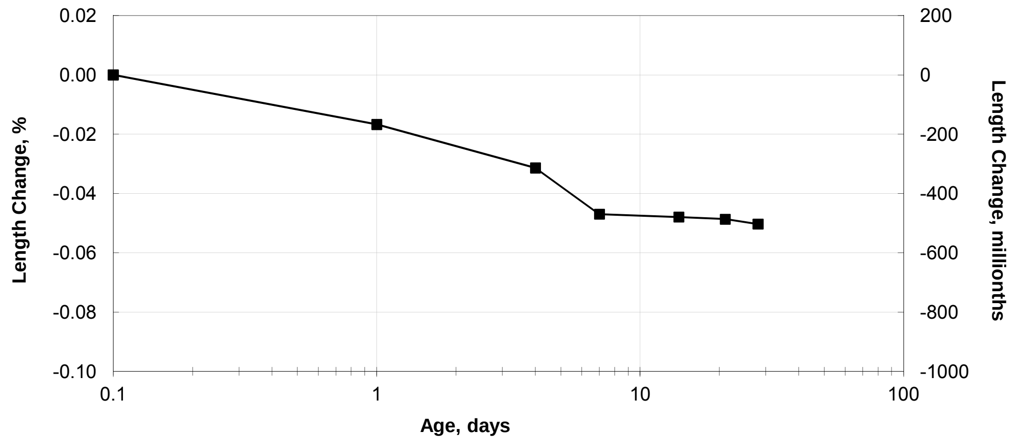
Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories
2. Test specimens are 3x3x11.25-in. prisms.
3. Specimens were cured with moist burlap for 4 hours, then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

Client:	**Illinois Tollway**	CTL Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

AASHTO T160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Mix ID: CAC - 24 Hours Moist Burlap Cure



				Specimen Length, in.			*Length Change, %*			**Average, %**	*Length Change, millionths*			**Average, millionths**
Date	Age, days	Days of Drying	Condition	A	B	C	A	B	C		A	B	C	
6/27/2014	1	0	Start dry	-0.0304	-0.0476	0.0083	0.000	0.000	0.000	**0.000**	0	0	0	**0**
6/28/2014	2	1	dry	-0.0320	-0.0493	0.0066	-0.016	-0.017	-0.017	**-0.017**	-160	-170	-170	**-167**
7/1/2014	5	4	dry	-0.0334	-0.0508	0.0051	-0.030	-0.032	-0.032	**-0.031**	-300	-320	-320	**-313**
7/4/2014	8	7	dry	-0.0351	-0.0523	0.0036	-0.047	-0.047	-0.047	**-0.047**	-470	-470	-470	**-470**
7/11/2014	15	14	dry	-0.0351	-0.0524	0.0034	-0.047	-0.048	-0.049	**-0.048**	-470	-480	-490	**-480**
7/18/2014	22	21	dry	-0.0352	-0.0524	0.0033	-0.048	-0.048	-0.050	**-0.049**	-480	-480	-500	**-487**
7/25/2014	29	28	dry	-0.0353	-0.0526	0.0031	-0.049	-0.050	-0.052	**-0.050**	-490	-500	-520	**-503**

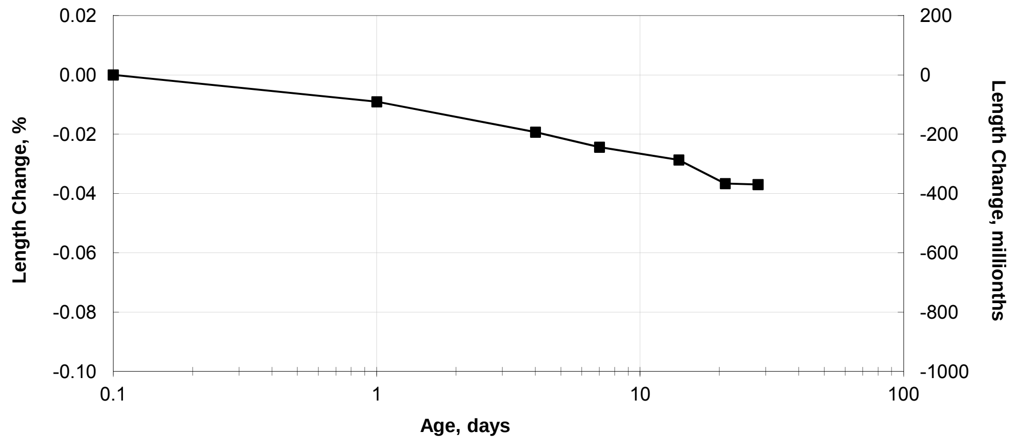
Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories
2. Test specimens are 3x3x11.25-in. prisms.
3. Specimens were cured with moist burlap for 24 hours, then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

Client:	**Illinois Tollway**	CTL Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

AASHTO T160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Mix ID: CAC - 7 Day Moist Cure



Date	Age, days	Days of Drying	Condition	Specimen Length, in. A	B	C	*Length Change, %* A	B	C	**Average, %**	*Length Change, millionths* A	B	C	**Average, millionths**
6/27/2014	1	--	Initial	-0.0445	-0.0422	-0.0158	0.000	0.000	0.000	**0.000**	0	0	0	**0**
7/3/2014	7	0	Start dry	-0.0441	-0.0420	-0.0155	0.000	0.000	0.000	**0.000**	0	0	0	**0**
7/4/2014	8	1	dry	-0.0451	-0.0429	-0.0163	-0.010	-0.009	-0.008	**-0.009**	-100	-90	-80	**-90**
7/7/2014	11	4	dry	-0.0462	-0.0439	-0.0173	-0.021	-0.019	-0.018	**-0.019**	-210	-190	-180	**-193**
7/10/2014	14	7	dry	-0.0467	-0.0444	-0.0178	-0.026	-0.024	-0.023	**-0.024**	-260	-240	-230	**-243**
7/17/2014	21	14	dry	-0.0471	-0.0448	-0.0183	-0.030	-0.028	-0.028	**-0.029**	-300	-280	-280	**-287**
7/24/2014	28	21	dry	-0.0479	-0.0456	-0.0191	-0.038	-0.036	-0.036	**-0.037**	-380	-360	-360	**-367**
7/31/2014	35	28	dry	-0.0480	-0.0456	-0.0191	-0.039	-0.036	-0.036	**-0.037**	-390	-360	-360	**-370**

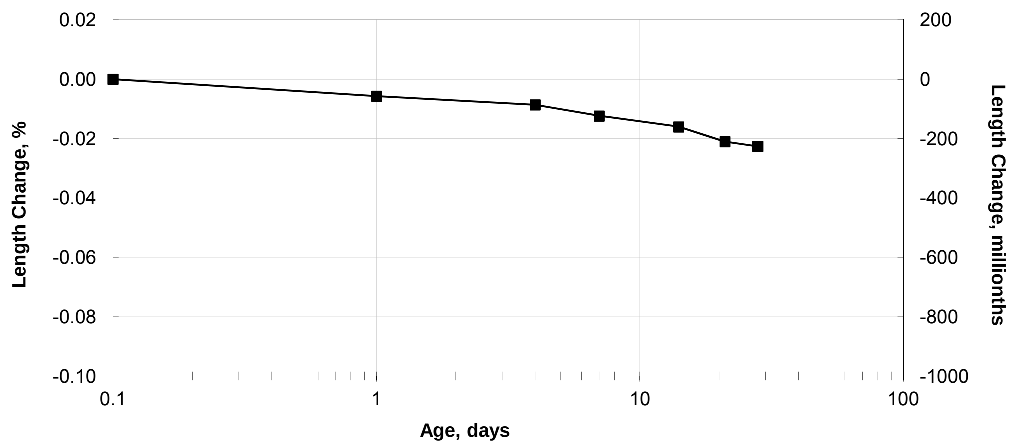
Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories
2. Test specimens are 3x3x11.25-in. prisms.
3. Specimens stored at 73.4±3°F in saturated lime water for 7 days, then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

Client:	**Illinois Tollway**	CTL Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

AASHTO T160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Mix ID: CAC - 7 Day Elevated Temperature Cure (122°F)



				Specimen Length, in.			*Length Change, %*			**Average, %**	*Length Change, millionths*			**Average, millionths**
Date	Age, days	Days of Drying	Condition	A	B	C	A	B	C		A	B	C	
6/27/2014	1	--	Initial	0.0013	-0.0216	0.0062	0.000	0.000	0.000	**0.000**	0	0	0	**0**
7/3/2014	7	0	Start dry	0.0028	-0.0200	0.0079	0.000	0.000	0.000	**0.000**	0	0	0	**0**
7/4/2014	8	1	dry	0.0023	-0.0206	0.0073	-0.005	-0.006	-0.006	**-0.006**	-50	-60	-60	**-57**
7/7/2014	11	4	dry	0.0020	-0.0209	0.0070	-0.008	-0.009	-0.009	**-0.009**	-80	-90	-90	**-87**
7/10/2014	14	7	dry	0.0016	-0.0213	0.0067	-0.012	-0.013	-0.012	**-0.012**	-120	-130	-120	**-123**
7/17/2014	21	14	dry	0.0012	-0.0217	0.0064	-0.016	-0.017	-0.015	**-0.016**	-160	-170	-150	**-160**
7/24/2014	28	21	dry	0.0007	-0.0222	0.0059	-0.021	-0.022	-0.020	**-0.021**	-210	-220	-200	**-210**
7/31/2014	35	28	dry	0.0006	-0.0224	0.0057	-0.022	-0.024	-0.022	**-0.023**	-220	-240	-220	**-227**

Notes:

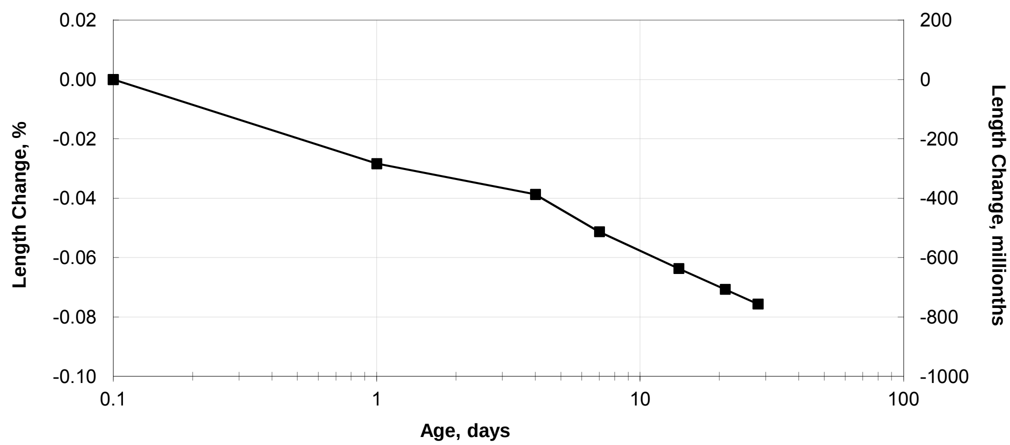
1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories
2. Test specimens are 3x3x11.25-in. prisms.
3. Specimens stored at 122°F in water for 7 days, then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

Client:	**Illinois Tollway**	CTL Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

AASHTO T160 / ASTM C157/C157M

Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Mix ID: LCAC - 4 Hours Plastic Cover Cure



				Specimen Length, in.			*Length Change, %*			**Average, %**	*Length Change, millionths*			**Average, millionths**
Date	Age, days	Days of Drying	Condition	A	B	C	A	B	C		A	B	C	
6/26/2014	0	0	Start dry	-0.0452	-0.0078	0.0086	0.000	0.000	0.000	**0.000**	0	0	0	**0**
6/27/2014	1	1	dry	-0.0479	-0.0108	0.0058	-0.027	-0.030	-0.028	**-0.028**	-270	-300	-280	**-283**
6/30/2014	4	4	dry	-0.0490	-0.0118	0.0048	-0.038	-0.040	-0.038	**-0.039**	-380	-400	-380	**-387**
7/3/2014	7	7	dry	-0.0503	-0.0130	0.0035	-0.051	-0.052	-0.051	**-0.051**	-510	-520	-510	**-513**
7/10/2014	14	14	dry	-0.0515	-0.0142	0.0022	-0.063	-0.064	-0.064	**-0.064**	-630	-640	-640	**-637**
7/17/2014	21	21	dry	-0.0522	-0.0149	0.0015	-0.070	-0.071	-0.071	**-0.071**	-700	-710	-710	**-707**
7/24/2014	28	28	dry	-0.0527	-0.0153	0.0009	-0.075	-0.075	-0.077	**-0.076**	-750	-750	-770	**-757**

Notes:

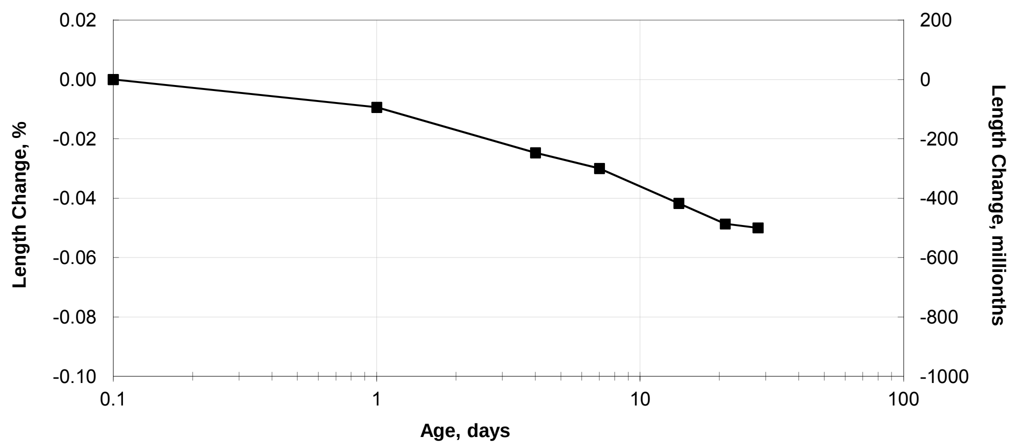
1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories
2. Test specimens are 3x3x11.25-in. prisms.
3. Specimens were cured with a plastic sheet for 4 hours, then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

CTLGROUP

Client:	**Illinois Tollway**	CTL Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

AASHTO T160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Mix ID: LCAC - 24 Hours Plastic Cover Cure



				Specimen Length, in.			*Length Change, %*			**Average, %**	*Length Change, millionths*			**Average, millionths**
Date	Age, days	Days of Drying	Condition	A	B	C	A	B	C		A	B	C	
6/27/2014	1	0	Start dry	-0.0017	-0.0283	-0.0141	0.000	0.000	0.000	**0.000**	0	0	0	**0**
6/28/2014	2	1	dry	-0.0027	-0.0292	-0.0150	-0.010	-0.009	-0.009	**-0.009**	-100	-90	-90	**-93**
7/1/2014	5	4	dry	-0.0040	-0.0309	-0.0166	-0.023	-0.026	-0.025	**-0.025**	-230	-260	-250	**-247**
7/4/2014	8	7	dry	-0.0046	-0.0314	-0.0171	-0.029	-0.031	-0.030	**-0.030**	-290	-310	-300	**-300**
7/11/2014	15	14	dry	-0.0059	-0.0324	-0.0183	-0.042	-0.041	-0.042	**-0.042**	-420	-410	-420	**-417**
7/18/2014	22	21	dry	-0.0067	-0.0331	-0.0189	-0.050	-0.048	-0.048	**-0.049**	-500	-480	-480	**-487**
7/25/2014	29	28	dry	-0.0067	-0.0333	-0.0191	-0.050	-0.050	-0.050	**-0.050**	-500	-500	-500	**-500**

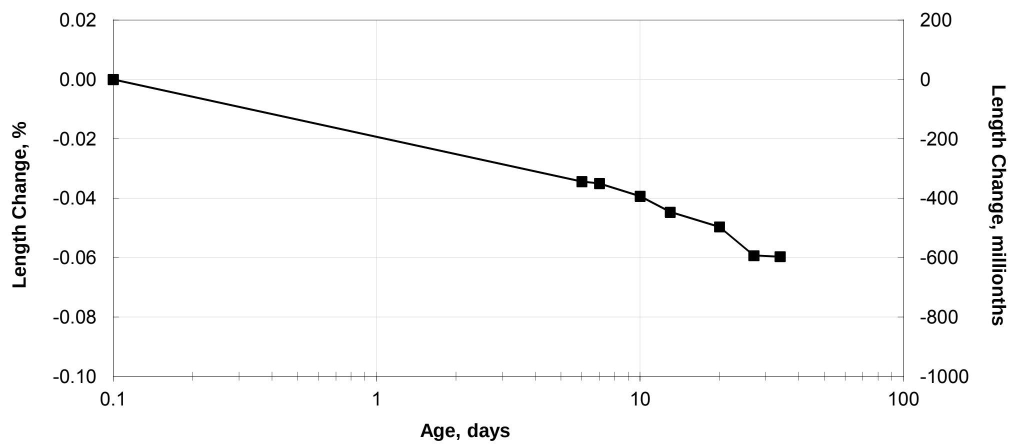
Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories
2. Test specimens are 3x3x11.25-in. prisms.
3. Specimens were cured with a plastic sheet for 24 hours, then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

Client:	**Illinois Tollway**	CTL Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

AASHTO T160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Mix ID: LCAC - 1 Day Cure



				Specimen Length, in.			*Length Change, %*			**Average, %**	*Length Change, millionths*			**Average, millionths**
Date	Age, days	Days of Drying	Condition	A	B	C	A	B	C		A	B	C	
6/27/2014	1	0	Start dry	-0.0058	-0.0427	0.0057	0.000	0.000	0.000	**0.000**	0	0	0	**0**
7/3/2014	7	6	dry	-0.0094	-0.0457	0.0020	-0.036	-0.030	-0.037	**-0.034**	-360	-300	-370	**-343**
7/4/2014	8	7	dry	-0.0095	-0.0458	0.0020	-0.037	-0.031	-0.037	**-0.035**	-370	-310	-370	**-350**
7/7/2014	11	10	dry	-0.0099	-0.0462	0.0015	-0.041	-0.035	-0.042	**-0.039**	-410	-350	-420	**-393**
7/10/2014	14	13	dry	-0.0104	-0.0468	0.0010	-0.046	-0.041	-0.047	**-0.045**	-460	-410	-470	**-447**
7/17/2014	21	20	dry	-0.0109	-0.0473	0.0005	-0.051	-0.046	-0.052	**-0.050**	-510	-460	-520	**-497**
7/24/2014	28	27	dry	-0.0120	-0.0482	-0.0004	-0.062	-0.055	-0.061	**-0.059**	-620	-550	-610	**-593**
7/31/2014	35	34	dry	-0.0120	-0.0482	-0.0005	-0.062	-0.055	-0.062	**-0.060**	-620	-550	-620	**-597**

Notes:

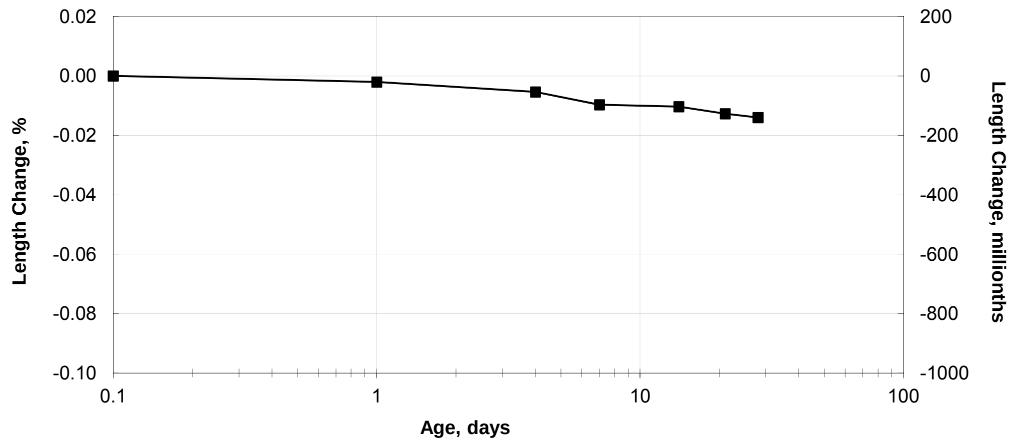
1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories
2. Test specimens are 3x3x11.25-in. prisms.
3. Specimens were cured with a plastic sheet for 24 hours, then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

CTLGroup

Client:	**Illinois Tollway**	CTL Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

AASHTO T160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Mix ID: LCAC - 7 Day Elevated Temperature Cure (122°F)



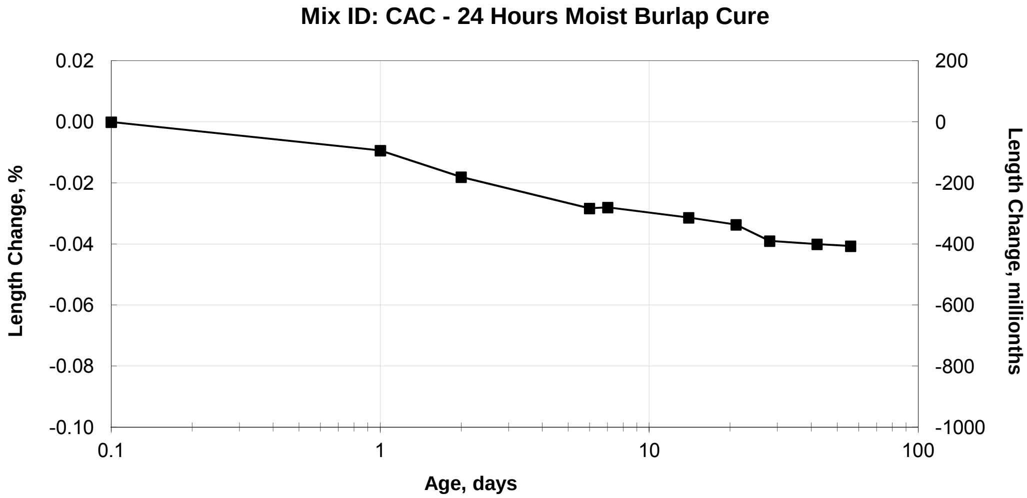
				Specimen Length, in.			*Length Change, %*			**Average, %**	*Length Change, millionths*			**Average, millionths**
Date	Age, days	Days of Drying	Condition	A	B	C	A	B	C		A	B	C	
6/27/2014	1	--	Initial	-0.0529	-0.0001	0.0007	0.000	0.000	0.000	**0.000**	0	0	0	**0**
7/3/2014	7	0	Start dry	-0.0514	0.0014	0.0020	0.000	0.000	0.000	**0.000**	0	0	0	**0**
7/4/2014	8	1	dry	-0.0517	0.0012	0.0019	-0.003	-0.002	-0.001	**-0.002**	-30	-20	-10	**-20**
7/7/2014	11	4	dry	-0.0520	0.0009	0.0015	-0.006	-0.005	-0.005	**-0.005**	-60	-50	-50	**-53**
7/10/2014	14	7	dry	-0.0524	0.0005	0.0010	-0.010	-0.009	-0.010	**-0.010**	-100	-90	-100	**-97**
7/17/2014	21	14	dry	-0.0525	0.0004	0.0010	-0.011	-0.010	-0.010	**-0.010**	-110	-100	-100	**-103**
7/24/2014	28	21	dry	-0.0527	0.0001	0.0008	-0.013	-0.013	-0.012	**-0.013**	-130	-130	-120	**-127**
7/31/2014	35	28	dry	-0.0529	0.0000	0.0007	-0.015	-0.014	-0.013	**-0.014**	-150	-140	-130	**-140**

Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories
2. Test specimens are 3x3x11.25-in. prisms.
3. Specimens stored at 122°F in water for 7 days, then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

Client:	**Illinois Tollway**	CTLGroup Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

AASHTO T160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete



				Specimen Length, in.			*Length Change, %*			**Average, %**	*Length Change, millionths*			**Average, millionths**
Date	Age, days	Days of Drying	Condition	A	B	C	A	B	C		A	B	C	
9/11/2014	1	0	Start dry	-0.0323	0.0203	0.0024	0.000	0.000	0.000	**0.000**	0	0	0	**0**
9/12/2014	2	1	dry	-0.0333	0.0195	0.0014	-0.010	-0.008	-0.010	**-0.009**	-100	-80	-100	**-93**
9/13/2014	3	2	dry	-0.0348	0.0191	0.0007	-0.025	-0.012	-0.017	**-0.018**	-250	-120	-170	**-180**
9/17/2014	7	6	dry	-0.0358	0.0180	-0.0003	-0.035	-0.023	-0.027	**-0.028**	-350	-230	-270	**-283**
9/18/2014	8	7	dry	-0.0358	0.0181	-0.0003	-0.035	-0.022	-0.027	**-0.028**	-350	-220	-270	**-280**
9/25/2014	15	14	dry	-0.0362	0.0178	-0.0006	-0.039	-0.025	-0.030	**-0.031**	-390	-250	-300	**-313**
10/2/2014	22	21	dry	-0.0364	0.0175	-0.0008	-0.041	-0.028	-0.032	**-0.034**	-410	-280	-320	**-337**
10/9/2014	29	28	dry	-0.0370	0.0167	-0.0010	-0.047	-0.036	-0.034	**-0.039**	-470	-360	-340	**-390**
10/23/2014	43	42	dry	-0.0370	0.0166	-0.0012	-0.047	-0.037	-0.036	**-0.040**	-470	-370	-360	**-400**
11/6/2014	57	56	dry	-0.0371	0.0166	-0.0013	-0.048	-0.037	-0.037	**-0.041**	-480	-370	-370	**-407**

Notes:

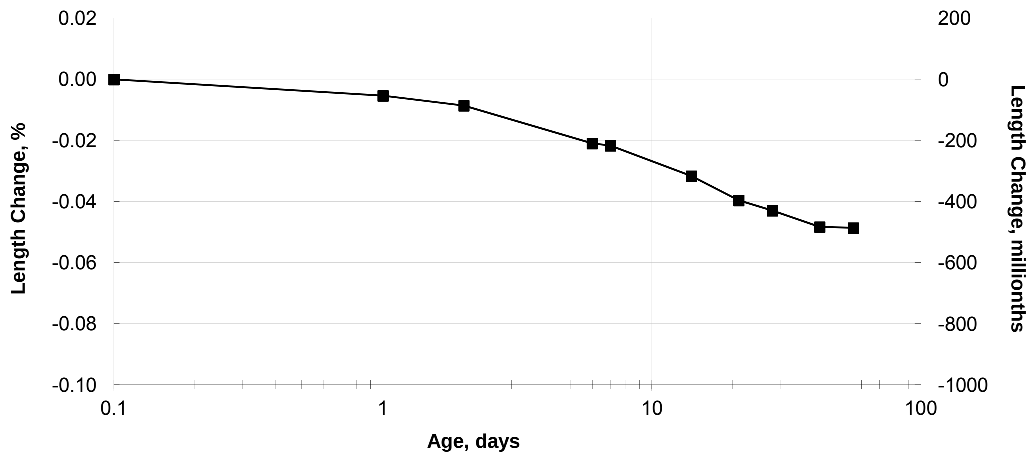
1. Specimens fabricated on September 10, 2014 at CTLGroup Laboratories.
2. Test specimens are 3x3x11.25-in. prisms.
3. Specimens were cured with moist burlap for 24 hours and then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

CTLGroup

Client:	**Illinois Tollway**	CTLGroup Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

AASHTO T160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Mix ID: CAC - 24 Hour Elevated Temperature Cure (100°F)



				Specimen Length, in.			*Length Change, %*			**Average, %**	*Length Change, millionths*			**Average, millionths**
Date	Age, days	Days of Drying	Condition	A	B	C	A	B	C		A	B	C	
9/11/2014	1	0	Start dry	0.0035	-0.0138	0.0107	0.000	0.000	0.000	**0.000**	0	0	0	**0**
9/12/2014	2	1	dry	0.0030	-0.0142	0.0100	-0.005	-0.004	-0.007	**-0.005**	-50	-40	-70	**-53**
9/13/2014	3	2	dry	0.0028	-0.0145	0.0095	-0.007	-0.007	-0.012	**-0.009**	-70	-70	-120	**-87**
9/17/2014	7	6	dry	0.0016	-0.0157	0.0082	-0.019	-0.019	-0.025	**-0.021**	-190	-190	-250	**-210**
9/18/2014	8	7	dry	0.0016	-0.0159	0.0082	-0.019	-0.021	-0.025	**-0.022**	-190	-210	-250	**-217**
9/25/2014	15	14	dry	0.0007	-0.0168	0.0070	-0.028	-0.030	-0.037	**-0.032**	-280	-300	-370	**-317**
10/2/2014	22	21	dry	0.0000	-0.0177	0.0062	-0.035	-0.039	-0.045	**-0.040**	-350	-390	-450	**-397**
10/9/2014	29	28	dry	-0.0006	-0.0179	0.0060	-0.041	-0.041	-0.047	**-0.043**	-410	-410	-470	**-430**
10/23/2014	43	42	dry	-0.0011	-0.0185	0.0055	-0.046	-0.047	-0.052	**-0.048**	-460	-470	-520	**-483**
11/6/2014	57	56	dry	-0.0011	-0.0186	0.0055	-0.046	-0.048	-0.052	**-0.049**	-460	-480	-520	**-487**

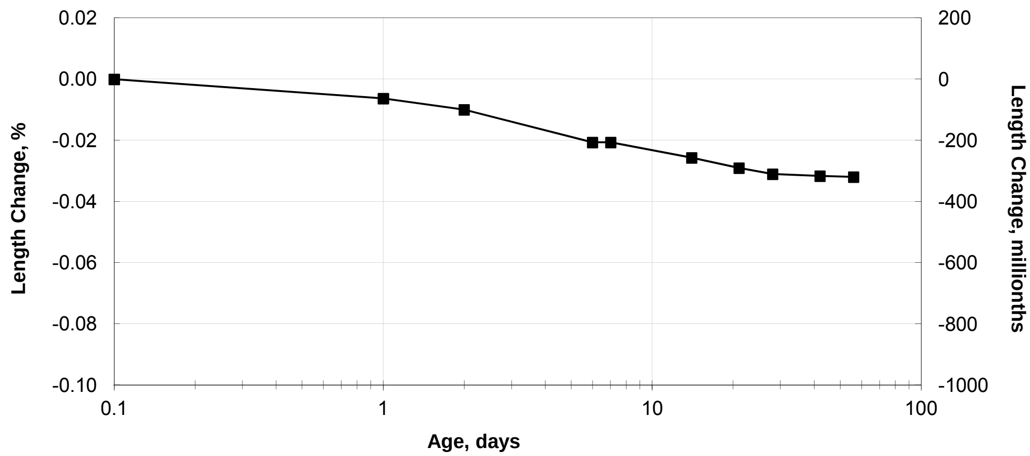
Notes:

1. Specimens fabricated on September 10, 2014 at CTLGroup Laboratories.
2. Test specimens are 3x3x11.25-in. prisms.
3. Specimens cured at 100°F with moist burlap and plastic for 24 hours and then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

Client:	**Illinois Tollway**	CTLGroup Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

AASHTO T160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Mix ID: CAC-SRA - 24 Hours Moist Burlap Cure



				Specimen Length, in.			*Length Change, %*			**Average, %**	*Length Change, millionths*			**Average, millionths**
Date	Age, days	Days of Drying	Condition	A	B	C	A	B	C		A	B	C	
9/11/2014	1	0	Start dry	-0.0325	-0.0336	-0.0363	0.000	0.000	0.000	**0.000**	0	0	0	**0**
9/12/2014	2	1	dry	-0.0331	-0.0342	-0.0370	-0.006	-0.006	-0.007	**-0.006**	-60	-60	-70	**-63**
9/13/2014	3	2	dry	-0.0334	-0.0346	-0.0374	-0.009	-0.010	-0.011	**-0.010**	-90	-100	-110	**-100**
9/17/2014	7	6	dry	-0.0345	-0.0357	-0.0384	-0.020	-0.021	-0.021	**-0.021**	-200	-210	-210	**-207**
9/18/2014	8	7	dry	-0.0345	-0.0357	-0.0384	-0.020	-0.021	-0.021	**-0.021**	-200	-210	-210	**-207**
9/25/2014	15	14	dry	-0.0349	-0.0363	-0.0389	-0.024	-0.027	-0.026	**-0.026**	-240	-270	-260	**-257**
10/2/2014	22	21	dry	-0.0353	-0.0366	-0.0392	-0.028	-0.030	-0.029	**-0.029**	-280	-300	-290	**-290**
10/9/2014	29	28	dry	-0.0353	-0.0370	-0.0394	-0.028	-0.034	-0.031	**-0.031**	-280	-340	-310	**-310**
10/23/2014	43	42	dry	-0.0354	-0.0371	-0.0394	-0.029	-0.035	-0.031	**-0.032**	-290	-350	-310	**-317**
11/6/2014	57	56	dry	-0.0355	-0.0371	-0.0394	-0.030	-0.035	-0.031	**-0.032**	-300	-350	-310	**-320**

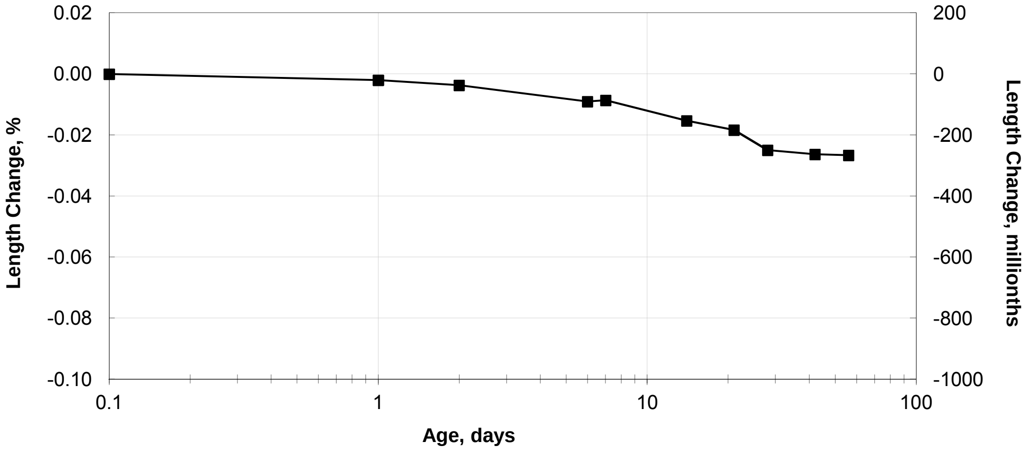
Notes:

1. Specimens fabricated on September 10, 2014 at CTLGroup Laboratories.
2. Test specimens are 3x3x11.25-in. prisms.
3. Specimens were cured with moist burlap for 24 hours and then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

Client:	**Illinois Tollway**	CTLGroup Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

AASHTO T160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Mix ID: CAC-SRA - 24 Hour Elevated Temperature Cure (100°F)



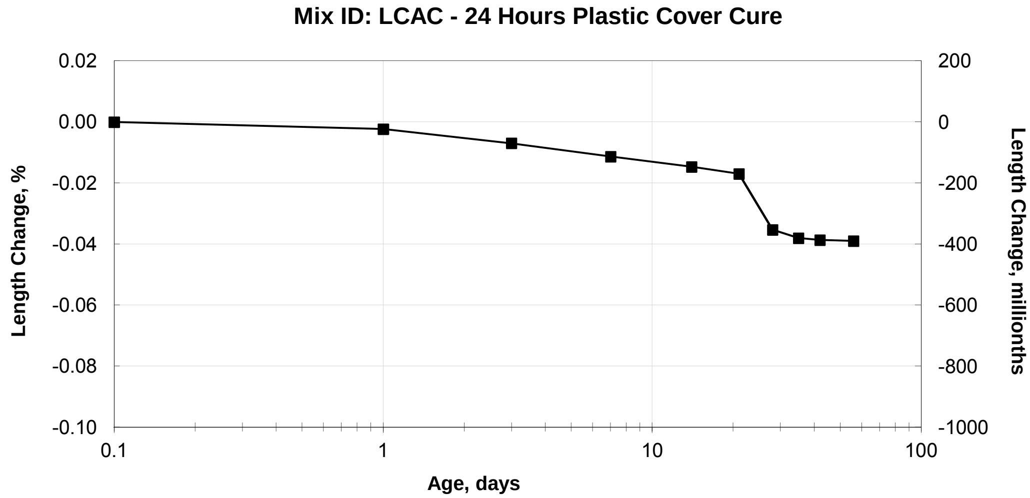
				Specimen Length, in.			*Length Change, %*			**Average, %**	*Length Change, millionths*			**Average, millionths**
Date	Age, days	Days of Drying	Condition	A	B	C	A	B	C		A	B	C	
9/11/2014	1	0	Start dry	-0.0381	-0.0246	-0.0352	0.000	0.000	0.000	**0.000**	0	0	0	**0**
9/12/2014	2	1	dry	-0.0383	-0.0248	-0.0354	-0.002	-0.002	-0.002	**-0.002**	-20	-20	-20	**-20**
9/13/2014	3	2	dry	-0.0384	-0.0250	-0.0356	-0.003	-0.004	-0.004	**-0.004**	-30	-40	-40	**-37**
9/17/2014	7	6	dry	-0.0390	-0.0255	-0.0361	-0.009	-0.009	-0.009	**-0.009**	-90	-90	-90	**-90**
9/18/2014	8	7	dry	-0.0390	-0.0253	-0.0362	-0.009	-0.007	-0.010	**-0.009**	-90	-70	-100	**-87**
9/25/2014	15	14	dry	-0.0396	-0.0260	-0.0369	-0.015	-0.014	-0.017	**-0.015**	-150	-140	-170	**-153**
10/2/2014	22	21	dry	-0.0399	-0.0262	-0.0373	-0.018	-0.016	-0.021	**-0.018**	-180	-160	-210	**-183**
10/9/2014	29	28	dry	-0.0402	-0.0270	-0.0382	-0.021	-0.024	-0.030	**-0.025**	-210	-240	-300	**-250**
10/23/2014	43	42	dry	-0.0404	-0.0271	-0.0383	-0.023	-0.025	-0.031	**-0.026**	-230	-250	-310	**-263**
11/6/2014	57	56	dry	-0.0404	-0.0272	-0.0383	-0.023	-0.026	-0.031	**-0.027**	-230	-260	-310	**-267**

Notes:

1. Specimens fabricated on September 10, 2014 at CTLGroup Laboratories.
2. Test specimens are 3x3x11.25-in. prisms.
3. Specimens cured at 100°F with moist burlap and plastic for 24 hours and then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

Client:	**Illinois Tollway**	CTLGroup Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

AASHTO T160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete



				Specimen Length, in.			*Length Change, %*			**Average, %**	*Length Change, millionths*			**Average, millionths**
Date	Age, days	Days of Drying	Condition	A	B	C	A	B	C		A	B	C	
9/12/2014	1	0	Start dry	0.0065	0.0012	-0.0023	0.000	0.000	0.000	**0.000**	0	0	0	**0**
9/13/2014	2	1	dry	0.0062	0.0010	-0.0025	-0.003	-0.002	-0.002	**-0.002**	-30	-20	-20	**-23**
9/15/2014	4	3	dry	0.0057	0.0006	-0.0030	-0.008	-0.006	-0.007	**-0.007**	-80	-60	-70	**-70**
9/19/2014	8	7	dry	0.0053	0.0001	-0.0034	-0.012	-0.011	-0.011	**-0.011**	-120	-110	-110	**-113**
9/26/2014	15	14	dry	0.0050	-0.0003	-0.0037	-0.015	-0.015	-0.014	**-0.015**	-150	-150	-140	**-147**
10/3/2014	22	21	dry	0.0047	-0.0005	-0.0039	-0.018	-0.017	-0.016	**-0.017**	-180	-170	-160	**-170**
10/10/2014	29	28	dry	0.0027	-0.0023	-0.0056	-0.038	-0.035	-0.033	**-0.035**	-380	-350	-330	**-353**
10/17/2014	36	35	dry	0.0024	-0.0026	-0.0058	-0.041	-0.038	-0.035	**-0.038**	-410	-380	-350	**-380**
10/24/2014	43	42	dry	0.0024	-0.0027	-0.0059	-0.041	-0.039	-0.036	**-0.039**	-410	-390	-360	**-387**
11/7/2014	57	56	dry	0.0023	-0.0027	-0.0059	-0.042	-0.039	-0.036	**-0.039**	-420	-390	-360	**-390**

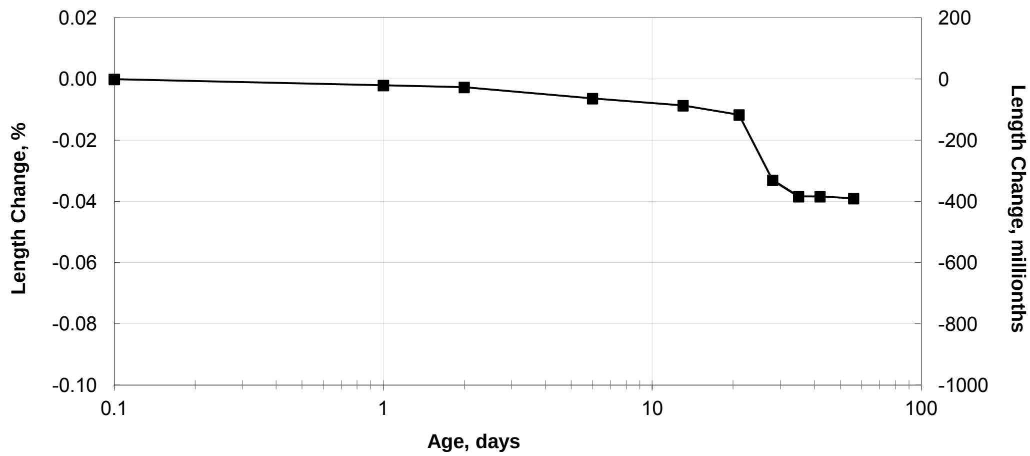
Notes:

1. Specimens fabricated on September 11, 2014 at CTLGroup Laboratories.
2. Test specimens are 3x3x11.25-in. prisms.
3. Specimens were cured with a plastic sheet for 24 hours and then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

Client:	**Illinois Tollway**	CTLGroup Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**February 12, 2015**	Approved by:	**B. Birch**

AASHTO T160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Mix ID: CAC - 24 Hour Elevated Temperature Cure (100°F)



				Specimen Length, in.			*Length Change, %*			**Average, %**	*Length Change, millionths*			**Average, millionths**
Date	Age, days	Days of Drying	Condition	A	B	C	A	B	C		A	B	C	
9/12/2014	1	0	Initial	-0.0381	0.0106	-0.0092	0.000	0.000	0.000	**0.000**	0	0	0	**0**
9/13/2014	2	1	Start dry	-0.0383	0.0104	-0.0094	-0.002	-0.002	-0.002	**-0.002**	-20	-20	-20	**-20**
9/15/2014	4	2	dry	-0.0384	0.0103	-0.0094	-0.003	-0.003	-0.002	**-0.003**	-30	-30	-20	**-27**
9/19/2014	8	6	dry	-0.0388	0.0100	-0.0098	-0.007	-0.006	-0.006	**-0.006**	-70	-60	-60	**-63**
9/26/2014	15	13	dry	-0.0390	0.0098	-0.0101	-0.009	-0.008	-0.009	**-0.009**	-90	-80	-90	**-87**
10/3/2014	22	21	dry	-0.0393	0.0095	-0.0104	-0.012	-0.011	-0.012	**-0.012**	-120	-110	-120	**-117**
10/10/2014	29	28	dry	-0.0411	0.0073	-0.0128	-0.030	-0.033	-0.036	**-0.033**	-300	-330	-360	**-330**
10/17/2014	36	35	dry	-0.0416	0.0067	-0.0133	-0.035	-0.039	-0.041	**-0.038**	-350	-390	-410	**-383**
10/24/2014	43	42	dry	-0.0416	0.0067	-0.0133	-0.035	-0.039	-0.041	**-0.038**	-350	-390	-410	**-383**
11/7/2014	57	56	dry	-0.0417	0.0066	-0.0133	-0.036	-0.040	-0.041	**-0.039**	-360	-400	-410	**-390**

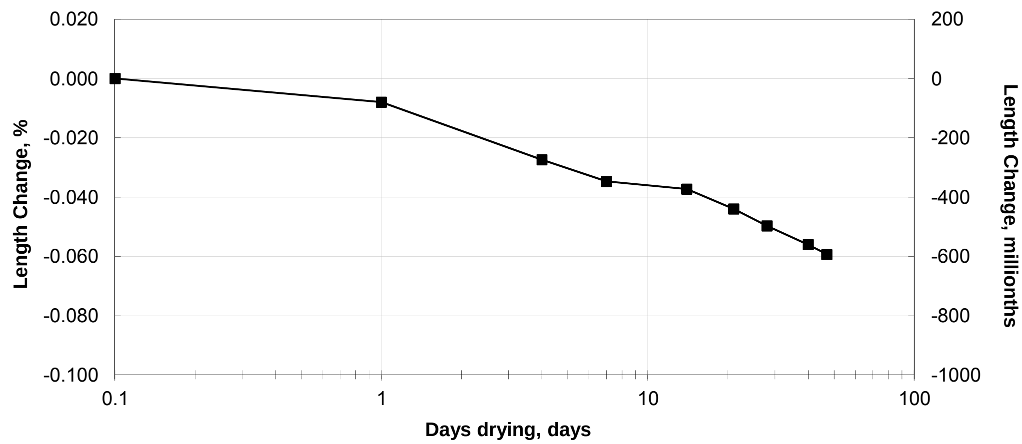
Notes:

1. Specimens fabricated on September 11, 2014 at CTLGroup Laboratories.
2. Test specimens are 3x3x11.25-in. prisms.
3. Specimens cured at 100°F with moist burlap and plastic for 24 hours and then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

Client:	**Illinois Tollway**	CTLGroup Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Report Date:	**April 13, 2016**	Approved by:	**B. Birch**

AASHTO T 160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Mix ID: ASRA (Mix 5) 2/19/16



Date	Age, days	Days of Drying	Condition	Comparator Measurement, in. A	B	C	*Length Change, %* A	B	C	**Average, %**	*Length Change, millionths* A	B	C	**Average, millionths**
2/20/2016	1	--	initial	-0.0328	-0.0556	0.0057	0.002	0.002	0.002	**0.002**	20	20	20	**20**
2/26/2016	7	0	start dry	-0.0326	-0.0554	0.0059	0.000	0.000	0.000	**0.000**	0	0	0	**0**
2/27/2016	8	1	dry	-0.0335	-0.0562	0.0052	-0.009	-0.008	-0.007	**-0.008**	-90	-80	-70	**-80**
3/1/2016	11	4	dry	-0.0353	-0.0582	0.0032	-0.027	-0.028	-0.027	**-0.027**	-270	-280	-270	**-273**
3/4/2016	14	7	dry	-0.0360	-0.0590	0.0025	-0.034	-0.036	-0.034	**-0.035**	-340	-360	-340	**-347**
3/11/2016	21	14	dry	-0.0363	-0.0593	0.0023	-0.037	-0.039	-0.036	**-0.037**	-370	-390	-360	**-373**
3/18/2016	28	21	dry	-0.0369	-0.0599	0.0015	-0.043	-0.045	-0.044	**-0.044**	-430	-450	-440	**-440**
3/25/2016	35	28	dry	-0.0376	-0.0604	0.0010	-0.050	-0.050	-0.049	**-0.050**	-500	-500	-490	**-497**
4/6/2016	47	40	dry	-0.0383	-0.0610	0.0004	-0.057	-0.056	-0.055	**-0.056**	-570	-560	-550	**-560**
4/13/2016	54	47	dry	-0.0387	-0.0613	0.0001	-0.061	-0.059	-0.058	**-0.059**	-610	-590	-580	**-593**

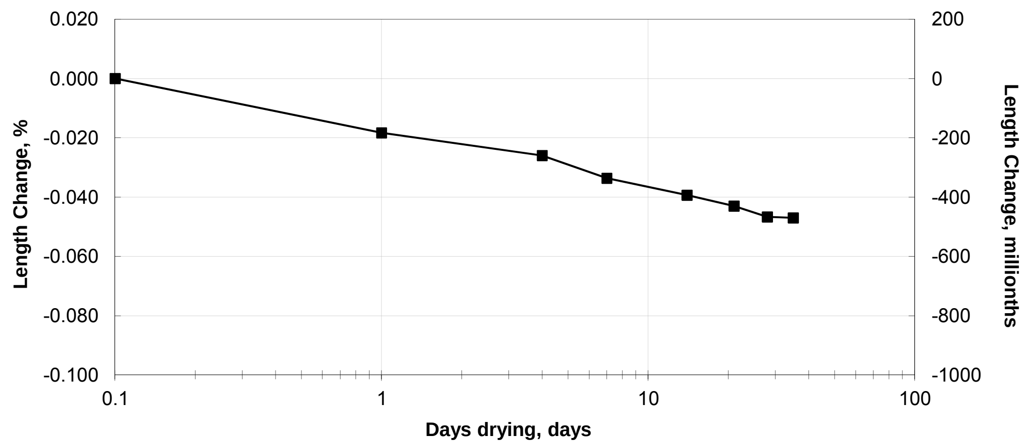
Notes:

1. Specimens fabricated on February 19, 2016 by CTLGroup.
2. Test specimens are 4x4x11.25-in. concrete prisms.
3. 3. Specimens stored at 73.4±3°F in saturated lime water for 7 days, then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

Client:	**Illinois Tollway**	CTLGroup Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Report Date:	**April 19, 2016**	Approved by:	**B. Birch**

AASHTO T 160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Mix ID: ASRA (Mix B) 3/8/16



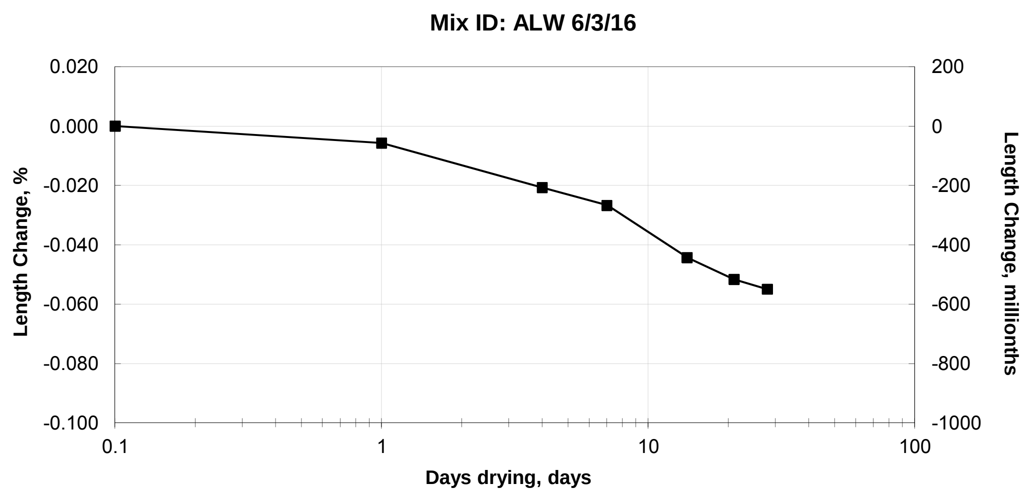
Date	Age, days	Days of Drying	Condition	Comparator Measurement, in. A	B	C	*Length Change, %* A	B	C	**Average, %**	*Length Change, millionths* A	B	C	**Average, millionths**
3/8/2016	0	--	initial	-0.0055	-0.0046	-0.0349	0.001	0.002	0.001	**0.001**	10	20	10	**13**
3/15/2016	7	0	start dry	-0.0054	-0.0044	-0.0348	0.000	0.000	0.000	**0.000**	0	0	0	**0**
3/16/2016	8	1	dry	-0.0073	-0.0062	-0.0366	-0.019	-0.018	-0.018	**-0.018**	-190	-180	-180	**-183**
3/19/2016	11	4	dry	-0.0080	-0.0071	-0.0373	-0.026	-0.027	-0.025	**-0.026**	-260	-270	-250	**-260**
3/22/2016	14	7	dry	-0.0088	-0.0079	-0.0380	-0.034	-0.035	-0.032	**-0.034**	-340	-350	-320	**-337**
3/29/2016	21	14	dry	-0.0094	-0.0084	-0.0386	-0.040	-0.040	-0.038	**-0.039**	-400	-400	-380	**-393**
4/5/2016	28	21	dry	-0.0097	-0.0088	-0.0390	-0.043	-0.044	-0.042	**-0.043**	-430	-440	-420	**-430**
4/12/2016	35	28	dry	-0.0101	-0.0092	-0.0393	-0.047	-0.048	-0.045	**-0.047**	-470	-480	-450	**-467**
4/19/2016	42	35	dry	-0.0102	-0.0092	-0.0393	-0.048	-0.048	-0.045	**-0.047**	-480	-480	-450	**-470**

Notes:
1. Specimens fabricated on March 8, 2016 by CTLGroup.
2. Test specimens are 4x4x11.25-in. concrete prisms.
3. 3. Specimens stored at 73.4±3°F in saturated lime water for 7 days, then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

Client:	**Illinois Tollway**	CTLGroup Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Report Date:	**October 7, 2016**	Approved by:	**B. Birch**

AASHTO T 160 / ASTM C157/C157M

Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete



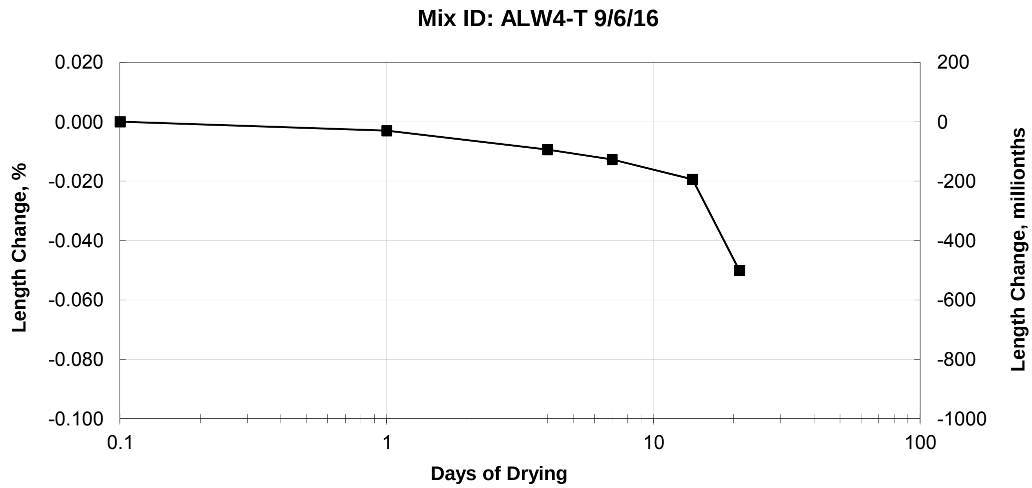
Date	Age, days	Days of Drying	Condition	Comparator Measurement, in. A	B	C	*Length Change, %* A	B	C	**Average, %**	*Length Change, millionths* A	B	C	**Average, millionths**
6/3/2016	0	--	initial	-0.0325	-0.0349	-0.0368	0.005	0.004	0.004	**0.004**	50	40	40	**43**
6/10/2016	7	0	start dry	-0.0320	-0.0345	-0.0364	0.000	0.000	0.000	**0.000**	0	0	0	**0**
6/11/2016	8	1	dry	-0.0326	-0.0351	-0.0369	-0.006	-0.006	-0.005	**-0.006**	-60	-60	-50	**-57**
6/14/2016	11	4	dry	-0.0343	-0.0364	-0.0384	-0.023	-0.019	-0.020	**-0.021**	-230	-190	-200	**-207**
6/17/2016	14	7	dry	-0.0349	-0.0370	-0.0390	-0.029	-0.025	-0.026	**-0.027**	-290	-250	-260	**-267**
6/24/2016	21	14	dry	-0.0367	-0.0387	-0.0408	-0.047	-0.042	-0.044	**-0.044**	-470	-420	-440	**-443**
7/1/2016	28	21	dry	-0.0374	-0.0395	-0.0415	-0.054	-0.050	-0.051	**-0.052**	-540	-500	-510	**-517**
7/8/2016	35	28	dry	-0.0378	-0.0398	-0.0418	-0.058	-0.053	-0.054	**-0.055**	-580	-530	-540	**-550**

Notes:

1. Specimens fabricated on June 3, 2016 by CTLGroup.
2. Test specimens are 3x3x11.25-in. concrete prisms.
3. Specimens stored at 73.4±3°F in saturated lime water for 7 days, then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.

Client:	**Illinois Tollway**	CTLGroup Project No.	**057177**
Project:	**Calcium Aluminate Cement Project**	CTLGroup Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Report Date:	**October 7, 2016**	Approved by:	**B. Birch**

AASHTO T 160 / ASTM C157/C157M
Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete



Date	Age, days	Days of Drying	Condition	Comparator Measurement, in. A	B	C	*Length Change, %* A	B	C	**Average, %**	*Length Change, millionths* A	B	C	**Average, millionths**
9/6/2016	0	--	Initial	-0.0318	-0.0340	0.0076								
9/13/2016	7	0	Start Dry	-0.0288	-0.0312	0.0102	0.000	0.000	0.000	**0.000**	0	0	0	**0**
9/14/2016	8	1	Dry	-0.0291	-0.0315	0.0099	-0.003	-0.003	-0.003	**-0.003**	-30	-30	-30	**-30**
9/17/2016	11	4	Dry	-0.0297	-0.0322	0.0093	-0.009	-0.010	-0.009	**-0.009**	-90	-100	-90	**-93**
9/20/2016	14	7	Dry	-0.0300	-0.0325	0.0089	-0.012	-0.013	-0.013	**-0.013**	-120	-130	-130	**-127**
9/27/2016	21	14	Dry	-0.0306	-0.0333	0.0083	-0.018	-0.021	-0.019	**-0.019**	-180	-212	-190	**-194**
10/4/2016	28	21	Dry	-0.0337	-0.0362	0.0051	-0.049	-0.050	-0.051	**-0.050**	-490	-500	-510	**-500**

Notes:

1. Specimens fabricated on September 6, 2016 by CTLGroup.
2. Test specimens are 3x3x11.25-in. concrete prisms.
3. Specimens stored at 73.4±3°F in saturated lime water for 7 days, then stored in a controlled environment kept nominally at 73.4±3°F and 50±4% RH for the remainder of testing.
4. This report may not be reproduced except in its entirety.

APPENDIX F

ASTM C1581 RESTRAINED DRYING SHRINKAGE

TEST RESULTS

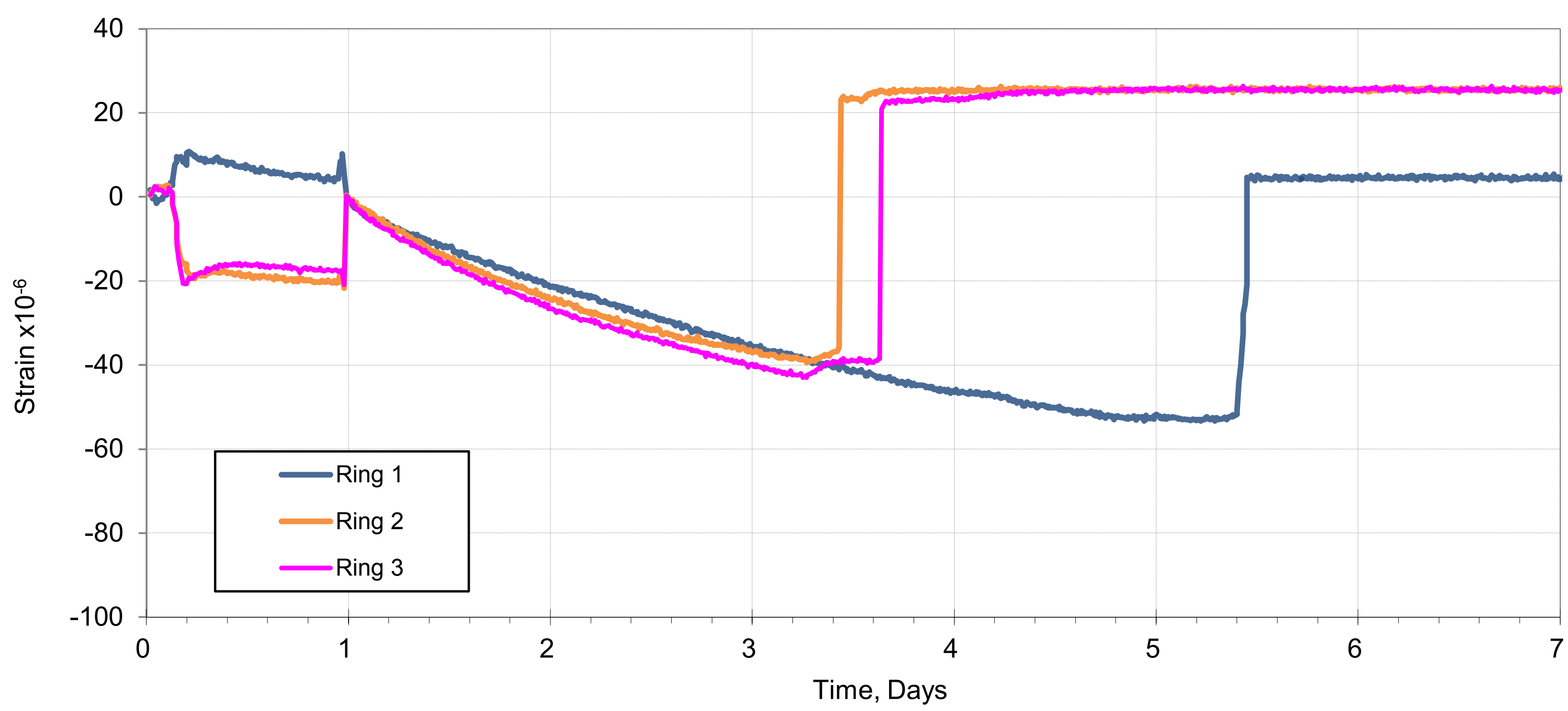
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**JP/BS/GN**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

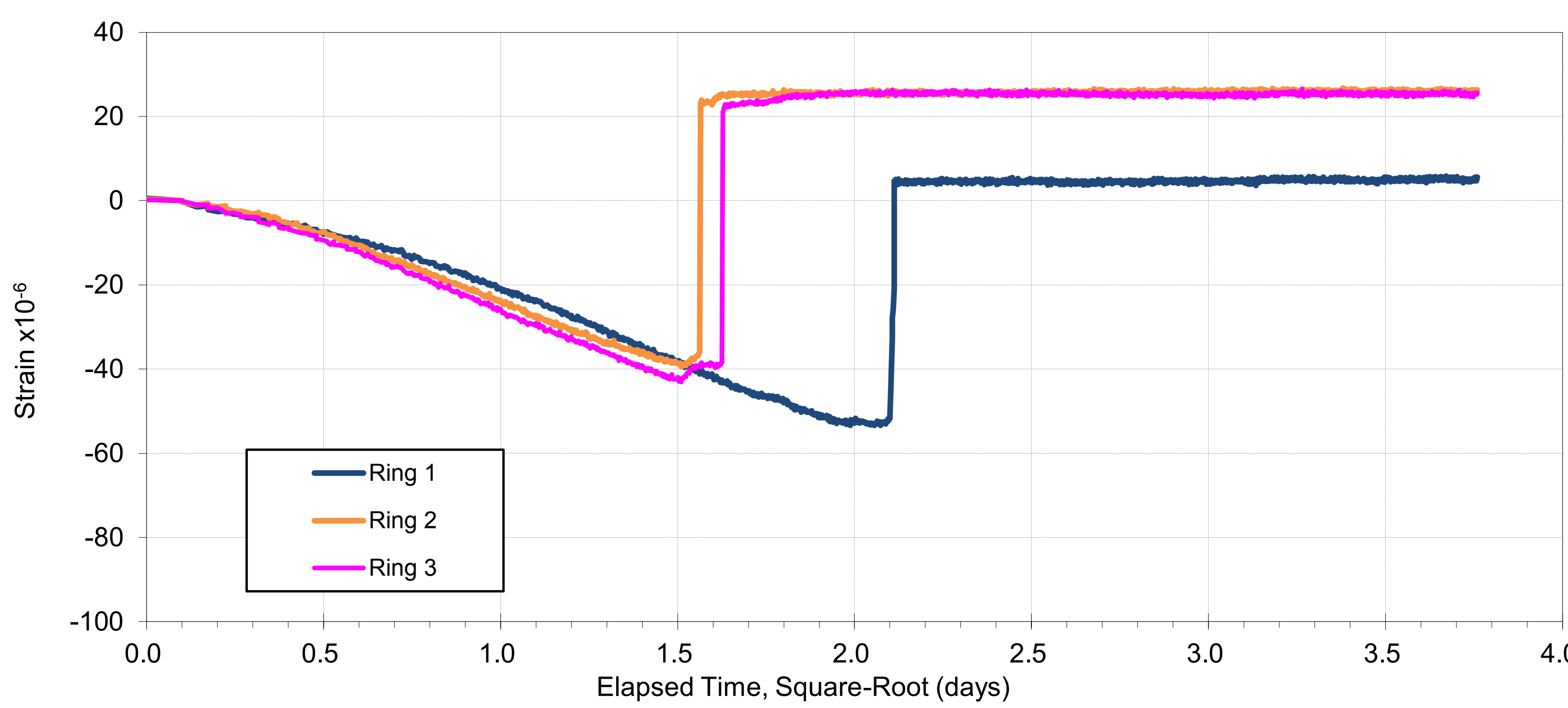
ASTM C 1581-09a
Age at Cracking and Induced Tensile Stress
Characteristics of Mortar and Concrete under Restrained Shrinkage

Mixture	Specimen	Time to Cracking, days	Initial Strain, ε_o	Maximum Strain, ε_{max}	Average Strain Rate Factor, α_{avg}	Stress Rate (q), psi/day
CAC	Ring 1	5.47	1.1	-53	-30.0	67.2
	Ring 2	3.46	-16.5	-39	-30.0	84.3
	Ring 3	3.66	-22.4	-43	-30.2	82.7
	Average	**4.2**	**-12.6**	**-45**	**-30.1**	**78.1**

Notes:

1. Casting Date and Time: Thursday, June 26, 2014 8:42 AM
2. Casting Location: Samples were fabricated at CTLGroup in Skokie, IL
3. Type and Duration of Curing: Moist burlap and polyethylene sheet for 24 hours at 73.5 ± 1.5°F (23.0 ± 1.0°C)
4. Testing Environment: 73.5 ± 1.5°F (23.0 ± 1.0°C) and 50 ± 4% RH
5. Initiation of Drying: Friday, June 27, 2014 8:27 AM
6. This report may not be reproduced except in its entirety.





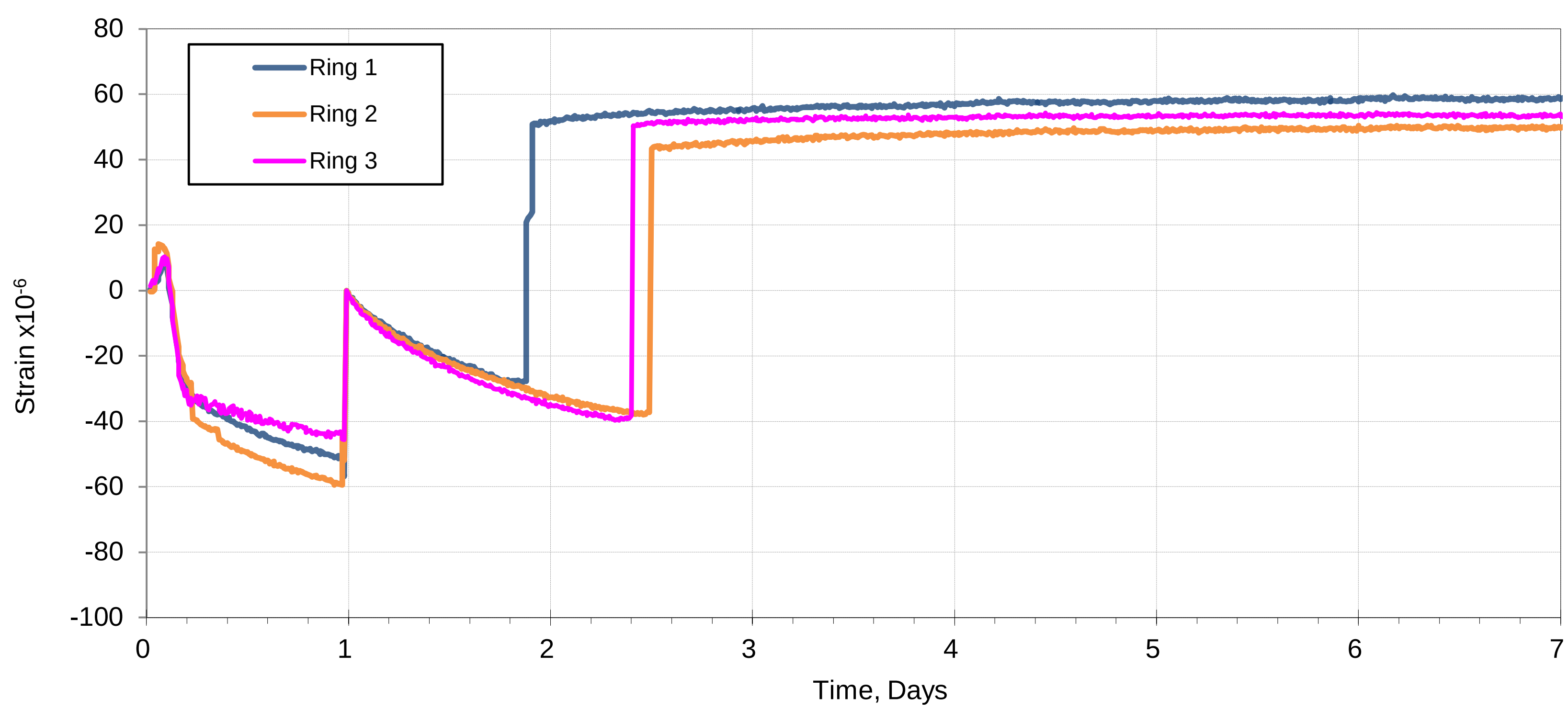
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**JP/BS/GN**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

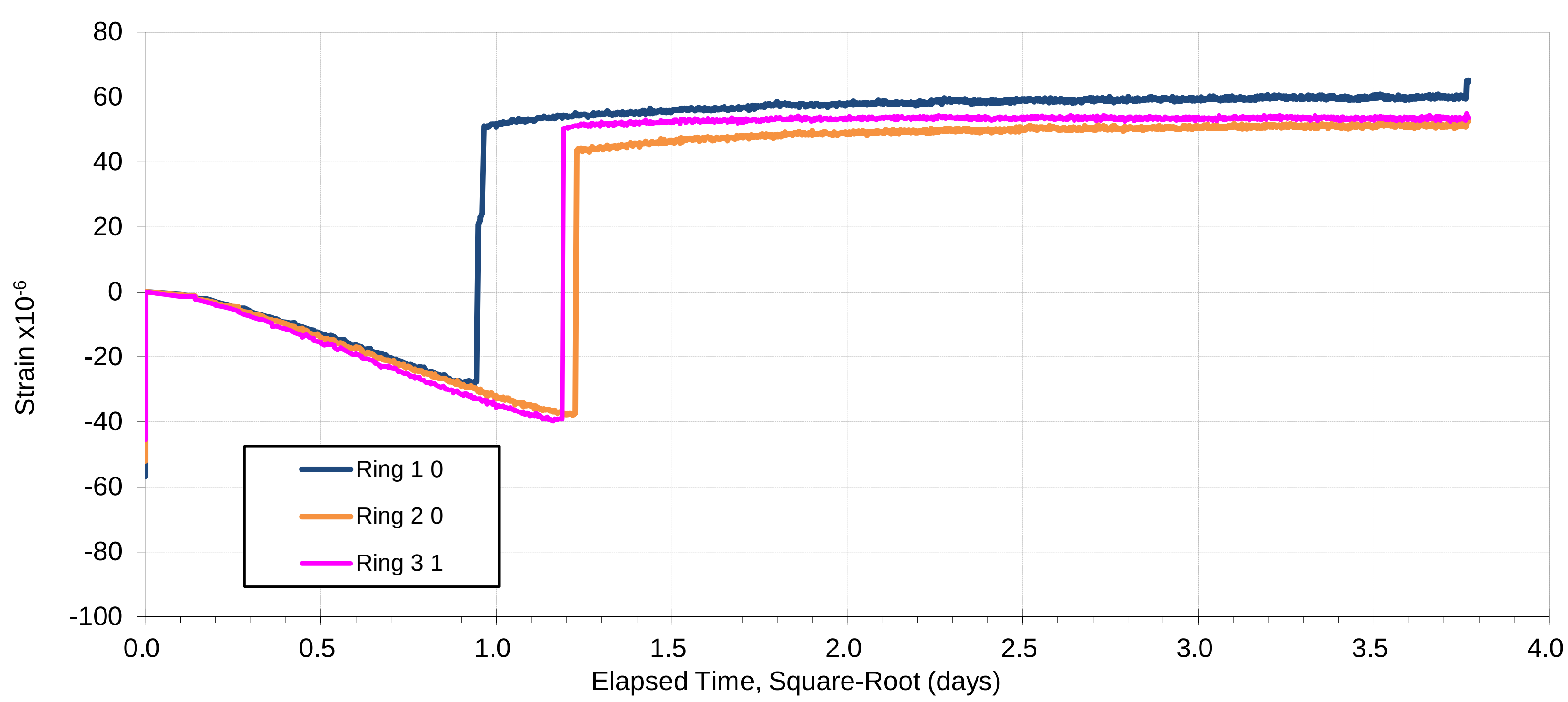
ASTM C 1581-09a
Age at Cracking and Induced Tensile Stress
Characteristics of Mortar and Concrete under Restrained Shrinkage

Mixture	Specimen	Time to Cracking, days	Initial Strain, ε_o	Maximum Strain, ε_{max}	Average Strain Rate Factor, α_{avg}	Stress Rate (q), psi/day
LCAC	Ring 1	1.89	-57.7	-57	-35.5	135.3
	Ring 2	2.51	-52.8	-59	-35.0	115.7
	Ring 3	2.42	-47.5	-46	-37.4	125.7
	Average	**2.3**	**-52.7**	**-54**	**-36.0**	**125.6**

Notes:

1. Casting Date and Time: Thursday, June 26, 2014 8:11 AM
2. Casting Location: Samples were fabricated at CTLGroup in Skokie, IL
3. Type and Duration of Curing: Moist burlap and polyethylene sheet for 24 hours at 73.5 ± 1.5°F (23.0 ± 1.0°C)
4. Testing Environment: 73.5 ± 1.5°F (23.0 ± 1.0°C) and 50 ± 4% RH
5. Initiation of Drying: Friday, June 27, 2014 7:50 AM
6. This report may not be reproduced except in its entirety.



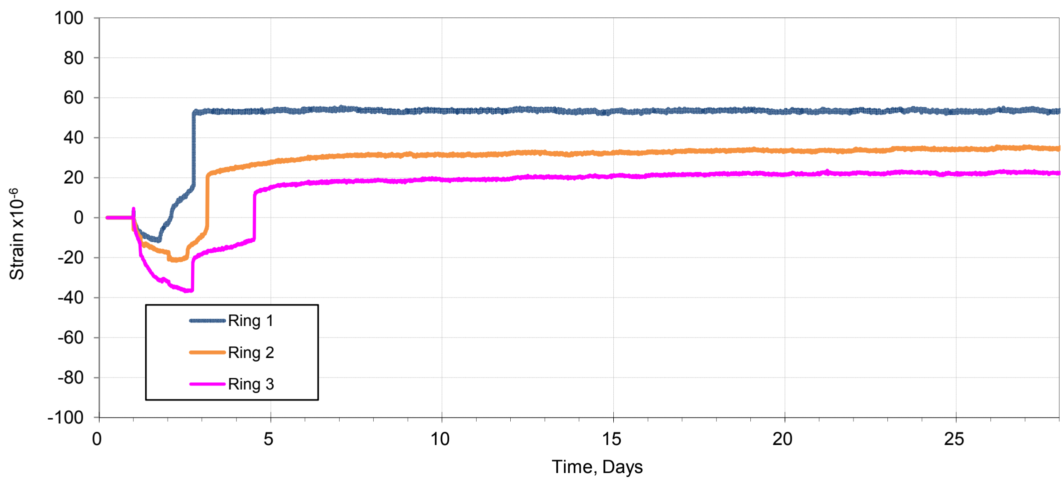


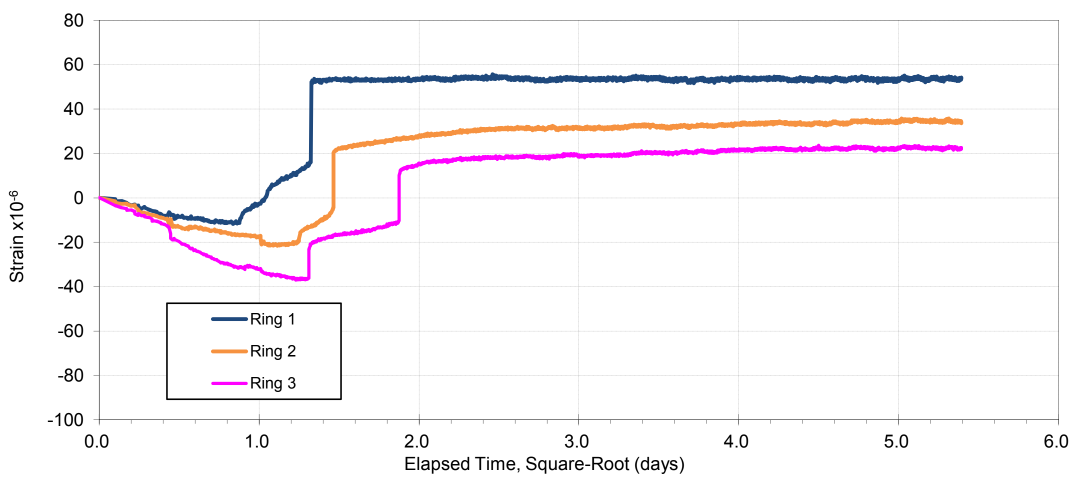
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**JP/BS/GN**
Date Reported:	**February 12, 2015**	Approved:	**J. Gajda**

ASTM C 1581-09a
Age at Cracking and Induced Tensile Stress
Characteristics of Mortar and Concrete under Restrained Shrinkage

Mixture	Specimen	Time to Cracking, days	Initial Strain, ε_o	Maximum Strain, ε_{max}	Average Strain Rate Factor, α_{avg}	Stress Rate (q), psi/day
CAC	Ring 1	1.74	-28.5	-12	-12.5	49.6
	Ring 2	2.55	-16.4	-22	-15.4	50.4
	Ring 3	2.73	-21.7	-37	-26.5	84.0
	Average	**2.3**	**-22.2**	**-24**	**-18.1**	**61.4**

Notes:
1. Casting Date and Time: Wednesday, September 10, 2014 9:37 AM
2. Casting Location: Samples were fabricated at CTLGroup in Skokie, IL
3. Type and Duration of Curing: Moist burlap and polyethylene sheet for 24 hours at 73.5 ± 1.5°F (23.0 ± 1.0°C)
4. Testing Environment: 73.5 ± 1.5°F (23.0 ± 1.0°C) and 50 ± 4% RH
5. Initiation of Drying: Thursday, September 11, 2014 9:43 AM
6. This report may not be reproduced except in its entirety.





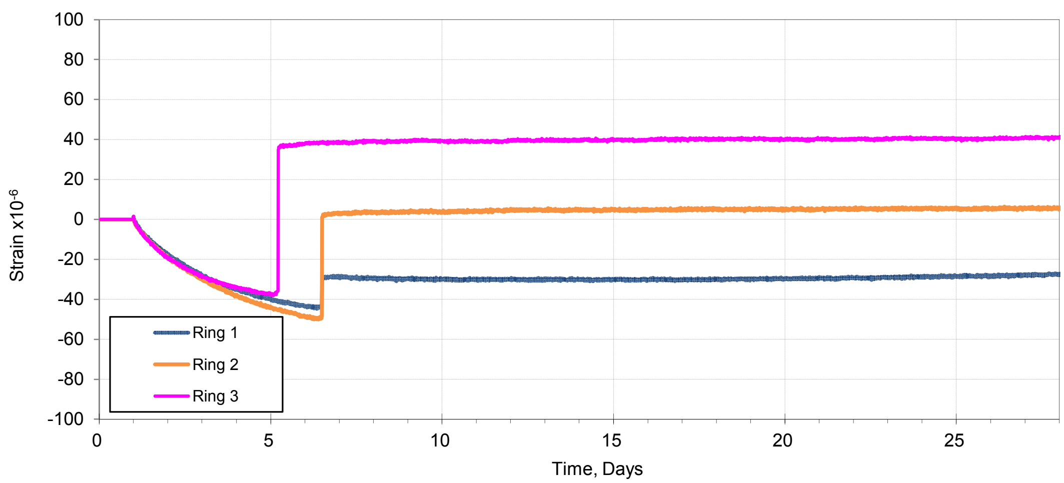
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**JP/BS/GN**
Date Reported:	**February 12, 2015**	Approved:	**J. Gajda**

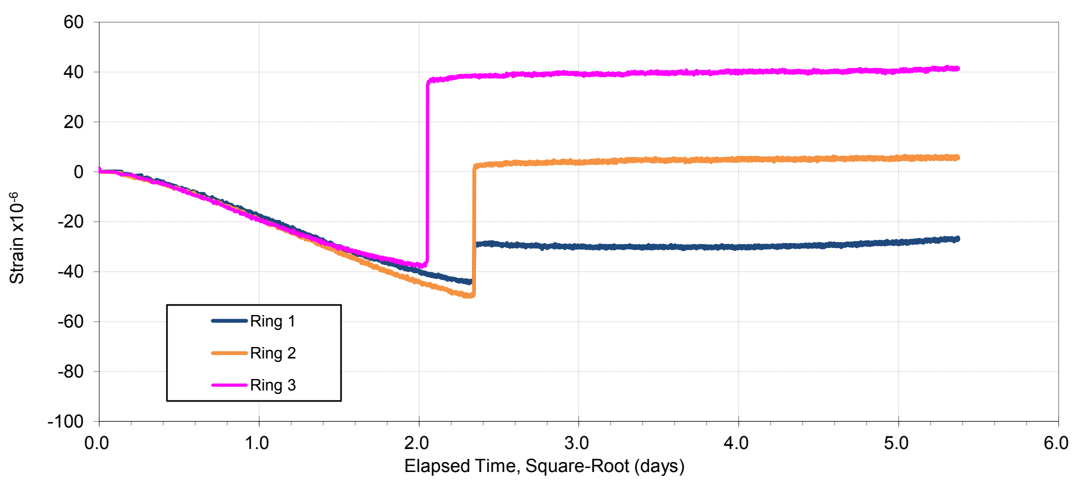
ASTM C 1581-09a
Age at Cracking and Induced Tensile Stress
Characteristics of Mortar and Concrete under Restrained Shrinkage

Mixture	Specimen	Time to Cracking, days	Initial Strain, ε_o	Maximum Strain, ε_{max}	Average Strain Rate Factor, α_{avg}	Stress Rate (q), psi/day
CAC-SRA	Ring 1	6.50	-44.3	-45	-21.4	43.9
	Ring 2	6.50	-34.6	-50	-24.0	49.4
	Ring 3	5.22	-45.6	-38	-20.4	46.6
	Average	**6.1**	**-41.5**	**-44**	**-21.9**	**46.7**

Notes:

1. Casting Date and Time: Wednesday, September 10, 2014 2:30 PM
2. Casting Location: Samples were fabricated at CTLGroup in Skokie, IL
3. Type and Duration of Curing: Moist burlap and polyethylene sheet for 24 hours at 73.5 ± 1.5°F (23.0 ± 1.0°C)
4. Testing Environment: 73.5 ± 1.5°F (23.0 ± 1.0°C) and 50 ± 4% RH
5. Initiation of Drying: Thursday, September 11, 2014 2:30 PM
6. This report may not be reproduced except in its entirety.





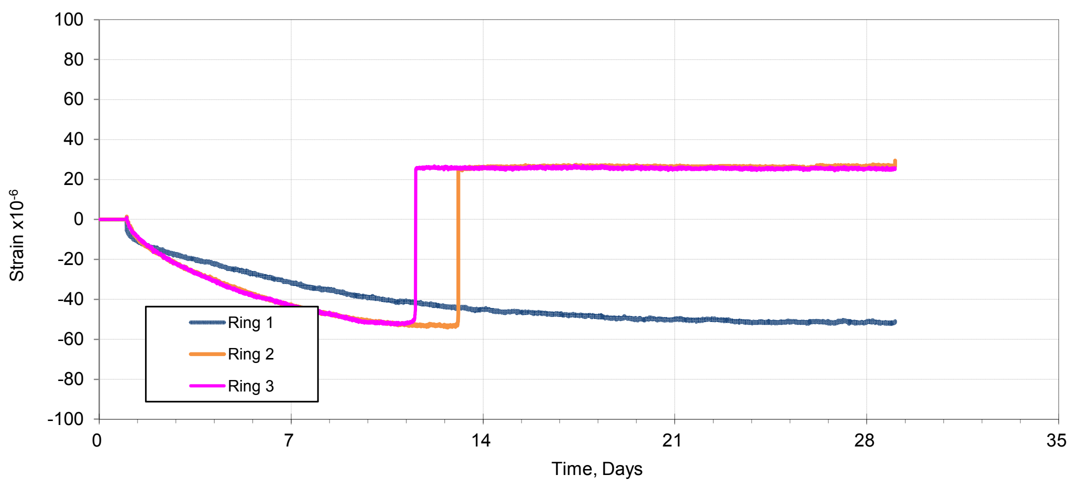
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**JP/BS/GN**
Date Reported:	**February 12, 2015**	Approved:	**J. Gajda**

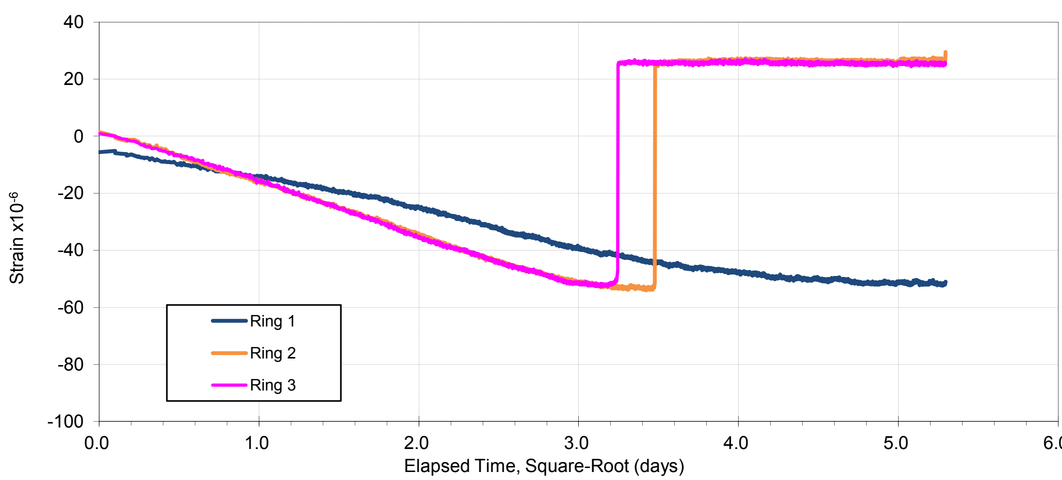
ASTM C 1581-09a
Age at Cracking and Induced Tensile Stress
Characteristics of Mortar and Concrete under Restrained Shrinkage

Mixture	Specimen	Time to Cracking, days	Initial Strain, ε_o	Maximum Strain, ε_{max}	Average Strain Rate Factor, α_{avg}	Stress Rate (q), psi/day
LCAC	Ring 1	N/A	1.5	-52	-9.2	8.9
	Ring 2	13.10	-29.3	-54	-16.6	23.9
	Ring 3	11.55	-22.3	-53	-17.6	27.1
	Average	**N/A**	**-16.7**	**-53**	**-14.4**	**20.0**

Notes:

1. Casting Date and Time: Thursday, September 11, 2014 10:26 AM
2. Casting Location: Samples were fabricated at CTLGroup in Skokie, IL
3. Type and Duration of Curing: Moist burlap and polyethylene sheet for 24 hours at 73.5 ± 1.5°F (23.0 ± 1.0°C)
4. Testing Environment: 73.5 ± 1.5°F (23.0 ± 1.0°C) and 50 ± 4% RH
5. Initiation of Drying: Friday, September 12, 2014 10:35 AM
6. This report may not be reproduced except in its entirety.



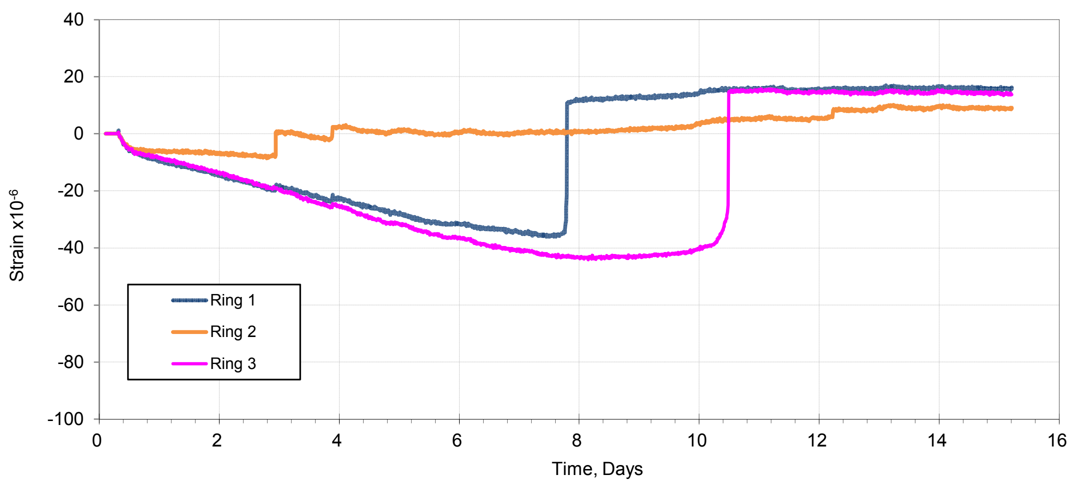


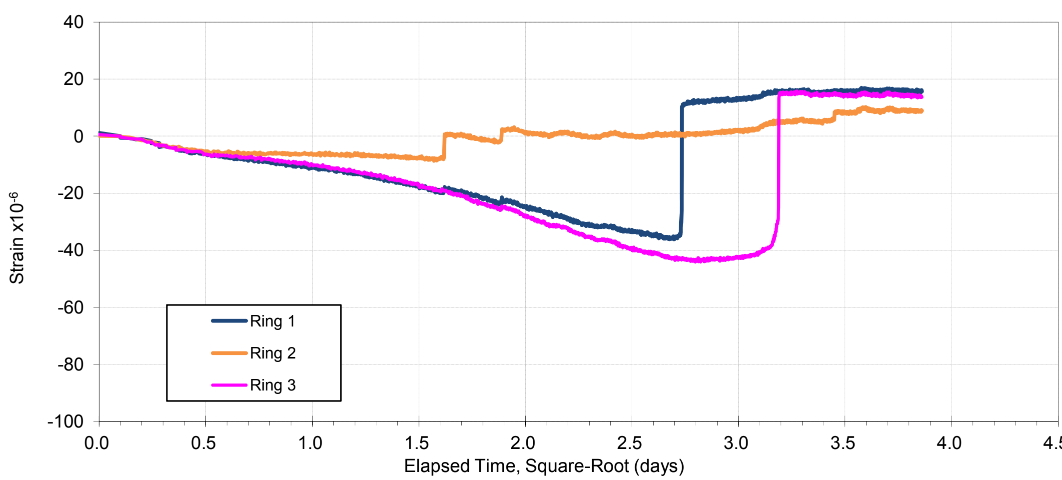
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**JP/BS/GN**
Date Reported:	**July 27, 2016**	Approved:	**J. Gajda**

ASTM C 1581-09a
Age at Cracking and Induced Tensile Stress
Characteristics of Mortar and Concrete under Restrained Shrinkage

Mixture	Specimen	Time to Cracking, days	Initial Strain, ε_o	Maximum Strain, ε_{max}	Average Strain Rate Factor, α_{avg}	Stress Rate (q), psi/day
LCAC ASRA	Ring 1	7.78	5.4	-36	-9.5	17.8
	Ring 2	2.94	1.3	-9	-3.0	9.2
	Ring 3	10.49	-10.9	-44	-16.1	26.0
	Average	**7.1**	**-1.4**	**-30**	**-9.5**	**17.7**

Notes:
1. Casting Date and Time: Friday, February 19, 2016 11:29 AM
2. Casting Location: Samples were fabricated at CTLGroup in Skokie, IL
3. Type and Duration of Curing: Moist burlap and polyethylene sheet for 8 hours at 73.5 ± 1.5°F (23.0 ± 1.0°C)
4. Testing Environment: 73.5 ± 1.5°F (23.0 ± 1.0°C) and 50 ± 4% RH
5. Initiation of Drying: Friday, February 19, 2016 7:05 PM
6. This report may not be reproduced except in its entirety.





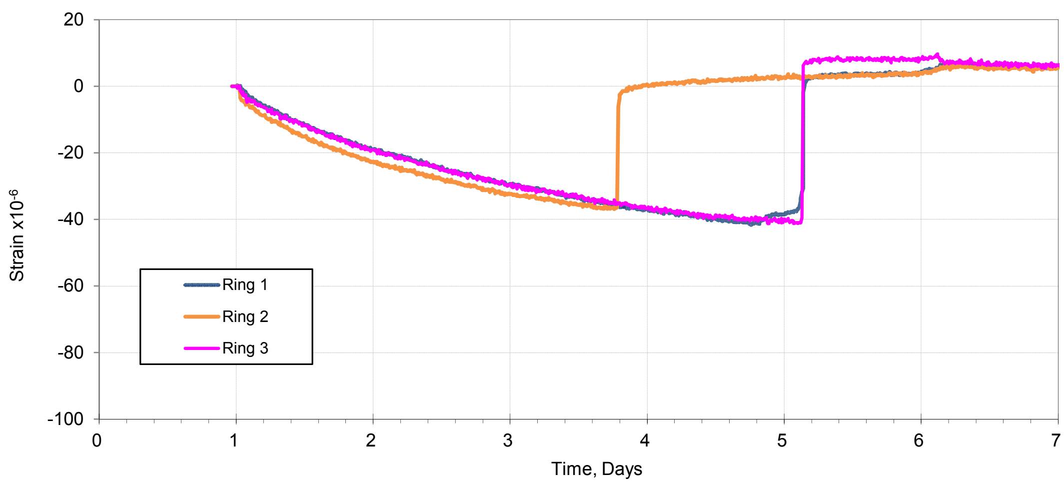
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**JP/BS/GN**
Date Reported:	**July 27, 2016**	Approved:	**J. Gajda**

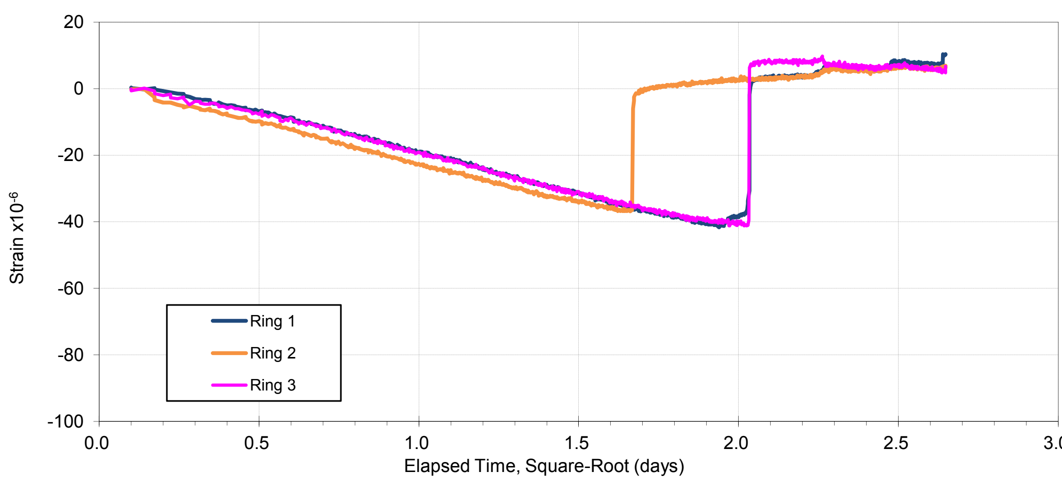
ASTM C 1581-09a
Age at Cracking and Induced Tensile Stress
Characteristics of Mortar and Concrete under Restrained Shrinkage

Mixture	Specimen	Time to Cracking, days	Initial Strain, ε_o	Maximum Strain, ε_{max}	Average Strain Rate Factor, α_{avg}	Stress Rate (q), psi/day
LCAC ASRA2	Ring 1	5.14	-26.6	-42	-23.0	53.2
	Ring 2	3.79	-34.3	-37	-23.5	63.2
	Ring 3	5.13	-26.0	-41	-22.7	52.5
	Average	**4.7**	**-29.0**	**-40**	**-23.1**	**56.3**

Notes:

1. Casting Date and Time: Tuesday, March 08, 2016 8:25 AM
2. Casting Location: Samples were fabricated at CTLGroup in Skokie, IL
3. Type and Duration of Curing: Moist burlap and polyethylene sheet for 24 hours at 73.5 ± 1.5°F (23.0 ± 1.0°C)
4. Testing Environment: 73.5 ± 1.5°F (23.0 ± 1.0°C) and 50 ± 4% RH
5. Initiation of Drying: Wednesday, March 09, 2016 8:25 AM
6. This report may not be reproduced except in its entirety.





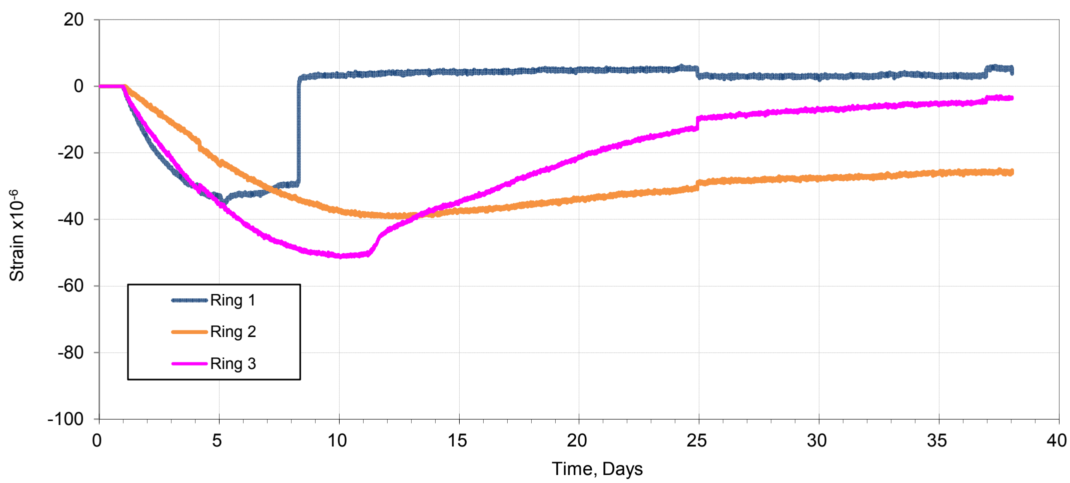
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**JP/BS/GN**
Date Reported:	**July 27, 2016**	Approved:	**J. Gajda**

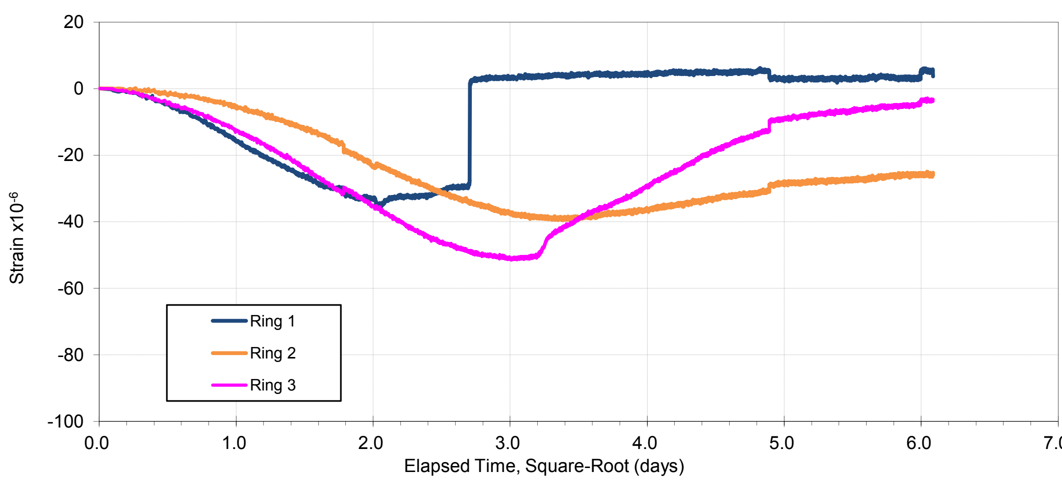
ASTM C 1581-09a
Age at Cracking and Induced Tensile Stress
Characteristics of Mortar and Concrete under Restrained Shrinkage

Mixture	Specimen	Time to Cracking, days	Initial Strain, ε_o	Maximum Strain, ε_{max}	Average Strain Rate Factor, α_{avg}	Stress Rate (q), psi/day
LCAC ASLW	Ring 1	8.32	5.4	-36	-11.5	21.0
	Ring 2	+38.04	1.3	-40	-1.8	1.5
	Ring 3	+38.04	-10.9	-52	7.1	6.0
	Average	**+28.13**	**-1.4**	**-42**	**-2.1**	**9.5**

Notes:

1. Casting Date and Time: Friday, June 03, 2016 10:31 AM
2. Casting Location: Samples were fabricated at CTLGroup in Skokie, IL
3. Type and Duration of Curing: Moist burlap and polyethylene sheet for 8 hours at 73.5 ± 1.5°F (23.0 ± 1.0°C)
4. Testing Environment: 73.5 ± 1.5°F (23.0 ± 1.0°C) and 50 ± 4% RH
5. Initiation of Drying: Saturday, June 04, 2016 10:31 AM
6. This report may not be reproduced except in its entirety.



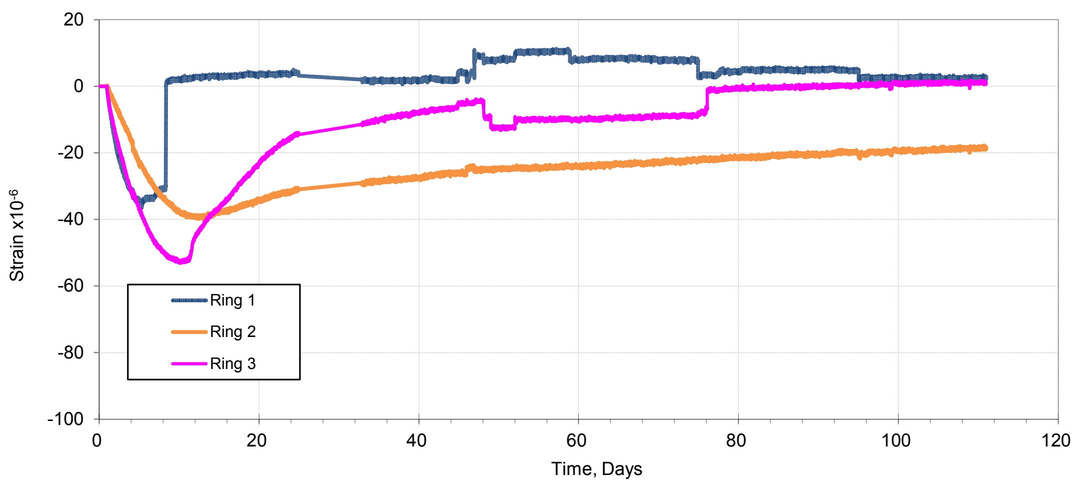


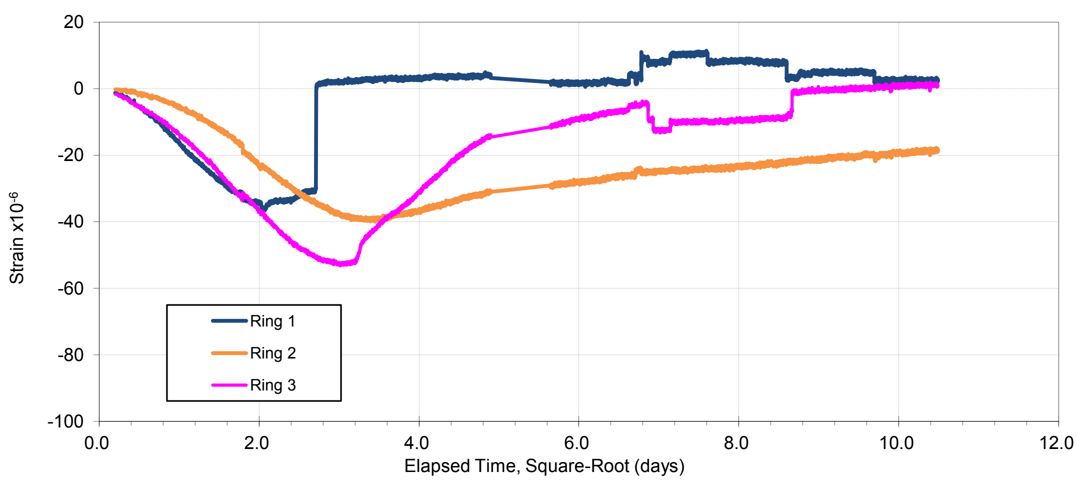
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**JP/BS/GN**
Date Reported:	**July 27, 2016**	Approved:	**J. Gajda**

ASTM C 1581-09a
Age at Cracking and Induced Tensile Stress
Characteristics of Mortar and Concrete under Restrained Shrinkage

Mixture	Specimen	Time to Cracking, days	Initial Strain, ε_o	Maximum Strain, ε_{max}	Average Strain Rate Factor, α_{avg}	Stress Rate (q), psi/day
LCAC ALW	Ring 1	8.32	5.4	-37	-11.7	21.2
	Ring 2	+38.04	1.3	-40	1.3	1.1
	Ring 3	+38.04	-10.9	-53	4.7	4.0
	Average	**+28.13**	**-1.4**	**-43**	**-1.9**	**8.8**

Notes:
1. Casting Date and Time: Friday, June 03, 2016 10:31 AM
2. Casting Location: Samples were fabricated at CTLGroup in Skokie, IL
3. Type and Duration of Curing: Moist burlap and polyethylene sheet for 8 hours at 73.5 ± 1.5°F (23.0 ± 1.0°C)
4. Testing Environment: 73.5 ± 1.5°F (23.0 ± 1.0°C) and 50 ± 4% RH
5. Initiation of Drying: Saturday, June 04, 2016 10:31 AM
6. This report may not be reproduced except in its entirety.



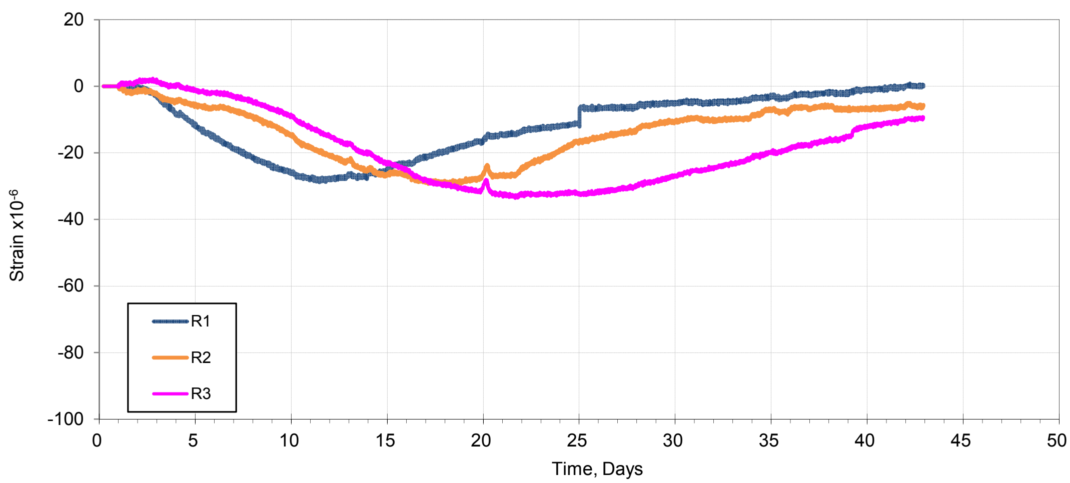


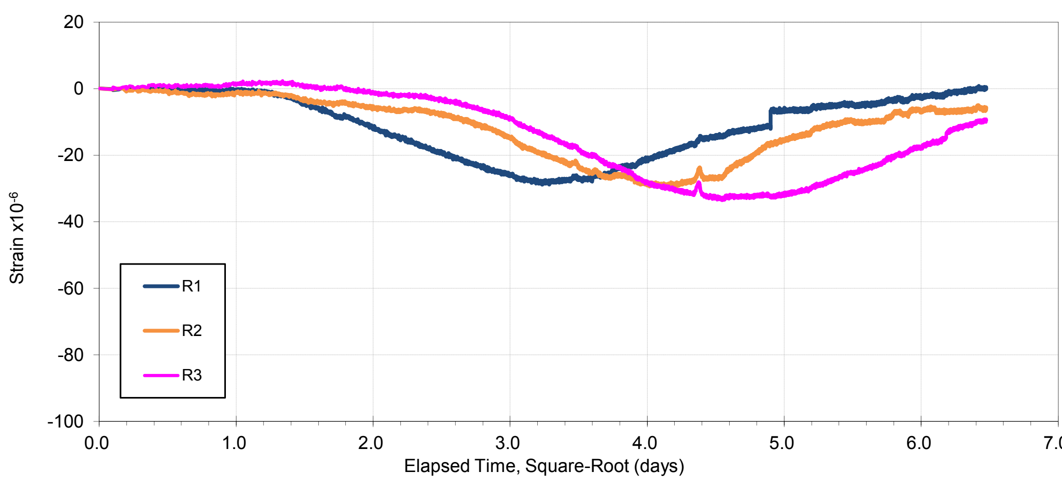
ASTM C 1581-09a
Age at Cracking and Induced Tensile Stress
Characteristics of Mortar and Concrete under Restrained Shrinkage

Mixture	Specimen	Time to Cracking, days	Initial Strain, ε_o	Maximum Strain, ε_{max}	Average Strain Rate Factor, α_{avg}	Stress Rate (q), psi/day
ALW4-T	R1	N/A	5.4	-29	2.8	3.7
	R2	N/A	1.3	-30	0.0	0.1
	R3	N/A	-10.9	-34	-4.1	5.4
	Average	**N/A**	**-1.4**	**-31**	**-0.4**	**3.0**

Notes: **NOTE: All rings experienced small distributed cracking after about 2 weeks but none were full depth.**

1. Casting Date and Time: Tuesday, September 06, 2016 11:00 AM
2. Casting Location: Samples were fabricated at CTLGroup in Skokie, IL
3. Type and Duration of Curing: Moist burlap and polyethylene sheet for 8 hours at 73.5 ± 1.5°F (23.0 ± 1.0°C)
4. Testing Environment: 73.5 ± 1.5°F (23.0 ± 1.0°C) and 50 ± 4% RH
5. Initiation of Drying: Wednesday, September 07, 2016 11:00 AM
6. This report may not be reproduced except in its entirety.





APPENDIX G

ASTM C666 FREEZE-THAW RESISTANCE

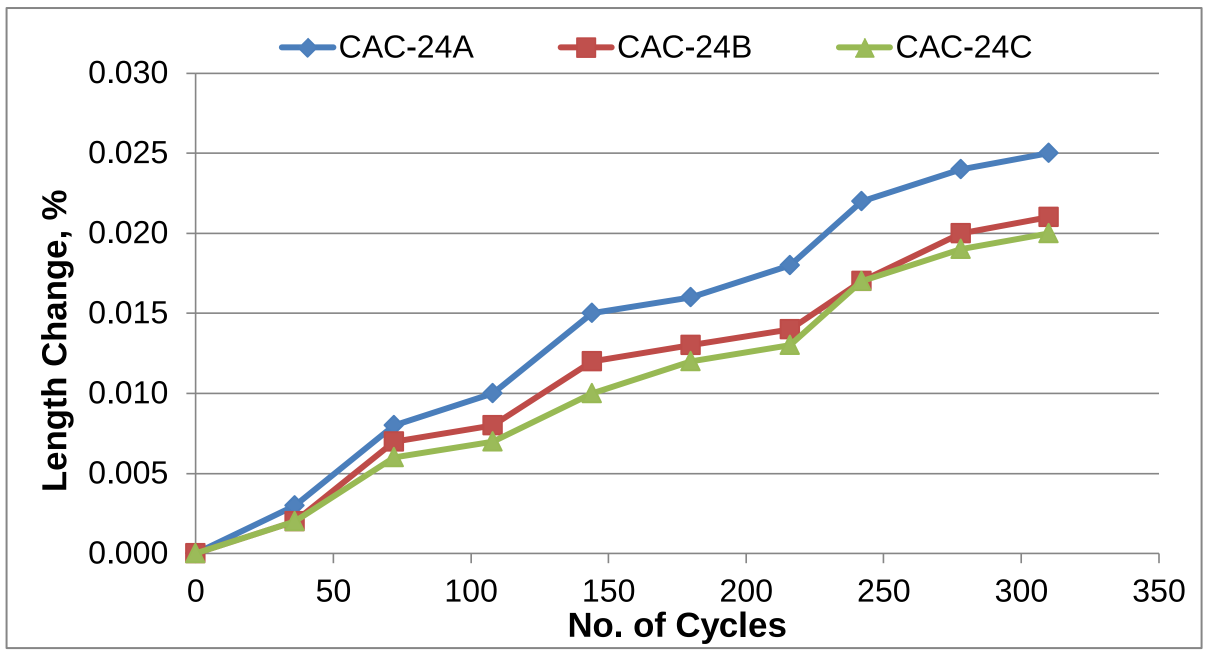
TEST RESULTS

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Proj. Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

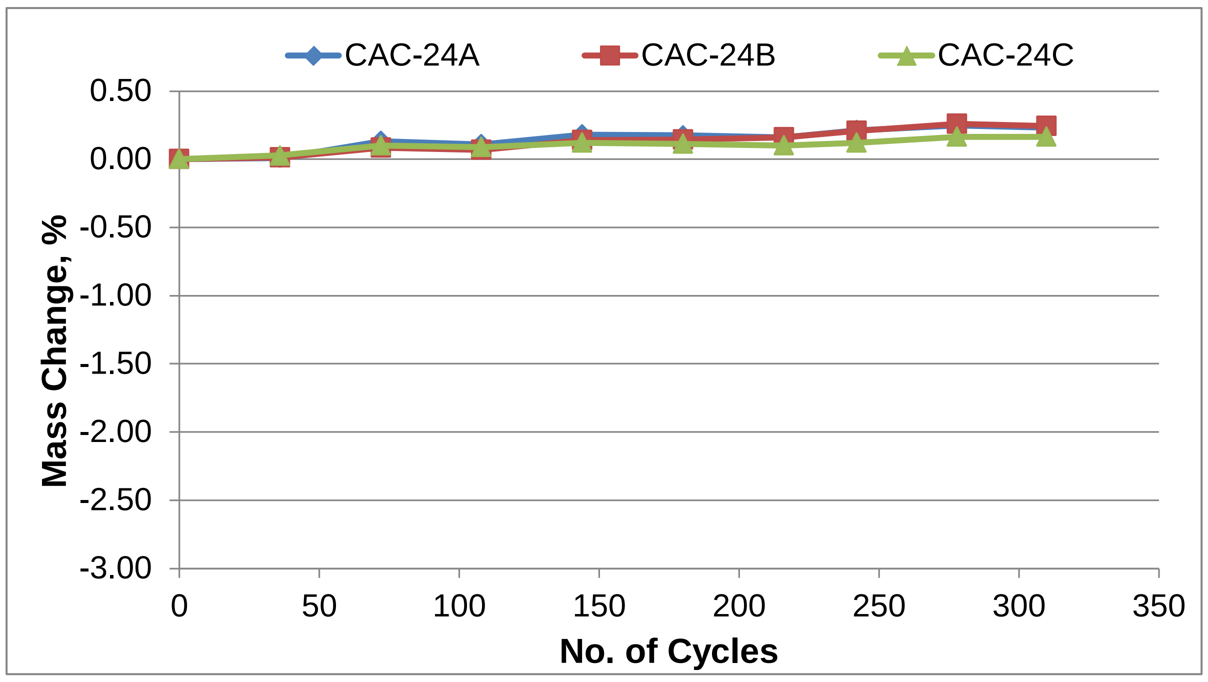
ASTM C666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
Procedure A, Freezing and Thawing in Water

Mix ID: CAC - 24 Hours Moist Burlap Cure

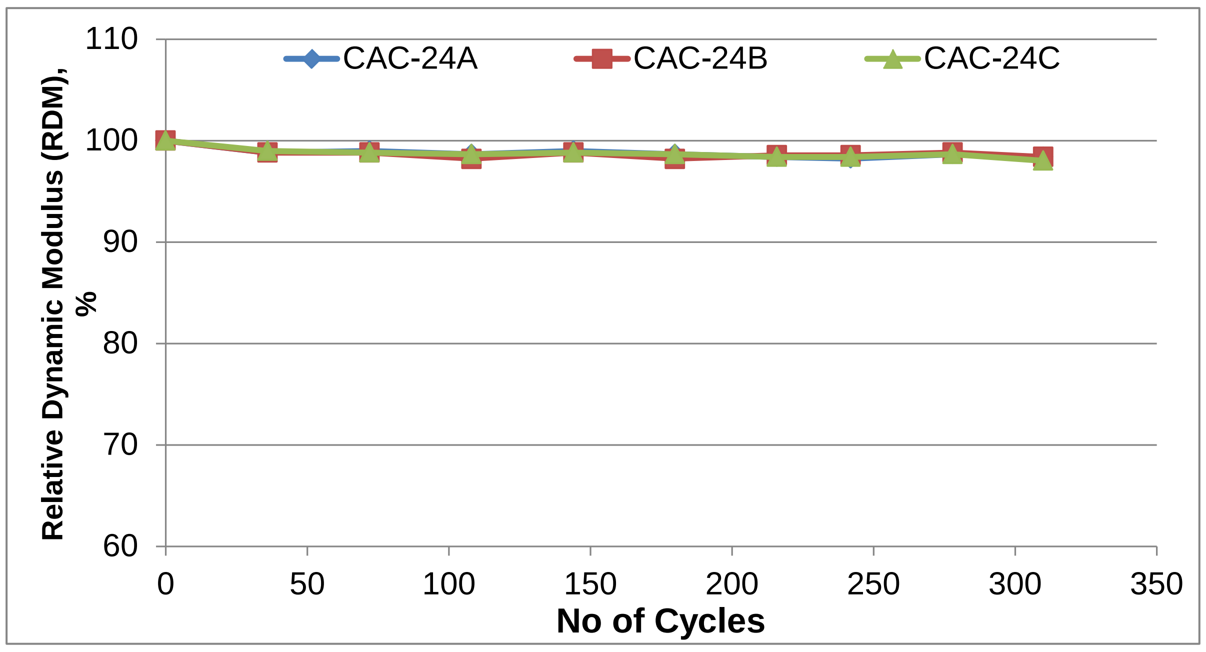
Freeze-Thaw Cycles	Length Change, %			
	CAC-24A	CAC-24B	CAC-24C	Average
0	0.000	0.000	0.000	0.000
36	0.003	0.002	0.002	0.002
72	0.008	0.007	0.006	0.007
108	0.010	0.008	0.007	0.008
144	0.015	0.012	0.010	0.012
180	0.016	0.013	0.012	0.014
216	0.018	0.014	0.013	0.015
242	0.022	0.017	0.017	0.019
278	0.024	0.020	0.019	0.021
310	0.025	0.021	0.020	0.022



Freeze-Thaw Cycles	Mass Change, %			
	CAC-24A	CAC-24B	CAC-24C	Average
Initial Mass	4069.5 g	4028.2 g	4025 g	--
0	0.00	0.00	0.00	0.00
36	0.01	0.01	0.03	0.02
72	0.13	0.08	0.10	0.11
108	0.11	0.07	0.09	0.09
144	0.18	0.14	0.12	0.15
180	0.17	0.15	0.11	0.15
216	0.16	0.16	0.10	0.14
242	0.21	0.21	0.12	0.18
278	0.25	0.26	0.16	0.22
310	0.23	0.24	0.16	0.21



Freeze-Thaw Cycles	Relative Dynamic Modulus, %			
	CAC-24A	CAC-24B	CAC-24C	Average
0	100	100	100	100
36	99	99	99	99
72	99	99	99	99
108	99	98	99	98
144	99	99	99	99
180	99	98	99	98
216	98	99	98	98
242	98	99	98	98
278	99	99	99	99
310	98	98	98	98



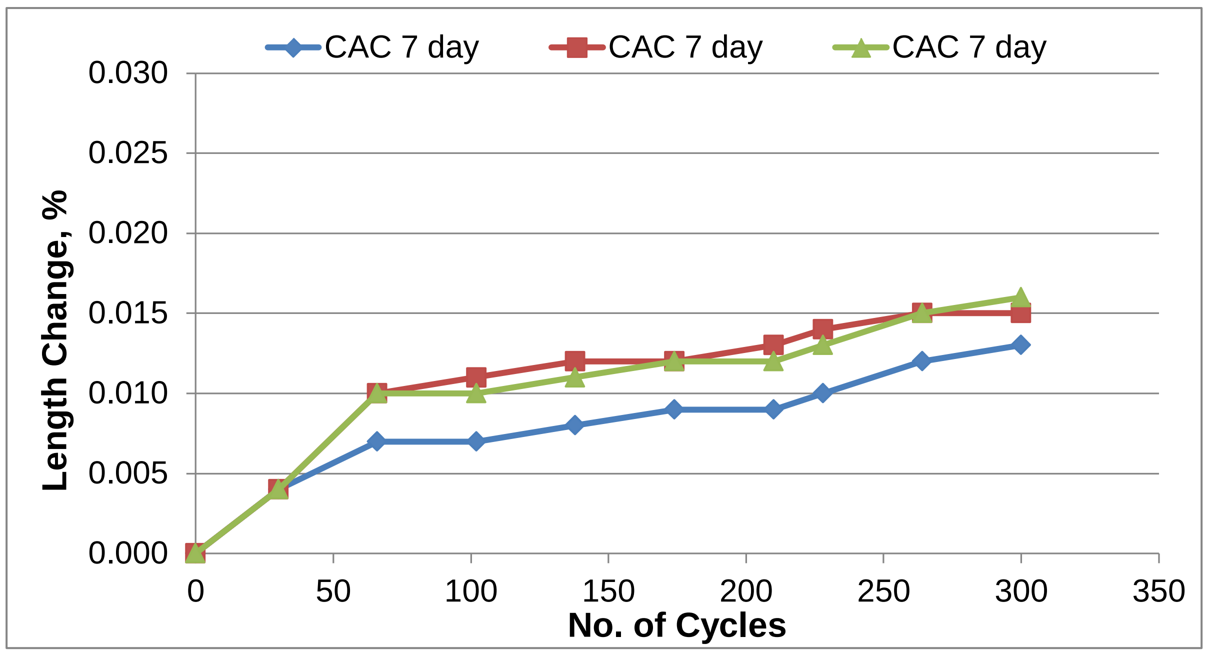
Notes:
1. Specimens were fabricated on June 26, 2014 at CTLGroup laboratories. Testing began after specimens were removed from their molds at an age of 24 hours.
2. Test specimens measure approximately 3x3x11-in. at 0 cycles.
3. A negative mass change indicates mass loss; a positive mass change indicates a mass gain.
4. The relative dynamic modulus was determined by the transverse frequency method of ASTM C215, Section 9.
5. This report may not be reproduced except in its entirety.

Client: **Illinois Tollway** | CTL Project No: **057177**
Project: **Calcium Aluminate Cement Project** | CTL Proj. Mgr.: **M. D'Ambrosia**
Contact: **Steve Gillen** | Technician: **W. Demharter**
Date Reported: **August 19, 2015** | Approved: **B. Birch**

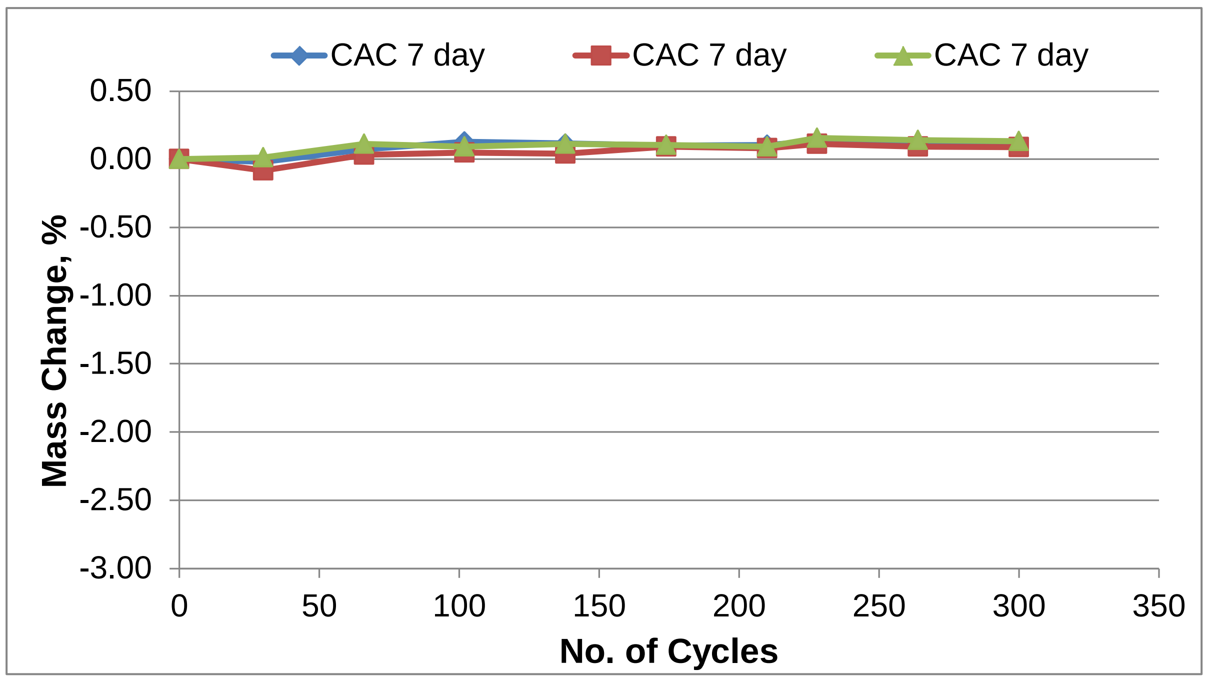
ASTM C666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing Procedure A, Freezing and Thawing in Water

Mix ID: CAC - 7 Day Moist Cure

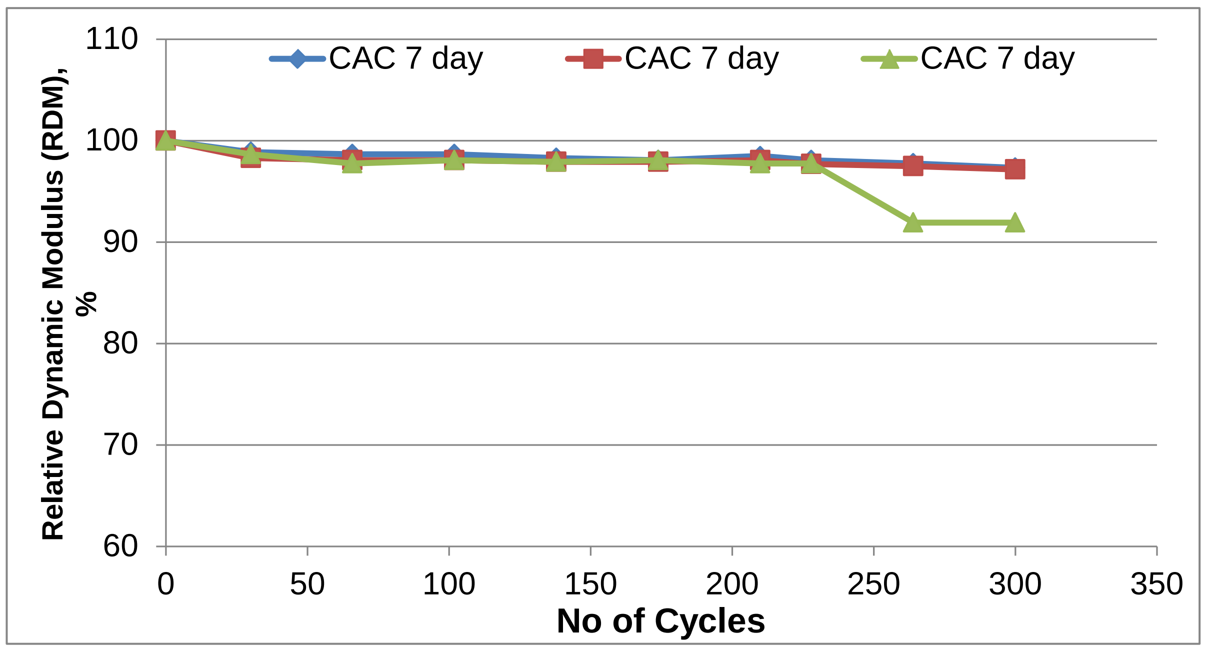
Freeze-Thaw Cycles	Length Change, %			
	CAC 7 day	CAC 7 day	CAC 7 day	Average
0	0.000	0.000	0.000	0.000
30	0.004	0.004	0.004	0.004
66	0.007	0.010	0.010	0.009
102	0.007	0.011	0.010	0.009
138	0.008	0.012	0.011	0.010
174	0.009	0.012	0.012	0.011
210	0.009	0.013	0.012	0.011
228	0.010	0.014	0.013	0.012
264	0.012	0.015	0.015	0.014
300	0.013	0.015	0.016	0.015



Freeze-Thaw Cycles	Mass Change, %			
	CAC 7 day	CAC 7 day	CAC 7 day	Average
Initial Mass	4004.8 g	4060.3 g	4042.3 g	--
0	0.00	0.00	0.00	0.00
30	-0.02	-0.08	0.01	-0.03
66	0.07	0.03	0.11	0.07
102	0.13	0.05	0.09	0.09
138	0.11	0.04	0.11	0.09
174	0.10	0.09	0.11	0.10
210	0.10	0.08	0.09	0.09
228	0.13	0.11	0.16	0.13
264	0.11	0.09	0.14	0.12
300	0.10	0.09	0.13	0.11



Freeze-Thaw Cycles	Relative Dynamic Modulus, %			
	CAC 7 day	CAC 7 day	CAC 7 day	Average
0	100	100	100	100
30	99	98	99	99
66	99	98	98	98
102	99	98	98	98
138	98	98	98	98
174	98	98	98	98
210	98	98	98	98
228	98	98	98	98
264	98	97	92	96
300	97	97	92	95



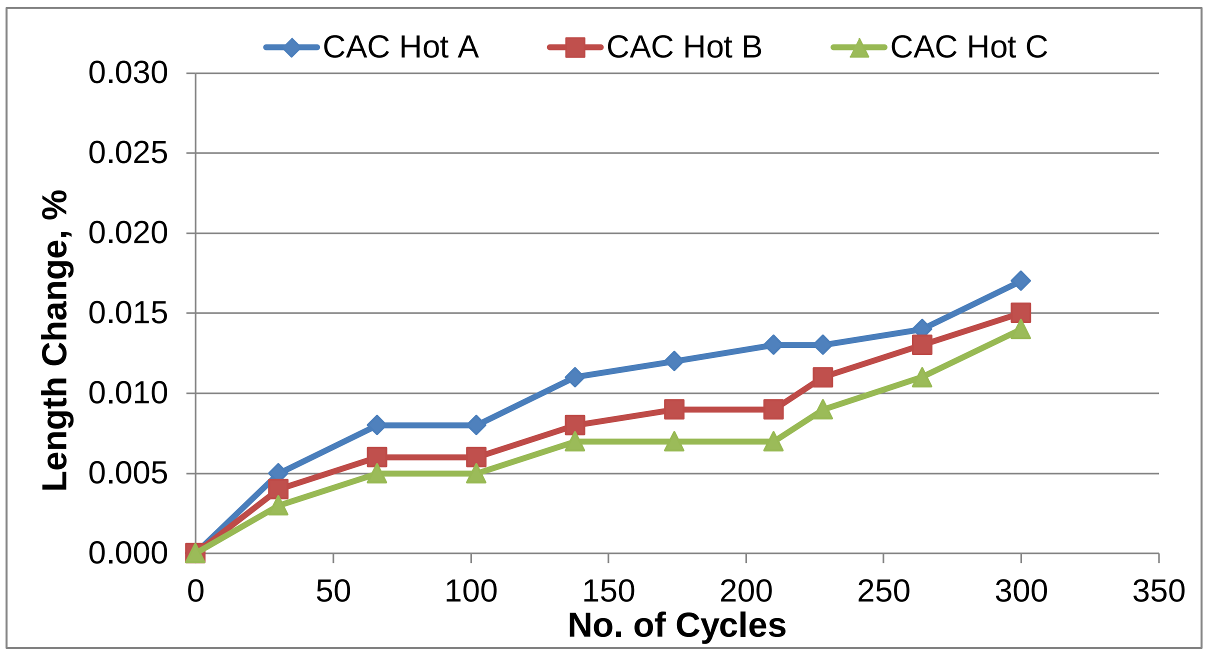
Notes:
1. Specimens were fabricated on June 26, 2014 at CTLGroup laboratories. Specimens were demolded after 1 day and stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity until an age of 7 days. Testing started at 7 days.
2. Test specimens measure approximately 3x3x11-in. at 0 cycles.
3. A negative mass change indicates mass loss; a positive mass change indicates a mass gain.
4. The relative dynamic modulus was determined by the transverse frequency method of ASTM C215, Section 9.
5. This report may not be reproduced except in its entirety.

Client: **Illinois Tollway** | CTL Project No: **057177**
Project: **Calcium Aluminate Cement Project** | CTL Proj. Mgr.: **M. D'Ambrosia**
Contact: **Steve Gillen** | Technician: **W. Demharter**
Date Reported: **August 19, 2015** | Approved: **B. Birch**

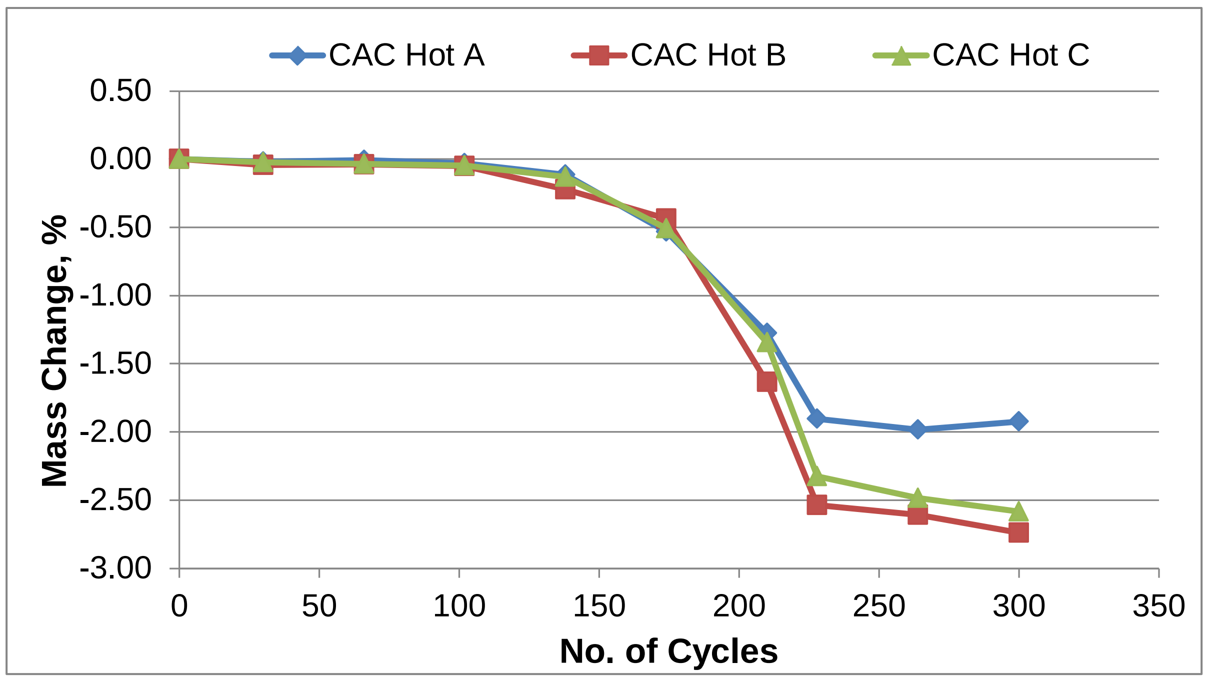
ASTM C666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing Procedure A, Freezing and Thawing in Water

Mix ID: CAC Hot - 7 Day Elevated Temperature Cure (122°F)

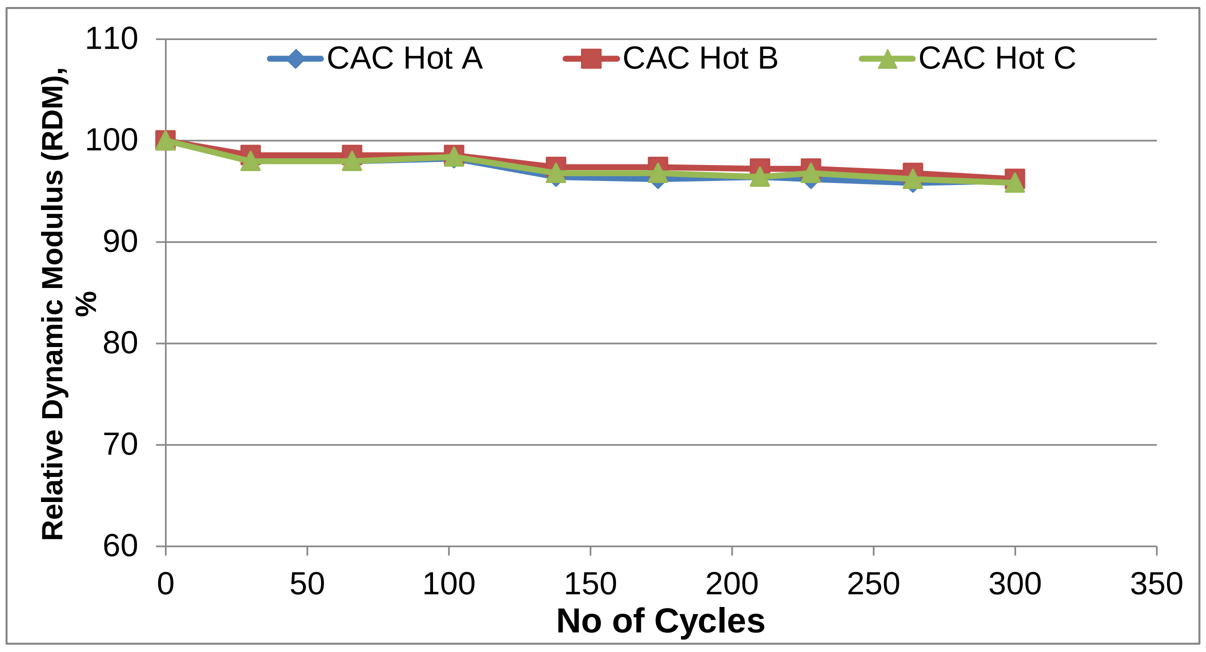
Freeze-Thaw Cycles	Length Change, %			
	CAC Hot A	CAC Hot B	CAC Hot C	Average
0	0.000	0.000	0.000	0.000
30	0.005	0.004	0.003	0.004
66	0.008	0.006	0.005	0.006
102	0.008	0.006	0.005	0.006
138	0.011	0.008	0.007	0.009
174	0.012	0.009	0.007	0.009
210	0.013	0.009	0.007	0.010
228	0.013	0.011	0.009	0.011
264	0.014	0.013	0.011	0.013
300	0.017	0.015	0.014	0.015



Freeze-Thaw Cycles	Mass Change, %			
	CAC Hot A	CAC Hot B	CAC Hot C	Average
Initial Mass	4082.6 g	4093.7 g	4095.9 g	--
0	0.00	0.00	0.00	0.00
30	-0.02	-0.04	-0.02	-0.03
66	-0.01	-0.04	-0.03	-0.03
102	-0.03	-0.05	-0.05	-0.04
138	-0.12	-0.22	-0.13	-0.16
174	-0.53	-0.43	-0.51	-0.49
210	-1.27	-1.63	-1.34	-1.42
228	-1.90	-2.54	-2.33	-2.26
264	-1.98	-2.61	-2.49	-2.36
300	-1.92	-2.74	-2.58	-2.41



Freeze-Thaw Cycles	Relative Dynamic Modulus, %			
	CAC Hot A	CAC Hot B	CAC Hot C	Average
0	100	100	100	100
30	98	99	98	98
66	98	99	98	98
102	98	99	98	98
138	96	97	97	97
174	96	97	97	97
210	96	97	96	97
228	96	97	97	97
264	96	97	96	96
300	96	96	96	96



Notes:
1. Specimens were fabricated on June 26, 2014 at CTLGroup laboratories. Specimens were demolded after 1 day and stored in a water tank at 50°C [122°F] until an age of 7 days. Testing started at 7 days.
2. Test specimens measure approximately 3x3x11-in. at 0 cycles.
3. A negative mass change indicates mass loss; a positive mass change indicates a mass gain.
4. The relative dynamic modulus was determined by the transverse frequency method of ASTM C215, Section 9.
5. This report may not be reproduced except in its entirety.

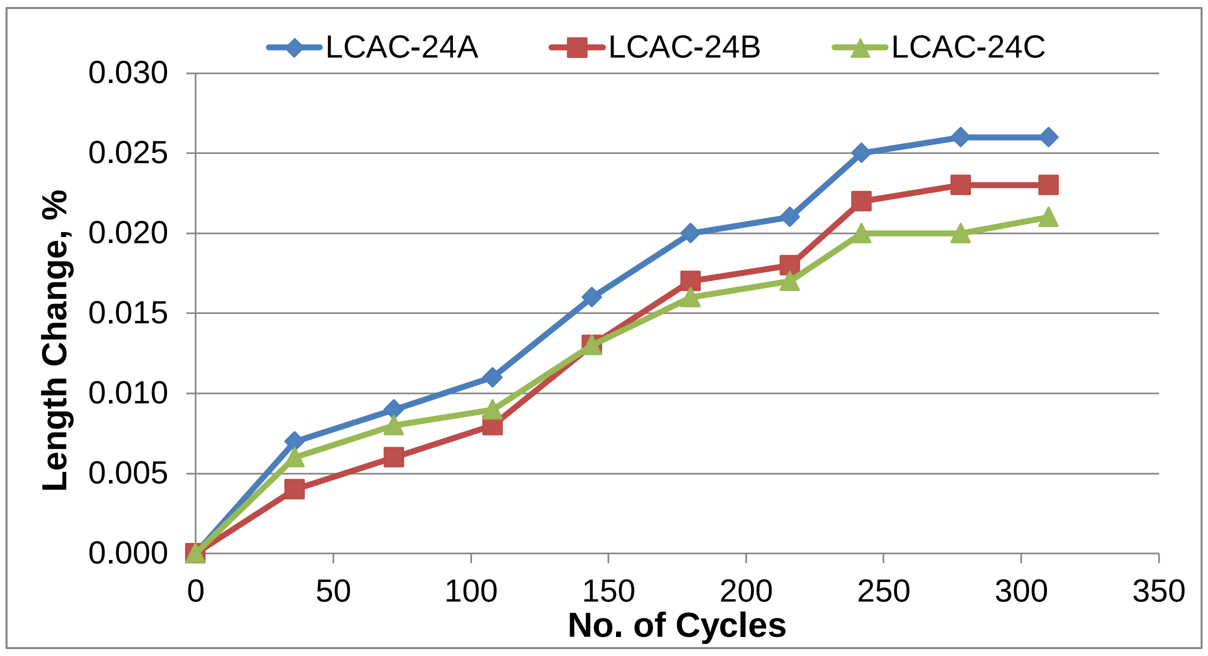
CTLGROUP

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Proj. Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

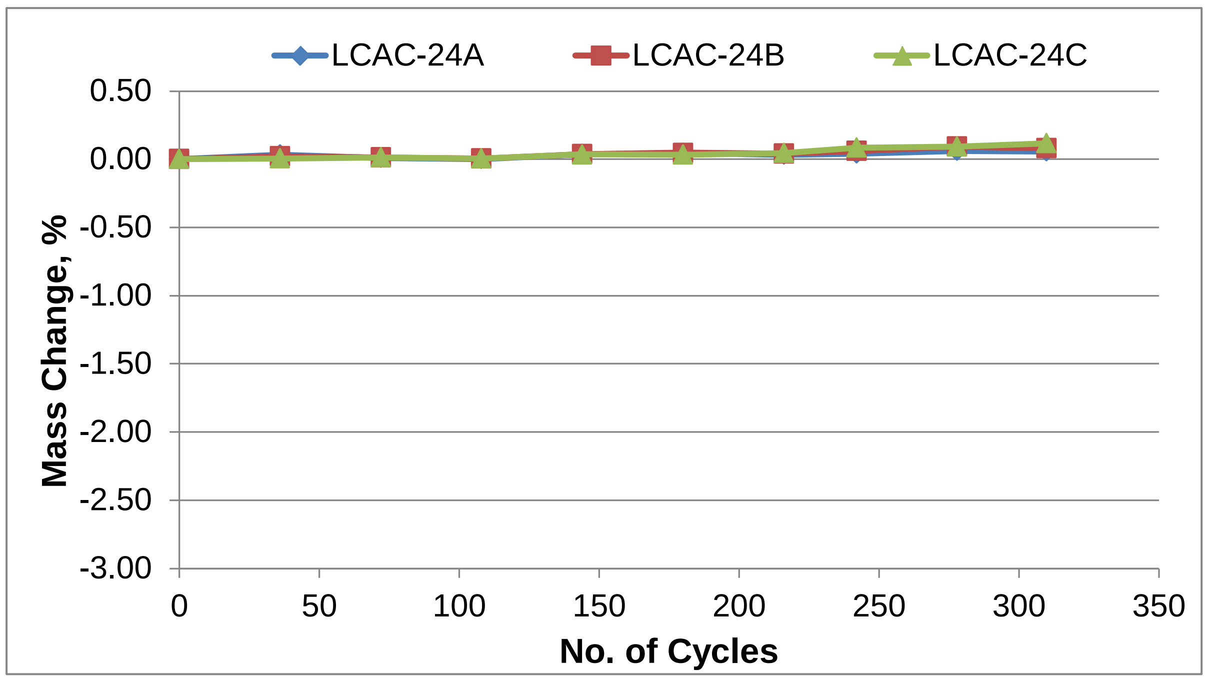
ASTM C666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing Procedure A, Freezing and Thawing in Water

Mix ID: LCAC - 24 Hours Plastic Cover Cure

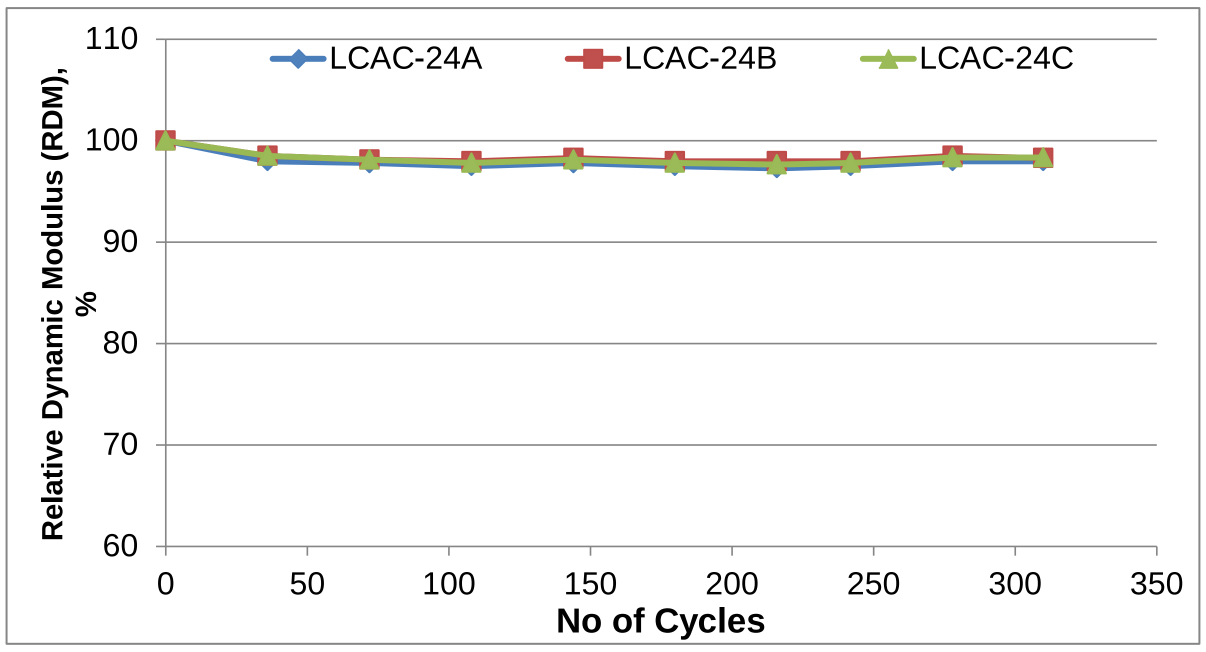
Freeze-Thaw	**Length Change, %**			
Cycles	LCAC-24A	LCAC-24B	LCAC-24C	Average
0	0.000	0.000	0.000	0.000
36	0.007	0.004	0.006	0.006
72	0.009	0.006	0.008	0.008
108	0.011	0.008	0.009	0.009
144	0.016	0.013	0.013	0.014
180	0.020	0.017	0.016	0.018
216	0.021	0.018	0.017	0.019
242	0.025	0.022	0.020	0.022
278	0.026	0.023	0.020	0.023
310	0.026	0.023	0.021	0.023



Freeze-Thaw	**Mass Change, %**			
Cycles	LCAC-24A	LCAC-24B	LCAC-24C	Average
Initial Mass	7242.5 g	7210.1 g	7382.5 g	--
0	0.00	0.00	0.00	0.00
36	0.03	0.02	0.01	0.02
72	0.01	0.01	0.01	0.01
108	0.00	0.01	0.01	0.01
144	0.04	0.04	0.04	0.04
180	0.05	0.05	0.03	0.04
216	0.03	0.04	0.05	0.04
242	0.04	0.06	0.09	0.06
278	0.06	0.09	0.09	0.08
310	0.06	0.08	0.12	0.08



Freeze-Thaw	**Relative Dynamic Modulus, %**			
Cycles	LCAC-24A	LCAC-24B	LCAC-24C	Average
0	100	100	100	100
36	98	98	98	98
72	98	98	98	98
108	97	98	98	98
144	98	98	98	98
180	97	98	98	98
216	97	98	98	98
242	97	98	98	98
278	98	98	98	98
310	98	98	98	98



Notes:
1. Specimens were fabricated on June 26, 2014 at CTLGroup laboratories. Testing began after specimens were removed from their molds at an age of 24 hours.
2. Test specimens measure approximately 3x3x11-in. at 0 cycles.
3. A negative mass change indicates mass loss; a positive mass change indicates a mass gain.
4. The relative dynamic modulus was determined by the transverse frequency method of ASTM C215, Section 9.
5. This report may not be reproduced except in its entirety.

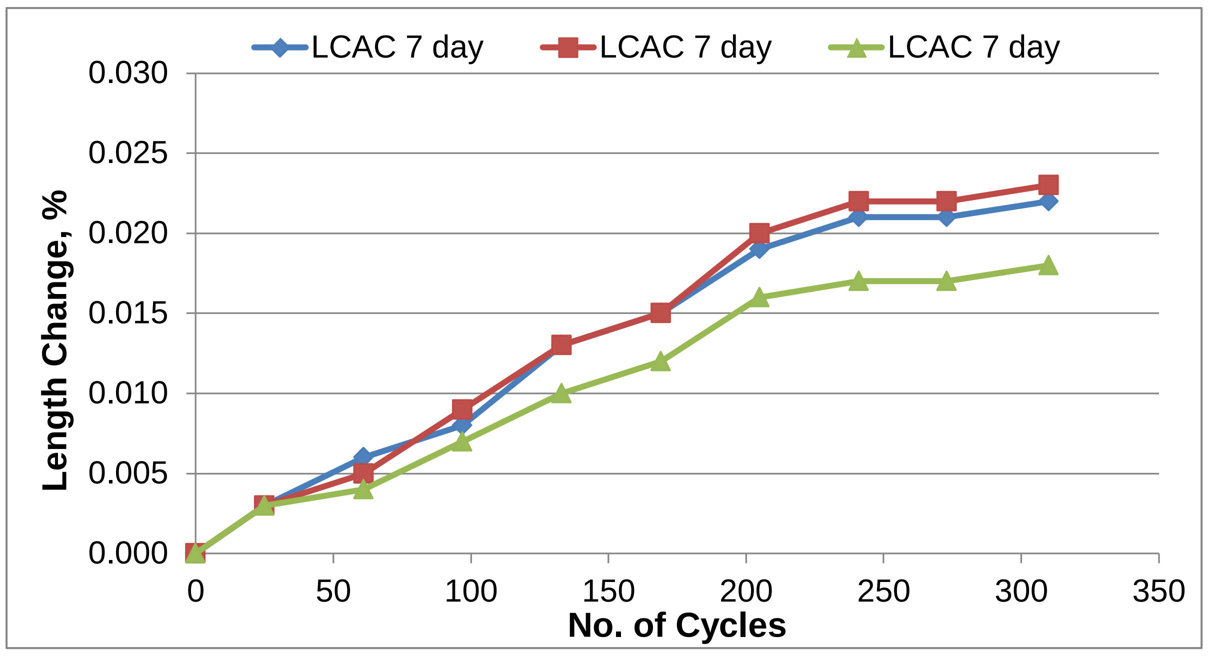
CTLGROUP

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Proj. Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

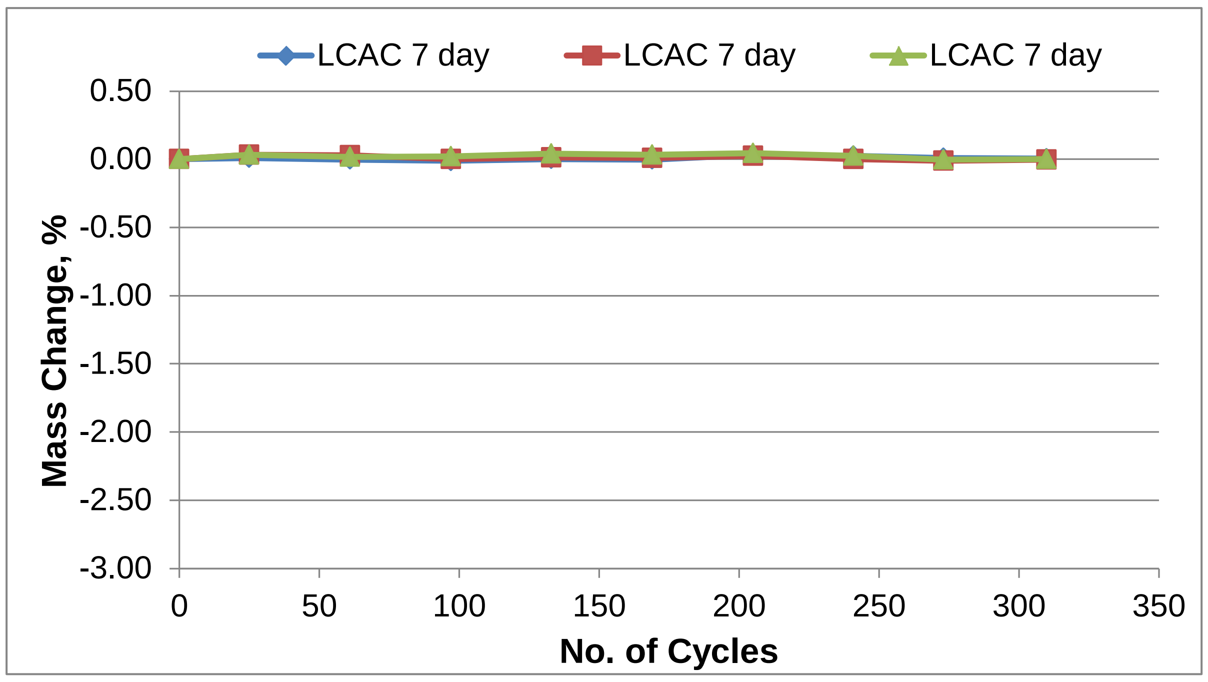
ASTM C666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing Procedure A, Freezing and Thawing in Water

Mix ID: LCAC - 7 Day Cure

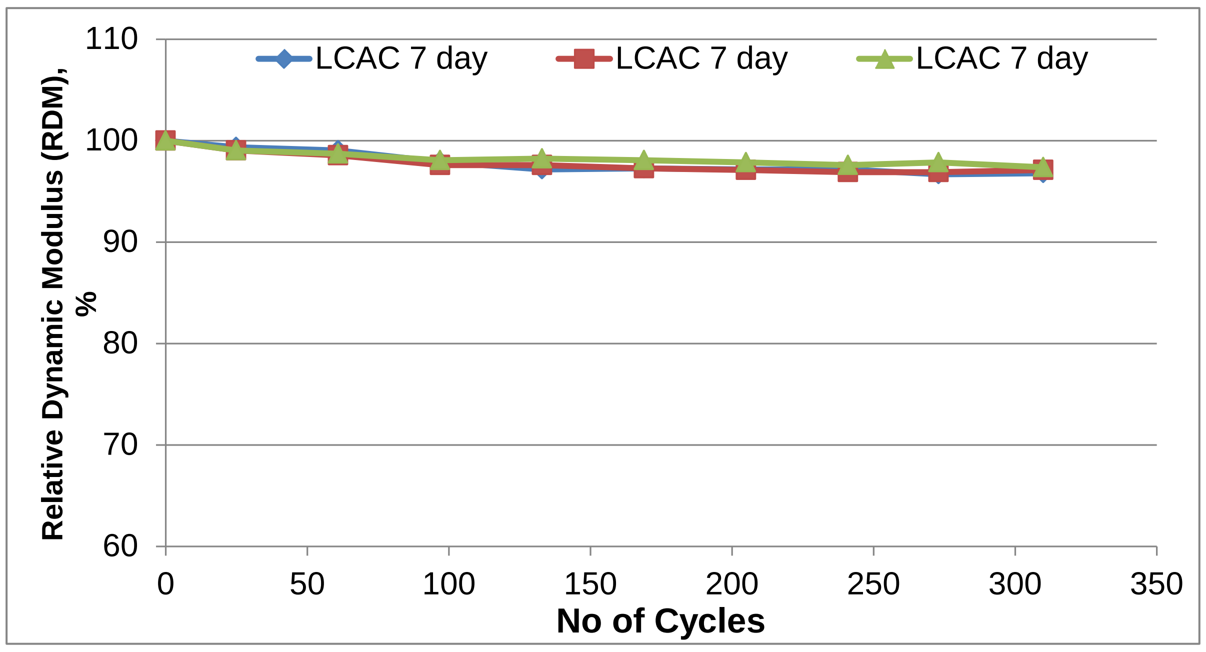
Freeze-Thaw	**Length Change, %**			
Cycles	LCAC 7 day	LCAC 7 day	LCAC 7 day	Average
0	0.000	0.000	0.000	0.000
25	0.003	0.003	0.003	0.003
61	0.006	0.005	0.004	0.005
97	0.008	0.009	0.007	0.008
133	0.013	0.013	0.010	0.012
169	0.015	0.015	0.012	0.014
205	0.019	0.020	0.016	0.018
241	0.021	0.022	0.017	0.020
273	0.021	0.022	0.017	0.020
310	0.022	0.023	0.018	0.021



Freeze-Thaw	**Mass Change, %**			
Cycles	LCAC 7 day	LCAC 7 day	LCAC 7 day	Average
Initial Mass	7167.3 g	7313.9 g	7251.8 g	--
0	0.00	0.00	0.00	0.00
25	0.01	0.03	0.03	0.03
61	0.00	0.03	0.02	0.01
97	-0.01	0.00	0.02	0.00
133	0.00	0.01	0.04	0.02
169	0.00	0.01	0.03	0.01
205	0.03	0.02	0.05	0.03
241	0.02	0.00	0.02	0.02
273	0.01	-0.01	0.00	0.00
310	0.01	0.00	0.00	0.00



Freeze-Thaw	**Relative Dynamic Modulus, %**			
Cycles	LCAC 7 day	LCAC 7 day	LCAC 7 day	Average
0	100	100	100	100
25	99	99	99	99
61	99	99	99	99
97	98	98	98	98
133	97	98	98	98
169	97	97	98	98
205	97	97	98	97
241	97	97	98	97
273	97	97	98	97
310	97	97	97	97



Notes:
1. Specimens were fabricated on June 26, 2014 at CTLGroup laboratories. Specimens were demolded after 1 day and stored in an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity until an age of 7 days. Testing started at 7 days.
2. Test specimens measure approximately 3x3x11-in. at 0 cycles.
3. A negative mass change indicates mass loss; a positive mass change indicates a mass gain.
4. The relative dynamic modulus was determined by the transverse frequency method of ASTM C215, Section 9.
5. This report may not be reproduced except in its entirety.

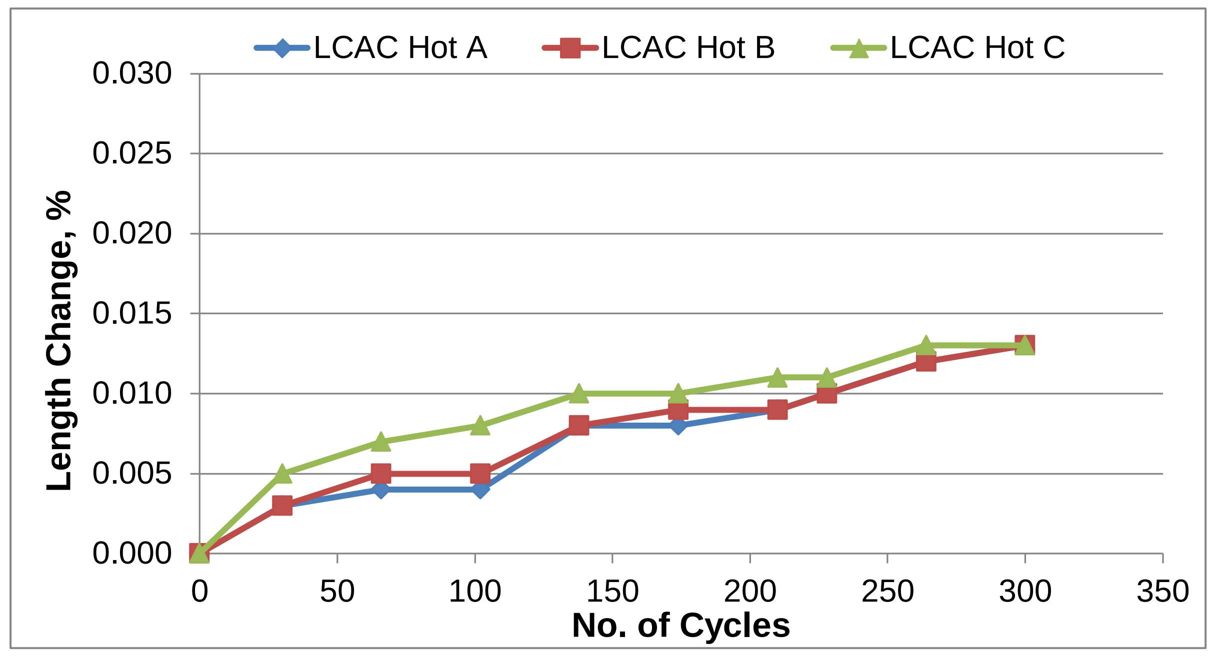
CTLGroup

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Proj. Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

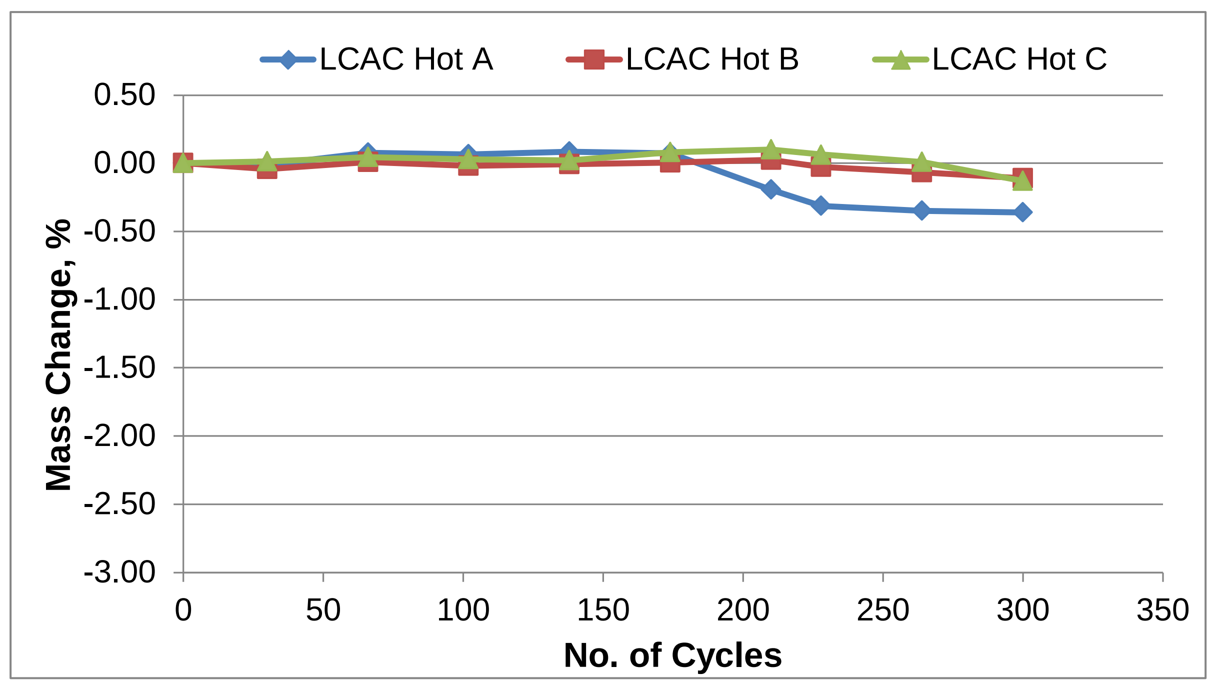
ASTM C666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
Procedure A, Freezing and Thawing in Water

Mix ID: LCAC Hot - 7 Day Elevated Temperature Cure (122°F)

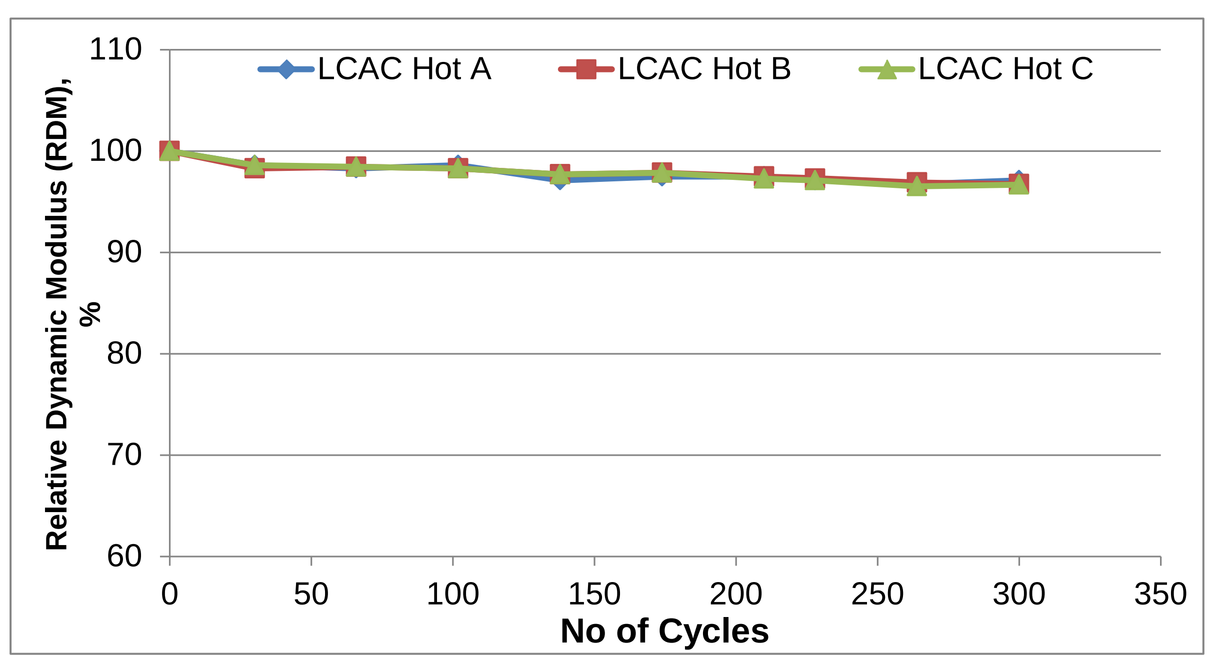
Freeze-Thaw Cycles	Length Change, %			
	LCAC Hot A	LCAC Hot B	LCAC Hot C	Average
0	0.000	0.000	0.000	0.000
30	0.003	0.003	0.005	0.004
66	0.004	0.005	0.007	0.005
102	0.004	0.005	0.008	0.006
138	0.008	0.008	0.010	0.009
174	0.008	0.009	0.010	0.009
210	0.009	0.009	0.011	0.010
228	0.010	0.010	0.011	0.010
264	0.012	0.012	0.013	0.012
300	0.013	0.013	0.013	0.013



Freeze-Thaw Cycles	Mass Change, %			
	LCAC Hot A	LCAC Hot B	LCAC Hot C	Average
Initial Mass	4205 g	4173.7 g	4127.3 g	--
0	0.00	0.00	0.00	0.00
30	-0.01	-0.04	0.01	-0.01
66	0.08	0.01	0.04	0.04
102	0.06	-0.02	0.03	0.02
138	0.09	-0.01	0.02	0.03
174	0.07	0.00	0.08	0.05
210	-0.20	0.03	0.10	-0.02
228	-0.31	-0.03	0.06	-0.09
264	-0.35	-0.07	0.01	-0.13
300	-0.36	-0.11	-0.13	-0.20



Freeze-Thaw Cycles	Relative Dynamic Modulus, %			
	LCAC Hot A	LCAC Hot B	LCAC Hot C	Average
0	100	100	100	100
30	99	98	99	98
66	98	98	98	98
102	99	98	98	98
138	97	98	98	97
174	97	98	98	98
210	97	97	97	97
228	97	97	97	97
264	97	97	97	97
300	97	97	97	97



Notes:
1. Specimens were fabricated on June 26, 2014 at CTLGroup laboratories. Specimens were demolded after 1 day and stored in a water tank at 50°C [122°F] until an age of 7 days. Testing started at 7 days.
2. Test specimens measure approximately 3x3x11-in. at 0 cycles.
3. A negative mass change indicates mass loss; a positive mass change indicates a mass gain.
4. The relative dynamic modulus was determined by the transverse frequency method of ASTM C215, Section 9.
5. This report may not be reproduced except in its entirety.

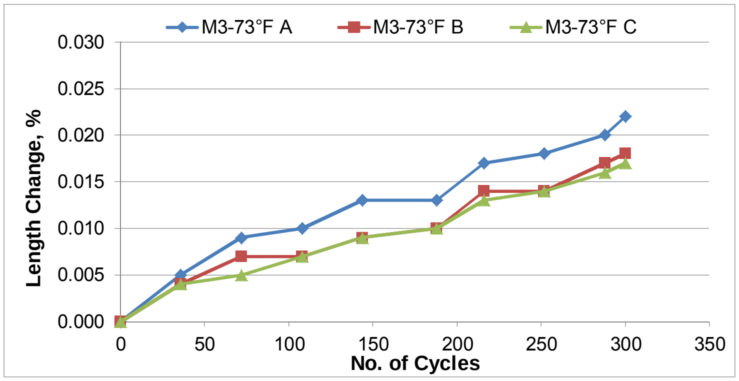
CTLGROUP

Client:	Illinois Tollway	CTL Project No:	057177
Project:	Calcium Aluminate Cement Project	CTL Proj. Mgr.:	M. D'Ambrosia
Contact:	Steve Gillen	Technician:	W. Demharter
Date Reported:	April 6, 2016	Approved:	B. Birch

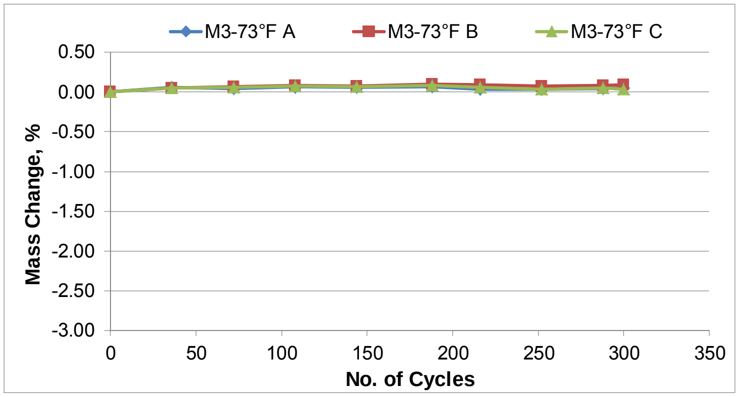
ASTM C666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
Procedure A, Freezing and Thawing in Water

Mix ID: LCAC-ASRA (2/19/16) 14 days standard cure

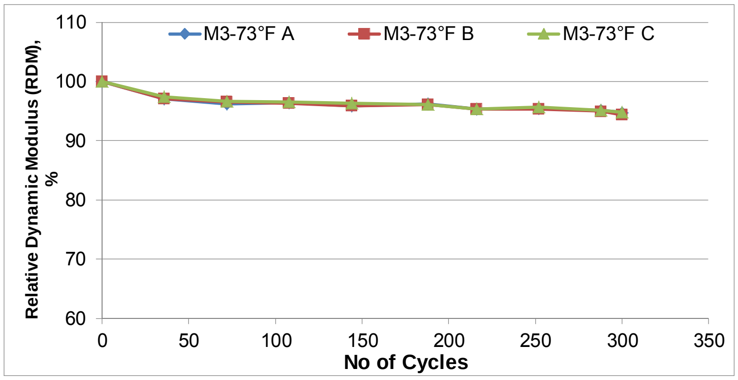
Freeze-Thaw	Length Change, %			
Cycles	M3-73°F A	M3-73°F B	M3-73°F C	Average
0	0.000	0.000	0.000	0.000
36	0.005	0.004	0.004	0.004
72	0.009	0.007	0.005	0.007
108	0.010	0.007	0.007	0.008
144	0.013	0.009	0.009	0.010
188	0.013	0.010	0.010	0.011
216	0.017	0.014	0.013	0.015
252	0.018	0.014	0.014	0.015
288	0.020	0.017	0.016	0.018
300	0.022	0.018	0.017	0.019



Freeze-Thaw	Mass Change, %			
Cycles	M3-73°F A	M3-73°F B	M3-73°F C	Average
Initial Mass	4122.3 g	4135.9 g	4171.5 g	--
0	0.00	0.00	0.00	0.00
36	0.06	0.05	0.05	0.05
72	0.04	0.07	0.06	0.06
108	0.06	0.08	0.08	0.07
144	0.06	0.08	0.07	0.07
188	0.07	0.10	0.08	0.08
216	0.04	0.09	0.06	0.06
252	0.03	0.07	0.04	0.05
288	0.04	0.08	0.05	0.06
300	0.05	0.09	0.04	0.06



Freeze-Thaw	Relative Dynamic Modulus, %			
Cycles	M3-73°F A	M3-73°F B	M3-73°F C	Average
0	100	100	100	100
36	97	97	97	97
72	96	97	97	96
108	96	96	97	96
144	96	96	96	96
188	96	96	96	96
216	95	95	95	95
252	96	95	96	96
288	95	95	95	95
300	95	94	95	95



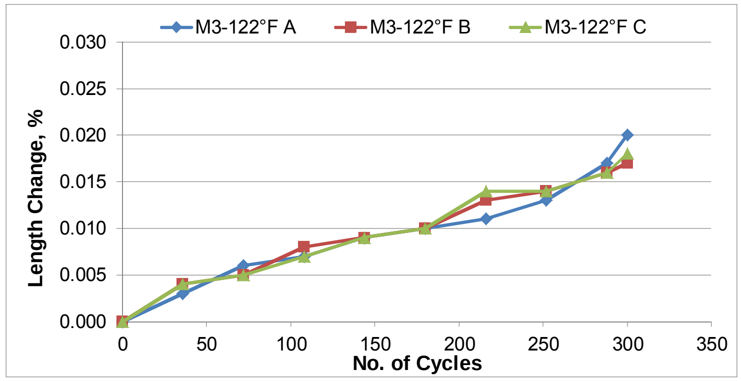
Notes:
1. Specimens were fabricated on February 19, 2016 at CTLGroup laboratories. Testing began after specimens were removed from their molds and cured for 14 days at 100% RH and 73°F.
2. Test specimens measure approximately 3x3x11-in. at 0 cycles.
3. A negative mass change indicates mass loss; a positive mass change indicates a mass gain.
4. The relative dynamic modulus was determined by the transverse frequency method of ASTM C215, Section 9.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Proj. Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**April 6, 2016**	Approved:	**B. Birch**

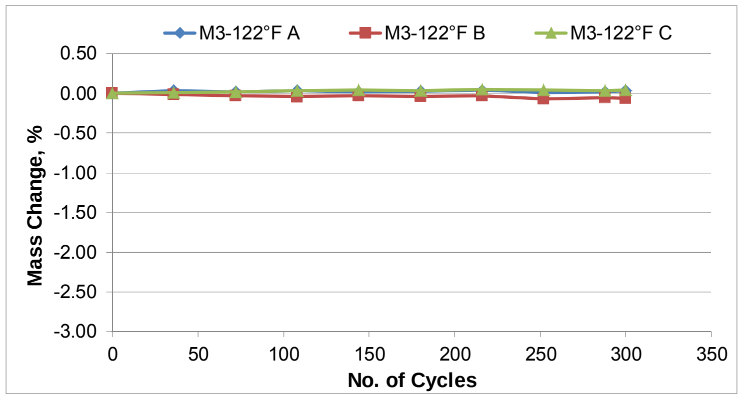
ASTM C666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
Procedure A, Freezing and Thawing in Water

Mix ID: LCAC-ASRA (2/19/16) 14 days hot (122°F) cure

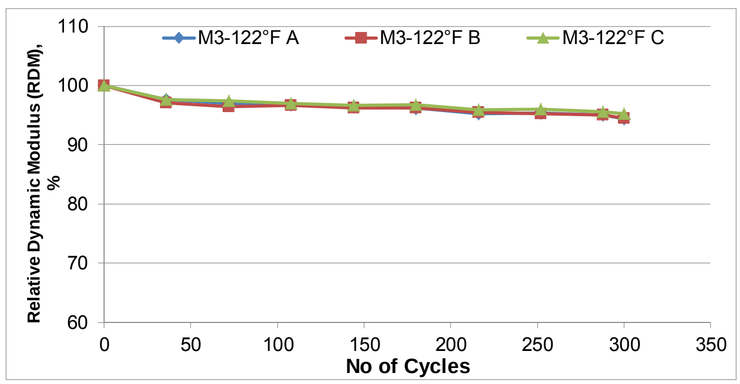
Freeze-Thaw	Length Change, %			
Cycles	M3-122°F A	M3-122°F B	M3-122°F C	Average
0	0.000	0.000	0.000	0.000
36	0.003	0.004	0.004	0.004
72	0.006	0.005	0.005	0.005
108	0.007	0.008	0.007	0.007
144	0.009	0.009	0.009	0.009
180	0.010	0.010	0.010	0.010
216	0.011	0.013	0.014	0.013
252	0.013	0.014	0.014	0.014
288	0.017	0.016	0.016	0.016
300	0.020	0.017	0.018	0.018



Freeze-Thaw	Mass Change, %			
Cycles	M3-122°F A	M3-122°F B	M3-122°F C	Average
Initial Mass	4097.8 g	4099.7 g	4143.7 g	--
0	0.00	0.00	0.00	0.00
36	0.03	-0.01	0.01	0.01
72	0.02	-0.03	0.02	0.00
108	0.03	-0.04	0.03	0.01
144	0.02	-0.03	0.05	0.01
180	0.03	-0.04	0.03	0.01
216	0.04	-0.03	0.05	0.02
252	0.01	-0.07	0.04	-0.01
288	0.02	-0.05	0.03	0.00
300	0.03	-0.06	0.05	0.01



Freeze-Thaw	Relative Dynamic Modulus, %			
Cycles	M3-122°F A	M3-122°F B	M3-122°F C	Average
0	100	100	100	100
36	98	97	98	97
72	97	96	97	97
108	97	97	97	97
144	96	96	97	96
180	96	96	97	96
216	95	95	96	96
252	95	95	96	96
288	95	95	96	95
300	94	94	95	95



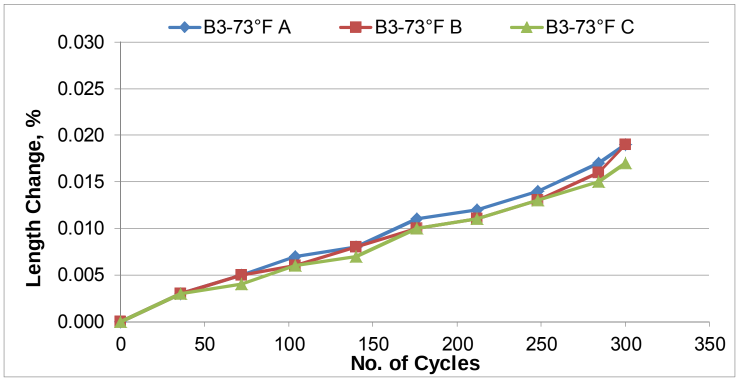
Notes:
1. Specimens were fabricated on February 19, 2016 at CTLGroup laboratories. Testing began after specimens were removed from their molds and cured for 14 days submerged in limewater at 122°F.
2. Test specimens measure approximately 3x3x11-in. at 0 cycles.
3. A negative mass change indicates mass loss; a positive mass change indicates a mass gain.
4. The relative dynamic modulus was determined by the transverse frequency method of ASTM C215, Section 9.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Proj. Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**October 7, 2016**	Approved:	**B. Birch**

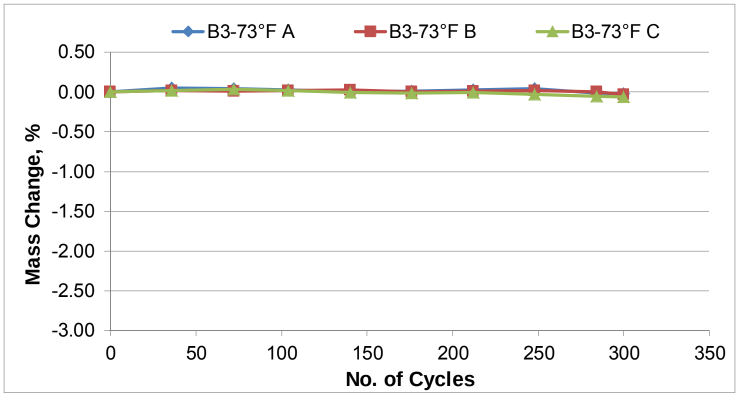
ASTM C666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
Procedure A, Freezing and Thawing in Water

Mix ID: LCAC-ASRA (03/08/2016) 14 days standard cure

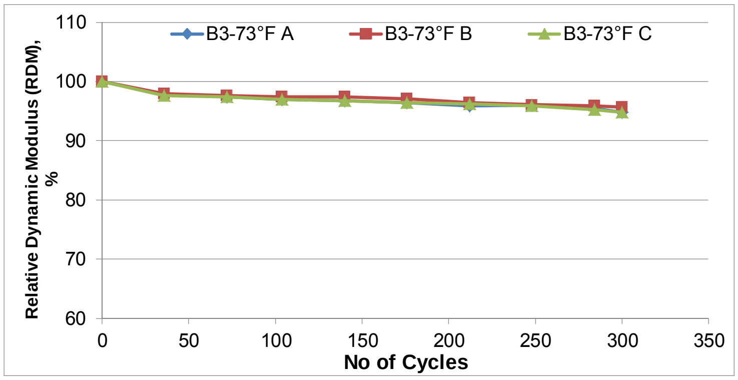
Freeze-Thaw Cycles	Length Change, %			
	B3-73°F A	B3-73°F B	B3-73°F C	Average
0	0.000	0.000	0.000	0.000
36	0.003	0.003	0.003	0.003
72	0.005	0.005	0.004	0.005
104	0.007	0.006	0.006	0.006
140	0.008	0.008	0.007	0.008
176	0.011	0.010	0.010	0.010
212	0.012	0.011	0.011	0.011
248	0.014	0.013	0.013	0.013
284	0.017	0.016	0.015	0.016
300	0.019	0.019	0.017	0.018



Freeze-Thaw Cycles	Mass Change, %			
	B3-73°F A	B3-73°F B	B3-73°F C	Average
Initial Mass	3955 g	4010.9 g	4008.2 g	--
0	0.00	0.00	0.00	0.00
36	0.05	0.02	0.02	0.03
72	0.04	0.01	0.03	0.03
104	0.03	0.02	0.02	0.02
140	0.00	0.02	0.00	0.01
176	0.01	0.00	-0.01	0.00
212	0.03	0.01	-0.01	0.01
248	0.04	0.02	-0.03	0.01
284	-0.01	0.00	-0.05	-0.02
300	-0.03	-0.03	-0.06	-0.04



Freeze-Thaw Cycles	Relative Dynamic Modulus, %			
	B3-73°F A	B3-73°F B	B3-73°F C	Average
0	100	100	100	100
36	98	98	98	98
72	97	98	97	97
104	97	97	97	97
140	97	97	97	97
176	96	97	96	97
212	96	96	96	96
248	96	96	96	96
284	95	96	95	96
300	95	96	95	95



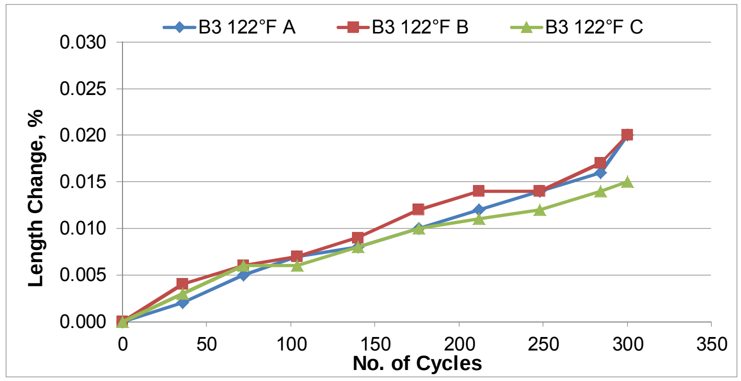
Notes:
1. Specimens were fabricated on March 8, 2016 at CTLGroup laboratories. Testing began after specimens were removed from their molds and cured for 14 days at 100% RH and 73°F.
2. Test specimens measure approximately 3x3x11-in. at 0 cycles.
3. A negative mass change indicates mass loss; a positive mass change indicates a mass gain.
4. The relative dynamic modulus was determined by the transverse frequency method of ASTM C215, Section 9.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Proj. Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**W. Demharter**
Date Reported:	**October 7, 2016**	Approved:	**B. Birch**

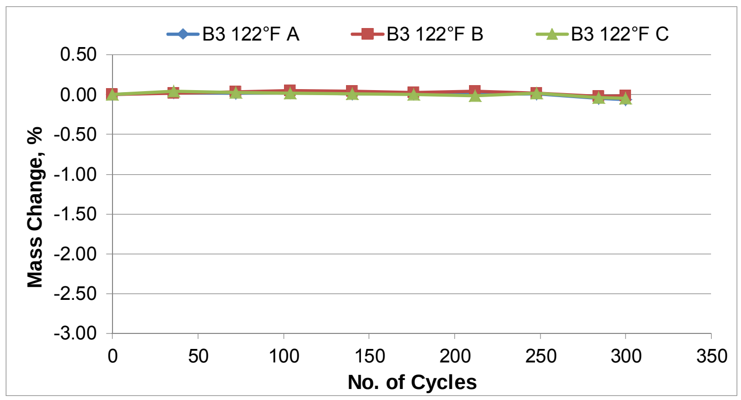
ASTM C666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing Procedure A, Freezing and Thawing in Water

Mix ID: LCAC-ASRA (03/08/2016) 14 days hot (122°F) cure

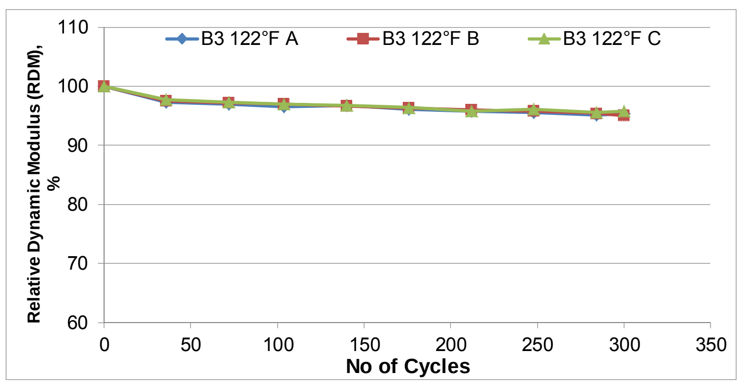
Freeze-Thaw	**Length Change, %**			
Cycles	B3 122°F A	B3 122°F B	B3 122°F C	Average
0	0.000	0.000	0.000	0.000
36	0.002	0.004	0.003	0.003
72	0.005	0.006	0.006	0.006
104	0.007	0.007	0.006	0.007
140	0.008	0.009	0.008	0.008
176	0.010	0.012	0.010	0.011
212	0.012	0.014	0.011	0.012
248	0.014	0.014	0.012	0.013
284	0.016	0.017	0.014	0.016
300	0.020	0.020	0.015	0.018



Freeze-Thaw	**Mass Change, %**			
Cycles	B3 122°F A	B3 122°F B	B3 122°F C	Average
Initial Mass	4027.9 g	3964.1 g	4015.4 g	--
0	0.00	0.00	0.00	0.00
36	0.03	0.02	0.04	0.03
72	0.02	0.03	0.03	0.03
104	0.03	0.05	0.01	0.03
140	0.01	0.04	0.01	0.02
176	0.01	0.03	0.00	0.01
212	0.00	0.04	-0.01	0.01
248	0.01	0.02	0.01	0.02
284	-0.04	-0.03	-0.04	-0.04
300	-0.06	-0.01	-0.04	-0.04



Freeze-Thaw	**Relative Dynamic Modulus, %**			
Cycles	B3 122°F A	B3 122°F B	B3 122°F C	Average
0	100	100	100	100
36	97	98	98	98
72	97	97	97	97
104	97	97	97	97
140	97	97	97	97
176	96	96	96	96
212	96	96	96	96
248	96	96	96	96
284	95	95	96	95
300	95	95	96	95



Notes:
1. Specimens were fabricated on March 8, 2016 at CTLGroup laboratories. Testing began after specimens were removed from their molds and cured for 14 days submerged in limewater at 122°F.
2. Test specimens measure approximately 3x3x11-in. at 0 cycles.
3. A negative mass change indicates mass loss; a positive mass change indicates a mass gain.
4. The relative dynamic modulus was determined by the transverse frequency method of ASTM C215, Section 9.
5. This report may not be reproduced except in its entirety.

Client: **Illinois Tollway** | CTLGroup Project No: **057212**
Project: **Calcium Aluminate Cement Project** | CTLGroup Proj. Mgr.: **M. D'Ambrosia**
Contact: **Steve Gillen** | Technician: **W. Demharter**
Report Date: **November 15, 2016** | Approved: **B. Birch**

ASTM C666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
Procedure A, Freezing and Thawing in Water

Mix ID: ALW4-T, 9/6/2016

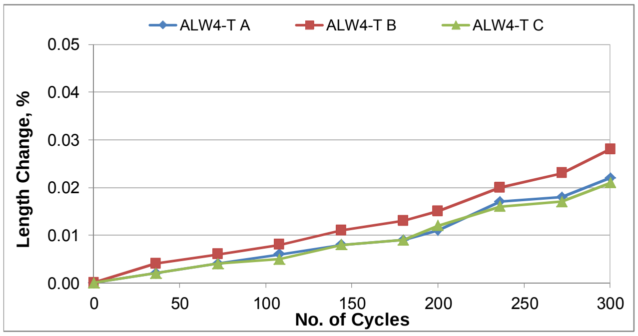
Summary of Test Results

Average length change at 300 cycles: 0.024%

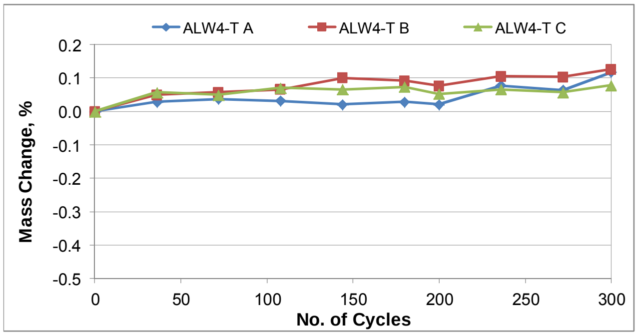
Average mass change at 300 cycles: 0.11%

Average durability factor at 300 cycles: 94%

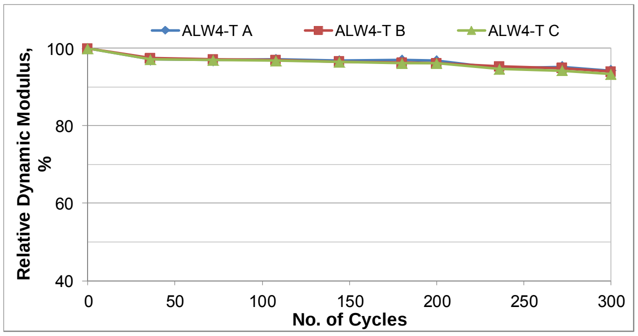
Freeze-Thaw	Length Change, %			
Cycles	ALW4-T A	ALW4-T B	ALW4-T C	Average
0	0.000	0.000	0.000	0.000
36	0.002	0.004	0.002	0.003
72	0.004	0.006	0.004	0.005
108	0.006	0.008	0.005	0.006
144	0.008	0.011	0.008	0.009
180	0.009	0.013	0.009	0.010
200	0.011	0.015	0.012	0.013
236	0.017	0.020	0.016	0.018
272	0.018	0.023	0.017	0.019
300	0.022	0.028	0.021	0.024



Freeze-Thaw	Mass Change, %			
Cycles	ALW4-T A	ALW4-T B	ALW4-T C	Average
Initial Mass	3745.2 g	3784.1 g	3792.1 g	--
0	0.00	0.00	0.00	0.00
36	0.03	0.05	0.06	0.05
72	0.04	0.06	0.05	0.05
108	0.03	0.07	0.07	0.06
144	0.02	0.10	0.07	0.06
180	0.03	0.09	0.07	0.07
200	0.02	0.08	0.05	0.05
236	0.08	0.11	0.07	0.08
272	0.06	0.10	0.06	0.08
300	0.12	0.13	0.08	0.11



Freeze-Thaw	Relative Dynamic Modulus, %			
Cycles	ALW4-T A	ALW4-T B	ALW4-T C	Average
0	100	100	100	100
36	97	97	97	97
72	97	97	97	97
108	97	97	97	97
144	97	97	97	97
180	97	96	96	96
200	97	96	96	96
236	95	95	95	95
272	95	95	94	95
300	94	94	93	94



Notes:
1. Specimens were fabricated by CTLGroup on September 6, 2016.
2. Upon removal from the molds, samples were cured in limewater at 73°F for 14 days.
3. Test specimens measure approximately 3x3x11-in. at 0 cycles.
4. A negative mass change indicates mass loss; a positive mass change indicates a mass gain.
5. The relative dynamic modulus was determined by the transverse frequency method of ASTM C215, Section 9.
6. This report may not be reproduced except in its entirety.

APPENDIX H

ASTM C672 SALT SCALING

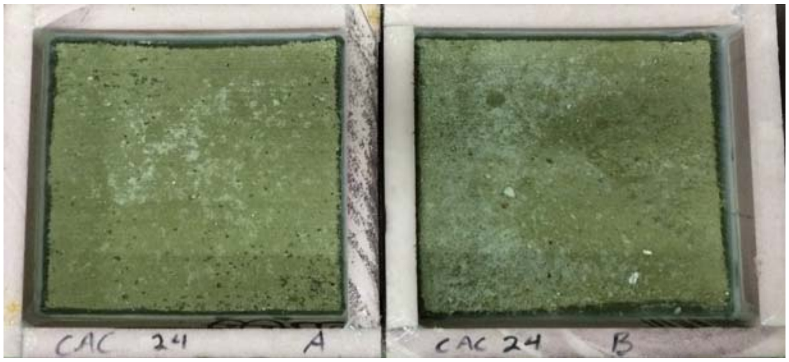
TEST RESULTS

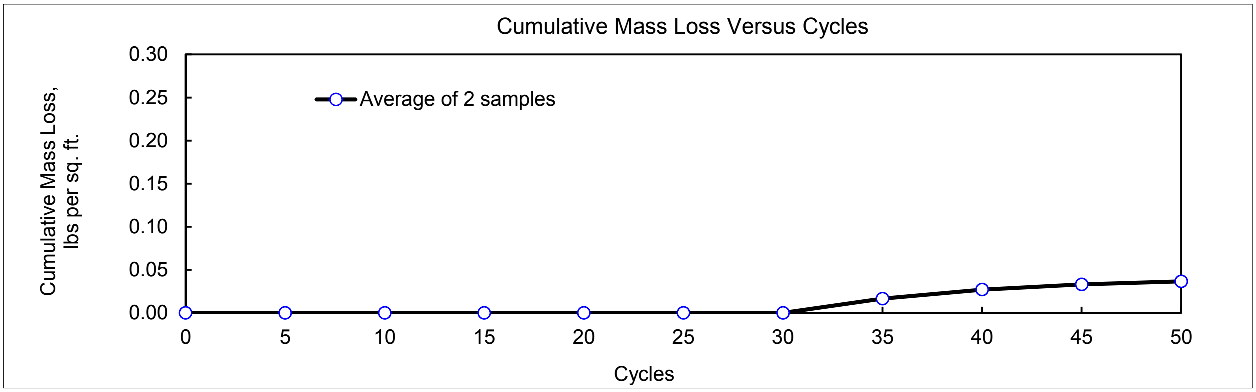
Client:	Illinois Tollway	CTL Project No:	057177
Project:	Calcium Aluminate Cement Project	CTL Project Mgr.:	M. D'Ambrosia
Contact:	Steve Gillen	Analyst:	W. Demharter
Date Reported:	August 19, 2015	Approved:	B. Birch

ASTM C672 - Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals

Mix ID: CAC - 24 Hours Moist Burlap Cure

	Cumulative Mass Loss, lbs per sq. ft.			Visual Scale Rating		
Cycle	CAC 24hr A	CAC 24hr B	Ave	CAC 24hr A	CAC 24hr B	Ave
0	0.00	0.00	0.00	0	0	0.0
5	0.00	0.00	0.00	0	0	0.0
10	0.00	0.00	0.00	0	0	0.0
15	0.00	0.00	0.00	0	0	0.0
20	0.00	0.00	0.00	0	0	0.0
25	0.00	0.00	0.00	0	0	0.0
30	0.00	0.00	0.00	0	0	0.0
35	0.01	0.03	0.02	1	2	1.5
40	0.02	0.04	0.03	1	2	1.5
45	0.02	0.04	0.03	1	2	1.5
50	0.03	0.05	0.04	1	2	1.5





Notes:
1. Samples were cast on June 26, 2014 by CTL.
2. Samples demolded after 24 hours and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity for 14 days prior to testing.
3. 4% $CaCl_2$ was used as the deicer solution.
4. These results specifically refer to the submitted samples.

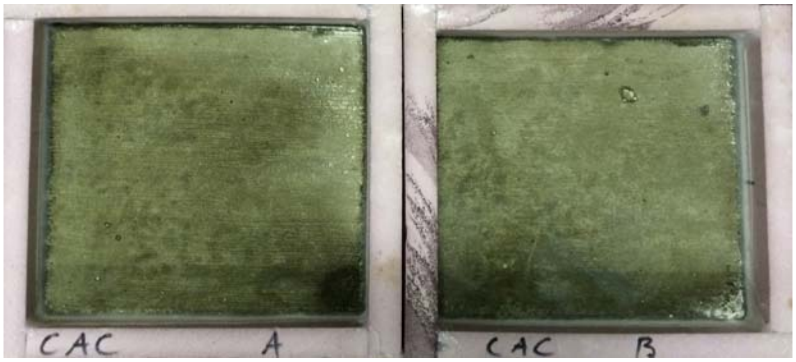
Rating / Condition of Surface
0 - No scaling
1 - Very slight scaling (1/8 in. depth max, no coarse aggregate visible)
2 - Slight to moderate scaling
3 - Moderate scaling (some coarse aggregate visible)
4 - Moderate to severe scaling
5 - Severe scaling (coarse aggregate visible over entire surface)

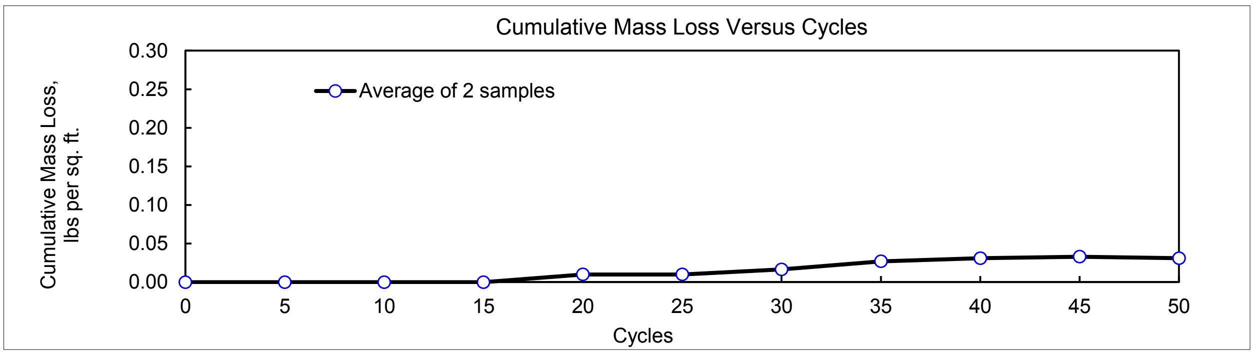
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

ASTM C672 - Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals

Mix ID: CAC - 7 Day Moist Cure

	Cumulative Mass Loss, lbs per sq. ft.			Visual Scale Rating		
Cycle	CAC A	CAC B	Ave	CAC A	CAC B	Ave
0	0.00	0.00	0.00	0	0	0.0
5	0.00	0.00	0.00	0	0	0.0
10	0.00	0.00	0.00	0	0	0.0
15	0.00	0.00	0.00	0	0	0.0
20	0.01	0.01	0.01	1	1	1.0
25	0.01	0.01	0.01	1	1	1.0
30	0.02	0.02	0.02	1	1	1.0
35	0.03	0.03	0.03	1	1	1.0
40	0.03	0.03	0.03	1	1	1.0
45	0.03	0.03	0.03	1	1	1.0
50	0.03	0.03	0.03	1	1	1.0





Notes:
1. Samples were cast on June 26, 2014 by CTL.
2. Samples stored in a moist room for 7 days at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity for 14 days prior to testing.
3. 4% $CaCl_2$ was used as the deicer solution.
4. These results specifically refer to the submitted samples.

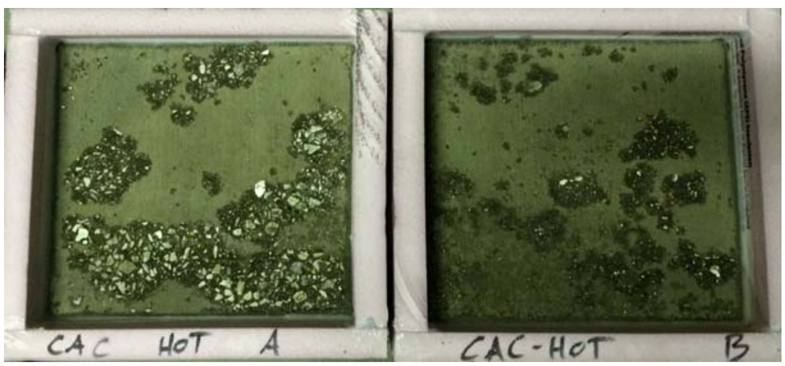
Rating / Condition of Surface
0 - No scaling
1 - Very slight scaling (1/8 in. depth max, no coarse aggregate visible)
2 - Slight to moderate scaling
3 - Moderate scaling (some coarse aggregate visible)
4 - Moderate to severe scaling
5 - Severe scaling (coarse aggregate visible over entire surface)

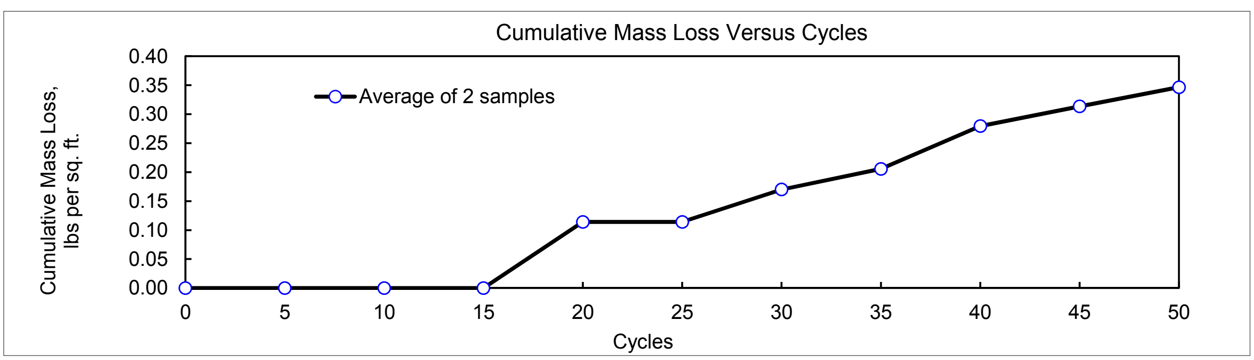
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

ASTM C672 - Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals

Mix ID: CAC Hot- 7 Day Elevated Temperature Cure (122°F)

	Cumulative Mass Loss, lbs per sq. ft.			Visual Scale Rating		
Cycle	CAC HOT A	CAC HOT B	Ave	CAC HOT A	CAC HOT B	Ave
0	0.00	0.00	0.00	0	0	0.0
5	0.00	0.00	0.00	0	0	0.0
10	0.00	0.00	0.00	0	0	0.0
15	0.00	0.00	0.00	0	0	0.0
20	0.08	0.15	0.11	2	3	2.5
25	0.08	0.15	0.11	2	3	2.5
30	0.12	0.22	0.17	2	3	2.5
35	0.15	0.26	0.21	2	3	2.5
40	0.21	0.35	0.28	3	4	3.5
45	0.25	0.38	0.31	3	4	3.5
50	0.28	0.42	0.35	3	4	3.5





Notes:
1. Samples were cast on June 26, 2014 by CTL.
2. Samples stored in a water tank for 7 days at 50°C [122°F] and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity for 14 days prior to testing.
3. 4% $CaCl_2$ was used as the deicer solution.
4. These results specifically refer to the submitted samples.

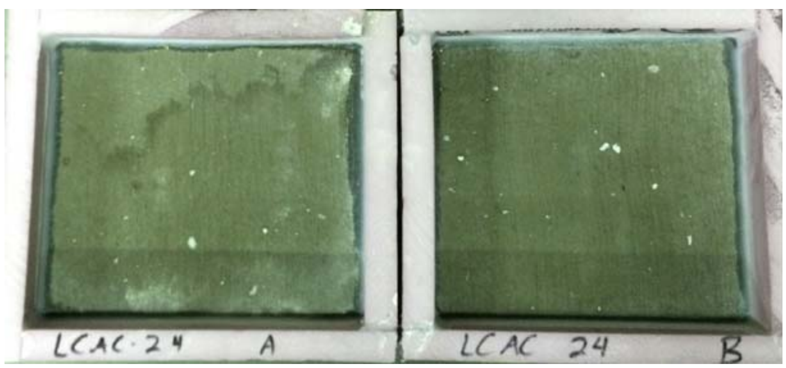
Rating / Condition of Surface
0 - No scaling
1 - Very slight scaling (1/8 in. depth max, no coarse aggregate visible)
2 - Slight to moderate scaling
3 - Moderate scaling (some coarse aggregate visible)
4 - Moderate to severe scaling
5 - Severe scaling (coarse aggregate visible over entire surface)

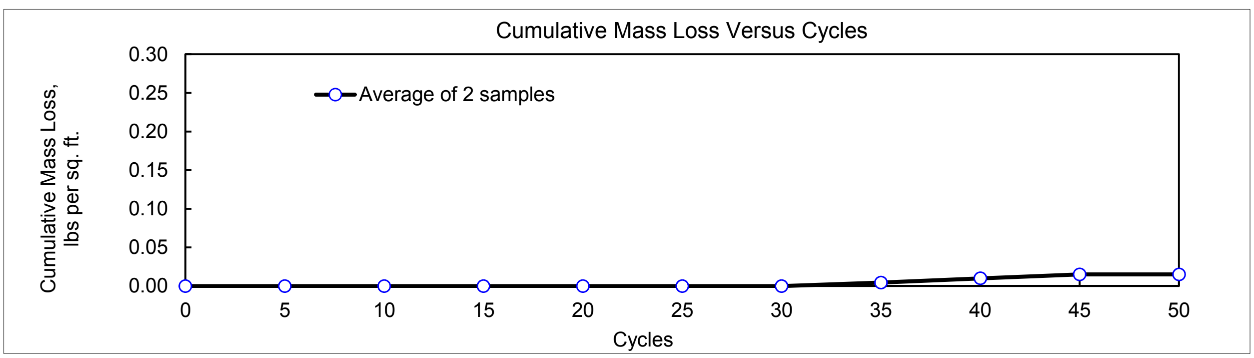
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

ASTM C672 - Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals

Mix ID: LCAC - 24 Hours Plastic Cover Cure

	Cumulative Mass Loss, lbs per sq. ft.			Visual Scale Rating		
Cycle	LCAC 24hr A	LCAC 24hr B	Ave	LCAC 24hr A	LCAC 24hr B	Ave
0	0.00	0.00	0.00	0	0	0.0
5	0.00	0.00	0.00	0	0	0.0
10	0.00	0.00	0.00	0	0	0.0
15	0.00	0.00	0.00	0	0	0.0
20	0.00	0.00	0.00	0	0	0.0
25	0.00	0.00	0.00	0	0	0.0
30	0.00	0.00	0.00	0	0	0.0
35	0.00	0.01	0.00	1	1	1.0
40	0.01	0.01	0.01	1	1	1.0
45	0.01	0.02	0.02	1	1	1.0
50	0.01	0.02	0.02	1	1	1.0





Notes:
1. Samples were cast on June 26, 2014 by CTL.
2. Samples demolded after 24 hours and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity for 14 days prior to testing.
3. 4% $CaCl_2$ was used as the deicer solution.
4. These results specifically refer to the submitted samples.

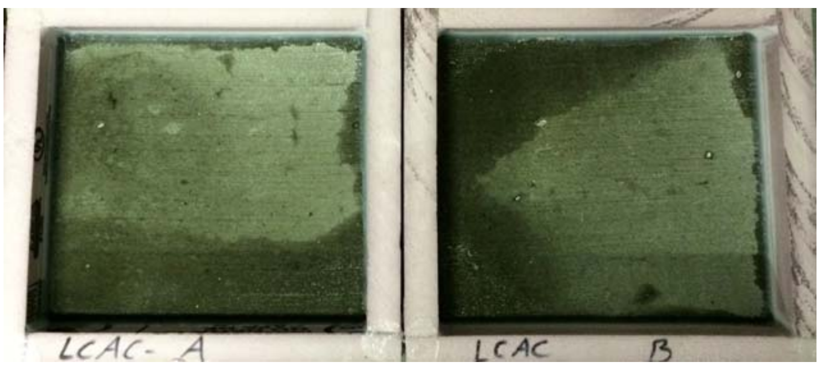
Rating / Condition of Surface
0 - No scaling
1 - Very slight scaling (1/8 in. depth max, no coarse aggregate visible)
2 - Slight to moderate scaling
3 - Moderate scaling (some coarse aggregate visible)
4 - Moderate to severe scaling
5 - Severe scaling (coarse aggregate visible over entire surface)

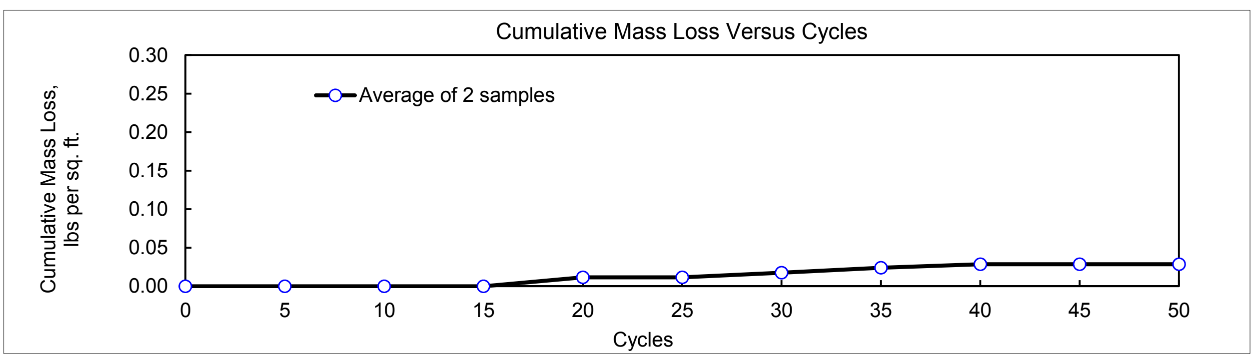
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**W. Demharter**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

ASTM C672 - Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals

Mix ID: LCAC - 7 Day Cure

	Cumulative Mass Loss, lbs per sq. ft.			Visual Scale Rating		
Cycle	LCAC A	LCAC B	Ave	LCAC A	LCAC B	Ave
0	0.00	0.00	0.00	0	0	0.0
5	0.00	0.00	0.00	0	0	0.0
10	0.00	0.00	0.00	0	0	0.0
15	0.00	0.00	0.00	0	0	0.0
20	0.01	0.01	0.01	1	1	1.0
25	0.01	0.01	0.01	1	1	1.0
30	0.02	0.02	0.02	1	1	1.0
35	0.03	0.02	0.02	1	1	1.0
40	0.03	0.03	0.03	1	1	1.0
45	0.03	0.03	0.03	1	1	1.0
50	0.03	0.03	0.03	1	1	1.0





Notes:
1. Samples were cast on June 26, 2014 by CTL.
2. Samples stored in an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity for 21 days prior to testing.
3. 4% $CaCl_2$ was used as the deicer solution.
4. These results specifically refer to the submitted samples.

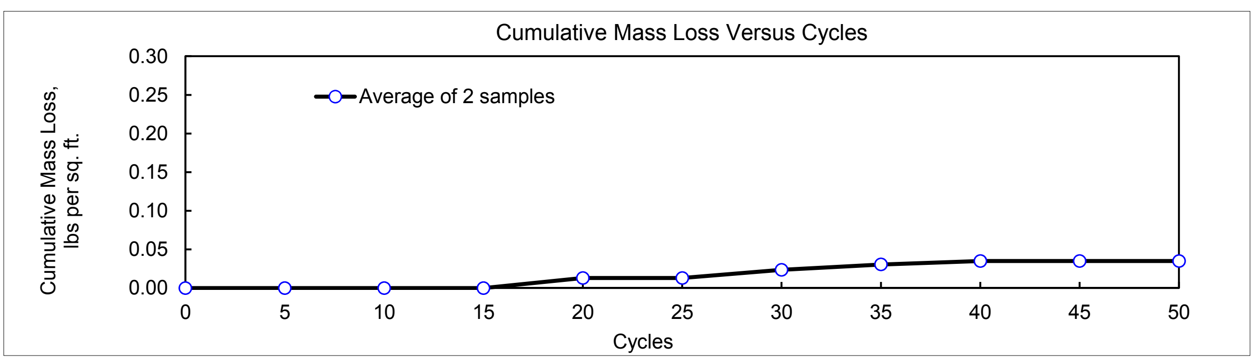
Rating / Condition of Surface
0 - No scaling
1 - Very slight scaling (1/8 in. depth max, no coarse aggregate visible)
2 - Slight to moderate scaling
3 - Moderate scaling (some coarse aggregate visible)
4 - Moderate to severe scaling
5 - Severe scaling (coarse aggregate visible over entire surface)

Client:	Illinois Tollway	CTL Project No:	057177
Project:	Calcium Aluminate Cement Project	CTL Project Mgr.:	M. D'Ambrosia
Contact:	Steve Gillen	Analyst:	W. Demharter
Date Reported:	August 19, 2015	Approved:	B. Birch

ASTM C672 - Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals

Mix ID: LCAC Hot - 7 Day Elevated Temperature Cure (122°F)

	Cumulative Mass Loss, lbs per sq. ft.			Visual Scale Rating		
Cycle	LCAC HOT A	LCAC HOT B	Ave	LCAC HOT A	LCAC HOT B	Ave
0	0.00	0.00	0.00	0	0	0.0
5	0.00	0.00	0.00	0	0	0.0
10	0.00	0.00	0.00	0	0	0.0
15	0.00	0.00	0.00	0	0	0.0
20	0.01	0.02	0.01	1	1	1.0
25	0.01	0.02	0.01	1	1	1.0
30	0.02	0.02	0.02	1	1	1.0
35	0.03	0.03	0.03	1	1	1.0
40	0.03	0.04	0.04	1	1	1.0
45	0.03	0.04	0.04	1	1	1.0
50	0.03	0.04	0.04	1	1	1.0



Notes:
1. Samples were cast on June 26, 2014 by CTL.
2. Samples stored in a water tank for 7 days at 50°C [122°F] and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity for 14 days prior to testing.
3. 4% $CaCl_2$ was used as the deicer solution.
4. These results specifically refer to the submitted samples.

Rating / Condition of Surface
0 - No scaling
1 - Very slight scaling (1/8 in. depth max, no coarse aggregate visible)
2 - Slight to moderate scaling
3 - Moderate scaling (some coarse aggregate visible)
4 - Moderate to severe scaling
5 - Severe scaling (coarse aggregate visible over entire surface)

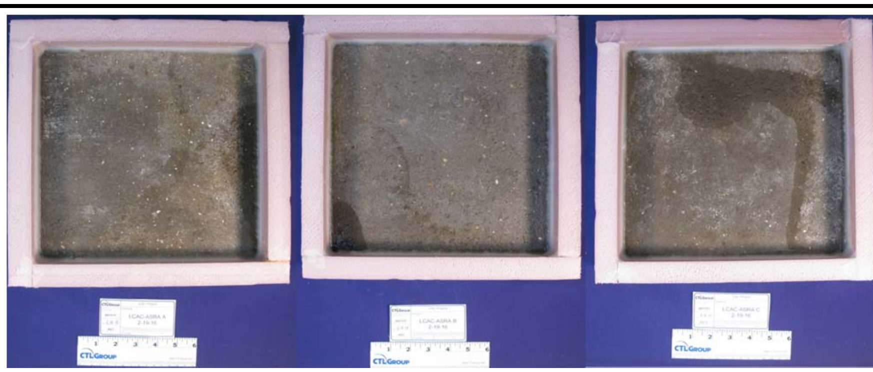
Client: **Illinois Tollway**
Project: **Calcium Aluminate Cement Project**
Contact: **Steve Gillen**
Date Reported: **June 16, 2016**

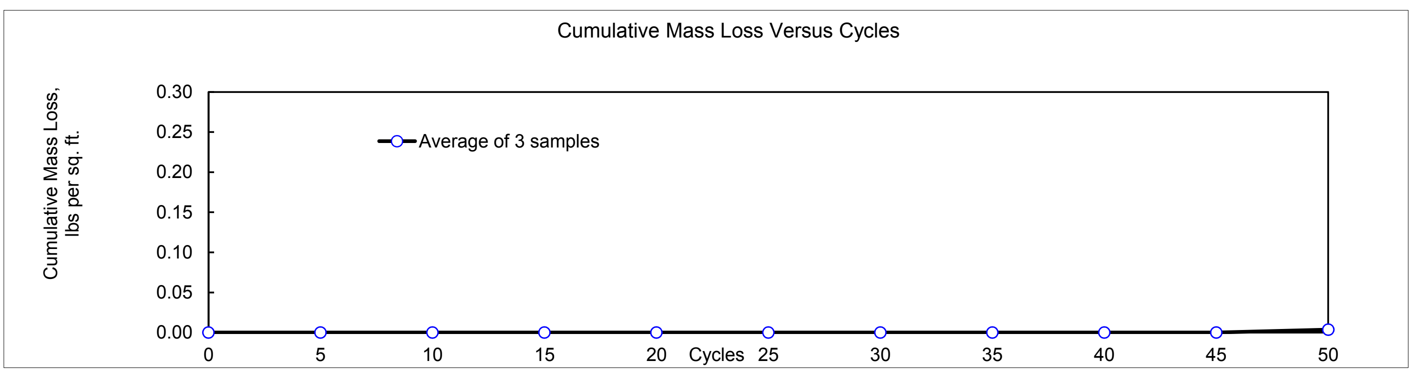
CTL Project No: **057177**
CTL Project Mgr.: **M. D'Ambrosia**
Analyst: **W. Demharter**
Approved: **B. Birch**

ASTM C672 - Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals

Mix ID: ASRA 2/19/16

	Cumulative Mass Loss, lbs per sq. ft.				Visual Scale Rating			
Cycle	M3-A	M3-B	M3-C	Ave	M3-A	M3-B	M3-C	Ave
0	0.00	0.00	0.00	0.00	0	0	0	0
5	0.00	0.00	0.00	0.00	0	0	0	0
10	0.00	0.00	0.00	0.00	0	0	0	0
15	0.00	0.00	0.00	0.00	0	0	0	0
20	0.00	0.00	0.00	0.00	0	0	0	0
25	0.00	0.00	0.00	0.00	0	0	0	0
30	0.00	0.00	0.00	0.00	0	0	0	0
35	0.00	0.00	0.00	0.00	0	0	0	0
40	0.00	0.00	0.00	0.00	0	0	0	0
45	0.00	0.00	0.00	0.00	0	0	0	0
50	0.00	0.01	0.00	0.00	0	0	0	0





Notes:
1. Samples were cast on February 19, 2016 by CTLGroup.
2. Samples demolded after 24 hours and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity for 14 days. At 14 days the samples were transferred to a 100°F lime water tank for 14 days prior to testing.
3. 4% $CaCl_2$ was used as the deicer solution.
4. These results specifically refer to the submitted samples.

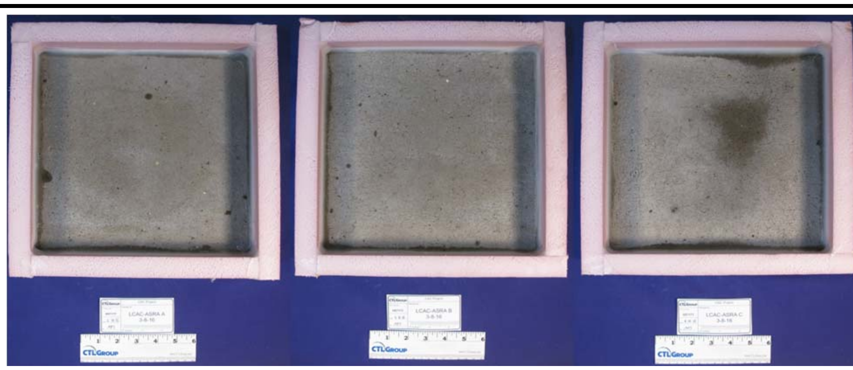
Rating / Condition of Surface
0 - No scaling
1 - Very slight scaling (1/8 in. depth max, no coarse aggregate visible)
2 - Slight to moderate scaling
3 - Moderate scaling (some coarse aggregate visible)
4 - Moderate to severe scaling
5 - Severe scaling (coarse aggregate visible over entire surface)

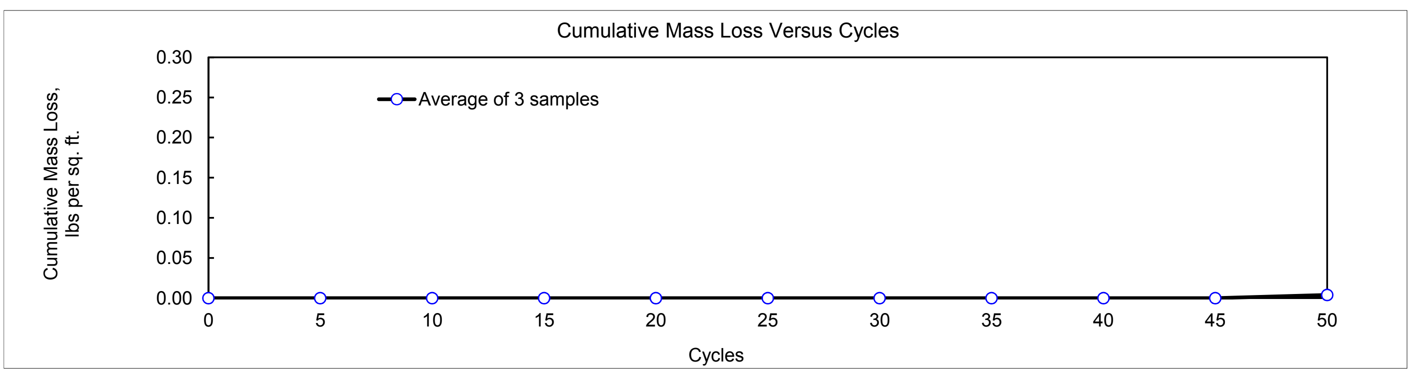
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**W. Demharter**
Date Reported:	**June 16, 2016**	Approved:	**B. Birch**

ASTM C672 - Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals

Mix ID: ASRA2 3/8/16

	Cumulative Mass Loss, lbs per sq. ft.				Visual Scale Rating			
Cycle	B3-A	B3-B	B3-C	Ave	B3-A	B3-B	B3-C	Ave
0	0.00	0.00	0.00	0.00	0	0	0	0
5	0.00	0.00	0.00	0.00	0	0	0	0
10	0.00	0.00	0.00	0.00	0	0	0	0
15	0.00	0.00	0.00	0.00	0	0	0	0
20	0.00	0.00	0.00	0.00	0	0	0	0
25	0.00	0.00	0.00	0.00	0	0	0	0
30	0.00	0.00	0.00	0.00	0	0	0	0
35	0.00	0.00	0.00	0.00	0	0	0	0
40	0.00	0.00	0.00	0.00	0	0	0	0
45	0.00	0.00	0.00	0.00	0	0	0	0
50	0.00	0.01	0.00	0.00	0	0	0	0





Notes:
1. Samples were cast on March 8, 2016 by CTL.
2. Samples demolded after 24 hours and then transferred an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity for 14 days. At 14 days the samples were transferred to a 100°F lime water tank for 14 days prior to testing.
3. 4% $CaCl_2$ was used as the deicer solution.
4. These results specifically refer to the submitted samples.

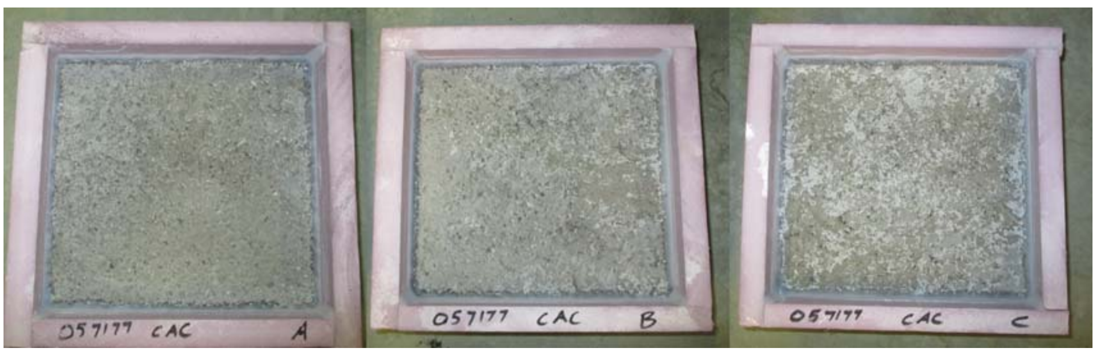
Rating / Condition of Surface
0 - No scaling
1 - Very slight scaling (1/8 in. depth max, no coarse aggregate visible)
2 - Slight to moderate scaling
3 - Moderate scaling (some coarse aggregate visible)
4 - Moderate to severe scaling
5 - Severe scaling (coarse aggregate visible over entire surface)

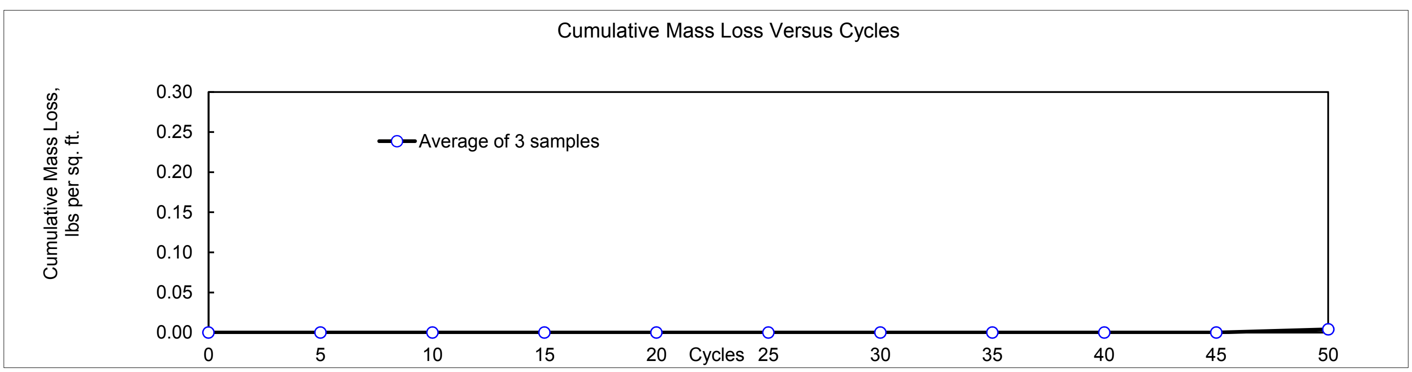
Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**W. Demharter**
Date Reported:	**December 15, 2016**	Approved:	**B. Birch**

ASTM C672 - Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals

Mix ID: ALW4-T 9-6-16

	Cumulative Mass Loss, lbs per sq. ft.				Visual Scale Rating			
Cycle	M3-A	M3-B	M3-C	Ave	M3-A	M3-B	M3-C	Ave
0	0.00	0.00	0.00	0.00	0	0	0	0
5	0.00	0.00	0.00	0.00	0	0	0	0
10	0.00	0.00	0.00	0.00	0	0	0	0
15	0.00	0.00	0.00	0.00	0	0	0	0
20	0.00	0.00	0.00	0.00	0	0	0	0
25	0.00	0.00	0.00	0.00	0	0	0	0
30	0.00	0.00	0.00	0.00	0	0	0	0
35	0.00	0.00	0.00	0.00	0	0	0	0
40	0.00	0.00	0.00	0.00	0	0	0	0
45	0.00	0.00	0.00	0.00	0	0	0	0
50	0.00	0.01	0.00	0.00	0	0	0	0





Notes:
1. Samples were cast on September 6, 2016 by CTLGroup.
2. Samples demolded after 6 hours and then transferred to a 73°F lime water tank for 28 days prior to testing.
3. 4% $CaCl_2$ was used as the deicer solution.
4. These results specifically refer to the submitted samples.

Rating / Condition of Surface
0 - No scaling
1 - Very slight scaling (1/8 in. depth max, no coarse aggregate visible)
2 - Slight to moderate scaling
3 - Moderate scaling (some coarse aggregate visible)
4 - Moderate to severe scaling
5 - Severe scaling (coarse aggregate visible over entire surface)

APPENDIX I

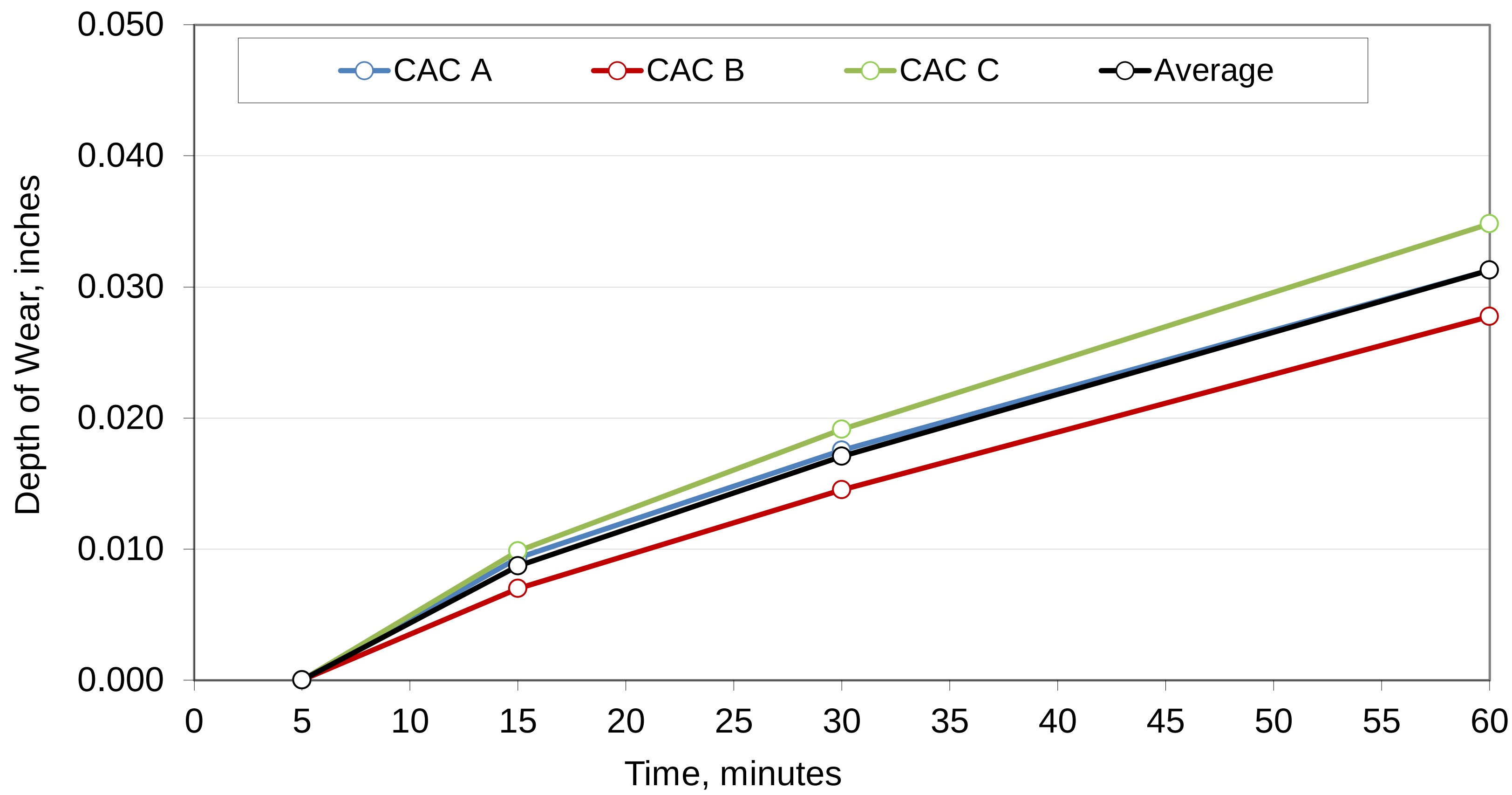
ASTM C779 ABRASION RESISTANCE

TEST RESULTS

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**J. Pycz**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

ASTM C779 Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces
Procedure A - Revolving Discs

	Depth of Wear, inches			
Sample ID	5 minutes	15 minutes	30 minutes	60 minutes
CAC A	0.000	0.009	0.018	0.031
CAC B	0.000	0.007	0.015	0.028
CAC C	0.000	0.010	0.019	0.035
Average	0.000	0.009	0.017	0.031



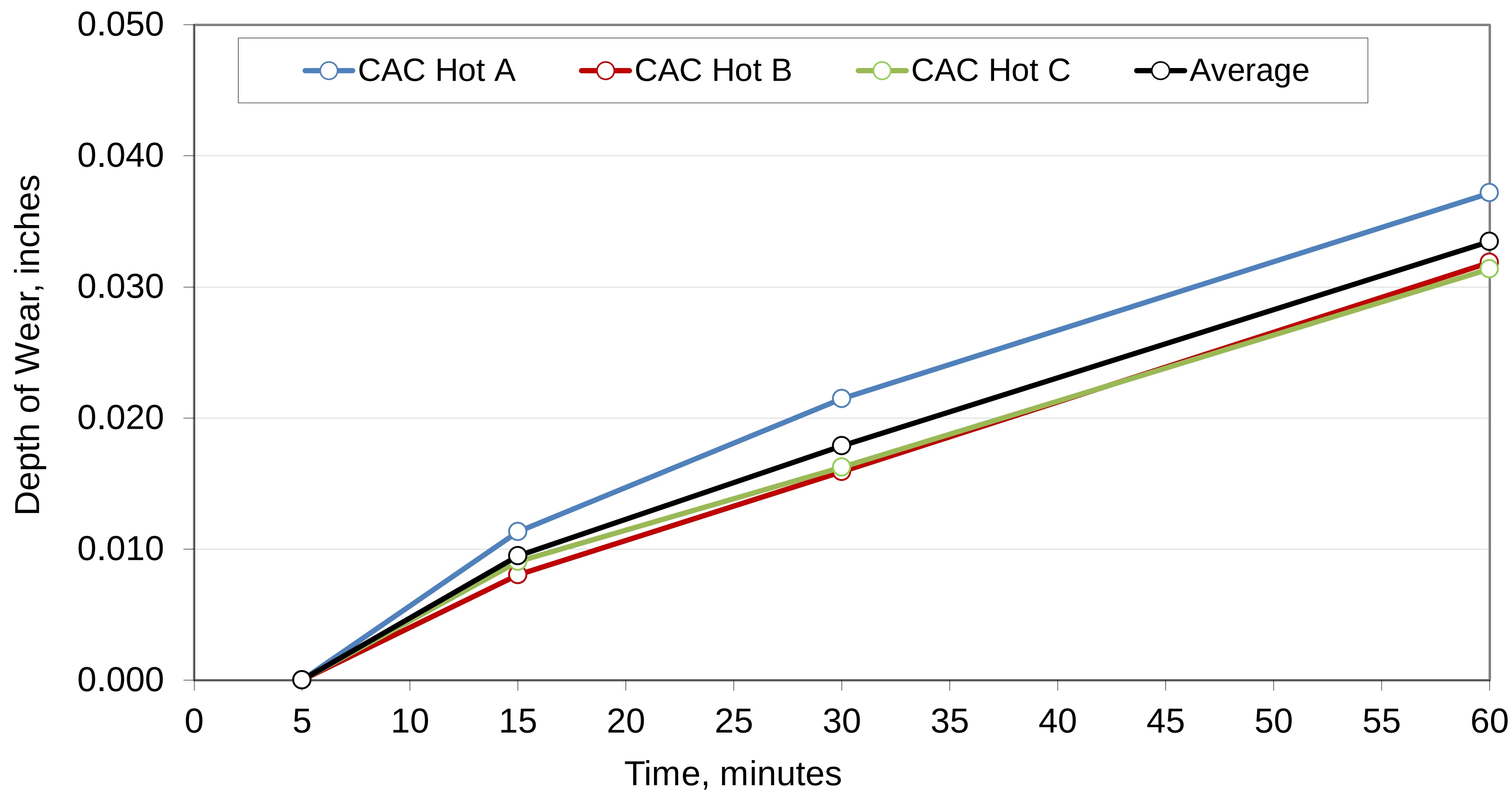
Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. The results specifically represent the tested sample.
4. Specimens were stored for 7 days in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity and then transferred to an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity for 14 days prior to testing.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**J. Pycz**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

ASTM C779 Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces
Procedure A - Revolving Discs

	Depth of Wear, inches			
Sample ID	5 minutes	15 minutes	30 minutes	60 minutes
CAC Hot A	0.000	0.011	0.021	0.037
CAC Hot B	0.000	0.008	0.016	0.032
CAC Hot C	0.000	0.009	0.016	0.031
Average	0.000	0.009	0.018	0.033



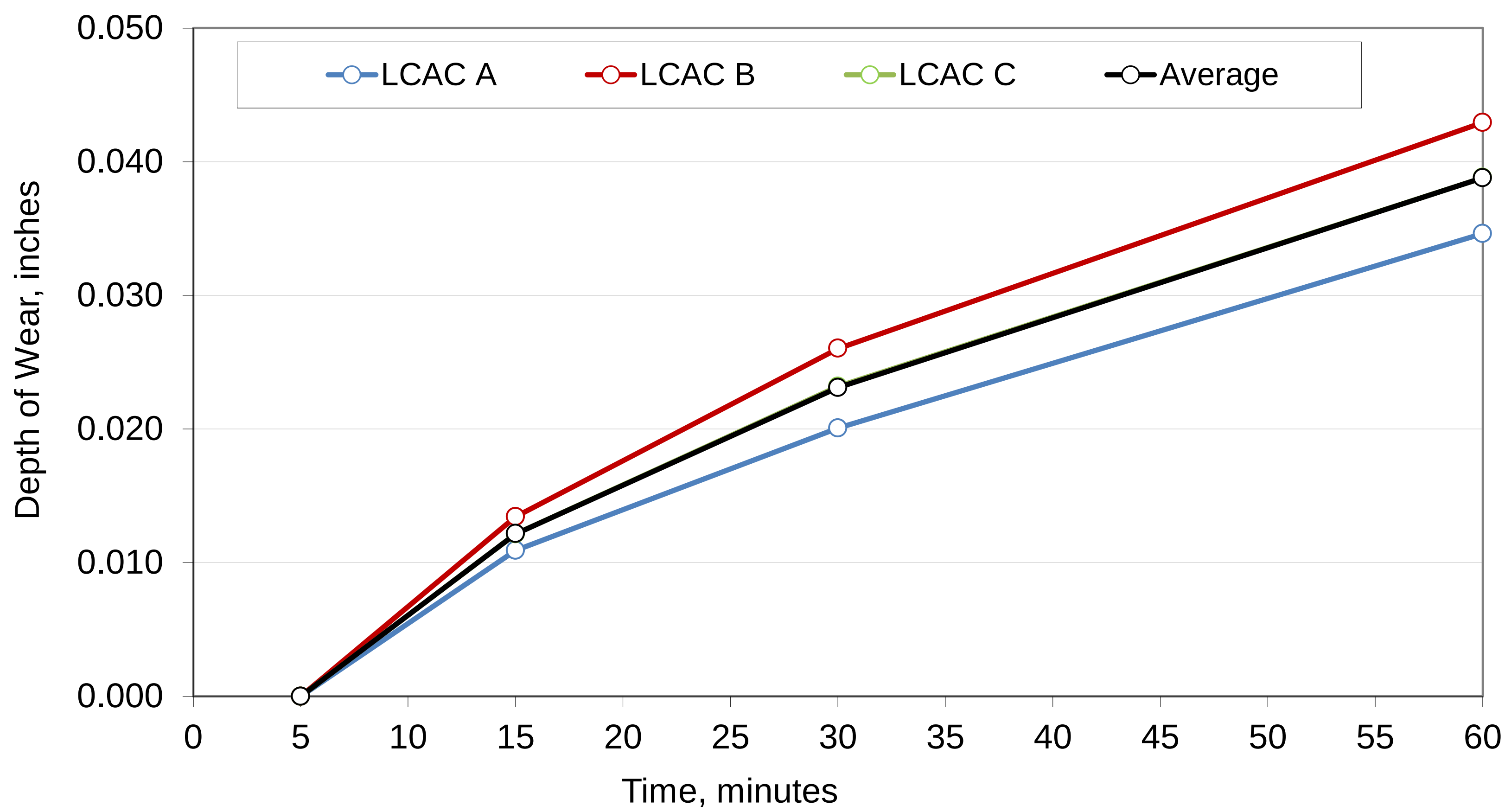
Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. The results specifically represent the tested sample.
4. Specimens were stored in a water tank for 7 days at 50°C [122°F] and then transferred to an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity for 14 days prior to testing.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**J. Pycz**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

ASTM C779 Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces
Procedure A - Revolving Discs

	Depth of Wear, inches			
Sample ID	5 minutes	15 minutes	30 minutes	60 minutes
LCAC A	0.000	0.011	0.020	0.035
LCAC B	0.000	0.013	0.026	0.043
LCAC C	0.000	0.012	0.023	0.039
Average	0.000	0.012	0.023	0.039



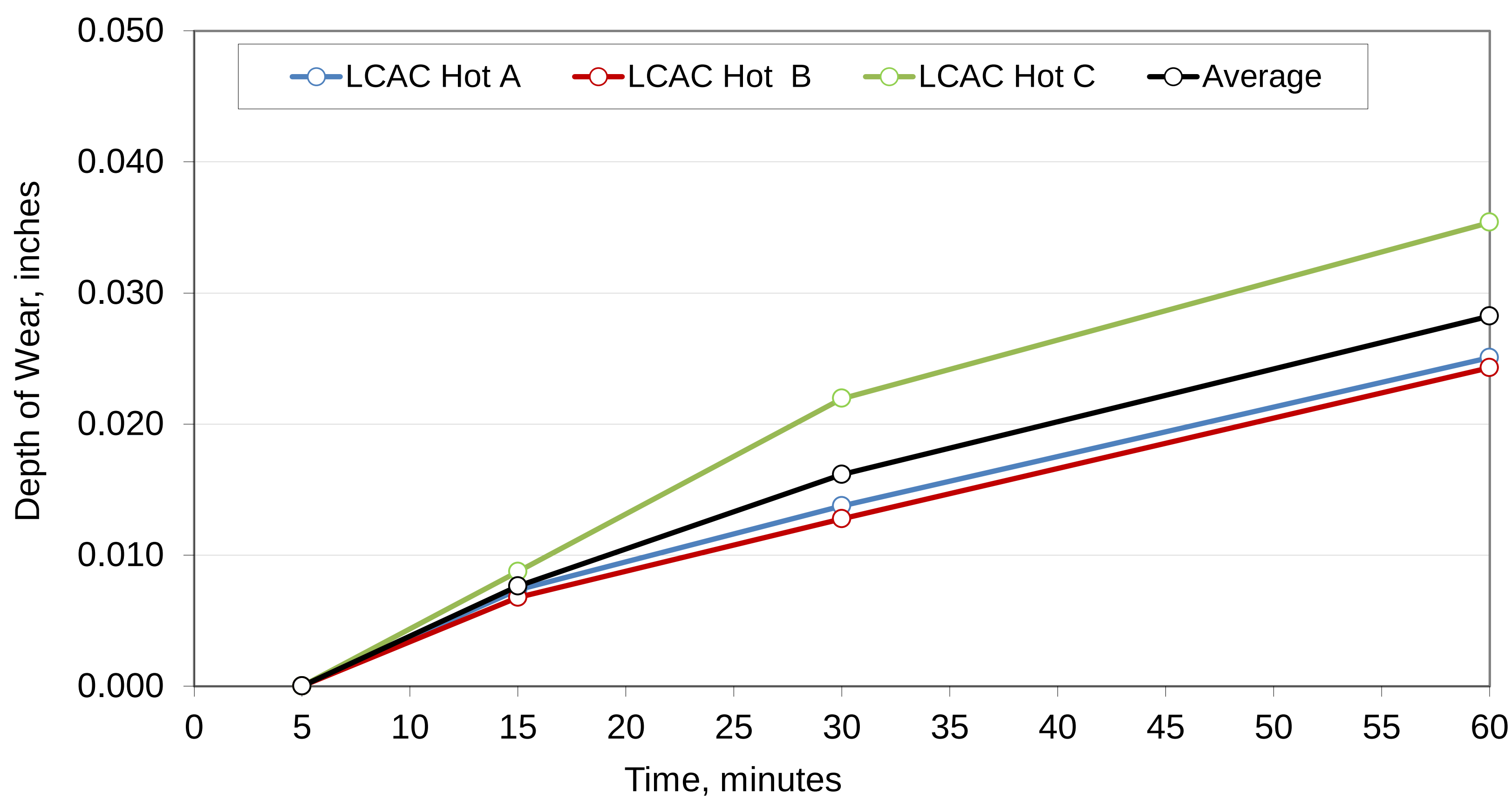
Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. The results specifically represent the tested sample.
4. Specimens were stored in an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity for 21 days prior to testing.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**J. Pycz**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

ASTM C779 Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces
Procedure A - Revolving Discs

	Depth of Wear, inches			
Sample ID	5 minutes	15 minutes	30 minutes	60 minutes
LCAC Hot A	0.000	0.007	0.014	0.025
LCAC Hot B	0.000	0.007	0.013	0.024
LCAC Hot C	0.000	0.009	0.022	0.035
Average	0.000	0.008	0.016	0.028



Notes:

1. Specimens fabricated on June 26, 2014 at CTLGroup Laboratories.
2. Specimens were made of calcium aluminate cement concrete.
3. The results specifically represent the tested sample.
4. Specimens were stored in a water tank for 7 days at 50°C [122°F] and 100% relative humidity and then transferred to an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity for 14 days prior to testing.
5. This report may not be reproduced except in its entirety.

APPENDIX J

ASTM C1202 RAPID CHLORIDE PENETRABILITY TEST RESULTS

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**P. Brindise**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

REPORT of ANALYSIS

ASTM C1202 (AASHTO T227)

Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Age on Test Date	Charge Passed (coulombs)	Chloride Ion Penetrability
CAC-1	6/26/2014	6/27/2014	1	707	Very Low
CAC-2	6/26/2014	6/27/2014	1	745	Very Low
CAC-3	6/26/2014	6/27/2014	1	765	Very Low
Average				**739**	**Very Low**

Interpretation of results:

ASTM C1202 - 12, Table X1.1: Chloride Ion Penetrability Based on Charge Passed

Charge Passed (coulombs)	Chloride Ion Penetrability
>4000	High
2000 - 4000	Moderate
1000 - 2000	Low
100 - 1000	Very Low
< 100	Negligible

Notes:

1. Specimens fabricated on June 26, 2014 by CTLGroup.
2. One 4x2-inch nominal disk was saw-cut from the top of each submitted 4x8-inch concrete cylinder.
3. Test preparations began at an age of 24 hours with the removal of the mold.
4. This analysis specifically represents the submitted samples.
5. This report may not be reproduced except in its entirety.

CTLGroup

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**P. Brindise**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

REPORT of ANALYSIS

ASTM C1202 (AASHTO T227)

Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Age on Test Date	Charge Passed (coulombs)	Chloride Ion Penetrability
CAC-1	6/26/2014	7/7/2014	11	435	Very Low
CAC-2	6/26/2014	7/7/2014	11	329	Very Low
CAC-3	6/26/2014	7/7/2014	11	429	Very Low
Average				**398**	**Very Low**

Interpretation of results:

ASTM C1202 - 12, Table X1.1: Chloride Ion Penetrability Based on Charge Passed

Charge Passed (coulombs)	Chloride Ion Penetrability
>4000	High
2000 - 4000	Moderate
1000 - 2000	Low
100 - 1000	Very Low
< 100	Negligible

Notes:

1. Specimens fabricated on June 26, 2014 by CTLGroup.
2. One 4x2-inch nominal disk was saw-cut from the top of each submitted 4x8-inch concrete cylinder.
3. Specimens were cured in limewater at 23.0 ± 2.0°C [73.5 ± 3.5°F] until test preparations.
4. This analysis specifically represents the submitted samples.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**P. Brindise**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

REPORT of ANALYSIS

ASTM C1202 (AASHTO T227)

Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Age on Test Date	Charge Passed (coulombs)	Chloride Ion Penetrability
CAC Hot-1	6/26/2014	7/7/2014	11	1271	Low
CAC Hot-2	6/26/2014	7/7/2014	11	1189	Low
CAC Hot-3	6/26/2014	7/7/2014	11	1295	Low
Average				**1252**	**Low**

Interpretation of results:

ASTM C1202 - 12, Table X1.1: Chloride Ion Penetrability Based on Charge Passed

Charge Passed (coulombs)	Chloride Ion Penetrability
>4000	High
2000 - 4000	Moderate
1000 - 2000	Low
100 - 1000	Very Low
< 100	Negligible

Notes:

1. Specimens fabricated on June 26, 2014 by CTLGroup.
2. One 4x2-inch nominal disk was saw-cut from the top of each submitted 4x8-inch concrete cylinder.
3. Specimens were cured in a water tank at 50°C [122°F] until an age of 7 days and then transferred to limewater at 23.0 ± 2.0°C [73.5 ± 3.5°F] until test preparations.
4. This analysis specifically represents the submitted samples.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**P. Brindise**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

REPORT of ANALYSIS

ASTM C1202 (AASHTO T227)

Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Age on Test Date	Charge Passed (coulombs)	Chloride Ion Penetrability
LCAC-1	6/26/2014	6/27/2014	1	573	Very Low
LCAC-2	6/26/2014	6/27/2014	1	592	Very Low
LCAC-3	6/26/2014	6/27/2014	1	604	Very Low
Average				**590**	**Very Low**

Interpretation of results:

ASTM C1202 - 12, Table X1.1: Chloride Ion Penetrability Based on Charge Passed

Charge Passed (coulombs)	Chloride Ion Penetrability
>4000	High
2000 - 4000	Moderate
1000 - 2000	Low
100 - 1000	Very Low
< 100	Negligible

Notes:

1. Specimens fabricated on June 26, 2014 by CTLGroup.
2. One 4x2-inch nominal disk was saw-cut from the top of each submitted 4x8-inch concrete cylinder.
3. Test preparations began at an age of 24 hours with the removal of the mold.
4. This analysis specifically represents the submitted samples.
5. This report may not be reproduced except in its entirety.

CTLGroup

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**P. Brindise**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

REPORT of ANALYSIS

ASTM C1202 (AASHTO T227)

Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Age on Test Date	Charge Passed (coulombs)	Chloride Ion Penetrability
LCAC-1	6/26/2014	7/7/2014	11	237	Very Low
LCAC-2	6/26/2014	7/7/2014	11	252	Very Low
LCAC-3	6/26/2014	7/7/2014	11	260	Very Low
Average				**250**	**Very Low**

Interpretation of results:

ASTM C1202 - 12, Table X1.1: Chloride Ion Penetrability Based on Charge Passed

Charge Passed (coulombs)	Chloride Ion Penetrability
>4000	High
2000 - 4000	Moderate
1000 - 2000	Low
100 - 1000	Very Low
< 100	Negligible

Notes:

1. Specimens fabricated on June 26, 2014 by CTLGroup.
2. One 4x2-inch nominal disk was saw-cut from the top of each submitted 4x8-inch concrete cylinder.
3. Specimens were cured at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity until test preparations.
4. This analysis specifically represents the submitted samples.
5. This report may not be reproduced except in its entirety.

CTLGROUP

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**P. Brindise**
Date Reported:	**August 19, 2015**	Approved by:	**B. Birch**

REPORT of ANALYSIS

ASTM C1202 (AASHTO T227)

Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Age on Test Date	Charge Passed (coulombs)	Chloride Ion Penetrability
LCAC Hot-1	6/26/2014	7/8/2014	12	502	Very Low
LCAC Hot-2	6/26/2014	7/8/2014	12	566	Very Low
LCAC Hot-3	6/26/2014	7/7/2014	11	481	Very Low
Average				**516**	**Very Low**

Interpretation of results:

ASTM C1202 - 12, Table X1.1: Chloride Ion Penetrability Based on Charge Passed

Charge Passed (coulombs)	Chloride Ion Penetrability
>4000	High
2000 - 4000	Moderate
1000 - 2000	Low
100 - 1000	Very Low
< 100	Negligible

Notes:

1. Specimens fabricated on June 26, 2014 by CTLGroup.
2. One 4x2-inch nominal disk was saw-cut from the top of each submitted 4x8-inch concrete cylinder.
3. Specimens were cured in a water tank at 50°C [122°F] until an age of 7 days and then transferred to an environment at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity until test preparations.
4. This analysis specifically represents the submitted samples.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**P. Brindise**
Date Reported:	**April 6, 2016**	Approved by:	**J. Pacheco**

REPORT of ANALYSIS

ASTM C1202 (AASHTO T227)

Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Age on Test Date	Charge Passed (coulombs)	Chloride Ion Penetrability
ASRA (1)	2/19/2016	3/18/2016	28	92.21	Negligible
ASRA (2)	2/19/2016	3/18/2016	28	90.32	Negligible
ASRA (3)	2/19/2016	3/18/2016	28	88.91	Negligible
Average				**90**	**Negligible**

Interpretation of results:

ASTM C1202 - 12, Table X1.1: Chloride Ion Penetrability Based on Charge Passed

Charge Passed (coulombs)	Chloride Ion Penetrability
>4000	High
2000 - 4000	Moderate
1000 - 2000	Low
100 - 1000	Very Low
< 100	Negligible

Notes:

1. Specimens fabricated on February 19, 2016 by CTLGroup.
2. One 4x2-inch nominal disk was saw-cut from the top of each submitted 4x8-inch concrete cylinder.
3. Specimens were cured in a water tank at 73°F until until test preparations started.
4. This analysis specifically represents the submitted samples.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**P. Brindise**
Date Reported:	**April 6, 2016**	Approved by:	**J. Pacheco**

REPORT of ANALYSIS

ASTM C1202 (AASHTO T227)

Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Age on Test Date	Charge Passed (coulombs)	Chloride Ion Penetrability
ASRA (1) accelerated	2/19/2016	3/18/2016	28	162.12	Very Low
ASRA (2) accelerated	2/19/2016	3/18/2016	28	144.89	Very Low
ASRA (3) accelerated	2/19/2016	3/18/2016	28	139.79	Very Low
Average				**149**	**Very Low**

Interpretation of results:

ASTM C1202 - 12, Table X1.1: Chloride Ion Penetrability Based on Charge Passed

Charge Passed (coulombs)	Chloride Ion Penetrability
>4000	High
2000 - 4000	Moderate
1000 - 2000	Low
100 - 1000	Very Low
< 100	Negligible

Notes:

1. Specimens fabricated on February 19, 2016 by CTLGroup.
2. One 4x2-inch nominal disk was saw-cut from the top of each submitted 4x8-inch concrete cylinder.
3. Specimens were cured in a limewater tank at 73°F until for days and then transferred to a limewater tank at 122°F for 21 days.
4. This analysis specifically represents the submitted samples.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**P. Brindise**
Date Reported:		Approved by:	**J. Pacheco**

REPORT of ANALYSIS

ASTM C1202 (AASHTO T227)

Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Age on Test Date	Charge Passed (coulombs)	Chloride Ion Penetrability
ASRA2 (1)	3/8/2016	4/6/2016	29	272.48	Very Low
ASRA2 (2)	3/8/2016	4/6/2016	29	316.92	Very Low
ASRA2 (3)	3/8/2016	4/6/2016	29	297.44	Very Low
Average				**296**	**Very Low**

Interpretation of results:

ASTM C1202 - 12, Table X1.1: Chloride Ion Penetrability Based on Charge Passed

Charge Passed (coulombs)	Chloride Ion Penetrability
>4000	High
2000 - 4000	Moderate
1000 - 2000	Low
100 - 1000	Very Low
< 100	Negligible

Notes:

1. Specimens fabricated on March 8, 2016 by CTLGroup.
2. One 4x2-inch nominal disk was saw-cut from the top of each submitted 4x8-inch concrete cylinder.
3. Specimens were cured in a water tank at 73°F until until test preparations started.
4. This analysis specifically represents the submitted samples.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**P. Brindise**
Date Reported:		Approved by:	**J. Pacheco**

REPORT of ANALYSIS

ASTM C1202 (AASHTO T227)

Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Reported Cast Date	Test Date	Age on Test Date	Charge Passed (coulombs)	Chloride Ion Penetrability
ASRA2 (1) accelerated	3/8/2016	4/13/2016	36	360	Very Low
ASRA2 (2) accelerated	3/8/2016	4/13/2016	36	358	Very Low
Average				**359**	**Very Low**

Interpretation of results:

ASTM C1202 - 12, Table X1.1: Chloride Ion Penetrability Based on Charge Passed

Charge Passed (coulombs)	Chloride Ion Penetrability
>4000	High
2000 - 4000	Moderate
1000 - 2000	Low
100 - 1000	Very Low
< 100	Negligible

Notes:

1. Specimens fabricated on March 8, 2016 by CTLGroup.
2. One 4x2-inch nominal disk was saw-cut from the top of each submitted 4x8-inch concrete cylinder.
3. Specimens were cured in a limewater tank at 73°F until for days and then transferred to a limewater tank at 122°F for 21 days.
4. This analysis specifically represents the submitted samples.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**J. Pycz**
Date Reported:	**October 5, 2016**	Approved by:	**J. Pacheco**

REPORT of ANALYSIS

ASTM C1202 (AASHTO T227)

Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Cast Date	Test Date	Age on Test Date	Charge Passed (coulombs)	Chloride Ion Penetrability
ALW4-T A	9/6/2016	10/4/2016	28	302	Very Low
ALW4-T B	9/6/2016	10/4/2016	28	377	Very Low
ALW4-T C	9/6/2016	10/4/2016	28	312	Very Low
Average				**330**	**Very Low**

Interpretation of results:

ASTM C1202 - 12, Table X1.1: Chloride Ion Penetrability Based on Charge Passed

Charge Passed (coulombs)	Chloride Ion Penetrability
>4000	High
2000 - 4000	Moderate
1000 - 2000	Low
100 - 1000	Very Low
< 100	Negligible

Notes:

1. Specimens fabricated on September 6, 2016 by CTLGroup.
2. One 4x2-inch nominal disk was saw-cut from the top of each submitted 4x8-inch concrete cylinder.
3. Prior to the testing, specimens were cured in a limewater bath at 73°F for 28 days.
4. This analysis specifically represents the submitted samples.
5. This report may not be reproduced except in its entirety.

CTLGROUP

Client:	**Illinois Tollway**	CTL Project No.:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Technician:	**J. Pycz**
Date Reported:	**October 5, 2016**	Approved by:	**J. Pacheco**

REPORT of ANALYSIS

ASTM C1202 (AASHTO T227)

Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Sample ID	Cast Date	Test Date	Age on Test Date	Charge Passed (coulombs)	Chloride Ion Penetrability
ALW4-T D accelerated	9/6/2016	10/4/2016	28	515	Very Low
ALW4-T E accelerated	9/6/2016	10/4/2016	28	468	Very Low
ALW4-T F accelerated	9/6/2016	10/4/2016	28	507	Very Low
Average				**497**	**Very Low**

Interpretation of results:

ASTM C1202 - 12, Table X1.1: Chloride Ion Penetrability Based on Charge Passed

Charge Passed (coulombs)	Chloride Ion Penetrability
>4000	High
2000 - 4000	Moderate
1000 - 2000	Low
100 - 1000	Very Low
< 100	Negligible

Notes:

1. Specimens fabricated on September 6, 2016 by CTLGroup.
2. One 4x2-inch nominal disk was saw-cut from the top of each submitted 4x8-inch concrete cylinder.
3. Prior to the testing, specimens were cured in a limewater bath at 73°F for 7 days and then transferred to limewater bath at 100°F for 21 days.
4. This analysis specifically represents the submitted samples.
5. This report may not be reproduced except in its entirety.

APPENDIX K

ASTM C1556 CHLORIDE DIFFUSION COEFFICIENT

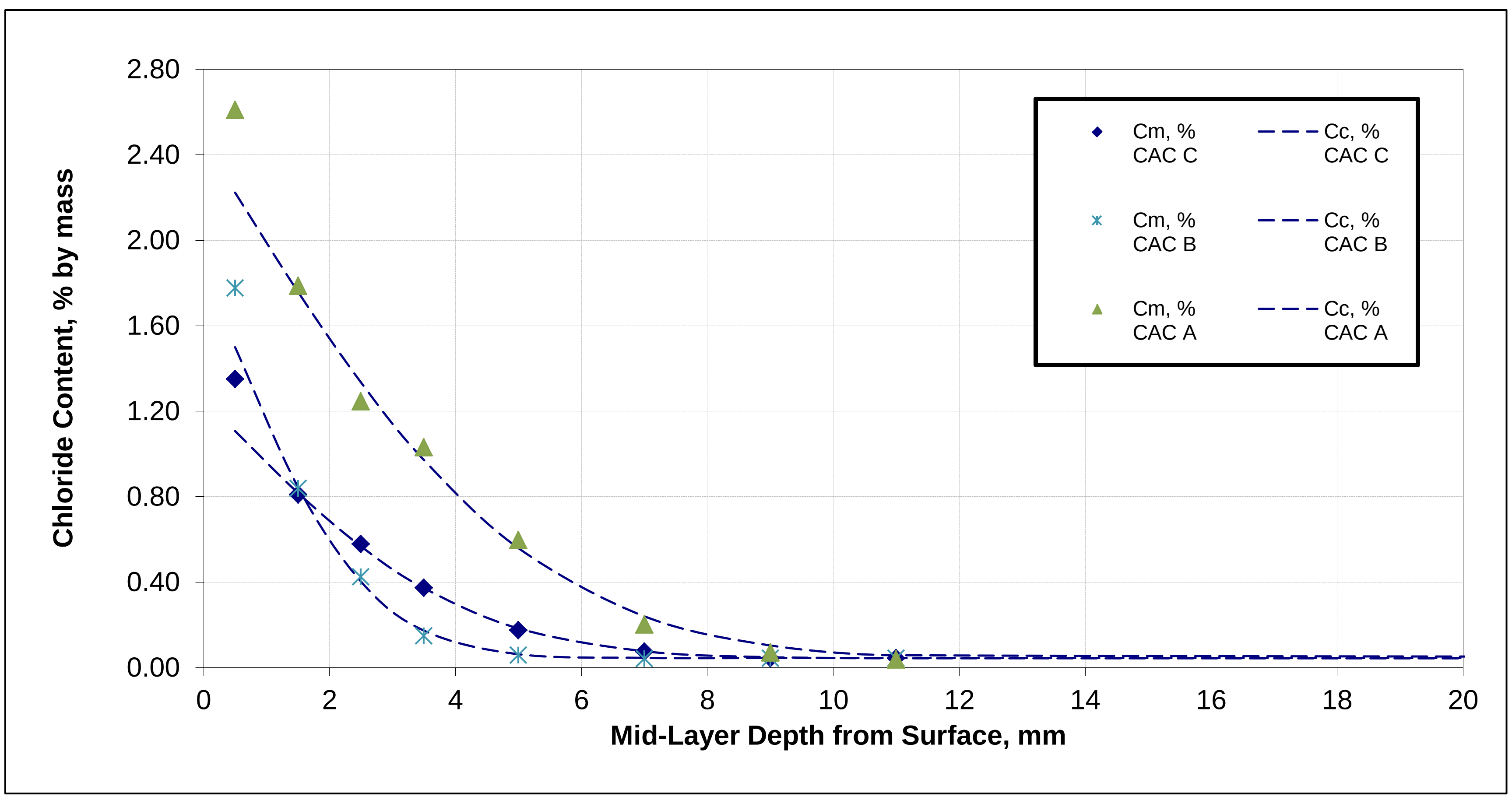
TEST RESULTS

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

ASTM C1556 Standard Test Method for Determining the Apparent Chloride Diffusion Coefficient of Cementitious Mixtures by Bulk Diffusion

Mix ID: CAC, 24 hours old at time of exposure

.	Cm, % CAC A	Cm, % CAC B	Cm, % CAC C	Cc, % CAC A	Cc, % CAC B	Cc, % CAC C
0.5	2.610	1.777	1.351	2.223	1.500	1.107
1.5	1.787	0.839	0.811	1.758	0.845	0.818
2.5	1.246	0.424	0.579	1.335	0.403	0.568
3.5	1.032	0.149	0.373	0.971	0.173	0.372
5.0	0.596	0.059	0.175	0.559	0.063	0.183
7.0	0.202	0.042	0.074	0.240	0.046	0.076
9.0	0.071	0.043	0.045	0.104	0.045	0.049
11.0	0.037	0.043	0.044	0.058	0.045	0.044
55.0	0.043	0.045	0.043	0.043	0.045	0.043
Exposure time, t, days				35	35	35
Initial Chloride Content, Ci, %				0.043	0.045	0.043
Surface Chloride Content, C_s, %				**2.46**	**1.87**	**1.26**
Calculated Diffusion Coefficient, D_a, m²/s ($x10^{-12}$)				**2.7**	**0.6**	**1.7**



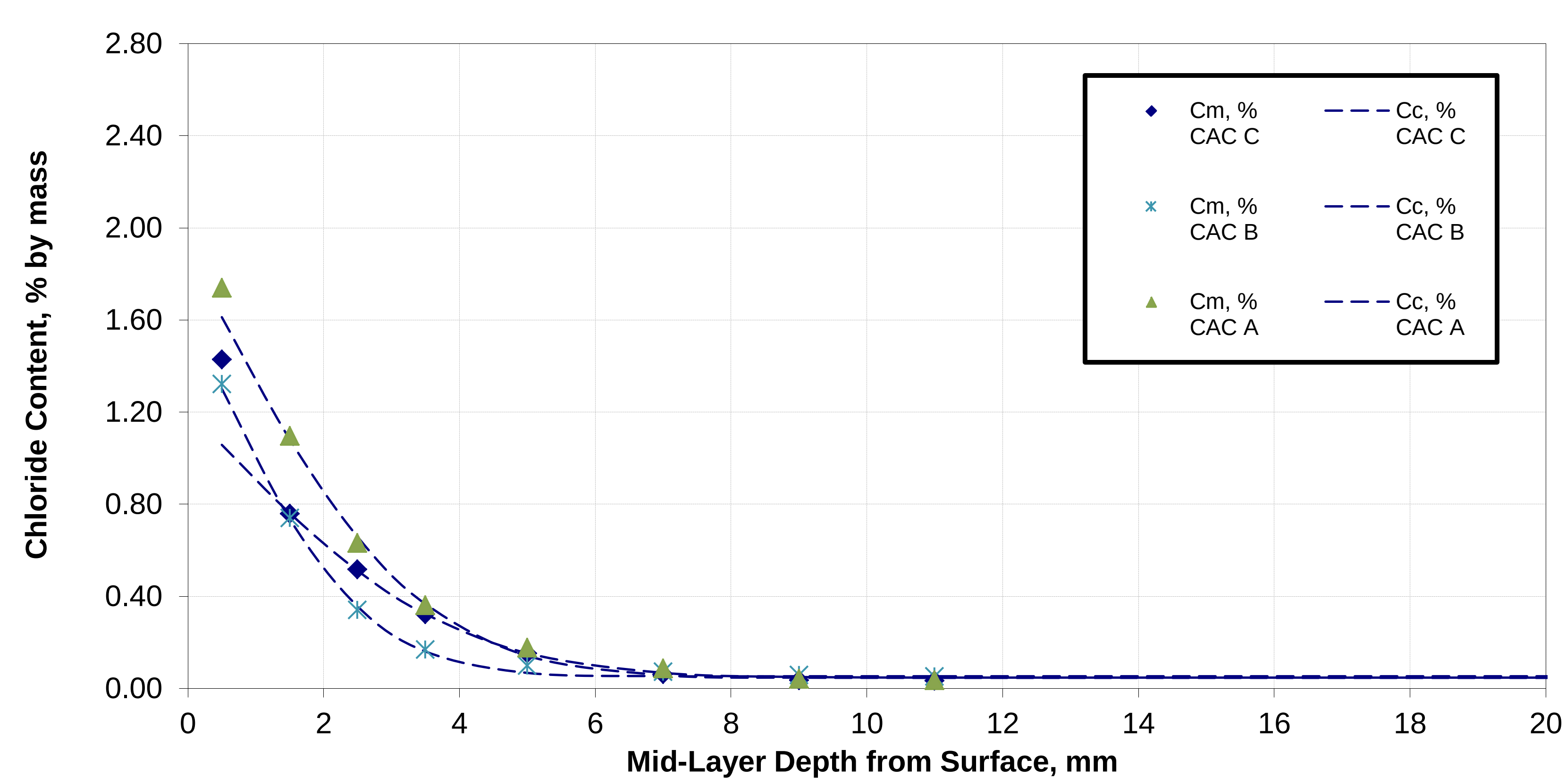
Notes:
1. This report represents specifically the samples tested.
2. Samples were 1 day old at time of preparation for exposure.
3. The samples were obtained, treated, prepared and calculations conducted following ASTM C1556.
4. The chloride content was determined by ASTM C1152.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

ASTM C1556 Standard Test Method for Determining the Apparent Chloride Diffusion Coefficient of Cementitious Mixtures by Bulk Diffusion

Mix ID: CAC, 7 days old at time of exposure

.	Cm, % CAC A	Cm, % CAC B	Cm, % CAC C	Cc, % CAC A	Cc, % CAC B	Cc, % CAC C
0.5	1.739	1.323	1.428	1.612	1.301	1.058
1.5	1.096	0.741	0.758	1.082	0.736	0.761
2.5	0.631	0.341	0.518	0.658	0.356	0.511
3.5	0.361	0.169	0.322	0.367	0.161	0.323
5.0	0.178	0.099	0.152	0.142	0.068	0.153
7.0	0.087	0.072	0.062	0.058	0.053	0.068
9.0	0.042	0.058	0.036	0.047	0.053	0.050
11.0	0.036	0.052	0.033	0.046	0.053	0.047
55.0	0.046	0.053	0.047	0.046	0.053	0.047
Exposure time, t, days				35	35	35
Initial Chloride Content, Ci, %				0.046	0.053	0.047
Surface Chloride Content, C_s, %				**1.90**	**1.62**	**1.21**
Calculated Diffusion Coefficient, D_a, m²/s (x10^{-12})				**1.1**	**0.6**	**1.4**



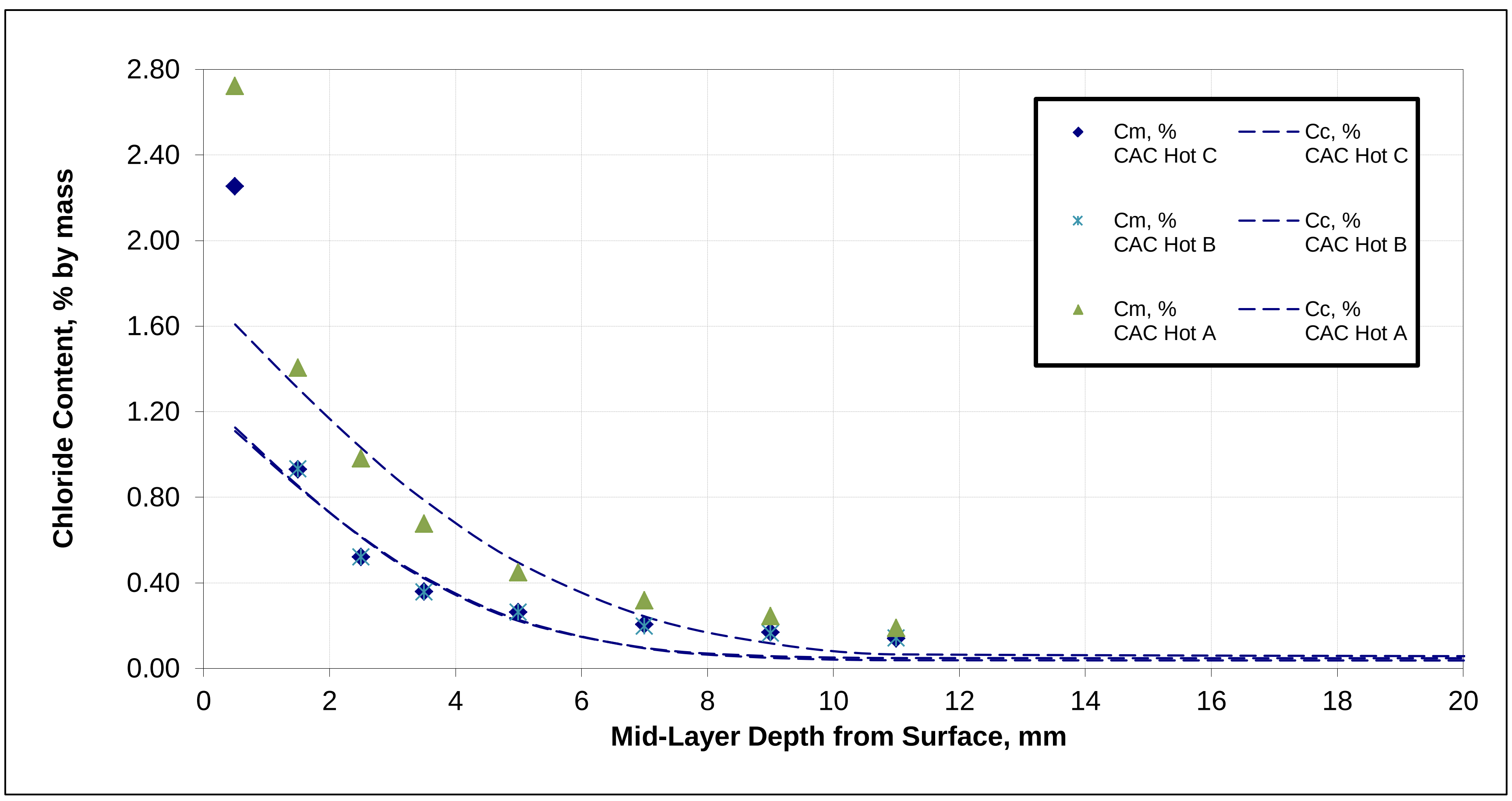
Notes:
1. This report represents specifically the samples tested.
2. Samples were stored in a moist room at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 100% relative humidity until an age of 7 days.
3. Samples were 7 days old at time of preparation for exposure.
4. The samples were obtained, treated, prepared and calculations conducted following ASTM C1556.
5. The chloride content was determined by ASTM C1152.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

ASTM C1556 Standard Test Method for Determining the Apparent Chloride Diffusion Coefficient of Cementitious Mixtures by Bulk Diffusion

Mix ID: CAC Hot, 7 days old at time of exposure

.	Cm, % CAC Hot A	Cm, % CAC Hot B	Cm, % CAC Hot C	Cc, % CAC Hot A	Cc, % CAC Hot B	Cc, % CAC Hot C
0.5	2.724	3.380	2.254	1.608	1.109	1.126
1.5	1.407	0.932	0.931	1.309	0.849	0.854
2.5	0.982	0.522	0.521	1.032	0.617	0.614
3.5	0.677	0.357	0.359	0.787	0.427	0.421
5.0	0.450	0.264	0.264	0.494	0.227	0.222
7.0	0.319	0.198	0.205	0.243	0.094	0.097
9.0	0.244	0.165	0.169	0.118	0.049	0.057
11.0	0.189	0.142	0.140	0.066	0.038	0.049
55.0	0.042	0.036	0.047	0.042	0.036	0.047
Exposure time, t, days				35	35	35
Initial Chloride Content, Ci, %				0.042	0.036	0.047
Surface Chloride Content, C_s, %				**1.76**	**1.24**	**1.27**
Calculated Diffusion Coefficient, D_a, m²/s ($x10^{-12}$)				**3.3**	**2.1**	**1.9**



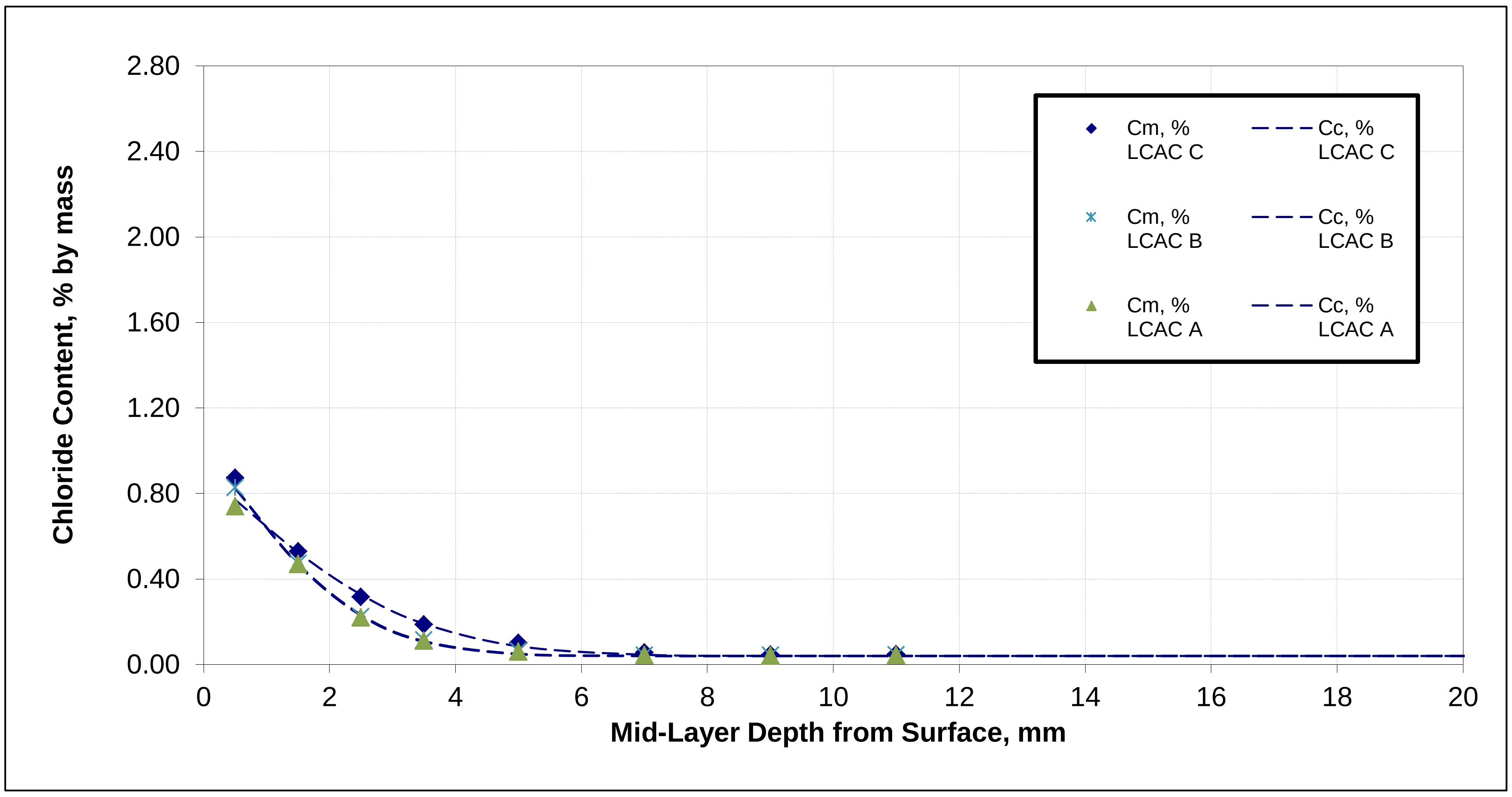
Notes:
1. This report represents specifically the samples tested.
2. Samples stored in a water tank at 50°C [122°F] until an age of 7 days.
3. Samples were 7 days old at time of preparation for exposure.
4. The samples were obtained, treated, prepared and calculations conducted following ASTM C1556.
5. The chloride content was determined by ASTM C1152.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

ASTM C1556 Standard Test Method for Determining the Apparent Chloride Diffusion Coefficient of Cementitious Mixtures by Bulk Diffusion

Mix ID: LCAC, 24 hours old at time of exposure

.	Cm, % LCAC A	Cm, % LCAC B	Cm, % LCAC C	Cc, % LCAC A	Cc, % LCAC B	Cc, % LCAC C
0.5	0.741	0.828	0.874	0.824	0.827	0.771
1.5	0.470	0.475	0.530	0.467	0.472	0.524
2.5	0.220	0.225	0.317	0.229	0.233	0.327
3.5	0.112	0.115	0.187	0.106	0.110	0.191
5.0	0.061	0.065	0.101	0.048	0.050	0.085
7.0	0.044	0.045	0.057	0.039	0.041	0.046
9.0	0.042	0.044	0.047	0.039	0.041	0.040
11.0	0.045	0.046	0.048	0.039	0.041	0.040
55.0	0.039	0.041	0.040	0.039	0.041	0.040
Exposure time, t, days				35	35	35
Initial Chloride Content, Ci, %				0.039	0.041	0.040
Surface Chloride Content, C_s, %				**1.03**	**1.03**	**0.90**
Calculated Diffusion Coefficient, D_a, m²/s ($x10^{-12}$)				**0.6**	**0.6**	**1.1**



Notes:

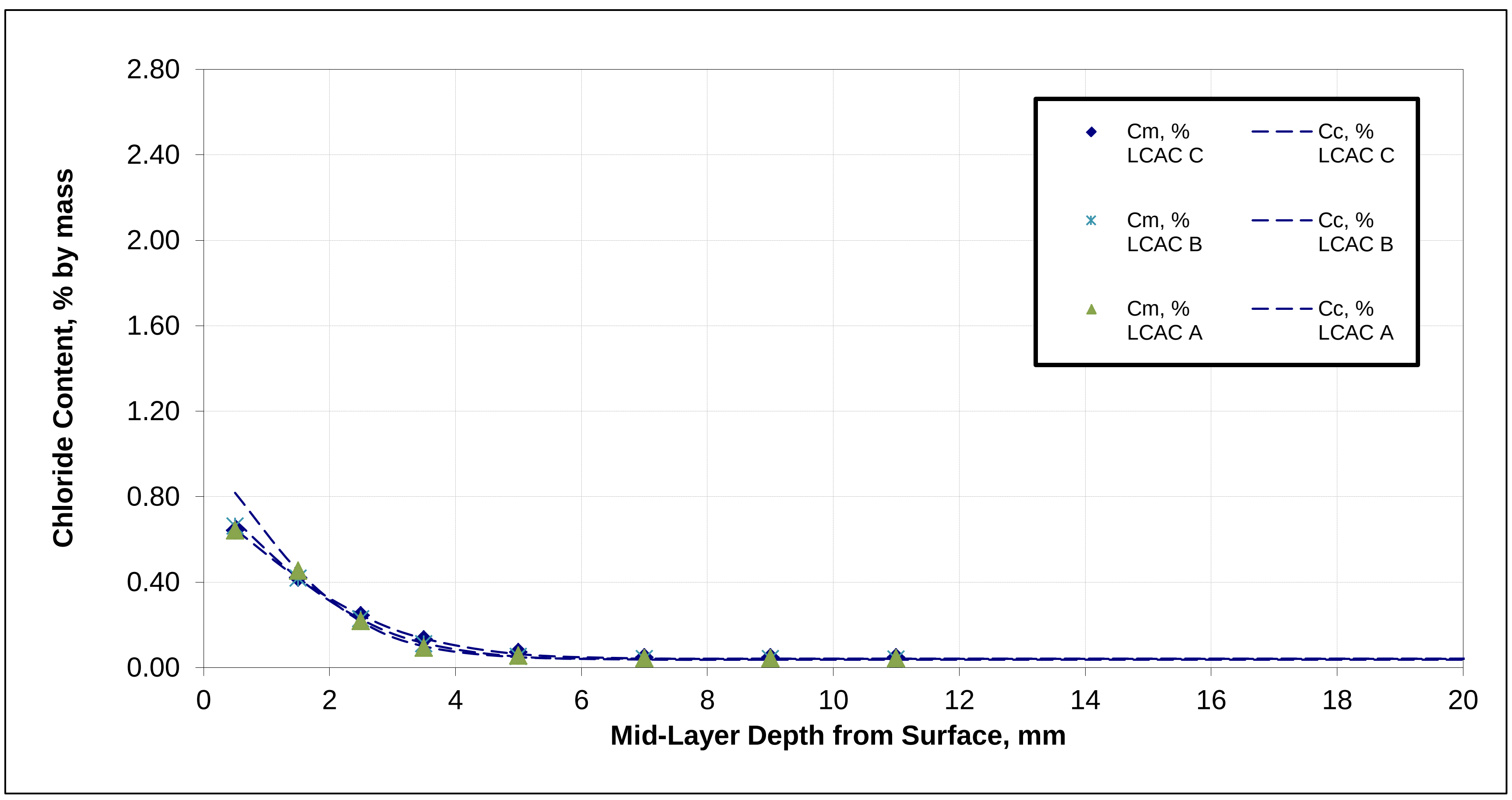
1. This report represents specifically the samples tested.
2. Samples were 1 day old at time of preparation for exposure.
3. The samples were obtained, treated, prepared and calculations conducted following ASTM C1556.
4. The chloride content was determined by ASTM C1152.
5. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

ASTM C1556 Standard Test Method for Determining the Apparent Chloride Diffusion Coefficient of Cementitious Mixtures by Bulk Diffusion

Mix ID: LCAC, 7 days old at time of exposure

.	Cm, % LCAC A	Cm, % LCAC B	Cm, % LCAC C	Cc, % LCAC A	Cc, % LCAC B	Cc, % LCAC C
0.5	0.643	0.662	0.643	0.818	0.689	0.647
1.5	0.453	0.419	0.420	0.454	0.420	0.419
2.5	0.219	0.229	0.244	0.216	0.226	0.245
3.5	0.094	0.111	0.132	0.100	0.115	0.136
5.0	0.056	0.053	0.073	0.049	0.051	0.063
7.0	0.045	0.042	0.049	0.042	0.038	0.043
9.0	0.043	0.042	0.049	0.042	0.037	0.041
11.0	0.045	0.040	0.049	0.042	0.037	0.041
55.0	0.042	0.037	0.041	0.042	0.037	0.041
Exposure time, t, days				35	35	35
Initial Chloride Content, Ci, %				0.042	0.037	0.041
Surface Chloride Content, C_s, %				**1.03**	**0.84**	**0.77**
Calculated Diffusion Coefficient, D_a, m²/s ($x10^{-12}$)				**0.6**	**0.7**	**0.9**



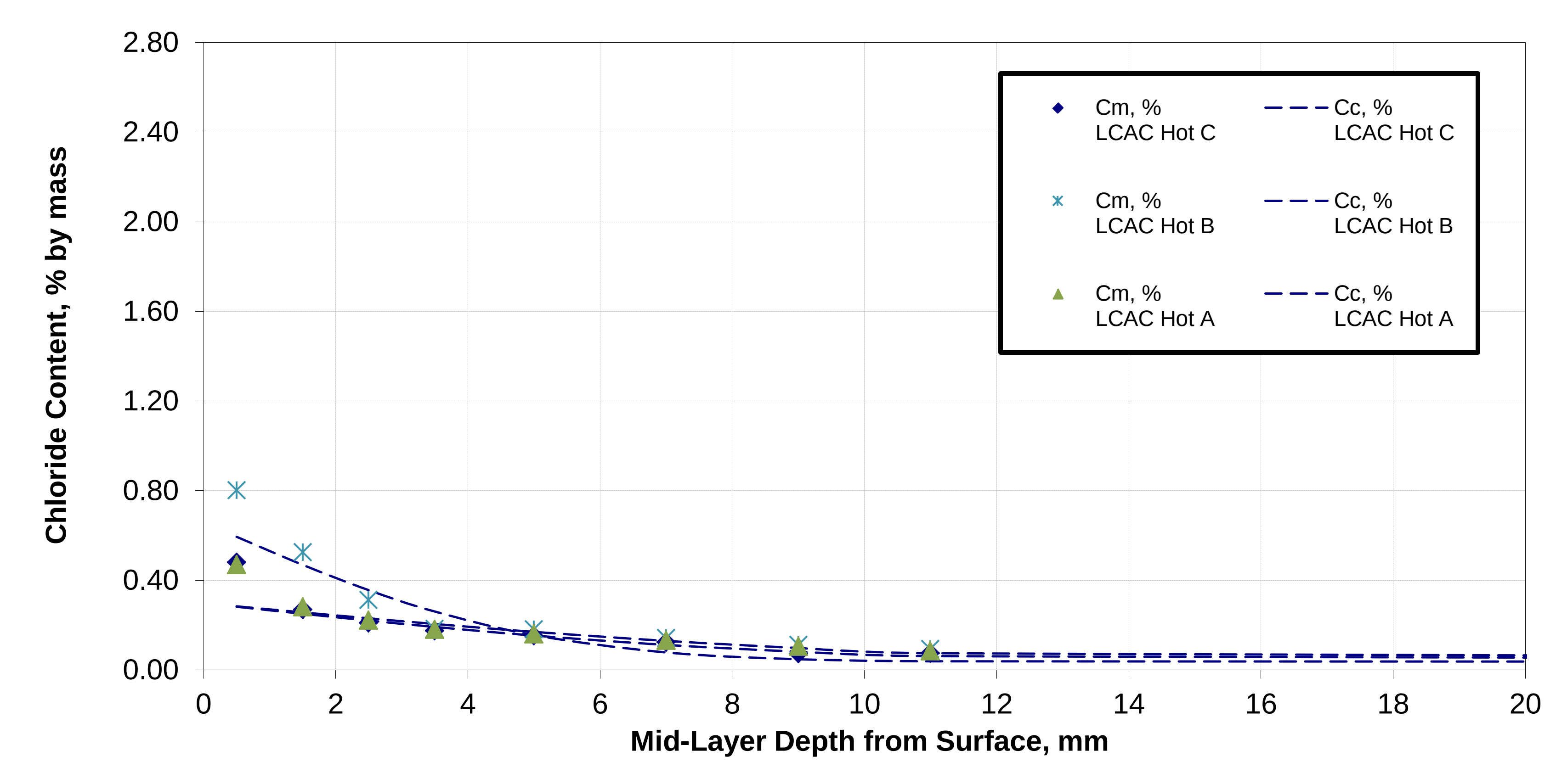
Notes:
1. This report represents specifically the samples tested.
2. Samples were stored in an environment maintained at 23.0 ± 2.0°C [73.5 ± 3.5°F] and 45-55% relative humidity until an age of 7 days.
3. Samples were 7 days old at time of preparation for exposure.
4. The samples were obtained, treated, prepared and calculations conducted following ASTM C1556.
5. The chloride content was determined by ASTM C1152.
6. This report may not be reproduced except in its entirety.

Client:	**Illinois Tollway**	CTL Project No:	**057177**
Project:	**Calcium Aluminate Cement Project**	CTL Project Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**A. Bentivegna**
Date Reported:	**August 19, 2015**	Approved:	**B. Birch**

ASTM C1556 Standard Test Method for Determining the Apparent Chloride Diffusion Coefficient of Cementitious Mixtures by Bulk Diffusion

Mix ID: LCAC Hot, 7 days old at time of exposure

.	Cm, % LCAC Hot A	Cm, % LCAC Hot B	Cm, % LCAC Hot C	Cc, % LCAC Hot A	Cc, % LCAC Hot B	Cc, % LCAC Hot C
0.5	0.471	0.801	0.480	0.284	0.594	0.282
1.5	0.281	0.525	0.269	0.257	0.469	0.251
2.5	0.223	0.313	0.209	0.230	0.356	0.220
3.5	0.182	0.184	0.175	0.205	0.261	0.192
5.0	0.160	0.181	0.153	0.170	0.155	0.153
7.0	0.133	0.142	0.123	0.130	0.078	0.112
9.0	0.106	0.112	0.073	0.098	0.048	0.081
11.0	0.085	0.093	0.075	0.075	0.039	0.061
55.0	0.035	0.036	0.037	0.035	0.036	0.037
Exposure time, t, days				35	35	35
Initial Chloride Content, Ci, %				0.035	0.036	0.037
Surface Chloride Content, C_s, %				**0.30**	**0.66**	**0.30**
Calculated Diffusion Coefficient, D_a, m²/s ($x10^{-12}$)				**9.7**	**2.4**	**7.1**



Notes:
1. This report represents specifically the samples tested.
2. Samples stored in a water tank at 50°C [122°F] until an age of 7 days.
3. Samples were 7 days old at time of preparation for exposure.
4. The samples were obtained, treated, prepared and calculations conducted following ASTM C1556.
5. The chloride content was determined by ASTM C1152.
6. This report may not be reproduced except in its entirety.

APPENDIX L

ASTM C457 & C856 PETHROPGRAPHIC ANALYSIS

TEST RESULTS

REPORT OF AIR-VOID SYSTEM ANALYSIS

ASTM C457 Modified Point-Count Method (Procedure B)

CTLGroup Project No.: 057177
Client: Applied Research Associates, Inc.
Client Project: Tollway Materials Consulting

Report Date: September 8, 2014
Sample Received[1]: August 27, 2014
Tested By: Jackie Ferraro
Approved By: Jean L. Randolph

Client Sample ID	CTLGroup Sample ID	Total Air Content (%)	Spacing Factor (in.)	Specific Surface ($in.^2/in.^3$)	No. Voids/ Inch	Paste Content (%)	Paste-Air Ratio
CAC 6/26/14	3761301	4.2	0.008	677	7.0	26.3	6.32

Maximum Size Aggregate (in.): 0.50.

Area Tested ($in.^2$): 21.0.

Length of Traverse (in.): 80.1.

Number of Points: 1201.

Sample Location & Orientation: Concrete cylinder.

Orientation and Position of Cut Surfaces: Parallel to the long axis of the cylinder.

Magnification during Test: 100x.

Notes:
1. Date sample was received in the CTLGroup Petrographic Laboratory.
2. Results refer specifically to the sample submitted.
3. Paste content was calculated from the data collected from the point-count analysis.
4. For additional information consult ASTM C457-12, Appendix (X1. Interpretation of Results).
5. This report may not be reproduced except in its entirety.

REPORT OF AIR-VOID SYSTEM ANALYSIS
ASTM C457 Modified Point-Count Method (Procedure B)

CTLGroup Project No.: 057177
Client: Applied Research Associates, Inc.
Client Project: Tollway Materials Consulting

Report Date: September 8, 2014
Sample Received[1]: August 27, 2014
Tested By: Jackie Ferraro
Approved By: Jean L. Randolph

Client Sample ID	CTLGroup Sample ID	Total Air Content (%)	Spacing Factor (in.)	Specific Surface ($in.^2/in.^3$)	No. Voids/ Inch	Paste Content (%)	Paste-Air Ratio
LCAC 6/26/14	3761302	3.3	0.013	453	3.8	27.4	8.23

Maximum Size Aggregate (in.): 0.50.

Area Tested ($in.^2$): 21.0.

Length of Traverse (in.): 80.1.

Number of Points: 1201.

Sample Location & Orientation: Concrete cylinder.

Orientation and Position of Cut Surfaces: Parallel to the long axis of the cylinder.

Magnification during Test: 100x.

Notes:
1. Date sample was received in the CTLGroup Petrographic Laboratory.
2. Results refer specifically to the sample submitted.
3. Paste content was calculated from the data collected from the point-count analysis.
4. For additional information consult ASTM C457-12, Appendix (X1. Interpretation of Results).
5. This report may not be reproduced except in its entirety.

Client:	**Applied Research Associates, Inc.**	CTL Project No:	**057177**
Project:	**ARA Tollway Work - CAC Project**	CTL Proj. Mgr.:	**M. D'Ambrosia**
Contact:	**Steve Gillen**	Analyst:	**Casey Ricks**
Report Date:	**February 24, 2016**	Approved:	**Jean L. Randolph**

REPORT OF AIR-VOID SYSTEM ANALYSIS
ASTM C457 Modified Point-Count Method (Procedure B)

Client Sample ID	**Area Tested** (in.^{2})	**Length of Traverse** (in.)	**Number of Points**	**Total Air Content** (%)	**Spacing Factor** (in.)	**Specific Surface** (in.^{2}/in.^{3})	**No. Voids/ Inch**	**Paste Content** (%)	**Paste-Air Ratio**
LCAC (1/21/16)	24.5	90.2	1351	1.8	0.020	390	1.7	27.1	15.25
LCAC-A (1/21/16)	24.5	90.3	1350	1.4	0.015	537	1.9	25.3	17.95
LCAC-AD (1/21/16)	24.5	90.8	1351	2.3	0.023	310	1.8	28.3	12.32
LCAC-ASRA (1/21/16)	24.5	90.2	1350	2.2	0.028	248	1.4	28.0	12.60

Notes:
1. All specimens are 4-in. by 8-in. concrete cylinders, cast by CTLGroup on the date included in the Client Sample ID.
2. Orientation and Position of Cut Surfaces: The concrete specimens were cut in half longitudinally and one half was lapped for testing.
3. Magnification during Test: 100x.
4. Results refer specifically to the samples submitted.
5. Paste content was calculated from the data collected from the point-count analysis.
6. For additional information consult ASTM C457-12, Appendix (X1. Interpretation of Results).
7. This report may not be reproduced except in its entirety.

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM C856

STRUCTURE: Laboratory fabricated cylinder | *DATE RECEIVED*: September 13, 2016

LOCATION: None | *EXAMINED BY*: M. Strow/V. Jennings

SAMPLE

Client Identification: LCAC #2 Truck 9-6-16.

CTLGroup Identification: 4301901.

Dimensions: Diameter is 101 mm (4.0 in.); length is 203 mm (8.0 in.).

Top End: Rough and fairly uneven struck surface. Paste is dark brownish gray and hard.

Bottom End: Flat and smooth formed surface. Paste is dark brownish gray and hard.

Cracks, Large Voids: No cracks or large voids observed.

AGGREGATES

Coarse: Crushed limestone.

Intermediate to Fine: Lightweight expanded slag.

Fine: Manufactured sand consisting predominantly of limestone with much lesser amounts of quartz.

Gradation & Top Size: Visually appears evenly graded to an observed top size of 11 mm (0.4 in.).

Shape, Texture, Distribution: Coarse– angular to subangular, and equant to elongated in shape; distribution is fairly uniform. The amount if coarse aggregate slightly increases with depth. Intermediate to fine– subangular to rounded, and generally equant, with irregular, rough surface texture; distribution is fairly uniform. Fine– angular to subangular, and generally equant; distribution is uniform. Volume of particles is relatively low.

PASTE

Color: Dark gray-brown.

Hardness: Moderately hard.

Luster: Subvitreous to slightly vitreous.

PASTE (cont.)

Paste-Aggregate Bond: Tight; surfaces of freshly fractured concrete extend through a large majority of aggregate particles.

Air Content: Concrete appears air-entrained based on abundance of small, spherical voids in paste matrix. Results of air-void system analysis:

Total Air Content	Spacing Factor	Specific Surface	No. Voids/ Inch	Paste Content	Paste-Air Ratio
3.3%	0.011 in.	627 $in.^2/in.^3$	5.2	36.7%	11.00

Depth of Carbonation: Negligible along both struck and formed surfaces.

Calcium Hydroxide: None observed.

Residual Portland Cement Clinker Particles: None observed.

Residual Calcium Aluminate Cement Particles: Large amounts of residual and relic calcium aluminate cement particles, estimated greater than 35%.

Supplementary Cementitious Materials: None observed.

Secondary Deposits: None observed.

MICROCRACKING: A few vertical microcracks extend from struck cylinder surface to depths of up to 12 mm (0.5 in.). Several microcracks extend perpendicularly from formed cylinder surfaces, to depths of up to 17 mm (0.7 in.). Short, discontinuous, randomly-oriented microcracks are very scarce, but present, in paste within body of cylinder.

ESTIMATED WATER-CEMENTITIOUS MATERIALS RATIO: Low to moderately low, based on the physical properties of the hardened paste. No numerical estimate is provided for the submitted cylinder due to presence of calcium aluminate cement.

MISCELLANEOUS:

1. One localized region near top surface is soft and powdery (Fig. 1); region appears to represent lump of cement and aggregate that did not mix with water.
2. Paste exhibits low to very low water absorbency.
3. Paste contains a small amount of carbonate fines.

Fig. 1 Cut and lapped section of Sample LCAC Truck #2 9-6-16, struck surface at left. Section exhibits soft and powdery lump of unwetted cement and aggregate (red circle). Scale is in inches.

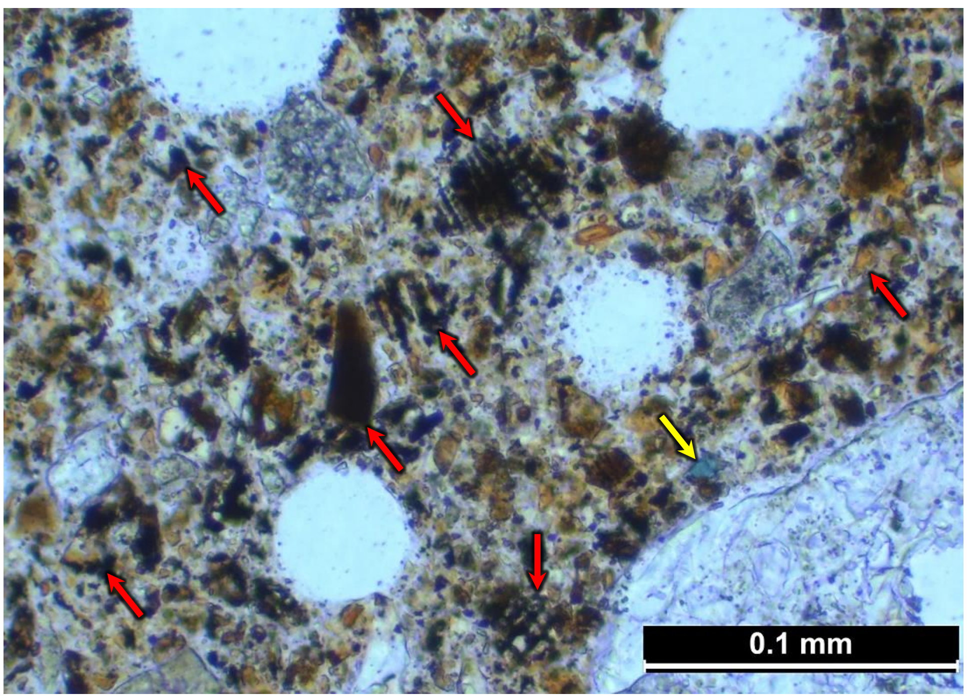


Fig. 2 Transmitted-light photomicrograph of Sample LCAC #2 Truck 9-6-16 in thin section, showing paste microstructure. Red arrows indicate residual calcium aluminate cement particles, comprised of various phases. Yellow arrow indicates particle of blue pleochroite phase. Plane-polarized light.

METHODS OF TEST

Petrographic examination of the provided cylinder was performed in accordance with ASTM C856-14, "Standard Practice for Petrographic Examination of Hardened Concrete." The cylinder was cut in half longitudinally, and one of the resulting halves was ground (lapped) to produce a smooth, flat, semi-polished surface. Lapped and freshly broken surfaces of the concrete were examined using a stereomicroscope at magnifications up to 45X.

For thin-section study, a small rectangular block was cut from the cylinder, and one side of the block was lapped to produce a smooth, flat surface. The block was cleaned and dried, and the prepared surface was mounted on a ground glass microscope slide with epoxy resin. After the epoxy hardened, the thickness of the mounted block was reduced to approximately 20 μm (0.0008 in.). The resulting thin section was examined using a polarized-light (petrographic) microscope at magnifications up to 400X to study aggregate and paste mineralogy and microstructure.

Estimated water-cementitious materials ratio (w/cm), when reported, is based on observed concrete and paste properties including, but not limited to: 1) relative amounts of residual (unhydrated and partially hydrated) portland cement clinker particles and supplementary cementitious materials, such as slag cement or fly ash; 2) amount and size of calcium hydroxide crystals; 3) paste hardness, color, and luster; 4) paste-aggregate bond; and 5) relative absorbency of paste as indicated by the readiness of a freshly fractured surface to absorb applied water droplets. These techniques have been widely used by industry professionals to estimate w/cm.

Depth and pattern of paste carbonation was determined by application of a pH indicator solution (phenolphthalein) to freshly fractured concrete surfaces. The solution imparts a deep magenta stain to high pH, non-carbonated paste. Carbonated paste does not change color.

Air-void system analysis was performed in accordance with ASTM C457-12, “Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete,” following Procedure B, the modified point-count method. Length of traverse: 80.4 in.; area traversed: 24 in.^{2}; number of stops: 1200. Paste content was calculated from the data collected from the point-count analysis.

Notes:
1. Results refer specifically to the sample submitted.
2. This report may not be reproduced except in its entirety.

APPENDIX M

FIELD PATCHES REPORTS

January 13, 2016

Mr. Steven L. Gillen
Illinois Tollway
2700 Ogden Avenue
Downers Grove, IL 60515-1703

Office: 630-241-6800 ext. 3944
Fax: 630-241-6105

Calcium Aluminate Cement Concrete Field Patches
CTLGroup Project Number 057177

Dear Mr. Gillen:

CTLGroup witnessed three field placements of latex modified calcium aluminate cement concrete (CAC) patches on Illinois Tollway property. CTLGroup instrumented all patches with thermocouples to monitor temperature in the patches. The mixture design provided by the concrete supplier is included in Figure 1. The mixture matches very closely with the mixtures used in our laboratory for prior experiments.

PATCH 1 – I-294 BRIDGE OVER NORTH AVE

The first patch was a bridge deck patch on Interstate 294 (I-294) over North Avenue and was placed October 18, 2015. The patch was in the north bound lane 4 approximately 30-ft from the south abutment (see Figure 2 for location details). The patch measured 5x5-ft, and 8-in thick. The patch was reinforced in both directions with bars ~0.75-in. diameter (as shown in Figure 3 and Figure 4). The transverse reinforcement included a lap splice in the middle of the top layer of reinforcement. The spacing for the top layer was ~6-in center to center and the bottom layer was ~9-in center to center. The longitudinal reinforcement was spaced 12-in on center in both top and bottom layers. The reinforcement layers were spaced 6-inches apart.

Thermocouples were placed in three locations: the center, the middle of one edge, and a corner. At the center location four thermocouples were installed. One thermocouple was tied to the bottom layer of reinforcement and the tip of the thermocouple was located near the plywood form on the bottom. Tie wire was installed between the top and bottom layers of reinforcement. A second thermocouple was installed at the mid-depth by securing it to the tie wire with a zip tie. A third thermocouple was installed at the depth of the top layer of reinforcement, approximately 6-inches from the bottom surface and 2-in from the top surface. A fourth thermocouple was secured to the top layer of reinforcement and positioned vertically 1.5-in from the reinforcement near the top surface of the patch.

Two thermocouples were installed at the corner location. One thermocouple was placed mid depth at the south east corner and the second thermocouple was placed at the top surface.

Two thermocouples were installed at the edge location. One thermocouple was placed mid depth along the center of the southern edge of the patch and the second thermocouple was placed at the top surface at the same location.

A second patch measuring approximately 2x2-ft was adjacent to the instrumented patch. It was a partial depth patch (see Figure 3 and Figure 5) and was not instrumented but was observed for cracking.

The CAC mixture for this placement included accelerator and latex. See Figure 6 for the batch ticket. No additional water was added. Concrete placement began at ~6:25 AM. Placement and finishing were complete by 6:35 AM.

CTLGroup returned to the patch on October 19th to document the condition of the patches and remove the instrumentation. Cracking was observed in both directions of the patch with cracks ranging from 0.25 to 0.50 mm wide (see Figures 7 through 9). The cracking is documented in Figure 10.

The temperature data indicates the maximum temperature in the concrete occurred ~6 hours after concrete placement and the temperatures began decreasing as soon as the insulation was removed. The 2nd day temperatures values in the concrete are similar to the ambient temperatures indicating the bulk of the chemical reaction was complete. See Figure 10 for the temperature data collected at the center of the patch and Figure 12 for the data collected at the patch edge and corner locations. As expected the temperatures in these locations are lower than at the center and the corner location has the lowest temperatures. The difference between the surface and mid-depth temperature is greater at both of these locations, as compared to the data for the center location.

PATCH 2 – I-88 WESTBOUND – WEST OF TOLL PLAZA 61 I-PASS SENSORS

CTLGroup observed placement of a CAC full depth pavement (JPCP) patch on October 31, 2015. The patch was approximately 12.25x25.5-ft and 14-in thick. The patch was divided into 2 placements; the interior (outside traffic lane) patch was placed with CAC concrete with accelerator and the outside (shoulder) patch was placed with CAC with no accelerator. Both lanes are located in the Open Road Tolling lanes to the west of the monotube (see Figure 13 for location details). No additional water was added to either batch and both mixtures were latex modified CAC. CTLGroup installed thermocouples at the center of the accelerated (driving lane) patch, the center and the middle of the outside edge of the non-accelerated (shoulder) patch.

At each instrumented location 4 thermocouples were placed. The sensors were located 1-inch below the surface, 4-inches below the surface, 8-inches (7 inches for the outside edge location) below the surface (mid-depth) and 1-inch above the subgrade.

Concrete placement began at 3:00 AM and concluded by 3:45 AM in the accelerated patch. The bulkhead separating the driving lane patch from the shoulder patch as removed at 4:00 AM and concrete placement began at 4:15 AM in the non-accelerated patch. Placement concluded by 4:45 AM. See Figure 14 and Figure 15 for the batch tickets. Sensors were removed at approximately 6:00 AM on November 2, 2015.

Figure 16 and Figure 17 are overview photos of the accelerated and non-accelerated portions of the patch. The non-accelerated portion was tined for friction after placement. Figures 18 and 19 show close-up photos of small cracks found on the surface of the non-accelerated portion of the patch. There were very few of these cracks and are attributable to early age thermal stresses. There was a crack at the interface between the accelerated portion and the non-accelerated portion, as shown in Figure 20. This is caused by the accelerated portion undergoing thermal expansion at an early age while the non-accelerated portion was too weak to resist cracking. It is not anticipated that future patches will involve the placement of two different mixtures next to each other at the same time. As a result, this particular cracking mode is not likely to be repeated.

Figure 21 through Figure 23 present the temperature data collected for this patch. The accelerated CAC reached peak temperatures between 5 and 6 hours after placement with a maximum temperature of 119° at the upper-quarter sensor location (Figure 21). The maximum temperature in the non-accelerated CAC patch occurred 35-37 hours after placement with a maximum temperature of 88°F at the patch center (Figure 22) and 94°F at the patch edge (Figure 23).

PATCH 3 – I-294 SOUTHBOUND UNDER LAKE COOK RD

CTLGroup was onsite for the third patch placement on December 6th, 2015. The patch was located in lanes 2 and 3 (see Figure 24 for location details) and measured 25x13-ft and 12-in thick (see Figure 25). Epoxy coated dowel bars were installed in the north and south edges. Epoxy coated tie bars were in steel baskets at the location of the planned longitudinal joint. Thermocouples were installed in 3 locations (see Figure 26 through Figure 28); the center of the patch, the middle of the long edge (the south edge), and a corner (the south west corner).

Each location had four thermocouples. One at the bottom of the patch near the subgrade, one at the mid-depth location approximately 6-in above the subgrade, one at the upper-quarter location approximately 3-in below the surface and one near the top surface. Wooden dowel rods holding the thermocouples were installed at each location by first drilling a hole in the subgrade using a battery powered hammer drill and then the dowel rod was hammered in to the hole such that the top of the dowel rod was approximately 1/2-inch below the surface of the patch. The dowel rod had holes drilled in it every 1-inch and the thermocouples were threaded through the holes and secured with plastic zip-ties. Sensors were installed by 12:53 AM and the loggers recorded temperatures every 10-minutes.

The CAC mixture for this placement included accelerator and latex. No additional water was added. Concrete was first placed in the patch starting at 1:20 AM. The plastic air content was 4.9% and the concrete temperature was 58°F. The second truck began depositing concrete in the patch at 1:58 AM. The plastic air content of the concrete from the 2nd truck was 3.8% and the temperature was 56°F. Placement was complete by 2:23 AM and finishing was complete by 2:30 AM. Cylinder specimens were fabricated by 2:35 AM. One layer of plastic sheeting was placed over the patch. Figure 29 is a photo of the concrete during placement. See Figure 30 and Figure 31 for the batch tickets. The testing technician for Lorig reported 4 hour breaks at 6:38 AM, with compressive strengths of 2,810 psi and 2,850 psi. The plastic was removed from the patch at 7:05 AM (see Figure 32) by the laborers who were on site to saw the longitudinal joint. CTLGroup cut the thermocouples flush with the surface of the patch and removed the loggers at 7:07 AM.

Concrete temperatures at the center of the patch were still rising at the mid-depth and bottom sensors at the time the instrumentation was removed (see Figure 33). The temperatures at the corner and edge installations peaked at an elapsed time of ~ 4 hours (see Figure 34 and Figure 35). In all three locations the temperature of the concrete was still 40 to 60 degrees above ambient temperature.

SUMMARY

CTLGroup monitored three CAC patches and has several observations. When used with moderate to high dosage rates of accelerator (lithium sulfate-based), the strength gain characteristics are ideal for 6-8 hour closure patching work. With all three placements the concrete reached maximum temperature between 5 and 6 hours after placement. Cracking behavior was observed in the first patch, which was believed to be most severe when insulating blankets were utilized. Subsequent cracking severity has not yet been confirmed. Without insulating blankets, subsequent patches did not achieve the maximum temperatures observed in Patch 1. Additionally the larger mass of concrete found in patch 2 and patch 3 generated more heat and cooled more slowly than patch 1. The relatively small volume of concrete used in the patch 1 would not generate as much heat and was cooled more rapidly due to the temperature of the environment around it. An additional factor to consider about the first patch is it was the only path with reinforcing steel. The reinforcement would provide additional restraint against volume change that may have contributed to cracking.

Our recommendation is to continue without insulating blankets to minimize the thermal gradient and rapid drop in temperature associated with the removal of blankets. Also, further work should investigate shrinkage reducers as another way to mitigate cracking.

The non-accelerated patch took over 30 hours to reach maximum temperature and thus would be unsuitable for rapid patching work requiring a 6-8 hour opening window. It is recommended that further work be conducted to optimize the accelerator dosage for cold weather patching to minimize the potential for cracking.

Sincerely,

Benjamin F. Birch, PE (IL)
Materials and Mechanics
BBirch@CTLGroup.com
Phone: (847) 972-3246

Matthew D'Ambrosia, Ph.D., P.E. (IL, IN)
Senior Engineer, Materials and Mechanics
MDambrosia@CTLGroup.com
Phone: (847) 972-3264

HENRY FRERK SONS
SINCE 1888

Very High Early
Class CA
Producer # 3682-01
ISTHA # 90PCC1446

Material	Source	Mixture Formula
GCX Cement 37902	Lafarge / Keneos Aluminates Chesapeake, VA 4116-10	700 lbs.
QC/QA CM-13 022CM1301	Hanson Material Service Thornton, IL Yard 586 50312-04	1660 lbs.
FM-02 027FAM02	Meyer Material Algonquin, IL 51110-07	1316 lbs.
Styrofan 1186 43700	BASF - Charlotte, NC	16 3/4 gallons minimum
GCX 500 AC	Chryso Charlestown, IN 6173-01	2% per weight of cement or as needed
Water	Potable	17.6 gal. max.

Slump 3 – 6" Measured 5 minutes after discharge
Air 0-7%

Fig. 1 – Mixture design (accelerator mixture).

Notes

I-294 NB - Bridge over Lake St. & North Ave.

The full-depth bridge deck patch is in lane 4 approximately 30 feet from the south abutment.
Total size: 5 x 5 feet by 8 inches thick

The partial-depth deck patch is a few feet east of the full-depth patch. It is approximately 2 x 2 feet by 2.5 inches thick.

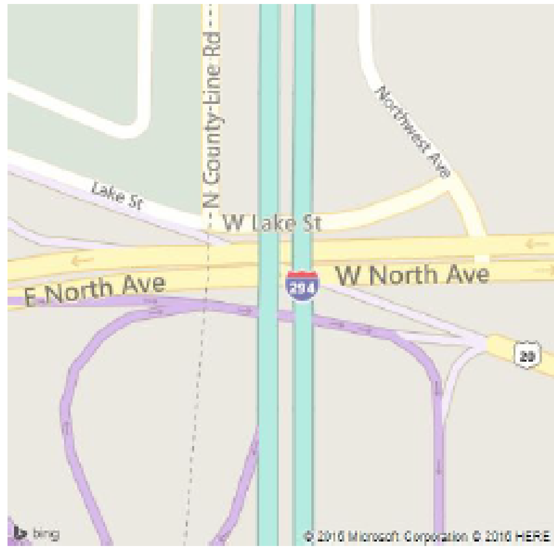


Fig. 2 – Patch 1 location detail.

Fig. 3 – Overview of patch location 1

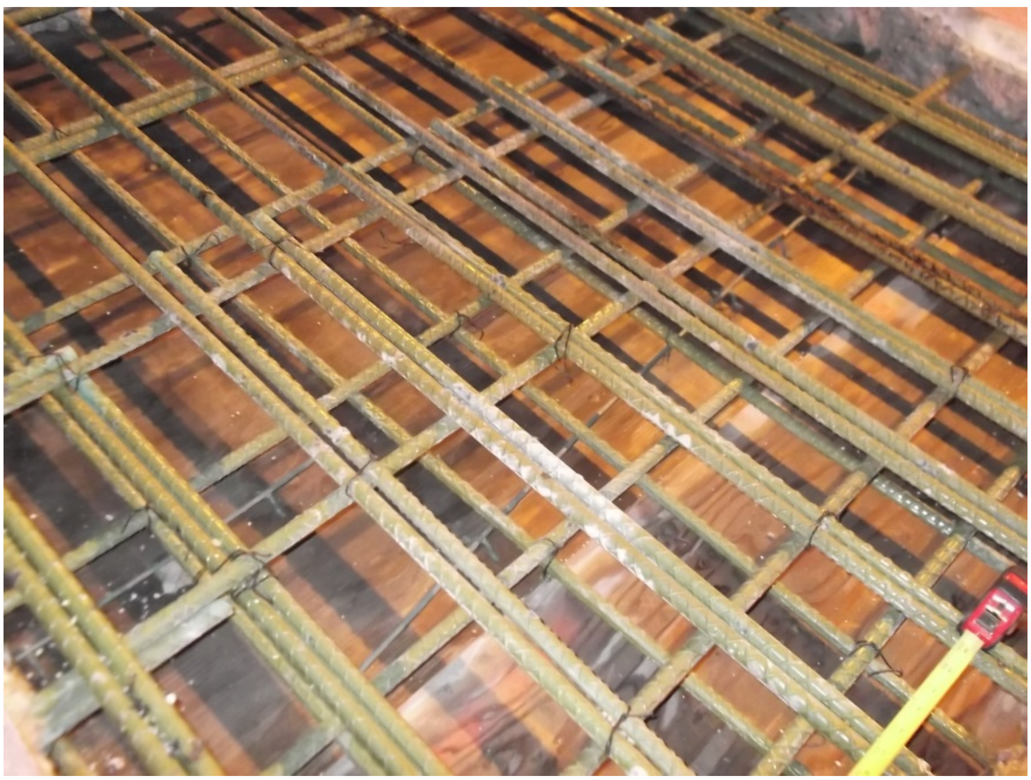
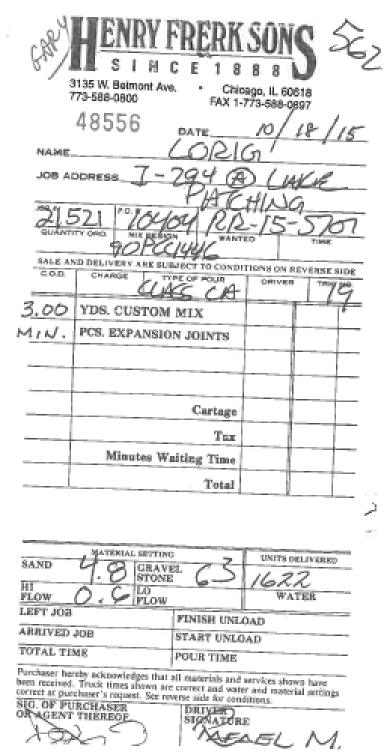


Fig. 4 – Layout of the reinforcement at the center of the patch.

Fig. 5 – Finished patch at location 1.



COPY
HENRY FRERK SONS
SINCE 1888
562
3135 W. Belmont Ave. • Chicago, IL 60618
773-588-0800 FAX 1-773-588-0897
48556
DATE 10/18/15
NAME LORIG
JOB ADDRESS I-294 @ LAKE
PATCHING
JOB 21521 P.O.# 10404 RR-15-5707
QUANTITY ORD. MIX DESIGN 40PCC1446 WANTED TIME
SALE AND DELIVERY ARE SUBJECT TO CONDITIONS ON REVERSE SIDE
C.O.D. CHARGE TYPE OF POUR CLASS CA DRIVER TRUCK NO. 79

3.00	YDS. CUSTOM MIX			
MIN.	PCS. EXPANSION JOINTS			
	Cartage			
	Tax			
	Minutes Waiting Time			
	Total			

MATERIAL SETTING				UNITS DELIVERED
SAND	4.8	GRAVEL STONE	63	1622
HI FLOW	0.6	LO FLOW		WATER

LEFT JOB	FINISH UNLOAD
ARRIVED JOB	START UNLOAD
TOTAL TIME	POUR TIME

Purchaser hereby acknowledges that all materials and services shown have been received. Truck times shown are correct and water and material settings correct at purchaser's request. See reverse side for conditions.

SIG. OF PURCHASER OR AGENT THEREOF | DRIVER SIGNATURE RAFAEL M.

Fig. 6 – Patch 1 Batch Ticket

Fig. 7 – Cracks meeting at center of patch.

Fig. 8 – Longitudinal crack at south edge (0.25mm).

Fig. 9 – Transverse crack (0.50mm).

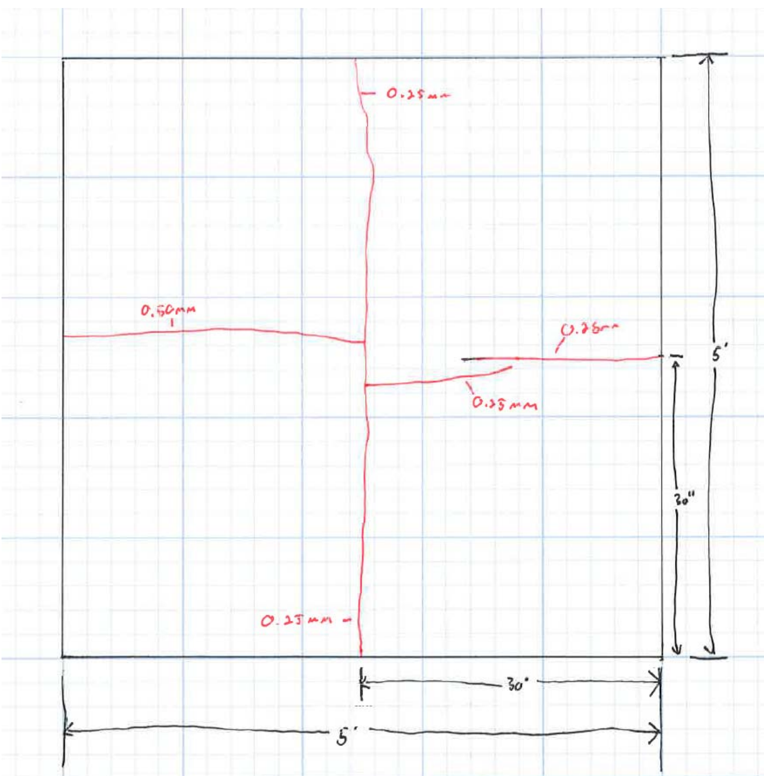


Fig. 10 – Crack map of patch 1.

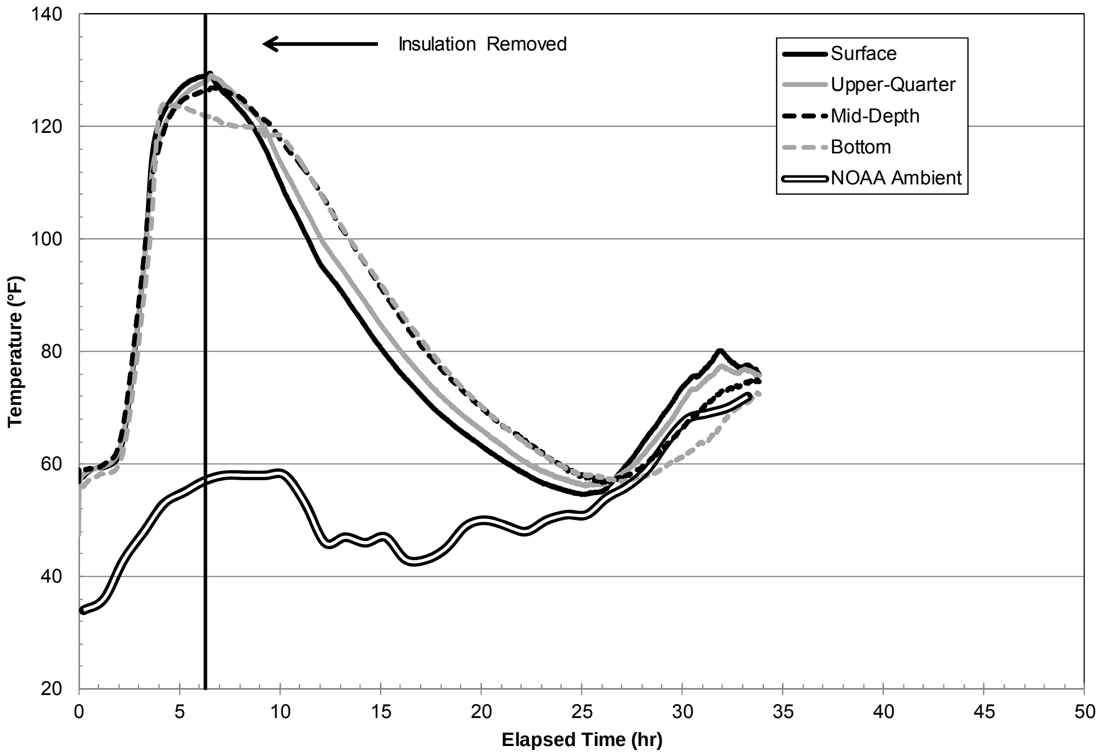


Fig. 11 – Patch center temperature data for patch 1.

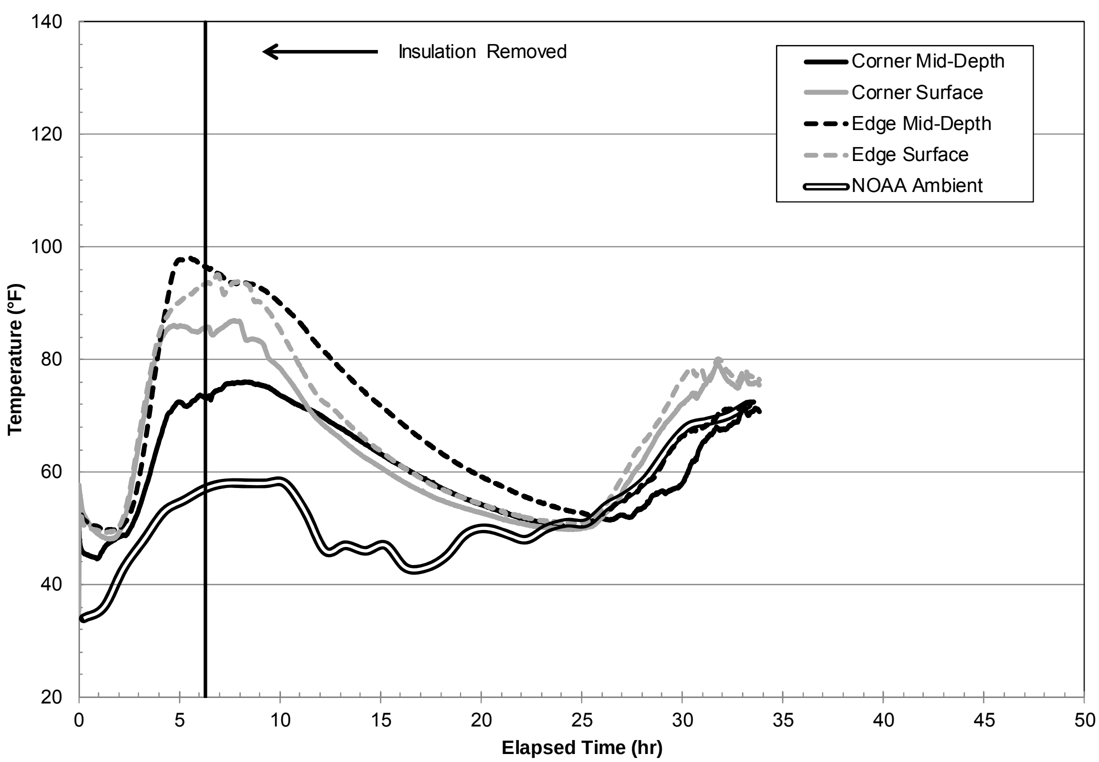


Fig.12 – Patch edge and corner temperature data for patch 1.

Notes

I-88 WB - Toll Plaza 61

There are 2 patches in the ORT lanes just west of the monotube.

Total: 12.25x 25.5 feet by 14 inches thick
Outside traffic lane (lane 3)
Outside shoulder lane (lane 4)

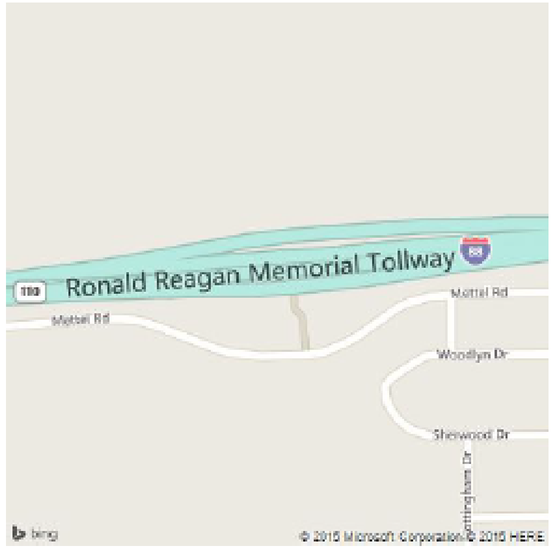
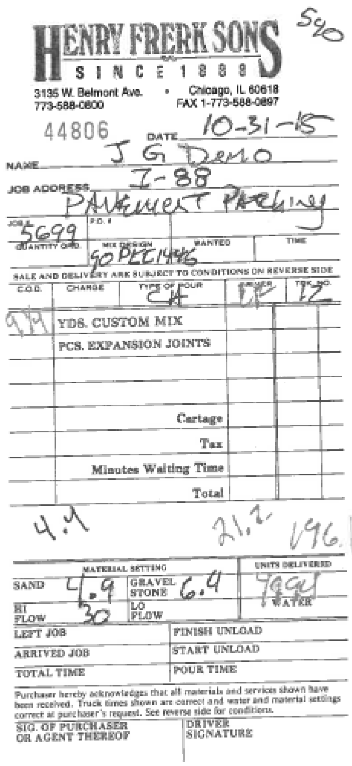
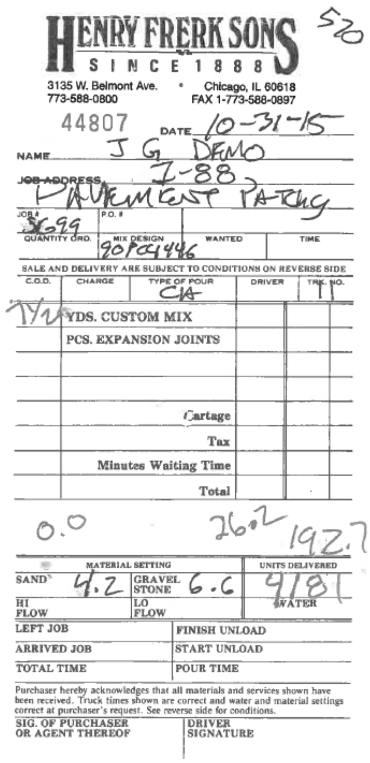


Fig. 13 – Patch location 2 detail.



540
HENRY FRERK SONS
SINCE 1888
3135 W. Belmont Ave. • Chicago, IL 60618
773-588-0800 FAX 1-773-588-0897
44806 DATE 10-31-15
NAME J G DEMO
JOB ADDRESS I-88
PAVEMENT PATCHING
JOB # 5699 P.O. #
QUANTITY ORD. MIX DESIGN 90PCC1446 WANTED TIME
SALE AND DELIVERY ARE SUBJECT TO CONDITIONS ON REVERSE SIDE
C.O.D. CHARGE TYPE OF POUR CF DRIVER TRK. NO. 12
9 1/4 YDS. CUSTOM MIX
PCS. EXPANSION JOINTS
Cartage
Tax
Minutes Waiting Time
Total
4.4 21.2 196
MATERIAL SETTING — SAND 4.9 GRAVEL STONE 6.4 — UNITS DELIVERED 4994 WATER
HI FLOW 30 LO FLOW
LEFT JOB FINISH UNLOAD
ARRIVED JOB START UNLOAD
TOTAL TIME POUR TIME
Purchaser hereby acknowledges that all materials and services shown have been received. Truck times shown are correct and water and material settings correct at purchaser's request. See reverse side for conditions.
SIG. OF PURCHASER OR AGENT THEREOF DRIVER SIGNATURE

Fig. 14 – Patch 2 batch ticket for mixture with accelerator.



520
HENRY FRERK SONS
SINCE 1888
3135 W. Belmont Ave. • Chicago, IL 60618
773-588-0800 FAX 1-773-588-0897
44807 DATE 10-31-15
NAME J G DEMO
JOB ADDRESS I-88
PAVEMENT PATCHING
JOB # 5699 P.O. #
QUANTITY ORD. MIX DESIGN 90PCC1446 WANTED TIME
SALE AND DELIVERY ARE SUBJECT TO CONDITIONS ON REVERSE SIDE
C.O.D. CHARGE TYPE OF POUR CIA DRIVER TRK. NO. 11
7 1/2 YDS. CUSTOM MIX
PCS. EXPANSION JOINTS
Cartage
Tax
Minutes Waiting Time
Total
0.0 26.2 192.7
MATERIAL SETTING — SAND 4.2 GRAVEL STONE 6.6 — UNITS DELIVERED 4181 WATER
HI FLOW LO FLOW
LEFT JOB FINISH UNLOAD
ARRIVED JOB START UNLOAD
TOTAL TIME POUR TIME
Purchaser hereby acknowledges that all materials and services shown have been received. Truck times shown are correct and water and material settings correct at purchaser's request. See reverse side for conditions.
SIG. OF PURCHASER OR AGENT THEREOF DRIVER SIGNATURE

Fig. 15 – Patch 2 batch ticket for mixture without accelerator.

Fig. 16 – Accelerated portion of patch 2

Fig. 17 – Non-accelerated portion of patch 2.

Fig. 18 – Cracking observed in non-accelerated portion of patch 2.

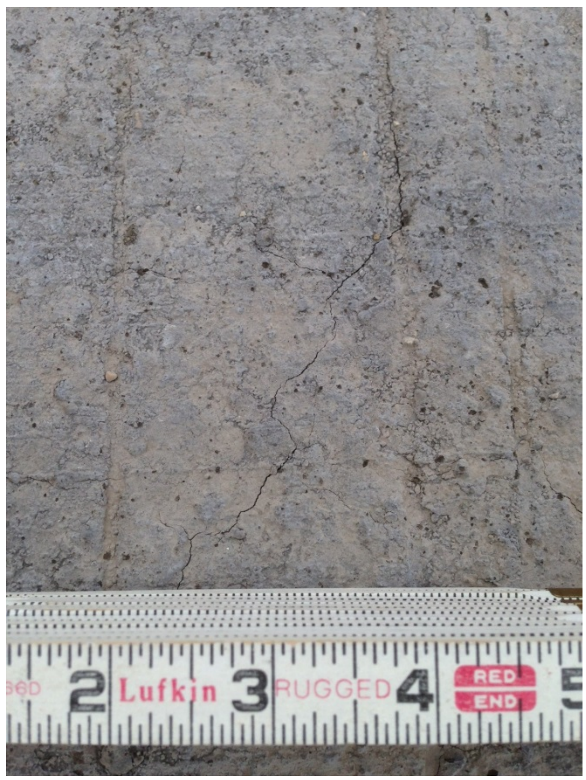


Fig. 19 – Cracking observed in non-accelerated portion of Patch 2.

Fig. 20 – Cracking at interface between accelerated and non-accelerated portion of Patch 2.

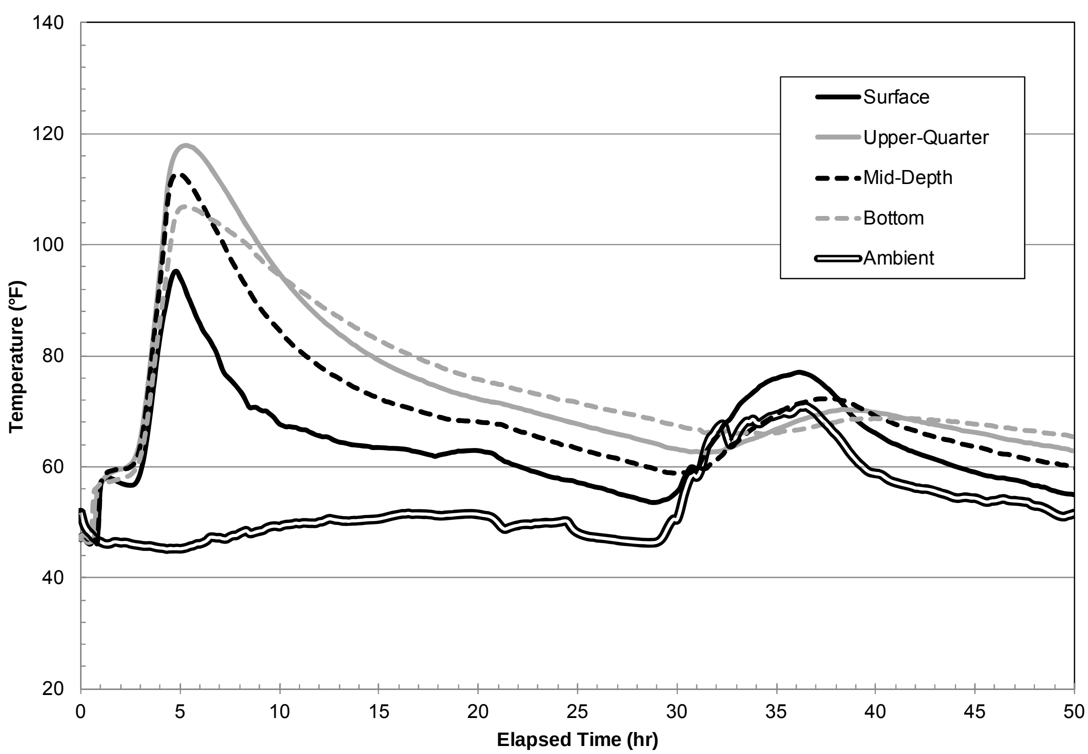


Fig. 21 – Patch center for accelerated placement of Patch 2.

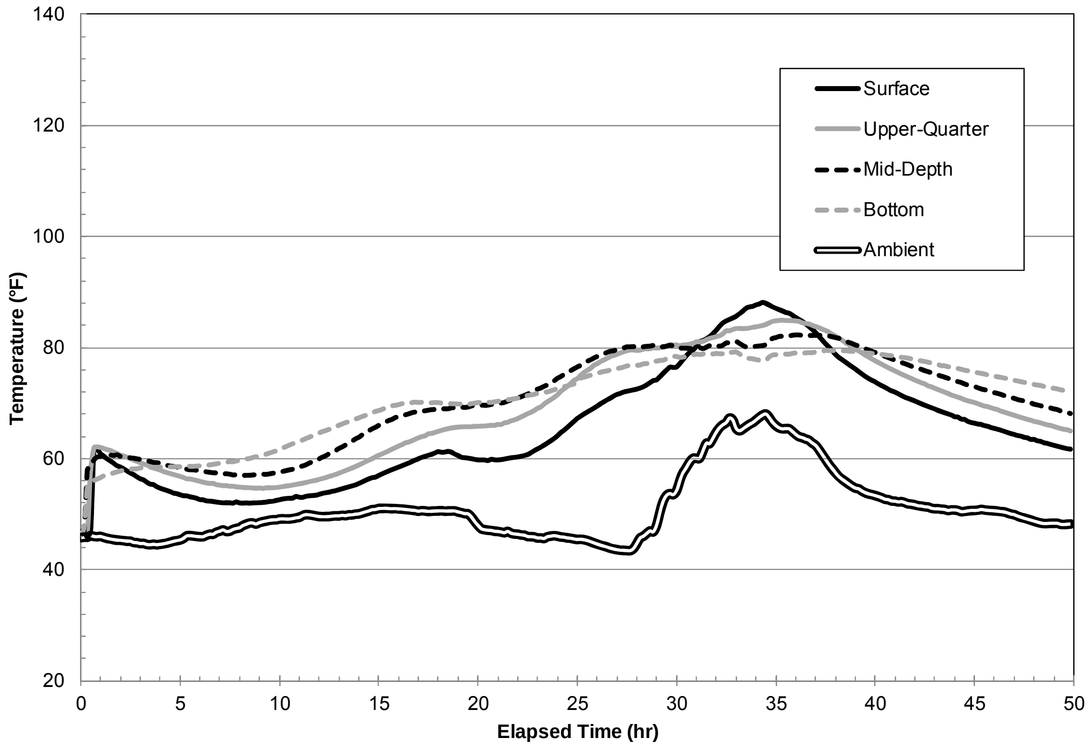


Fig. 22 – Patch center for non-accelerated placement of Patch 2.

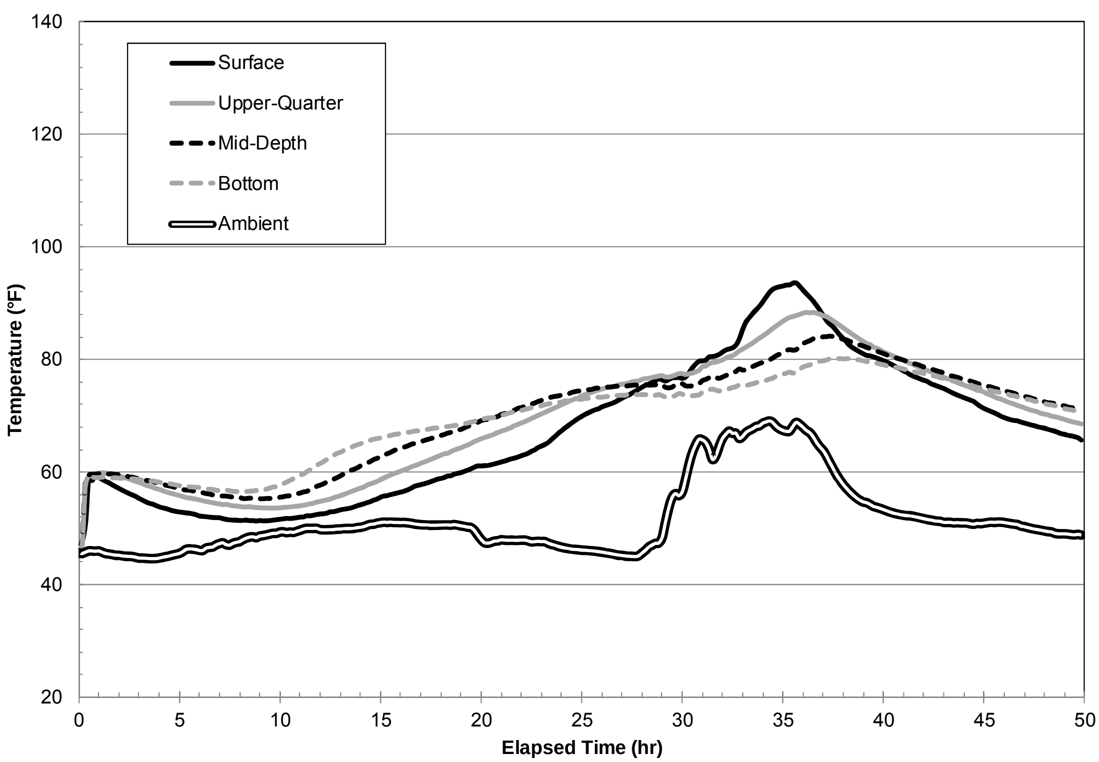


Fig. 23 – Patch edge for non-accelerated placement of Patch 2.

Notes

I-294 SB under Lake Cook Road bridge

There are 2 patches in the mainline directly under the Lake Cook Road bridge.
Total: 13 x 25 feet by 12 inches thick
Middle lane (lane 2) & Outside lane (lane 3)

Note: There are a total of 5 lanes within this section. My I-294 lane numbering starts from the edge of the gore.

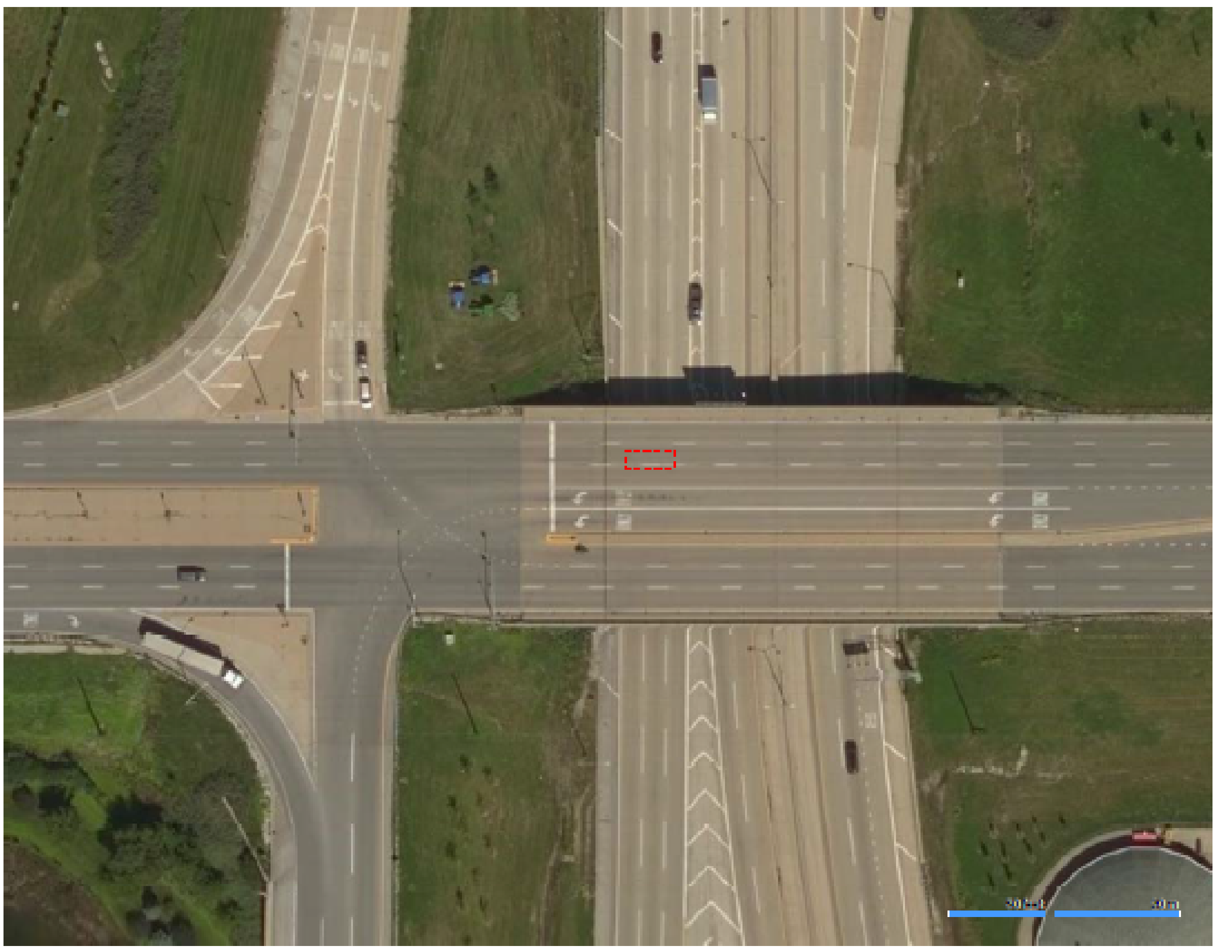


Fig. 24 – Patch 3 location detail.

Fig. 25 – Overview of patch 3.

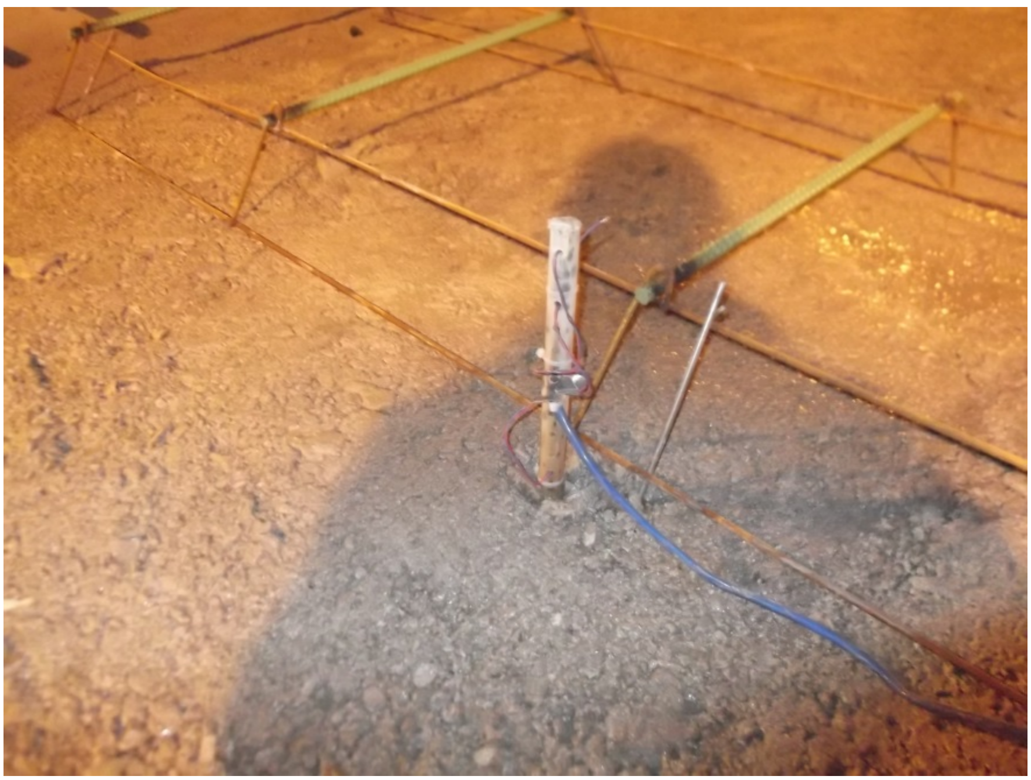


Fig. 26 – Layout of thermocouples at patch center (patch 3).

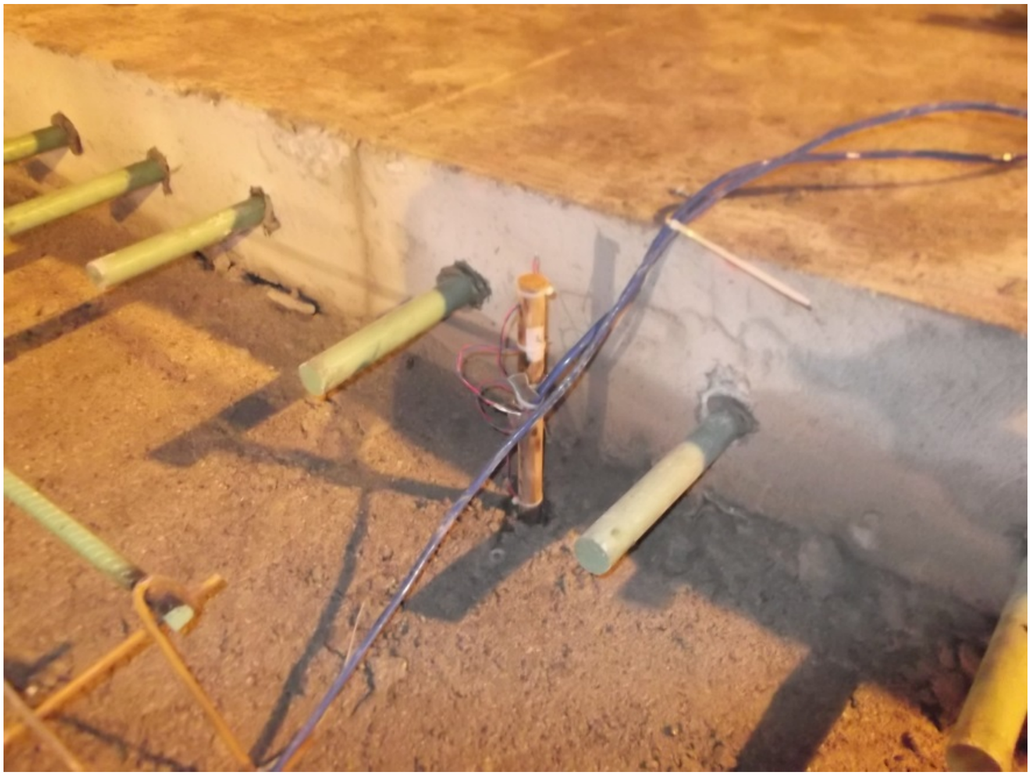
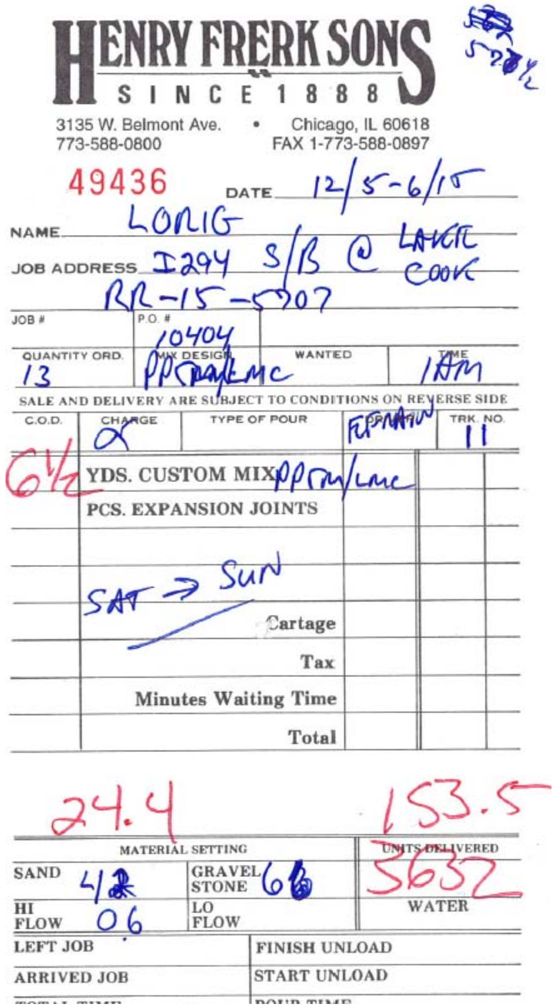


Fig. 27 – Layout of thermocouples at patch edge (patch 3).

Fig. 28 – Layout of thermocouples at patch corner (patch 3).

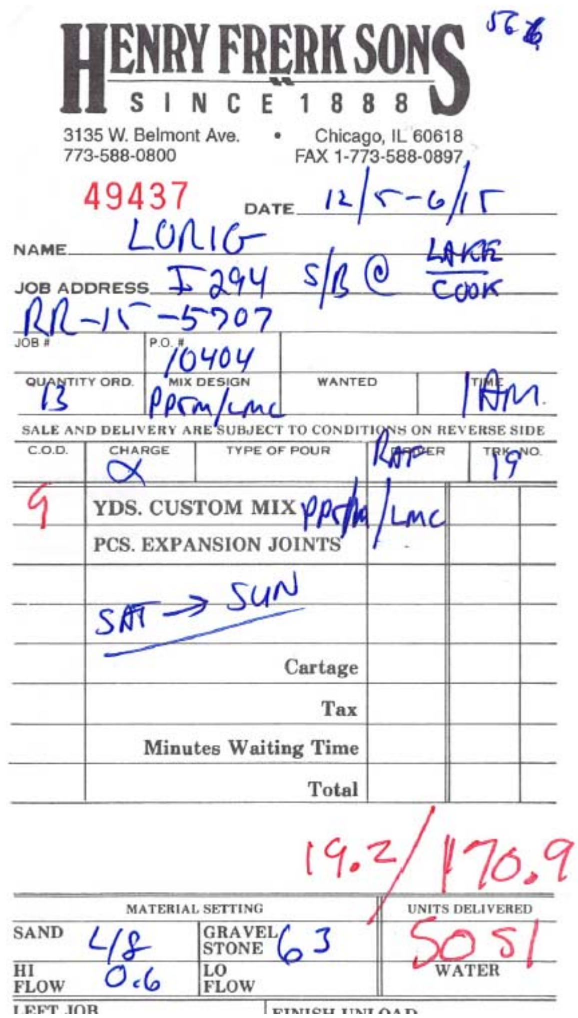
Fig. 29 – Concrete placement at patch 3.


HENRY FRERK SONS
SINCE 1888
3135 W. Belmont Ave. • Chicago, IL 60618
773-588-0800 FAX 1-773-588-0897

No.	49436
DATE	12/5-6/15
NAME	LORIG
JOB ADDRESS	I294 S/B @ LAKE COOK
JOB #	RR-15-5707
P.O. #	10404
QUANTITY ORD.	13
MIX DESIGN	PPC RM/LMC
TIME	1AM
CHARGE	✓
TRK. NO.	11
YDS. CUSTOM MIX	6½ PPCM/LMC
PCS. EXPANSION JOINTS	
	SAT → SUN
Cartage	
Tax	
Minutes Waiting Time	
Total	
	24.4 / 153.5
SAND	4/2
GRAVEL STONE	6
HI FLOW	06
LO FLOW	
UNITS DELIVERED	5632
WATER	
LEFT JOB	
ARRIVED JOB	
FINISH UNLOAD	
START UNLOAD	

SALE AND DELIVERY ARE SUBJECT TO CONDITIONS ON REVERSE SIDE

Fig. 30 – Patch 3 batch ticket (truck #1).


HENRY FRERK SONS
SINCE 1888
3135 W. Belmont Ave. • Chicago, IL 60618
773-588-0800 FAX 1-773-588-0897

No.	49437
DATE	12/5-6/15
NAME	LORIG
JOB ADDRESS	I294 S/B @ LAKE COOK
JOB #	RR-15-5707
P.O. #	10404
QUANTITY ORD.	13
MIX DESIGN	PPCM/LMC
TIME	1AM.
CHARGE	✓
TRK. NO.	19
YDS. CUSTOM MIX	9 PPCM/LMC
PCS. EXPANSION JOINTS	
	SAT → SUN
Cartage	
Tax	
Minutes Waiting Time	
Total	
	19.2 / 170.9
SAND	4/8
GRAVEL STONE	63
HI FLOW	0.6
LO FLOW	
UNITS DELIVERED	5051
WATER	

SALE AND DELIVERY ARE SUBJECT TO CONDITIONS ON REVERSE SIDE

Fig. 31 – Patch 3 batch ticket (truck #2).

Fig. 32 – Finished patch 3 (after removal of plastic, before saw-cutting).

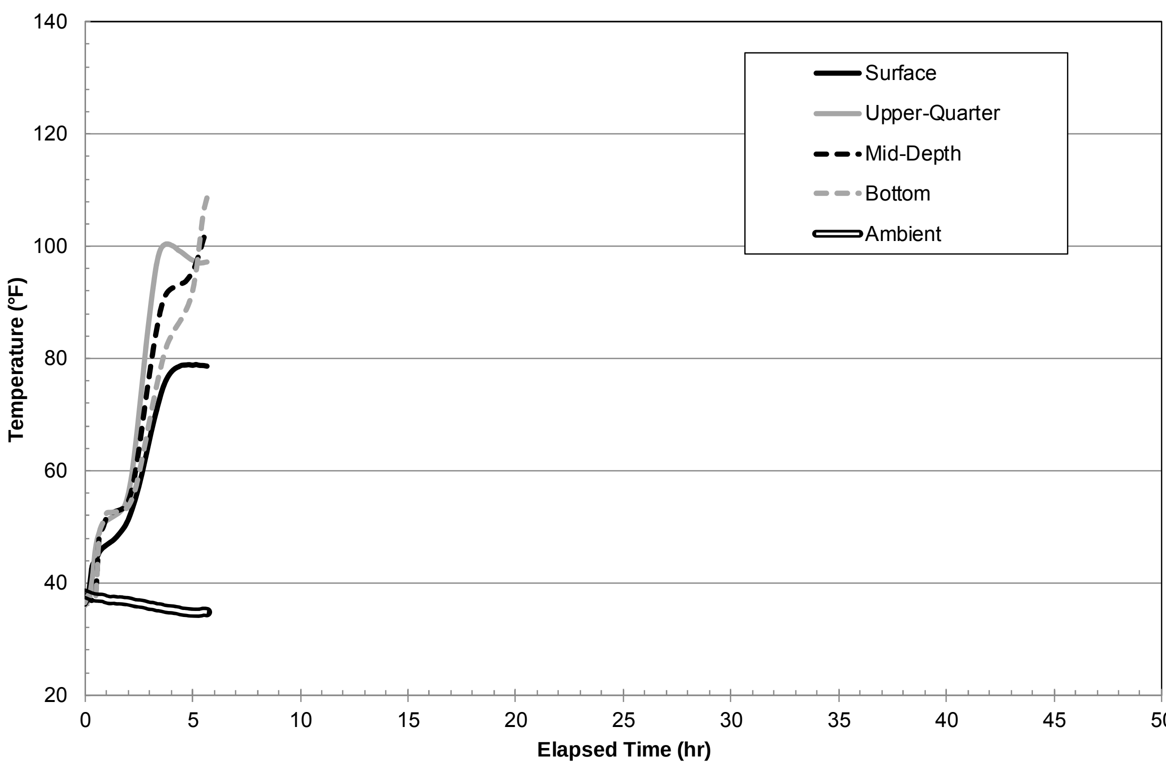


Fig. 33 – Patch center temperature data for patch 3.

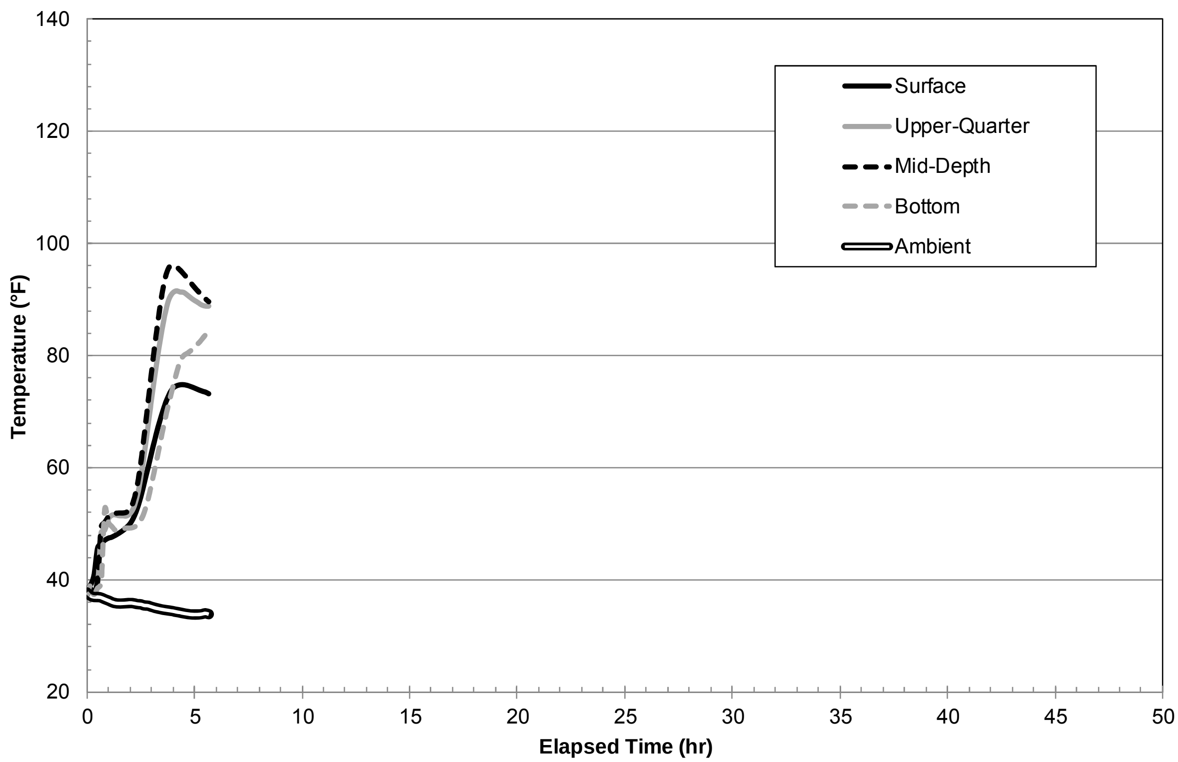


Fig. 34 – Patch edge temperature data for patch 3.

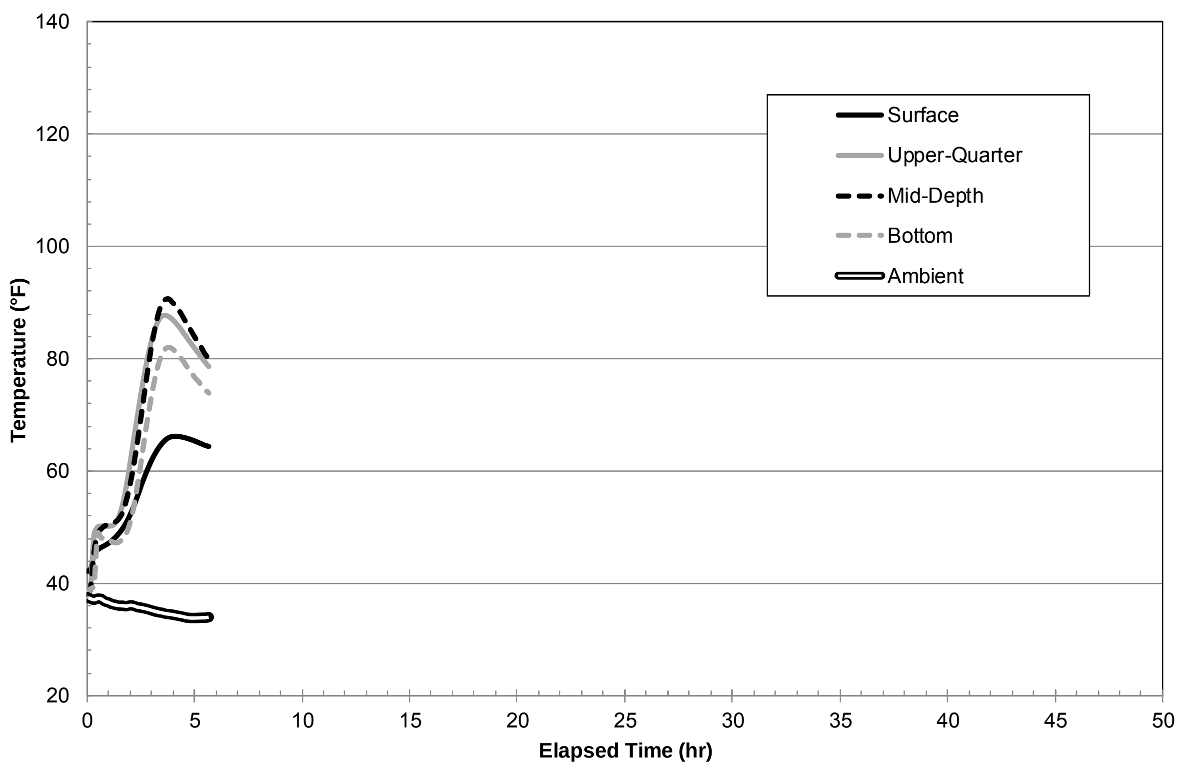


Fig. 35 – Patch corner temperature data for patch 3.

APPENDIX N

PERFORMANCE-RELATED SPECIAL PROVISION FOR CAC

PERFORMANCE-RELATED SPECIAL PROVISION FOR CALCIUM ALUMINATE CEMENT CONCRETE (Illinois Tollway)

Effective: December 11, 2014
Revised: September 15, 2016

DESCRIPTION

This work consists of designing and furnishing calcium aluminate cement Illinois Tollway Class calcium aluminate (CA) concrete for use in rapid repairs of Illinois Tollway pavements, approach slabs and bridge decks. The objective of this performance-related special provision is to provide the Illinois Tollway with a methodology to assure high quality concrete with a rapid hardening ability which will have robust durability.

Note: Calcium aluminate cement Class CA concrete is not acceptable for use in structural elements (such as girders, columns, and bents) due to a potential strength loss phenomenon known as conversion. Class CA concrete is only acceptable for use in flatwork concrete (such as pavements and bridge decks). Applications to bridge decks or approach slab repairs may be partial or full depth repairs as shown on the plans.

REFERENCE STANDARDS

Except where modified by the Illinois Department of Transportation or the Illinois Tollway, the following Standards shall apply:

Illinois Department of Transportation (IDOT)

- Standard Specifications for Road and Bridge Construction,
- Supplemental Specifications and Recurring Special Provisions

Test Procedures referenced herein, as described in the current edition of the IDOT Manual of Test Procedures for Materials, as well these test procedures:

- AASHTO T 22 Compressive Strength of Cylindrical Concrete Test Specimens
- AASHTO T 105 Chemical Analysis of Hydraulic Cement
- AASHTO T 119 Standard Test Method for Slump of Hydraulic-Cement Concrete
- AASHTO T 152 Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C494 Standard Specification for Chemical Admixtures for Concrete
- ASTM C685 Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
- ASTM C856 Petrographic Examination of Hardened Concrete
- ASTM C1581 Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage

- ASTM C1761 Standard Specification for Lightweight Aggregate for Internal Curing of Concrete
- ACI 304.6R-09 Guide for Use of Volumetric-Measuring and Continuous-Mixing Concrete Equipment

Indiana Department of Transportation (INDOT)

- ITM 222-15T Specific Gravity Factor and Absorption of Lightweight Fine Aggregate

MATERIALS AND MIXTURE PROPORTIONS

Calcium aluminate cement, mixing water, fine and coarse aggregates, saturated lightweight fine aggregates, and concrete admixtures used for Illinois Tollway Class CA concrete shall conform to the requirements of Section 1000 of Standard Specifications, with exceptions as noted. Specific references are as follows:

Material	Section
Calcium Aluminate Cement (See Note 1)	1001.01e
Mixing Water	1002
Fine Aggregates (See Note 2)	1003
Coarse Aggregates (See Note 2)	1004
Saturated Lightweight Aggregate (See Note 3)	1005
Concrete Admixtures (See Note 4)	1021

- Note 1: Calcium aluminate cement shall be used according to Article 1020.04 of the Standard Specifications or when approved by the Illinois Tollway. The chemical requirements shall be determined according to AASHTO T 105 and shall be as follows: minimum 38 percent aluminum oxide (Al_2O_3), maximum 42 percent calcium oxide (CaO), maximum 1 percent magnesium oxide (MgO), maximum 0.4 percent sulfur trioxide (SO_3), maximum 1 percent loss on ignition, and maximum 3.5 percent insoluble residue
- Note 2: Fine and coarse aggregate requirements shall be per IDOT Class BS concrete. Partial depth repairs for bridge decks and approach slabs shall require the use of CA-13, CA-14, CA-16 or a blend of these gradations as the coarse aggregate in the performance based mix design. If the performance based concrete mix is used for full depth repairs, then a CA-13, CA-14, CA-16, CA-7, CA-11, or a blend of these gradations shall be used as the coarse aggregate in the mix design.
- Note 3: Saturated lightweight fine aggregate meeting the requirements of ASTM C1761 or otherwise approved by the Illinois Tollway.

- Note 4: Latex-modifying admixtures and lithium based accelerators shall be from Illinois Tollway approved sources.

Supplementary Cementing Materials (SCMs)

The use of supplementary cementing materials is not permitted.

Mixture Proportions

The Contractor shall be responsible for determining the proportions of the concrete. In addition, the following requirements shall be met unless otherwise approved by the Engineer:

Proportions of Concrete		
Material/Properties	**Unit**	**Quantity**
Calcium Aluminate Cement	Minimum (lb/yd^3)	700
Total Water	Maximum (lb/yd^3)	256
Water to Cement Ratio	Maximum (w/c)	0.35
Latex Admixture (See Note 1)	Minimum	15% solids/cwt (Latex)
Saturated Lightweight Aggregate	Minimum	40% by volume of total aggregate

Note 1: The use of latex modifying admixture is required.

Note 2: The use of saturated lightweight aggregate is required.

MIXTURE QUALIFICATION REQUIREMENTS

Contractor shall provide Class CA concrete mixture proportions and test results that demonstrate conformance to the following performance requirements. The testing shall be performed by an AASHTO-accredited laboratory. Class CA concrete mixtures not used in the current calendar year will require a current report of petrographic examination, performed in accordance with ASTM C856, using concrete produced from a trial batch witnessed by the Illinois Tollway in the current calendar year. Class CA concrete must be produced in accordance with ASTM C685, which includes requirements for batching similar to ASTM C94 for ready mixed portland cement concrete. Qualification of mixtures shall be performed with concrete discharged from a volumetric mix truck, either on a field trial or cast directly at a testing laboratory.

Compressive Strength

Class CA concrete compressive strength measured in accordance with AASHTO T 22 shall not be less than 2,500 psi in 4 hours when applied to pavement repairs and shall not be less than 4,000 psi in 6 hours when applied to bridge deck repairs when cured in accordance with AASHTO T 23.

Time to Cracking

Net time to cracking for Class CA shall not be less than 14 days when determined in accordance with ASTM C1581. If necessary, prior to batching for a test sample all coarse aggregate particles exceeding ¾-inch shall be removed and replaced with an equal volume of minus ¾-inch graded coarse aggregate from the same source.

FIELD TRIAL BATCH ACCEPTANCE

Qualification of the concrete mixture will require a field trial batch in addition to laboratory testing. The field trial must be produced by an approved volumetric mixer under the supervision of the Illinois Tollway materials department and must meet the following characteristics:

- Compressive strength measured in accordance with AASHTO T 22 in 4 hours shall be no less than 2,500 psi when used for pavement repairs, and no less than 4,000 psi in 6 hours when used for superstructure repairs
- Electrical surface resistivity in accordance with AASHTO TP 95 on companion samples shall be determined at 4 hours and 6 hours.
- Unless otherwise approved by the Illinois Tollway, the slump shall be between 3 and 8 inches. Workability shall be maintained as long as necessary to facilitate placement by the contractor. Adjustment of accelerator dosage is permitted to increase working time provided the necessary strength can be achieved.
- Water / cementitious materials ratio – Design -0.03, +0.00.

MIXTURE QUALIFICATION SUBMITTAL

Submittal shall include:

1. Mixture design, showing:
    a. Quantities, description, sources and mill certifications of all mixture ingredients;
    b. Design water-cementitious materials ratio (w/cm);
    c. Design Slump;
    d. Design Air content;
    e. Gradation and absorption of fine and coarse aggregates;
    f. Gradation, absorption and desorption of lightweight aggregates;
    g. Bulk specific gravity (SSD) of all cementitious materials and aggregates;
    h. Theoretical mass and fresh density;
    i. Admixture dosages.
2. A mixture qualification report demonstrating that the concrete complies with the performance requirements specified herein.

3. Report of petrographic examination of trial batch concrete, performed in accordance with ASTM C856.
4. Report of chemical analysis by X-ray Fluorescence of trial batch concrete, performed in accordance with AASHTO T 105.

MATERIAL TOLERANCES

Calcium Aluminate Cement

No substitution of cement brand, source, or type is permitted.

Coarse and Fine Aggregate

Substitution of aggregates from different sources or size classifications shall only be permitted at the discretion of the Illinois Tollway materials department. Similar aggregate type and lithology are recommended to ensure that no change in constructability or performance occurs.

Lightweight Aggregates

Lightweight aggregates shall meet the requirements of ASTM C1761 unless otherwise approved by the Illinois Tollway. The surface moisture and absorption capacity shall be determined in accordance with Indiana Department of Transportation Procedure ITM 222-15T.

Concrete Admixtures and Other Materials

No changes in manufacturer or product shall be permitted without re-submittal unless approved by the Illinois Tollway materials department. A field trial batch may be required for any modification to a previously approved Class CA mix design to demonstrate similarity. Additional laboratory testing may also be required to validate performance. Testing will be limited only to tests defined in this special provision, and may consist only of selected tests depending on the substitution or change. The proposed change will be reviewed by the Illinois Tollway to select the required tests for requalification of any proposed modified mix design.

QUALITY MANAGEMENT PLAN

At least 14 days prior to the first concrete placement, the Contractor shall submit a Quality Management Plan (QMP), for materials and construction in accordance with the Illinois Tollway recurring Special Provision for Contractor's Quality Program Minimum job-site testing procedures shall be per the IDOT Recurring QC/QA Special Provision.

PRODUCTION AND TRANSPORTATION EQUIPMENT

The production facility and transportation equipment shall conform to the certification requirements of the Illinois Department of Transportation.

To insure production of quality Class CA concrete, each volumetric measuring unit must be calibrated for each respective concrete ingredient, following the manufacturer's recommendations and ASTM C685. The concrete supplier shall be certified by the Volumetric Mixer Manufacturers Bureau (VMMB) or have an inspection report signed and sealed by a licensed professional engineer demonstrating that the equipment meets all requirements of ASTM C685. Provide documentation of the certification and calibration records.

FIELD ACCEPTANCE

Acceptance to this specification shall be based on the following characteristics:

- Compressive strength measured in accordance with AASHTO T 22 in 4 hours shall be no less than 2,500 psi for pavement repairs and no less than 4,000 psi in 6 hours for superstructure repairs.
- Electrical surface resistivity in accordance with AASHTO TP 95 on companion samples shall be determined in 4 hours and 6 hours.
- Unless otherwise approved by the Illinois Tollway, the slump shall be between 3 and 8 inches when delivered to the project site.
- Prior to the start of the placement, contractor shall demonstrate that the mixture will remain in a workable state for a period of time that is sufficient to achieve adequate consolidation and surface finish. The workability window is specific to particular placement characteristics (placement size, ambient temperature, etc.) and shall be determined and agreed upon by the Contractor and Concrete Supplier.
- Water / cementitious materials ratio – Design -0.03, +0.00

Other quality assurance testing required by the Illinois Tollway, but not included as a basis for payment shall consist of:

- A petrographic examination in accordance with ASTM C856 and chemical analysis according to AASHTO T 105 may be used at the discretion of the Illinois Tollway to screen for changes in composition.

CERTIFICATION OF TESTING PERSONNEL

- Contractor personnel performing testing shall be IDOT certified Level I PCC Technician or higher.
- As recommended by ACI 304.6R, personnel authorized to make adjustments of the volumetric mixer proportioning controls should have received training and/or certification from the equipment manufacturer or have at least 4 weeks of supervised on-the-job training with qualified personnel.

APPENDIX O

VOLUMTETRIC BATCHING TRUCK CALIBRATION

CTLGroup
5400 Old Orchard Road, Skokie, IL 60077
(847) 965-7500

FIELD REPORT

Date: November 4, 2016

Project:	CAC Henry Frerk Sons Calibration	CTL Project No.:	057177
Location:	Henry Frerk Sons Yard @ 3135 W. Belmont, Chicago, IL	Client:	ISHTA
Contractor:	Henry Frerk Sons	Weather/Temp:	55°F

SUMMARY OF SERVICES PERFORMED

Ben Birch arrived on site at 8:30 AM.

Gary Vandenbroucke of Henry Frerk Sons (HFS) reported they would be performing calibrations on three trucks; #s 10, 11, and 14. Dan Gancarz of Illinois State Highway Toll Authority (ISHTA) and Greg Rohlf of S.T.A.T.E Testing (State) were also on hand. Greg reported STATE measured the moisture contents of the aggregate. The total moisture on the coarse aggregate was 3.84% (2.44% free moisture). The free moisture on the saturated lightweight aggregate using the centrifuge was 5.84% and the absorption was 17.56%.

The calibration proceeded for all three trucks. The liquid admixture pump for latex on truck #14 was down and will be calibrated at a later date. At one point calibrations were performed on truck #10 using the required time/counts of truck #11 (the truck #s were overlooked). This error was identified and the calibration steps for truck #10 that were in error were repeated.

Calibrations were performed by measuring how much cement was dispensed using a pre-determined # of counts (74) on the trucks "plate counter". The count of 74 is provided by the manufacturer as the # that should be close to 94lbs (1 bag of cement). This test was performed at least 4 times to establish the relationship between counts, weight of cement, and elapsed time (a stop watch is used to time the 74 counts). The # of counts necessary to dispense 0.5 bags of cement (47 lbs) is calculated and used for calibrating the aggregate gates (CNT0.5). The time it takes to dispense 0.5 or 1.0 bags of cement is used to calibrate the liquid admixture dispenser settings (T0.5, and T1.0).

The CNT0.5 value was used to calibrate the aggregate by applying a gate setting for 1 aggregate, measuring the aggregate dispensed while the conveyor runs for the CNT0.5 period, and then adjusting the gate setting and repeating as necessary until the amount of aggregate dispensed (at stock weight) is equal to what would be needed with 47 lb of cement (see the sheet for truck #10; 5.0 setting for the saturated lightweight aggregate and 5.4 for the CM13). Each time a setting was changed the conveyor was run and material was discarded to make sure no material remained on the conveyor from the previous setting. The gates can only be adjusted on 1/10th increments.

Liquid admixtures were calibrated by disconnecting the hoses where they dispense into the auger system. The hoses were used to dispense admixture directly into a kitchen type measuring cup (for the accelerator) or into a 5 gallon bucket (for the latex). The accelerator was adjusted by dispensing for the T0.5 seconds. The setting was adjusted until the volume dispensed was approximately equal to the target volume. As an example with truck 10 the accelerator was first dispensed at a setting of 0.6 and 12 ounces were produced in 11 seconds (~ time for 0.5 bags of cement). The setting was changed to 0.7 and 14 ounces were produced. The target was 14 ounces in 11 seconds. The setting of 0.7 was recorded as the final setting to use for this mixture. A similar procedure was used for latex, with T1.0 used as the dispensing time. The required volume of liquid admixture marked on a 5-gallon bucket and the settings on the latex dispenser were adjusted until the time it took to dispense the required latex for 1 bag of cement was equal to T1.0. As an example with Truck 10 the first latex setting took 18.5 seconds to dispense 29.7 pounds of admixture (3.5 gallons), the amount necessary for 1 bag of cement. The setting was changed to 12 and the time changed to 20.1 seconds. The T1.0 was 22 seconds so the value of 12 was used as the final setting.

By: Benjamin F. Birch

Title: Associate II, Materials and Mechanics

CTLGroup

5400 Old Orchard Road, Skokie, IL 60077
(847) 965-7500

FIELD REPORT

Date: November 4, 2016

Project:	CAC Henry Frerk Sons Calibration	CTL Project No.:	057177
Location:	Henry Frerk Sons Yard @ 3135 W. Belmont, Chicago, IL	Client:	ISHTA
Contractor:	Henry Frerk Sons	Weather/Temp:	55°F

SUMMARY OF SERVICES PERFORMED

Calibration work sheets produced by HFS on their own form and the ISHTA form (A20) are attached.

The latex on Truck #14 was not calibrated due to a faulty pump. Gary (HFS) reports it will be repaired and available for calibration the week of 11/7/16.

Ben Birch left the site at ~ 11:25AM.

Figure 1 - Controls of Volumetric Mixer.

By: Benjamin F. Birch

Title: Associate II, Materials and Mechanics

CTLGroup
5400 Old Orchard Road, Skokie, IL 60077
(847) 965-7500

FIELD REPORT

Date: November 4, 2016

Project:	CAC Henry Frerk Sons Calibration	CTL Project No.:	057177
Location:	Henry Frerk Sons Yard @ 3135 W. Belmont, Chicago, IL	Client:	ISHTA
Contractor:	Henry Frerk Sons	Weather/Temp:	55°F

SUMMARY OF SERVICES PERFORMED

Figure 2 - Dispensing Aggregate for Calibration Procedure.

By: Benjamin F. Birch

Title: Associate II, Materials and Mechanics

CTL GROUP
5400 Old Orchard Road, Skokie, IL 60077
(847) 965-7500

FIELD REPORT

Date: November 4, 2016

Project:	CAC Henry Frerk Sons Calibration	CTL Project No.:	057177
Location:	Henry Frerk Sons Yard @ 3135 W. Belmont, Chicago, IL	Client:	ISHTA
Contractor:	Henry Frerk Sons	Weather/Temp:	55°F

SUMMARY OF SERVICES PERFORMED

Figure 3 - Dispensing Accelerator for Calibration Procedure.

By: Benjamin F. Birch

Title: Associate II, Materials and Mechanics