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MEMORANDUM

To: Science & Technology Program Coordinator, Research and Development Office
Attn: 08-10000 (JWhitler)

From: Katie Bartojay P.E., Civil Engineer
Concrete, Geotechnical, and Structural Laboratory (86-68530)

KATIE BARTOJAY
Digitally signed by KATIE BARTOJAY
Date: 2018.04.30 06:44:03 -06'00'

Subject: Science and Technology Program Report ST-2018-7644-01 – Comparative Analysis on Reducing Concrete Shrinkage and Cracking

A report on Comparative Analysis on Reducing Concrete Shrinkage and Cracking, ST-2018-7644-01 from the Science and Technology Program has been prepared by the Technical Service Center at the request of the Research and Development Office. The report will be available in Adobe Acrobat Format on the Science and Technology website.

If you have any questions, please contact me at 303-445-2374 or at kbartojay@usbr.gov.

cc (w/att):
08-10000 (Whitler, Dorsey)
86-68530 (Lindenbach, White)

RECLAMATION

Managing Water in the West

Research and Development Office Comparative Analysis on Reducing Concrete Shrinkage and Cracking

Science and Technology Program
Final Report ST-2018-7644-01 (8530-2018-24)

U.S. Department of the Interior
Bureau of Reclamation
Research and Development Office

April 2018

Mission Statements

Protecting America's Great Outdoors and Powering Our Future

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

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Research and Development Office
Science and Technology Program

Concrete, Geotechnical, and Structural Laboratory, 86-68530

Final Report ST-2018-7644-01 (8530-2018-24)

Comparative Analysis on Reducing Concrete Shrinkage and Cracking

Catherine Lucero Digitally signed by CATHERINE LUCERO
Date: 2018.04.30 06:41:00 -06'00'

Prepared by: Catherine Lucero, MSCE, EIT
Civil Engineer, Concrete, Geotechnical, and Structural Laboratory, 86-68530

KATIE BARTOJAY Digitally signed by KATIE BARTOJAY
Date: 2018.04.30 06:45:01 -06'00'

Technical Approval/ Checked by: Katie Bartojay, PE, FACI
Civil Engineer, Concrete, Geotechnical, and Structural Laboratory, 86-68530

JEFFERY KEIM Digitally signed by JEFFERY KEIM
Date: 2018.04.30 07:42:00 -06'00'

Peer Review: Scott Keim, P.E.
Civil Engineer, Concrete, Geotechnical, and Structural Laboratory, 86-68530

Acronyms and Abbreviations

ACI	American Concrete Institute
ASTM	American Society for Testing of Materials
CDSRA	Chemical and Drying Shrinkage Reducing Admixture
ERDC	US Army Engineer Research and Development Center
HRWRA	High Range Water Reducing Admixture
NMSA	Nominal Maximum Size of Aggregate
SRA	Shrinkage Reducing Admixture
USACE	US Army Corps of Engineers

Executive Summary

Cracking due to shrinkage is a common issue in concrete. Internal strain can be generated by restraint, temperature, chemical shrinkage, and/or drying shrinkage. Shrinkage reducing additives have been on the market since the 1980's, but recent technologies have been developed to further decrease the risk of cracking due to shrinkage. Although many products and techniques claim to have an effect on concrete cracking, there is very little consistency in the testing and very little data available to compare the crack resistance of a concrete material. This research compared four commercially available shrinkage reducing admixtures as well as two low-shrinkage repair mortars. The results show that modern shrinkage reducing admixtures, including those with expansive components, perform well in reducing the drying shrinkage of concrete in both the free drying test (ASTM C157) and the restrained shrinkage test (ASTM C1581).

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Background

Concrete is typically jointed to force cracks to occur at particular locations. Cracks occur to alleviate internal strains that are greater than the material's tensile capacity. Internal strain can be generated by restraint, temperature, chemical shrinkage, and/or drying shrinkage. Joint spacing is generally selected using rules of thumb which were primarily based on older cement chemistries. During construction, requests are often made to extend the distance between joints and/or eliminating joints to increase the speed of construction.

Although many products and techniques claim to have an effect on concrete cracking, there is very little consistency in the testing and very little data available to compare the crack resistance of a concrete material.

A more comprehensive program to look at a number of products and/or techniques and compare them using the same suite of laboratory and field tests is needed to be able to quantify the properties that can be achieved with today's cementitious components and to provide Reclamation with the tools to specify appropriate and relevant properties when designing large concrete structures.

Previous Work

Previous studies by the Bureau of Reclamation have looked at specific concrete materials for repair type applications. A 2009 report partnering with Laval University and Vaycon Consulting focused on the development of test methods to evaluate cracking of repair materials [1]. The testing included large-scale field studies. Testing found that there was a good correlation between ASTM C1581, *Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage* (restrained shrinkage) and cracking behavior of experimental repairs.

The Science and Technology Program funded a scoping study in 2011 to summarize new technologies to mitigate early-age shrinkage [2]. Technologies identified included traditional shrinkage reducing admixtures (SRAs), use of internal curing (via lightweight aggregate or super-absorbent polymers), and shrinkage compensating materials such as magnesium oxide.

Studies were conducted prior to construction of a spillway inlet slab at Glen Elder Dam in 2011 [3]. Test placements containing Premier Magnesia Prevent-C exhibited 90% less cracking compared to concrete placed a year previously that did not contain any shrinkage reducing admixture. Due to the success of the test placements, about 100 cubic yards of concrete containing Prevent-C were placed.

In 2012, a literature review was done on shrinkage values of low-shrinkage concrete using shrinkage reducing technologies. Suggested limits on length change were 0.04% for normal concrete and 0.02% for low-shrinkage concrete at 28 days [4].

Another preliminary study looked at the effect of colloidal nano-silica on chemical shrinkage as evaluated with ASTM C1608, *Chemical Shrinkage of Hydraulic Cement Paste*. Based on the limited preliminary test results, the nano-silica improved the shrinkage when compared to an ordinary portland cement mixture, but did not have a significant effect on chemical shrinkage when compared to mixtures with pozzolans, such as Class F fly ash and Slag [5].

Experimental Program

Materials

Several admixtures were used in this study. There are many mechanisms in which admixtures can decrease curling or cracking due to shrinkage. Traditional SRAs are liquid surfactants that decrease the internal stresses caused by drying by reducing the surface tension of the pore solution of concrete [6]. Other products reduce the net shrinkage of concrete by introducing an expansive component, either calcium or magnesium based, that offsets the expected shrinkage, particularly at early ages. See Appendix A for product data sheets.

Table 1. Description of admixtures and repair products used

Mix ID	Manufacturer	Product Name	Product Description
S-1	Control Mix (mortar and concrete)		Type I/II Cement, 3/8" NMSA, No Pozzolan, No Air Entrainment
S-2	GCP	Eclipse Floor 4500	Clear liquid admixture. Reduces drying shrinkage strain and curling by reducing the surface tension of pore solution of concrete. For use with non air-entrained concrete. Marketed As: Shrinkage reducing admixture
S-3	Euclid	Conex	Free-flowing fine beige powder. Reduces net shrinkage by forming an expansive calcium hydroxide platelet crystal system (Type G component, ACI 223). Expansion not through ettringite formation. Marketed As: Shrinkage Compensating Admixture
S-4	Premier Magnesia	Prevent-C	Free-flowing fine off-white powder. Reduces net shrinkage with an expansive component as well as by reducing the surface tension of the pore solution. Marketed As: Shrinkage-reducing and crack-control concrete admixture
S-5	BASF	MasterLife CRA 007	Yellow liquid admixture. Reduces probability of cracking due to drying shrinkage as well as reduces the initial crack width when cracking does occur. Marketed As: Crack-reducing admixture
S-M*	BASF	MasterEmaco 440	Bagged "shrinkage compensating" repair mortar. Dual expansion system compensates for shrinkage in plastic and hardened states. Marketed As: Shrinkage-compensated repair mortar
S-S*	Sika	Sikacrete SCC 211 +	Bagged self-consolidating concrete containing factory blended coarse aggregate. Mix is polymer modified and also contains a migrating corrosion inhibitor Marketed As: Self consolidating concrete

Eclipse Floor 4500 is a traditional shrinkage reducing admixture that alters the basic mechanism of shrinkage without adding any expansive materials to the concrete. It can be used for several applications including industrial floors, bridge decks, parking garages, marine structures, and hydraulic structures [7].

Euclid Conex is a shrinkage compensating admixture that is primarily used in flatwork concrete, bridge decks, parking structures, arenas, walls and parapets, and piers. It has an expansive component [8].

Premier Magnesia's Prevent-C has been used with success on Reclamation projects including the spillways at Glen Elder Dam and Echo Dam [9]. The largest placement at Echo Dam was 53 ft by 62 ft by 3.5 ft (some placements were as thick as 5.5ft) and was achieved by incorporating 4% Prevent-C into the cement and fly ash concrete mixtures. The US Army Corps of Engineers have also used Prevent-C on large dam projects including Fort Randall Dam in Pickstown, South Dakota. Other notable applications include concrete floors and slabs. A 7,000 square foot concrete floor at the Cathedral Church of St. Paul was poured and finished in one placement with no joints. The use of Prevent-C resulted in a crack-free slab [10].

Masterlife CRA 007 is a relatively newly marketed shrinkage reducing and compensating admixture that claims to reduce joint maintenance costs in concrete slabs and permits increase in joint spacing. The product also provides enhanced performance by reducing the initial crack width if cracking does occur [11].

The MasterEmaco and Sikacrete are concrete repair mortars and these products were include in the study, because these products (or equals) are often selected by Operations and Maintenance personnel when performing smaller concrete repairs.

During the study, because time and equipment allowed, both the colloidal nano-silica and carbon nano-tube technology were evaluated in some of the tests, even though they are not marketed as shrinkage-reducing admixtures or currently being used on Reclamation projects. These products or results are not included in this report, but it is recommended that future concrete research consider these types of products when additional strength, or abrasion resistance is needed.

Mixture Proportions

Tests were conducted on both mortar and concrete containing pea gravel sized 3/8" nominal maximum size aggregate (NMSA). Mortar mixtures were proportioned with a water content to ensure normal consistency per ASTM C109, *Compressive Strength of Hydraulic Cement Mortars or Cube Specimens* [12]. For mixtures containing SRAs, the water content was adjusted so the resulting mortar had the same flow as the control mixture. The dosage of SRA used was the median manufacturer's recommended dose. For example, if the manufacturer recommended 1.0 to 2.0 gal/yd^3, a dosage of 1.5 gal/yd^3 was selected. For individual mixture proportions, see Appendix B.

Test Methods

Several tests were used to evaluate shrinkage and cracking potential, including ASTM C157, *Length Change of Hardened Hydraulic-Cement Mortar and Concrete* [13] and ASTM C1581 *Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage* [14] on both mortar and concrete. In addition, compressive strength was also measured to determine whether the additive had a negative influence on strength.

ASTM C157 is commonly used in specifications when shrinkage cracking is a concern. The test can be performed on mortar using bars with a 1-in. by 1-in. cross section or on concrete using bars with a 3-in. by 3-in. cross section. According to ASTM C157, the length change is calculated as follows:

$$\Delta L_x = \frac{CRD - initial\ CRD}{G} \times 100$$

Where:

ΔL_x = length change of specimen at any age, %
CRD = difference between the comparator reading of the specimen and the reference bar
G = the gage length (10-in.)

When following ASTM C157, the initial comparator reading is taken at an age of 24 ± ½ hour after the addition of water to the cement during the mixing operation. However, a modified calculation is sometimes specified where the initial comparator reading is taken after the curing period (7 days in a lime water bath). This method is more conservative, and does not capture the initial expansion of the specimens while they are curing. Both calculations were performed.

For the concrete mixtures, a modified procedure was also performed in addition to the standard test and the modified calculation. In this report they will be labeled “Standard Test”, “Modified Calculation”, and “Modified Procedure (No Soak)”. The Modified Procedure (No Soak) simulates a worst-case scenario where drying is initiated at an age of 24 hours ± ½ hour and proper curing is not done.

ASTM C1581 is typically specified for pavement construction but has application to Reclamation’s large concrete spillway slabs. The time to cracking and the strain development rate are used to categorize the mixture as having low, medium, or high potential for cracking as listed in Table 2. The strain on the inner ring is recorded immediately after the mortar or concrete is placed. The strain is recorded while the mortar or concrete is wet-cured for 24 hours before being de-molded and subjected to a drying environment (50% relative humidity). Figure 1 shows a typical strain vs time plot for the test. The time to cracking is clearly shown as a sharp decrease in strain.

Table 2. Potential for cracking classification from ASTM C1581

Net Time-to-Cracking, t_{cr}, days	Average Stress Rate, S (MPa/day)	Average Stress Rate, S (psi/day)	Potential for Cracking
$0 < t_{cr} \leq 7$	$S \geq 0.34$	$S \geq 50$	High
$7 < t_{cr} \leq 14$	$0.17 \leq S < 0.34$	$25 \leq S < 50$	Moderate-High
$14 < t_{cr} \leq 28$	$0.10 \leq S < 0.17$	$15 \leq S < 25$	Moderate-Low
$t_{cr} > 28$	$S < 0.10$	$S < 15$	Low

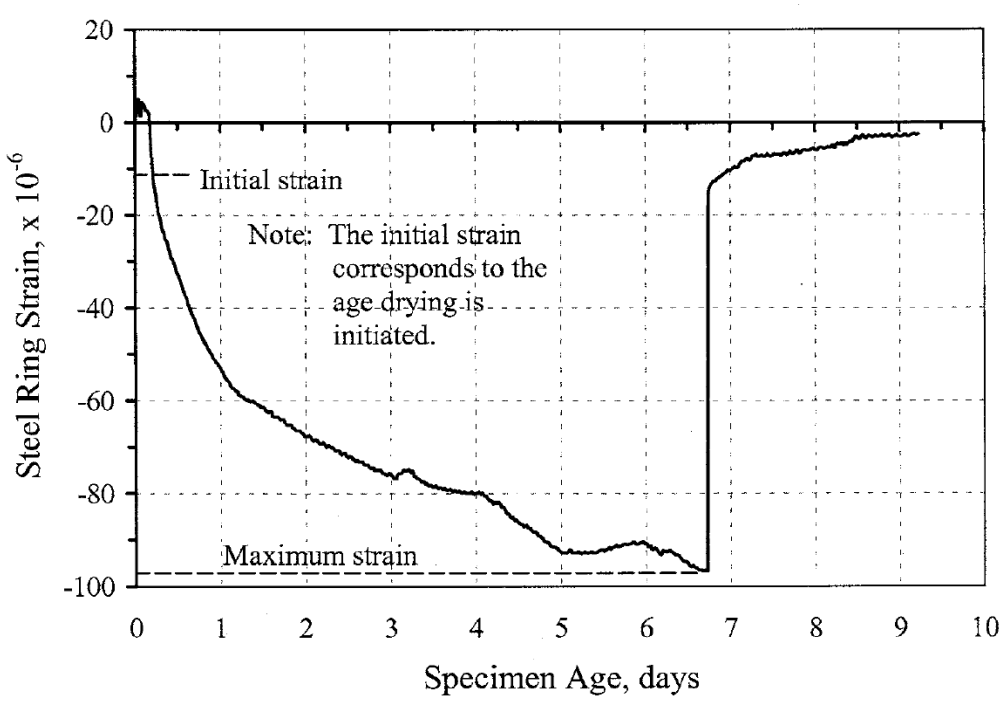

Figure 1. Steel ring strain versus specimen age for a typical ASTM C1581 test.

Results

ASTM C109/C39 Compressive Strength

Compressive strength of both mortar and concrete was tested. In general, the early-age strengths were lower with the admixtures, but caught up to the control at later ages. No 56-day breaks are presented for the Conex mortar cubes due to an error in testing of these samples.

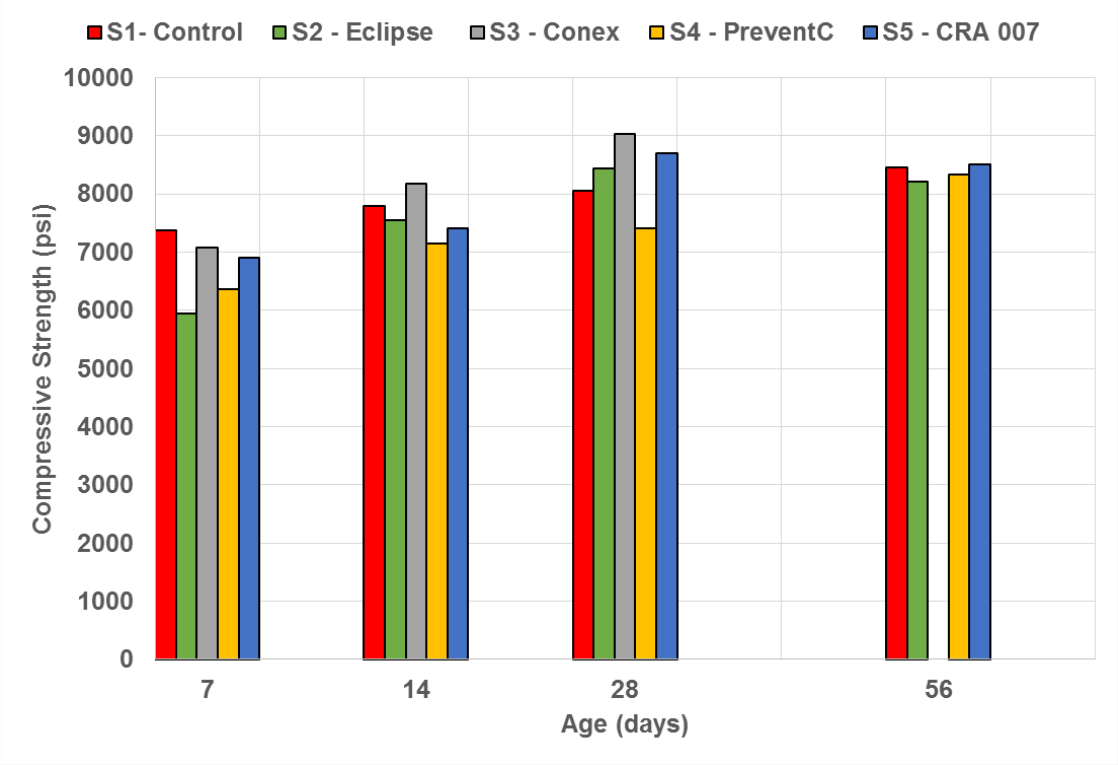

Figure 2. Compressive strength of mortar cubes at 7, 14, 28 and 56 days

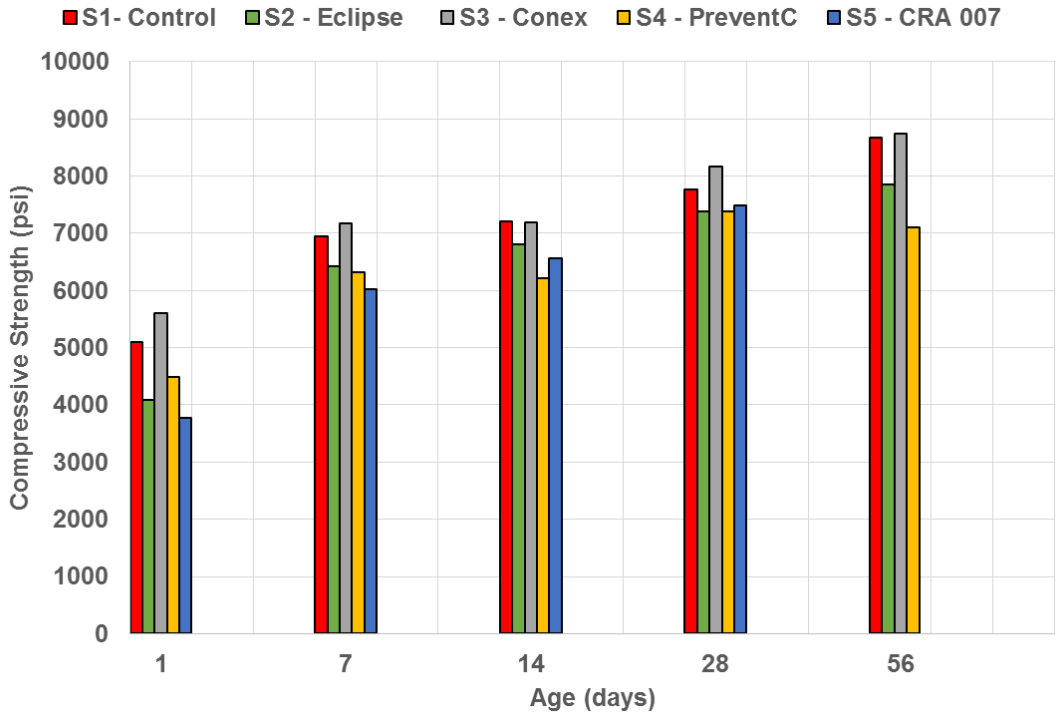

Figure 3. Compressive strength of concrete cylinders at 1, 7, 14, 28, and 56 days

Resistivity Testing

The electrical resistivity of the concrete cylinders was measured with a Proceq Resipod Concrete Resistivity Meter conforming to requirements of AASHTO T 358. Electrical resistivity of concrete surfaces correlates directly to permeability, the likelihood and rate of reinforcing steel corrosion, as well as chloride diffusion rate. The concrete containing Conex and Prevent C had a higher resistivity compared to the concrete containing Eclipse or CRA007.

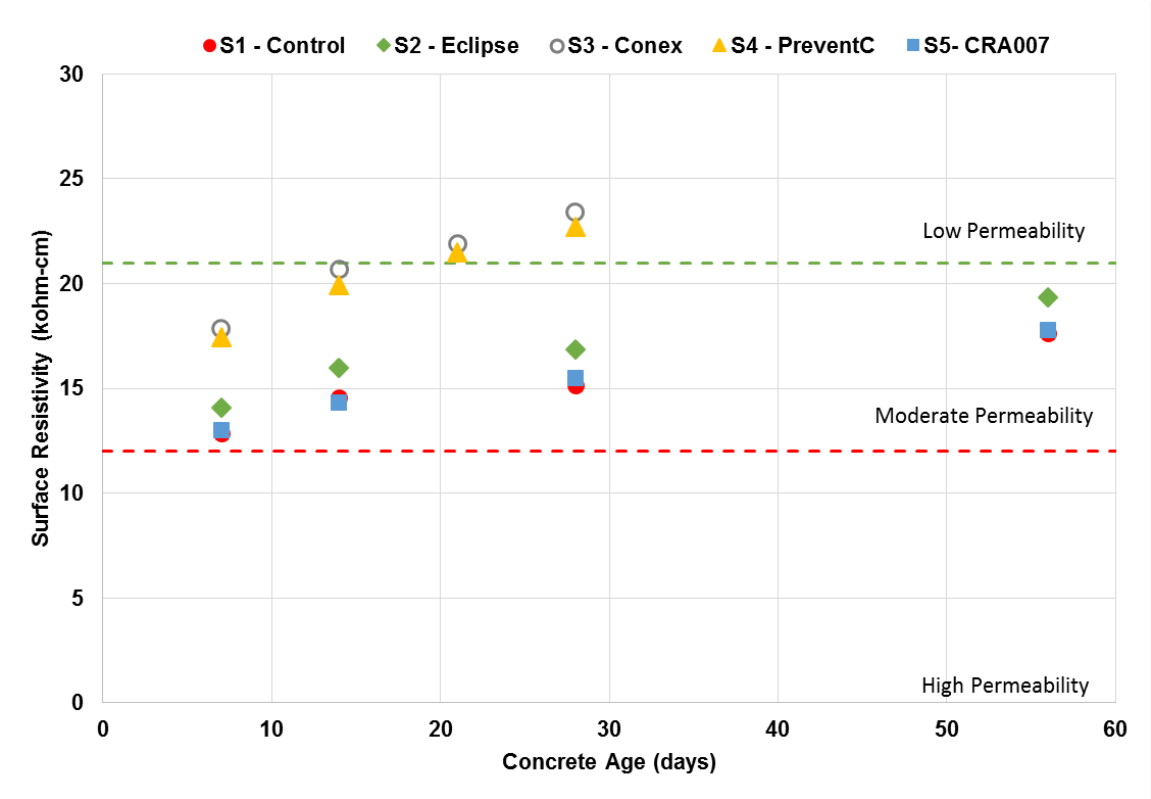

Figure 4. Surface resistivity of concrete and permeability classifications per AASHTO TP 95

ASTM C157 Length Change

The free length change was tested on both mortar and concrete. Mortar contains more paste and does not contain coarse aggregates, so it was expected to exhibit more shrinkage than the concrete specimens. The test is also influenced by the specimen size, so the smaller cross sectional area of the mortar bars also contributes to the larger length changes. This is a good prescreening tests, but acceptance testing during construction is generally performed on larger concrete prism tests.

Mortar Bar

Mortar bars were tested in accordance with the Standard ASTM C157. Table 3 summarizes the 35-day shrinkage results as calculated according to ASTM C157, Equation 1 as well as the Modified Calculation described in the Test Methods section. The 35-days refers to the concrete age and corresponds to 28-days of drying after a 7-day curing period in lime water. Figure 3 and Figure 4 plot the change in length over time. The influence of the expansive admixtures can be seen in Figure 3. Some expansion is expected as the bars cure in a lime water bath, but both Conex and Prevent-C (S-3 and S-4) were well above the other three mortars. After 28 days of drying, all of the shrinkage reducing additives performed better than the control.

If a Modified Calculation is used, as seen in Figure 4, the influence of the early-age expansion is not taken into consideration. If this calculation is used, the mortar containing Conex slightly underperforms compared to the control mixture. The other admixtures still show an improvement in shrinkage. This can be due to the mechanism of shrinkage-reduction used in Conex. The primary component is expansive to offset the expected effects of chemical, autogeneous, and drying shrinkage. The other admixtures greatly influence the pore solution which decreases drying shrinkage, so their effect is still seen with the modified calculation.

Table 3. Measured length change of mortar.

Mix ID	Standard Test 35-Day Shrinkage (%)	Modified Calculation 35-Day Shrinkage (%)
S-1	-0.082%	-0.091%
S-2	-0.064%	-0.075%
S-3	-0.063%	-0.095%
S-4	-0.058%	-0.080%
S-5	-0.068%	-0.074%

** 35-Day refers to concrete age. Corresponds to 28-days of drying.

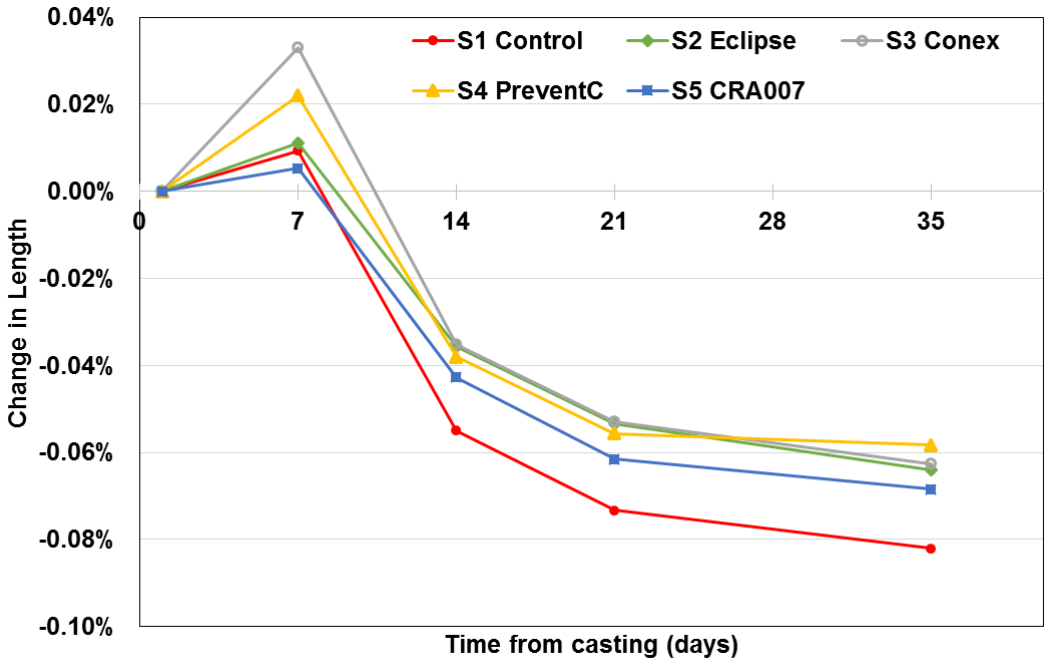

Figure 5. Standard Test length change of mortar bars. L_0 is taken as the length upon demolding at 24 hours

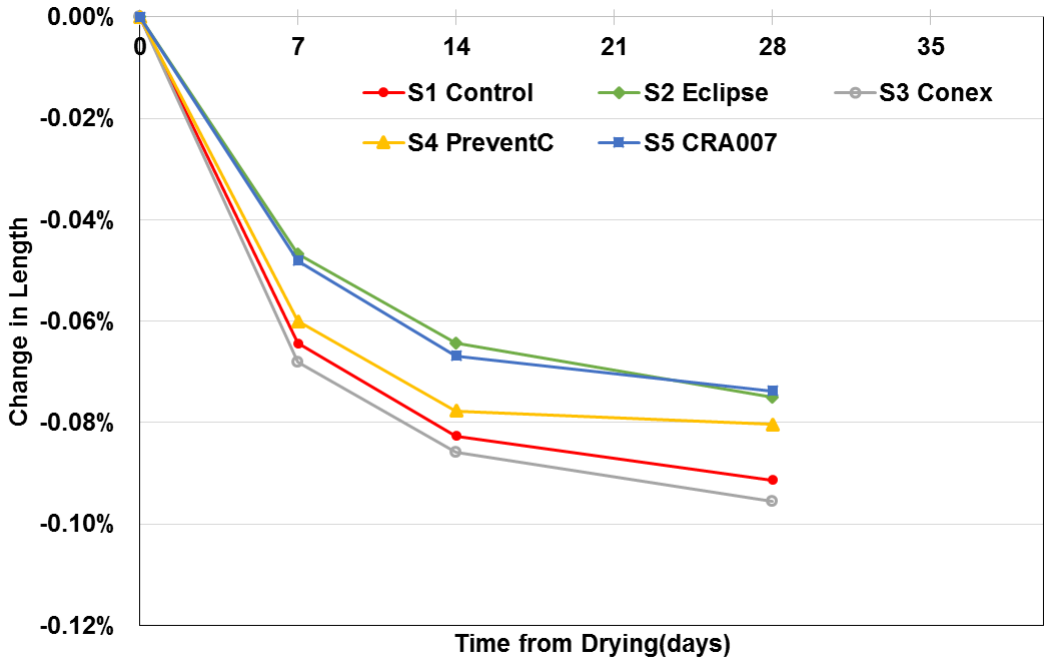

Figure 6. Modified Calculation length change of mortar bars. L_0 is taken as the length after the 7-day soak

Concrete

Concrete bars were tested in accordance with ASTM C157 Standard Test, Modified Calculation, as well as with a modification that eliminates the lime water curing period (Modified Procedure (No Soak)). Pre-proportioned repair materials (designated SS and SM) were also included in this round of testing.

Figure 5 and Figure 6 show the length change over time for the Standard C157 procedure. As seen in the mortar testing, the Conex displayed a high expansion while curing in lime water. Unlike the mortar testing, the Prevent-C expanded much less than anticipated, even less than the Control mixture.

The Modified Procedure (No Soak) simulates a worst-case scenario where drying is initiated at an age of 24 ± ½ hour with no proper curing. Surprisingly, the Control mixture was not greatly influenced by the absence of curing as seen in Figure 7 and Table 4. The more traditional surface-tension reducing type of admixtures (Eclipse and CRA007) performed the best in the modified test.

Table 4. Measured length change of concrete

Mix ID	Standard Test 35-Day Shrinkage (%)	Modified Calculation 35-Day Shrinkage (%)	Modified Procedure (No Soak) 28-Day Shrinkage (%)
S-1	-0.030%	-0.046%	-0.030%
S-2	-0.021%	-0.046%	-0.017%
S-3	-0.036%	-0.076%	-0.047%
S-4	-0.029%	-0.035%	-0.062%
S-5	-0.010%	-0.032%	-0.031%
S-S	-0.035%	-0.029%	-0.054%
S-M	-0.055%	-0.060%	-0.058%

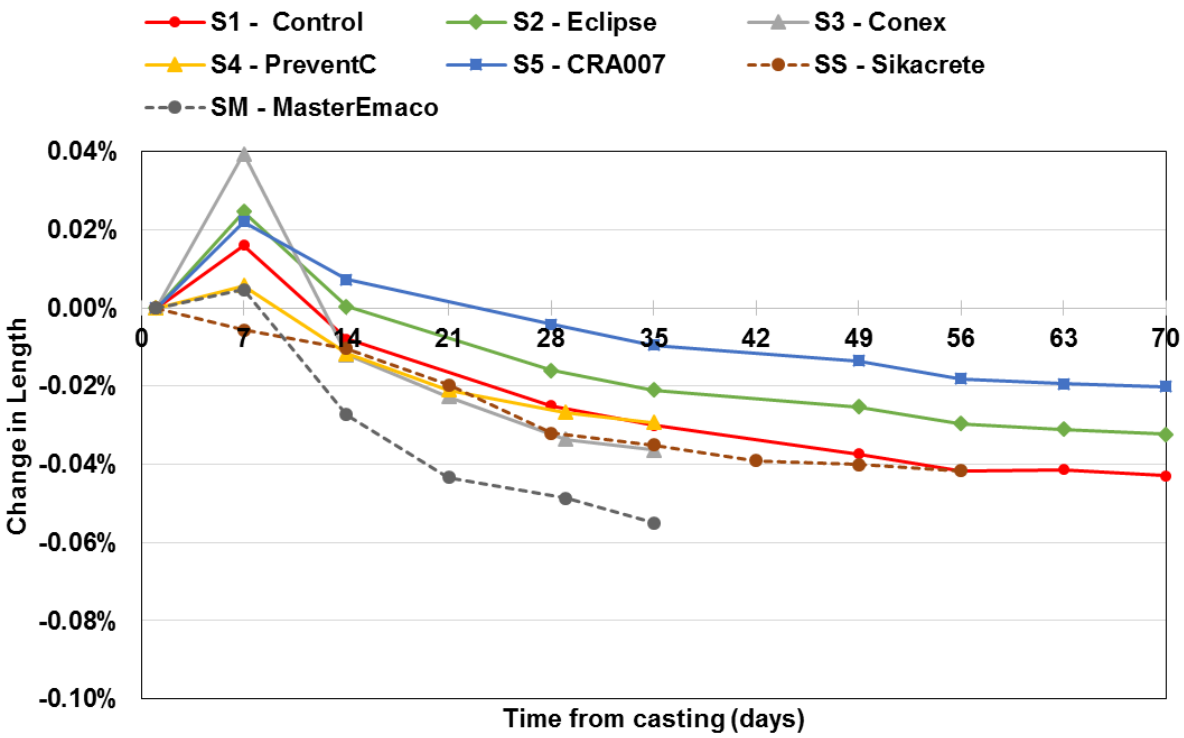

Figure 7. Standard Test length change of concrete bars. L_0 is taken as the length upon demolding at 24 hours

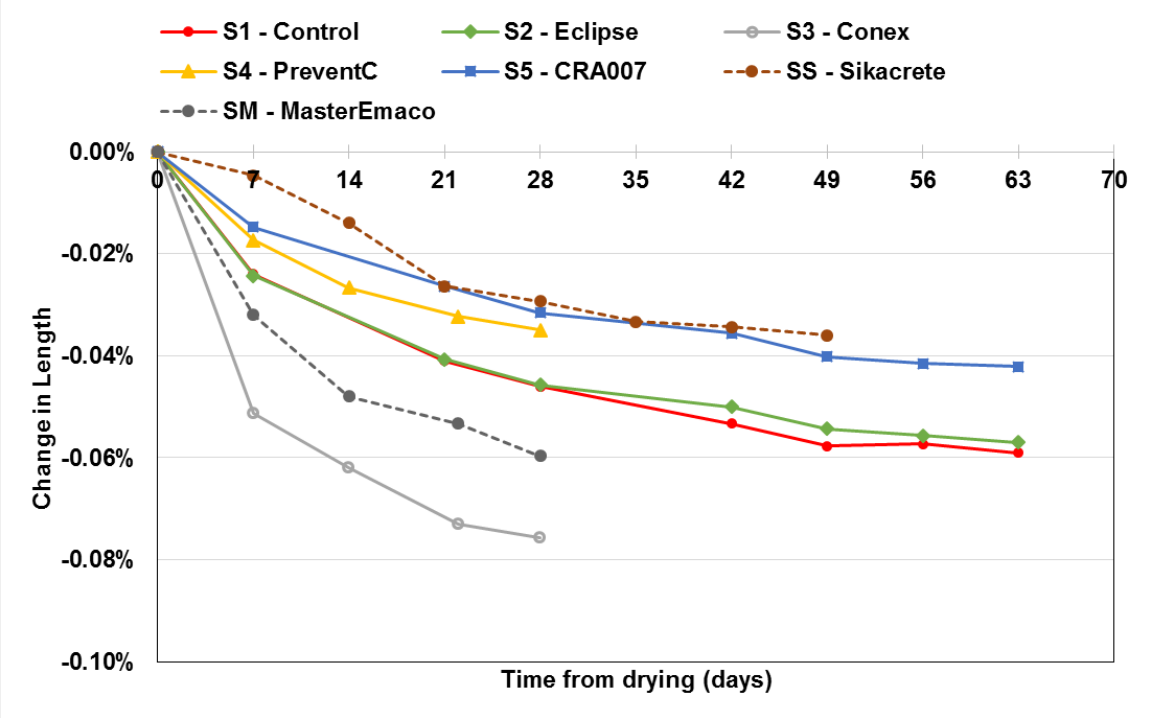

Figure 8. Modified Calculation length change of concrete bars. L_0 is taken as the length after the 7-day soak

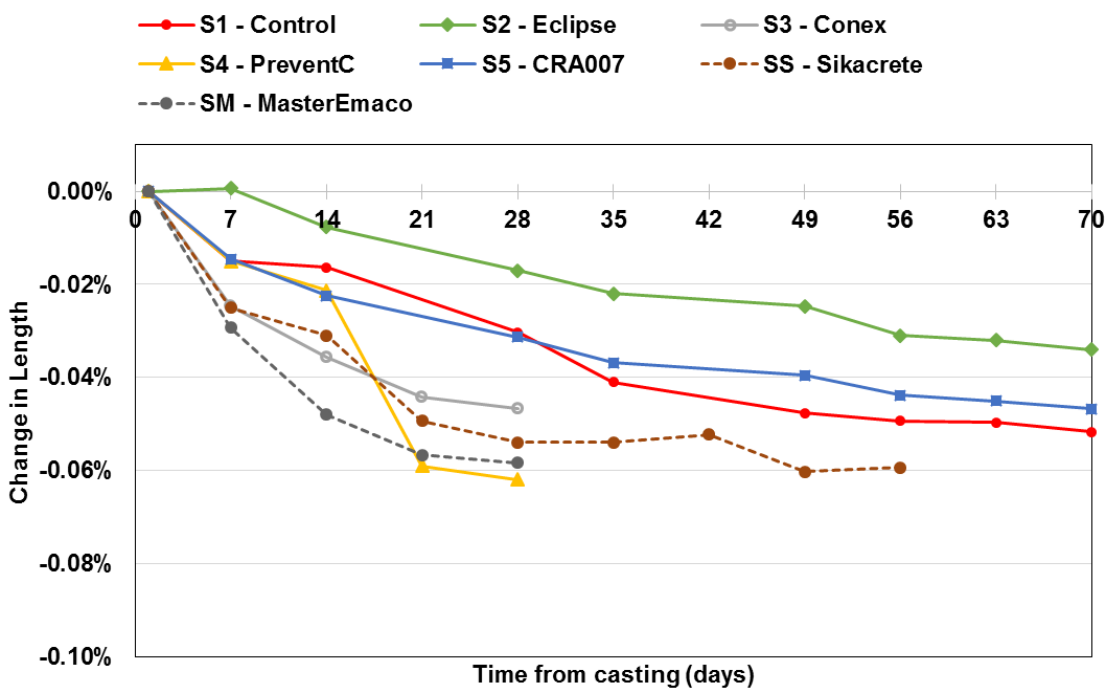

Figure 9. Modified Procedure (No Soak) length change of concrete bars. Drying initiated immediately after demolding after 24 hours

Typical limits on shrinkage are specified between 0.04% and 0.03%. When tested and calculated in accordance with C157, all of the concrete mixtures tested (with the exception of the MasterEmaco repair mortar) fell within that range.

ASTM C1581 Restrained Shrinkage

The restrained shrinkage was tested on mortar and concrete. The following figures show the average strain of three specimens for each mixture. Figure 8 shows the results of the mortar. Conex exhibits an obvious expansion, well past the first 24 hours when the mortar is wet cured. Unlike the C157 bars, the mortar containing Prevent-C did not show expansion in the rings. All of the mortars containing additives outperformed the Control in terms of time to cracking.

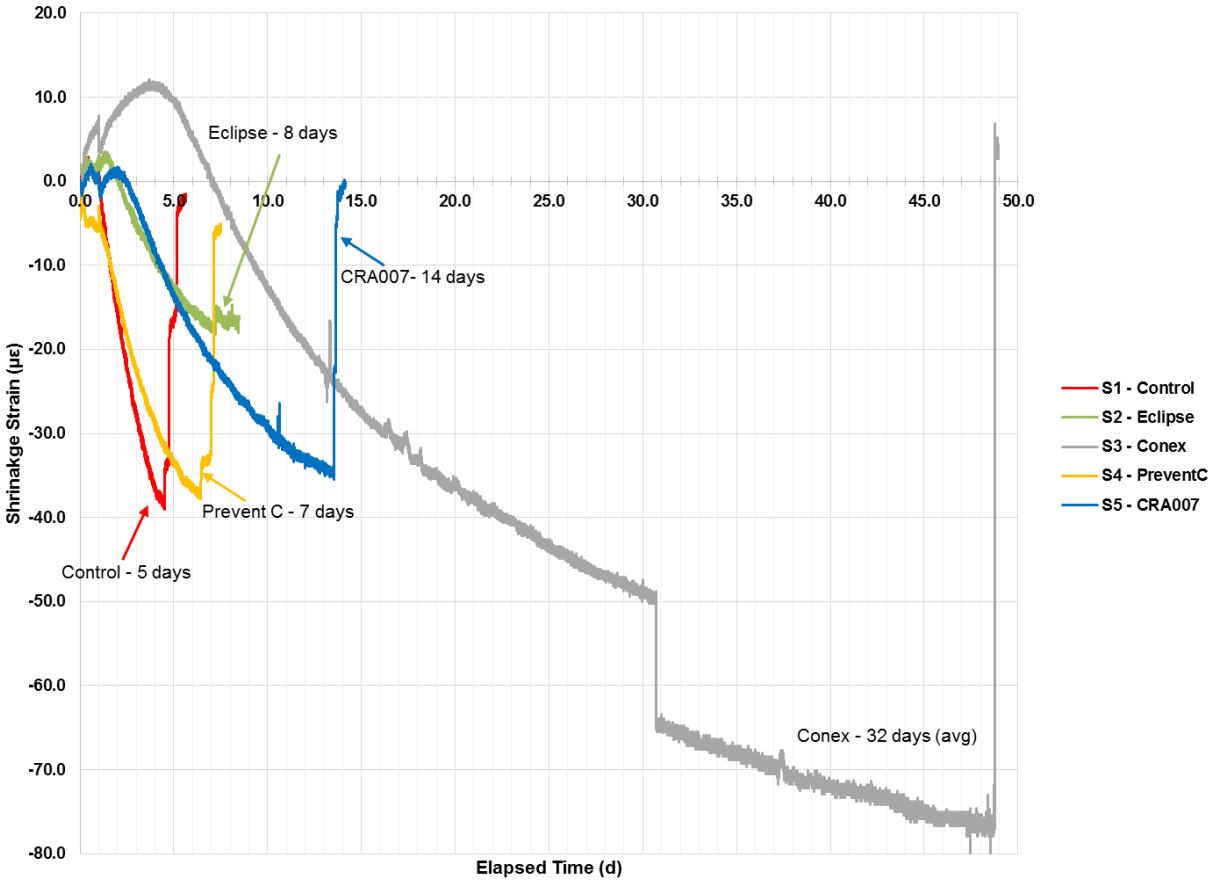

Figure 10. Mortar restrained shrinkage test results (average of 3 rings per mixture)

Figure 9 and Table 5 show ASTM C1581 results for concrete mixtures as well as the pre-proportioned product MasterEmaco and Sikacrete, however the Sikacrete strain gage data was not included on the graph due to a data collection error. Like the mortar results indicated, Mixtures S2 through S5 outperformed the control concrete. The repair mortar cracked at 3.5 days, half the time of the Control concrete.

The repair mortars, although marketed as low-shrink, are not directly comparable to the concrete and mortar mixes. They were included in the testing for comparison so that a reasonable awareness of the shrinkage strain of these products could be considered when they are used in a concrete repair.

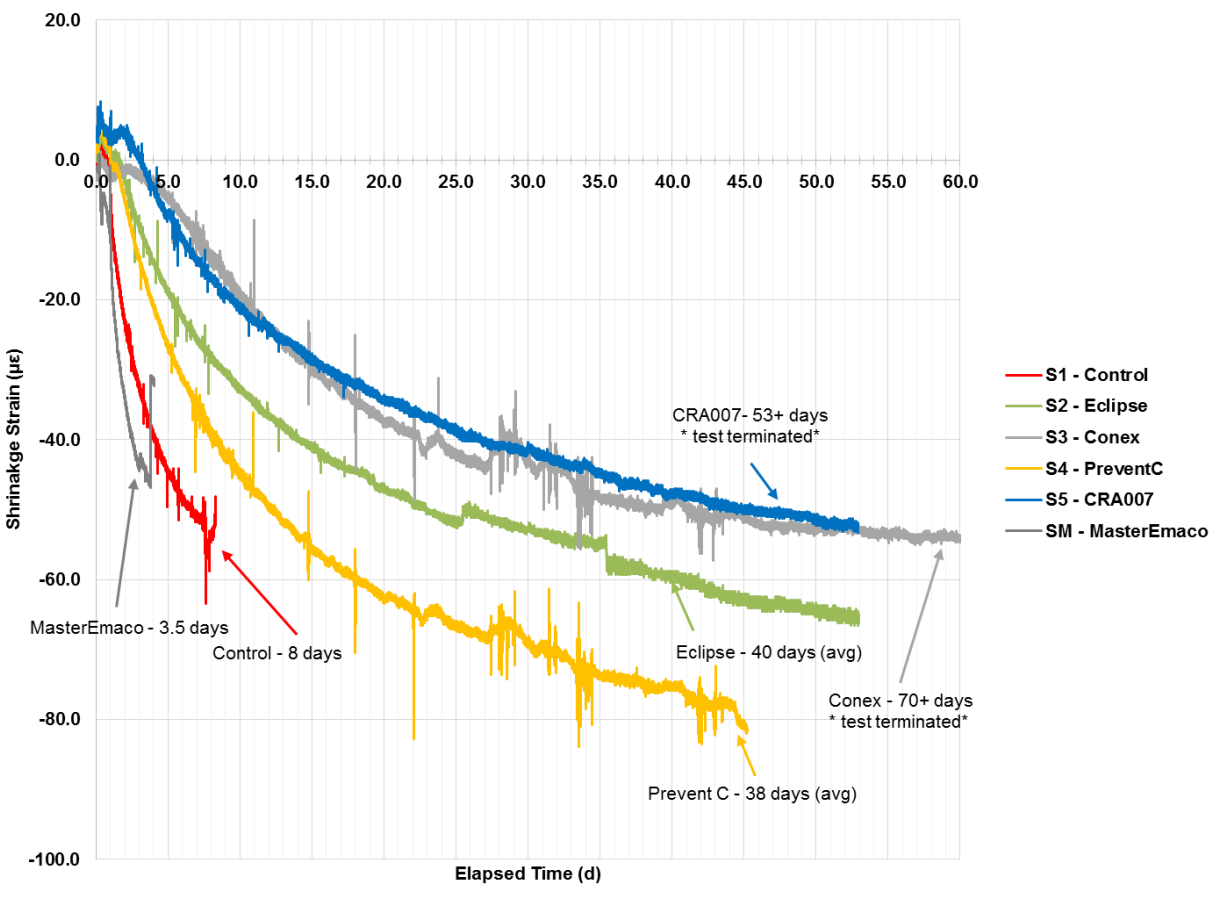

Figure 11. Concrete restrained shrinkage test (average of 3 rings per mixture)

Table 5. Average time to cracking and potential for cracking

Mix ID	Average Net Time-to-Cracking (t_{cr}), days	Average Initial Strain (με)	Average Maximum Strain (με)	Potential for Cracking
S-1	7.9	-2.2	-59.5	Moderate-High
S-2	39.4	1.7	-58.7	Low
S-3	70 *	-2.3	-55.4 *	Low
S-4	38.1	-0.6	-77.2	Low
S-5	53 *	4.9	-46.9 *	Low
S-S	9.7	**	**	Moderate-High
S-M	3.6	-3.4	-48.6	High

* Test terminated before cracking occurred
** Early age strain gage data collection failure

Expansion

In addition to ASTM tests, a proprietary test that measures expansive strain in a sealed specimen was conducted on the products to evaluate the relative expansiveness of the materials to each other admixture or additive. As seen in Figure 10, the pea gravel concrete mixture containing Conex expanded significantly more than the other admixtures, with the Prevent-C mixture the next highest and the control the lowest. This is consistent with the high-expansion trend seen in the mortar tests (both ASTM C157 and C1581).

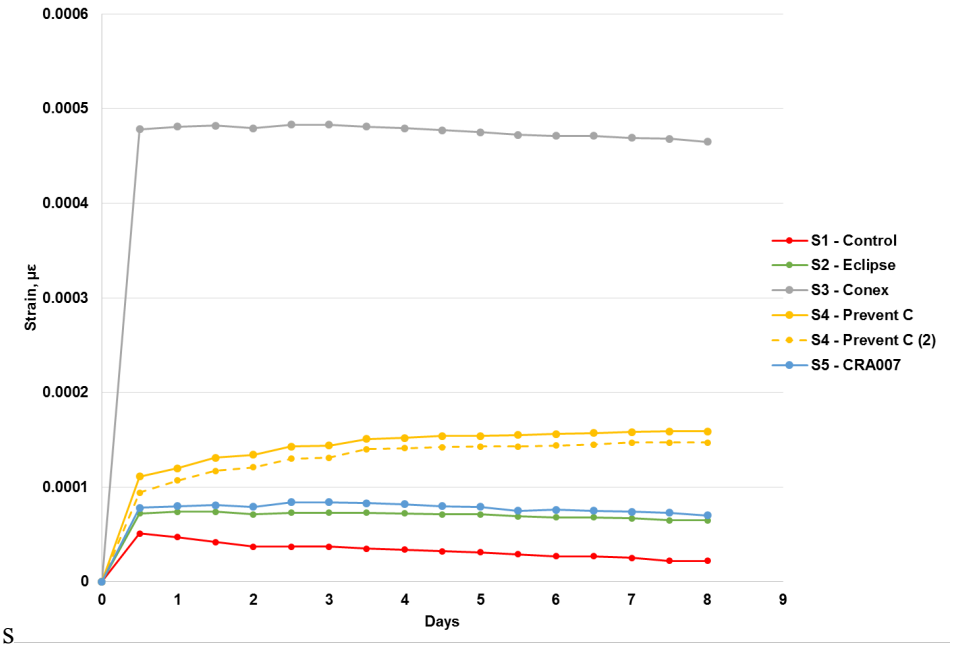

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Figure 12. Radial strain due to early age expansion (proprietary test)

Discussion

For Reclamation projects, our shrinkage reduction needs vary depending on the use and configuration of the structure. In some cases, shrinkage is not a concern (i.e., simple structures, mechanical pads, sidewalks). In others, some moderate level of shrinkage reduction may be required (smaller walls or slabs). But for critical concrete infrastructure, a higher level of shrinkage reduction may be necessary to achieve the desired service life, extend joint locations in placements, or increase water-tightness. It is not cost effective to require very low shrinkage concrete on all projects or all placements, as these admixture costs may add considerable cost to a cubic yard of concrete.

This study aimed to evaluate these products to evaluate their shrinkage performance and to assist in the proper materials selection for different types of projects and give Reclamation designers confidence in these selections. Currently, for moderate shrinkage reduction, Reclamation specifies a traditional Shrinkage Reducing Admixture (like the Eclipse Floor or equal). Based on the results in this study, this appears to continue to be a reasonable recommendation. For more

aggressive shrinkage reduction, Reclamation has been specifying Prevent C, or equal, and has successfully used this on multiple projects to date. Based on the performance of Prevent C and MasterlifeCRA007 in this study, both products, or equal, could be considered a reasonable recommendation for inclusion in a concrete specification when low to very-low concrete shrinkage is desired.

Conclusions and Recommendations

- There are several commercially available admixtures and additives available to decrease the net shrinkage of concrete. Some reduce drying shrinkage by reducing the surface tension of the pore solution, others work by incorporating an expansive component.
- New technologies allow crack widths to be minimized, which decreases the potential for fluid ingress and subsequent deterioration if cracking does occur.
- Reclamation specifications should continue to specify a traditional Shrinkage Reducing Admixture when moderate shrinkage reduction is required.
- For critical structures where very low shrinkage is needed, such as spillway slabs or areas of large repair or where greater joint spacing is required, a shrinkage reducing and compensating product should specified. Products such as Prevent C, MasterlifeCRA007, or equal, can be specified.
- Specifications requiring low or very-low shrinkage should include a performance specification for the concrete mixtures to meet ASTM C 1581 “low” shrinkage with time to crack (t_{cr}) greater than 28 days.
- Because the expansive properties of the Conex product were only limitedly investigated during this study, these types of products should not yet be included in Reclamation project specifications where low shrinkage is the primary goal.
- Additional testing on more expansive products, such as Conex (or equal) and how they would impact the types of concrete placements Reclamation typically installs is also recommended.
- Shrinkage reducing and compensating (expansive) products should continue to be investigated. There was a large discrepancy between the early-age expansion of the mortar and the concrete as seen in both the ASTM C157 and C1581 tests.
- While shrinkage reducing admixtures can drastically reduce the shrinkage, it is still important to use a well-proportioned concrete mixture and proper curing methods to minimize the amount of cracking.
- Further testing should be conducted to evaluate the effectiveness of shrinkage reducing and shrinkage compensating admixtures with the addition of supplementary cementitious materials such as fly ash or slag as well as ASTM C595 blended cements.
- Future testing should include:
    - air entrained mixtures
    - mixtures over the full range of a products’ dosage
    - additional repair mortars
    - colloidal nano-silica and carbon nano-tube technology for additional applications

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Appendix A – Product Data Sheets

Eclipse® Floor
Shrinkage-reducing admixture

Product Description

Eclipse® Floor is a liquid admixture for concrete that dramatically reduces drying shrinkage and the potential for drying shrinkage-induced cracking and curling. Rather than functioning as an expansive agent, Eclipse Floor acts by reducing the surface tension of pore water. Eclipse Floor is specifically formulated for use in non air-entrained concrete applications. Eclipse Floor is a clear liquid admixture that weighs approximately 0.92kg/L.

Chemical Action

Drying shrinkage of concrete is a complicated phenomenon, widely acknowledged to be the function of several mechanisms. The driving factor causing shrinkage for internal relative humidity in excess of 40% is the surface tension of water. As water-filled pores in the size range of 2.5 to 50nm (nm or nanometre, is one billionth of a metre) lose moisture, curved menisci are formed and the surface tension of water pulls the walls of the pores. Eclipse Floor reduces the surface tension of water, thereby reducing the force pulling in on the walls of the pores – and the resultant shrinkage strain is reduced.

Applications

Eclipse Floor can be used in slab-on-grade construction, and any structure where it is important to control drying shrinkage cracks. For slab-on-grade construction, Eclipse Floor can be used to increase joint spacings, providing for flatter, more durable and lower maintenance floors.

Product Advantages

- Eclipse Floor reduces drying shrinkage and curling. Depending on the shrinkage characteristics of the concrete mixture containing the product, it enables joint spacings to be increased.
- Eclipse Floor contains no expansive material, but chemically acts to significantly reduce the primary internal forces that cause shrinkage and curling.
- Eclipse Floor at a dosage of 7.5L/m³ has been shown to reduce drying shrinkage, as measured by ASTM C157, by as much as 80% at 28 days, and up to 50% at one year or beyond.
- Reducing drying shrinkage, curling and resultant cracking helps reduce maintenance costs over the service life of the structure.

Addition Rates

Typical dosage rates of Eclipse Floor in concrete flooring mixes will be in the range of 2.5 to 7.5L/m³, although doses as low as 1L/m³ and as high as 12.5L/m³ have been used. Since Eclipse Floor works primarily to reduce the surface tension of pore water, its effectiveness is primarily a function of the concentration as a percent by weight of the mix water. Therefore, if the total water content of a concrete mix is reduced, less Eclipse Floor is required to obtain optimum results.

Compatibility with Other Admixtures

Eclipse Floor is fully compatible with the complete line of GCP admixtures. In mixtures containing mid- or high-range water reducers, it is recommended that Eclipse Floor be used with polycarboxylate based MIRA® mid-range water reducers and ADVA® high-range water reducers. In general, Eclipse Floor may be added to the concrete batch sequencing at any time, however, preferably after the dry materials and most of the water. Different sequencing may be used if local testing shows better performance.

Eclipse Floor may cause slight retarding properties (set times are extended less than one hour) and aid in extending slump life.

Mixture Adjustment

Eclipse Floor is a clear liquid admixture. It contains no water, but is added at high dosages and should be accounted for in the mix design. For a conventional concrete mix with 7.5L/m^3 of Eclipse Floor, an equivalent volume of water should be reduced from the mix design.

Dispensing Equipment

Please contact your local GCP representative for further information regarding the dispensing equipment for this product.

Other Precautions

During concrete placement and finishing operations, small amounts of Eclipse Floor will volatilise into the atmosphere and may cause minor irritation. Adequate ventilation should be provided during placement and finishing to prevent this irritation.

Eclipse Floor has a flash point of 102ºC. This is substantially above the upper limit of 60ºC for classification as a flammable material, and above the limit of 93ºC where the Department of Transportation (DOT in USA) would classify as a combustible material. Nonetheless, this product must be treated with care and protected from excessive heat, open flame or sparks. For more information, please refer to the Material Safety Data Sheet.

gcpat.com | For technical information: asia.enq@gcpat.com

Australia 1800 855 525 New Zealand +64 9 448 1146 China Mainland +86 21 3158 2888 Hong Kong +852 2675 7898
India: Chennai +91 44 6624 2308 Delhi +91 124 402 8923 Indonesia +62 21 893 4260 Japan +81 3 5226 0231 Korea +82 32 820 0800
Malaysia +60 3 9074 6133 Philippines +63 49 549 7373 Singapore +65 6265 3033 Thailand +66 2 709 4470 Vietnam +84 8 3710 6168

GCP Applied Technologies Inc., 62 Whittemore Avenue, Cambridge, MA 02140, USA

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gcp applied technologies

GRACE CONSTRUCTION & PACKAGING

CONEX

Shrinkage Compensating Admixture

EUCLID CHEMICAL

Description

CONEX is a powdered admixture used for the compensation and total overall reduction of net shrinkage for Portland Cement concrete. Its functional mechanism is based on the formation of an expansive component. CONEX is an expansive Type G component, which produces a calcium hydroxide platelet crystal system, as specified in ACI 223.

Primary Applications

- Flatwork concrete
- Bridge decks
- Parking structures
- Interior/Exterior
- Arena/Artificial skating rinks
- Walls/Parapets
- Storage tanks
- Watertight construction
- Toppings
- Piers

Features/Benefits

- The expansion characteristics of CONEX allow for net shrinkage reduction for concrete.
- Use of this admixture does not cause any slump loss and may be used in conjunction with other Euclid Chemical admixtures.
- Will not affect the mechanical strengths.
- It is compatible with the majority of Portland cements.
- CONEX does not affect the air content, set time, or other characteristics of fresh concrete.
- Freeze-thaw and Salt Scaling Resistance are not affected given that an adequate air void system is provided.
- Expansion process is not through ettringite formation.

Technical Information

Specific Gravity .....3.13 - 3.16
pH.....12.5 - 13

Appearance: CONEX is a free-flowing fine beige powder designed to be mixed with concrete.

Test Methods used to evaluate Conex:

- ASTM C 878
- ASTM C157 modified in accordance with Technical Bulletin ECTB 10-17
- Embedded vibrating strain gauges

For more information please contact your Euclid Technical Sales Representative.

Packaging

CONEX is packaged in 50 lb (22.7 kg) pails and 22 lb (10 kg) pulpable bags.

Shelf Life

1 year in original, unopened 50 lb (22.7 kg) pails and 22 lb (10 kg) pulpable bags.

19215 Redwood Road • Cleveland, OH 44110
800-321-7628 t • 216-531-9596 f

www.euclidchemical.com

Directions for Use

- For best results, use CONEX in concrete with the W/C (water to cement ratio) lower than 0.60.
- CONEX should be uniformly added with the cement or with the aggregates on the conveyor or in the scale, taking into consideration the safety of the operator.
- Concrete treated with CONEX may be finished and placed in the same fashion as conventional concrete.
- Typical dosage rate of 2-10% bwoc (by weight of cementitious). Before use, test in accordance with ACI 223 to determine the correct dose needed.
- Concrete should be mixed a minimum of 10 minutes, at normal mixing speed, after all concrete constituents have been batched to ensure thorough dispersion of all materials.

Trials are recommended to determine appropriate dosage and will depend on: local materials, mix design, and structural design.

Precautions/Limitations

- The use of this product requires a minimum 48 hour wet curing period, with maximum performance obtained after a 7 day curing period. For optimal moist curing efficiency, the use of curing blankets is recommended.
- As soon as the moist curing period is finished, it is recommended to use a curing compound as provided by The Euclid Chemical Company.
- Preliminary trials should be done to determine the optimum dosage.
- CONEX is sensitive to humidity, free water, and to CO_2, and should be stored and handled in the same manner as Portland cement. Keep in perfectly sealed, original package and in a dry location.
- In all cases, consult the Safety Data Sheet before use.

PREMIERCPG
CONSTRUCTION PRODUCTS GROUP

Product Information

PREVent-C™ Shrinkage-reducing Admixture

Description: Shrinkage-reducing and crack-control admixture for cementitious mixes.

Typical Properties:

Appearance	Free-flowing powder, off-white to light brown	
Density	Loose bulk density (lb/ft3) Tapped bulk density (lb/ft3)	43.3 59.5
pH (10% aqueous slurry)	10-11	

Product Description:

PREVent-C admixture is a specially formulated powder that provides dual functionality to prevent cracking or curling caused by shrinkage. PREVent-C can reduce shrinkage-induced cracking by as much as 90 to100%, depending on mix design and amount of PREVent-C used. A minimum of 80% shrinkage reduction can be expected in most cases. Based on new, innovative technology developed by PremierCPG, the material is designed to facilitate expansion of concrete at the same rate as drying shrinkage during the curing period, and to reduce the capillary surface tension of pore water. Surface tension of capillary pore water has been linked to formation of a meniscus during hydration, which accounts, at least partially, for shrinkage. Expansion ceases within 28 days during hydration and does not continue once the concrete has hardened. PREVent-C has no known detrimental effects on either plastic or hardened properties of concrete and cementitious mixes. In air-entrained concrete, a small increase in air-entraining admixture may be necessary to obtain desired air content. Admixture meets ASTM C 494 Type S standards.

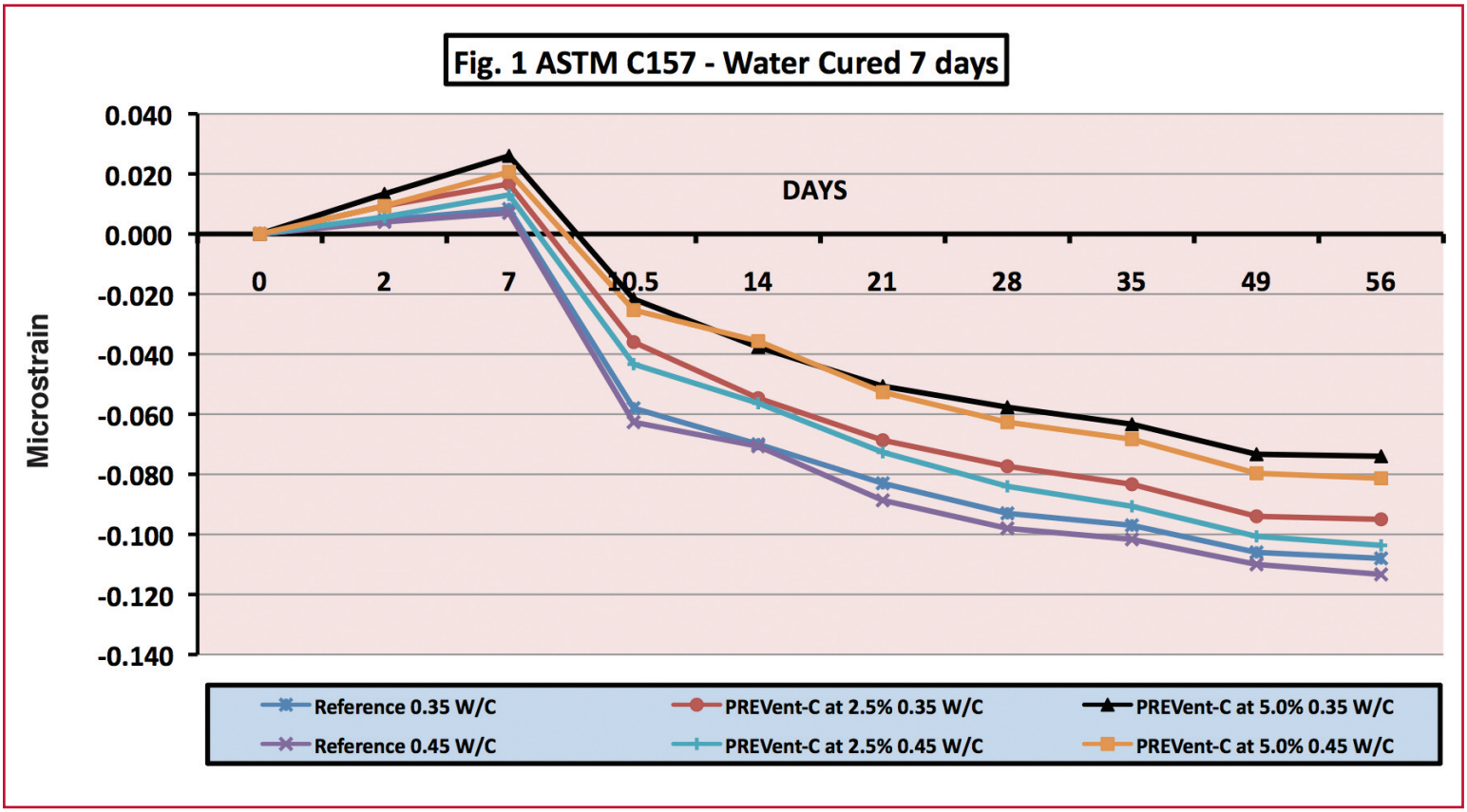
Uses:

PREVent-C can be used in all types of concretes and mortars, whether cast-in-place, mass, precast or prestressed. The material can be used in straight Portland cement mixes or blended cement mixes. Typical applications include bridge decks, parking structures, dams, runways, stadiums, flooring applications, decorative concrete, and masonry or tile grouts and mortars. The material is especially effective where concrete is highly restrained, like with most steel or other reinforced concrete applications. It is also effective with both air-entrained and non-air entrained concrete. Because it is

a free-flowing powder, PREVent-C can be pre-blended with dry packaged mixes, mortars and grouts, or added at the time of use. The material also is effective for use with shotcrete mixes. PREVent-C reduces both drying and autogenous shrinkage-induced macrocracks and microcracks in concrete, which enhances its sustainability. PREVent-C does not contain chlorides or other materials that could contribute to corrosivity of reinforcing steel.

Performance: Figure 1 illustrates the effectiveness of PREVent-C in reducing drying shrinkage in ASTM C157. At 5 addition, based on cement content, PREVent-C reduced shrinkage microstrain to below 0.06 in 28 days and did not exceed 0.09% even after 56 days in mixes at both 0.35 w/c and 0.45 w/c. This level of shrinkage-versus-control is expected to significantly reduce shrinkage-induced cracking.

Figure 1:



Testing in mortar on the ASTM C1581 ring test yielded no cracking after >200 days, at which time the test was stopped as microstrain actually was decreasing slightly, indicating no cracking was expected.

PREMIERCPG
CONSTRUCTION PRODUCTS GROUP

Benefits:

- Significantly reduces shrinkage cracking
- Reduces compressive creep
- Reduces autogenous shrinkage
- Improves durability
- Decreases curling and related cracks
- More effective and economical than alternative SRAs
- Allows for reduced usage of control joints
- Reduces water and salt infiltration by reducing cracks

PREVent-C may cause slight retardation of set time, varying according to the mix and source of cement. When using PREVent-C, a slight decrease in air content may be experienced that can easily be adjusted by a small increase in the addition rate of air-entraining agent. No known negative effects on strength gain or plastic properties of concrete are expected by the addition of PREVent-C to the concrete mix.

Addition Rates:

Typical PREVent-C addition rates are 5% w/w addition, based on cement content, or 5 lbs. for each 100 lbs. of cement in concrete, mortar or grout. Depending on the mix, this usage level is expected to decrease shrinkage cracking and creep by more than 80%. Addition rate can be varied (higher or lower) to obtain the desired shrinkage-cracking requirements. It is recommended that trial mixes be tested according to ASTM C157 prior to placement.

TO PREVENT DRYING SHRINKAGE, ENSURE THAT PROPER CURING IS PROVIDED WHEN PLACING CONCRETE. PREVent-C is not designed to compensate for improper or inadequate curing procedures.

Usage:

PREVent-C should be added to the mix as a powder, just like cement or pozzolans. Do not pre-dissolve or mix as a slurry in water before adding. PREVent-C should be added to the mix before other admixtures or water. Allow sufficient time for mixing (minimum 60 seconds) to ensure even distribution of product in the mix.

Material has been tested for compatibility with several admixtures. While no negative interactions have been observed, it is always prudent to test mixes with other admixtures being used to avoid unexpected negative effects.

Packaging: PREVent-C is available in 50-lb. lined bags and 1,000- and 2,000-lb. lined bulk sacks. Bulk truckload or railcar delivery is available upon request.

Handling and Storage: Store in a dry, protected place. The product is stable under normal conditions of dry storage. Do not allow water to get inside containers; reaction with water will cause the product to swell, generate heat, and expand its container. Exposed, unprotected material will absorb moisture and carbon dioxide from the air. Minimize the generation of dust during handling and transfer of material. While PREVent-C has low toxicity, appropriate personal protective equipment always should be worn when handling material. See MSDS for more information.

The Premier Construction Group is a division of Premier Magnesia LLC

BASF

We create chemistry

3

03 30 00	Cast-in-Place Concrete
03 40 00	Precast Concrete
03 70 00	Mass Concrete

MasterLife® CRA 007

Crack-Reducing Admixture

Description

MasterLife CRA 007 crack-reducing admixture is an innovative liquid chemical admixture that is specifically formulated to reduce the magnitude of drying shrinkage and minimize the potential for cracking. Compared to a shrinkage-reducing admixture, MasterLife CRA 007 crack-reducing admixture provides enhanced performance through (i) significant reduction in the potential for shrinkage cracking, and (ii) reduced initial crack widths if cracking does occur. MasterLife CRA 007 admixture meets ASTM C 494/C 494M, Standard Specification for Chemical Admixtures for Concrete, requirements for Type S, Specific Performance Admixtures.

Applications

Recommended for use in ready-mixed or precast concrete structures requiring shrinkage reduction and long-term durability, including:

- Slabs, parking structures, bridge decks, pavements, water-retaining structures
- Wet-mix shotcrete
- Mortars and grouts

Features

- Suitable for use in air-entrained concrete
- Reduces drying shrinkage
- Delays time-to-cracking as measured in ASTM C 1581/C 1581M ring test
- Reduces crack widths

Benefits

- Enhances watertightness in water-retaining structures
- Increases concrete durability and service life
- Reduces joint maintenance costs in concrete slabs
- Permits increase in joint spacing
- Reduces the environmental footprint of concrete

Performance Characteristics

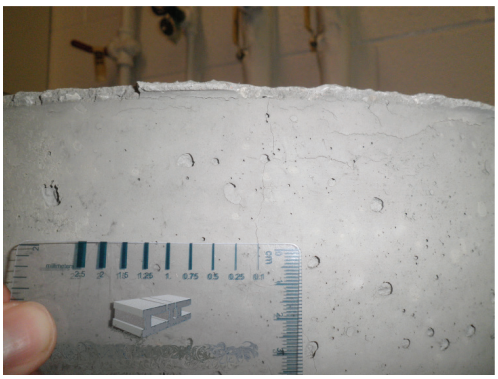
MasterLife CRA 007 admixture does not affect slump, may delay time of set slightly and increase bleed time depending upon dosage, temperature, and mixture components. A slight reduction in compressive strength may be experienced depending on the concrete mixture ingredients and their proportions. MasterAir® AE 200 air-entraining admixture is the recommended air-entraining admixture for application in air-entrained concrete. Field trial batches should be conducted to achieve desired performance.

MASTER® BUILDERS SOLUTIONS

Drying Shrinkage

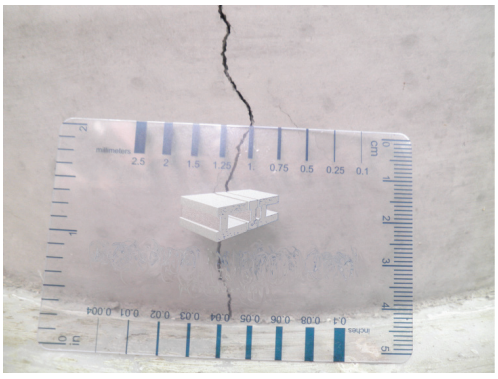
MasterLife CRA 007 admixture reduces the drying shrinkage of concrete relative to a plain reference mixture as measured by the ASTM C 157/C 157M test method. The reduction in drying shrinkage is similar to that obtained with conventional shrinkage-reducing admixtures. However, MasterLife CRA 007 admixture provides a greater reduction in the potential for cracking and initial crack width should cracking occur. As shown in the pictures, concrete specimens treated with MasterLife CRA 007 admixture showed a ten-fold reduction in initial crack width compared to plain concrete or conventional shrinkage-reducing admixture-treated concrete specimens, when tested in accordance with ASTM C 1581/C 1581M.

CRA-treated concrete



Crack width ≈ 100 µm (0.1 mm)

Untreated or SRA-treated concrete



Crack width ≈ 1,000 µm (1 mm)

Guidelines for Use

Dosage: The recommended dosage range of MasterLife CRA 007 admixture is 1.0 to 2.0 gal/yd^3 (5.0 to 10.0 L/m^3), depending on the specific application. However, dosages outside of this range may be required depending on the level of shrinkage reduction and crack control desired. A reduction of mix water content equivalent to the dosage of MasterLife CRA 007 admixture utilized is recommended.

Mixing: MasterLife CRA 007 admixture may be added to the concrete mixture during the initial batch sequence or at the jobsite. If the delayed addition method is used, mixing at high speed for 3 to 5 minutes after the addition of MasterLife CRA 007 admixture will result in mixture uniformity.

Product Notes

Corrosivity – Non-Chloride, Non-Corrosive: MasterLife CRA 007 admixture will neither initiate nor promote corrosion of reinforcing steel, prestressing steel or of galvanized steel floor and roof systems. Neither calcium chloride nor other chloride-based ingredients are used in the manufacture of MasterLife CRA 007 admixture.

Compatibility: MasterLife CRA 007 admixture is compatible with all BASF water-reducers, mid-range water-reducers, high-range water-reducers, set retarders, and accelerators. MasterLife CRA 007 admixture should be added separately to the concrete mixture to ensure desired results.

Odor: A slight odor may be noticed when MasterLife CRA 007 admixture is used in concrete placed in confined areas. This non-harmful odor is an aromatic indication that the admixture is in the concrete.

Storage and Handling

Storage Temperature: MasterLife CRA 007 admixture is a potentially combustible material with a flash point of 189 °F (87 °C). This is substantially above the upper limit of 140 °F (60 °C) for classification as a flammable material, and close to the limit of 200 °F (93 °C) where DOT requirements would classify this as a combustible material. Nonetheless, this product must be treated with care and protected from excessive heat, open flame or sparks. For more information refer to the Safety Data Sheet. MasterLife CRA 007 admixture should be stored at ambient temperatures above 35 °F (2 °C), and precautions should be taken to protect the admixture from freezing. If MasterLife CRA 007 admixture freezes, thaw and reconstitute by mild mechanical agitation. **Do not use pressurized air for agitation**.

Shelf Life: MasterLife CRA 007 admixture has a minimum shelf life of 24 months. Depending on storage conditions, the shelf life may be greater than stated. Please contact your local sales representative regarding suitability for use and dosage recommendations if the shelf life of MasterLife CRA 007 admixture has been exceeded.

Durability

MasterLife CRA 007 admixture can be used in combination with other BASF durability-enhancing products such as MasterFiber® products, MasterLife CI 30 corrosion inhibitor, MasterLife SF 100 silica fume, MasterLife 300 D integral waterproofing admixture, and MasterLife ASR 30 alkali-silica reaction inhibitor to provide extended service life of concrete structures exposed to aggressive environments.

Packaging

MasterLife CRA 007 admixture is available in 55 gal (208 L) drums and 268 gal (1014 L) totes.

Related Documents

Safety Data Sheets: MasterLife CRA 007 admixture

Additional Information

For additional information on MasterLife CRA 007 admixture or its use in developing concrete mixtures with special performance characteristics, contact your local sales representative.

The Admixture Systems business of BASF's Construction Chemicals division is the leading provider of solutions that improve placement, pumping, finishing, appearance and performance characteristics of specialty concrete used in the ready-mixed, precast, manufactured concrete products, underground construction and paving markets. For over 100 years we have offered reliable products and innovative technologies, and through the Master Builders Solutions brand, we are connected globally with experts from many fields to provide sustainable solutions for the construction industry.

Limited Warranty Notice

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NSF Certified to NSF/ANSI 61

BASF Corporation
Admixture Systems
www.master-builders-solutions.basf.us

United States
23700 Chagrin Boulevard
Cleveland, Ohio 44122-5544
Tel: 800 628-9990 ■ Fax: 216 839-8821

Canada
1800 Clark Boulevard
Brampton, Ontario L6T 4M7
Tel: 800 387-5862 ■ Fax: 905 792-0651

BASF

We create chemistry

Technical Data Guide

3 | 03 01 00
Maintenance of Concrete

MasterEmaco® S 440

Pourable and pumpable pre-extended self-consolidating repair mortar

FORMERLY LA40 REPAIR MORTAR

PACKAGING
55 lb (25 kg) polyethylene-lined bags

YIELD
0.43 ft^3 (0.012 m^3) per 55 lb (25 kg) bag

STORAGE
Store in unopened containers in cool, clean, dry conditions

SHELF LIFE
1 year when properly stored

VOC CONTENT
0 g/L less water and exempt solvents

DESCRIPTION
MasterEmaco S 440 is a one-component, shrinkage-compensated, self-consolidating repair mortar. It is designed for large volume repairs, including structural elements in applications from 1.5" (38 mm) to full depth.

PRODUCT HIGHLIGHTS
- Dual expansion system compensates for shrinkage in plastic and hardened states
- High early strength allows early form removal
- Low permeability protects against carbon dioxide and chloride intrusion
- Excellent freeze/thaw resistance for durability in cold, wet environments
- Flowability makes it ideal for placement by pumping or pouring into congested locations
- Self-consolidation minimizes honeycombing without vibration

APPLICATIONS
- Interior and exterior
- Large volume structural repairs
- Repair or replacement of concrete elements

SUBSTRATES
- Concrete

HOW TO APPLY

SURFACE PREPARATION

CONCRETE

1. Concrete must be structurally sound and fully cured (28 days).
2. Saw cut the perimeter of the area being repaired into a square with a minimum depth of ½" (13 mm).
3. Refer to current ICRI Guideline no. 310.2R for surface prep requirements to permit proper bond.

REINFORCING STEEL

1. Remove all oxidation and scale from the exposed reinforcing steel in accordance with ICRI Technical Guideline No. 310.1R.
2. For additional protection from future corrosion, coat the prepared reinforcing steel with MasterProtect P 8100 AP.

Technical Data

Composition

MasterEmaco S 440 is a proprietary blend of cement, graded aggregate, shrinkage-compensating agents, and additives.

Test Data

PROPERTY	RESULTS	TEST METHOD
Fresh wet density, lb/ft^3 (kg/m^3)	142 (2,275)	ASTM C 138
Slump Flow*, in (cm) **Visual Stability Index**	25 (63.5) 0 (Highly Stable - No Bleeding)	ASTM C1611
J-Ring Slump Flow*, in (cm) **Passing Ability,** in (cm)	24.5 (62.5) 0.5 (1) No visible blocking	ASTM C1621
Compressive strength, psi (MPa); 2" (51 mm) cubes 1 day 7 days 28 days	 2,500 (17.2) 5,000 (34.5) 6,000 (41.4)	ASTM C 109
Compressive strength, psi (MPa); 3 by 6" (76 by 152 mm) cylinders, at 28 days	5,000 (34.5)	ASTM C 39
Flexural strength, psi (MPa), at 28 days	1,150 (7.9)	ASTM C 348
Slant shear bond strength, psi (MPa), at 28 days	3,000 (20.7)	ASTM C 882, (modified[1])
Splitting tensile strength, psi (MPa), at 28 days	500 (3.4)	ASTM C 496
Drying shrinkage, µstrain, at 28 days	350	ASTM C 157, (unmodified)
Drying shrinkage, µstrain, at 21 days	611	ASTM C 157, (modified)
Freeze/thaw resistance, % RDM[2]	100	ASTM C 666
Coefficient of thermal expansion, in/in/° F (cm/cm/° C)	5.5 x 10^{-6} (9.9 x 10^{-6})	CRD C 39

[1]No bonding agent

[2]RDM = Relative Dynamic Modulus

*2.75 qts water / 55 lb bag (Minimum water addition)

Results were obtained with a water per powder ratio of 2.7 qts per 55 lb (2.6 L per 25 kg) bag.

All application and performance values are typical for the material, but may vary with test methods, conditions, and configurations.

MIXING

1. Ensure that MasterEmaco S 440 is thoroughly mixed; a forced-action mixer is essential. Mixing in a suitably sized container using an appropriate paddle with a slow-speed (400–500 rpm) heavy-duty drill is acceptable. Do not use free-fall mixers.
2. Measure 2.7 quarts (2.6 L) of potable water and pour 2 quarts into the mixer. With the machine in operation, add 1 full 55 lb (25 kg) bag of MasterEmaco S 440 and mix for 1 minute before adding the rest of the water. Always add powder into the water. The quantities mixed may be scaled up as required.
3. Mix for a further 2–3 minutes to obtain a smooth consistency.
4. When using the drill-and-paddle mixing method, place the complete 2.7 quarts (2.6 L) of water in the mixing drum. With the paddle rotating, add 1 full 55 lb (25 kg) bag of MasterEmaco S 440 and mix 3 minutes to reach a smooth, even consistency.
5. Depending on the ambient temperatures and the desired consistency, additional water may be added. The total water content should not exceed 2.9 quarts (2.7 L) per 55 lb (25 kg) bag.

APPLICATION

1. Build forms in accordance with ACI 347R. Keep the unrestrained surface area of the repair to a minimum.
2. Saturate the prepared concrete substrate by filling the prepared formwork with clean water 24 hours before placement.
3. Immediately before the placement of MasterEmaco S 440, completely drain this water and seal the drainage outlets, leaving the substrate saturated surface-dry (SSD) with no ponded water remaining.
4. In jobsite circumstances where the formwork cannot be filled with water to achieve an SSD surface, the prepared concrete substrates must be thoroughly hosed down with clean water to achieve an equal level of saturation. Apply the repair material with sufficient pressure to ensure intimate contact with the substrate.
5. A long open-time bonding agent such as MasterEmaco P 124 may be used in place of a saturated substrate. In such a case, place the MasterEmaco S 440 before the bonding agent becomes tack free.
6. Immediately after mixing, pump or pour the MasterEmaco S 440 into the formed area. The material does not require vibrating.
7. The recommended application range of MasterEmaco S 440 is from 40 to 85° F (4 to 29° C). Follow ACI 305 and 306 for hot or cold weather guidelines.

CURING

1. Leave the formwork in place until the compressive strength reaches 2,500 psi (17.2 MPa) or a strength specified by the engineer.
2. Cure with an approved curing compound compliant with ASTM C 309 or preferably ASTM C 1315. If the repair area will receive a coating, wet curing is recommended.

CLEAN UP

Clean tools and equipment with clean water immediately after use. Cured material must be removed mechanically.

FOR BEST PERFORMANCE

- Minimum ambient, surface, and material temperature is 40° F (4° C) and rising.
- Do not mix longer than 5 minutes.
- Minimum application thickness is 1.5" (38 mm). When the depth is less than 1.5", use MasterEmaco S 440 MC.
- Do not mix partial bags.
- Do not use to make overlay repairs where the surface of fresh, wet MasterEmaco S 440 will remain unrestrained during cure.
- Do not vibrate
- Do not add plasticizers, accelerators, retarders, or other additives.
- For professional use only; not for sale to or use by the general public.
- Make certain the most current versions of product data sheet and SDS are being used; visit www.master-builders-solutions.BASF.us to verify the most current versions.
- Proper application is the responsibility of the user. Field visits by BASF personnel are for the purpose of making technical recommendations only and not for supervising or providing quality control on the jobsite.

HEALTH, SAFETY AND ENVIRONMENTAL

Read, understand and follow all Safety Data Sheets and product label information for this product prior to use. The SDS can be obtained by visiting www.master-builders-solutions.basf.us, e-mailing your request to basfbscst@basf.com or calling 1(800)433-9517. Use only as directed. **For medical emergencies only, call ChemTrec® 1(800) 424-9300.**

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www.master-builders-solutions.basf.us

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Sika ViscoCrete® Technology

Sikacrete® 211 SCC Plus

One-component, cementitious, polymer-modified, self consolidating concrete mix with an integral migrating corrosion inhibitor

Construction

Description	Sikacrete® 211 SCC Plus is a one-component, self consolidating concrete containing factory blended coarse aggregate. This self consolidating concrete bag is silica fume and polymer modified and also contains a migrating corrosion inhibitor.
Where to Use	▪ Full depth repairs. ▪ On grade, above and below grade on concrete. ▪ On horizontal surfaces. ▪ Vertical and overhead surfaces when formed and pumped or poured. ▪ As a structural repair material for parking facilities, industrial plants, walkways, bridges, tunnels, dams, and balconies. ▪ Filler for voids and cavities.
Advantages	▪ Self consolidating concrete - Excellent placement characteristics. ▪ Polymer-modified. ▪ Integral Penetrating Corrosion Inhibitor. ▪ Silica Fume Enhanced. ▪ Prepackaged coarse aggregate. Eliminates the need to extend material in the field. Eliminates the risk of reactive aggregate. ▪ Can be pumped or poured into forms and gets excellent consolidation without vibrating.
Coverage	Approximately 0.50 ft.^{3}/bag. Actual results on site may vary.
Packaging	65 lb. bag.

Typical Data *(Material and curing conditions @ 73°F (23°C) and 50% R.H.)*

RESULTS MAY DIFFER BASED UPON STATISTICAL VARIATIONS DEPENDING UPON MIXING METHODS AND EQUIPMENT, TEMPERATURE, APPLICATION METHODS, TEST METHODS, ACTUAL SITE CONDITIONS AND CURING CONDITIONS.

Shelf Life		1 year in original, unopened packaging.
Storage Conditions		Store dry at 40°-95°F (4°-35°C). **Condition material to 65°-75°F (18°-24°C) before using.**
Initial Spread		SCC, 27-33 Inches approx.
Spread at 30 min.		> 15 inches
Application Time		60 minutes
Flexural Strength (ASTM C-78)	**1 day**	500 psi (3.4 MPa)
	7 days	750 psi (5.2 MPa)
	28 days	1,000 psi (6.9 MPa)
Splitting Tensile Strength (ASTM C-496)	**7 days**	750 psi (5.1 MPa)
	28 days	1,000 psi (6.9 MPa)
Slant Shear Bond Strength* (ASTM C-882 modified)		
	1 day	1,000 psi (6.9 MPa)
	7 days	1,500 psi (10.3 MPa)
	28 days	2,500 psi (17.2 MPa)
Direct Tensile Bond (ACI 503)	**1 day**	250 psi (1.7 MPa)
	7 days	300 psi (2.1 MPa)
Compressive Strength (ASTM C-39)		
	1 day	2,000 psi (13.8 MPa)
	7 days	5,500 psi (37.9 MPa)
	28 days	6,500 psi (44.8 MPa)
Shrinkage (ASTM C-157)	**28 days**	<0.05%
Chloride ion permeability (ASTM C-1202)	**28 days**	<650 Coloumbs

Freeze Thaw Resistance (ASTM C-666)	**300 cycles**	> 99%
Scaling Resistance (ASTM C-672)	**50 cycles**	2
Sulfate Resistance (ASTM C-1012)		
Length change after 6 months		0.006

* Mortar scrubbed into substrate.

Construction

How to Use

Surface Preparation

Remove all deteriorated concrete, dirt, oil, grease, and all bond-inhibiting materials from surface. Be sure repair area is not less than 1 in. in depth. Preparation work should be done by high pressure water blast, scabbler, or other appropriate mechanical means to obtain an exposed aggregate surface with a minimum surface profile of ±1/8 in. (CSP-7-8). Saturate surface with clean water. Substrate should be saturated surface dry (SSD) with no standing water during application.

Reinforcing Steel: Steel reinforcement should be thoroughly prepared by mechanical cleaning to remove all traces of rust. Where corrosion has occurred due to the presence of chlorides, the steel should be high-pressure washed with clean water after mechanical cleaning. For priming and protection of reinforcing steel use Sika® Armatec® 110 EpoCem (consult Technical Data Sheet).

Mixing

Start mixing with 5.5 pints of water. An additional 0.5 pint can be added if needed. Do not over water as excess water will cause segregation. Add Sikacrete® 211 while continuing to mix. Mix to a uniform consistency, maximum 3 minutes. Mechanically mix with a low-speed drill (400-600 rpm) and paddle or in appropriate-size mortar mixer or concrete mixer.

Application

Pre-wet surface to SSD(Saturated Surface Dry). Ensure good intimate contact with the substrate is achieved. To accomplish this, material should be scrubbed into the substrate or other suitable means should be employed such as vibration of the material or pumping under pressure. Vibrate form while pouring or pumping. Pump with a variable pressure pump. Continue pumping until a 3 to 5 psi increase in normal line pressure is evident then STOP pumping. Form should not deflect. Vent to be capped when steady flow is evident, and forms stripped when appropriate.

Tooling and finishing

As per ACI recommendations for portland cement concrete, curing is required. Moist cure with wet burlap and polyethylene, a fine mist of water or a water based* compatible curing compound. Curing compounds adversely affect the adhesion of following layers of mortar, leveling mortar or protective coatings. Moist curing should commence immediately after finishing. Protect newly applied material from direct sunlight, wind, rain and frost.

*Pretesting of curing compound is recommended.

Limitations

- Application thickness: Minimum 1 in. (25 mm); Maximum 8 in. (200 mm). Thicker applications have been done successfully. Please consult Sika Technical Service.
- Minimum ambient and surface temperatures 45°F (7°C) and rising at time of application.
- As with all cement based materials, avoid contact with aluminum to prevent adverse chemical reaction and possible product failure. Insulate potential areas of contact by coating aluminum bars, rails, posts, with an appropriate epoxy such as Sikadur® 32 Hi-Mod.

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Sika Corporation
201 Polito Avenue
Lyndhurst, NJ 07071
Phone: 800-933-7452
Fax: 201-933-6225

Sika Canada Inc.
601 Delmar Avenue
Pointe Claire
Quebec H9R 4A9
Phone: 514-697-2610
Fax: 514-694-2792

Sika Mexicana S.A. de C.V.
Carretera Libre Celaya Km. 8.5
Fracc. Industrial Balvanera
Corregidora, Queretaro
C.P. 76920
Phone: 52 442 2385800
Fax: 52 442 2250537

Appendix B – Mortar and Concrete Mixture Proportions

Table B-1. Mortar Mixture Proportions (Per Cubic Yard)

Material	S1 Control	S2 Eclipse	S3 Conex	S4 Prevent C	S5 CRA007
Cement, lb.	850	850	850	850	850
Sand (SSD), lb.	2337	2337	2337	2337	2337
Water	390	292	390	390	292
SRA	--	1 gal.	51 lb.	42.5 lb.	1 gal.

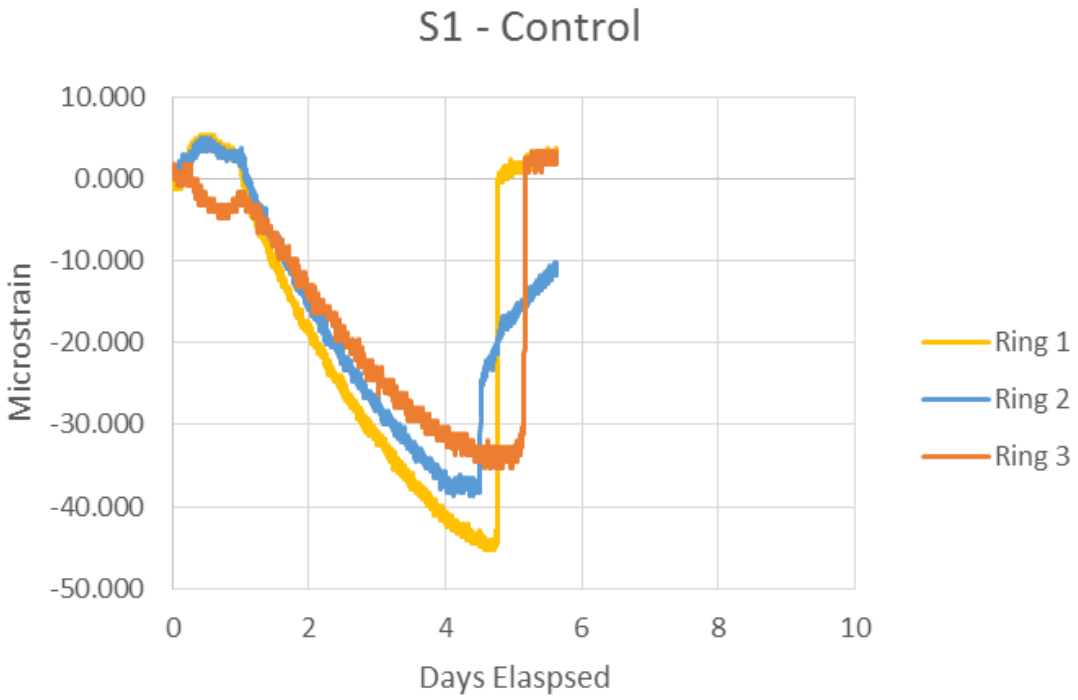
*** w/c of 0.46 required for normal consistency (flow = 113.8)**

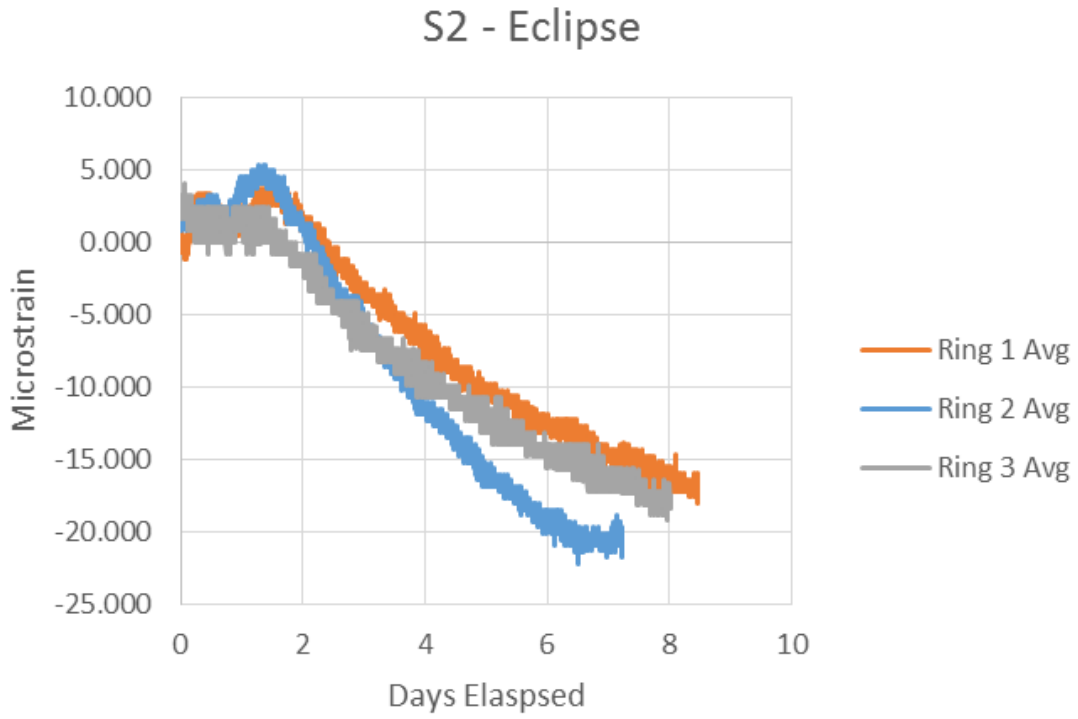
Table B-2. Concrete Mixture Proportions (Per Cublic Yard)

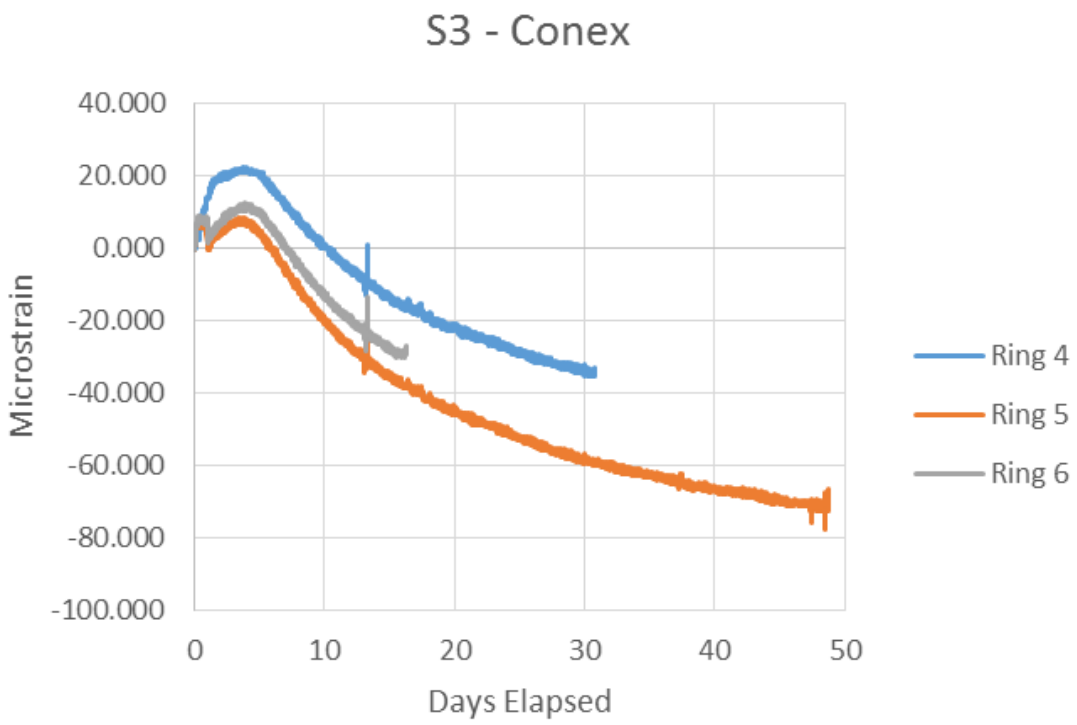
Material	S1 Control	S2 Eclipse	S3 Conex	S4 Prevent C	S5 CRA007
Cement, lb.	750	750	750	750	750
Sand (SSD), lb.	1342	1342	1342	1342	1342
3/8" Rock (SSD), lb.	1353	1353	1353	1353	1353
Water	300	292	300	300	292
WRA, oz.	28	28	28	28	28
SRA	--	1 gal.	45 lb.	38 lb.	1 gal.

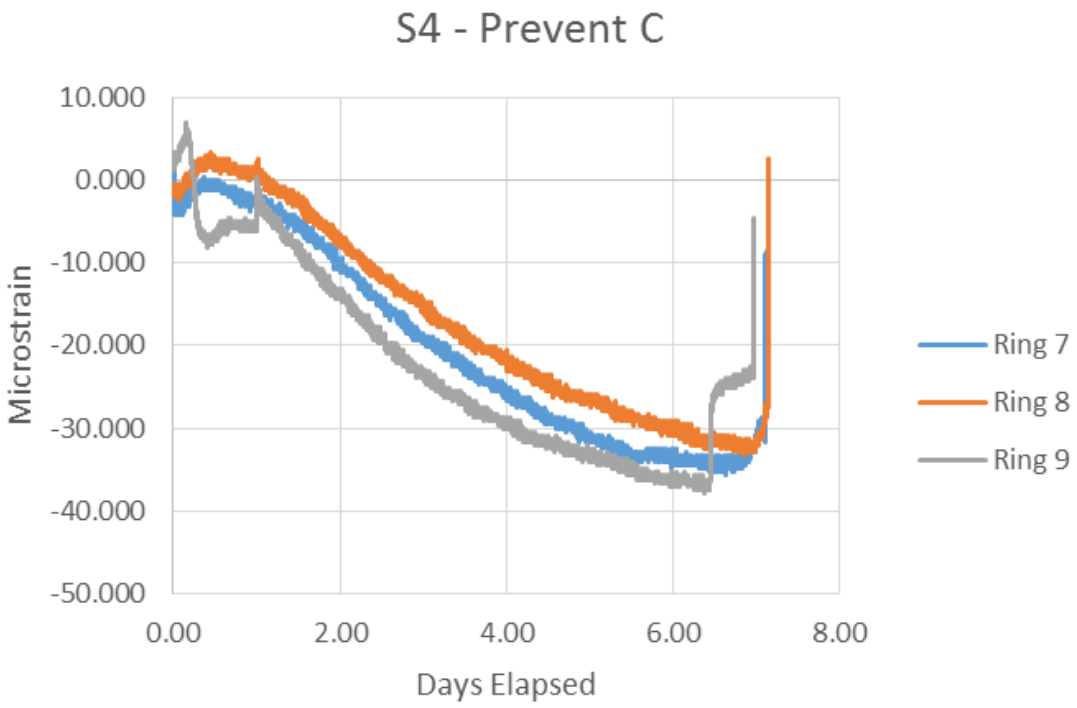
Appendix C – ASTM C1581 Individual Ring Test Results

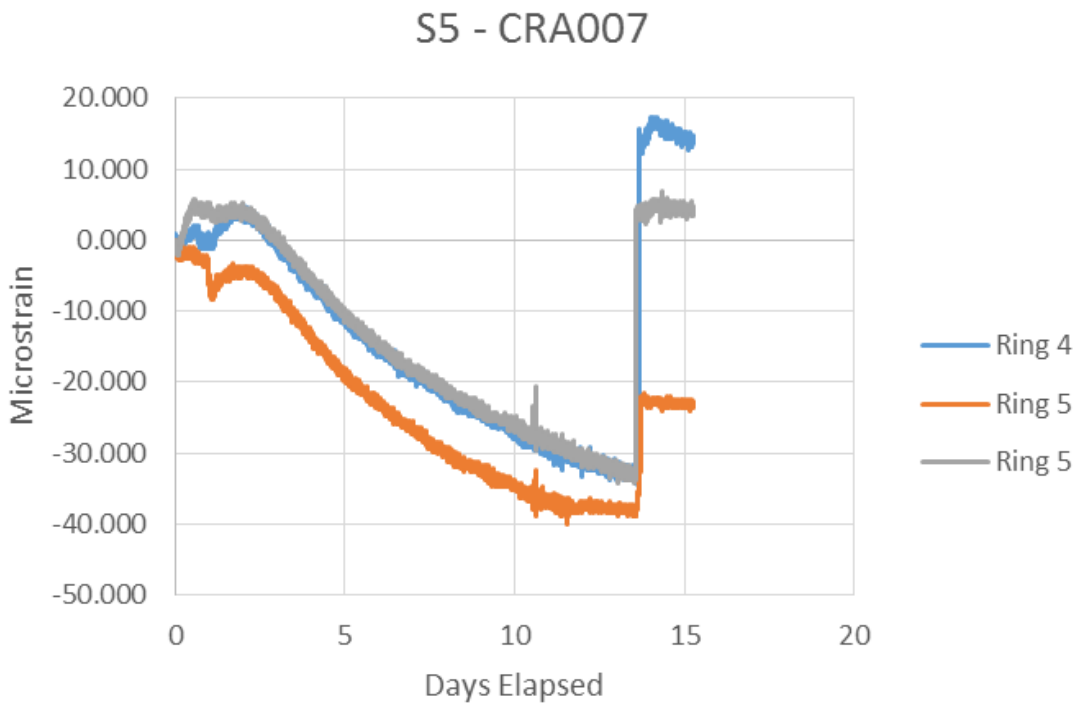
Mortar Mixtures



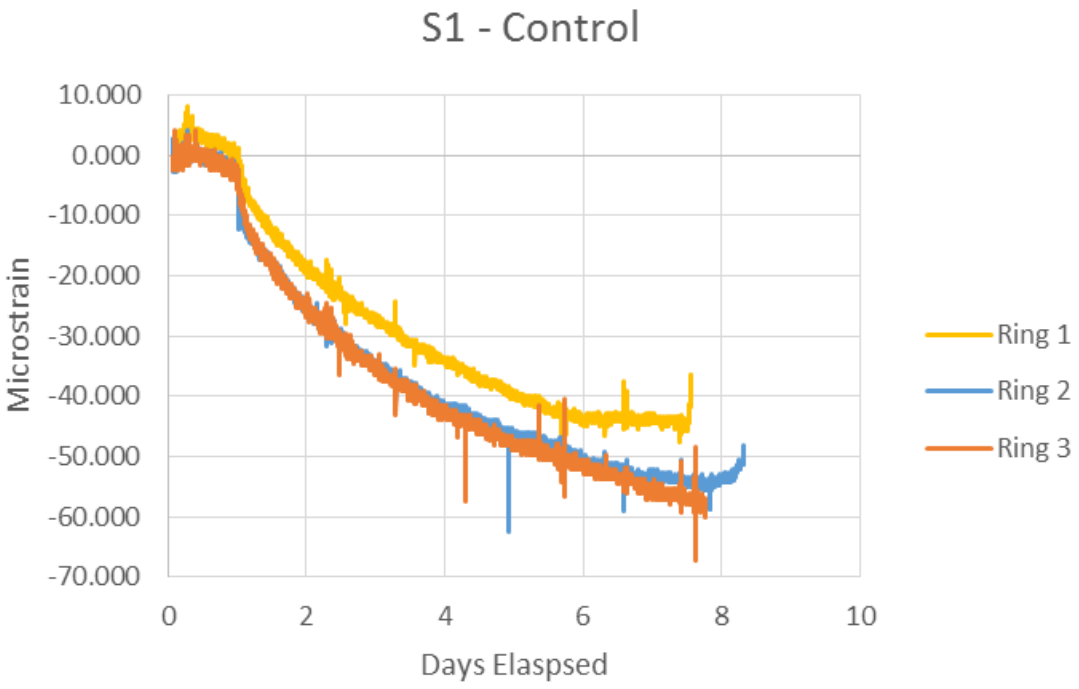


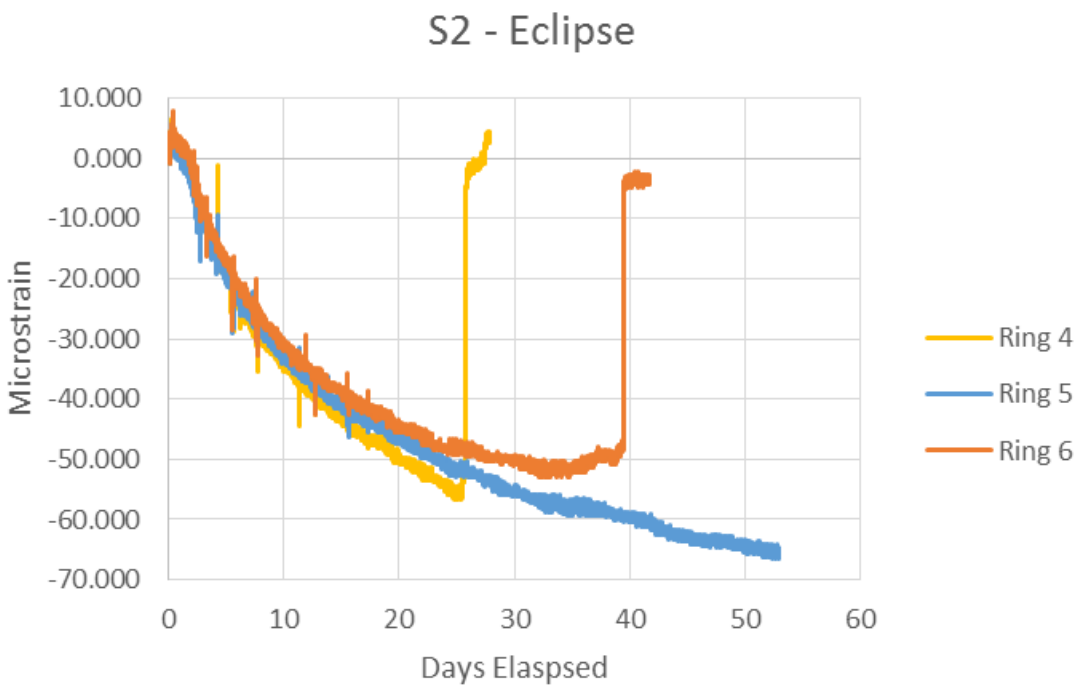

S3 - Conex
40.000
20.000
0.000
-20.000
-40.000
-60.000
-80.000
-100.000
Microstrain
0
10
20
30
40
50
Days Elapsed
Ring 4
Ring 5
Ring 6

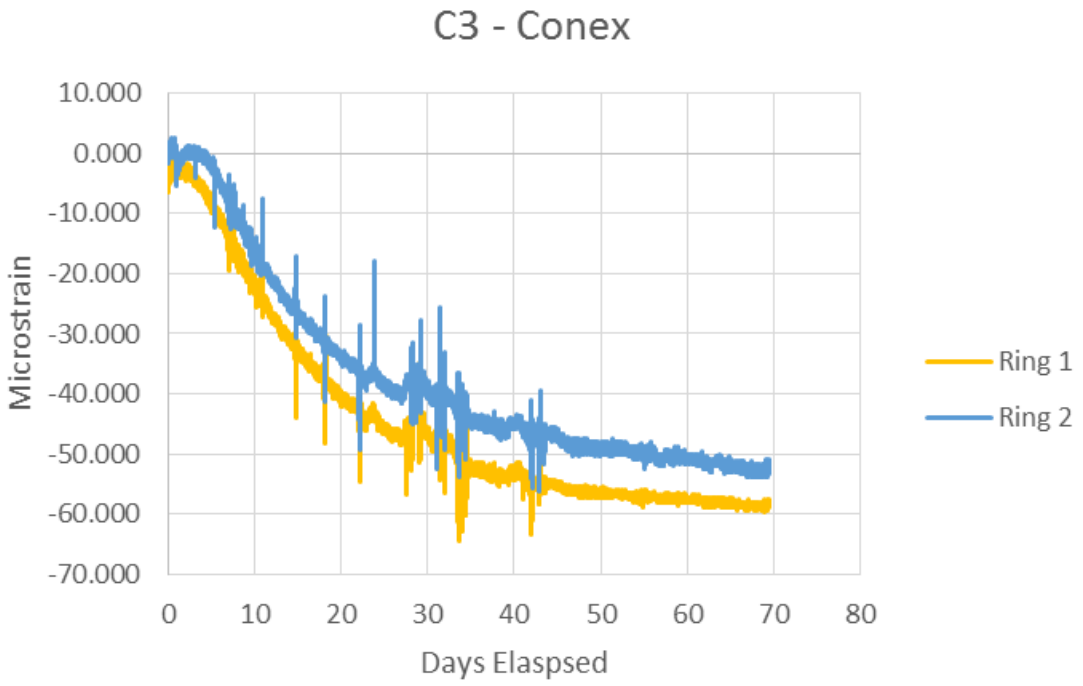

S4 - Prevent C
10.000
0.000
-10.000
-20.000
-30.000
-40.000
-50.000
Microstrain
0.00
2.00
4.00
6.00
8.00
Days Elapsed
Ring 7
Ring 8
Ring 9

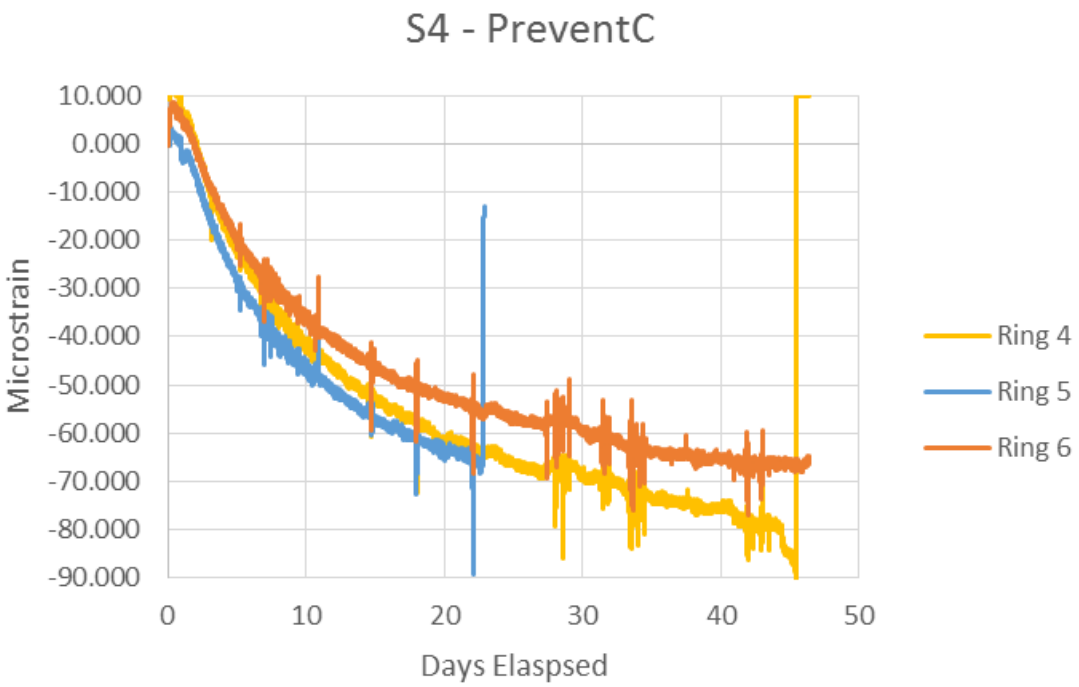


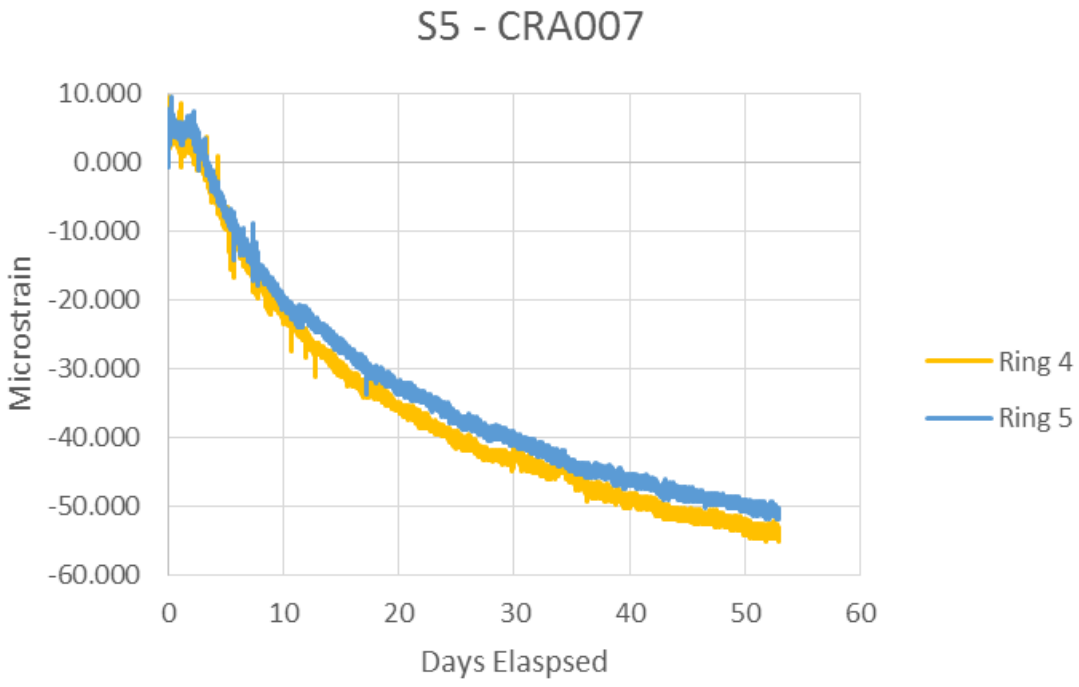
Concrete Mixtures




S2 - Eclipse
10.000
0.000
-10.000
-20.000
-30.000
-40.000
-50.000
-60.000
-70.000
Microstrain
0
10
20
30
40
50
60
Days Elaspsed
Ring 4
Ring 5
Ring 6


C3 - Conex
10.000
0.000
-10.000
-20.000
-30.000
-40.000
-50.000
-60.000
-70.000
Microstrain
0
10
20
30
40
50
60
70
80
Days Elaspsed
Ring 1
Ring 2


S4 - PreventC
10.000
0.000
-10.000
-20.000
-30.000
-40.000
-50.000
-60.000
-70.000
-80.000
-90.000
Microstrain
0
10
20
30
40
50
Days Elaspsed
Ring 4
Ring 5
Ring 6


S5 - CRA007
10.000
0.000
-10.000
-20.000
-30.000
-40.000
-50.000
-60.000
Microstrain
0
10
20
30
40
50
60
Days Elaspsed
Ring 4
Ring 5

Appendix D – Lab Testing Photo

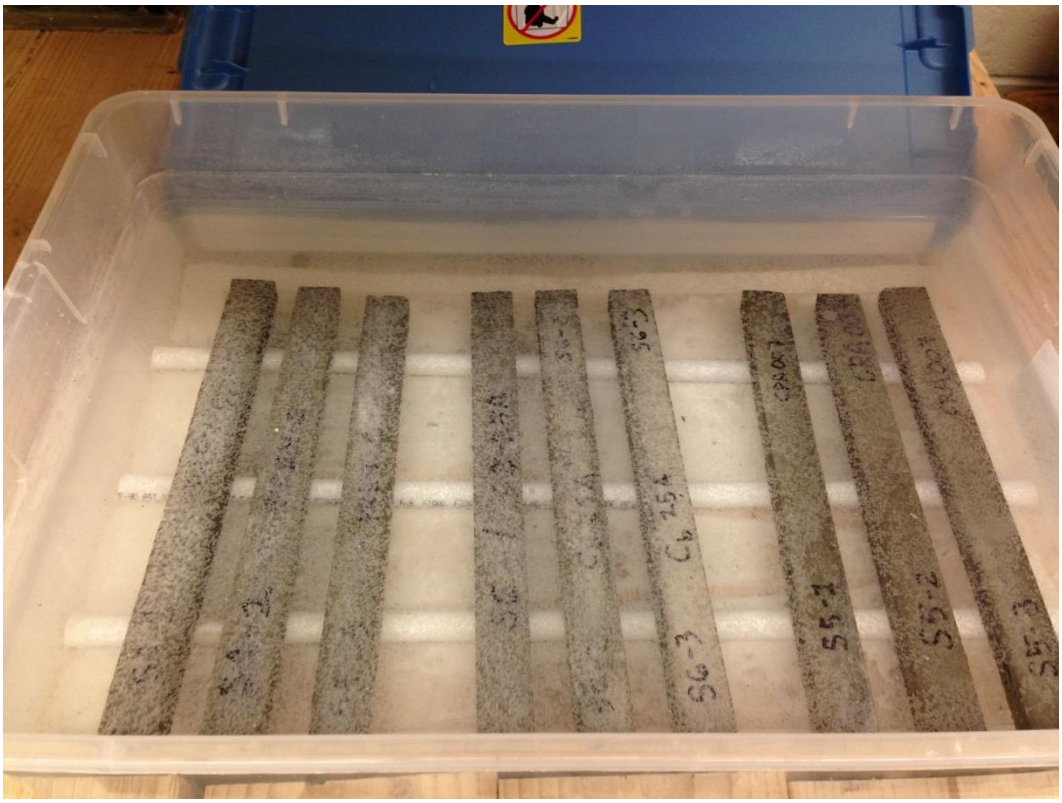


Figure D - 1. ASTM C157 Mortar bars soaking in lime water prior to drying

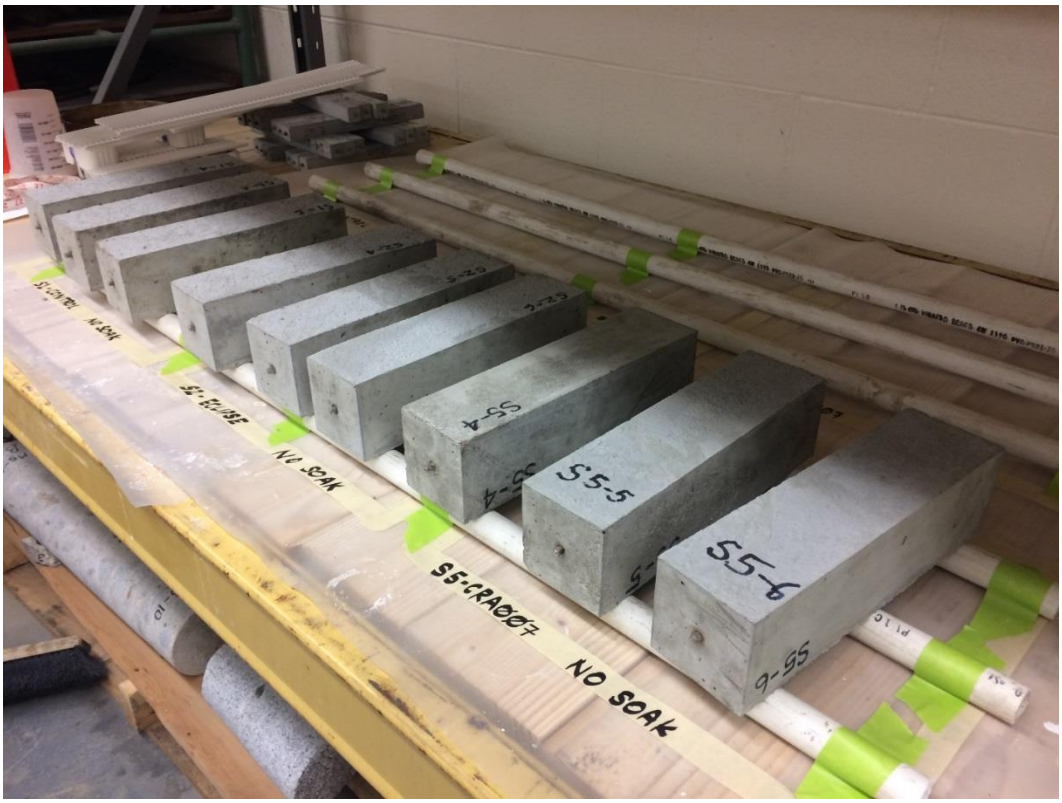


Figure D - 2. ASTM C157 Concrete bars drying at 50% relative humidity

Figure D - 3. ASTM C1581 testing set up

Figure D - 4. Crack width of control mortar

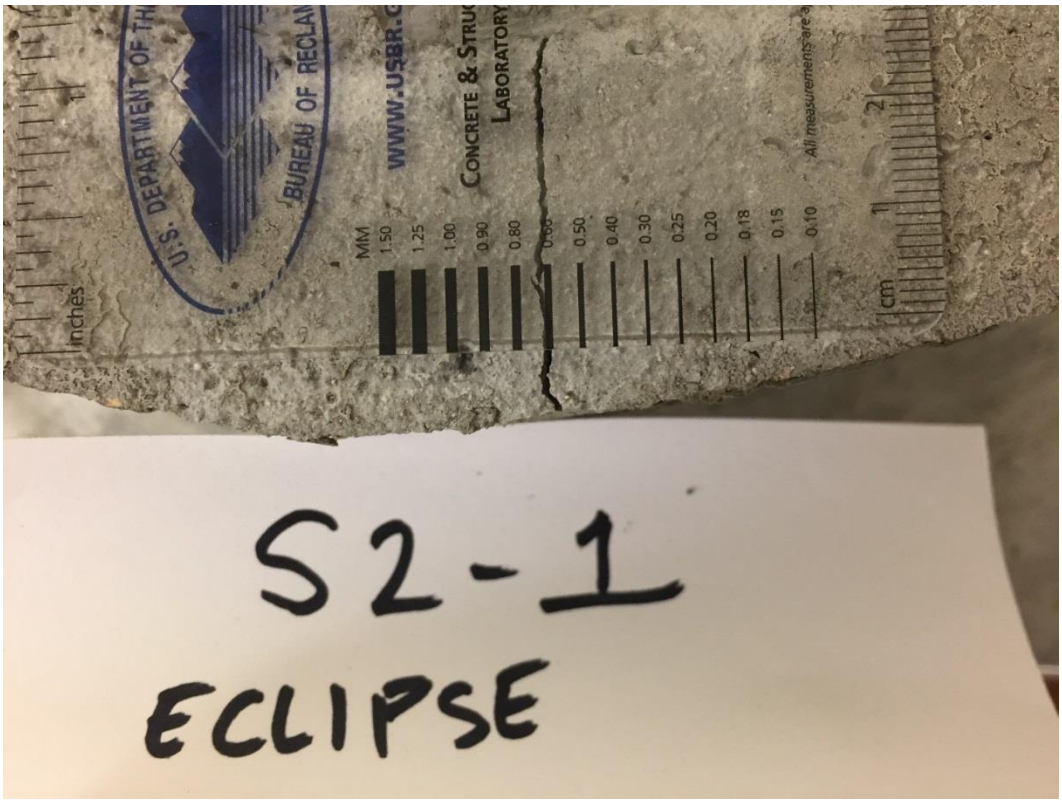


Figure D - 5. Crack width of mortar containing Eclipse Floor

Figure D - 6. Crack width of mortar containing CRA007

Figure D - 7. Crack width of Control concrete mixture

Figure D - 8. Crack width of concrete containing Eclipse Floor