Civil & Environmental Engineering

PEAK TEMPERATURE DETERMINATION OF DRILLED SHAFTS EXCLUDED FROM MASS CONCRETE CONSIDERATION IN CURRENT SPECIFICATIONS

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FINAL REPORT

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Disclaimer

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
TEMPERATURE (exact degrees)				
^{o}F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^{o}C

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fL	foot-Lamberts	3.426	candela/m^2	cd/m^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa
kip	kilopound	4.45	kilonewtons	kN

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2
kN	kilonewtons	0.225	kilopound	kip

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

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16. Abstract

Drilled shafts are reinforced concrete deep foundation elements that typically range in diameter from 3 to 15 feet. Within the past 20 years, drilled shaft installation plans for FDOT projects have gone from requiring no mass concrete information (regardless of shaft diameter) to requiring steps to control temperature for shafts greater than 6 feet in diameter. However, the most recent specifications were in conflict, where all other concrete elements were required to assess temperature for any element with a minimum dimension greater than 3 feet and volume to surface area ratio greater than 1 foot. Shafts supporting miscellaneous (non-bridge) structures until recently required no temperature control regardless of dimensions. While the term mass concrete stems from massive structures that traditionally generated unsafe temperature levels, today concrete mix designs use far more cementitious materials per unit volume. Hence, unsafe temperature levels can occur with nearly any size foundation element if the cementitious materials content is too high.

Recently, the American Concrete Institute (ACI) suggested restrictions on peak and differential temperature limits based on a concrete element minimum dimension and the weight of cementitious materials per unit volume. Using the ACI criteria, a typical FDOT drilled shaft with the minimum specified 600 lbs/yd^3 of cementitious materials would be restricted to a size no larger than 2 feet in diameter; the minimum FDOT shaft diameter is 3.5 feet. Hence, the ACI criteria, if applied to FDOT projects, requires all shafts to provide a temperature control plan. The disconnect between FDOT shafts and the ACI criteria is two-fold: (1) the curing conditions of underground concrete is not the same as above ground formed and poured elements, and (2) FDOT peak temperature limits are higher than ACI limits. This study did not aim to address which of the two temperature limits is most correct, but rather focused on determining the developed peak and differential temperature in drilled shafts with varied concrete mix designs and from shafts of different diameters.

Shaft temperature information was obtained from hundreds of shafts routinely tested using thermal integrity methods and from shafts more thoroughly instrumented to determine the cross-shaft temperature distribution. Results of field data were then used to calibrate numerical models where the internal temperature rise, magnitude, and distribution was verified. Model runs were used to produce predictive methods to better assess when a given shaft size and mix design might be unsafe. However, the threshold of safety is left to the reviewer when using a given acceptance criteria (FDOT, ACI, or other).

17. Key Words
Drilled shaft, peak temperature, differential temperature, mass concrete

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Executive Summary

Drilled shafts are reinforced concrete deep foundation elements that typically range in diameter from 3 to 15 feet. Within the past 20 years, drilled shaft installation plans for FDOT projects have gone from requiring no mass concrete information (regardless of shaft diameter) to requiring steps to control temperature for shafts greater than 6 feet in diameter. However, the most recent specifications were in conflict, where all other concrete elements were required to assess temperature for any element with a minimum dimension greater than 3 feet and the volume to surface area ratio is no more than 1 foot. For shafts supporting miscellaneous (non-bridge) structures until recently required no temperature control regardless of dimensions. While the term mass concrete stems from massive structures that traditionally generated unsafe temperature levels, today concrete mix designs use far more cementitious materials per unit volume. Hence, unsafe temperature levels can occur with nearly any size foundation element if the cementitious materials content is too high.

Recently, the American Concrete Institute (ACI) suggested restrictions on peak and differential temperature limits based on a concrete element minimum dimension and the weight of cementitious materials per unit volume. Using the ACI criteria, a typical FDOT drilled shaft with the minimum specified 600 lbs/yd^3 of cementitious materials would be restricted to a size no larger than 2 feet in diameter; the minimum FDOT shaft diameter is 3.5 feet. Hence, the ACI criteria, if applied to FDOT projects, requires all shafts to provide a temperature control plan. The disconnect between FDOT shafts and the ACI criteria is two-fold: (1) the curing conditions of underground concrete is not the same as above ground formed and poured elements, and (2) FDOT peak temperature limits are higher than ACI limits. This study did not aim to address which of the two temperature limits is most correct, but rather focused on determining the true peak and differential temperature in drilled shafts with varied concrete mix designs and from shafts of different diameters.

Shaft temperature information was obtained from hundreds of shafts routinely tested using thermal integrity methods and from shafts more thoroughly instrumented to determine the cross-shaft temperature distribution. Results of field data were then used to calibrate numerical models where the internal temperature rise, magnitude, and distribution was verified. Model runs were used to produce predictive methods to better assess when a given shaft size and mix design might be unsafe. However, the threshold of safety is left to the reviewer when using a given acceptance criteria (FDOT, ACI, or other).

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Chapter One: Introduction

The internal temperature of concrete rises during curing due to heat energy production resulting from the hydration of cementitious materials; however concrete quality can degrade if the internal temperature becomes too hot. The internal temperature of a concrete element is capable of exceeding safe temperature limits when a concrete element is very large, or the concrete mix design includes substantial quantities of cementitious materials. In practice, these conditions should be avoided by implementing temperature-control measures, however recent studies conducted at the University of South Florida have shown drilled shafts commonly exceed temperature limitations set by the American Concrete Institute. When these temperature limitations are exceeded, the risk for temperature-related durability and structural issues increases. Issues stemming from increased curing temperatures include severe surface cracking, delayed expansion of cement products after concrete hardening, and reduction in concrete strength. Figure 1.1 shows an example of a shaft that exhibited one or all of the possible high temperature induced problems; adjacent shafts were constructed to which the structural loads were transferred via the beam shown. To date, there is no design guide to predict how hot a drilled shaft will get or quality assurance method to confirm temperature limits have not been exceeded in the field.

Figure 1.1 Example of a damaged drilled shaft.

[This is a photograph of a drilled shaft exhibiting severe cracking and spalling.]

The goal of this study was to develop and implement methods to predict peak and differential temperatures of drilled shafts to determine if unsafe temperature conditions may arise for a given design. This study was divided into three methods of investigation: (1) cataloging and examining a database of previously collected thermal data from drilled shafts, (2) collecting new thermal data using specialized field-testing devices in specialized configurations, and (3) thermal modeling based on concrete mixes commonly used in drilled shaft construction.

1.1 Objective Statement

The objectives of this research were multifold: (1) assess previously collected data to determine if shafts have been exceeding FDOT and/or ACI temperature limits, (2) record temperature measurements in newly constructed drilled shafts to determine temperature distribution and evolution patterns during curing, (3) build and calibrate numerical models of drilled shaft temperature distributions over time, (4) develop design aids to predict peak and differential temperatures of drilled shafts, and (5) explore the possibility of expanding existing quality assurance methods to confirm temperature limits are not exceeded post construction.

1.2 Background

The following provides a brief discussion of heat energy production that occurs during concrete curing (heat of hydration), mass concrete and mass concrete effects, mass concrete specifications, drilled shaft construction, as well as quality assurance and quality control of drilled shafts.

1.2.1 Heat of Hydration

Curing concrete produces heat energy that in turn elevates the internal temperature of the concrete. Energy production is the byproduct of exothermic chemical reactions that occur as cementitious materials hydrate. The amount of energy released is directly related to the degree of hydration, or the number of reactions that have already taken place (Johnson, 2017). Heat energy production is a function of both concrete element size (total volume) and concrete mix design, where higher strength concretes use more cementitious materials, and these materials have a wide range of contributing components. The parameters of interest include cementitious material content, cement chemistry, supplementary cementitious material (SCM) chemistry, cementitious material fineness, water-to-cement ratio, SCM-to-Portland cement ratio, and chemical admixtures. The parameters affect both how much and how quickly the heat energy is produced.

1.2.2 Concrete and Mass Concrete Effects

When large amounts of cementitious materials are used in a concrete mix design or when the concrete elements are of a massive size, the internal temperature can exceed safe temperature limits rendering the concrete weaker and/or less durable (ACI Committee 207, 2007). This condition is termed mass concrete. Historically, mass concrete has been defined by physical dimensions with the intent of identifying when differential temperatures may induce early-onset cracking leading to reduced service life. In recent years, specifications have identified temperature thresholds for both differential and peak temperatures, or performance-based criteria. The research behind these performance-based criteria also provides insights into what damage looks like as a result of exceeding these temperature thresholds.

Exceeding temperature limits has the potential to result in concrete elements exhibiting damage similar to Figure 1.2. Historically, high temperature concrete was only observed in structures too large to dissipate the increase in temperature to the surrounding environment and was given the term mass concrete. Today, high temperatures have been shown to occur in elements as small as 30 inches in diameter; this suggests the term mass concrete is a misnomer as an element does not need to be physically massive to create excessively high temperatures as the concrete cures.

Figure 1.2 Temperature-induced damage to drilled shaft (courtesy of Chris Harris with R.W. Harris, Inc.).

[This is a detail photograph of a drilled shaft exhibiting large surface cracks.]

1.2.3 Mass Concrete Specifications

Specifications providing guidance for mass concrete considerations are primarily published by the American Concrete Institute (ACI). The Florida Department of Transportation (FDOT) also provides guidance for projects located within the state of Florida. ACI offers a number of specifications that discuss various temperature limitations as well as specific definitions for mass concrete. These specifications include:

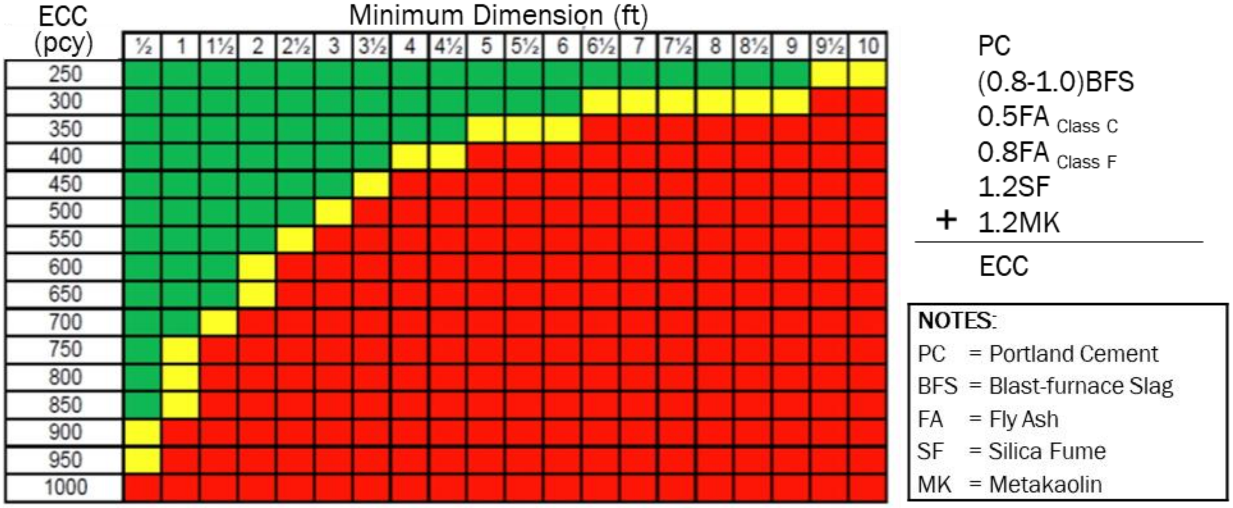
- ACI CT-21: Concrete Terminology
- ACI 201.2R-16: Guide to Durable Concrete

- ACI 224R-01: Control of Cracking in Concrete Structures
- ACI PRC-207.1-21: Mass Concrete – Guide
- ACI 207.2R-07: Report on Thermal and Volume Change Effects on Cracking of Mass Concrete
- ACI 301-16: Specifications for Structural Concrete
- ACI 308R-16: Guide to External Curing of Concrete

ACI Concrete Terminology (ACI CT) and Specifications for Structural Concrete (ACI 301) define the term mass concrete as, “any volume of structural concrete in which a combination of dimensions of the member being cast, the boundary conditions, the characteristics of the concrete mixture, and the ambient conditions can lead to undesirable thermal stresses, cracking, deleterious chemical reactions, or reduction in the long-term strength as a result of elevated concrete temperature due to heat from hydration.” ACI PRC-207.1 also references the same definition but notes, “there is currently no universally accepted definition for mass concrete based on specific characteristics of concrete or placements that require control of temperatures and temperature differences” (ACI, 2021; ACI Committee 207, 2021; ACI Committee 301, 2016).

The Mass Concrete Guide (ACI Committee 207, 2021) uses an equivalent cement content (ECC) of the concrete and the minimum dimension of an element “to define mass concrete as a function of the primary influencers” Figure 1.3 shows red, green and yellow fields corresponding to good, bad, and borderline expected temperatures, respectively, as a function of ECC and concrete element size. It does not indicate what criterion or criteria were used to define these thresholds. It should further be noted that ACI 224R (2001) specifically calls out “concrete dams, powerplants, bridge piers, and other large structural elements” as “mass concrete structures.” This specification additionally references a now-superseded definition of mass concrete from ACI 116R (2000) which reads, “any volume of concrete with dimensions large enough to require that measures be taken to cope with generation of heat from hydration of the cement and attendant volume change to minimize cracking.”

ACI 308R (2016) makes mention of specific structures most frequently qualifying as mass concrete. These structures include “piers, abutments, dams, heavy footings, and similar massive construction.” It then asserts, “the impact of temperature rise and thermal gradients should be considered in all concrete, whether the concrete is reinforced or not.”



ECC (pcy)	Minimum Dimension (ft)																			
	½	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10
250	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟨	🟨
300	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟨	🟨	🟨	🟨	🟨	🟨	🟥	🟥
350	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟨	🟨	🟨	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
400	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟨	🟨	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
450	🟩	🟩	🟩	🟩	🟩	🟩	🟨	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
500	🟩	🟩	🟩	🟩	🟩	🟨	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
550	🟩	🟩	🟩	🟩	🟨	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
600	🟩	🟩	🟩	🟨	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
650	🟩	🟩	🟩	🟨	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
700	🟩	🟩	🟨	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
750	🟩	🟨	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
800	🟩	🟨	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
850	🟩	🟨	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
900	🟨	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
950	🟨	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
1000	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥

$$\begin{array}{rl} & PC \\ & (0.8\text{-}1.0)BFS \\ & 0.5FA_{\text{Class C}} \\ & 0.8FA_{\text{Class F}} \\ & 1.2SF \\ + & 1.2MK \\ \hline & ECC \end{array}$$

NOTES:
PC = Portland Cement
BFS = Blast-furnace Slag
FA = Fly Ash
SF = Silica Fume
MK = Metakaolin

Figure 1.3 Adapted ACI PRC-207.1 definition of mass concrete as a function of equivalent cement content (ECC) of the concrete and minimum dimension.

[This figure is essentially a table where across the top of the table are twenty columns with headings showing minimum dimensions of any concrete element to be considered where the values range from 0.5ft to 10ft in increments of 0.5ft. Down the left side of the table is a listing of 16 equivalent cement contents in units of pounds per cubic yard ranging from 250 to 1000pcy in increments of 50pcy. In the field of the table each cell is colored red, green, or yellow denoting, bad, good, and borderline, respectively, when considering if a concrete element might present with mass concrete problems. Lastly, the figure has an equivalent cement content calculator to the right of the table where slag, fly ash, silica fume, and metakaolin are given multipliers of 0.8 to 1.0, 0.5 or 0.8, 1.2, and 1.2, respectively, to compute the Portland cement equivalent.]

Two temperature limitations exist for curing concrete: differential temperature and maximum concrete temperature, or peak temperature. ACI 201.2R (2016) recommends to not exceed 158°F to minimize the risk of negatively impacting concrete durability as a result of delayed ettringite formation (DEF) reactions. This is a type of sulfate attack that damages cured concrete due to the expansion of cement hydration products during repeated wetting and drying and typically only occurs in concrete that has been exposed to temperatures in excess of 158°F while curing (ACI, 2021). Table 6.2.2.2 in ACI 201 (2016), as well as Table 3.10 in ACI 308R (2016), further provide conditions to minimize, but not eliminate, risk of expansion when temperatures are between 158°F and 185°F. Per both ACI 201.2R Table 6.2.2.2 (2016) and ACI 308R Table 3.10 (2016), one of the following conditions excerpted below may be used to achieve this:

1. Portland cement meeting requirements of ASTM C150/150M moderate or high sulfate-resisting and low-alkali cement with a fineness value less than or equal to 430 m3/kg
2. Portland cement with a 1-day mortar strength less than or equal to 2850 psi (20 MPa)
3. Any Portland cement meeting requirements of ASTM C150/150M in combination with the following proportions of pozzolan or slag cement:
    a. Greater than or equal to 25% fly ash meeting the requirements of ASTM C618 for Class F fly ash

   b. Greater than or equal to 35% fly ash meeting the requirements of ASTM C618 for Class C fly ash
   c. Greater than or equal to 35% slag cement meeting the requirements of ASTM C989/C989M
   d. Greater than or equal to 5% silica fume meeting the requirements of ASTM C1240 in combination with at least 25% slag cement
   e. Greater than or equal to 5% silica fume meeting the requirements of ASTM C1240 in combination with at least 20% Class F fly ash
   f. Greater than or equal to 10% metakaolin meeting the requirements of ASTM C618
4. An ASTM C595/C595M or ASTM C1157/C1157M blended hydraulic cement with the same pozzolan or slag cement content as listed in Item 3

Under no circumstances should internal concrete temperature exceed 185°F (ACI Committee 201, 2016; ACI Committee 308, 2016).

Regarding differential temperature, ACI 301 (2016) states that the maximum temperature differential between the center of an element and the surface “shall not exceed 35°F.” For marine structures involving thick sections and rather high cement factors to achieve appropriate in-place strengths before exposure to sea water, ACI 201.2R (2016) also recommends treating these structures as “mass concrete in which the effect of heat of hydration is considered.” When these conditions are present, ACI 201.2R (2016) states that recommendations in ACI 207.1R, ACI 207.2R, and ACI 224R apply. Similarly, ACI 308.R (2016) states that temperature rise and gradient issues are “exacerbated where high-strength and high cementitious-materials contents are required.”

For projects located in the state of Florida, the specifications discussing mass concrete considerations published by the FDOT include:

- Standard Specifications for Road and Bridge Construction
- Structures Design Guidelines

FDOT size-based guidelines for physical element dimensions can be contradictory. In the state of Florida where differential and peak temperatures are limited to 35°F and 180°F, respectively, drilled shafts are not evaluated for potential temperature issues when used to support miscellaneous structures, regardless of size, which may unintentionally lead to reduced durability/longevity:

> *346-3.3 Mass Concrete “Mass concrete control provisions are not required for drilled shafts supporting sign, signal, lighting or intelligent transportation (ITS) structures.”* FDOT Standard Specifications for Road and Bridge Construction (2019a)

In the FDOT Structures Design Guidelines, drilled shafts have a minimum diameter limitation of 6 feet before being considered mass concrete:

> *1.4.4 Mass Concrete C.2 "All drilled shafts with design diameters greater than 6 feet shall be designated as mass concrete."* FDOT Structures Design Guidelines (2019b)

The same specification, however, states:

> *"… When the minimum dimension of the concrete exceeds 3 feet and the ratio of volume of concrete to the surface area is greater than 1 foot, provide for mass concrete."* FDOT Structures Design Guidelines (2019b) However, drilled shafts are excluded from consideration in the latest version (2023).

This criterion would then include shafts as small as 4 feet in diameter, which have been shown in some instances to exceed mass concrete temperature thresholds. The current use of excess cementitious materials to promote high early strengths in the field further aggravates the situation by increasing the likelihood of inducing core temperatures higher than 180°F and causing differential temperatures that exceed 35°F. A study in 2007 (Mullins & Kranc, 2007) showed shafts as small as 48 inches in diameter can exceed both differential and peak temperature limits. More recently in 2020, augered cast-in-place piles as small as 30 inches in diameter also exceeded both differential and peak temperature limits (Mullins, 2021). This suggests that the mass concrete definitions dependent on physical dimensions have become unreliable, especially in cases where high-early-strength or high-performance concretes are used. Therefore, with these specifications, one can expect some drilled shafts built in Florida to have poor durability.

1.2.4 Drilled Shaft Construction

Drilled shafts are cast-in-place, deep foundational elements. Drilled shaft lengths can be upwards of 300 feet with diameters anywhere from 2 to 30 feet (Gunaratne, 2014). As a cast-in-place element, prior to concrete placement, an excavation is first completed using an auger with a diameter of the shaft that will be constructed (Figure 1.4). A steel casing is also used and can be partial or full length, temporary or permanent. A slurry material consisting of either bentonite or polymer is used to stabilize the borehole when full length casing is not used and the soil is inherently unstable. This includes high water table conditions. Once the excavation is complete, a reinforcement cage is lowered into place within the excavation (Figure 1.5), and concrete is placed. During concreting, a tremie or pump truck slick line is lowered down to the bottom of the excavation and the concrete level rises from the bottom up displacing the slurry. In the example presented in Figure 1.6, the casing was temporary and was removed near the end of concrete placement (Figure 1.6, middle). An above ground form was then added to complete concreting and bring the top of shaft to the finished above-grade surface (Figure 1.6, right).

Figure 1.4 Drilled shaft excavation.

[This is two photographs showing the excavation process for a drilled shaft foundation. The photo on the left shows the drilled shaft site with the staged reinforcement cage, partial excavation with a steel casing installed, and a drilled rig in operation. The photo on the right is a more detailed photo of the partial excavation with installed steel casing and drill rig emptying the auger.]

Figure 1.5 Drilled shaft reinforcement cage placement.

[This is a series of three photos showing the installation of the reinforcement cage for a drilled shaft foundation. The photo on the left shows the reinforcement cage alignment with the excavation; the center photo shows the reinforcement cage partially lowered into the excavation; and the photo on the right shows the reinforcement cage lowered into the excavations roughly two-thirds of the way.]

Figure 1.6 Drilled shaft concrete placement.

[This is a series of three photos showing drilled shaft concrete placement. The photo on the left is a detail photo of the drilled shaft excavation with visible slurry and a concrete delivery truck actively pouring concrete into the tremie; the center photo shows the drilled shaft after concrete was overpoured and the temporary casing was removed; and the photo on the right shows the drilled shaft after a beauty ring was installed and surrounding area was cleaned with finishing concrete being placed.]

The method of construction always requires at least a temporary surface casing (if not full length) *"from at least 1 foot above the ground surface to at least 1-1/2 shaft diameters below the ground surface to prevent caving of the surface soils and to aid in maintaining shaft position and alignment"* (FDOT 2023 Standard Specifications, 455-15.1.3).

Surface casings described above are virtually always larger than the design diameter which brings about the term as-built diameter. This term is referenced in Section 346-4.2 (FDOT 2023) where *"instrumentation and temperature monitoring are not required for miscellaneous drilled shafts supporting sign, signal, lighting or Intelligent Transportation System (ITS) structures when the* ***as built diameter is six feet or less****, and the total cementitious materials content of the concrete mix design is less than or equal to 752 pounds per cubic yard."* This now puts some oversight on shafts supporting miscellaneous structures.

For the full-length temporary casing method, the outer diameter of the casing can be the same as the design diameter of the shaft; hence, the as-built diameter is the design diameter in that case. The Structures Design Guidelines Section 1.4.4-C.2 references the design diameter and not the as-built diameter: *"All drilled shafts with* ***design diameters greater than 6-feet*** *shall be designated as mass concrete."* This could lead to larger elements that do not meet the as-built dimension limit; the worst case, however, can only be 12 inch larger than the design diameter per Section 455-15.1.3 *"Do not use a temporary casing larger than 12 inches of the shaft diameter"* (FDOT 2023 Standard Specifications).

1.2.5 Drilled Shaft Quality Assurance and Quality Control

As a below-grade, cast-in-place concrete structural element, the quality assurance of drilled shafts is just as important as above ground elements but more difficult to guarantee. Various methods to assess structural integrity of the fully cured concrete have been developed, such as gamma gamma logging (GGL) and crosshole sonic logging (CSL); another test method takes advantage of the temperature rise from heat of hydration that takes place during concrete curing. Taking temperature measurements during curing is non-destructive and can be used to evaluate both concrete integrity and homogeneity as well as reinforcement cage location relative to the true center of cast-in-place concrete foundation elements such as bored piles, drilled shafts, continuous flight auger piles, barrettes, dams, or diaphragm walls (ASTM, 2014). ASTM D7949 (2014) designates this test as *Thermal Integrity Profiling of Concrete Deep Foundations*. Thermal Integrity Profiling (TIP) involves recording temperature measurements along the length of a drilled shaft at discrete locations around the reinforcement cage via one of two measurement techniques: Method A - use of a thermal probe lowered into access tubes, or Method B - multiple embedded thermal sensors. The probe system is fitted with four laterally directed, orthogonally aligned infrared thermal sensors and measures access tube wall temperatures in all directions as it is lowered into the shaft at access tube locations. The thermal wire system includes cables fitted with evenly spaced sensors and samples thermal data from each installed wire at time intervals specified by the user, typically every 15 minutes. The advantage of probe systems is that the device is reusable; the advantage of thermal wires (one-time use) is the ability to take measurements continuously with time. Figure 1.7 shows thermal wires being tied to a shaft reinforcing cage at one of the studied sites. Figure 1.8 shows a TIP probe system in use. The data collected from both techniques results in a continuous vertical temperature profile. A combination of several physical, chemical, and molecular principles is incorporated into this type of evaluation and explains the mechanisms behind heat production of the curing concrete, heat diffusion into the surrounding soil, and the temperature distribution created by an ideally shaped drilled shaft (Mullins, 2010).

Figure 1.7 Installation of thermal wires to a shaft reinforcing cage at a construction site located on the University of South Florida Tampa Campus.

[This is a photograph of a project site located on the University of South Florida Tampa Campus primarily showing three graduate students installing thermal wires on a drilled shaft reinforcing cage. There are eight rods evenly spaced down the length of the reinforcement cage and are set through the center to allow for easy access to the thermal wire throughout the length of the reinforcement cage. The first rod in the foreground also holds the thermal wire spool.]

Figure 1.8 TIP probe system in use.

[This is a photograph of a project site showing a recently installed drilled shaft with access tubes coming up out of the top of the shaft. The principal investigator is in the process of using the Thermal Integrity Profiling (TIP) probe system.]

Analysis of the collected time, temperature, and depth data includes creating shaft temperature profiles over time for given depths, as well as plotting all temperature data versus depth (see Figures 1.8 and 1.9). The two immediate benefits of the thermal integrity technology are: (1) determination of the as-built shape of the shaft and provided concrete cover and (2) verification that reinforcing steel is appropriately centered in the concrete (Johnson, 2014; Johnson, 2016; Mullins, 2010). In some cases, routine thermal integrity tests (Figure 1.10 [left]) have discovered unsafe temperatures (>>158°F) at the cage location which raises the question: how hot did the center of the shaft get? Figure 1.10, left, presents routine data collected from a drilled shaft as part of an FDOT project (HEFT II) in June 2018 in Miami, Florida.

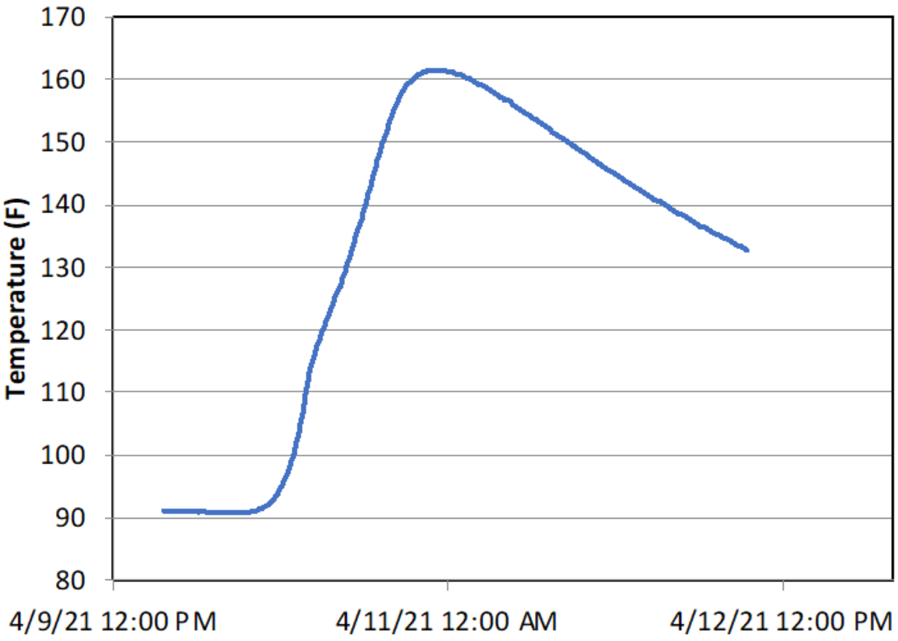


Figure 1.9 Example of a temperature versus time plot at a discrete drilled shaft depth.

[This figure is an example plot of average drilled shaft temperature measurements taken at the reinforcement cage versus time. The time period these measurements were taken spans three days (April 9, 2021 to April 12, 2021), and the temperature measurements start at just over 90ºF, rise steeply to just over 160ºF on April 11, 2021 then gradually fall to just over 130ºF when data recording ended on April 12, 2021 12:00 PM.]

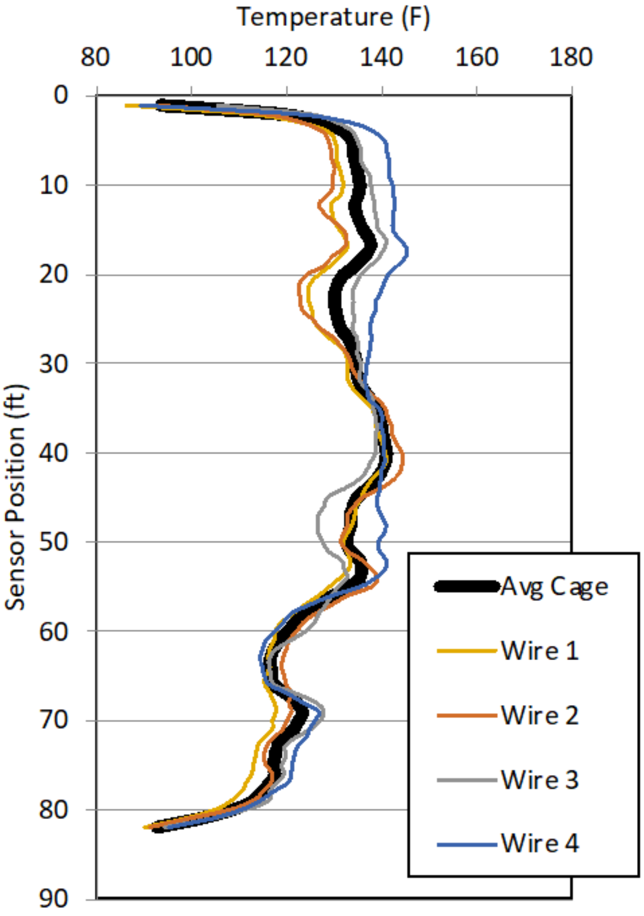


Figure 1.10 Example of an average drilled shaft temperature profile that includes individual thermal wire data measured via a four-wire installation as well as the average profile resulting from all four wires. This profile represents the basic shape of the shaft.

[This figure is an example plot of an average drilled shaft temperature profile that includes the individual thermal wire data measured via a four-wire installation at the reinforcement cage, as well as the average profile resulting from all four wires. The y-axis of the plot illustrates the sensor position or elevation with a zero elevation at the top. The x-axis is the measured temperature data. This profile represents the basic shape of the drilled shaft.]

1.3 Organization of the Report

This report is divided into five ensuing chapters that track the various tasks performed in the process of determining peak temperatures in drilled shafts excluded from mass concrete consideration in current specifications. Chapter 2 discusses the collection and cataloging of thermal integrity data from previous testing. Chapter 3 presents newly collected thermal data from five drilled shafts constructed in or near the Tampa Bay area with a focus on shaft core temperature distributions. Along with temperature data, environmental conditions during construction, concrete mix design, and mill certificates associated with each drilled shaft were also collected, cataloged, and presented in this chapter. Chapter 4 details the modeling approach and verification used to generate 330 model temperature distributions over a time period of 200 hours; 110 models for three unique concrete mix designs. Temperature distributions are presented as contour plots dependent on drilled shaft diameter and total cementitious content. This chapter also describes the analysis methods used to develop ten closed-form equations to be used to predict peak and differential temperatures of drilled shafts either at the design phase or as a quality assurance method to confirm temperature limits have not been exceeded in the field. Chapter 5 provides a summary and discussion with recommendations.

Chapter Two: Obtain Previously Collected Data

This chapter highlights the cataloging of previously collected thermal integrity profiles, corresponding project information including site location, shaft size, thermal profile data, mix design, date of testing, and hydration time/age when tested. A summary of the profiles and project information catalogued as well as an exploratory analysis of this catalogued information and relevant discussion of the results.

2.1 Introduction

Three databases of drilled shaft thermal data and available project information were mined for relevant information to shaft internal temperatures. The first database contained data from 118 drilled shafts evaluated as part of the Lee Roy Selmon Expressway Connector project in Hillsborough County, Florida. The second database contained data from 232 drilled shafts evaluated as part of the Lee Roy Selmon Expressway Re-decking project in Hillsborough County, Florida. Finally, the third database was obtained from local engineering consultants, which contained 207 project folders, many containing datasets for multiple drilled shafts.

In total, this phase of data collection included thermal integrity information from 662 drilled shafts. Included with the temperature data was project and shaft dimension information including:

- Drilled shaft location by county
- Thermal testing date
- Concrete age at time of testing
- Maximum drilled shaft temperature measured at the cage as reported in readily available testing results documents or deliverable reports
- Average drilled shaft temperature as reported in readily available testing results documents or deliverable reports
- Reinforcement cage diameter as reported in readily available testing results documents or deliverable reports
- Inventory of file contents with specific attention to availability of raw thermal data files, testing method used (wire or probe), number of wires or tubes tested in each shaft, availability of results documents or deliverable reports, availability of project photos or videos, availability of mix tickets, concrete supplier (if known), availability of mill certificates, availability of Standard Penetration Test (SPT) borings, availability of FDOT drilled shaft logs, and whether any other integrity reports or analysis spreadsheets were available [e.g. cross sonic logging (CSL) or gamma-gamma logging (GGL) analysis].

2.2 Summary of Catalogued Drilled Shafts

A total of 662 drilled shafts had preliminary information cataloged from the three available databases. The concrete age at time of thermal testing ranges from 8.7 to 139.8 hours. Average drilled shaft temperatures measured at the cage as reported in readily available testing results documents, deliverable reports, or thermal data files range from 83.5°F to 160.7°F. Peak average drilled shaft temperatures measured at the cage as reported in readily available testing results documents, deliverable reports, or thermal data files range from 86.8°F to 183.8°F. Local maximum shaft temperatures measured at the cage as reported in readily available testing results documents, deliverable reports, or thermal data files range from 86.8°F to 188.9°F. Cataloged drilled shafts were found to be located in the following Florida counties: Broward, Duval, Citrus, Miami-Dade, Lake, Hillsborough, Palm Beach, Hernando, Polk, St. Lucie, and Okeechobee. Six drilled shaft locations are unknown. A breakdown of the number of drilled shafts per county can be found in Table 2.1.

Regarding file inventory, all cataloged drilled shafts include availability to raw thermal data per wire or tube, depending on testing method used; 227 drilled shafts include available FDOT drilled shaft logs, 78 drilled shafts include available SPT borings; and 202 shafts include both the concrete supplier and available mix designs.

Table 2.1 Breakdown of the number of drilled shafts per county

County	**Number of Drilled Shafts**
Broward	170
Duval	2
Citrus	6
Miami-Dade	74
Lake	2
Hillsborough	350
Palm Beach	27
Hernando	3
Polk	8
St. Lucie	12
Okeechobee	1

2.3 Exploratory Analysis

This preliminary exploratory analysis of cataloged information focused on general trends seen between drilled shaft size (by way of reported reinforcement cage diameter), concrete age at time of testing, average shaft temperatures, and local maximum temperatures. This analysis did not consider variations in concrete mix design. The 662 data points were sorted by reinforcement cage size and plotted to explore various temperature distributions as they relate to concrete age.

Local maximum cage temperatures from the 662 shafts were first plotted against shaft diameters (Figure 2.1). The data shows a wide range of maximum temperatures for each shaft size/diameter which indicates another variable is contributing to the peak temperature (e.g. ambient temperature, mix design, or concrete age at time of testing). This plot also helps clarify how the data points are sorted with different marker sizes and colors. Larger markers indicate larger diameter shafts; marker colors and sizes are kept consistent throughout.

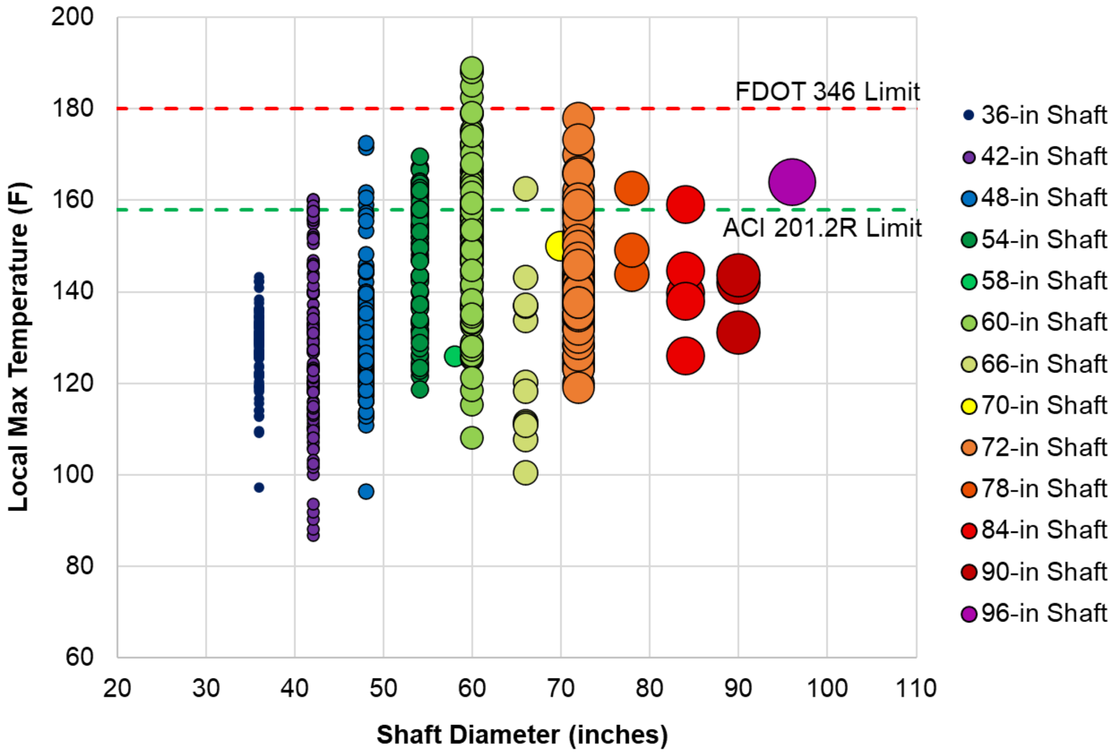


Figure 2.1 Plot presenting maximum cage temperature (at time of testing) vs drilled shaft diameter. *[This figure shows 662 data points where local maximum temperature is plotted against shaft diameter. A violet to red color spectrum is used to identify the shaft size in the field of data points where red represents larger shafts and violet represents smaller shafts. It shows that cage diameter, and therefore shaft size, is not controlling maximum temperatures. This plot also helps to clarify how the data points are displayed.]*

Maintaining the breakdown by shaft diameter, local maximum temperatures were then plotted versus concrete age at time of testing (Figure 2.2). There does appear to be a general trend of increasing temperature up to 24 to 48 hours, then a subtle reduction thereafter.

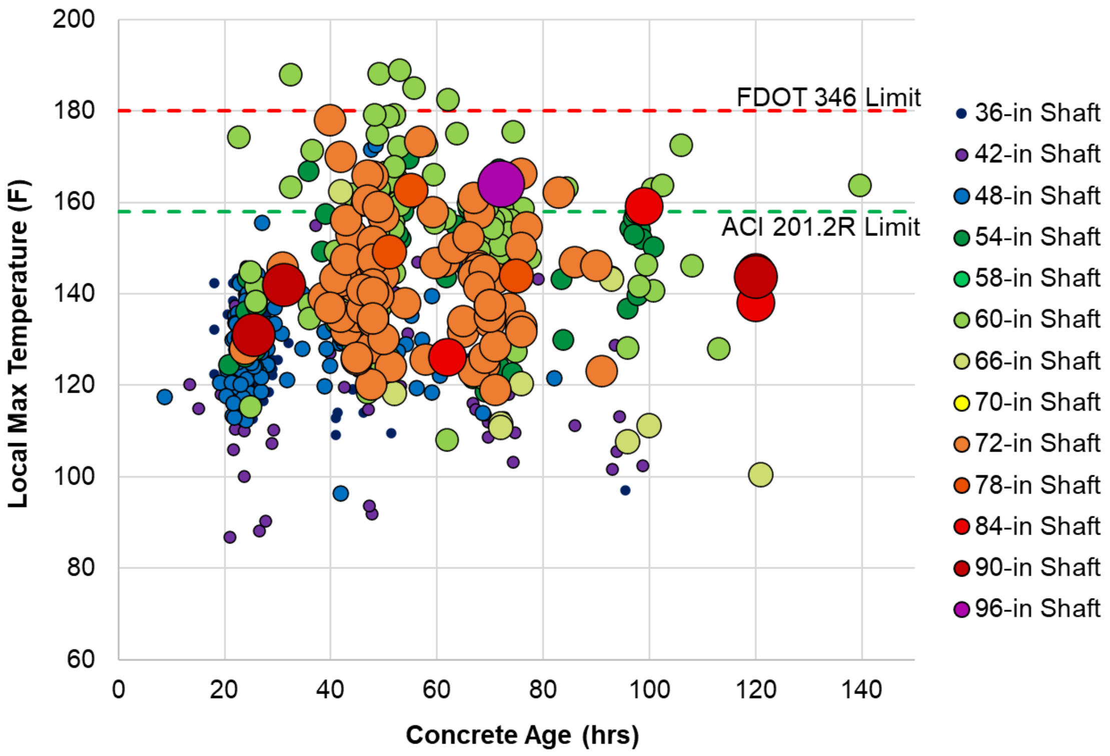


Figure 2.2 Plot presenting maximum cage temperature vs concrete age.

[This figure shows 662 data points where the local maximum temperature and concrete age are sorted by shaft diameter. A violet to red color spectrum is used to identify the shaft size in the field of data points where red represents larger shafts and violet represents smaller shafts. It shows a general trend of increasing temperature up to 24 - 48 hours, then a subtle reduction thereafter.]

In a similar format to Figure 2.2, average shaft temperatures at the cage were plotted against concrete age at time of testing (Figure 2.3). This is the average of the average between all tubes or wires (depending on method of testing).

Lastly, peak average temperatures at the cage were plotted against concrete age at time of testing (Figure 2.4).

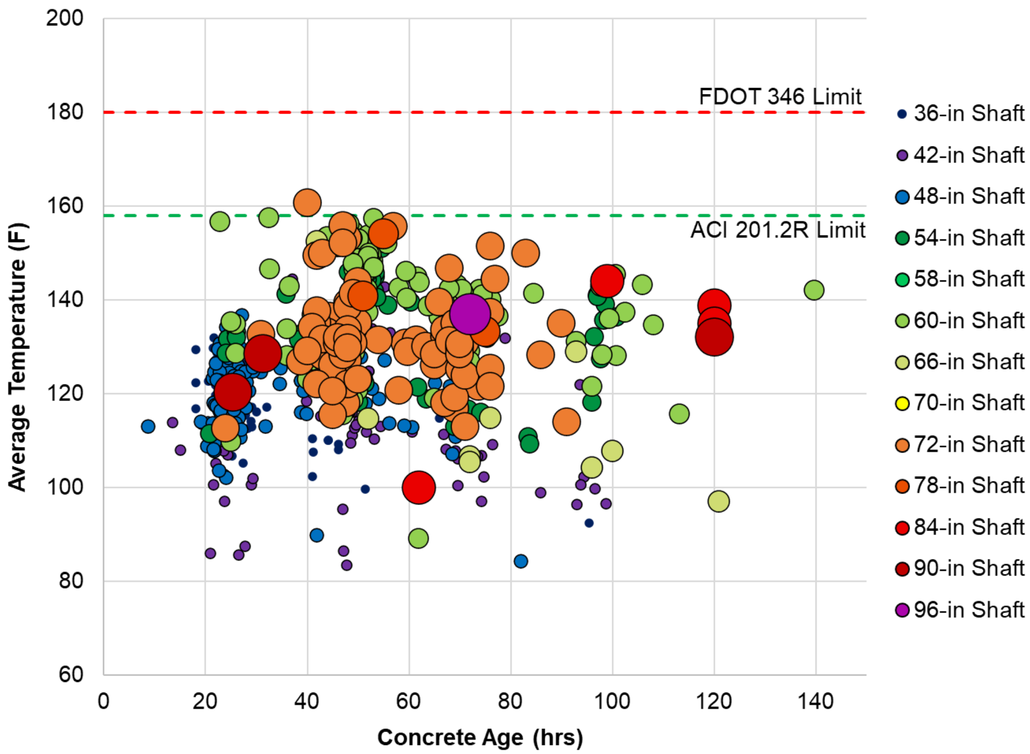


Figure 2.3 Plot presenting average temperature vs concrete age.

[This figure shows 662 data points where the average temperature and concrete age are sorted by shaft diameter. A violet to red color spectrum is used to identify the shaft size in the field of data points where red represents larger shafts and violet represents smaller shafts.]

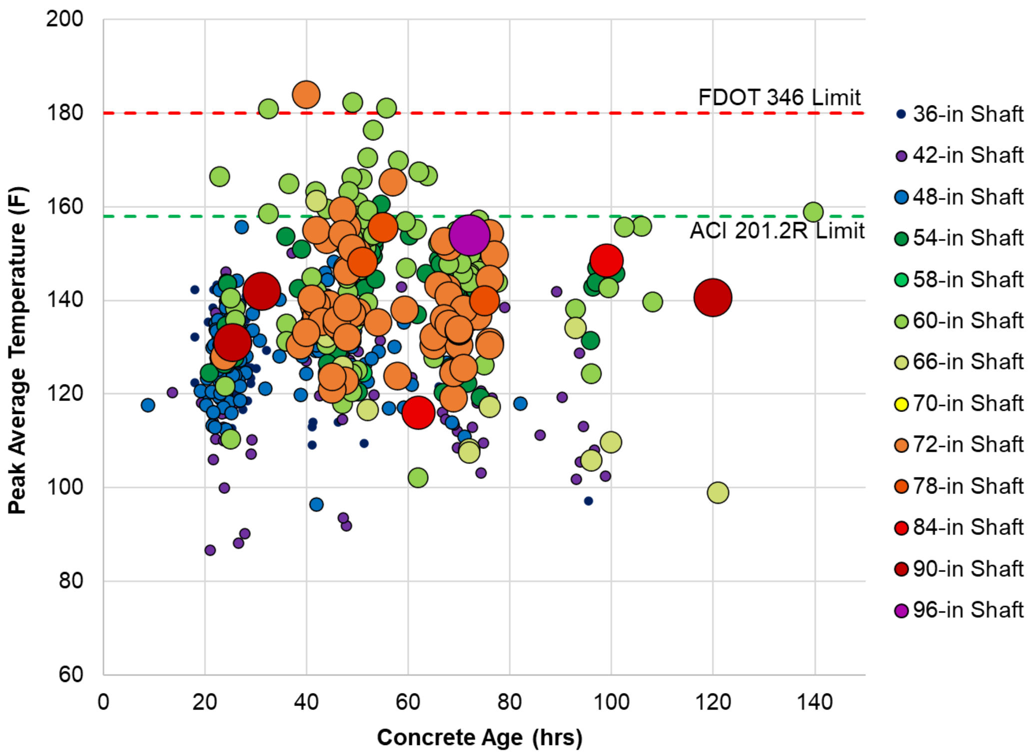


Figure 2.4 Plot presenting peak average temperature vs concrete age.

[This figure shows 662 data points where the peak average temperature and concrete age are sorted by shaft diameter. A violet to red color spectrum is used to identify the shaft size in the field of data points where red represents larger shafts and violet represents smaller shafts.]

Chapter Three: Collection of New Data

This chapter discusses the collection of new temperature data and associated field documentation from newly constructed cast-in-place concrete foundation elements. Six sites were investigated using internal temperature schemes: four project sites were FDOT shaft sites coordinated/provided by district engineers and/or consultants working for FDOT, one site was at the University of South Florida Tampa Campus, and the last was a cell tower foundation. The following is a list of these projects:

1. Judy Genshaft Honors College (University of South Florida) in Tampa, Florida.
2. Polk Parkway Drilled Shaft OC-13 in Auburndale, Florida.
3. I-4 Drilled Shaft OC-19 in Polk City, Florida.
4. I-395, SR 836, and I-95 Intersection in Miami, Florida.
5. N. Florida & Sinclair Hills Drilled Shaft in Tampa, Florida.
6. US 17 Drilled Shaft 1-4 in Bartow, Florida.

3.1 Judy Genshaft Honors College Drilled Shaft DS-6, Tampa, Florida

Drilled shaft DS-6 was constructed by R.W. Harris, Inc. on April 9, 2021, as part of the Judy Genshaft Honors College project located on the University of South Florida (USF) campus in Tampa, Florida (Figure 4.1). This drilled shaft was designed to be 42 inches in diameter, 82 feet long, and was cast with a full-length temporary casing (no slurry was used).

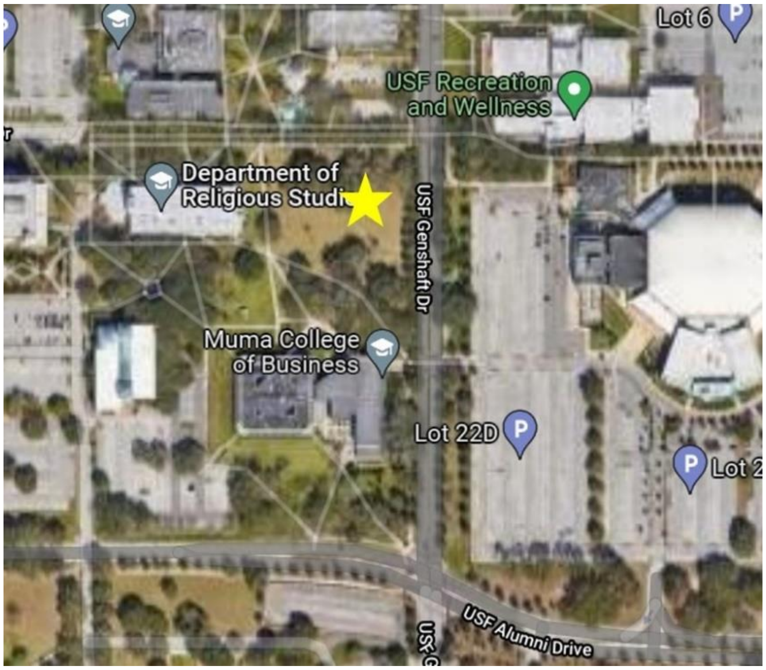


Figure 3.1 Satellite imagery illustrating the general location of DS-6.

[Figure 3.1 Detailed Description: This is a photo of satellite imagery illustrating the general location of drilled shaft DS-6, which is denoted by a yellow star. The main cross streets are USF Genshaft Drive and USF Alumni Drive on the USF Tampa Campus. DS-6 is located in the northwest quadrant just north of the Muma College of Business.]

Testing began on April 9, 2021, and concluded on April 12, 2021, during which the air temperature averaged approximately 72°F. The concrete mix design is provided in Table 3.1 with the complete concrete mix design submittal document included in Appendix A.

Table 3.1 DS-6 concrete mix proportions

Material	**Amount**
Cement	275 lb
Slag	425 lb
Coarse Aggregate	1,450 lb
Fine Aggregate	1,362 lb
Water	275 lb
Admixture (Air Entrainer)	0.5 oz/cy
Admixture (Stabilizer)	2.00 to 10.00 oz/cwt
Admixture (Water Reducer)	2.00 to 10.00 oz/cwt
Shaft Diameter	42 in.
Cementitious Material	700 lb/yd^3
Slag Percentage	60.7%
w/cm Ratio	0.39

3.1.1 Instrumentation

Instrumentation included the following sensor and data collection components: TIP^{TM} Thermal Wire and Thermal Acquisition Ports (TAP), both manufactured by Pile Dynamics, Inc. The thermal wires used included digital thermal sensors positioned every 12 inches along the length of the wire. Using a combination of plastic wire ties and PEX tie wire, four 90-foot thermal wires were installed along the length of the reinforcement cage and positioned roughly 90 degrees apart around the circumference of the cage (Figure 3.2). An additional center thermal wire, 25 feet in length, was installed along an additional rebar positioned and secured using rebar cross bracing at the center of the reinforcement cage (Figure 3.3) located at the top 25 feet of the drilled shaft. Figure 3.4 shows the fully instrumented reinforcement cage ready to be placed before concreting. The thermal wire connector ends and above-concrete sensors were bundled and protected using heavy duty plastic bags tightly wrapped in all-weather duct tape to ensure they remained clean during concrete placement. Once concrete placement was complete, the protective plastic was removed and TAP boxes were connected to each thermal wire (Figure 3.5). Each TAP was powered by a rechargeable battery and automatically sampled and recorded temperature measurement data provided the thermal wire was properly connected and was not damaged during construction. For purposes of this study, data was collected every 15 minutes.

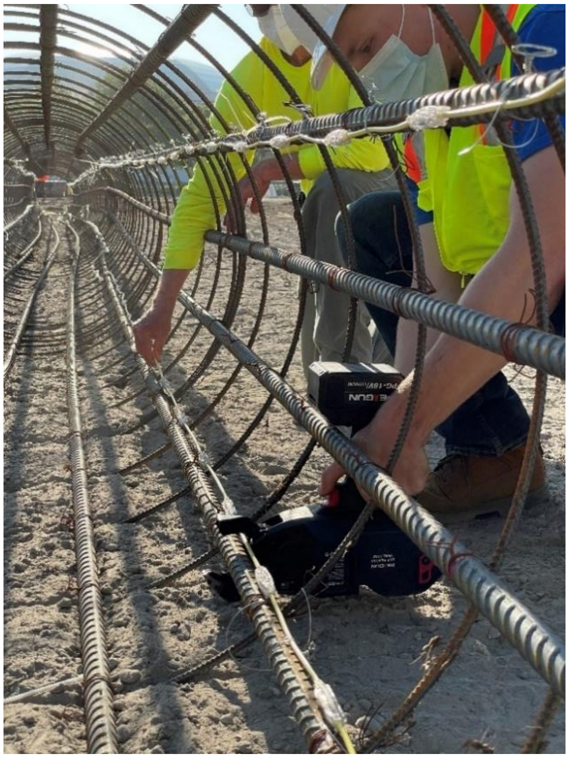


Figure 3.2 Installation of thermal wires along the length of the DS-6 reinforcement cage. *[This is a photo taken from inside the DS-6 reinforcement cage showing a completely installed thermal wire at the top right and an in process thermal wire installation at the bottom right.]*

Figure 3.3 Installation of center wire along additional center rebar.

[Figure 3.3 Detailed Description: This is a photo taken from inside the DS-6 reinforcement cage showing the in-process installation of the center thermal wire. Center rebar cross bracing and a 25-foot center rebar have already been installed.]

Figure 3.4 Fully instrumented DS-6 reinforcement cage ready to be placed for concrete casting.

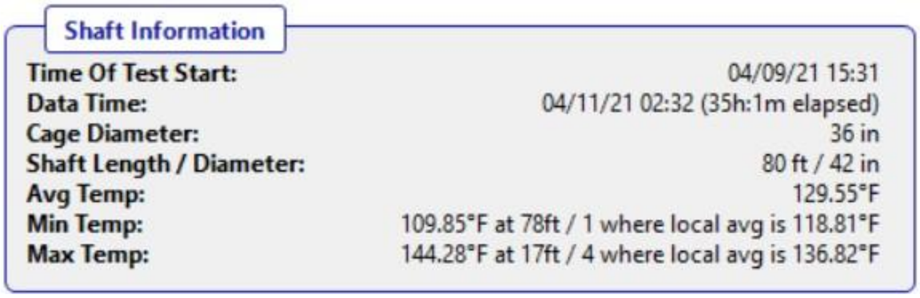
[This is a photo of the DS-6 reinforcement cage laying on its side showing the full cage length and diameter taken from the top of the cage. All cage thermal wires and center thermal wire have been installed, and all above-concrete sensors and wire connector ends have been bundled and secured in heavy-duty plastic bags and Gorilla tape. The cage is staged for auger location placement and concrete casting.]

Figure 3.5 Connection of the Thermal Acquisition Port boxes after concrete placement.
[This is a photo of DS-6 after concrete placement with approximately five feet of rebar stick-up illustrating the connection of Thermal Acquisition Port boxes to the thermal wires to begin data collection.]

3.1.2 Collected Data

Temperature measurement data from the installed thermal wires, environmental conditions during construction, concrete mix design, and mill certificates associated with drilled shaft DS-6 were collected and cataloged. Data was collected from April 9th through the 12th, 2021.

General information pertaining to the test shaft is presented in Figure 3.6 from the TIP Reported software. This includes the time at which data collection started, elapsed data time, drilled shaft diameter, reinforcement cage diameter, drilled shaft length, average temperature, and local minimum and maximum temperatures. This information is typically used in the assessment of the shaft integrity, size and shape, and cage concentricity. For this study, this information was used to correlate such parameters with peak and differential temperature measurements. Elapsed data time is a feature of thermal testing via wire method as data is collected every 15 minutes, which allows for a time/temperature trace for each sensor.



Time Of Test Start: 04/09/21 15:31
Data Time: 04/11/21 02:32 (35h:1m elapsed)
Cage Diameter: 36 in
Shaft Length / Diameter: 80 ft / 42 in
Avg Temp: 129.55°F
Min Temp: 109.85°F at 78ft / 1 where local avg is 118.81°F
Max Temp: 144.28°F at 17ft / 4 where local avg is 136.82°F

Figure 3.6 DS-6 Temperature Analysis Shaft Information (4/11/21 0232hrs).

[This is a screenshot displaying temperature analysis shaft information from the TIP Reporter software. The information shown is: time of test start at 4/9/21 1531hrs, data time at 4/11/21 0232hrs, cage diameter of 36 inches, shaft length/diameter of 80 feet/42 inches, average temperature of 129.55ºF, minimum temperature of 109.85ºF at 78 feet (wire 1) where local average is 118.81ºF, and maximum temperature is 144.28ºF at 17 feet (wire 4) where local average is 136.82ºF.]

Figure 3.7 shows all temperature data versus depth for DS-6 recorded 35 hours after casting. This is when peak average cage temperature occurred, where average refers to the average temperature of all four thermal wires located at the reinforcement cage. The average temperature profile is given as the bold black line marker also denoted as "AVG" in the plot legend. The location of peak average cage temperature is marked at 39 feet where the local peak average temperature was 141.1°F. This depth location was used to plot the temperature evolution over time for the entire data collection duration (Figure 3.8).

In addition to the cage wire data, the center wire data versus depth is also presented in Figure 3.9. This plot presents two data series: the peak temperatures for each individual sensor which occurred at varied times (denoted as "Max"), and center wire measurements recorded 30.3 hours into testing when the peak temperature of any sensor was recorded. This occurred at a depth of 16 feet with the maximum temperature measuring 161.26°F. Again, data from this depth was used to plot the temperature evolution at that depth over time for the entire testing duration (Figure 3.10).

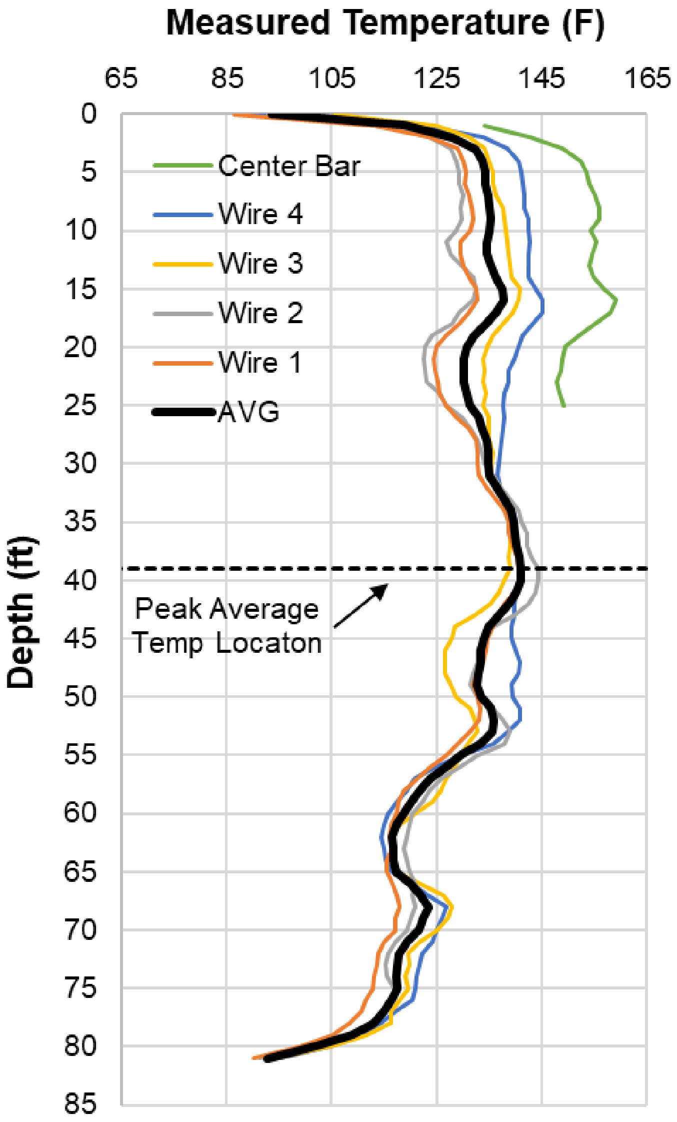


Figure 3.7 Plot presenting DS-6 cage temperature versus depth data at peak average cage temperature (35 hours into testing).

[This is a plot presenting temperature data on the x-axis versus depth data on the y-axis and includes temperature measurements from all four thermal wires installed at the reinforcement cage as well as the thermal wire installed along a center rebar. The depth reaches just past 80 feet, and temperature measurements range from approximately 90°F to 160°F. There is also an annotation noting the peak average cage temperature of the shaft located at 39 feet measuring 141.1°F.]

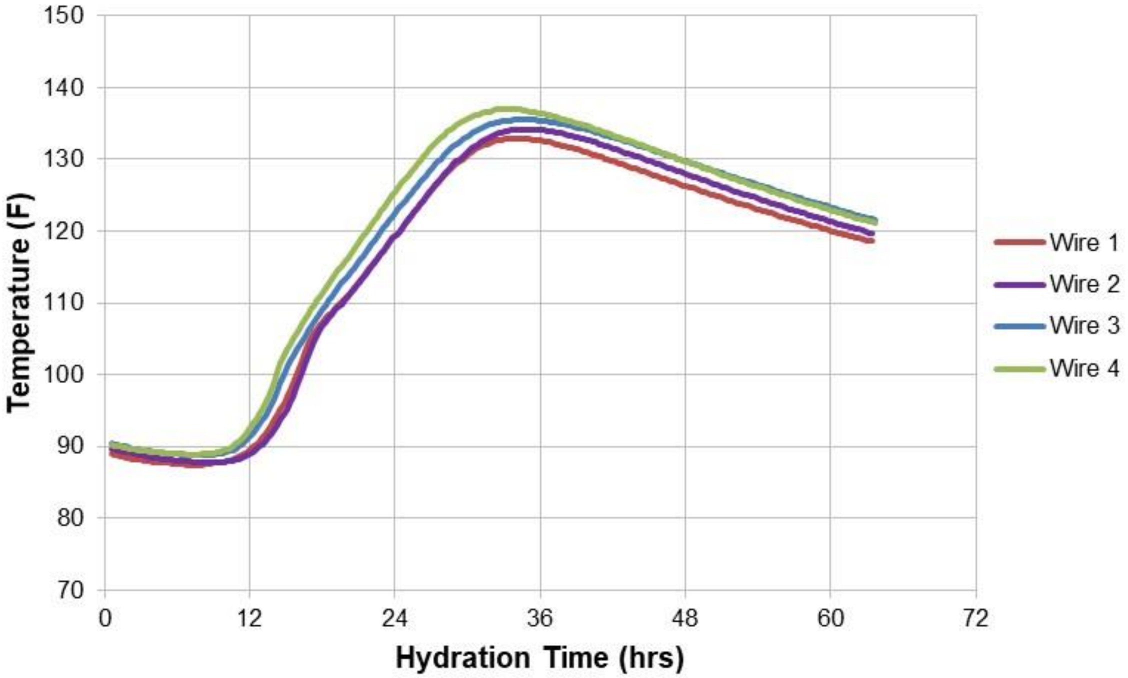


Figure 3.8 Plot presenting DS-6 temperature versus time data at a depth of 39 feet, where peak average cage temperature occurred (35 hours into testing).

[This is a plot presenting temperature data on the y-axis versus time on the x-axis at a depth of 40 feet and includes temperature measurements from all four thermal wires installed at the reinforcement cage. The time ranges from 0 hours to 63 hours, and the temperature measurements range from approximately 90ºF to 138ºF.]

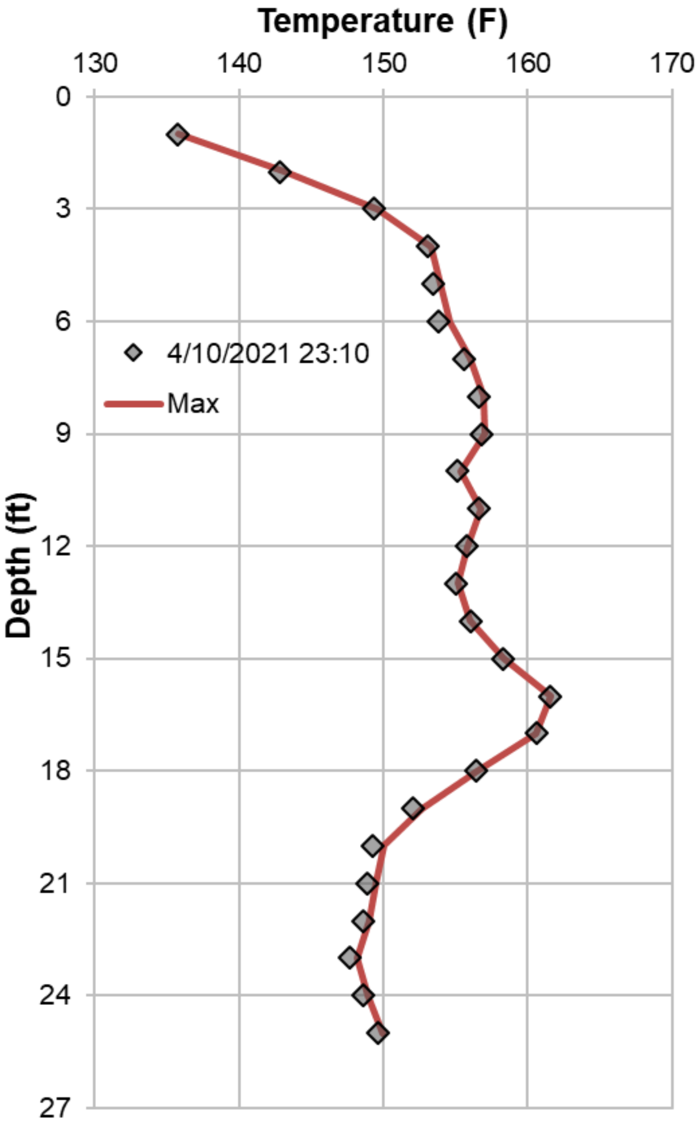


Figure 3.9 Plot presenting DS-6 center wire temperature versus depth data at the time of peak temperature of the center wire (30 hours into testing).

[This is a plot presenting center wire temperature data on the x-axis versus depth data on the y-axis. The depth reaches 25 feet, and temperature measurements range from approximately 135ºF to 161ºF.]

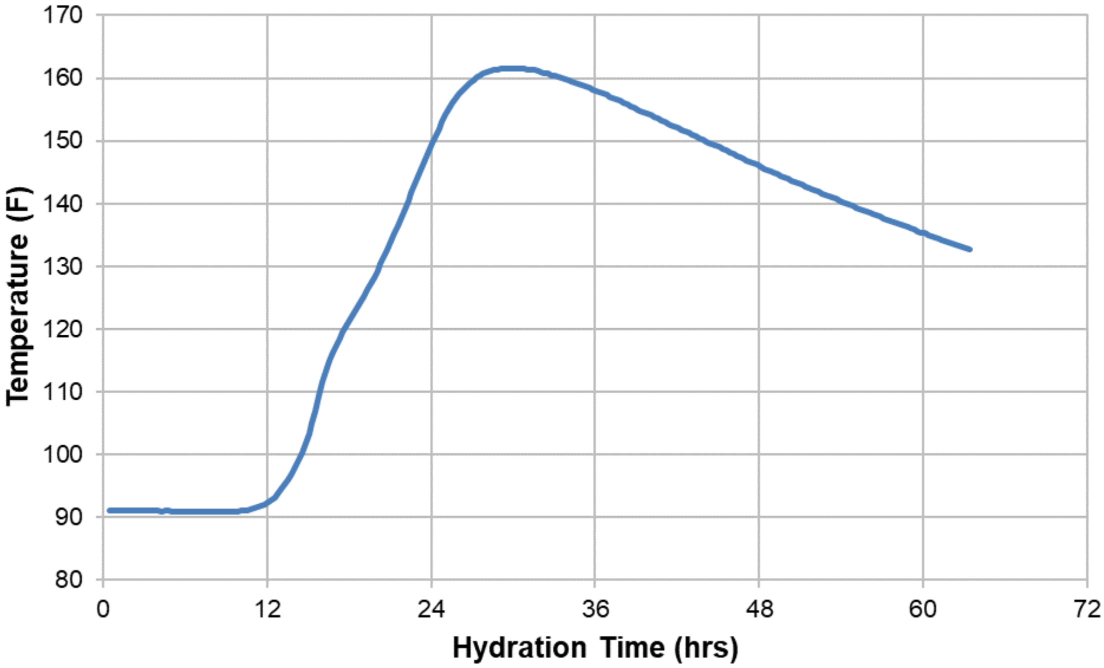


Figure 3.10 Plot presenting DS-6 center wire temperature versus time data at a depth of 16 feet, where peak center wire temperature occurred.

[This is a plot presenting temperature data on the y-axis versus time on the x-axis at a depth of 40 feet and includes temperature measurements from the center thermal wire. The time ranges from 0 hours to 63 hours, and the temperature measurements range from approximately 90ºF to 161ºF.]

Figure 3.11 presents the radius versus depth profile for DS-6. This plot also includes concrete cover results based on the location of the reinforcement cage. The Radius Analysis Shaft Information table from the TIP Reporter software is shown in Figure 3.12. Rather than average, minimum, and maximum temperature information, this provides average, minimum, and maximum shaft radius information.

The last results plot generated by TIP Reporter is a 3D radius view of the shaft. This plot is interactive and can be rotated within the software. Due to the static nature of the figures in this report, however, Figure 3.13 provides a view of the general shaft shape. It should be noted that this figure is not to scale, and the vertical dimensions do not correspond to the lateral dimension.

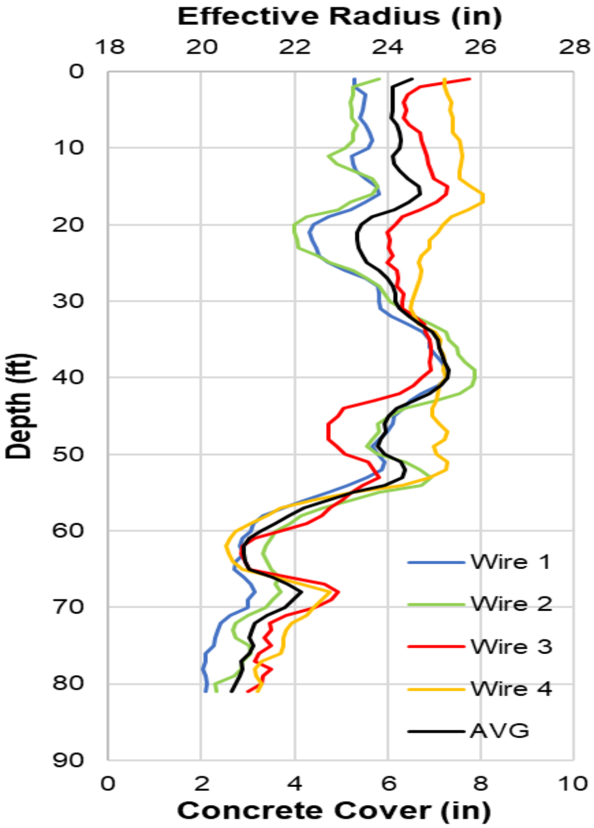
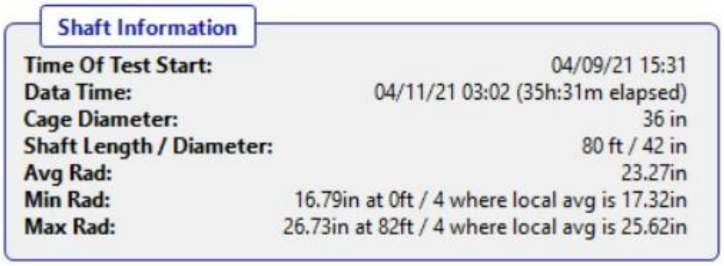


Figure 3.11 Plot presenting DS-6 radius versus depth data.

[This is a plot presenting radius and concrete cover data on the x-axis versus depth data on the y-axis and includes radius values for the locations of all four thermal wires installed at the reinforcement cage. The depth reaches just over 80 feet, and radius values range from approximately 22 to 26 inches. Concrete cover values range from approximately 2 to 8 inches.]



Shaft Information

Time Of Test Start:	04/09/21 15:31
Data Time:	04/11/21 03:02 (35h:31m elapsed)
Cage Diameter:	36 in
Shaft Length / Diameter:	80 ft / 42 in
Avg Rad:	23.27in
Min Rad:	16.79in at 0ft / 4 where local avg is 17.32in
Max Rad:	26.73in at 82ft / 4 where local avg is 25.62in

Figure 3.12 DS-6 Radius Analysis Shaft Information.

[This is a screenshot displaying radius analysis shaft information from the TIP Reporter software. The information shown is: time of test start at 4/9/21 1531hrs, data time at 4/11/21 0302hrs, cage diameter of 36 inches, shaft length/diameter of 80 feet/42 inches, average radius of 23.27 inches, minimum radius of 16.79 inches at 0 feet (wire 4) where local average is 17.32 inches, and maximum radius of 26.73 inches at 82 feet (wire 4) where local average is 25.62 inches.]

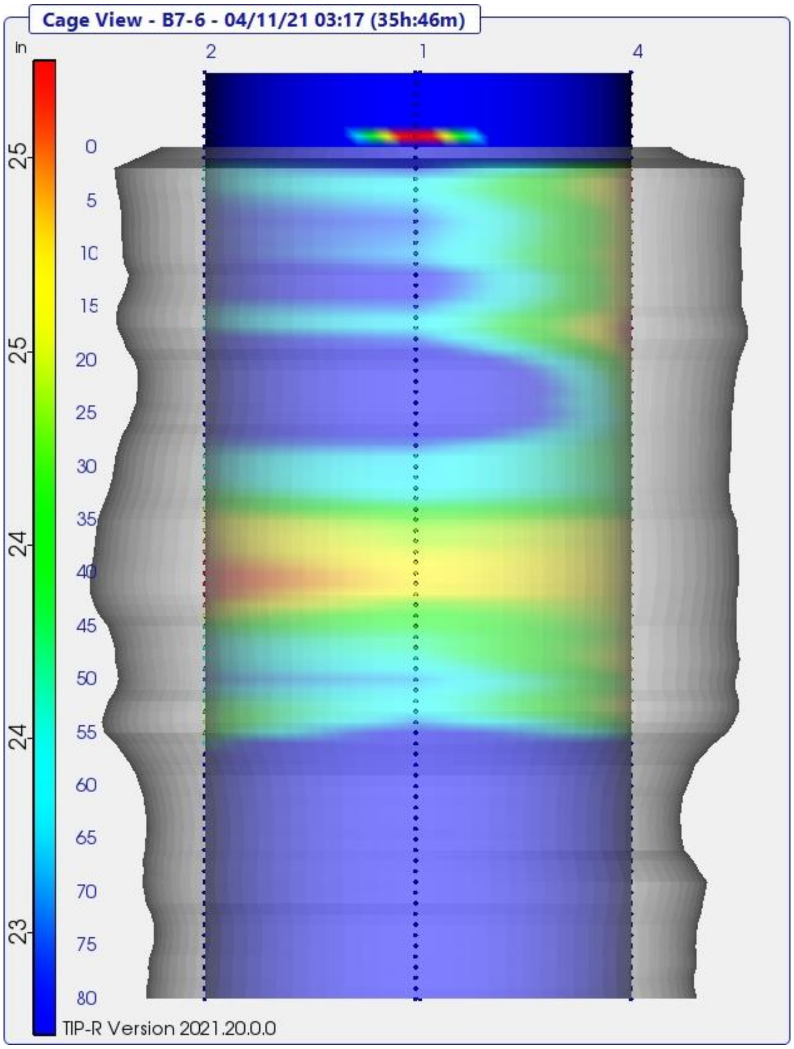


Figure 3.13 DS-6 3D radius view.

[Figure 3.13 Detailed Description: This is a plot generated by TIP reporter showing 3D radius view of DS-6. It can be seen that the general shape of the drilled shaft is not symmetrical with varying concrete cover.]

3.2 Polk Parkway Drilled Shaft OC-13, Auburndale, Florida

Drilled shaft OC-13 was constructed by Conti Corporation on November 4, 2021, on the north side of US 92 just east of the Polk Parkway in Auburndale, Florida (Figure 3.14). This drilled shaft had a design diameter of 72 inches, length of 44 feet and was cast with a full-length, 84-inch diameter temporary casing.

Figure 3.14 Satellite imagery illustrating the general location of OC-13.

[This is a photo of satellite imagery illustrating the general location of drilled shaft OC-13, which is denoted by a yellow star. The main crossroads are State Road 570 (Polk Parkway) and US 92 in Auburndale, Florida. OC-13 is located in the northeast quadrant on the north should of US 92 just east of the exit off the Polk Parkway.]

Testing began on November 4, 2021, and concluded on November 8, 2021, during which the air temperature averaged approximately 66°F. The concrete mix proportions from each truck ticket are provided in Tables 3.2 through 3.10. Interestingly, these tables show similarities in the first 7 trucks with w/c ratios of 0.38-0.39 but the last two trucks with about half the volume of the first trucks reported w/c ratio of 0.28. It is unclear if these trucks were excepted with slump testing or further Q/C. Copies of the delivery tickets are provided in Appendix B.

Table 3.2 OC-13 truck #1 (9 cubic yards) concrete mix proportions.

Material	**Amount**
Cement	2,375 lb (263.89 lb/yd^3)
Slag	3,540 lb (393.33 lb/yd^3)
Coarse Aggregate (2% moisture)	14,440 lb (1,604.44 lb/yd^3)
Fine Aggregate (4.2% moisture)	12,040 lb (1,337.78 lb/yd^3)
Batch Water	1,516 lb (168.44 lb/yd^3)
Admixture (Air)	6 oz.
Admixture (Water Reducer #1)	621 oz.
Admixture (Water Reducer #2)	207 oz.
Cementitious Material	687.22 lb/yd^3
Slag Percentage	60%
w/cm Ratio	0.39

Table 3.3 OC-13 truck #2 (9 cubic yards) concrete mix proportions.

Material	**Amount**
Cement	2,370 lb (263.33 lb/yd^3)
Slag	3,550 lb (394.44 lb/yd^3)
Coarse Aggregate (2% moisture)	14,560 lb (1,617.78 lb/yd^3)
Fine Aggregate (4.2% moisture)	11,960 lb (1,328.89 lb/yd^3)
Batch Water	1,441 lb (160.11 lb/yd^3)
Admixture (Air)	7 oz.
Admixture (Water Reducer #1)	621 oz.
Admixture (Water Reducer #2)	207 oz.
Cementitious Material	657.78 lb/yd^3
Slag Percentage	60%
w/cm Ratio	0.38

Table 3.4 OC-13 truck #3 (9 cubic yards) concrete mix proportions.

Material	Amount
Cement	2,375 lb (236.89 lb/yd^3)
Slag	3,535 lb (392.78 lb/yd^3)
Coarse Aggregate (2% moisture)	14,440 lb (1,604.44 lb/yd^3)
Fine Aggregate (4.2% moisture)	12,000 lb (1,333.33 lb/yd^3)
Batch Water	1,441 lb (160.11 lb/yd^3)
Admixture (Air)	6 oz.
Admixture (Water Reducer #1)	621 oz.
Admixture (Water Reducer #2)	207 oz.
Cementitious Material	656.67 lb/yd^3
Slag Percentage	60%
w/cm Ratio	0.38

Table 3.5 OC-13 truck #4 (9 cubic yards) concrete mix proportions.

Material	Amount
Cement	2,385 lb (265 lb/yd^3)
Slag	3,550 lb (394.44 lb/yd^3)
Coarse Aggregate (2% moisture)	14,460 lb (1,606.67 lb/yd^3)
Fine Aggregate (4.2% moisture)	12,080 lb (1,342.22 lb/yd^3)
Batch Water	1,441 lb (160.11 lb/yd^3)
Admixture (Air)	6 oz.
Admixture (Water Reducer #1)	621 oz.
Admixture (Water Reducer #2)	207 oz.
Cementitious Material	659.44 lb/yd^3
Slag Percentage	60%
w/cm Ratio	0.38

Table 3.6 OC-13 truck #5 (9 cubic yards) concrete mix proportions.

Material	**Amount**
Cement	2,385 lb (265.00 lb/yd^3)
Slag	3,525 lb (391.67 lb/yd^3)
Coarse Aggregate (2% moisture)	14,200 lb (1,577.78 lb/yd^3)
Fine Aggregate (4.2% moisture)	12,080 lb (1,342.22 lb/yd^3)
Batch Water	1,441 lb (160.11 lb/yd^3)
Admixture (Air)	6 oz.
Admixture (Water Reducer #1)	621 oz.
Admixture (Water Reducer #2)	210 oz.
Cementitious Material	656.67 lb/yd^3
Slag Percentage	60%
w/cm Ratio	0.38

Table 3.7 OC-13 truck #6 (9 cubic yards) concrete mix proportions.

Material	**Amount**
Cement	2,385 lb (265.00 lb/yd^3)
Slag	3,525 lb (391.67 lb/yd^3)
Coarse Aggregate (2% moisture)	14,260 lb (1,584.44 lb/yd^3)
Fine Aggregate (4.2% moisture)	12,140 lb (1,348.89 lb/yd^3)
Batch Water	1,441 lb (160.11 lb/yd^3)
Admixture (Air)	5 oz.
Admixture (Water Reducer #1)	621 oz.
Admixture (Water Reducer #2)	210 oz.
Cementitious Material	656.67 lb/yd^3
Slag Percentage	60%
w/cm Ratio	0.38

Table 3.8 OC-13 truck #7 (8 cubic yards) concrete mix proportions.

Material	**Amount**
Cement	2,105 lb (263.13 lb/yd^3)
Slag	3,140 lb (392.50 lb/yd^3)
Coarse Aggregate (2% moisture)	12,900 lb (1,612.50 lb/yd^3)
Fine Aggregate (4.2% moisture)	10,640 lb (1,330.00 lb/yd^3)
Batch Water	1,282 lb (160.25 lb/yd^3)
Admixture (Air)	6 oz.
Admixture (Water Reducer #1)	555 oz.
Admixture (Water Reducer #2)	183 oz.
Cementitious Material	655.63 lb/yd^3
Slag Percentage	60%
w/cm Ratio	0.38

Table 3.9 OC-13 truck #8 (4 cubic yards) concrete mix proportions.

Material	**Amount**
Cement	1,055 lb (263.75 lb/yd^3)
Slag	1,560 lb (390.00 lb/yd^3)
Coarse Aggregate (2% moisture)	6,460 lb (1,615.00 lb/yd^3)
Fine Aggregate (4.2% moisture)	5,320 lb (1,330.00 lb/yd^3)
Batch Water	391 lb (97.75 lb/yd^3)
Admixture (Air)	3 oz.
Admixture (Water Reducer #1)	276 oz.
Admixture (Water Reducer #2)	93 oz.
Cementitious Material	653.75 lb/yd^3
Slag Percentage	60%
w/cm Ratio	0.28

Table 3.10 OC-13 truck #9 (6 cubic yards) concrete mix proportions.

Material	**Amount**
Cement	1,580 lb (263.33 lb/yd^3)
Slag	2,360 lb (393.33 lb/yd^3)
Coarse Aggregate (2% moisture)	9,660 lb (1,610.00 lb/yd^3)
Fine Aggregate (4.2% moisture)	8,000 lb (1,333.33 lb/yd^3)
Batch Water	583 lb (97.17 lb/yd^3)
Admixture (Air)	4 oz.
Admixture (Water Reducer #1)	414 oz.
Admixture (Water Reducer #2)	138 oz.
Cementitious Material	656.67 lb/yd^3
Slag Percentage	60%
w/cm Ratio	0.28

3.2.1 Instrumentation

Similar to DS-6, instrumentation of OC-13 included the following sensor and data collection components: TIP^{TM} Thermal Wire and Thermal Acquisition Ports (TAP). Using a combination of plastic wire ties and PEX tie wire, four 50-foot thermal wires were installed along the length of the reinforcement cage and positioned roughly 90 degrees apart around the cage circumference (Figure 3.15). An additional center thermal wire, 25 feet in length, was installed along a 10-foot rebar positioned and secured using rebar cross bracing at the center of the reinforcement cage (Figures 3.16 and 3.17) extending 6.5 to 16.5 feet below the top of the drilled shaft. The length of the center rebar made use of the first 10 out of 25 available sensors along the center thermal wire. The remaining 15 sensors were positioned across the shaft diameter and secured to the center rebar cross bracing (Figure 3.18). These remaining sensors allowed temperature data to be collected along three cross bracing legs to give the radial temperature distribution. Figure 3.19 shows the fully instrumented reinforcement cage ready to be placed in the excavation. The thermal wire connector ends and above-concrete sensors were bundled and protected using heavy duty plastic bags tightly wrapped with all-weather duct tape to ensure they remained clean during concrete placement. Figure 3.20 shows the fully instrumented reinforcement cage placed in the excavation prior to concreting. Once concrete placement was complete, the protective plastic was removed, and TAP boxes were connected to each thermal wire (Figure 3.21).

Figure 3.15 Installation of thermal wires along the length of the OC-13 reinforcement cage.

[This is a photo taken from the top of the OC-13 reinforcement cage showing installed cage thermal wires positioned roughly 90 degrees apart radially.]

Figure 3.16 Installation of the center rebar cross bracing for drilled shaft OC-13.

[This is a photo taken from inside the OC-13 reinforcement cage showing a graduate student securing the cross bracing that will be used to secure the center rebar for the center thermal wire.]

Figure 3.17 Installation of center thermal wire in OC-13 reinforcement cage.

[This is a photo taken showing the inside of the OC-13 reinforcement cage where several graduate students are installing the center thermal wire along the 10-foot center rebar.]

Figure 3.18 Installation of the bottom 15 sensors of the center thermal wire in an across-shaft configuration along the bottom rebar cross bracing in OC-13 reinforcement cage.

[Figure 3.18 Detailed Description: This is two side-by-side photos taken inside the OC-13 reinforcement cage showing a graduate student installing the bottom 15 sensors of the center thermal wire. The left photo shows a graduate student securing the wire to the bottom rebar cross bracing with a PEX rebar tie gun. The right photo shows a graduate student taking measurements between each sensor after installation.]

Figure 3.19 Fully instrumented OC-13 reinforcement cage ready to be placed for concrete casting. *[This is a photo taken from outside the top of the OC-13 reinforcement cage. All cage thermal wires and center thermal wire have been installed, and all above-concrete sensors and wire connector ends have been bundled and secured in heavy-duty plastic bags and Gorilla tape.]*

Figure 3.20 Fully instrumented OC-13 reinforcement cage placed in the augered location prior to concrete placement.

[This is a photo of the open excavation of OC-13 with the installed full-length temporary casing prior to concrete placement.]

Figure 3.21 Two out of five total OC-13 TAP boxes connected to their respective thermal wires.

[This is a photo of two TAP boxes hanging from the top stirrup of the OC-13 reinforcement cage and connected to their respective thermal wires after concrete placement. The front of one of the TAP boxes is visible showing an illuminated green light indicating successful connection.]

3.2.2 Collected Data

Temperature measurement data from the installed thermal wires, environmental conditions during construction, FDOT drilled shaft log, concrete mix design, and mill certificates associated with drilled shaft OC-13 were collected and cataloged. Below are graphical presentations, generated in Excel, of particular, relevant portions of the data collected from November 4th through the 8th, 2021. However full datasets are archived in both Excel and TIP Reporter formats. Upon data review, it was found that the center thermal wire for this study was unable to collect data after concrete placement. During construction, the rigid concrete pump line was observed to surge vertically during pumping. This led to the pump line coupler hitting the top center bar cross bracing and ultimately cause separation at the pump line coupling and damage to the thermal wire. Figure 3.22 shows the disconnected slick line just above the slurry level. OC-13 was also tested via the TIP probe method.

Figure 3.22 Tremie separation during OC-13 concrete placement.

[Figure 3.22 Detailed Description: This is a photo looking down into the augered location of OC-13. The hole is partially filled with concrete that is covered in slurry. In the upper left corner of the photo is the concrete pump line that is separated at one of the segment couplings.]

Table 3.11 below presents the software-reported Temperature Analysis Shaft Information for OC-13 based on the thermal probe data.

Table 3.11 OC-13 temperature analysis shaft information.

Drilled Shaft Diameter:	72 inches
Cage Diameter:	60 inches
Drilled Shaft Length:	41.5 feet
Average Temperature:	129.49°F
Local Minimum Temperature:	116.96°F at 18.6 feet on Tube 4
Local Maximum Temperature:	136.3°F at 24.4 feet on Tube 1

Figure 3.23 is a plot generated in TIP reporter presenting all temperature data at a depth of 27 feet over the entire testing time. This is the depth where peak average cage temperature occurred (based on the usable thermal wire data). Recall, this peak average is the average temperature of all four thermal wires located at the reinforcement cage and represents the temperature at the cage when centered within the concrete mass. When reviewing Figure 3.23, peak average cage temperature occurred late 11/5/21. Figure 3.24 shows the temperature profiles from probe data collected on 11/7, and shows the average probe temperature profile for that specific testing time and is given as the bold black line marker also denoted as “AVG” in the plot legend. Thermal wire data in this format was not available due to the previously mentioned sensor failures. These failures are shown in Figure 3.23 as sharp discontinuities where the recorded temperature falls off scale.

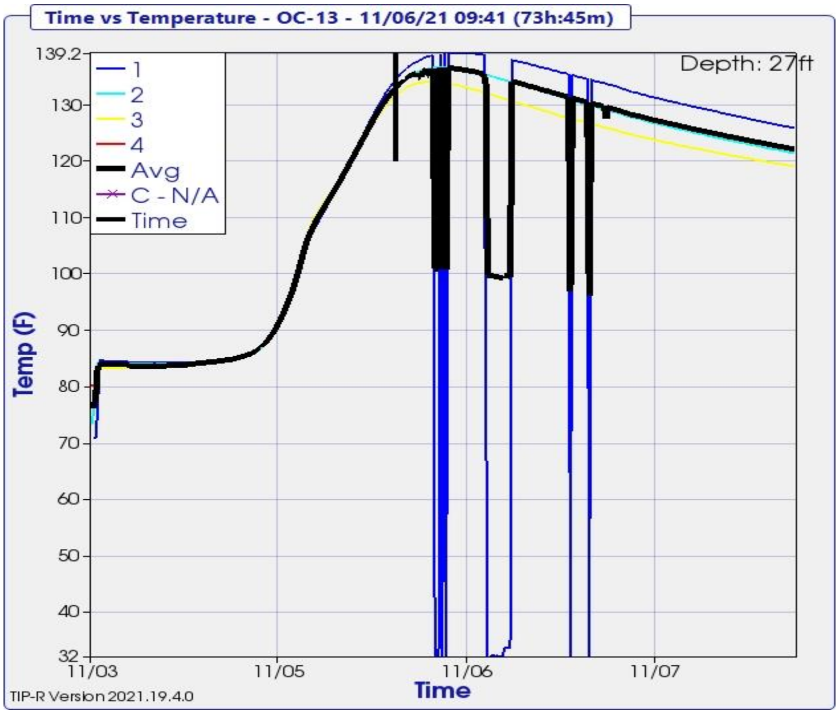


Figure 3.23 Plot presenting OC-13 temperature versus time thermal wire data at a depth of 27 feet, where peak average cage temperature occurred. Sensor failures are also present at this depth for wire #1.

[Figure 3.24 Detailed Description: This is a plot presenting wire temperature data on the y-axis versus time on the x-axis at a depth of 27 feet and includes temperature measurements from all four thermal wires installed at the reinforcement cage. This plot also illustrates the sensor failures that occurred and are shown as temperature data drops that drop well below the temperature evolution curve. The time ranges from 11/3/21 to 11/8/21, and the temperature measurements range from approximately 85ºF to 136ºF.]

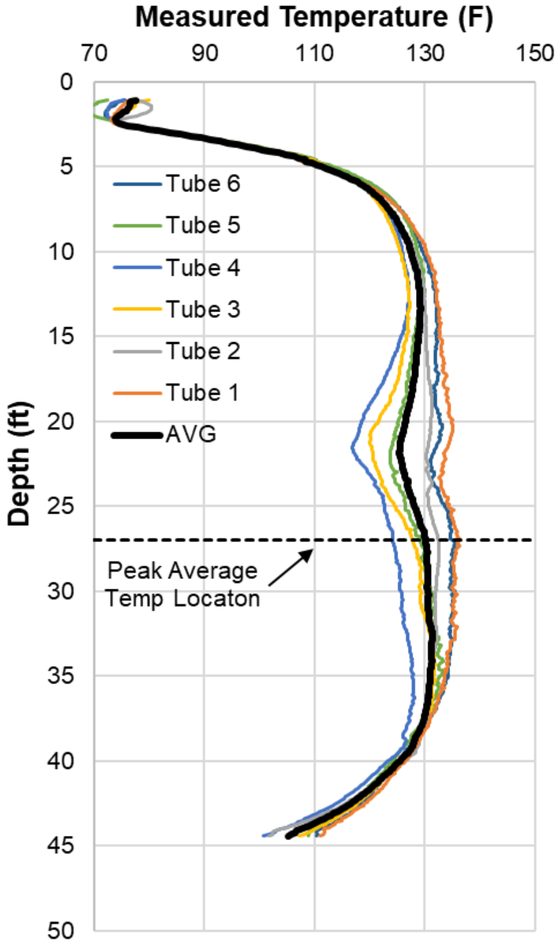


Figure 3.24 Plot presenting OC-13 temperature versus depth probe data.

[This is a plot presenting probe temperature data on the x-axis versus depth data on the y-axis and includes temperature measurements from all six access tubes installed at the reinforcement cage. The depth reaches 44 feet, and temperature measurements range from approximately 75ºF to 135ºF.]

Figure 3.25 presents the radius versus depth profile for OC-13 resulting from the collected probe data. This plot also includes concrete cover results based on the location of the reinforcement cage. Like the Temperature Analysis Shaft Information, the Radius Analysis Shaft Information is presented in Table 3.12 but summarizes the average, minimum, and maximum shaft radius information.

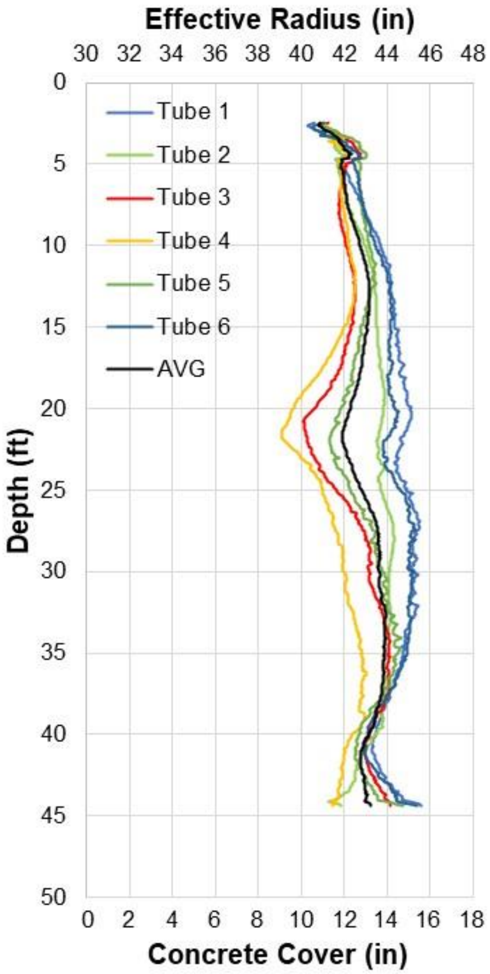


Figure 3.25 Plot presenting OC-13 radius versus depth probe data.

[This is a plot presenting radius and concrete cover data on the x-axis versus depth data on the y-axis and includes radius values for the locations of all six probe access tubes installed at the reinforcement cage. The depth reaches just past 42 feet, and radius values range from approximately 38 to 44 inches. Concrete cover values range from approximately 8 to 14 inches.]

Table 3.12 OC-13 radius analysis shaft information

Average Radius:	42.9 inches
Local Minimum Radius:	39.07 inches at 21.6 feet at Tube 4
Local Maximum Radius:	45.60 inches at 44.4 feet at Tube 1

The 3D radius view of the shaft is shown in Figure 3.26.

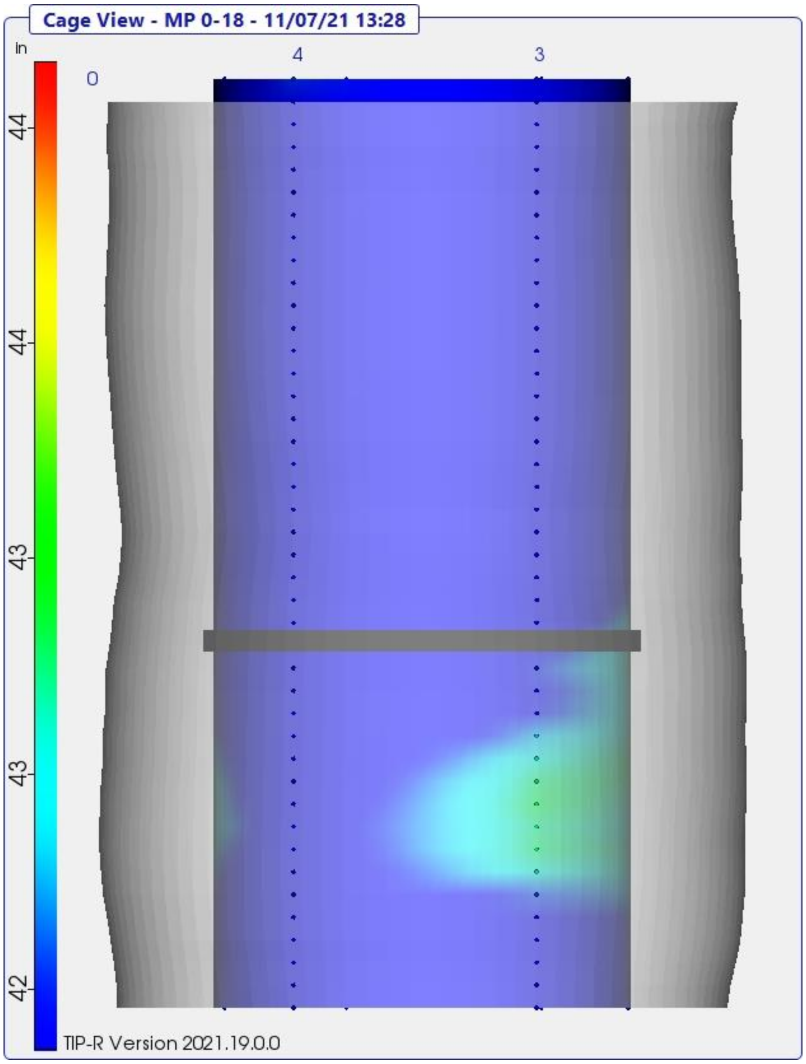


Figure 3.26 OC-13 3D radius view.

[This is a plot generated by TIP reporter showing 3D radius view of OC-13. It can be seen that the general shape of the drilled shaft is not symmetrical with varying concrete cover.]

3.3 I-4 Drilled Shaft OC-19, Polk City, Florida

Drilled shaft OC-19 was constructed by Conti Corporation on November 23, 2021, on the north side of I-4 just east of the Polk Parkway in Polk City, Florida (Figure 3.27). This drilled shaft had design diameter of 72 inches, length of 37 feet long, and was cast with a 10-foot long partial-length, 84-inch diameter temporary casing (Figure 3.28).

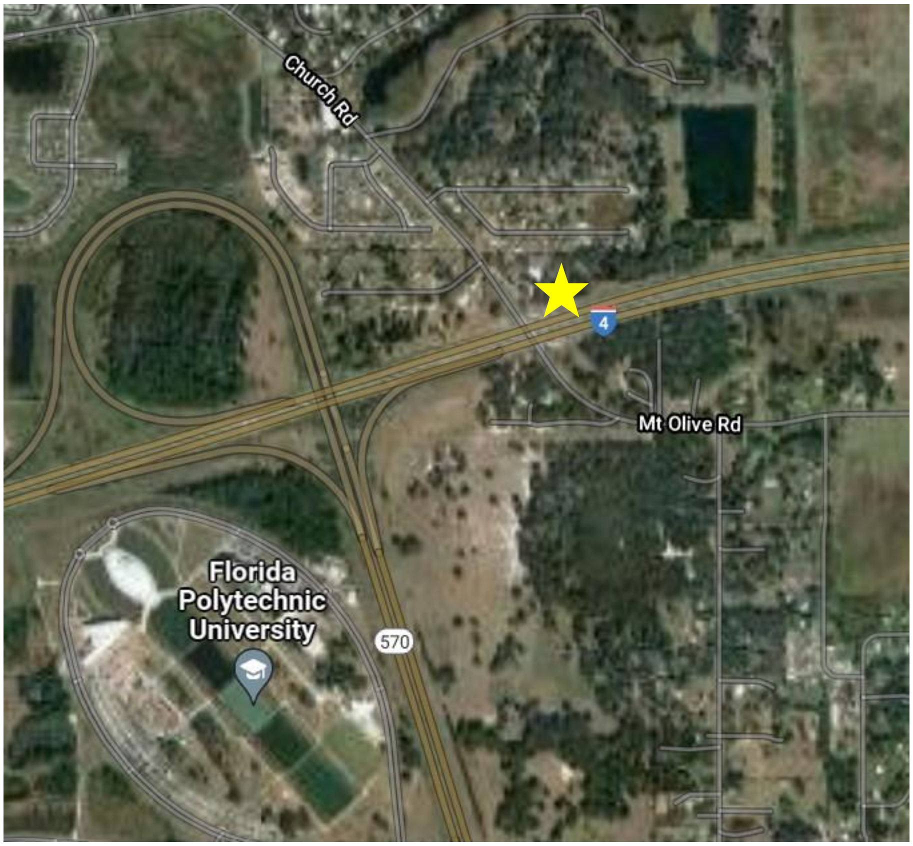


Figure 3.27 Satellite imagery illustrating the general location of OC-19.

[This is a photo of satellite imagery illustrating the general location of drilled shaft OC-19, which is denoted by a yellow star. The main crossroads are Church Road and I-4 in Polk City, Florida. OC-19 is located in the northeast quadrant on the north shoulder of I-4 westbound just east of Church Rd.]

Figure 3.28 Excavation of drilled shaft OC-19 with partial-length casing installed.

[This is a photo showing the construction location of drilled shaft OC-19. The location is still in the process of being augered with slurry flowing from a large hose line. The partial-length casing is already placed inside the augered portion.]

Testing began on November 23, 2021, and concluded on November 29, 2021, during which the air temperature averaged approximately 60°F. The concrete mix proportions for each truck are provided in Tables 3.13 through 3.18 with all original concrete delivery tickets included in Appendix C. The truck tickets confirm a more consistent concrete mix from all trucks where the w/c ratio only varied slightly from 0.39 to 0.4

Table 3.13 OC-19 truck #1 (9 cubic yards) concrete mix proportions.

Material	**Amount**
Cement	2,395 lb (266.11 lb/yd^3)
Slag	3,545 lb (393.89 lb/yd^3)
Coarse Aggregate (1.9% Moisture)	14,540 lb (1,615.56 lb/yd^3)
Fine Aggregate (3.9% Moisture)	11,900 lb (1,322.22 lb/yd^3)
Batch Water	1,599 lb (177.71 lb/yd^3)
Admixture (Air)	5 oz.
Admixture (Water Reducer #1)	531 oz.
Admixture (Water Reducer #2)	207 oz.
Cementitious Material	5940 lb (660.00 lb/yd^3)
Slag Percentage	60%
w/cm Ratio	0.39

Table 3.14 OC-19 truck #2 (9 cubic yards) concrete mix proportions.

Material	**Amount**
Cement	2,370 lb (263.33 lb/yd^3)
Slag	3,540 lb (393.33 lb/yd^3)
Coarse Aggregate (1.9% Moisture)	14,280 lb (1,586.67 lb/yd^3)
Fine Aggregate (3.9% Moisture)	11,940 lb (1,326.67 lb/yd^3)
Batch Water	1,599 lb (177.71 lb/yd^3)
Admixture (Air)	6 oz.
Admixture (Water Reducer #1)	534 oz.
Admixture (Water Reducer #2)	207 oz.
Cementitious Material	5910 lb (656.67 lb/yd^3)
Slag Percentage	60%
w/cm Ratio	0.40

Table 3.15 OC-19 truck #3 (9 cubic yards) concrete mix proportions.

Material	Amount
Cement	2,365 lb (262.78 lb/yd^3)
Slag	3,530 lb (392.22 lb/yd^3)
Coarse Aggregate (1.9% Moisture)	14,560 lb (1,617.78 lb/yd^3)
Fine Aggregate (3.9% Moisture)	11,960 lb (1,328.89 lb/yd^3)
Batch Water	1,599 lb (177.71 lb/yd^3)
Admixture (Air)	6 oz.
Admixture (Water Reducer #1)	531 oz.
Admixture (Water Reducer #2)	207 oz.
Cementitious Material	5925 lb (655.00 lb/yd^3)
Slag Percentage	60%
w/cm Ratio	0.40

Table 3.16 truck #4 (9 cubic yards) concrete mix proportions.

Material	Amount
Cement	2,430 lb (270 lb/yd^3)
Slag	3,550 lb (394.44 lb/yd^3)
Coarse Aggregate (1.9% Moisture)	14,380 lb (1,597.78 lb/yd^3)
Fine Aggregate (3.9% Moisture)	11,960 lb (1,328.89 lb/yd^3)
Batch Water	1,599 lb (177.71 lb/yd^3)
Admixture (Air)	6 oz.
Admixture (Water Reducer #1)	534 oz.
Admixture (Water Reducer #2)	207 oz.
Cementitious Material	5980 lb (664.44 lb/yd^3)
Slag Percentage	59%
w/cm Ratio	0.39

Table 3.17 OC-19 truck #5 (9 cubic yards) concrete mix proportions.

Material	Amount
Cement	2,390 lb (265.56 lb/yd^3)
Slag	3,530 lb (392.22 lb/yd^3)
Coarse Aggregate (1.9% Moisture)	14,540 lb (1,615.56 lb/yd^3)
Fine Aggregate (3.9% Moisture)	12,000 lb (1,333.33 lb/yd^3)
Batch Water	1,599 lb (177.71 lb/yd^3)
Admixture (Air)	6 oz.
Admixture (Water Reducer #1)	531 oz.
Admixture (Water Reducer #2)	207 oz.
Cementitious Material	5920 lb (657.78 lb/yd^3)
Slag Percentage	60%
w/cm Ratio	0.40

Table 3.18 OC-19 truck #6 (7 cubic yards) concrete mix proportions.

Material	Amount
Cement	1,860 lb (265.71 lb/yd^3)
Slag	2,755 lb (393.57 lb/yd^3)
Coarse Aggregate (1.9% Moisture)	11,280 lb (1,611.43 lb/yd^3)
Fine Aggregate (3.9% Moisture)	9,340 lb (1,334.29 lb/yd^3)
Batch Water	1,216 lb (173.74 lb/yd^3)
Admixture (Air)	4 oz.
Admixture (Water Reducer #1)	414 oz.
Admixture (Water Reducer #2)	159 oz.
Cementitious Material	4615 lb (659.29 lb/yd^3)
Slag Percentage	60%
w/cm Ratio	0.39

3.3.1 Instrumentation

Instrumentation of OC-19 included the following sensor and data collection components: TIP^{TM} Thermal Wire and Thermal Acquisition Ports (TAP). Using a combination of plastic wire ties and PEX tie wire, four 50-foot thermal wires were installed along the length of the reinforcement cage and positioned roughly 90 degrees apart radially (Figure 3.29). An additional center thermal wire, 25 feet in length, was installed along an additional 10-foot rebar positioned and secured using rebar cross bracing at the center of the reinforcement cage (Figure 3.30) located

6.5 feet below the top of the drilled shaft. The length of the center rebar made use of the first 10 out of 25 available sensors along the center thermal wire. The remaining 15 sensors were positioned across the shaft diameter and secured to the center rebar cross bracing (Figure 3.31). These remaining sensors provided for temperature data to be collected along three cross bracing legs. Figure 3.32 shows the fully instrumented reinforcement cage ready to be placed for concrete casting, and Figure 3.33 provides a sensor layout schematic. This schematic includes the full reinforcement cage layout (not to scale) (left), a plan view of the sensors installed along the cross bracing (top right), and a detail view of the full center wire with numbered sensors (bottom right). The starred sensor in the top right schematic represents sensor number 10, the first sensor located on the cross-bracing configuration. The thermal wire connector ends and above-concrete sensors were bundled and protected using heavy duty plastic bags tightly wrapped in all-weather duct tape to ensure they remained clean during concrete placement. Once concrete placement was complete, the protective plastic was removed, and TAP boxes were connected to each thermal wire.

Figure 3.29 Installation of thermal wires along the length of the OC-19 reinforcement cage.

[This is a photo taken from the top of the OC-19 reinforcement cage showing installed cage thermal wires positioned roughly 90 degrees apart radially.]

Figure 3.30 Installation of the center rebar cross bracing and the bottom 15 sensors of the center thermal wire in an across-shaft configuration along the bottom rebar cross bracing in OC-19 reinforcement cage.

[This is two side-by-side photos taken inside the OC-19 reinforcement cage showing a graduate student installing the center rebar cross bracing and the bottom 15 sensors of the center thermal wire. The left photo shows a graduate student securing the rebar cross bracing with rebar tie wire. The right photo shows a graduate student securing the bottom 15 sensors of the thermal wire to the bottom rebar cross bracing with a PEX rebar tie gun.]

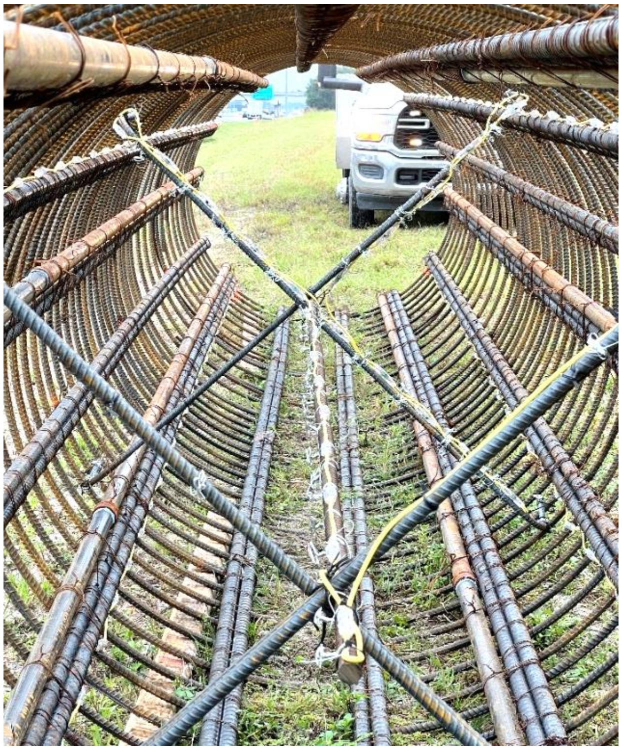


Figure 3.31 Complete installation of center thermal wire inside OC-19 reinforcement cage.

[This is a photo taken inside the OC-19 reinforcement cage showing center thermal wire installation including across shaft sensor configuration. The bottom 15 thermal sensors are shown to be installed on three out of four legs of the bottom cross bracing.]

Figure 3.32 Fully instrumented OC-19 reinforcement cage ready to be placed for concrete casting.

[This is a photo taken from outside the top of the OC-19 reinforcement cage. All cage thermal wires and center thermal wire have been installed, and all above-concrete sensors and wire connector ends have been bundled and secured in heavy-duty plastic bags and Gorilla tape.]

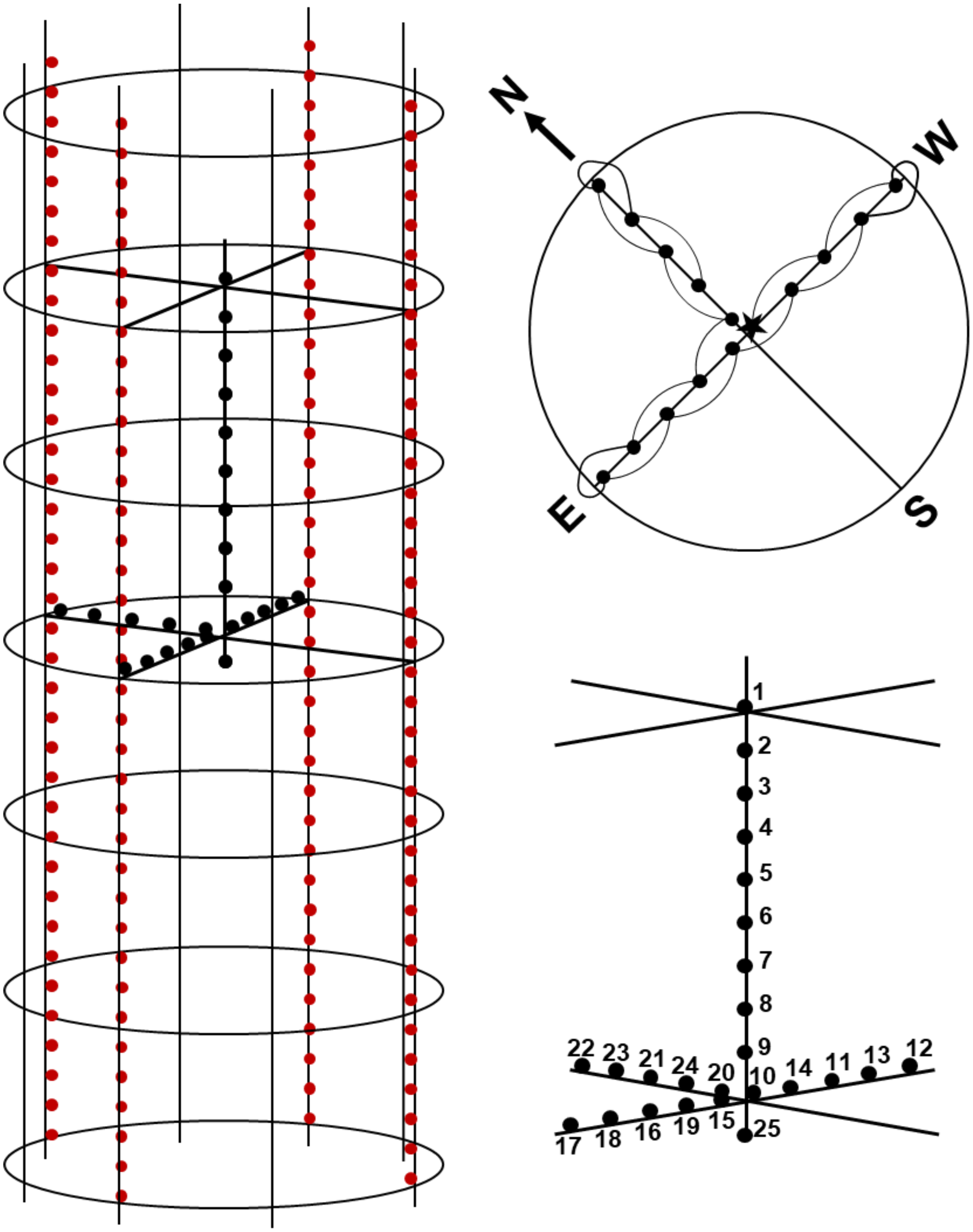


Figure 3.33 OC-19 thermal sensor layout schematic.

[This is a diagram illustrating the thermal sensor layout for drilled shaft OC-19. On the left shows a full reinforcement cage layout with four thermal wires located at the cage with sensors highlighted in red and a center thermal wire with sensors highlighted in black. On the right shows a detailed view of the center wire sensor layout with 10 sensors along a center rebar and the remaining 15 sensors along the rebar cross bracing in a N-S and E-W across-shaft configuration.]

3.3.2 Collected Data

Temperature measurement data from the installed thermal wires, environmental conditions during construction, FDOT drilled shaft log, concrete mix design, and mill certificates associated with drilled shaft OC-19 were collected and cataloged. Table 3.19 presents the Temperature Analysis Shaft Information for OC-19.

Table 3.19 OC-19 temperature analysis shaft information.

Data Collection Start Time:	11/23/21 15:34
Drilled Shaft Diameter:	84 inches
Cage Diameter:	60 inches
Drilled Shaft Length:	36.96 feet
Average Temperature:	117.1°F
Local Minimum Temperature:	109.85°F at 29 feet on Wire 3
Local Maximum Temperature:	130.44°F at 7 feet on Wire 2

Figure 3.34 presents all longitudinal temperature data versus depth for OC-19 recorded 47 hours after concreting. This is when peak average cage temperature occurred. The average temperature profile is given as the bold black line marker also denoted as “AVG”. The location of peak average cage temperature occurred in the oversized temporary surface casing at 6 feet with the temperature measurement of 130.67°F. This depth location was used to plot the temperature evolution at that depth for the entire testing duration (Figure 3.35).

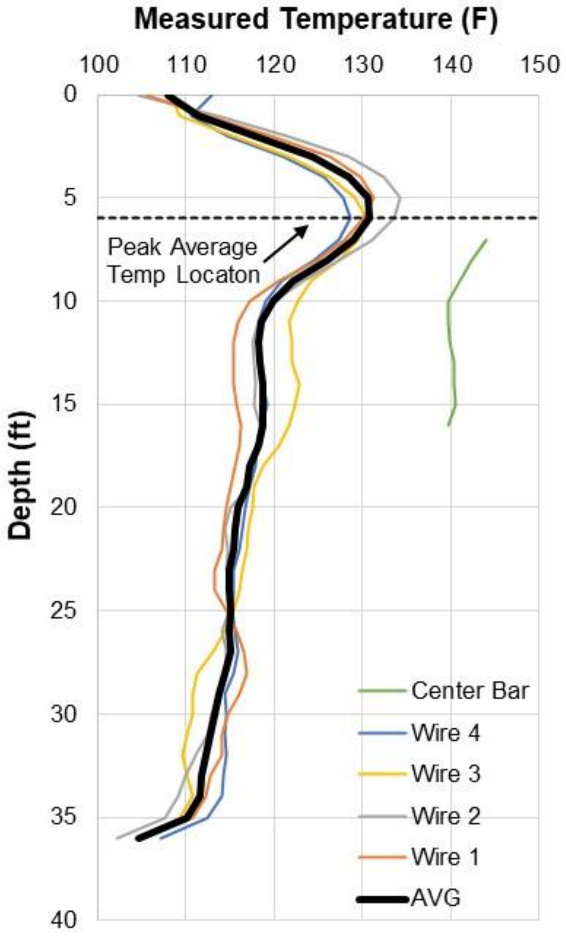


Figure 3.34 Plot presenting OC-19 temperature versus depth data at peak average cage temperature (47 hours into testing).

[This is a plot presenting temperature data on the x-axis versus depth data on the y-axis and includes temperature measurements from all four thermal wires installed at the reinforcement cage as well as the thermal wire installed along a center rebar. The depth reaches just past 35 feet, and temperature measurements range from approximately 110ºF to 142ºF.]

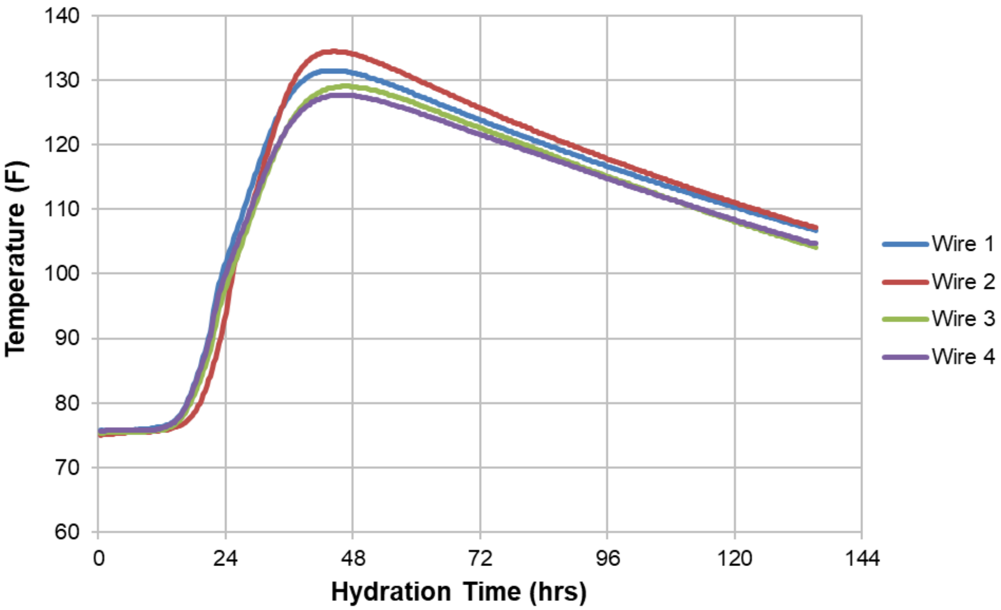


Figure 3.35 Plot presenting OC-19 temperature versus time data at a depth of 6 feet, where peak average cage temperature occurred (47 hours into testing).
[This is a plot presenting temperature data on the y-axis versus time on the x-axis at a depth of 6 feet and includes temperature measurements from all four thermal wires installed at the reinforcement cage. The time ranges from 0 to 135 hours, and the temperature measurements range from approximately 75°F to 135°F.]

Figures 3.36 and 3.37 present the data that was collected at the time of peak center wire temperature, where Figure 3.36 is temperature versus depth and Figure 3.37 is temperature evolution over time. The peak center wire temperature occurred in the first sensor at a depth of 7 feet and was measured to be 144.03°F. Looking at Figure 3.34 it can be inferred that an even higher core temperature was likely to have occurred at a depth of 5 feet which was more in the center of the oversized casing region.

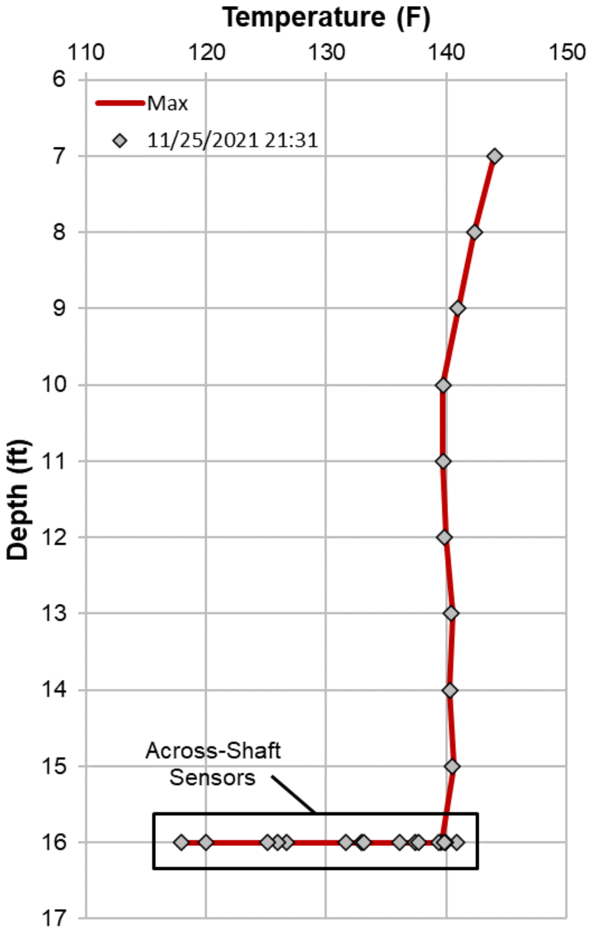


Figure 3.36 Plot presenting OC-19 center wire temperature versus depth data at the time of peak temperature of the center wire (49 hours into testing).

[This is a plot presenting temperature data on the x-axis versus depth data on the y-axis and includes temperature measurements from the thermal wire installed along a center rebar. The depth begins at 7 feet and ends at 16 feet where the sensors were transitioned to an across-shaft configuration, and temperature measurements range from approximately 118°F to 144°F.]

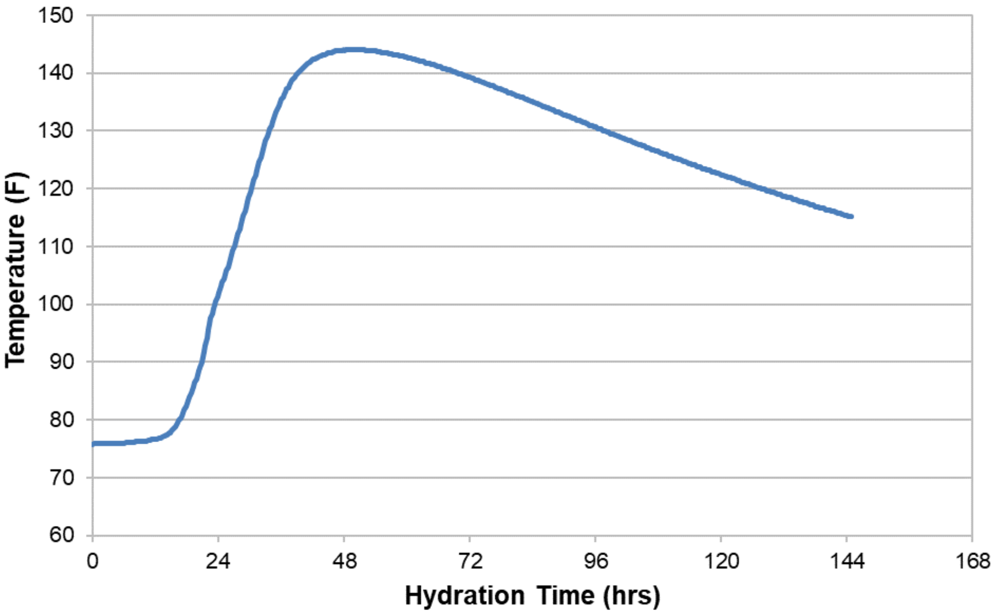


Figure 3.37 Plot presenting OC-19 center wire temperature versus time data at a depth of 1 foot, where peak center wire temperature occurred.

[This is a plot presenting temperature data on the y-axis versus time on the x-axis where the depth of interest is 7 feet and includes temperature measurements from the thermal wire installed along a center rebar. The time ranges from 0 to 144 hours, and the relevant temperature measurements range from approximately 75°F to 144°F.]

Figure 3.38 presents the across-shaft temperature distribution. The center bar was located at a zero radius and the cage was at plus or minus 30 inch radial locations relative to the center bar. The direction of the individual cage wire locations is also related to the radial locations. Looking back at Figure 3.31, the instrumentation that spans across the full shaft corresponded to the wire 2 to 4 direction (E-W). The perpendicular partial instrumentation corresponds to data extending from the center to the wire 1 cage location (north). Parabolic functions were also fit to these temperature distributions and returned R^2 values of 0.9961 and 0.9999, respectively. Figure 3.38 also shows the temperature differential between the top of the parabola and the cage location to be approximately 23°F. Temperature differential between parabola peak and cage location was also evaluated for the I-395, SR 836, and I-95 Intersection project discussed in Section 3.4, where several datasets have been collected from smaller elements.

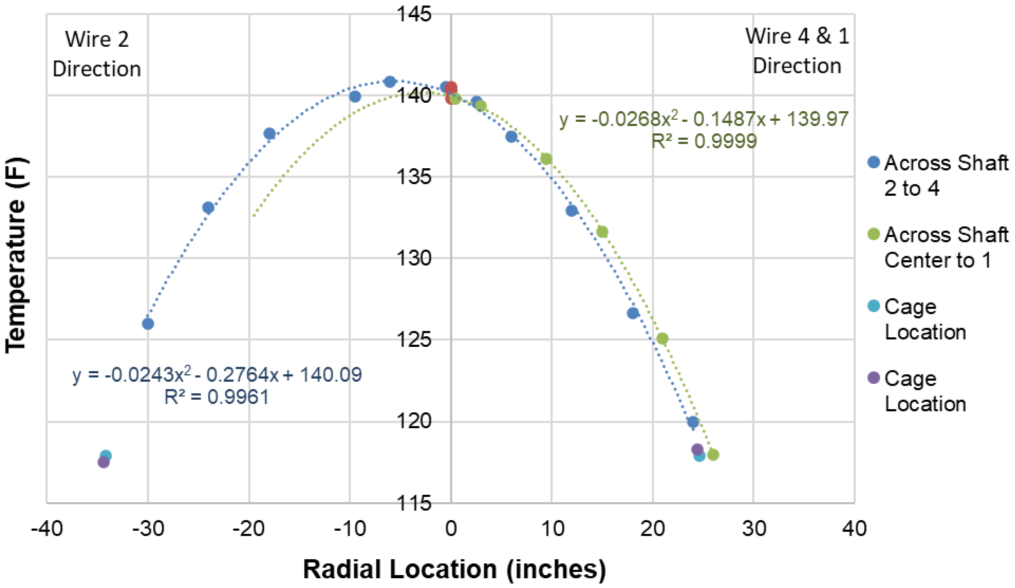


Figure 3.38 Plot presenting OC-19 data taken from the center wire sensors installed in an across-shaft configuration.

[This is a plot presenting temperature data on the y-axis versus radial location on the x-axis where the center of the shaft is located at a zero radius and the cage is at plus or minus radial locations in inches relative to center. There is a full temperature distribution for the portion across shaft between cage wires 2 and 4, and there is a half temperature distribution for the portion across shaft between the center and cage wire 1. The temperature differential between the cage locations and the peak is approximately 23ºF. The plot also includes parabolic equations for each distribution series and R values for each fit. These R values are 0.9961 and 0.9999, respectively.]

Similar to the Temperature Analysis Shaft Information, the Radius Analysis Shaft Information is presented in Table 3.20. Figure 3.39 presents the radius versus depth profile for OC-19. This plot also includes concrete cover results based on the size and location of the reinforcement cage. Figure 3.40 plots TIP Reporter-generated 3D radius view of the shaft.

Table 3.20 OC-19 radius analysis shaft information.

Average Radius:	37.13 inches
Local Minimum Radius:	34.56 inches at 36 feet at Wire 2
Local Maximum Radius:	42.28 inches at 5 feet at Wire 2

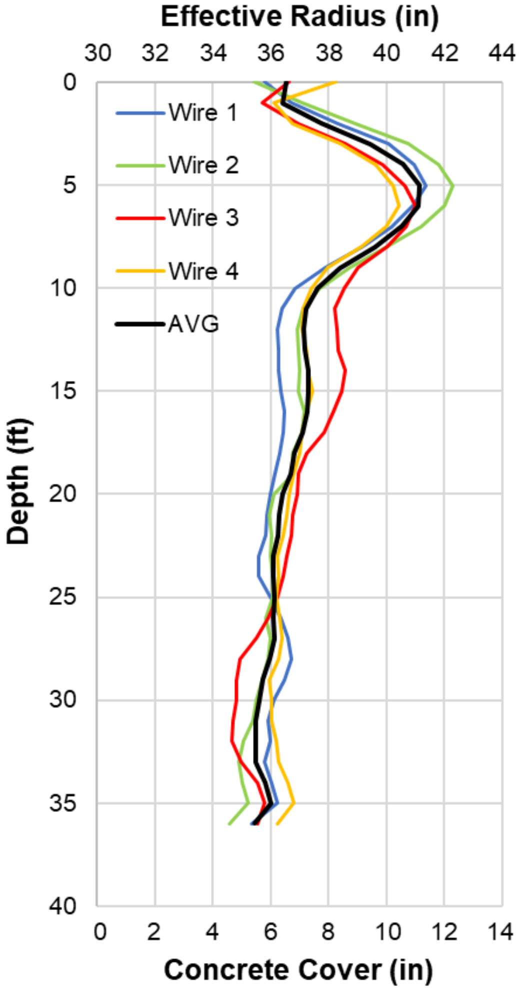


Figure 3.39 Plot presenting OC-19 radius versus depth data.

[This is a plot presenting radius and concrete cover data on the x-axis versus depth data on the y-axis and includes radius values for the locations of all four thermal wires installed at the reinforcement cage. The depth reaches 36 feet, and radius values range from approximately 35 to 42 inches. Concrete cover values range from approximately 5 to 12 inches.]

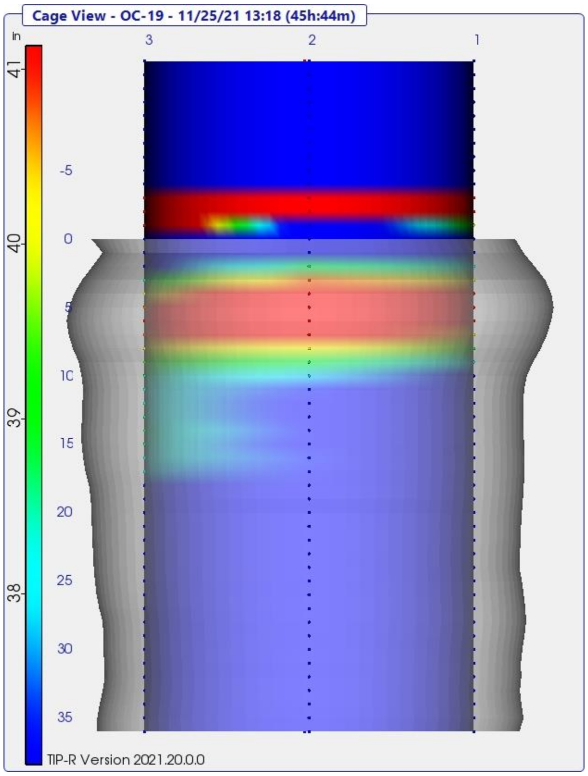


Figure 3.40 OC-19 3D radius view (not to scale).

[This is a plot generated by TIP reporter showing 3D radius view of OC-19. It can be seen that the general shape of the drilled shaft is not symmetrical with varying concrete cover.]

3.4 I-395, SR 836, and I-95 Intersection in Miami, Florida

While this study is named to focus on and determine the peak temperature of drilled shafts, all cementitious structural elements have the potential of generating elevated internal temperature distributions. Above-ground structural elements have unique temperature control issues not directly relatable to elements cast completely underground. Augered Cast-in-Place (ACIP) piles are similar to drilled shafts although their size is generally limited to be 4 feet in diameter or less. Nevertheless, temperature data from ACIP piles are just as valuable as that from drilled shafts.

ACIP piles installed in Miami for the I-395 Expansion Project were reviewed for inclusion in this study where high temperatures were recorded. All piles installed on this project were instrumented with thermal wire systems where four wires were installed on the cage. Many of the piles included a center bar with a fifth thermal wire (exactly like this Task). In these cases, the data was directly applicable to the Task goals. This site was particularly interesting given the measured temperatures were much higher than expected for such small elements. This was due to a high cementitious materials content discussed later. Table 3.21 presents a summary of twenty 36-inch diameter auger-cast-in-place elements where center bar instrumentation was included (not listed). The rationale for including center wire measurements was to confirm core temperatures were not exceeding safe limits. However, peak center bar temperatures do not reflect peak core temperatures if the cage is not centered in the pile. Likewise, the peak cage temperature may not reflect the hottest portion of the pile (at depth). So, the Table values list how and where the peak temperatures occurred:

- Max Avg: the maximum average temperature which represents the average of all four wire strings at a given depth.
- Elevation at Max: the location along the pile length where the Max Avg occurred
- Max Cage: the highest cage temperature recorded which may not occur at the same depth as the Max Avg
- Avg at Peak: the average of all four sensors at the depth where the Max Cage was measured.
- Avg Pile Temp: the average of all sensors from all depths which is used to determine a temperature to radius constant
- Grout Volume and Pile Length: used to determine the average pile radius

Table 3.21 Summary of ACIP cage temperature measurements.

Bridge	Pile #	Nom Pile Size	Grout Age	Max Avg	Elevation at Max	Max Cage	Avg at Peak	Avg Pile Temp	Grout Volume	Pile Length
		(in)	(hrs)	(F)	(ft)	(F)	(F)	(F)	(cuyd)	(ft)
8	19	36	27:47:00	174.5	-87.0	180.4	173.6	168.8	46.8	130.4
8	42	36	31:10:00	167.0	-68.0	176.8	166.2	160.8	46.5	130.5
8	43	36	30:49:00	175.5	-61.0	184.0	175.5	165.5	46.7	130.3
8	49	36	31:45:00	163.7	-66.0	171.5	163.7	156.5	46.7	127.2
8	59	36	31:52:00	170.1	-86.0	176.9	170.1	161.5	45.9	131.2
8	61	36	29:05:00	173.13	-87.3	178.25	173.13	165.16	47.5	130.2
8	66	36	29:02:00	162.0	-72.0	168.7	160.7	156.3	45.0	125.2
8	71	36	29:11:00	172.0	-90.0	177.6	170.6	165.8	46.2	131.0
8	79	36	29:21:00	165.5	-86.0	171.6	165.5	158.2	45.1	126.4
8	80	36	33:23:00	161.9	-72.0	167.5	161.9	152.6	46.3	131.1
8	85	36	29:00:00	171.0	-95.0	171.6	167.1	158.2	44.3	126.6
8	86	36	29:40:00	168.0	-72.0	172.7	167.5	159.8	46.6	130.2
8	91	36	31:28:00	162.0	-71.0	163.0	161.0	154.8	41.2	126.8
8	95	36	33:39:00	160.3	-59.0	168.8	160.3	152.2	44.3	126.3
8	99	36	29:21:00	157.0	-51.0	169.5	157.0	151.3	41.6	117.2
8	100	36	33:29:00	156.6	-73.0	168.1	156.6	149.7	38.1	127.0
8	107	36	26:33:00	167.0	-70.0	174.4	165.6	154.3	40.2	126.4
8	108	36	27:51:00	162.0	-60.0	171.1	160.1	146.3	41.4	126.9
8	112	36	28:07:00	163.0	-68.0	173.1	162.5	153.2	43.6	127.1
8	118	36	28:05:00	163.0	-78.0	170.0	161.0	154.5	44.4	127.3
8	123	36	26:38:00	164.2	-69.0	173.5	164.2	152.5	41.4	128.4

In several cases, the Max Cage temperatures exceeded the FDOT upper temperature limit of 180ºF. Center wire temperatures (Figure 3.41) were often higher than max cage measurements but in some cases were similar or lower indicating lateral movement of the cage within the pile where one side of the cage moved nearer the center of the pile.

A second outcome of the center wire measurements is and was to establish a simplistic center of pile temperature determination method based on empirical results. Thereby the average cage temperature profile was compared to the center bar temperature profile (Figure 3.41) to determine a cage to center of pile differential temperature for this grout mix design and pile size.

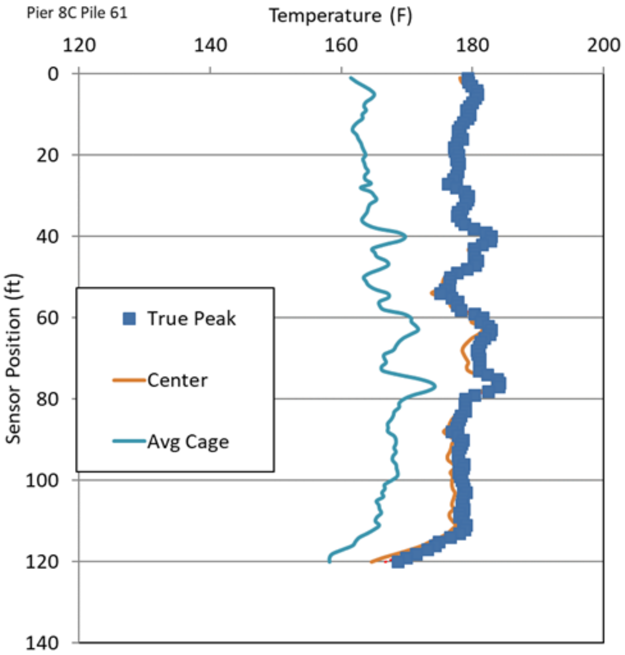


Figure 3.41 Typical average cage and center wire temperature profiles.

[This is a plot presenting temperature data on the x-axis and sensor position in feet on the y-axis. Three series of data are included on this plot: average temperature located at the reinforcement cage, center temperature, and a calculated true peak.]

The cage to center temperature difference at any given depth somewhat confirmed a constant relationship where the cage diameter and pile diameter were constant. For these piles the upper 40 feet of cage was larger in diameter to meet structural bending resistance needs, the lower portion of the cage was reduced in diameter and number of main bars to a minimum amount needed to extend thermal integrity sensors to the bottom of the piles. Therefore, warmer cage temperatures are observed in the lower half along with smaller cage to core differentials (Figure 3.42).

On average, the upper portion of the piles showed a differential temperature of 15ºF, and the lower portion of the piles was 12ºF (Table 3.22). Localized worst case differential values were somewhat higher, as high as 20ºF in one case. The usefulness of this approach and a goal for this study is and was to use cage-based measurements to predict the most probable core temperature. This was extended to all piles where cage-based temperature measurements should not exceed 165ºF (180ºF-15ºF) for 36-inch piles in the upper portion and 170ºF (180ºF-10ºF) in the lower portions (based on less restrictive 10ºF differential and not the 12ºF average differential shown in Table 3.22). A similar 10ºF differential was also applied to the smaller 30-inch piles on the project based on similar center-to-cage radial distance. Data from the 30-inch piles was also obtained for this project and added to the database.

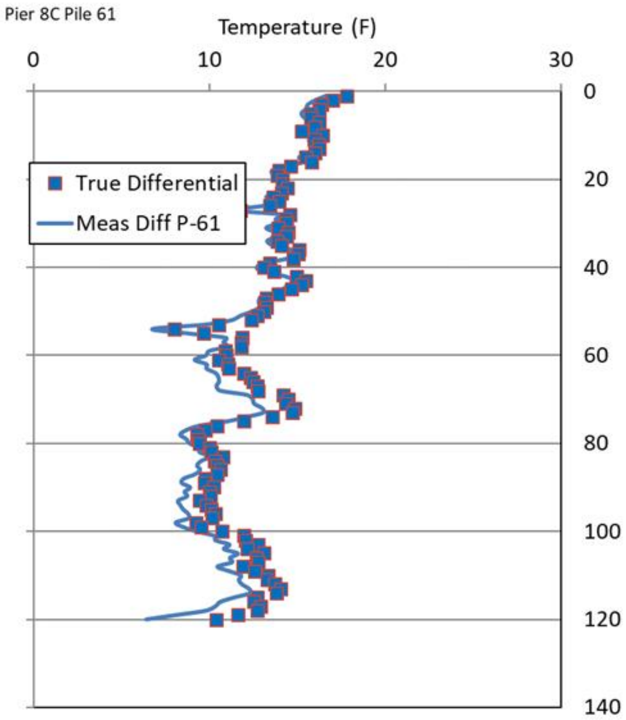


Figure 3.42 Temperature versus depth plot illustrating warmer cage temperatures are observed in the lower half along with smaller cage to core differentials.

[This is a plot presenting temperature data on the x-axis and sensor position in feet on the y-axis. Two series of data are included on this plot: true differential and measured difference.]

Table 3.22 Average cage to peak to cage temperature differentials for 36-inch elements.

	Avg Temp Diff (F)		Peak Temp Diff (F)	
Pile	Upper	Lower	Upper	Lower
P-26	15.3	10.3	18.0	15.3
P-42	15.5	13.5	17.7	17.0
P-43	14.4	11.6	16.4	15.6
P-49	12.7	9.8	14.4	11.2
P-59	14.4	11.6	16.4	15.6
P-61	14.9	11.6	17.8	14.9
P-71	15.1	11.3	17.1	13.5
P-80	15.5	12.9	19.9	17.7
P-95	15.1	10.6	17.9	13.7
P-107	15.3	15.9	18.2	24.0
P-108	14.1	11.5	19.4	18.9
P-112	13.6	12.6	15.1	16.0
P-118	15.2	9.5	18.0	11.9
P-123	12.3	10.1	14.7	15.5
Avg	15	12	17	16

Both Figures 3.41 and 3.42 note the true center and differential temperatures are needed to account for when a center bar (and wire) is not truly centered due to cage movement. An algorithm was developed to correct for cage movement based on a best fit equation, discussed later. In short, the algorithm iterates the cage position until the average cage temperature on both sides of the shaft best fits the polynomial curve formed by the center and opposite side cage temperature measurements (Figure 3.43). This is performed in both the north/south and east/west directions.

Figure 3.43 shows the lateral temperature distribution for the same pile shown in Figures 3.41 and 3.42 where the pile size was 36 inches in diameter, the center of pile is plotted at 18 inches on the x-axis, the radial location of the thermal sensors was ±10.75 inches from center of cage, the computed E-W offset was 1.9 inches, and the N-W offset was 0.4 inches. The cage and center of cage locations are shown as the dashed black lines.

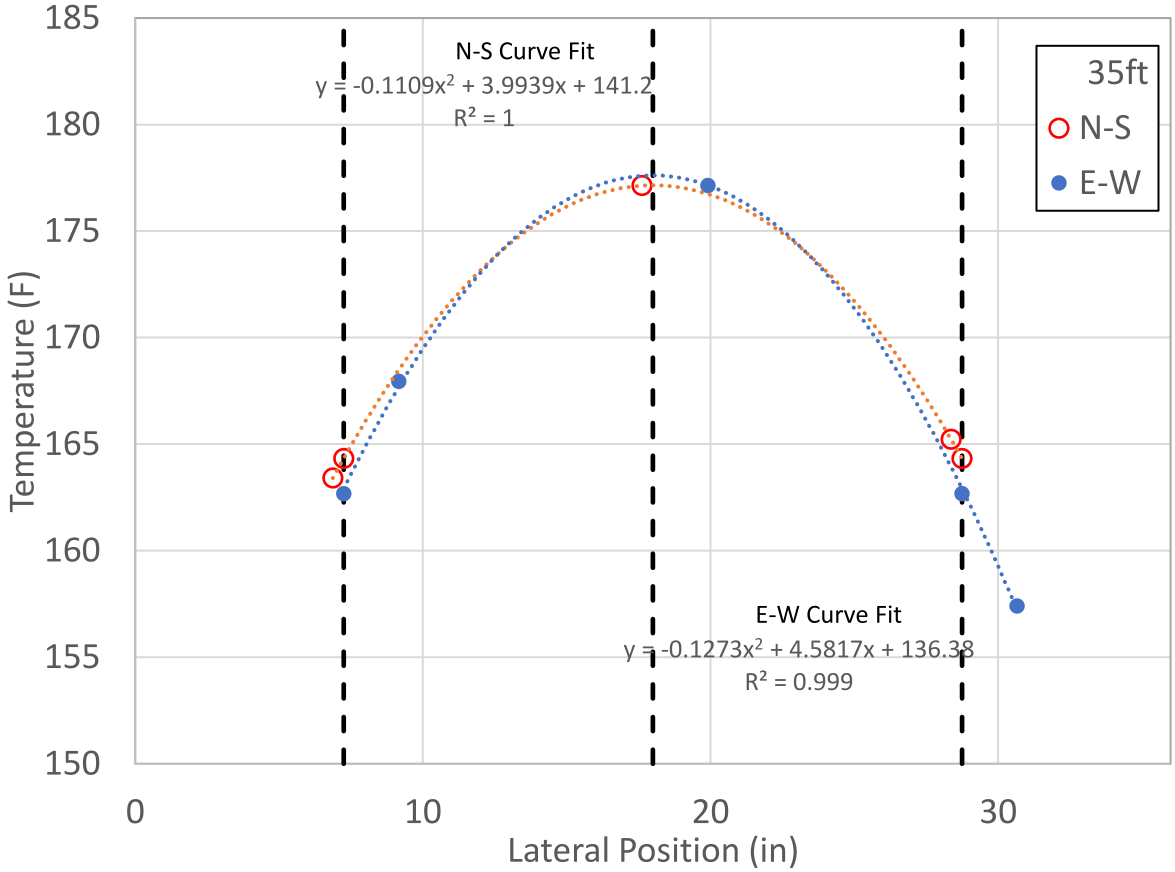


Figure 3.43 Best fit cage position based on the best fit average cage temperature. *[This is a plot presenting lateral sensor position in inches on the x-axis and temperature data on the y-axis for sensors at a depth of 35 feet. Data in the N-S direction and E-W direction are included.]*

3.5 North Florida Avenue and Sinclair Hills Drilled Shaft, Tampa, Florida

The Sinclair Hills drilled shaft was constructed by R.W. Harris, Inc. on July 7, 2022, on the east side of North Florida Avenue just south of Sinclair Hills Road (Figure 3.44). This drilled shaft was designed to be 72 inches in diameter, 36 feet long, and was cast with an 84-inch diameter, partial-length temporary casing (Figure 4.45).

Figure 3.44 Satellite imagery illustrating the general location of the Sinclair Hills drilled shaft.

[This is a photo of satellite imagery illustrating the general location of the Sinclair Hills drilled shaft, which is denoted by a yellow star. This shaft is located on N. Florida Avenue just south of Sinclair Hills Road in Tampa, Florida.]

Figure 3.45 Excavation of the Sinclair Hills drilled shaft with partial-length casing installed.
[This is a photo showing the construction location of the Sinclair Hills drilled shaft. The location is still in the process of being augered with slurry flowing from a large hose line. The partial-length casing is already placed inside the augered portion.]

Testing began on July 7, 2022, and concluded on July 12, 2022, during which the air temperature averaged approximately 85°F. The concrete mix proportions are provided in Table 3.23 with the complete concrete mix design submittal document and all original concrete delivery tickets included in Appendix D.

Table 3.23 Sinclair Hills drilled shaft concrete mix proportions.

Material	**Amount**
Cement (Type IL)	564 lb
Fly Ash (Class F)	140 lb
Coarse Aggregate	1614 lb
Fine Aggregate	1324 lb
Water	283 lb
Admixture (Air)	2.5 oz/cy
Admixture (Stabilizer)	1-15 oz/cwt CM
Admixture (Water Reducer #2)	1-15 oz/cwt CM
Cementitious Material	704 lb
Fly Ash Percentage	20%
w/cm Ratio	0.40

3.5.1 Instrumentation

Instrumentation of the Sinclair Hills drilled shaft included the following sensor and data collection components: TIP^{TM} Thermal Wire and Thermal Acquisition Ports (TAP). Using a combination of plastic wire ties and PEX tie wire, four 90-foot thermal wires were installed along the length of the reinforcement cage and positioned roughly 90 degrees apart around the circumference of the cage (Figure 3.46). An additional center thermal wire, 25 feet in length, was installed in an across-shaft cross configuration along rebar cross bracing at the center of the reinforcement cage (Figures 3.47 and 3.48) located 7 feet below the top of the drilled shaft. Figure 3.49 shows the fully instrumented reinforcement cage ready to be placed in the excavation. Figure 3.50 shows the sensor layout schematic unique to this shaft. This schematic includes the full reinforcement cage layout (not to scale, left) and a plan view of the sensors installed along the cross bracing (right). The thermal wire connector ends and above-concrete sensors were bundled and protected using heavy duty plastic bags tightly sealed with all-weather duct tape to ensure they remained clean during concrete placement. Once concrete placement was complete, the protective plastic was removed, and TAP boxes were connected to each thermal wire.

Figure 3.46 Installation of thermal wires along the length of the Sinclair Hills drilled shaft reinforcement cage.
[This is a photo taken from the top of the Sinclair Hills shaft reinforcement cage showing graduate students installing cage thermal wires positioned roughly 90 degrees apart radially.]

Figure 3.47 Installation of the rebar cross bracing and the center thermal wire in an across-shaft configuration along the rebar cross bracing.

[This is two side-by-side photos taken inside the Sinclair Hills shaft reinforcement cage showing graduate students installing the center rebar cross bracing and the center thermal wire. The left photo shows a graduate student securing the rebar cross bracing with rebar tie wire. The right photo shows graduate students securing the thermal wire to rebar cross bracing with a PEX rebar tie gun.]

Figure 3.48 Complete installation of center thermal wire inside Sinclair Hills drilled shaft reinforcement cage.

[This is a photo taken inside the Sinclair Hills shaft reinforcement cage showing center thermal wire installation including across shaft sensor configuration.]

Figure 3.49 Fully instrumented Sinclair Hills drilled shaft reinforcement cage ready to be placed for concrete casting.

[This is a photo taken from outside the top of the Sinclair Hills shaft reinforcement cage. All cage thermal wires and center thermal wire have been installed, and all above-concrete sensors and wire connector ends have been bundled and secured in heavy-duty plastic bags and Gorilla tape.]

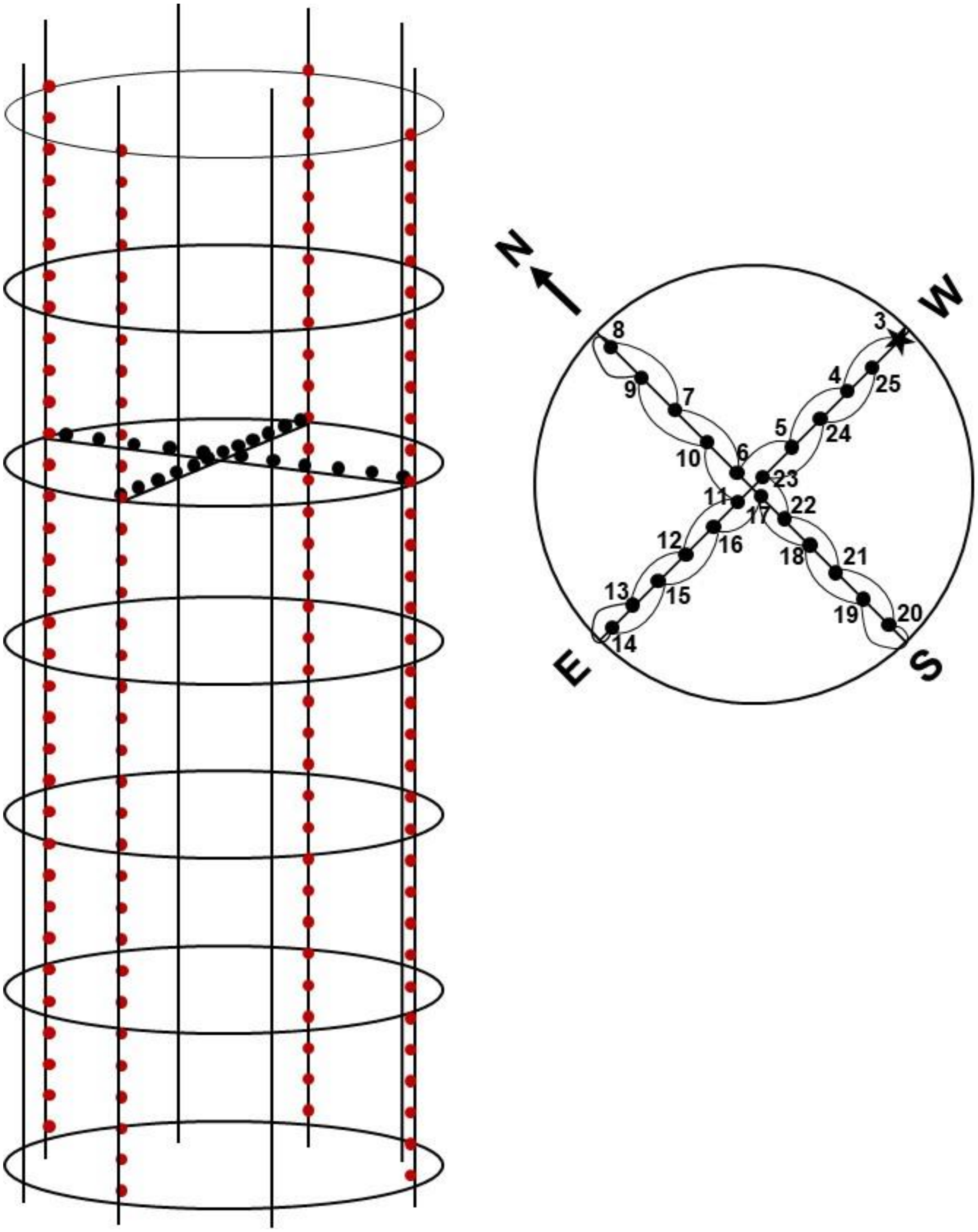


Figure 3.50 Sinclair Hills drilled shaft thermal sensor layout schematic.

[This is a diagram illustrating the thermal sensor layout for the Sinclair Hills drilled shaft. On the left shows a full reinforcement cage layout with four thermal wires located at the cage with sensors highlighted in red and a center thermal wire with sensors highlighted in black. On the right shows a detailed view of the center wire sensor layout with all 25 sensors along rebar cross bracing in a N-S and E-W across-shaft configuration.]

3.5.2 Collected Data

Temperature measurement data from the installed thermal wires, environmental conditions during construction, concrete mix design, and mill certificates associated with the Sinclair Hills drilled shaft were collected and cataloged. Table 4.24 presents the Temperature Analysis Shaft Information for the Sinclair Hills drilled shaft.

Table 3.24 Sinclair Hills drilled shaft temperature analysis shaft information.

Data Collection Start Time:	7/7/22 17:41
Drilled Shaft Diameter:	84 inches
Cage Diameter:	72 inches
Drilled Shaft Length:	33 feet
Average Temperature:	129.53°F
Local Minimum Temperature:	121.66°F at 16 feet on Wire 2
Local Maximum Temperature:	144.16°F at 7 feet on Wire 3

Figure 3.51 presents all longitudinal temperature data versus depth for the Sinclair Hills drilled shaft recorded 23 hours after concreting. This is when peak average cage temperature occurred. The average temperature profile is given as the bold black line marker also denoted as “AVG.” The location of peak average cage temperature is marked at 4 feet with a temperature measurement of 144.11°F. This depth location was used to plot the temperature evolution over time at that depth for the entire testing duration (Figure 3.52). In this plot it can be seen that the sensor in Wire 2 exhibited the telltale signs of intermittent readings from sensor failure. Fortunately, this did not significantly affect the analysis of this shaft.

Figure 3.53 presents the across-shaft temperature distribution where the center of the rebar cross bracing is located at a zero radius and the cage is at plus or minus radial locations in inches relative to the center of the rebar cross bracing. The direction of the individual cage wire locations is also related to the radial locations. Parabolic functions were fit to these temperature distributions and each returned an R^2 value of 0.9975. Figure 3.53 also shows that the temperature differential between the top of the parabola and the cage location to be approximately 40°F. However, by evaluating the slope of the function at a cage radius of 36 inches, the gradient can be calculated to be approximately 1.67 °F/in. When extending this slope to the edge of shaft with a 6 inch cover an additional 10°F can be included in the true core to shaft edge differential temperature, or 50°F.

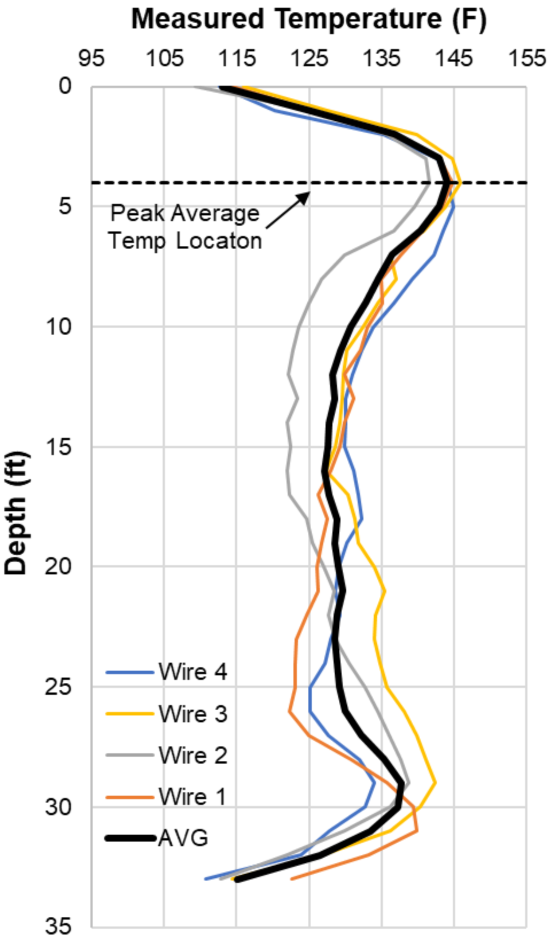


Figure 3.51 Plot presenting Sinclair Hills drilled shaft temperature versus depth data at peak average cage temperature (23 hours into testing).

[This is a plot presenting temperature data on the x-axis versus depth data on the y-axis and includes temperature measurements from all four thermal wires installed at the reinforcement cage. The depth reaches 34 feet, and temperature measurements range from approximately 115ºF to 142ºF.]

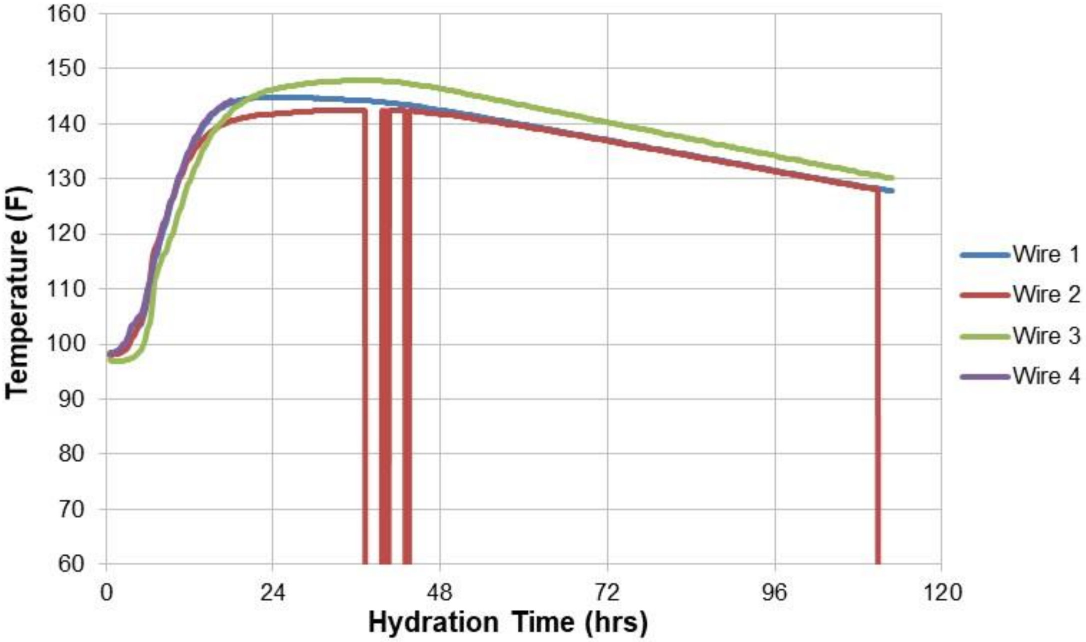


Figure 3.52 Plot presenting Sinclair Hills drilled shaft temperature versus time data at a depth of 4 feet, where peak average cage temperature occurred (23 hours into testing).

[This is a plot presenting temperature data on the y-axis versus time on the x-axis at a depth of 4 feet and includes temperature measurements from all four thermal wires installed at the reinforcement cage. The time ranges from 0 to 130 hours, and the temperature measurements range from approximately 99ºF to 147ºF.]

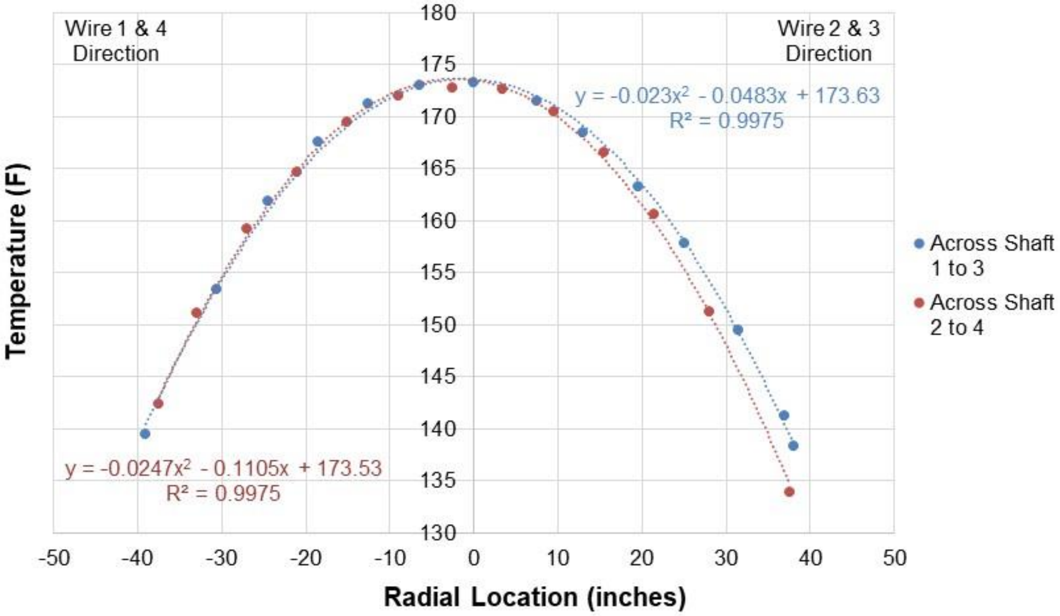


Figure 3.53 Plot presenting Sinclair Hills drilled shaft data taken from the center wire sensors installed in an across-shaft configuration.

[Figure 3.53 Detailed Description: This is a plot presenting temperature data on the y-axis versus radial location on the x-axis where the center of the shaft is located at a zero radius and the cage is at plus or minus radial locations in inches relative to center. There are full temperature distributions for the portion across shaft between cage wires 2 and 4 and wire 1 and 3, respectively. The temperature differential between the cage locations and the peak is approximately 40ºF. The plot also includes parabolic equations for each distribution series and R values for each fit. These R values are each 0.9975.]

Similar to the Temperature Analysis Shaft Information, the Radius Analysis Shaft Information is presented in Table 3.25. Rather than average, minimum, and maximum temperature information, this provides average, minimum, and maximum shaft radius information. Figure 3.54 presents the radius versus depth profile for the Sinclair Hills drilled shaft. This plot also includes concrete cover results based on the size and location of the reinforcement cage.

Table 3.25 Sinclair Hills drilled shaft radius analysis shaft information.

Average Radius:	43.74 inches
Local Minimum Radius:	40.05 inches at 16 feet at Wire 2
Local Maximum Radius:	48.24 inches at 3 feet at Wire 3

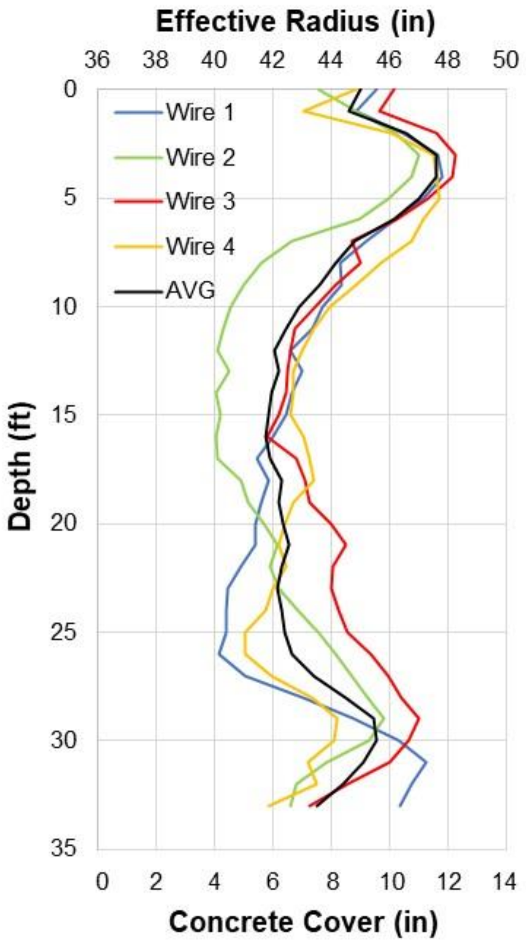


Figure 3.54 Plot presenting Sinclair Hills drilled shaft radius versus depth data.

[This is a plot presenting radius and concrete cover data on the x-axis versus depth data on the y-axis and includes radius values for the locations of all four thermal wires installed at the reinforcement cage. The depth reaches 34 feet, and radius values range from approximately 40 to 48 inches. Concrete cover values range from approximately 4 to 12 inches.]

3.6 US 17 Drilled Shaft 1-4, Bartow, Florida

Bartow drilled shaft 1-4 was constructed by Reliable Constructors, Inc. on November 30, 2022, at the northwest corner of US 17 and Spirit Lake Road (Figure 3.55). This drilled shaft was designed to be 54 inches in diameter, 17 feet long, and was cast with a 59-inch diameter, partial-length temporary surface casing (Figure 3.56).

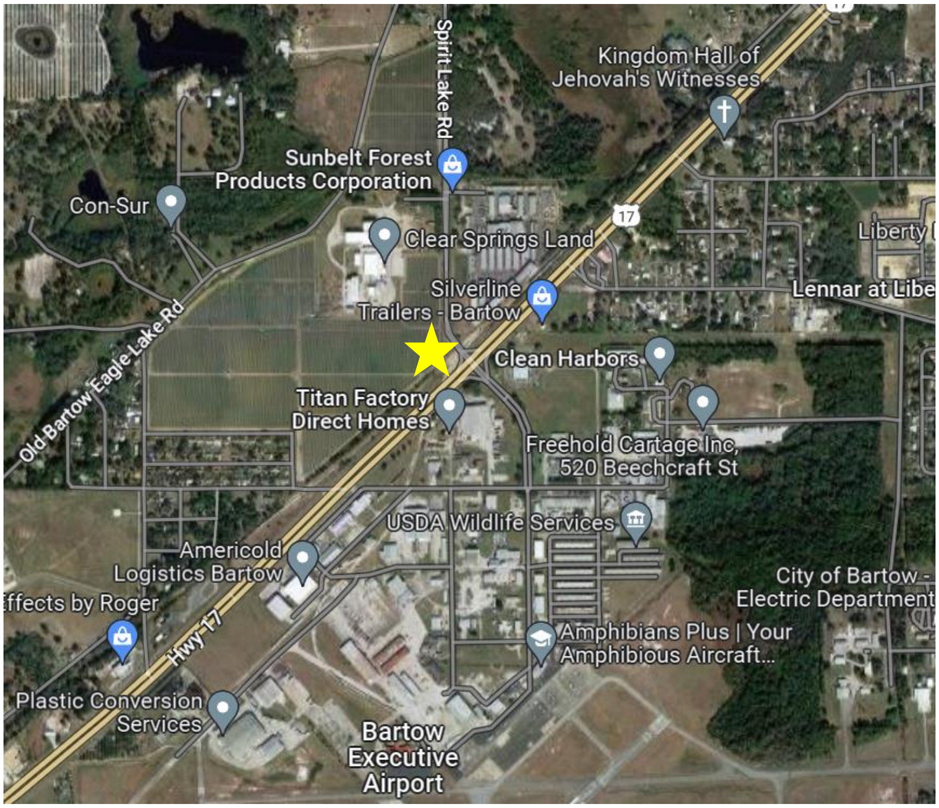


Figure 3.55 Satellite imagery illustrating the general location of Bartow drilled shaft 1-4.

[This is a photo of satellite imagery illustrating the general location of the Bartow drilled shaft, which is denoted by a yellow star. The main crossroads are US-17 and Spirit Lake Road in Bartow, Florida. The Bartow shaft is located in the northeast quadrant on the north shoulder of US-17 westbound just west of Spirit Lake Road.]

Figure 3.56 Partially augered location of Bartow shaft 1-4 with partial-length casing installed.

[This is a photo showing the construction location of the Bartow drilled shaft. The location is still in the process of being augered. The partial-length casing is already placed inside the augered portion.]

Testing began on November 30, 2022, and concluded on December 3, 2022, during which the air temperature averaged approximately 67°F. The concrete mix proportions for each concrete truck are provided in Tables 3.26 and 3.27 with original concrete delivery tickets and mill certificates included in Appendix E.

Table 3.26 Bartow shaft 1-4 truck #1 (9 cubic yards) concrete mix proportions.

Material	Amount
Cement (Type IL)	2,510 lb
Slag	3,985 lb
Coarse Aggregate (1.7% Moisture)	16,380 lb
Fine Aggregate (4.1% Moisture)	10,240 lb
Batch Water	1,857.59 lb
Admixture (Air)	7 oz.
Admixture (Water Reducer #1)	519 oz
Admixture (Water Reducer #2)	132 oz.
Cementitious Material	6,495 lb
Slag Percentage	61%
w/cm Ratio	0.39

Table 3.27 Bartow shaft 1-4 truck #2 (4 cubic yards) concrete mix proportions.

Material	Amount
Cement (Type IL)	1,135 lb
Slag	1,755 lb
Coarse Aggregate (1.7% Moisture)	7,280 lb
Fine Aggregate (4.1% Moisture)	4,580 lb
Batch Water	824.67 lb
Admixture (Air)	3 oz.
Admixture (Water Reducer #1)	231 oz.
Admixture (Water Reducer #2)	57 oz
Cementitious Material	2,890 lb
Slag Percentage	61%
w/cm Ratio	0.39

3.6.1 Instrumentation

Instrumentation of Bartow shaft 1-4 included the following sensor and data collection components: TIP^{TM} Thermal Wire and Thermal Acquisition Ports (TAP). Using a combination of plastic wire ties and PEX tie wire, four 56-foot thermal wire cutoffs from previously used 90-foot thermal wires were installed as four loops down along the length of the reinforcement cage, then returned back up the cage on an additional smaller rebar slightly offset approximately 3 inches inside the reinforcement cage using plastic spacers (Figure 3.57). This provided for thermal sensors to be aligned longitudinally but offset radially toward the center of shaft from the cage wire locations. Once fully installed, the distance between each cage sensor and corresponding offset sensor was measured. Each thermal wire was positioned roughly 90 degrees apart around the circumference of the cage. Figure 3.58 shows the fully instrumented reinforcement cage ready to be placed in the excavation. Figure 3.59 provides a sensor layout schematic. The thermal wire connector ends and above-concrete sensors were bundled and protected using heavy duty plastic bags tightly wrapped in all-weather tape to ensure they remained clean during concrete placement. Once concrete placement was complete, the protective plastic was removed, and TAP boxes were connected to each thermal wire.

Figure 3.57 Close up view of thermal wire installed at the reinforcement cage with offset return wire.

[This is a detail view of the inside of the Bartow shaft reinforcement cage showing a thermal wire installed along a cage rebar with a concentrically offset smaller rebar on which the thermal wire is returned.]

Figure 3.58 Fully instrumented Bartow shaft 1-4 reinforcement cage ready to be placed for concrete casting.

[This is a photo taken from outside the top of the Bartow shaft reinforcement cage. All cage thermal wires and center thermal wire have been installed, and all above-concrete sensors and wire connector ends have been bundled and secured in heavy-duty plastic bags and Gorilla tape.]

4.

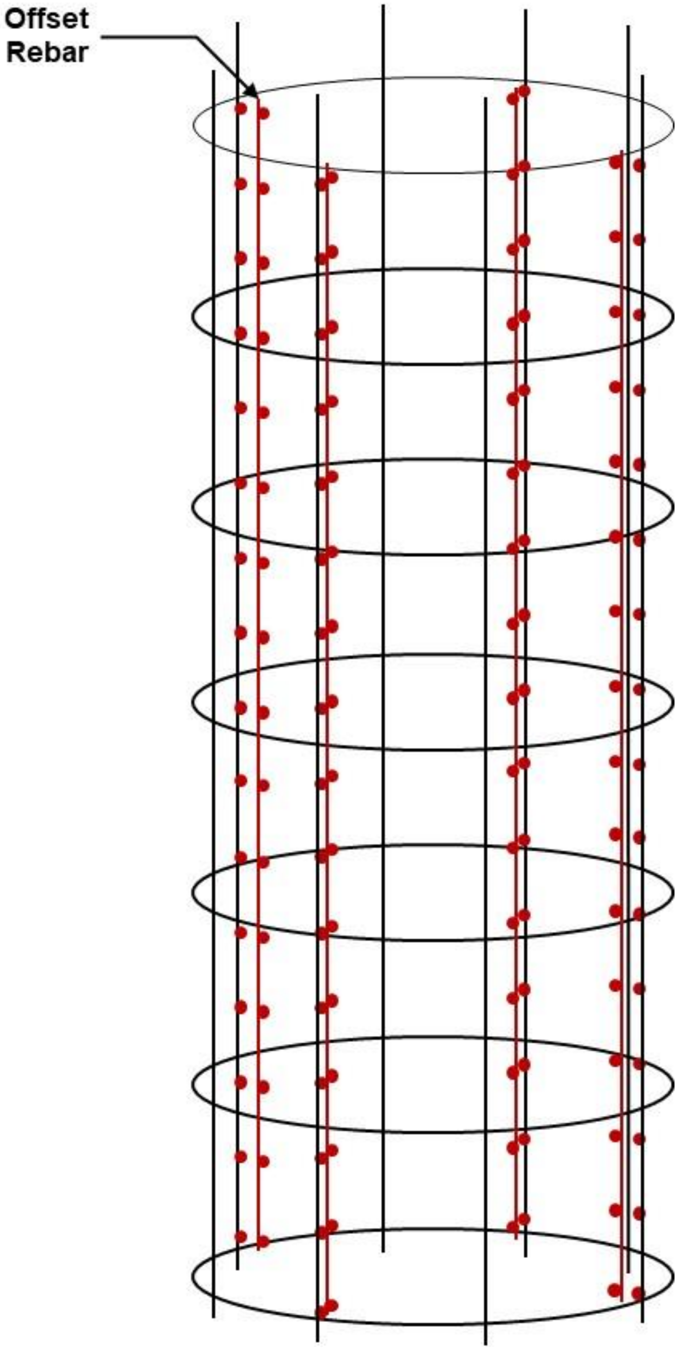


Figure 3.59 Bartow shaft 1-4 thermal sensor layout schematic.

[This is a diagram illustrating the thermal sensor layout the Bartow drilled shaft with all sensors highlighted in red.]

In addition to thermal wire sensors, several runs of thermal integrity probe testing were performed both one day and two days after concreting. The data collected via probe testing was not used below for traditional thermal integrity analysis but was analyzed using the individual infrared sensor readings. These data and subsequent analyses will be presented in detail in Chapter 4.

3.6.2 Collected Data

Temperature measurement data from the installed thermal wires, environmental conditions during construction, FDOT drilled shaft log, concrete mix design, and mill certificates associated with drilled shaft Bartow shaft 1-4 were collected and cataloged. Table 3.28 presents the Temperature Analysis Shaft Information for Bartow shaft 1-4.

Table 3.28 Bartow shaft 1-4 temperature analysis shaft information.

Data Collection Start Time:	11/30/22 14:12
Drilled Shaft Diameter:	54 inches
Cage Diameter:	42 inches
Drilled Shaft Length:	17.02 feet
Average Temperature:	121.65°F
Local Minimum Temperature:	100.83°F at 0 feet on Wire 1
Local Maximum Temperature:	130.99°F at 4 feet on Wire 1

Figure 3.60 presents all longitudinal temperature data versus depth for Bartow shaft 1-4 recorded 28 hours after concreting. This is when peak average cage temperature occurred. The average temperature profile is given as the bold black line marker also denoted as “AVG.” The location of peak average cage temperature is marked at 4 feet with the temperature measurement of 128.49°F shown. This depth location was used to plot the temperature evolution over time at that depth for the entire testing duration (Figure 3.61).

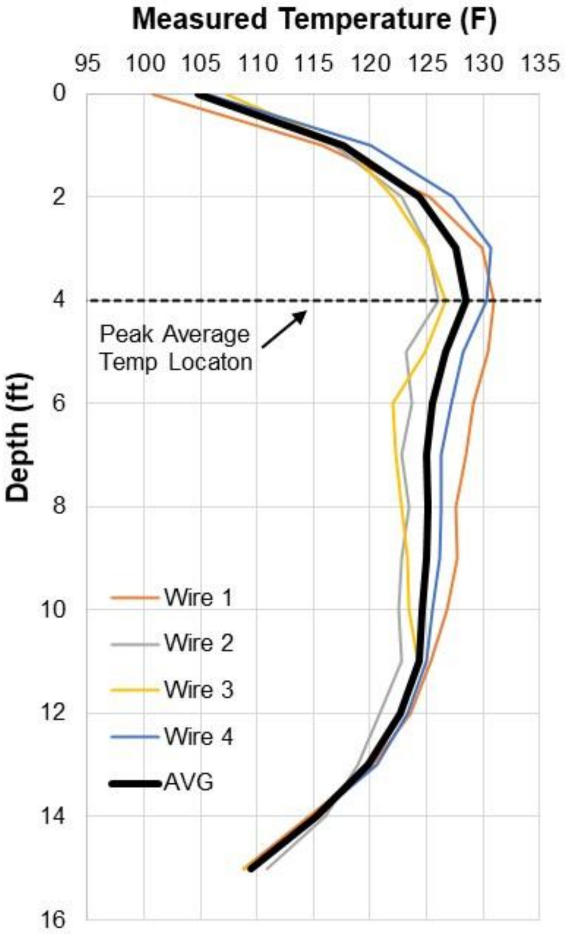


Figure 3.60 Plot presenting Bartow shaft 1-4 temperature versus depth data at peak average cage temperature (28 hours into testing).

[This is a plot presenting temperature data on the x-axis versus depth data on the y-axis and includes temperature measurements from all four thermal wires installed at the reinforcement cage. The depth reaches 15 feet, and temperature measurements range from approximately 100ºF to 131ºF.]

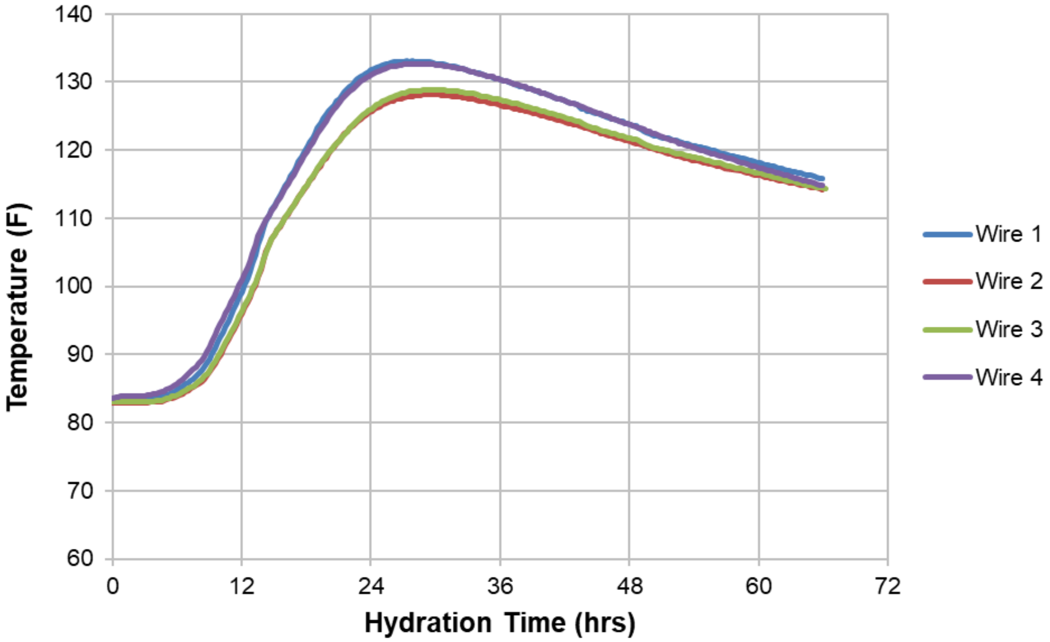


Figure 3.61 Plot presenting Bartow shaft 1-4 temperature versus time data at a depth of 4 feet, where peak average cage temperature occurred (28 hours into testing).

[This is a plot presenting temperature data on the y-axis versus time on the x-axis at a depth of 4 feet and includes temperature measurements from all four thermal wires installed at the reinforcement cage. The time ranges from 0 to 66 hours, and the temperature measurements range from approximately 84ºF to 133ºF.]

Figure 3.62 presents temperature gradient in °F/inch versus depth. The temperature gradient was calculated on one-foot depth increments by subtracting the temperature measured at the reinforcement cage location from the corresponding offset temperature measurement then dividing by each measured offset distance. Based on the across-shaft temperature distributions measured from the Sinclair Hills drilled shaft and OC-19, the relationship between temperature and distance at this location was assumed to be linear.

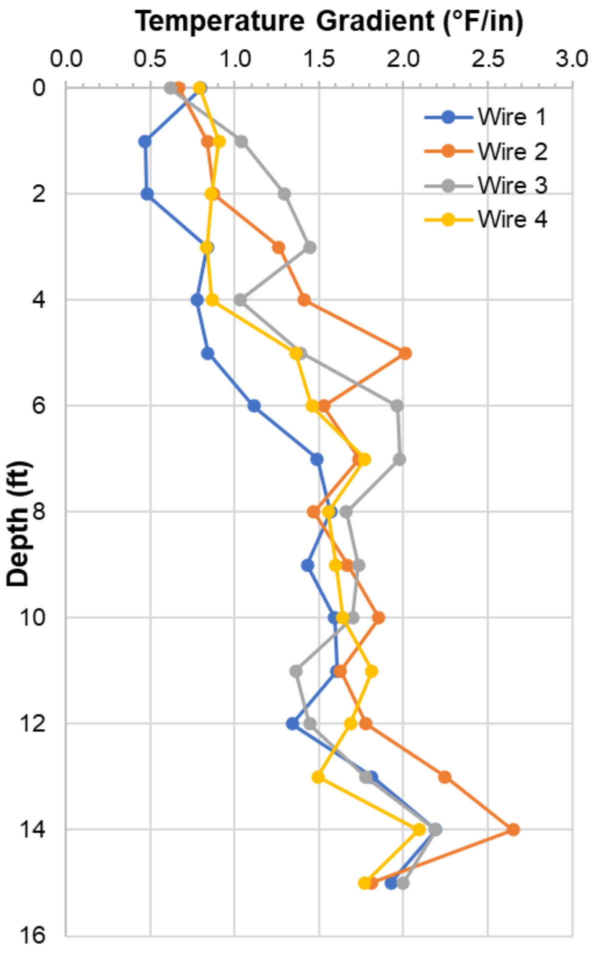


Figure 3.62 Plot presenting Bartow shaft 1-4 temperature gradient versus depth.

[This is a plot presenting temperature data on the x-axis versus depth data on the y-axis and includes temperature gradients from all four thermal wires. The depth reaches 15 feet, and temperature gradients range from approximately 0.5ºF/in to 2.6ºF/in.]

Similar to the Temperature Analysis Shaft Information, the Radius Analysis Shaft Information is presented in Table 3.29. Figure 3.63 presents the radius versus depth profile for Bartow shaft 1-4. This plot also includes concrete cover results based on the size and location of the reinforcement cage.

Table 3.29 Bartow shaft 1-4 radius analysis shaft information.

Average Radius:	28.1 inches
Local Minimum Radius:	27.09 inches at 6 feet at Wire 3
Local Maximum Radius:	29.68 inches at 2 feet at Wire 4

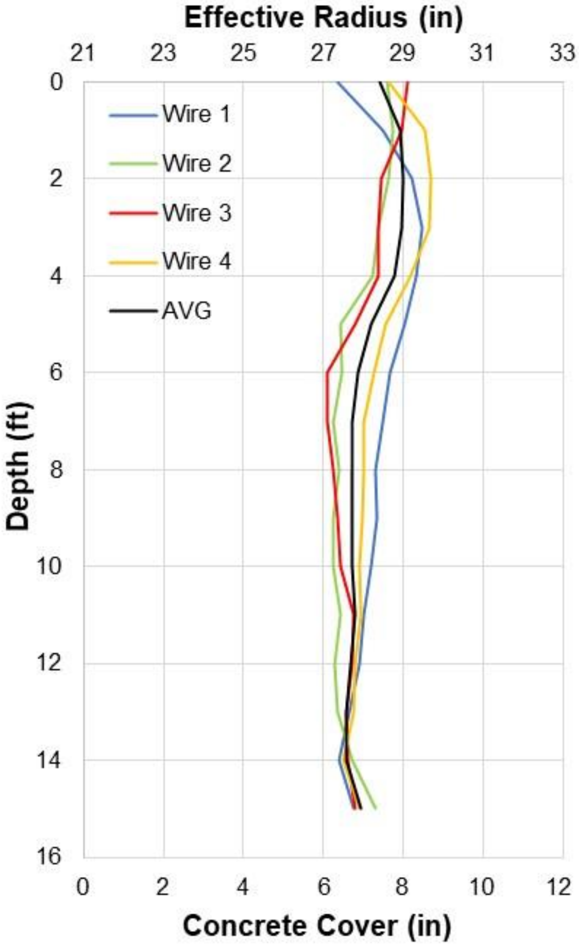


Figure 3.63 Plot presenting Bartow shaft 1-4 radius versus depth data.

[This is a plot presenting radius and concrete cover data on the x-axis versus depth data on the y-axis and includes radius values for the locations of all four thermal wires installed at the reinforcement cage. The depth reaches 15 feet, and radius values range from approximately 27 to 30 inches. Concrete cover values range from approximately 6 to 9 inches.]

3.6.3 Data Availability

All collected data was archived in various formats and posted on the USF research website for future queries (geotech.eng.usf.edu/downloads/PeakTemperatureProject).

Chapter Four: Data Analysis and Modeling

This chapter discusses the data analysis and modeling of drilled shaft temperature distributions. In addition to the collection of new temperature data, numerical modeling in COMSOL Multiphysics® was performed. A total of 330 modeled radial temperature distributions over time (from 1 to 200 hours on one-hour increments) were developed.

4.1 Modeling Approach

Extending the works of Schindler and Folliard (2002; 2005), Poole (2007) modeled the hydration of concrete, and therefore evolution of heat, for different concrete mix designs while also including supplementary cementitious materials such as blast furnace slag and fly ash. This collection of work follows a common parameter format that defines the degree of hydration curve and formulates these parameters: the ultimate degree of hydration (α_u), the rate of acceleration phase (β), and the start of acceleration phase (τ). Using the governing equations from Schindler, Folliard, and Poole (2002; 2005; 2007) as a heat source, Johnson (2017) developed a modeling method specific to COMSOL Multiphysics® that also incorporates heat diffusion into the soil. This model is a time dependent study that separates the time dependent solver into three segregated steps to properly apply the hydration model. These steps in order are: (1) Equivalent Age (t_e), (2) Degree of Hydration (α), and (3) Temperature (T). Similar to the model parameter formats of Schindler, Folliard, and Poole, mill certificate data for all cementitious materials (Portland cement, slag, and/or fly ash) are required inputs. Mill certificates for the cement, flyash, and slag are provided in the Appendices, Figures C.7, F.3, and C.8, respectively.

Following the general setup of the thermal model outlined in Johnson, 2017, a one-dimensional axisymmetric model using the *Heat Transfer in Solids* module with two separate Coefficient Form PDE modules was created in COMSOL Multiphysics®. This resulted in a two-dimensional geometry where a concrete shaft of diameter *D* is bounded by a concentric soil mass of diameter 4*D*. The thermal properties of the soil mass were those consistent with high diffusivity saturated sand and were used for all models. Specifically, the thermal conductivity was specified as 3 W/(m·K), density as 1700 kg/m^3, and heat capacity as 800 J/(kg·K). Both the soil and initial concrete temperatures were specified as 73°F, where the initial concrete temperature is intended to correspond to the batch temperature of a concrete mix. Three concrete mix designs (Table 4.1) were used to create eleven mix proportions with varying total cementitious contents (TCC). Specifically, the total cementitious contents for each mix proportion were, 260 lb/yd^3, 360 lb/yd^3, 460 lb/yd^3, 560 lb/yd^3, 660 lb/yd^3, 760 lb/yd^3, 860 lb/yd^3, 960 lb/yd^3, 1060 lb/yd^3, 1160 lb/yd^3, and 1260 lb/yd^3. Concrete shaft diameters ranged from one to ten feet, on one-foot increments, for each mix proportion. Water-to-cement ratios (by mass) and coarse-to-fine aggregate ratios (by volume) remained constant for each mix when scaling the cementitious contents. This resulted in a total of

330 modeled radial temperature distributions over time (from 1 to 200 hours on one-hour increments).

Table 4.1 Mix designs used to create model mix proportions with varying cementitious contents.

34% Fly Ash (Class F)		60% Slag (field site)		100% Cement	
Material	Amount	Material	Amount	Material	Amount
Cement	500 lb/yd^3	Cement	266.1 lb/yd^3	Cement	660 lb/yd^3
Fly Ash	255 lb/yd^3	Slag	393.9 lb/yd^3	Water	260 lb/yd^3
Water	312 lb/yd^3	Water	260.0 lb/yd^3	Coarse Agg.	1615 lb/yd^3
Coarse Agg.	1650 lb/yd^3	Coarse Agg.	1615.6 lb/yd^3	Fine Agg.	1322 lb/yd^3
Fine Agg.	990 lb/yd^3	Fine Agg.	1322.2 lb/yd^3		

4.2 Model Verification

Model values were verified using the data collected from OC-19 (Figure 4.1, left and top right). The concrete mix design used in this drilled shaft corresponds to that found in Table 4.1 (center). The cage location data was first combined with the corresponding across-shaft data. Two different curves are shown (Figure 4.1, bottom right) corresponding to the two lengths of the crossing bars (E-W in the open round markers and N-S in the filled round markers); a zero radial position corresponds to the intersection of the cross bars and the location of the center bar. Figure 4.1 (bottom right) also shows the highest measured temperatures did not occur at the center bar but rather 8.8 inches off-center in the N-S direction and 5.3 inches in the E-W direction. Two model value sets were overlayed for comparison: across shaft at the true center of the model (bold black curve) and across shaft at a 10-inch offset (bold dashed curve) resolved from the hypotenuse of the 8.8-inch and 5.3-inch N-S and E-W offsets, respectively. The offset model value set is nearly identical to the measured data set. Moreover, the across-shaft data at the true center of the model demonstrates that the true peak temperature is difficult to capture even with a center bar and cross bar installation.

The field data was further superimposed onto the modeled 3-D spatial temperature distribution in Figure 4.2. This shows how the N-S and E-W sensor data did not cross through the center of the shaft where the highest core temperatures occurred. The average cage temperature from the four thermal wires at a depth of 16 feet is also shown as the dashed cage position. The edge of shaft temperature shown as a solid black line was determined from model data and was 10°F less than the average cage temperature.

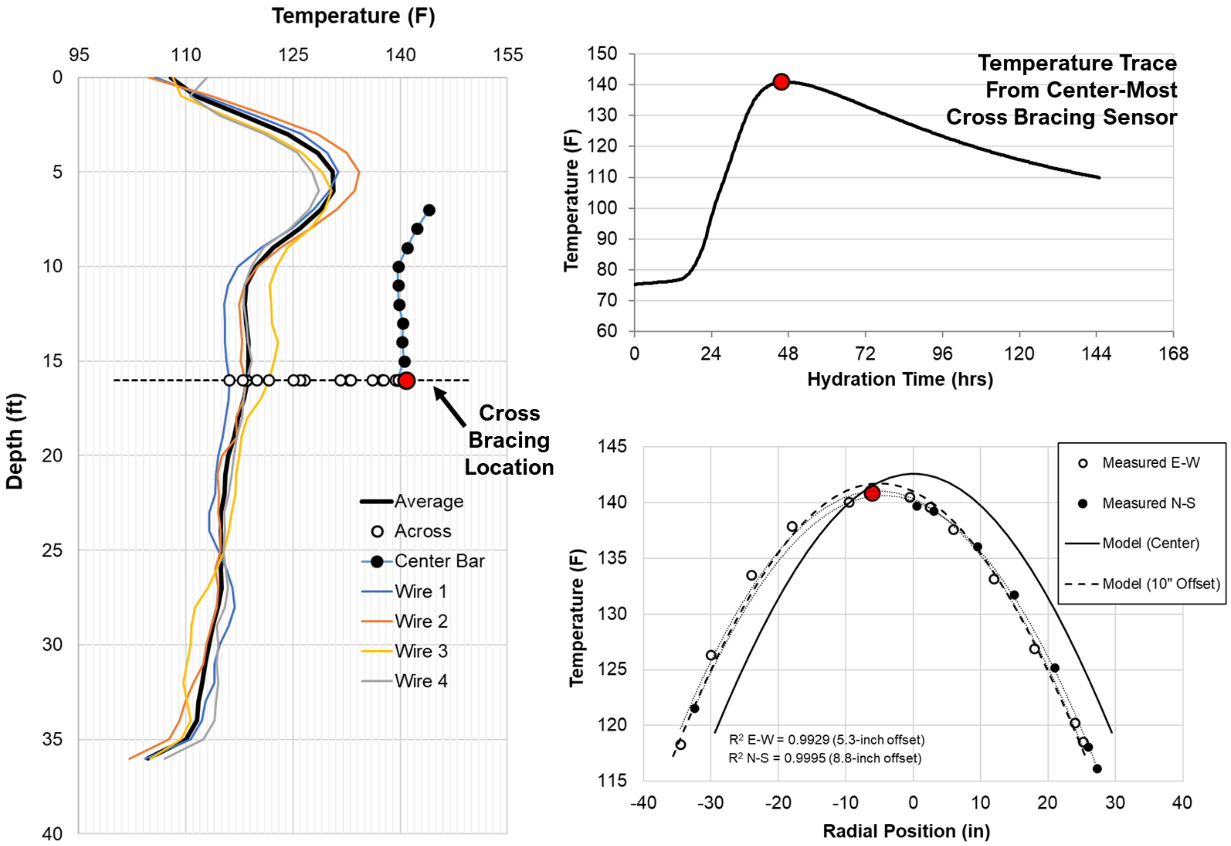


Figure 4.1 Model verification using OC-19 measured data.

[This is a compound figure with three plots: on the left is a plot where the x-axis is temperature and the y-axis is depth in feet with OC-19 temperature data from all four thermal wires located at the cage as well as the center thermal wire; the depth reaches 36 feet and the temperatures range from approximately 110°F to 143°F; the top right is a temperature evolution plot where the x-axis is hydration time in hours and the y-axis is temperature; the time ranges from 0 to 144 hours and the temperature ranges from approximately 75°F to 141°F; the bottom right is a plot presenting the across shaft temperature measurements from drilled shaft OC-19 with model values overlayed for model verification. Two model value sets are included: one from the true center of the model drilled shaft (bold solid curve) and another from a 10-inch offset of the center of the model drilled shaft (bold dashed curve).]

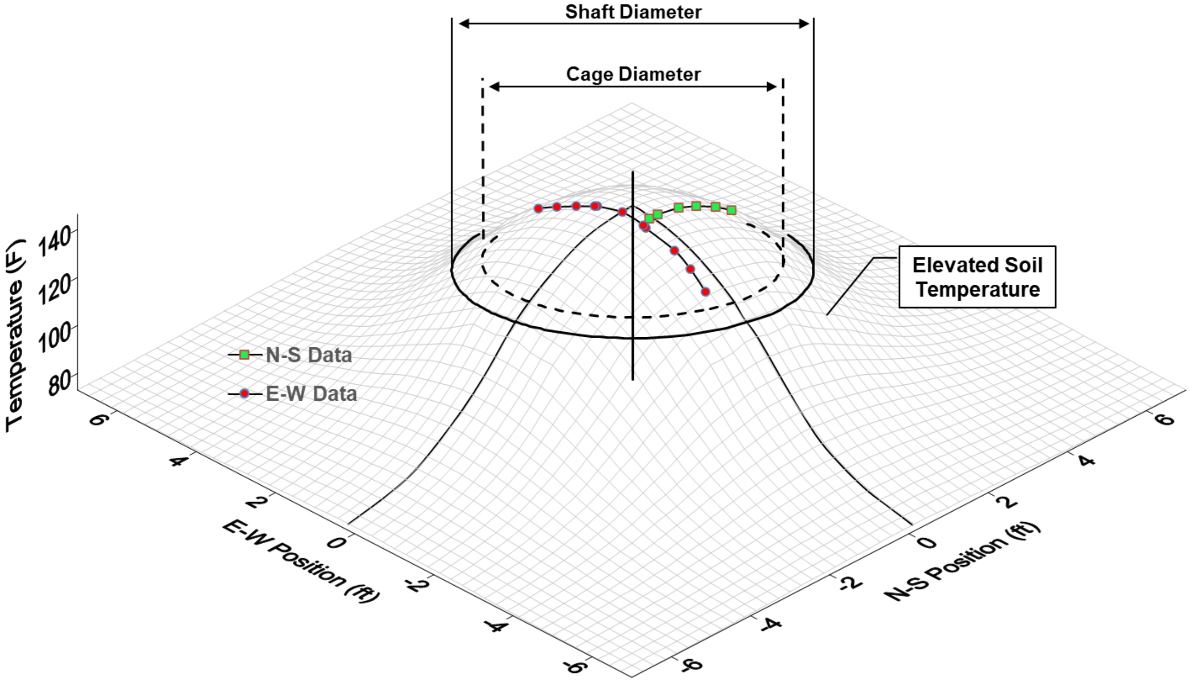


Figure 4.2 Three-dimensional illustration of N-S and E-W across-shaft temperature distributions overlayed on model temperature distribution mesh.
[This is a three-dimensional plot with E-W and N-S radial positions on the x and y axes, respectively, and temperature on the z-axis. Measured across-shaft data has been overlayed on top of the model temperature distribution mesh. Also included is the average cage temperature from the four thermal wires at a depth of 16 feet shown as the dashed cage position and the edge of shaft temperature (determined from model data) shown as a solid black line.]

4.3 Temperature Contour Plots

Using the data generated from the 330 modeled temperature distributions, contour plots were created for both peak and differential temperatures for the three chosen concrete mix proportions (Table 4.1) across the varying cementitious contents and drilled shaft diameters. As expected, peak temperatures were found to occur at the center of each model, and edge-to-core differential temperatures were calculated by subtracting the temperature located at the edge of the shaft model from the center/peak temperature. In addition to edge-to-core differential temperatures, cage-to-core differential temperatures were also calculated. Figures 4.3 to 4.5 show the peak temperature contours, Figures 4.6 to 4.8 edge-to-core differential temperature contours, and Figures 4.9 to 4.11 are the cage-to-core differentials all for fly ash, slag, and pure cement mixes, respectively.

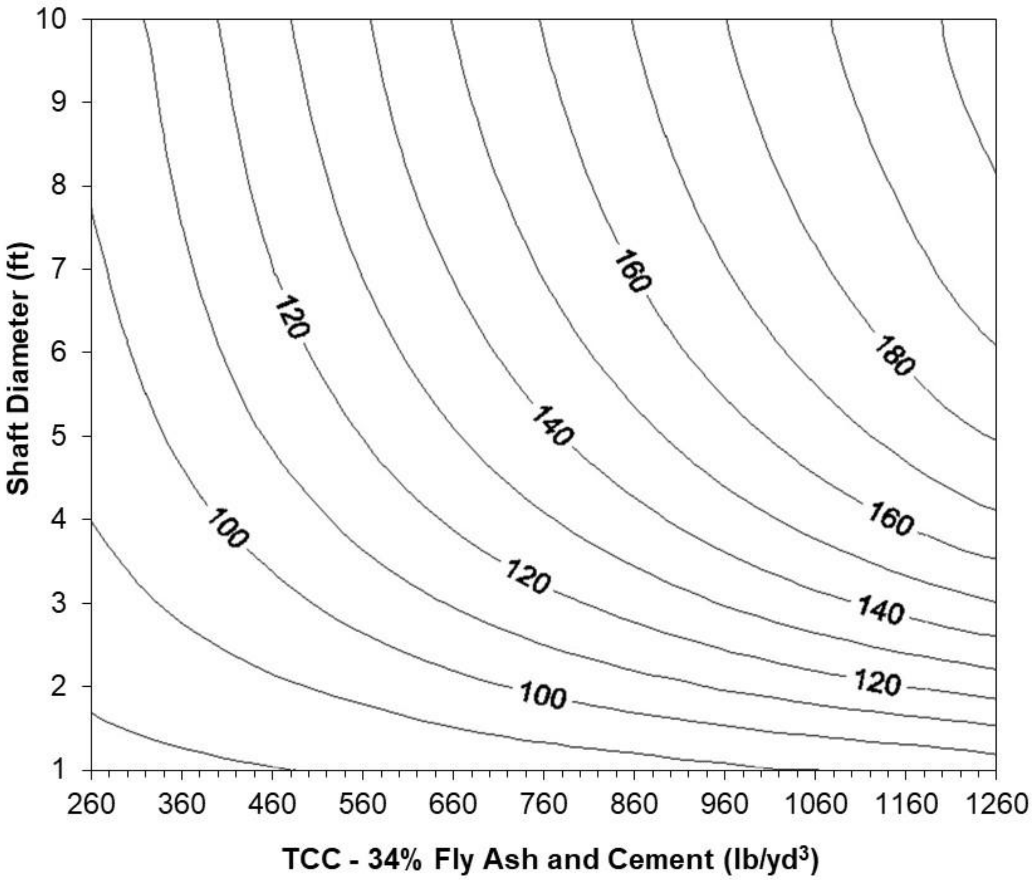


Figure 4.3 Peak temperature (°F) contour plot for 34% fly ash mix.

[This is a contour plot presenting modeled peak temperatures for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 34% fly ash concrete mix and various drilled shaft diameters (ranging from 1 to 10 feet on the y-axis). The lowest contour line is 80ºF and the highest contour line is 200ºF.]

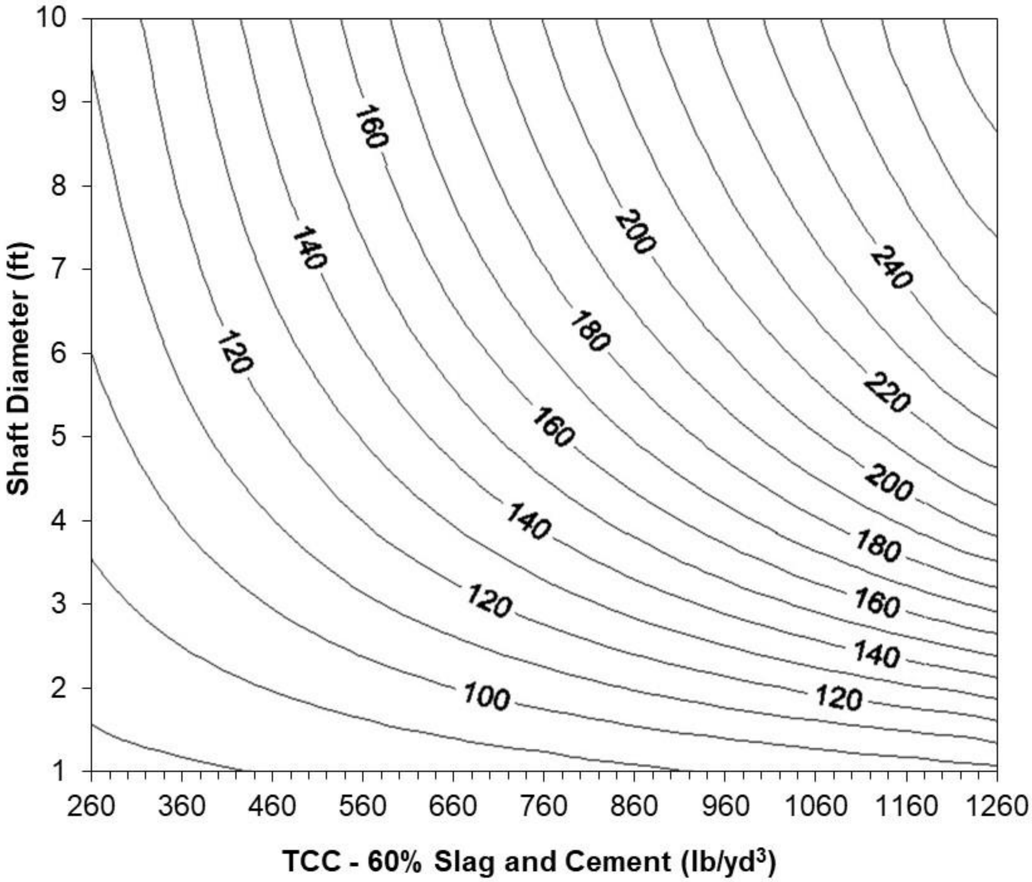


Figure 4.4 Peak temperature (°F) contour plot for 60% slag mix.

[This is a contour plot presenting modeled peak temperatures for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 60% slag concrete mix and various drilled shaft diameters (ranging from 1 to 10 feet on the y-axis). The lower contour line is 80ºF and the upper contour line is 270ºF.]

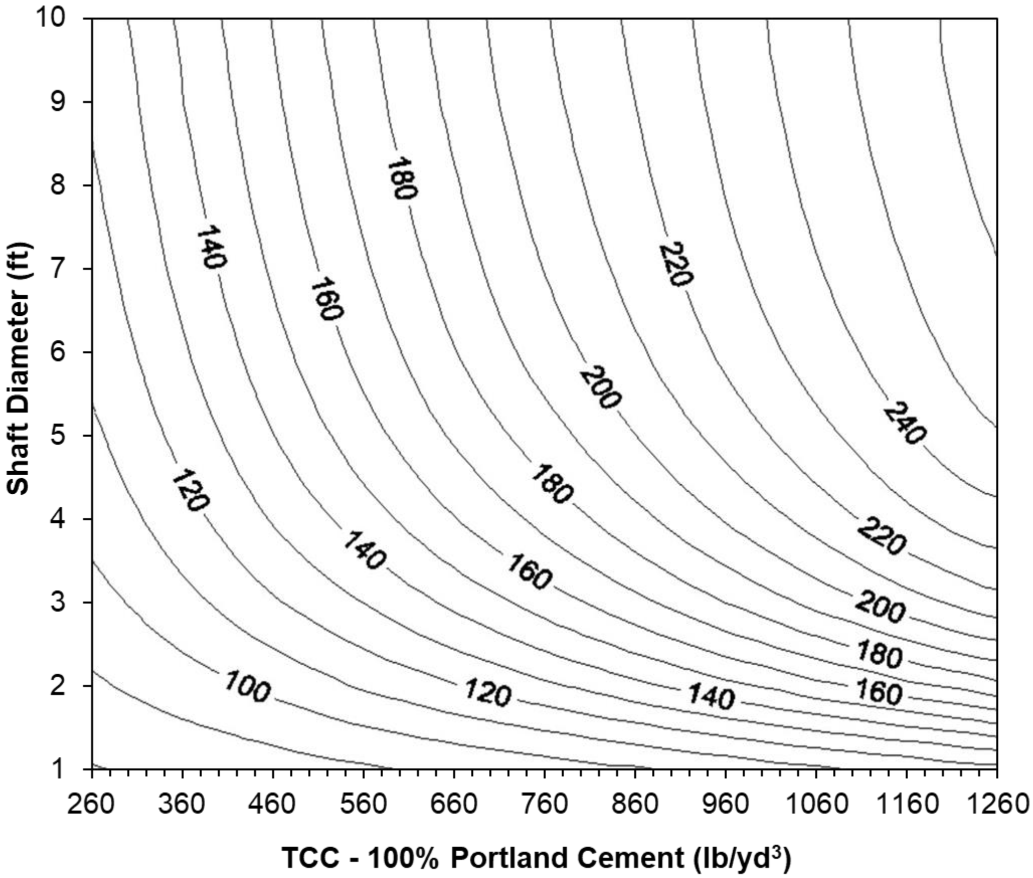


Figure 4.5 Peak temperature (°F) contour plot for 100% Portland cement mix.

[This is a contour plot presenting modeled peak temperatures for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 100% Portland cement concrete mix and various drilled shaft diameters (ranging from 1 to 10 feet on the y-axis). The lower contour line is 80ºF and the upper contour line is 260ºF.]

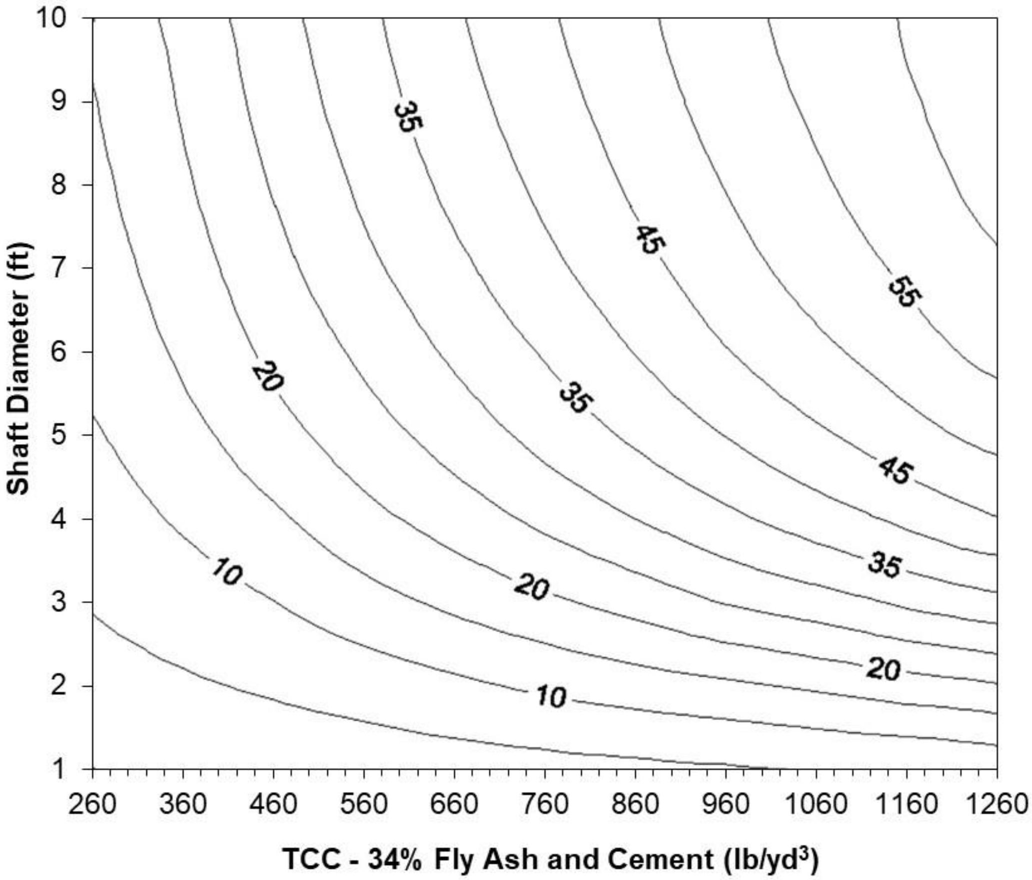


Figure 4.6 Edge-to-core differential temperature (°F) contour plot for 34% fly ash mix.

[This is a contour plot presenting modeled differential edge-to-core temperatures for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 34% fly ash concrete mix and various drilled shaft diameters (ranging from 1 to 10 feet on the y-axis). The lower contour line is 5ºF and the upper contour line is 60ºF.]

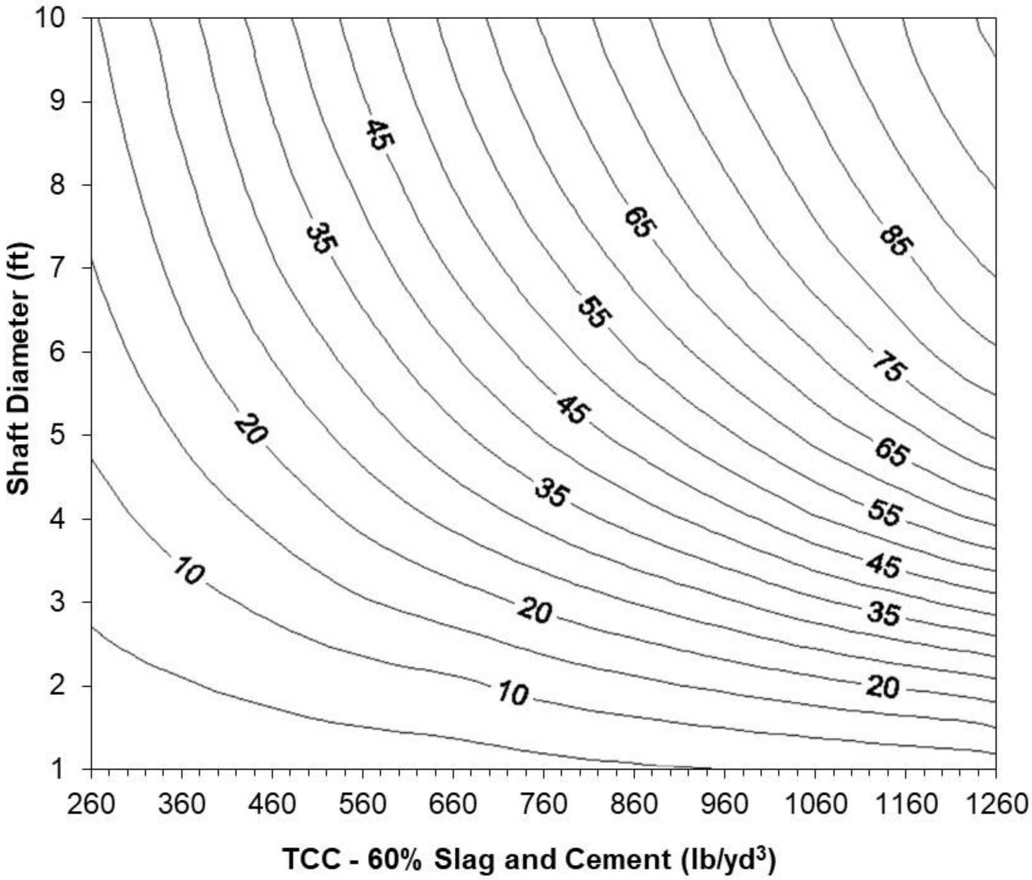


Figure 4.7 Edge-to-core differential temperature (°F) contour plot for 60% slag mix.

[This is a contour plot presenting modeled differential edge-to-core temperatures for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 60% slag concrete mix and various drilled shaft diameters (ranging from 1 to 10 feet on the y-axis). The lower contour line is 5ºF and the upper contour line is 100ºF.]

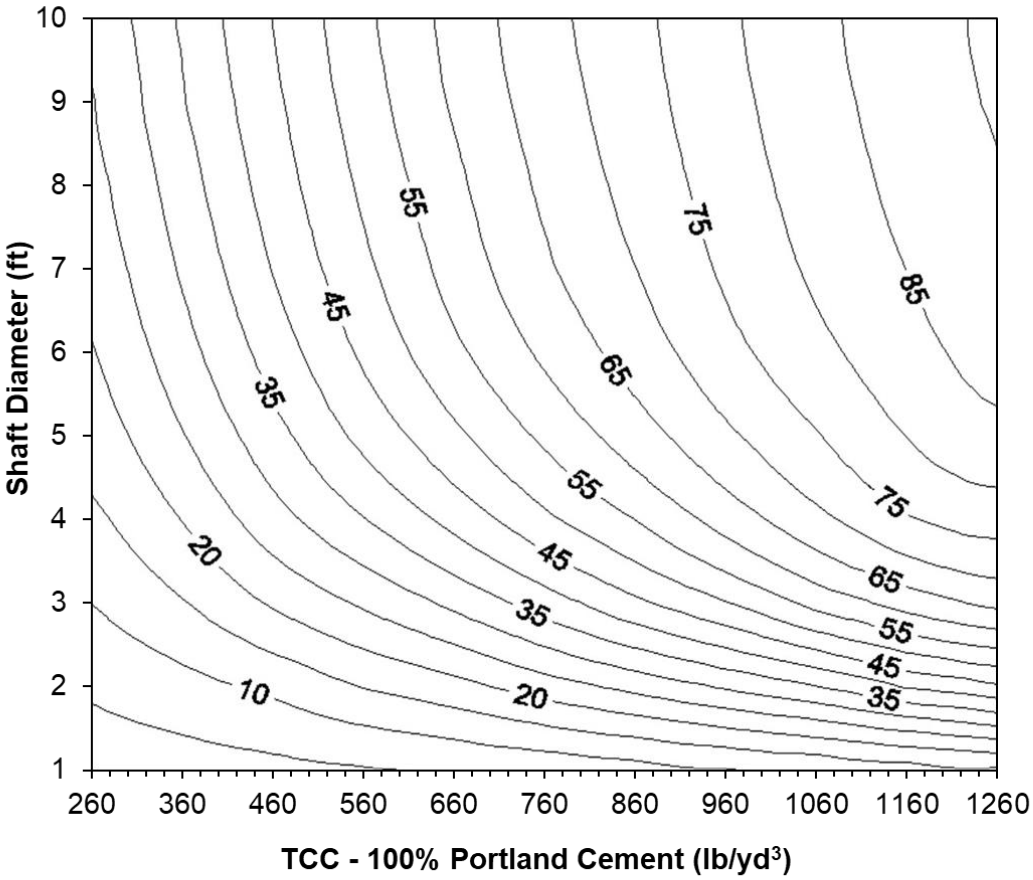


Figure 4.8 Edge-to-core differential temperature (°F) contour plot for 100% Portland cement mix. *[This is a contour plot presenting modeled differential edge-to-core temperatures for various cementitious material contents (ranging from 260 to 1260 lb/yd*^{3} *on the x-axis) for a 100% Portland cement concrete mix and various drilled shaft diameters (ranging from 1 to 10 feet on the y-axis). The lower contour line is 5ºF and the upper contour line is 90ºF.]*

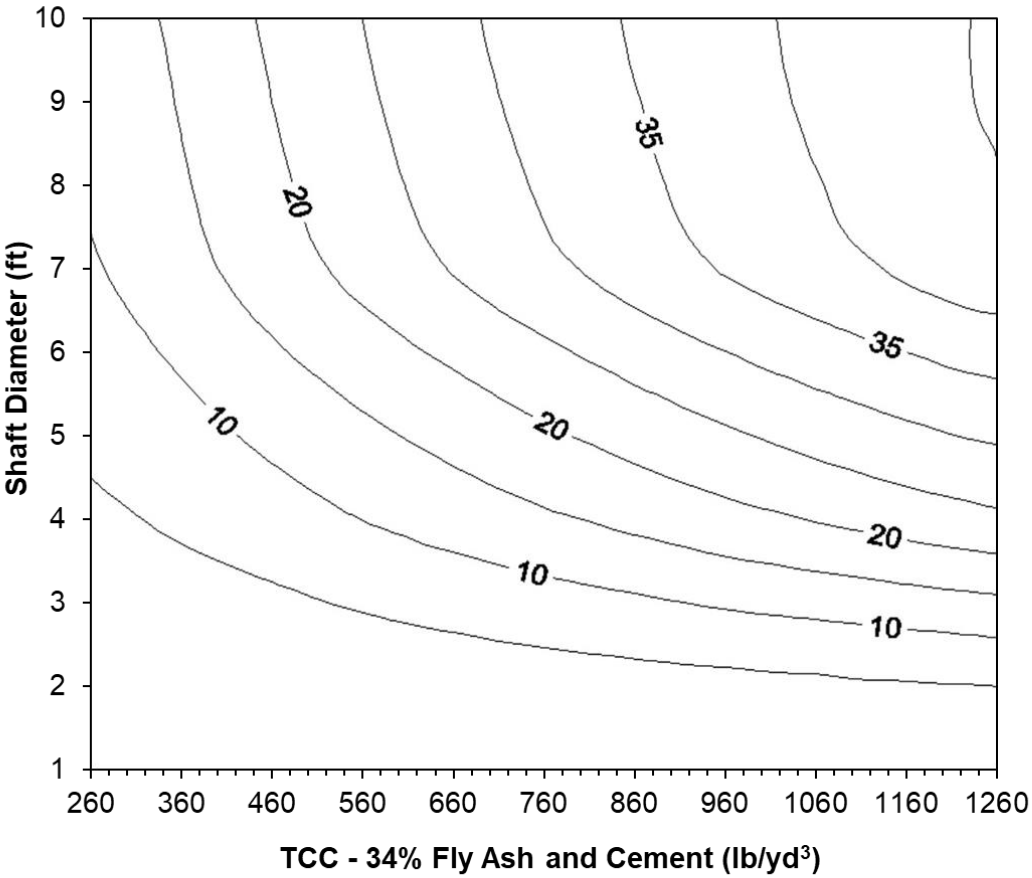


Figure 4.9 Cage-to-core differential temperature (°F) contour plot for 34% fly ash mix.

[This is a contour plot presenting modeled differential cage-to-core temperatures for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 34% fly ash concrete mix and various reinforcement cage radii (ranging from 0 to 4.5 feet on the y-axis). The lower contour line is 5ºF and the upper contour line is 45ºF.]

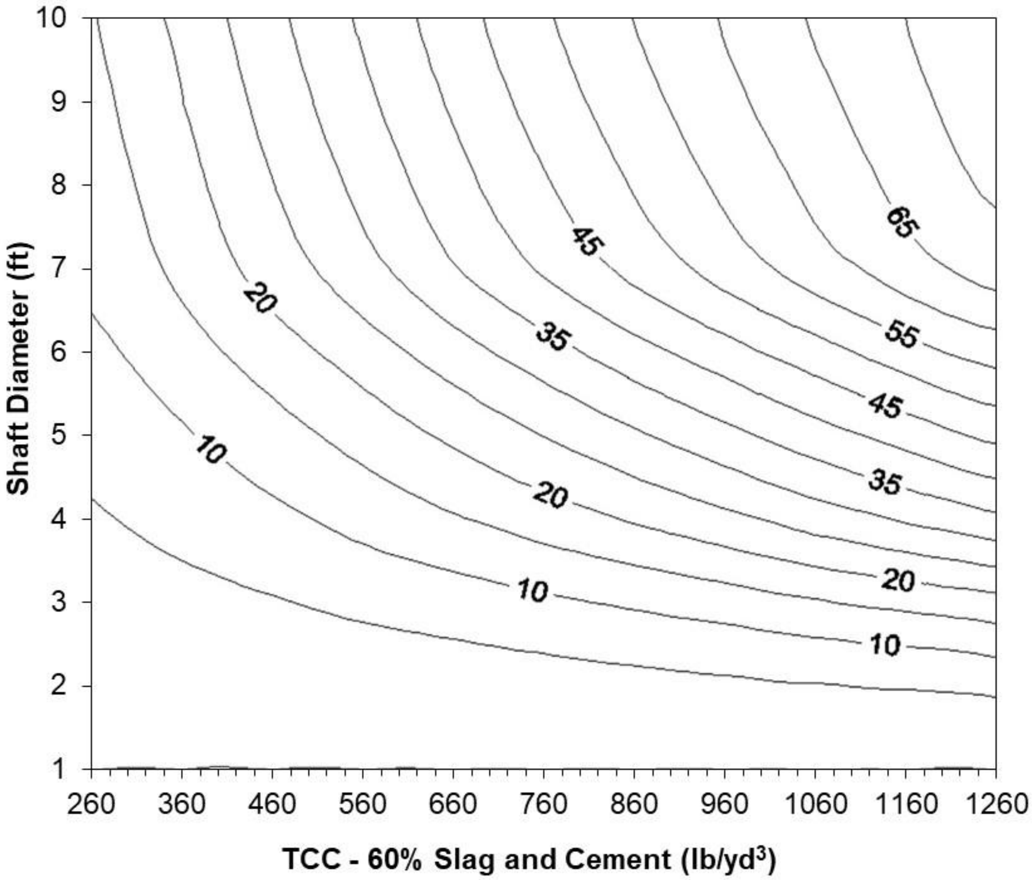


Figure 4.10 Cage-to-core differential temperature (°F) contour plot for 60% slag mix.

[This is a contour plot presenting modeled differential cage-to-core temperatures for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 60% slag concrete mix and various reinforcement cage radii (ranging from 0 to 4.5 feet on the y-axis). The lower contour line is 5°F and the upper contour line is 70°F.]

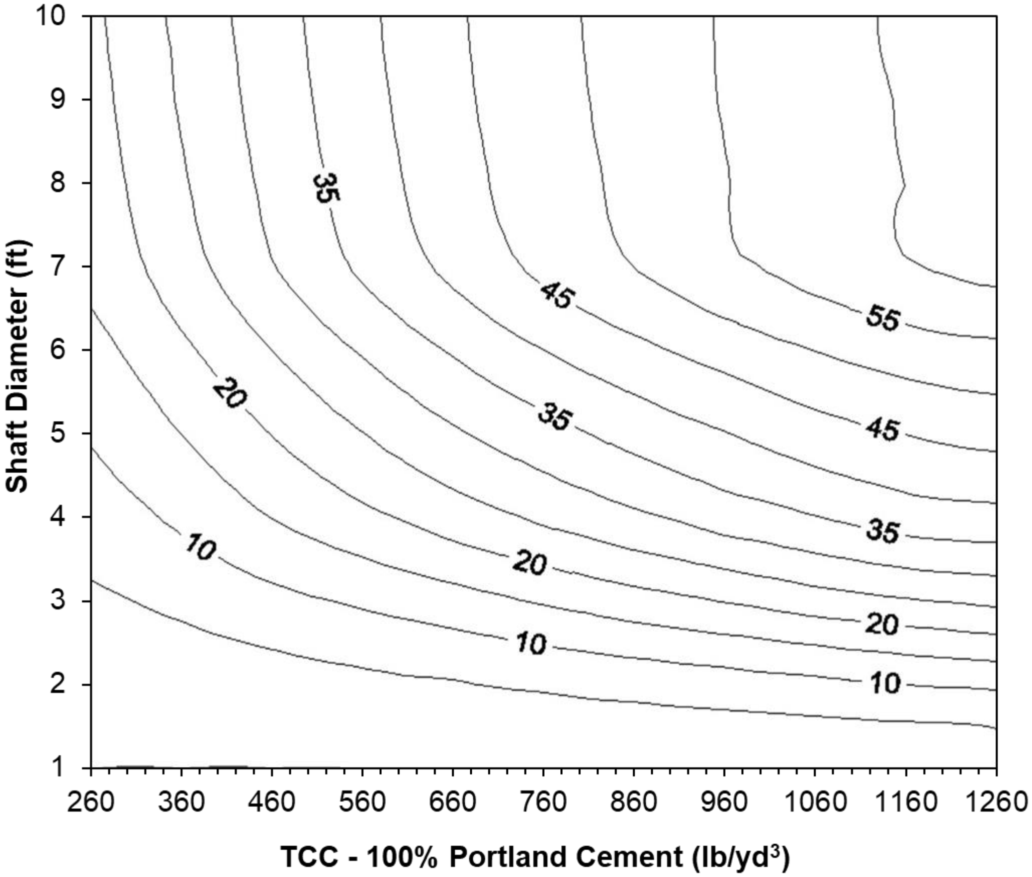


Figure 4.11 Cage-to-core differential temperature (°F) contour plot for 100% Portland cement mix. *[This is a contour plot presenting modeled differential cage-to-core temperatures for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 34% fly ash concrete mix and various reinforcement cage radii (ranging from 0 to 4.5 feet on the y-axis). The lower contour line is 5°F and the upper contour line is 60°F.]*

4.4 Data Analysis

The following explains the analysis and various prediction methods developed using both the collected field data and modeled temperature distributions presented in Chapter 3 and the preceding sections of Chapter 4.

4.4.1 Model Data Summaries

As noted, a total of 330 modeled radial temperature distributions over time were developed for three unique concrete mix designs, or 110 modeled radial temperature distributions for each mix design. The slag and fly ash mix designs were representative of common shaft mixes presently used in Florida and were based on two typical mixes found to occur most frequently in the database of shafts where temperature measurements and mix design were furnished. The pure Portland cement mix, while not commonly used, was presented for context and for possible later consideration by utility companies that are reluctant to use any replacement cementitious materials in transmission line power pole foundations. Summaries have been tabulated below for each mix design with respect to which conditions result in a failing drilled shaft based on a 160°F peak temperature or 35°F edge-to-core differential temperature (Tables 6.1–6.3).

Table 4.2 Drilled shaft diameter limits for each TCC – 34% fly ash mix.

TCC (pcy)	Diameter Limit (ft)
260	All diameters passed both peak and edge-to-core differential limits.
360	All diameters passed both peak and edge-to-core differential limits.
460	All diameters passed both peak and edge-to-core differential limits.
560	All diameters passed both peak and edge-to-core differential limits.
660	All diameters passed 160°F and 180°F peak temperature limit >7 ft fails edge-to-core differential
760	All diameters passed 180°F peak temperature limit >9 ft fails 160°F peak >5 ft fails edge-to-core differential
860	All diameters passed 180°F peak temperature limit >6 ft fails 160°F peak >4 ft fails edge-to-core differential
960	>9 ft fails 180°F peak >5 ft fails 160°F peak >4 ft fails edge-to-core differential
1060	>7 ft fails 180°F peak >4 ft fails 160°F peak >3 ft fails edge-to-core differential
1160	>7 ft fails 180°F peak >3 ft fails 160°F peak >3 ft edge-to-core differential
1260	>4 ft fails 180°F peak >3 ft fails 160°F peak >3 ft fails edge-to-core differential

Table 4.3 Drilled shaft diameter limits for each TCC – 60% slag mix.

TCC (pcy)	**Diameter Limit (ft)**
260	All diameters passed both peak and edge-to-core differential limits.
360	All diameters passed both peak and edge-to-core differential limits.
460	All diameters passed 160°F and 180°F peak temperature limit >8 ft fails edge-to-core differential
560	All diameters passed 180°F peak temperature limit >9 ft fails 160°F peak >6 ft fails edge-to-core differential
660	>9 ft fails 180°F peak >6 ft fails 160°F peak >5 ft fails edge-to-core differential
760	>7 ft fails 180°F peak >5 ft fails 160°F peak >4 ft fails edge-to-core differential
860	>5 ft fails 180°F peak >4 ft fails 160°F peak >3 ft fails edge-to-core differential
960	>4 ft fails 180°F peak >3 ft fails 160°F peak >3 ft fails edge-to-core differential
1060	>4 ft fails 180°F peak >3 ft fails 160°F peak >3 ft fails edge-to-core differential
1160	>3 ft fails 180°F peak >2 ft fails 160°F peak >2 ft fails edge-to-core differential
1260	>3 ft fails 180°F peak >2 ft fails 160°F peak >2 ft fails edge-to-core differential

Table 4.4 Drilled shaft diameter limits for each TCC – 100% Type IL cement mix.

TCC (pcy)	Diameter Limit (ft)
260	All diameters passed both peak and edge-to-core differential limits.
360	All diameters passed 160°F and 180°F peak temperature limit >9 ft fails edge-to-core differential
460	All diameters passed 180°F peak temperature limit >9 ft fails 160°F peak >5 ft fails edge-to-core differential
560	All diameters passed 180°F peak temperature limit >5 ft fails 160°F peak >4 ft fails edge-to-core differential
660	>6 ft fails 180°F peak >4 ft fails 160°F peak >3 ft fails edge-to-core differential
760	>4 ft fails 180°F peak >3 ft fails 160°F peak >2 ft fails edge-to-core differential
860	>3 ft fails 180°F peak >2 ft fails 160°F peak >2 ft fails edge-to-core differential
960	>3 ft fails 180°F peak >2 ft fails 160°F peak >2 ft fails edge-to-core differential
1060	>2 ft fails 180°F peak >2 ft fails 160°F peak >2 ft fails edge-to-core differential
1160	>2 ft fails 180°F peak >1 ft fails 160°F peak >1 ft edge-to-core differential
1260	>2 ft fails 180°F peak >1 ft fails 160°F peak >1 ft edge-to-core differential

4.4.2 Predictive Design Equations

Closed-form expressions for the contour plots presented above were also developed to aid the prediction of peak and differential temperature values. Using both non-linear and linear regression techniques, three-dimensional mathematical functions were derived for peak (T) and edge-to-core differential (ΔT) temperature distributions contour plots for each mix design. Plots were created for both edge-to-core differential temperature and peak temperature versus shaft radius for each mix design (Figures 4.12 through 4.17). Temperatures were grouped by total cementitious content. A non-linear regression (2nd order polynomial) was performed on the temperature versus shaft radius data for each cementitious content group. The non-linear regression coefficients were then plotted versus cementitious content (Figures 4.18 through 4.23), on which a second regression was performed. This is a convenient way to develop three dimensional equations (one dependent variable, T; two independent variables, shaft radius, R, and total cementitious content, TCC). For the slag and fly ash mix models, a linear regression was performed at this step; for the 100% Portland cement mix model, a non-linear regression (2nd order polynomial) was necessary. For the a_3, b_3, and c_3 coefficient regressions, the intercept was set to the concrete placement temperature used in the model, 73°F. This allows for concrete placement temperature to also be considered in the development of these closed-form expressions.

This analysis resulted in a total of six predictive equations (Equations 1–6 below), each dependent on total cementitious content (TCC), the concrete temperature when batched (T_{conc}, can be taken as average air temperature on the day of concrete batching), and shaft radius (R).

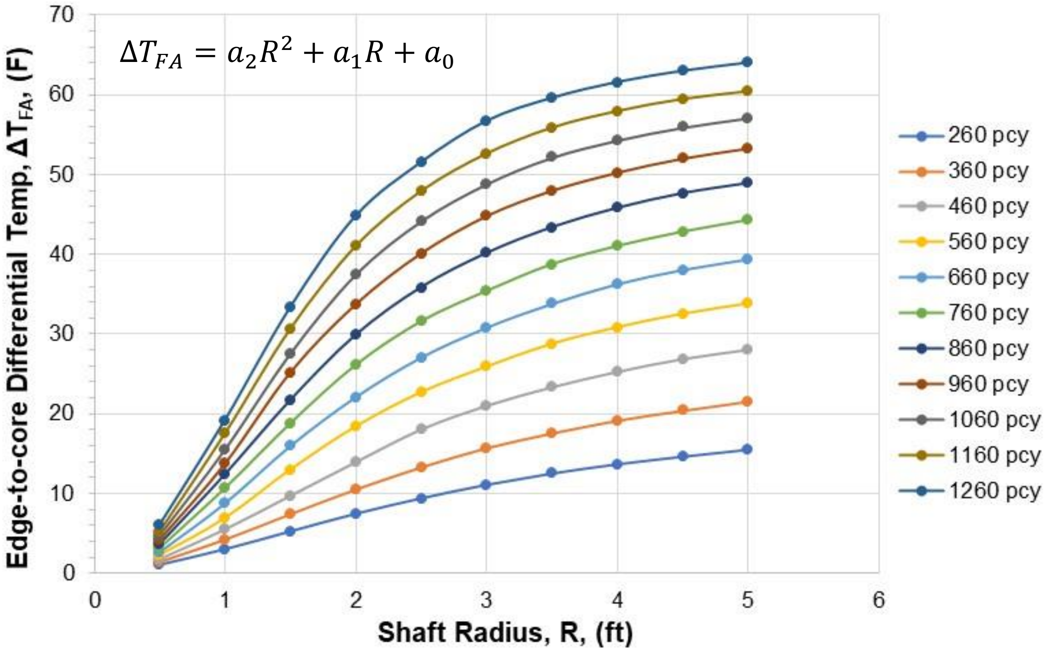


Figure 4.12 Model edge-to-core differential temperature (°F) versus shaft radius for 34% fly ash mix.

[Figure 4.12 Detailed Description: This is a plot presenting modeled edge-to-core differential temperatures on the y-axis and various reinforcement cage radii (ranging from 0 to 5 feet on the x-axis) for various cementitious material contents (ranging from 260 to 1260 lb/yd^3) for a 34% fly ash concrete mix. Each cementitious content is an individual data series, therefore this plot displays 11 individual curves.]

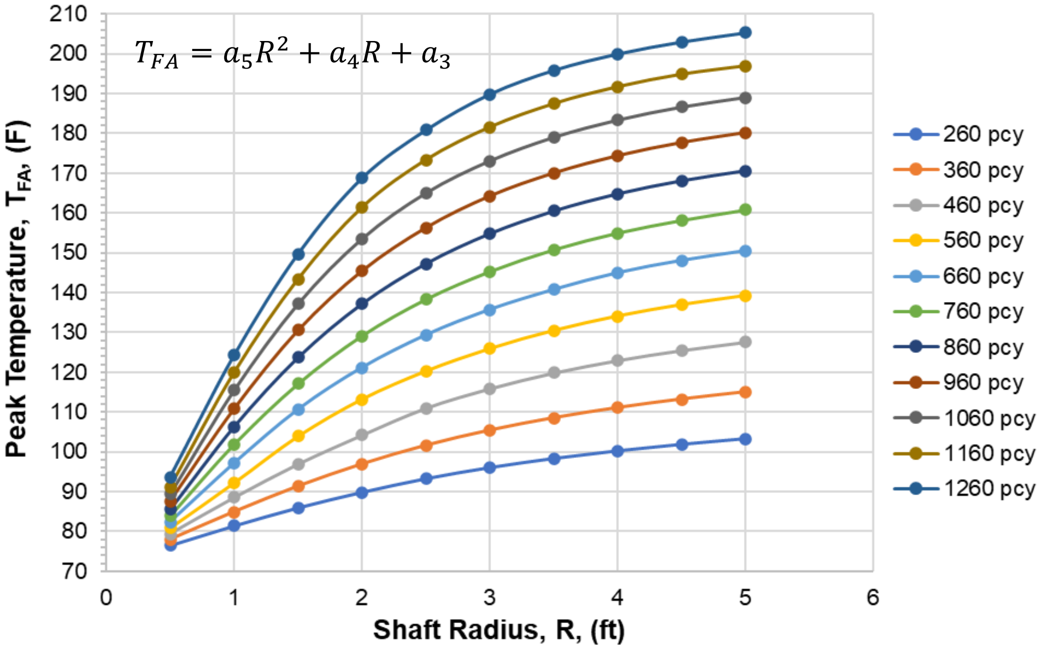


Figure 4.13 Model peak temperature (°F) versus shaft radius for 34% fly ash mix.
[This is a plot presenting modeled peak temperatures on the y-axis and various reinforcement cage radii (ranging from 0 to 5 feet on the x-axis) for various cementitious material contents (ranging from 260 to 1260 lb/yd^3*) for a 34% fly ash concrete mix. Each cementitious content is an individual data series, therefore this plot displays 11 individual curves.]*

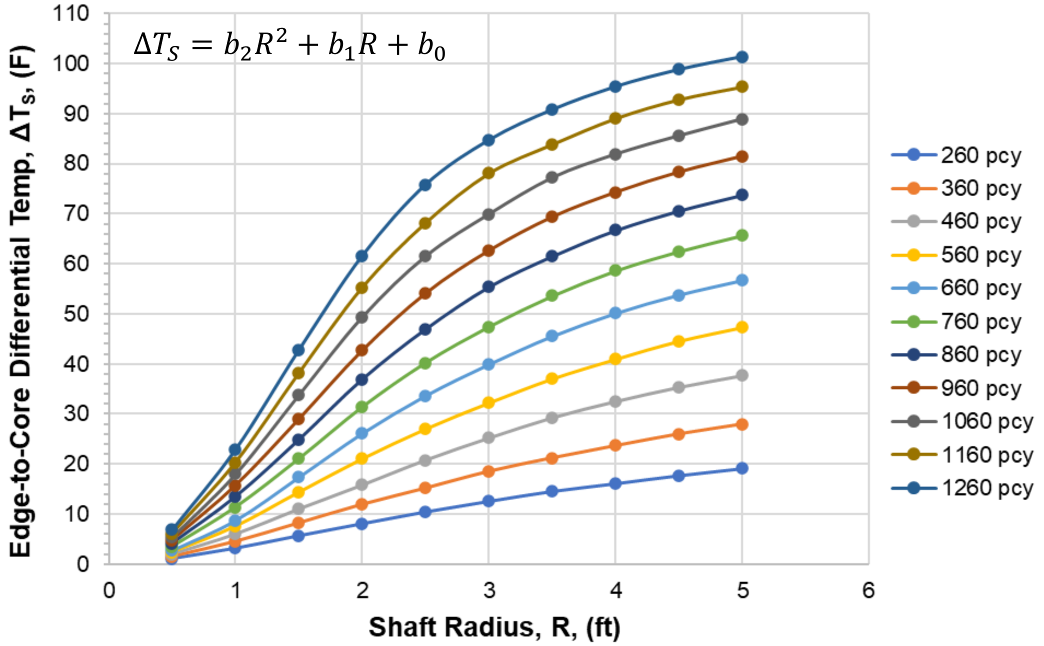


Figure 4.14 Model edge-to-core differential temperature (°F) versus shaft radius for 60% slag mix.

[Figure 4.14 Detailed Description: This is a plot presenting modeled edge-to-core differential temperatures on the y-axis and various reinforcement cage radii (ranging from 0 to 5 feet on the x-axis) for various cementitious material contents (ranging from 260 to 1260 lb/yd^3) for a 60% slag concrete mix. Each cementitious content is an individual data series, therefore this plot displays 11 individual curves.]

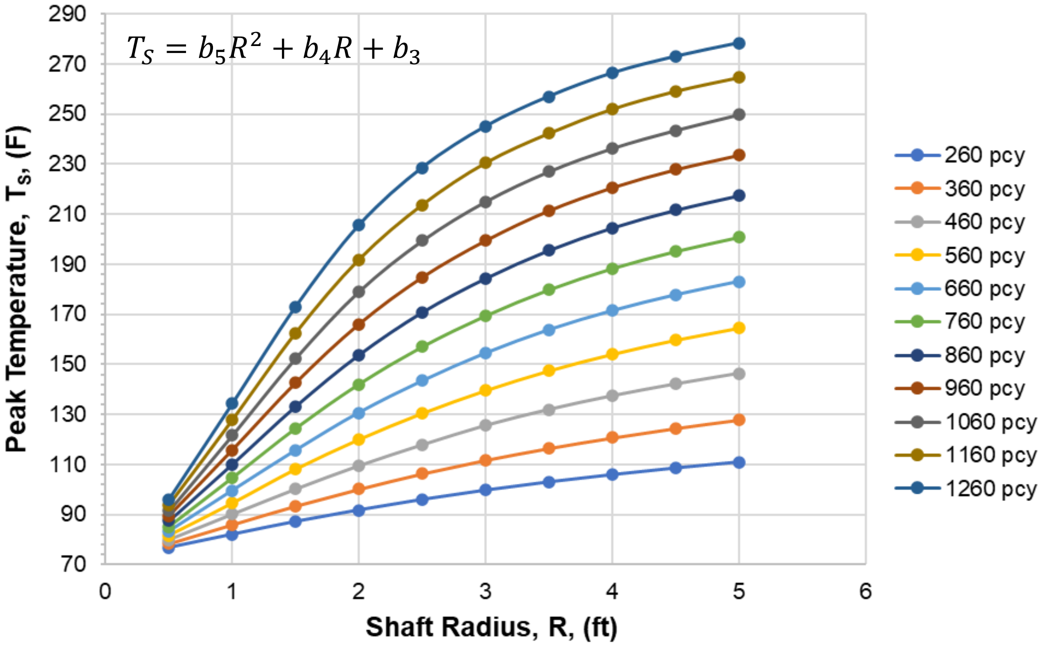


Figure 4.15 Model peak temperature (°F) versus shaft radius for 60% slag mix.

[Figure 4.15 Detailed Description: This is a plot presenting modeled peak temperatures on the y-axis and various reinforcement cage radii (ranging from 0 to 5 feet on the x-axis) for various cementitious material contents (ranging from 260 to 1260 lb/yd^3) for a 60% slag concrete mix. Each cementitious content is an individual data series, therefore this plot displays 11 individual curves.]

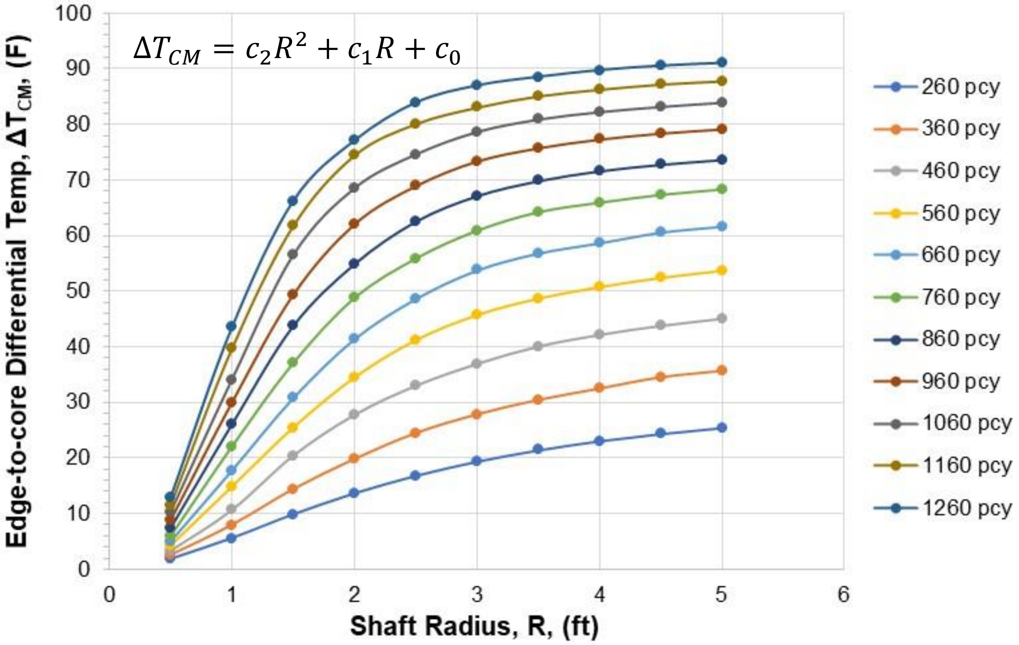


Figure 4.16 Model edge-to-core differential temperature (°F) versus shaft radius for 100% Type IL cement mix.

[This is a plot presenting modeled edge-to-core differential temperatures on the y-axis and various reinforcement cage radii (ranging from 0 to 5 feet on the x-axis) for various cementitious material contents (ranging from 260 to 1260 lb/yd^3) for a 100% Type IL cement concrete mix. Each cementitious content is an individual data series, therefore this plot displays 11 individual curves.]

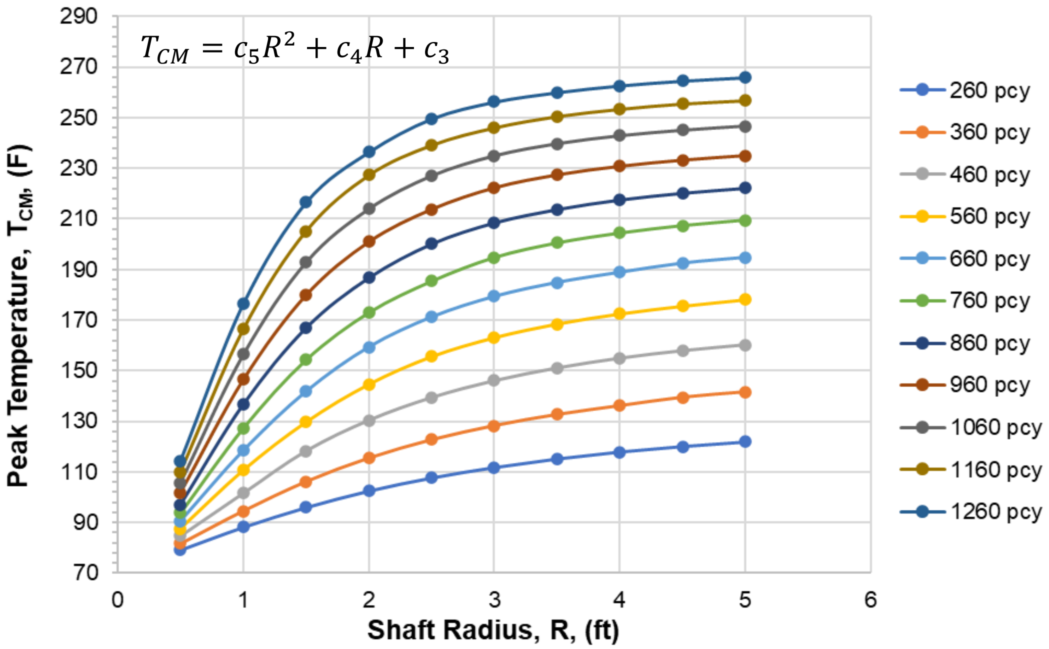


Figure 4.17 Model peak temperature (°F) versus shaft radius for 100% Type IL cement mix.

[Figure 4.17 Detailed Description: This is a plot presenting modeled peak temperatures on the y-axis and various reinforcement cage radii (ranging from 0 to 5 feet on the x-axis) for various cementitious material contents (ranging from 260 to 1260 lb/yd^3) for a 100% Type IL cement concrete mix. Each cementitious content is an individual data series, therefore this plot displays 11 individual curves.]

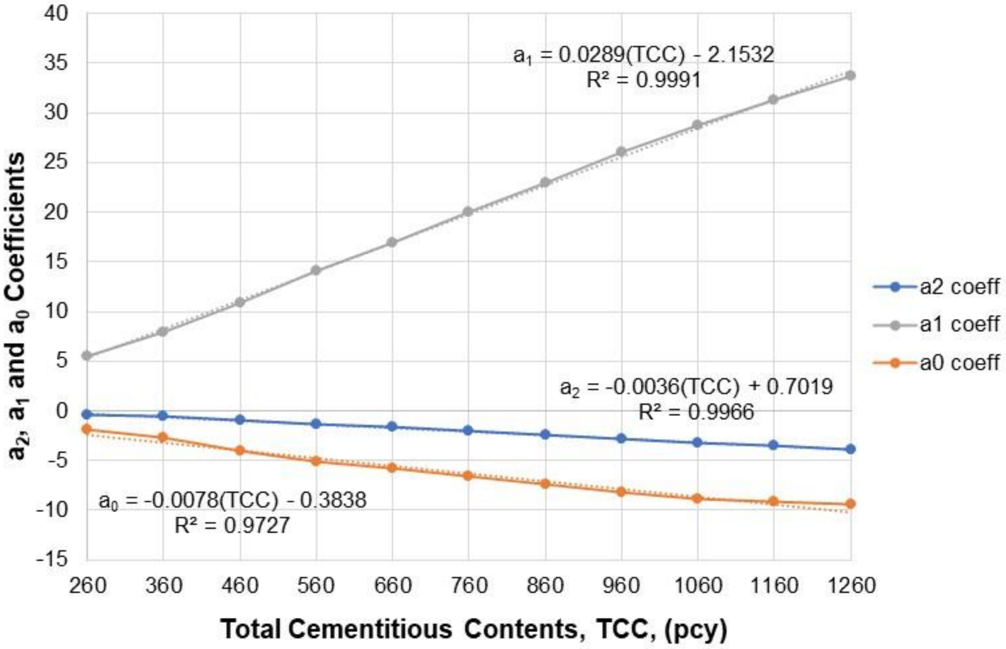


Figure 4.18 a_2, a_1, and a_0 regression coefficients versus cementitious contents for 34% fly ash mix. *[This is a plot presenting regression coefficients for a_2, a_1, and a_0 on the y-axis and for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 34% fly ash concrete mix. Each regression parameter is an individual data series, therefore this plot displays 3 individual curves with linear trendlines applied to each data series. Trendline equations and R^2 values are also included in the plot. The trendline equation for the a_0 data series is a_0=-0.0078(TCC)-0.3838 with an R^2=0.9727. The trendline equation for the a_1 data series is a_1=0.0289(TCC)-2.1532 with an R^2=0.9991. The trendline equation for the a_2 data series is a_2=-0.0036(TCC)+0.7019 with an R^2=0.9966.]*

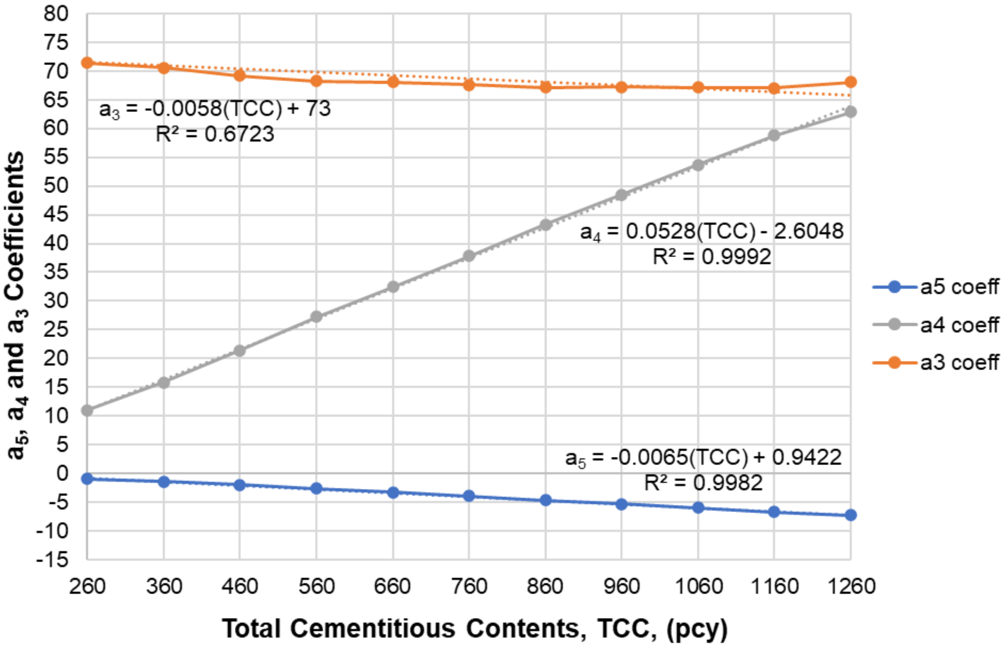


Figure 4.19 a_5, a_4, and a_3 regression coefficients versus cementitious contents for 34% fly ash mix. *[This is a plot presenting regression coefficients for a_5, a_4, and a_3 on the y-axis and for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 34% fly ash concrete mix. Each regression parameter is an individual data series, therefore this plot displays 3 individual curves with linear trendlines applied to each data series. Trendline equations and R^2 values are also included in the plot. The trendline equation for the a_3 data series is a_3=-0.0058(TCC)+73 with an R^2=0.6723. The trendline equation for the a_4 data series is a_4=-0.0528(TCC)-2.6048 with an R^2=0.9992. The trendline equation for the a_5 data series is a_5=-0.0065(TCC)+0.9422 with an R^2=0.9982.]*

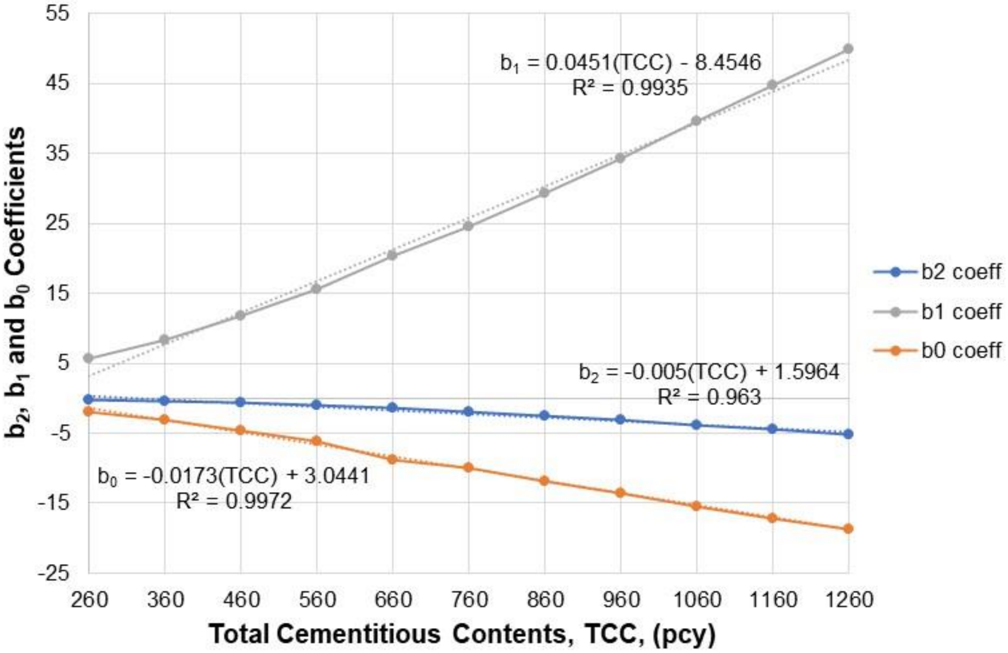


Figure 4.20 b_2, b_1, and b_0 regression coefficients versus cementitious contents for 60% slag mix.

[This is a plot presenting regression coefficients for b_2, b_1, and b_0 on the y-axis and for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 60% slag concrete mix. Each regression parameter is an individual data series, therefore this plot displays 3 individual curves with linear trendlines applied to each data series. Trendline equations and R^2 values are also included in the plot. The trendline equation for the b_0 data series is b_0=-0.0173(TCC)+3.0441 with an R^2=0.9972. The trendline equation for the b_1 data series is b_1=0.0451(TCC)-8.4546 with an R^2=0.9935. The trendline equation for the b_2 data series is b_2=-0.005(TCC)+1.5964 with an R^2=0.963.]

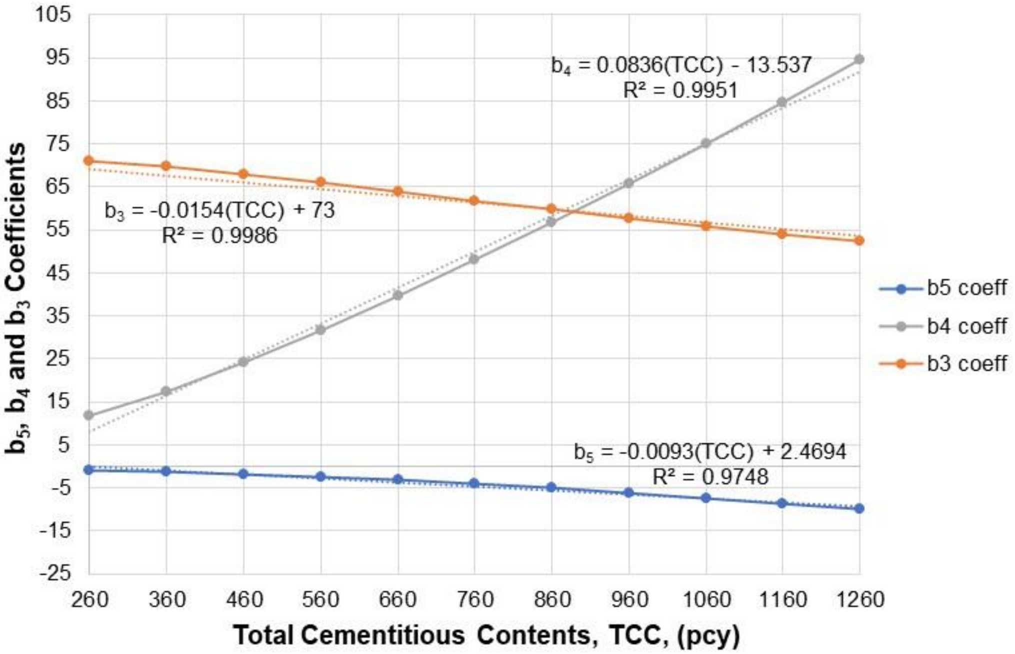


Figure 4.21 b_5, b_4, and b_3 regression coefficients versus cementitious contents for 60% slag mix.

[This is a plot presenting regression coefficients for b_5, b_4, and b_3 on the y-axis and for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 60% slag concrete mix. Each regression parameter is an individual data series, therefore this plot displays 3 individual curves with linear trendlines applied to each data series. Trendline equations and R^2 values are also included in the plot. The trendline equation for the b_3 data series is b_3=-0.0154(TCC)+73 with an R^2=0.9986. The trendline equation for the b_4 data series is b_4=0.0836(TCC)-13.537 with an R^2=0.9951. The trendline equation for the b_5 data series is b_5=-0.0093(TCC)+2.4694 with an R^2=0.9748.]

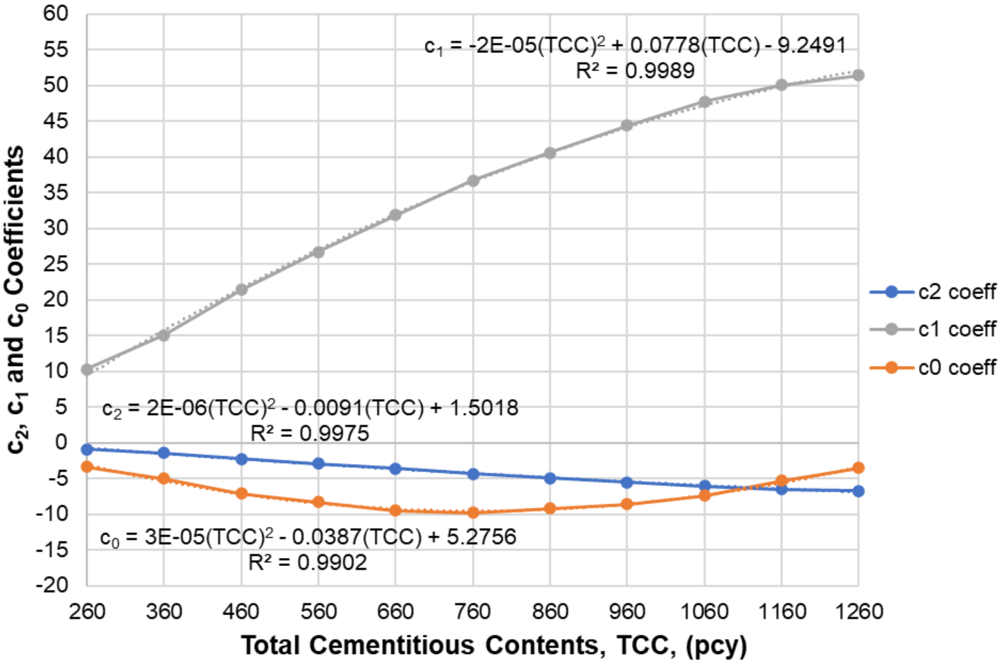


Figure 4.22 c_2, c_1, and c_0 regression coefficients versus cementitious contents for 100% Type IL cement mix.

[This is a plot presenting regression coefficients for c_2, c_1, and c_0 on the y-axis and for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 100% Type IL cement concrete mix. Each regression parameter is an individual data series, therefore this plot displays 3 individual curves with linear trendlines applied to each data series. Trendline equations and R^2 values are also included in the plot. The trendline equation for the c_0 data series is c_0=-0.00003(TCC)-0.0387(TCC)+5.2756 with an R^2=0.9902. The trendline equation for the c_1 data series is c_1=-0.00002(TCC)+0.0778(TCC)-9.2491 with an R^2=0.9989. The trendline equation for the c_2 data series is c_2=0.000002(TCC)-0.0091(TCC)+1.5018 with an R^2=0.9975.]

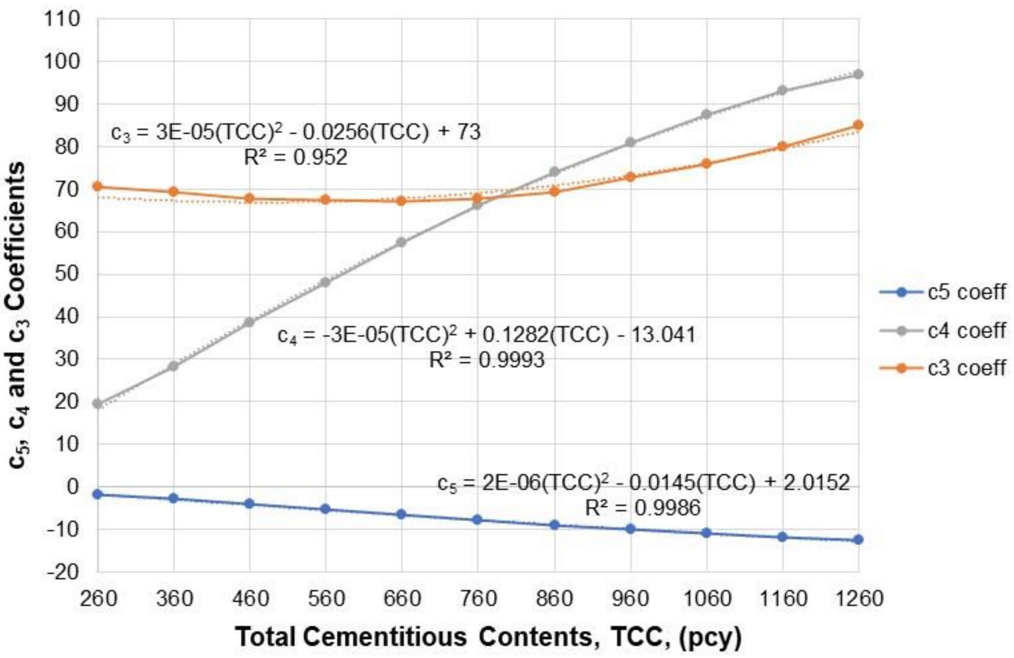


Figure 4.23 c_5, c_4, and c_3 regression coefficients versus cementitious contents for 100% Type IL cement mix.

[This is a plot presenting regression coefficients for c_5, c_4, and c_3 on the y-axis and for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 100% Type IL cement concrete mix. Each regression parameter is an individual data series, therefore this plot displays 3 individual curves with linear trendlines applied to each data series. Trendline equations and R^2 values are also included in the plot. The trendline equation for the c_3 data series is c_3=-0.00003(TCC)-0.0256(TCC)+73 with an R^2=0.952. The trendline equation for the c_4 data series is c_4=-0.00002(TCC)+0.1282(TCC)-13.041 with an R^2=0.9993. The trendline equation for the c_5 data series is c_5=0.000002(TCC)-0.0145(TCC)+2.0152 with an R^2=0.9986.]

$$\Delta T_{FA} = a_2 R^2 + a_1 R + a_0 \qquad (1)$$

where

$a_0 = -0.0078(TCC) - 0.3838$ (1.a)

$a_1 = 0.02892(TCC) - 2.1532$ (1.b)

$a_2 = -0.0036(TCC) + 0.70185$ (1.c)

$$T_{FA} = a_5 R^2 + a_4 R + a_3 \qquad (2)$$

where

$a_3 = -0.0058(TCC) + T_{conc}$ (2.a)

$a_4 = 0.05283(TCC) - 2.6048$ (2.b)

$a_5 = -0.0065(TCC) + 0.94216$ (2.c)

$$\Delta T_S = b_2R^2 + b_1R + b_0 \tag{3}$$

where

$b_0 = -0.0173(TCC) + 3.04413$ (3.a)

$b_1 = 0.04509(TCC) - 8.4546$ (3.b)

$b_2 = -0.005(TCC) + 1.5964$ (3.c)

$$T_S = b_5R^2 + b_4R + b_3 \tag{4}$$

where

$b_3 = -0.0154(TCC) + T_{conc}$ (4.a)

$b_4 = 0.08356(TCC) - 13.537$ (4.b)

$b_5 = -0.0093(TCC) + 2.46944$ (4.c)

$$\Delta T_{CM} = c_2R^2 + c_1R + c_0 \tag{5}$$

where

$c_0 = 0.0000253(TCC)^2 - 0.03869(TCC) + 5.275553$ (5.a)

$c_1 = -0.0000232(TCC)^2 + 0.07782(TCC) - 9.24907$ (5.b)

$c_2 = 0.0000019(TCC)^2 - 0.0091(TCC) + 1.501816$ (5.c)

$$T_{CM} = c_5R^2 + c_4R + c_3 \tag{6}$$

where

$c_3 = 0.00003(TCC)^2 - 0.0256\ (TCC) + T_{conc}$ (6.a)

$c_4 = -0.000032(TCC)^2 + 0.128232\ (TCC) - 13.0412$ (6.b)

$c_5 = 0.0000022(TCC)^2 - 0.01453\ (TCC) + 2.015242$ (6.c)

4.4.3 Quality Assurance Estimation Equations: Model Cage-to-Core Method

The cage-to-core differential temperatures resulting from the modeling were also used to derive closed-form expressions that can be used to predict cage-to-core differential temperature with the following information: reinforcement cage radius, total cementitious content, and type of supplementary cementitious material (fly ash or slag), if applicable. The calculated cage-to-core differential temperature can then be added to the average measured temperature at the reinforcement cage (such as those collected for thermal integrity profiling) to predict the core temperature from field measurements taken at the time of peak cage temperature. When/if applied to other times of testing, the predicted core temperature at that time will be higher than actual but would still underpredict the peak core temperature at the worst-case time.

Similar to the predictive design equations in Section 4.4.2, cage-to-core differential temperatures were grouped by total cementitious content and plotted versus reinforcement cage radius (Figures 4.24, 4.25, and 4.26). A non-linear regression (2nd order polynomial) was subsequently performed on the data for each cementitious content group. The non-linear regression coefficients were then plotted versus total cementitious content (Figure 4.27, 4.28, and 4.29), on which another regression was performed. For the slag mix and fly ash mix models, a linear regression was performed at this step, and for the 100% Portland cement mix model, a non-linear regression (2nd order polynomial) was performed.

This analysis, once again, resulted in a total of three predictive equations (Equations 7–9 below), each dependent on total cementitious content (*TCC*) and reinforcement cage radius (R_{cage}).

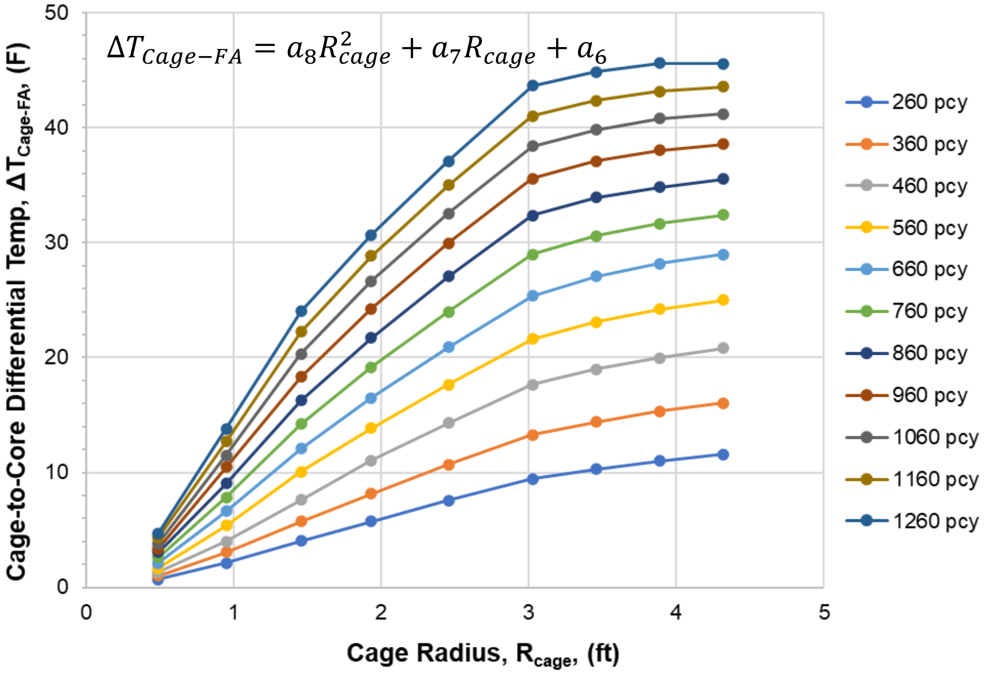


Figure 4.24 Model cage-to-core differential temperature (°F) versus reinforcement cage radius for 34% fly ash mix.

[This is a plot presenting modeled cage-to-core differential temperatures on the y-axis and various reinforcement cage radii (ranging from 0 to 4.5 feet on the x-axis) for various cementitious material contents (ranging from 260 to 1260 lb/yd^3) for a 34% fly ash concrete mix. Each cementitious content is an individual data series, therefore this plot displays 11 individual curves.]

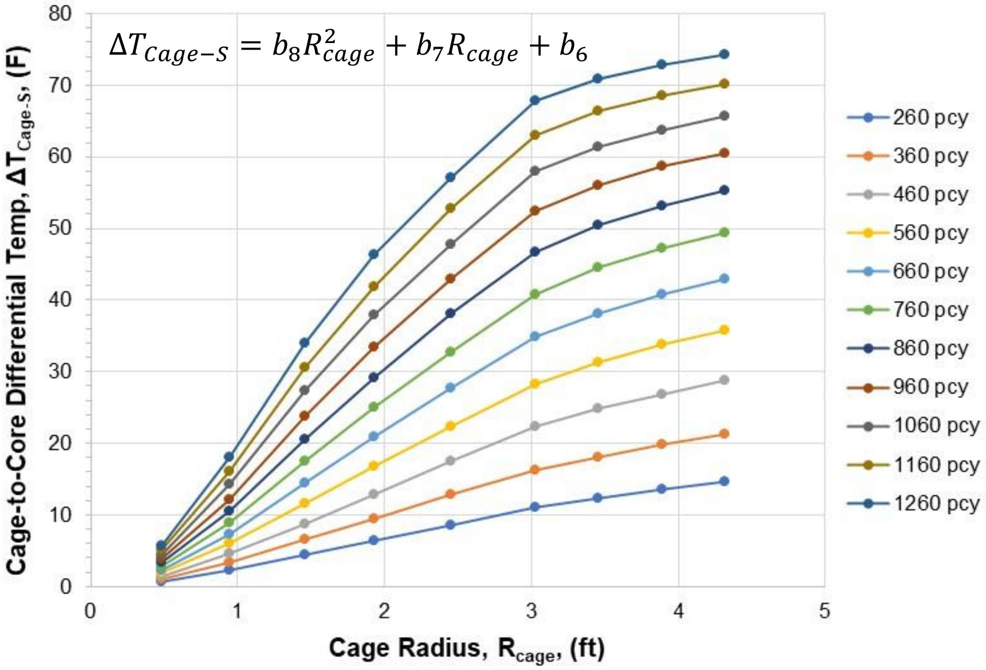


Figure 4.25 Model cage-to-core differential temperature (°F) versus reinforcement cage radius for 60% slag mix.

[This is a plot presenting modeled cage-to-core differential temperatures on the y-axis and various reinforcement cage radii (ranging from 0 to 4.5 feet on the x-axis) for various cementitious material contents (ranging from 260 to 1260 lb/yd^3) for a 60% slag concrete mix. Each cementitious content is an individual data series, therefore this plot displays 11 individual curves.]

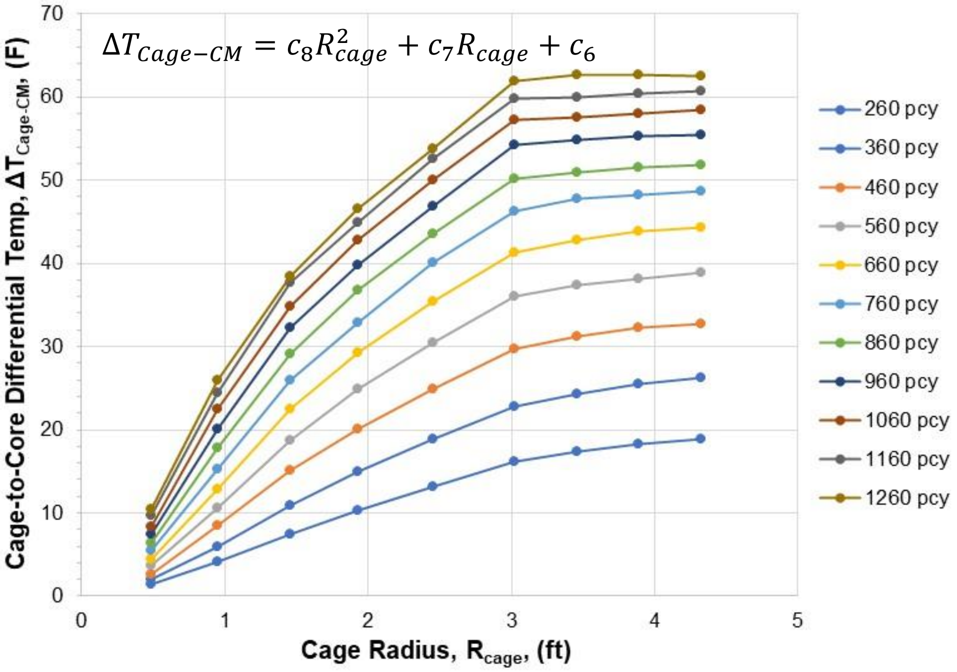


Figure 4.26 Model cage-to-core differential temperature (°F) versus reinforcement cage radius for 100% Type IL cement mix.

[This is a plot presenting modeled cage-to-core differential temperatures on the y-axis and various reinforcement cage radii (ranging from 0 to 4.5 feet on the x-axis) for various cementitious material contents (ranging from 260 to 1260 lb/yd^3) for a 100% Type IL cement concrete mix. Each cementitious content is an individual data series, therefore this plot displays 11 individual curves.]

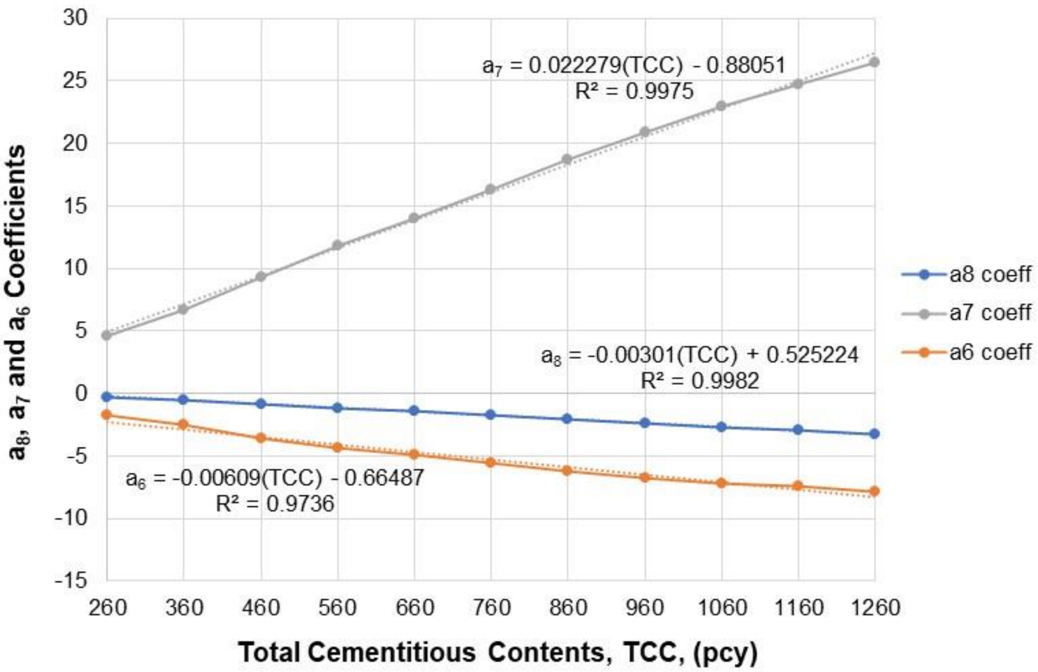


Figure 4.27 a_8, a_7, and a_6 regression coefficients versus cementitious contents for 34% fly ash mix. *[This is a plot presenting regression coefficients for a_8, a_7, and a_6 on the y-axis and for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 34% fly ash concrete mix. Each regression parameter is an individual data series, therefore this plot displays 3 individual curves with linear trendlines applied to each data series. Trendline equations and R^2 values are also included in the plot. The trendline equation for the a_6 data series is a_6=-0.00609(TCC)-0.66487 with an R^2=0.9736. The trendline equation for the a_7 data series is a_7=0.022279(TCC)-0.88051 with an R^2=0.9975. The trendline equation for the a_8 data series is a_8=-0.00301(TCC)+0.525224 with an R^2=0.9982.]*

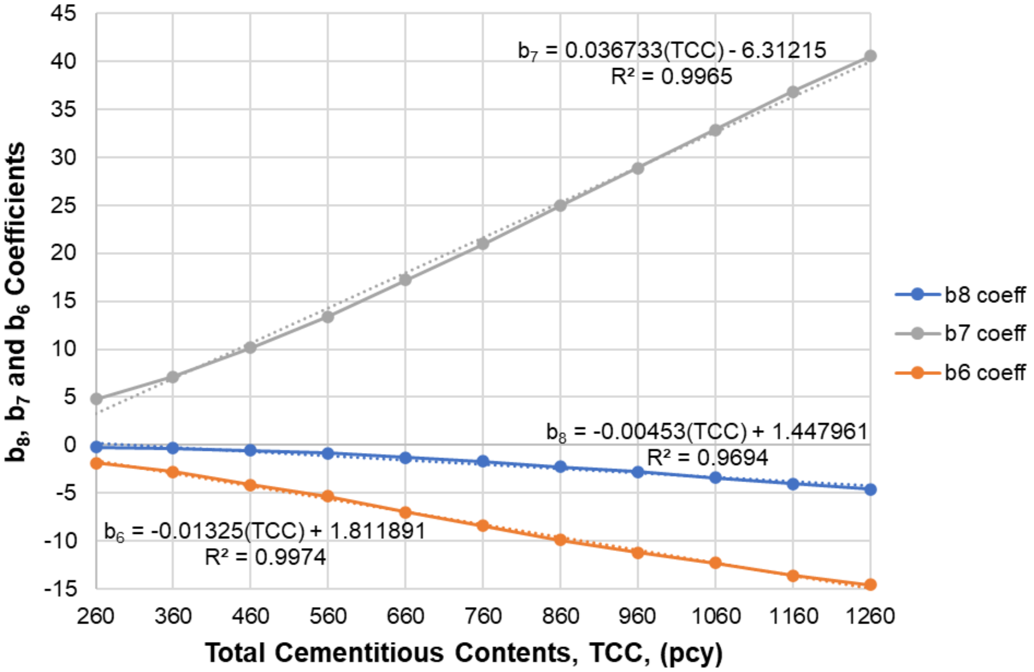


Figure 4.28 b_8, b_7, and b_6 regression coefficients versus cementitious contents for 60% slag mix.

[This is a plot presenting regression coefficients for b_8, b_7, and b_6 on the y-axis and for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 60% slag concrete mix. Each regression parameter is an individual data series, therefore this plot displays 3 individual curves with linear trendlines applied to each data series. Trendline equations and R^2 values are also included in the plot. The trendline equation for the b_6 data series is b_6=-0.01325(TCC)+1.811891 with an R^2=0.9974. The trendline equation for the b_7 data series is b_7=0.036733(TCC)-6.31215 with an R^2=0.9965. The trendline equation for the b_8 data series is b_8=-0.00453(TCC)+1.447961 with an R^2=0.9694.]

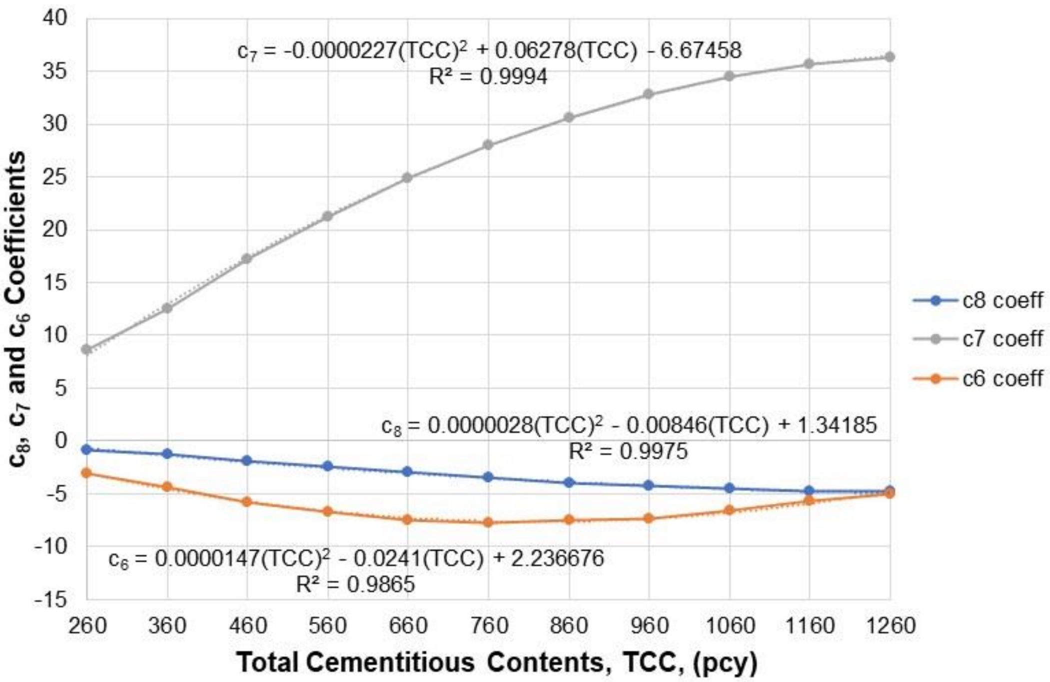


Figure 4.29 c_8, c_7, and c_6 regression coefficients versus cementitious contents for 100% Type IL cement mix.

[This is a plot presenting regression coefficients for c_8, c_7, and c_6 on the y-axis and for various cementitious material contents (ranging from 260 to 1260 lb/yd^3 on the x-axis) for a 100% Type IL cement concrete mix. Each regression parameter is an individual data series, therefore this plot displays 3 individual curves with linear trendlines applied to each data series. Trendline equations and R^2 values are also included in the plot. The trendline equation for the c_6 data series is c_6=0.0000147(TCC)-0.0241(TCC)+2.236676 with an R^2=0.9865. The trendline equation for the c_7 data series is c_7=-0.0000227(TCC)+0.06278(TCC)-6.67458 with an R^2=0.9994. The trendline equation for the c_8 data series is c_8=0.0000028(TCC)-0.00846(TCC)+1.34185 with an R^2=0.9975.]

$$\Delta T_{Cage-FA} = a_8 R_{cage}^2 + a_7 R_{cage} + a_6 \tag{7}$$

where

$a_6 = -0.00609(TCC) - 0.66487$ (7.a)

$a_7 = 0.022279(TCC) - 0.88051$ (7.b)

$a_8 = -0.00301(TCC) + 0.525224$ (7.c)

$$\Delta T_{Cage-S} = b_8 R_{cage}^2 + b_7 R_{cage} + b_6 \tag{8}$$

where

$b_6 = -0.01325(TCC) + 1.811891$ (8.a)

$b_7 = 0.036733(TCC) - 6.31215$ (8.b)

$b_8 = -0.00453(TCC) + 1.447961$ (8.c)

$$\Delta T_{Cage-CM} = c_8 R_{cage}^2 + c_7 R_{cage} + c_6 \tag{9}$$

where

$c_6 = 0.0000147(TCC)^2 \, - \, 0.0241(TCC) + 2.236676$ (9.a)

$c_7 = \, -0.0000227(TCC)^2 + 0.06278(TCC) - 6.67458$ (9.b)

$c_8 = \, 0.0000028(TCC)^2 - 0.00846(TCC) + 1.34185$ (9.c)

4.4.4 Quality Assurance Estimation Equations: Field Gradient Method

Both the modeled temperature distributions and collected thermal integrity temperature data show the across-shaft temperature distribution forms a bell shape. The inflection point along the edges of the bell occurs at the concrete/soil interface or slightly inside the concrete. Between the reinforcement cage, a parabolic shape exists. Figures 4.30 and 4.31 below illustrate these shapes for both the modeled temperature distributions and the collected thermal integrity temperature data from shaft OC-19, respectively. In Figure 4.31, note the strong parabolic fit quality (R^2=0.9999 and 0.9961) for the two across-shaft temperature distributions, each perpendicular to each other. It then stands to reason that a generic set of equations for the temperature distribution can be determined with the following considerations: the general equation for any parabola is

$$T(x) = ax^2 + bx + c \tag{10}$$

When the parabola is centered and x = 0 is at the core (and the hottest portion of a shaft), the equation can be reduced to Equation 10.a from the derivative of Equation 10. It is known that the slope at the top of the parabola will be flat and thus equal to zero. This is shown in Equation 10.b below.

$$T(x) = ax^2 + c \tag{10.a}$$

$$T'(0) = 0 = 2a(0) + b, \text{ therefore } b = 0 \tag{10.b}$$

Evaluation of the "a" coefficient can be similarly performed using the derivative of Equation 10.a knowing the slope of the parabola at the cage positions x = -R_{cage} and x = R_{cage}, where R_{cage} is the radius of the reinforcement cage (temperature measurement location). This slope can be taken as a °F/in gradient (∇). With these known variables, evaluation of the "a" coefficient becomes

$$T'(-R_{cage}) = \nabla = 2a(-R_{cage}) \tag{10.c}$$

$$a = -\frac{\nabla}{2R_{cage}} \tag{10.d}$$

The temperature gradient is specific to the concrete mix, time of testing, and depth location; R_{cage} is unique to the given shaft cage configuration. This leaves the core shaft temperature from Equation 10.a equal to coefficient "c" (Equation 10.f). Core temperature can then be solved for each depth location in the drilled shaft to find the worst-case internal temperature value.

$$T(R_{cage}) = T_{cage\ avg} = -\frac{\nabla}{2R_{cage}} R_{cage}^2 + c \tag{10.e}$$

$$c = core\ temp = \frac{\nabla}{2} R_{cage} + T_{cage\ avg} \tag{10.f}$$

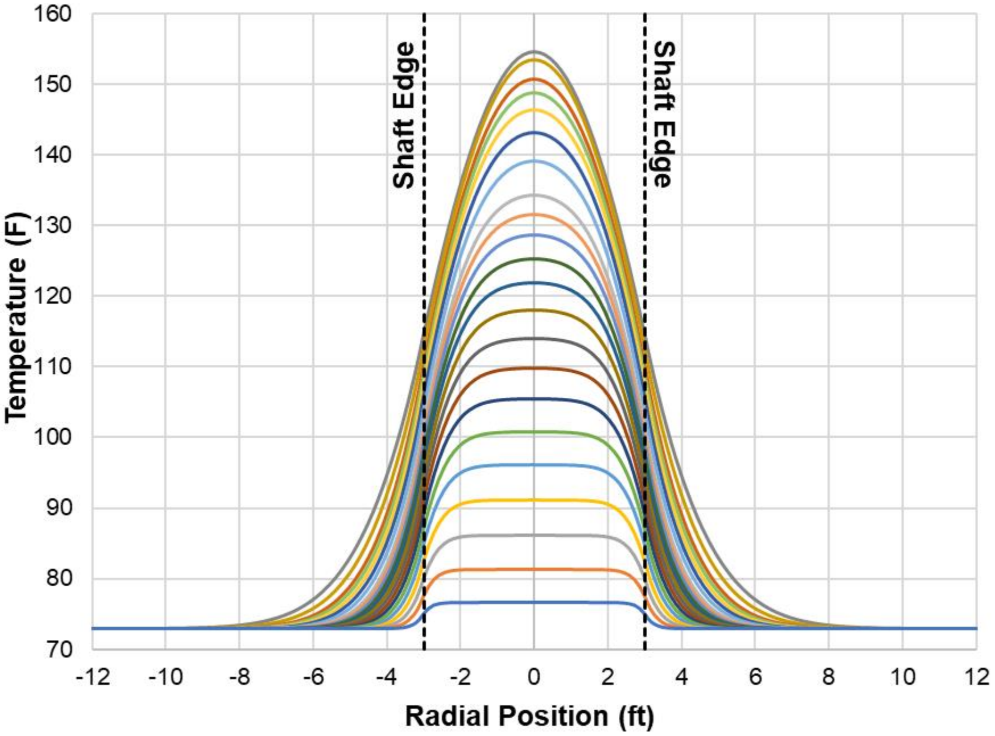


Figure 4.30 Modeled temperature distributions over time for a 6-foot shaft using the OC-19 concrete mix design.

[This is a plot where the x-axis is radial position in feet and the y-axis is temperature. The data presented is modeled across-shaft temperature distributions over time. Each across-shaft temperature distribution is generally parabolic in shape and as time increases, so does the height of each parabola.]

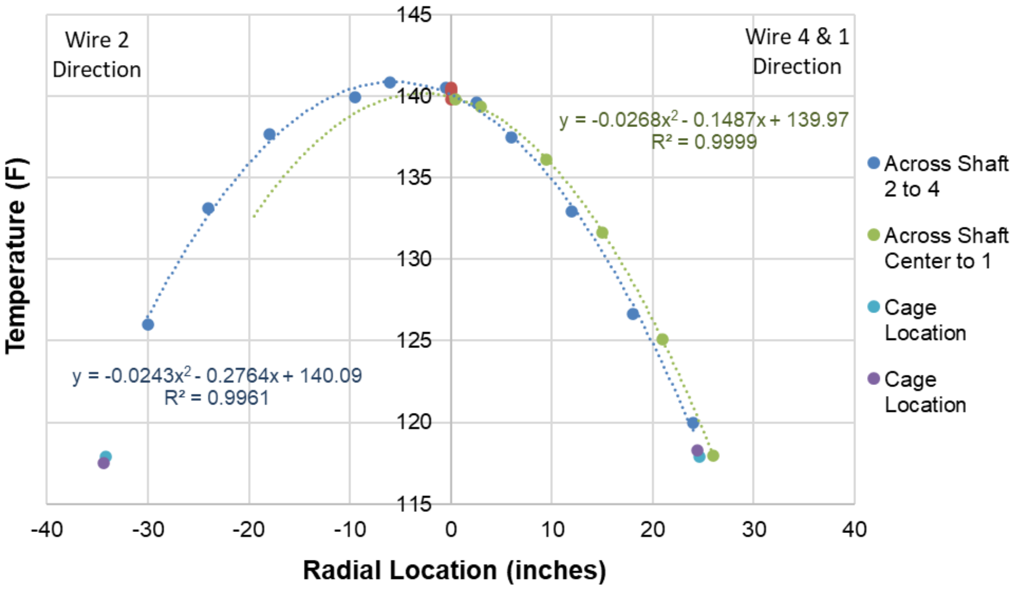


Figure 4.31 Plot presenting OC-19 data taken from the center wire sensors installed in an across-shaft configuration.

[This is a plot presenting temperature data on the y-axis versus radial location on the x-axis where the center of the shaft is located at a zero radius and the cage is at plus or minus radial locations in inches relative to center. There is a full temperature distribution for the portion across shaft between cage wires 2 and 4, and there is a half temperature distribution for the portion across shaft between the center and cage wire 1. The temperature differential between the cage locations and the peak is approximately 23°F. The plot also includes parabolic equations for each distribution series and R values for each fit. These R values are 0.9961 and 0.9999, respectively.]

While the slope of the parabolic temperature distribution of a drilled shaft is known as a temperature gradient, determining a value for the temperature gradient is a different matter. With full across-shaft temperature distributions (e.g. data collected from OC-19 and the Sinclair Hills drilled shaft), this gradient would be determined by calculating the change in temperature between two thermal sensors within the linear portion of the parabolic distribution and dividing by the distance between those sensors or by solving for the derivative of the bell curve function at $x=R_{cage}$.

The instrumentation of Bartow shaft 1-4 explored determining this gradient with both thermal wire offset sensors and readings of the individual infrared probe sensors. The wire instrumentation of Bartow shaft 1-4 included thermal wires down the length of the reinforcement cage rebar with a known offset using plastic spacers. This provided for thermal sensors to be aligned longitudinally but offset concentrically. Gradient calculations from these measurements were presented in Chapter 3 (Figure 3.62).

The thermal integrity probe method was also performed on Bartow shaft 1-4 (Figure 4.32). Access tubes consisted of both steel and PVC tubes. Specifically, tube numbers 1, 2, 4, 5, and 7 were steel and tube numbers 3 and 6 were PVC. Annotations specifying these tube numbers have been added to Figure 3.58 and presented below as Figure 4.33. The probe used (Figure 4.34) included four laterally directed infrared thermal sensors and measured the access tube wall temperature in four orthogonal directions. Probe sensors are numbered such that sensors 1 and 3 and sensors 2 and 4 are directed in opposite directions on the probe (180 deg apart). This specific probe also included a six-axis motion tracking device that combines a three-axis gyroscope, three-axis accelerometer, and digital motion processor (InvenSense, 2013), providing for the additional measurement of probe rotation angle. Several probe runs were performed where the probe was lowered, then paused at various depths to rotate within the access tube.

Figure 4.32 Thermal integrity probe test performed on Bartow shaft 1-4 with gyroscopic sensor. *[This is a photograph of a graduate student taking probe temperature measurements using a thermal probe equipped with a gyroscopic sensor. The graduate student is seen rotating the probe within the access tube.]*

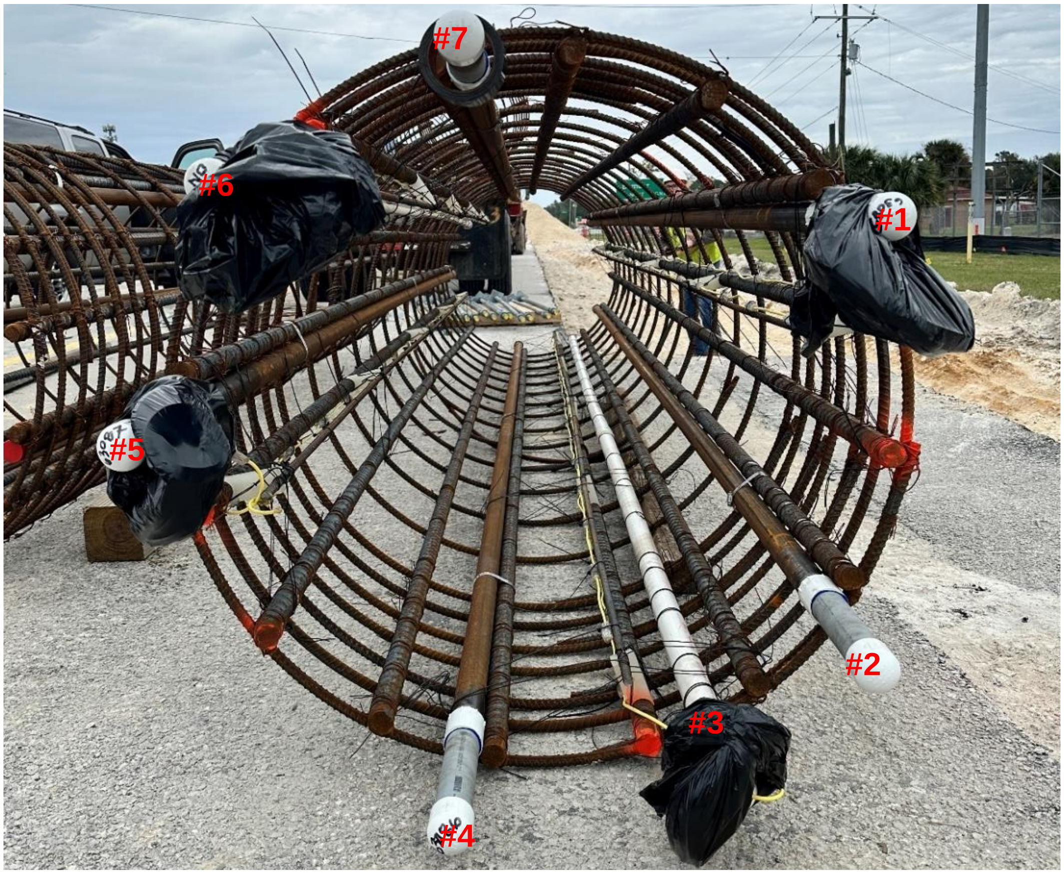


Figure 4.33 Fully instrumented Bartow shaft 1-4 reinforcement cage with annotated access tube numbers.

[This is a photo taken from outside the top of the Bartow shaft reinforcement cage. All cage thermal wires and center thermal wire have been installed, and all above-concrete sensors and wire connector ends have been bundled and secured in heavy-duty plastic bags and Gorilla tape. Steel and PVC access tubes have been labeled with numbers 1 through 7 that are referenced within this report.]

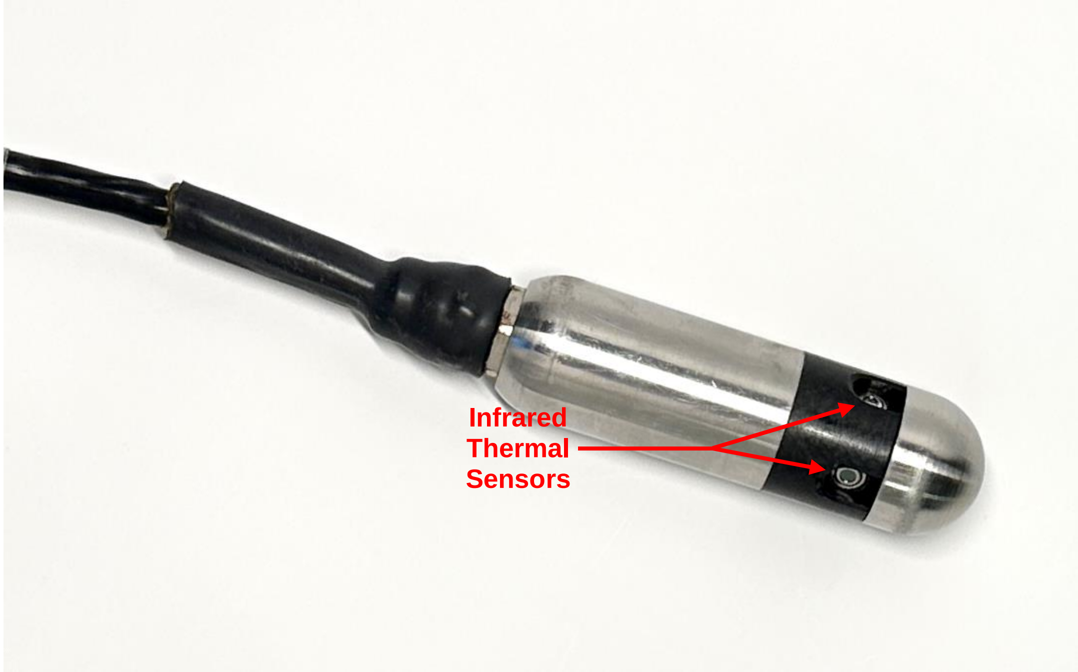


Figure 4.34 Gyro probe (showing 2 of 4 orthogonal infrared thermal sensors) used to test Bartow shaft 1-4.

[This is a detail photograph of the Thermal Integrity Profiling probe showing two of four infrared thermal sensors. Each infrared thermal sensor is positioned 90 degrees apart radially around the probe.]

Figure 4.35 below presents sample temperature data plotted against the recorded probe rotation measurement from one of these trials, specifically data collected two days after concreting from PVC access tube number 3 at a depth of approximately 12 feet. This plot clearly shows a variation in temperature as the sensor direction was rotated within the access tube. As sensor 1 measured its lowest temperature, sensor 3 was measuring its highest temperature. Similarly, as sensor 2 measured its lowest temperature, sensor 4 was measuring its highest temperature and vice versa. These internal tube temperature measurements were then plotted against the radial position within the access tube (Figure 4.36). When presented in this context, the linear relationship between the tube wall temperatures and radial shaft position within the access tube can be seen.

Figure 4.37 compares the temperature gradient calculations from the thermal wire measurements presented in Chapter 3 to the opposing probe sensor readings measuring the inside of the access tube converted to gradient assuming a 2-inch tube outer diameter. The data from Figures 4.35 and 4.36 were collected by deliberately stopping the probe and spinning the wire from the top of shaft; the data in Figure 4.37, however, shows a periodic high to low temperature trend which is the byproduct of twisted conductors within the lead wire. Hence, all probes naturally spin under normal operation in response the subtle external protrusion of the conductors through the environmental protective extruded casing. The true temperature gradient at a given depth may or may not be captured from one of the two opposing sensor sets. So, the highest values recorded represent when a set of sensors are focused directly inward and outward. This comparison shows a strong match between the two data collection methods.

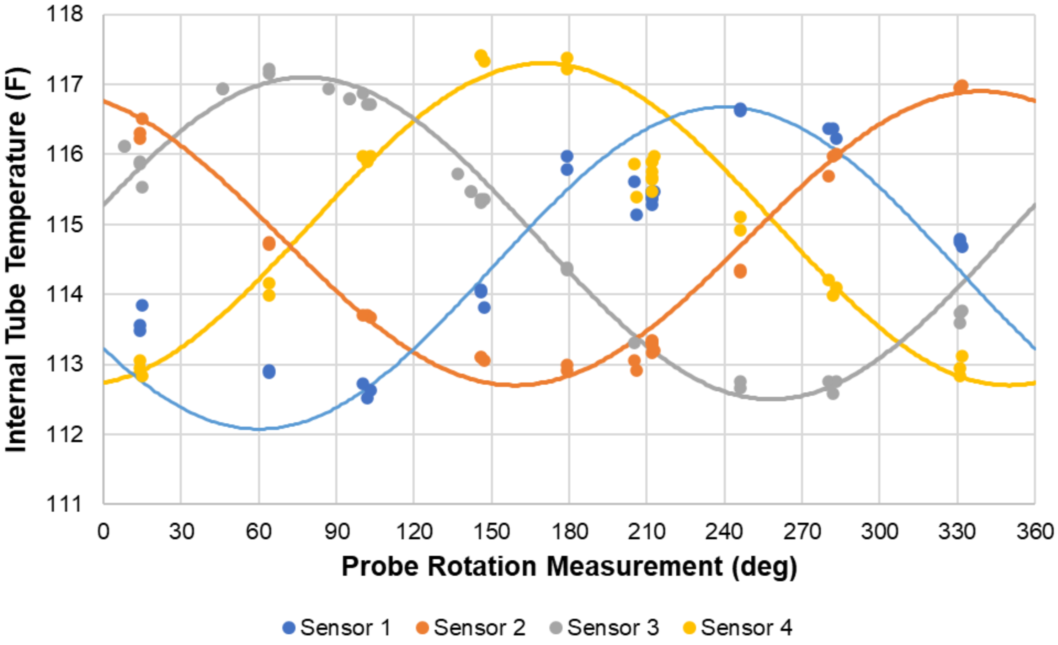


Figure 4.35 Plot presenting thermal probe spin test data: internal tube temperature versus probe rotation measurement for access tube #3 collected two days post concreting.

[This is a plot where the x-axis is probe rotation measurement in degrees and the y-axis is internal tube temperature. The data presented are temperature measurements taken from one of several probe runs performed where the probe was lowered, then paused at various depths to rotate within the access tube.]

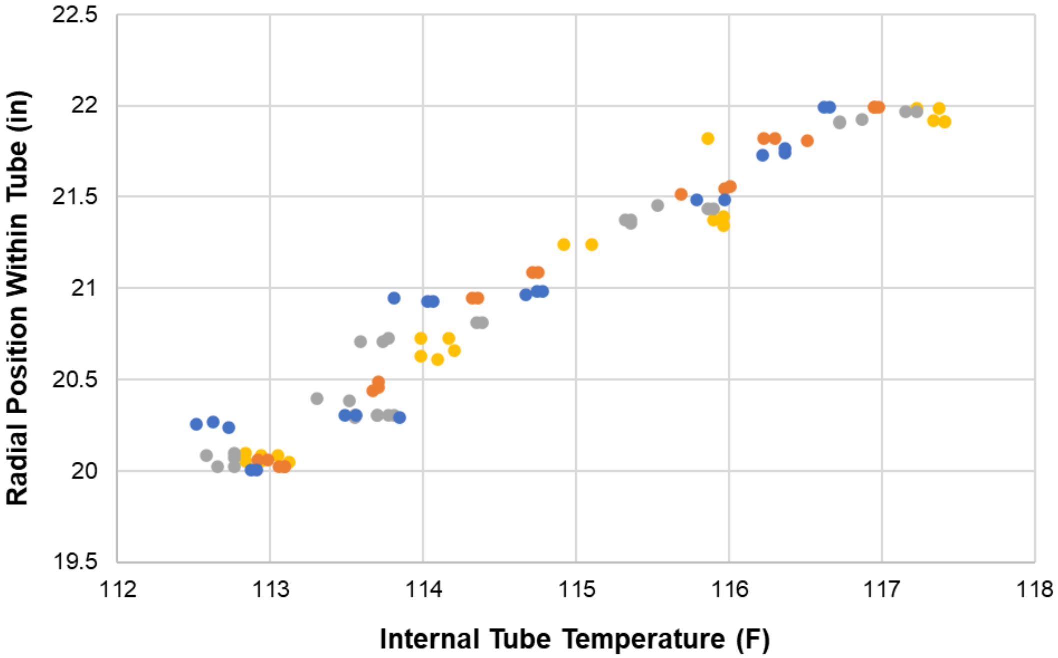


Figure 4.36 Plot presenting thermal probe spin test data: internal tube temperature versus radial position within the access tube.

[This is a plot where the x-axis is internal tube temperature and the y-axis is radial position within the access tube in inches. The data presented are the same temperature measurements from Figure 4.35 showing the linear relationship between temperature and radial position within an access tube.]

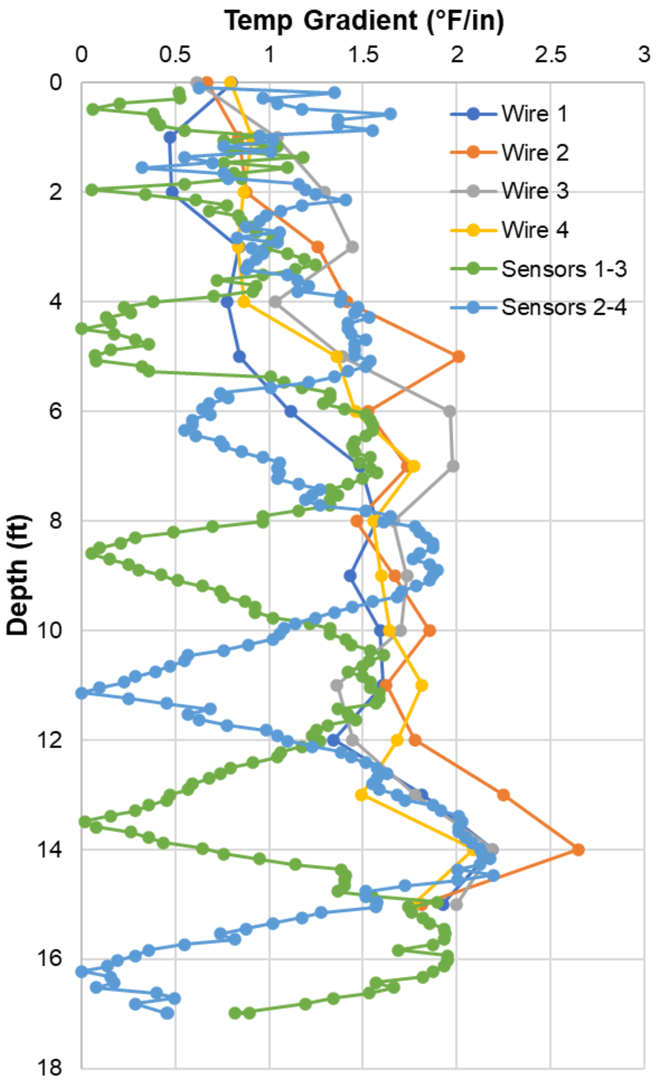


Figure 4.37 Temperature gradient comparison between thermal wire method and probe method. *[This is a plot where the x-axis is temperature gradient in °F/in and the y-axis is depth. The data presented are a comparison between the temperature gradients presented in Chapter 3, Section 3.6.2 and temperature gradients calculated from probe measurements.]*

Lastly, measured probe data collected from all access tubes was plotted versus depth and used to estimate core temperature versus depth by solving for constant c, the peak temperature, when the slope of the equation is known in Equation 10.f from probe gradient values (derivative of a parabolic function evaluated at the cage radius). Using the calculated temperature gradient, edge to core differential temperature was also estimated by extrapolating the bell curve slope to the shaft edge and subtracting that temperature from the estimated core temperature. Figure 4.38 presents these data and calculations and, at first glance, appears to be an acceptable drilled shaft with peak temperatures below 158°F, however differential temperatures exceed the 35°F threshold between the depths of 6 and 13 feet.

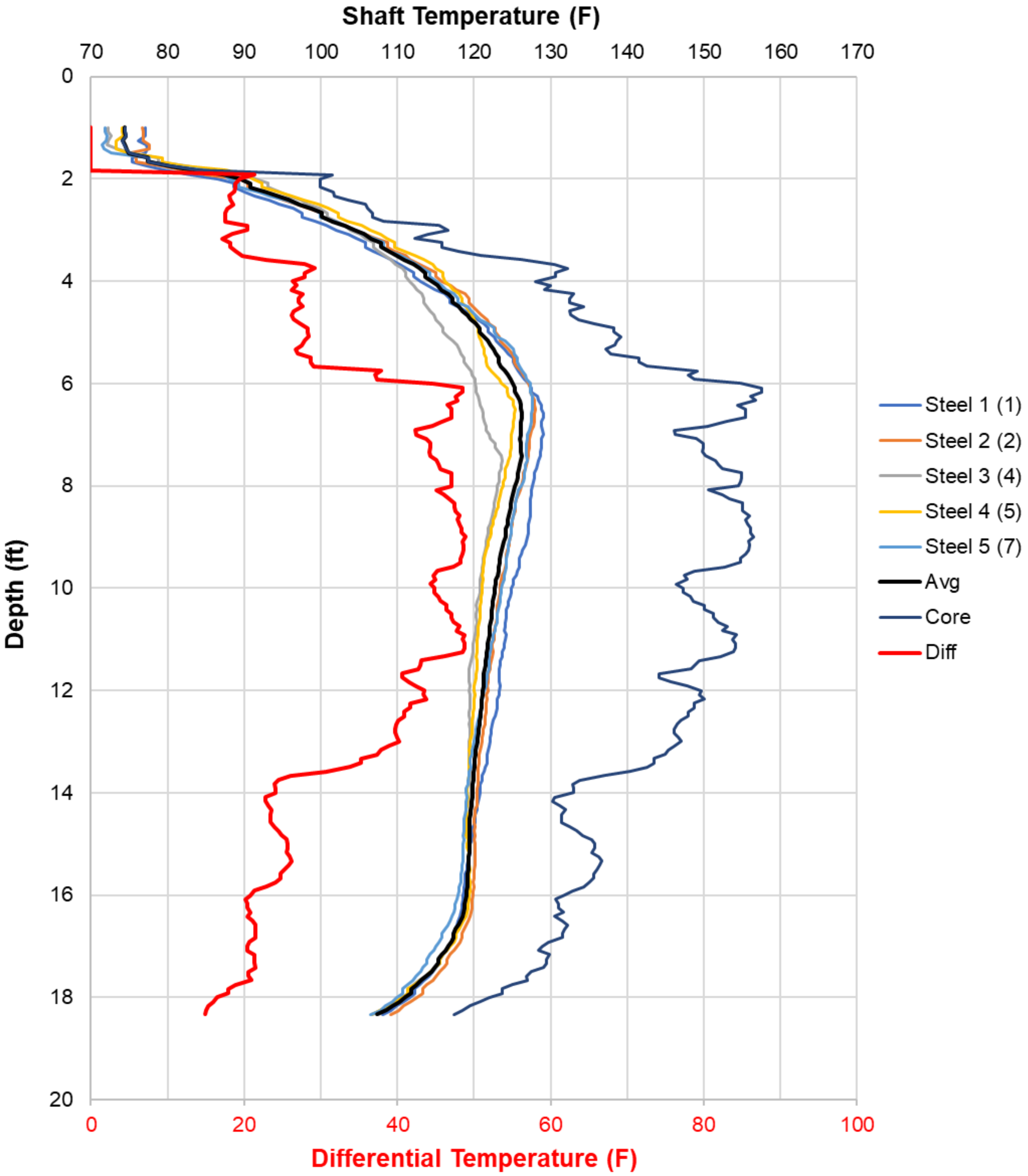


Figure 4.38 Plot presenting probe data collected from each steel access tube with corresponding calculated core and differential temperatures versus depth.

[This is a plot where there are dual x-axes, the top being drilled shaft temperature and the bottom being differential temperature, and the y-axis is depth in feet. The data presented include probe temperature measurements taken from all steel access tubes from the Bartow drilled shaft as well as calculated core and differential temperatures versus depth. The peak differential temperature occurs at approximately 11 feet and reads approximately 48°F. The peak core temperature occurs at approximately 6 feet and reads approximately 157°F.]

Chapter Five: Summary and Conclusions

With the objective of providing clarification as to what conditions constitute a drilled shaft as a mass concrete element, a study incorporating both specialized field temperature measurements and comprehensive numerical modeling was presented.

5.1 Summary

Within the past 20 years, drilled shaft installation plans for FDOT projects have transitioned from requiring no mass concrete information regardless of shaft diameter (e.g. Ringling Causeway Bridge built in 2002 is supported on two 9-foot diameter shafts where differential temperature cage to core reached 67°F) to requiring steps to control temperature for some shafts. However, the specifications at the time of this report were in conflict:

- Concrete elements other than shafts are required to assess temperature for any element with a minimum dimension greater than 3 feet.
- Shafts greater than 6 feet in diameter require a review of potentially high temperatures or a temperature control plan, but not with dimensions between 3.5 feet (FDOT minimum size shaft) and 6 feet.
- For shafts supporting miscellaneous (non-bridge) structures, no temperature control is required regardless of dimensions.

This conflict in part was the motivation for this study.

In recent years, post-construction integrity testing of drilled shafts has become commonplace to determine the distribution of concrete volume, local radii, and cage eccentricity. This has been made possible via temperature measurements and good inspection records. However, the consideration of long-term durability of drilled shafts has not received equal attention as evidenced by the exclusion of drilled shafts in many mass concrete specifications when considering internal temperature limits. The term mass concrete historically stems from massive structures that would generate unsafe temperature levels, but with nominal strength concrete containing low cementitious material contents (e.g. the Hoover Dam built circa 1931-35 is 45 feet thick near the top and 660 feet thick near the bottom, 726 feet tall, and 1233 feet long). Today, concrete mix designs use far more cementitious materials per unit volume. Consequently, unsafe temperature levels can occur within nearly any size foundation element if the cementitious materials content is high enough. While the limiting temperature thresholds can be debated, concrete durability is negatively affected by multiple consequences of excessive temperature during curing.

Recently, the American Concrete Institute (ACI) suggested restrictions on a concrete element dimension and the weight of cementitious materials per unit volume (Figure 1.3) to control peak and/or differential temperature generation. Unfortunately, it is unclear under what criterion (peak, differential, mill certificate composition, etc.) an element size and cementitious material content either failed (red) or passed (green). Using the ACI criteria, a typical FDOT drilled shaft concrete with the minimum specified 600 lbs/yd^3 of cementitious materials would be restricted to a size no larger than 2 feet in diameter; the minimum FDOT shaft diameter is 3.5 feet. Hence, the ACI criteria, if applied to FDOT projects, requires all shafts to provide a temperature control plan. The disconnect between FDOT shafts and the ACI criteria is two-fold: (1) the curing conditions of underground concrete are not the same as above-ground formed and poured elements, and (2) FDOT peak temperature limits are higher than ACI limits.

This study explored three areas to better define when a drilled shaft should be considered for mass concrete review: (1) past thermal integrity data, (2) shafts instrumented with centralized temperature measurement apparatuses, and (3) numerical modeling calibrated by field measurements and extended to multiple size and concrete mix designs to predict internal peak and differential temperature magnitudes.

In the first part of this study, shaft temperature information was obtained from hundreds of shafts routinely tested using thermal integrity methods. Time of testing (temperature measurements) ranged from 10 to 140 hours and recall thermal integrity measurements are taken at the location of the cage. Out of 662 cage-based measurements [not core temperatures], 5 shafts (0.8%) exceeded the FDOT 180°F peak temperature criterion and 90 (13.6%) exceeded the ACI 158°F peak temperature limit (Figure 2.2). This raises two points: (1) core temperature will always be higher than the thermal integrity cage measurements, and (2) thermal integrity testing was not necessarily conducted at peak temperature. Some were close to the time of peak temperature (i.e. 24-48 hours), but most were not. Thus, methods to predict the core temperature from cage measurements were developed.

The second part of the study involved field measurements where the limitations of cage based thermal integrity measurements were remedied. To ensure the temperature was collected at the time of peak temperature, permanently installed thermal sensors were used where the temperature was monitored from the time of initial casting to well past the peak temperature. Secondly, a series of cage measurement modifications were introduced where crisscrossing rebar were used to secure thermal sensors at the center of the cage. However, as the cage is not always centered/concentric in the excavation, the center of cage is likely to not be the hottest region of the shaft cross section. Hence, additional sensors were secured to the crisscrossing rebar to show the diametric temperature distributions in orthogonal directions (e.g., N-S and E-W). These data showed a near perfect fit for temperature versus radial position with a parabolic function.

With the success of the across-shaft temperature measurements, an offset thermal wire configuration was introduced with the intent of exploring temperature gradient. The measurements taken from the offset thermal wires were compared to thermal probe measurements and were found to match closely. While this is a good start, these gradients over relatively small distances should be compared against corresponding full across-shaft temperature distributions to determine if the small gradient is truly representative of the parabolic slope.

In part three, the results of extensive numerical modeling were presented with the intent of better quantifying the circumstances most likely to lead to mass concrete conditions in drilled shafts. Three typical cementitious material content proportions were considered: Portland cement and fly ash, Portland cement and slag, and pure Portland cement. Selection of the modeled fly ash and slag proportions were based on two typical mixes found to occur most frequently in the database of shafts where temperature measurements and mix design were furnished. Other cementitious materials proportions can be similarly modeled.

Model results were verified using field measurements where the peak temperature, temperature distribution across the shaft, and temperature versus time relationships matched closely. With this validation, the temperature results from the wide range of modeled parameters were used to identify the conditions that cause a drilled shaft to exceed ACI and/or FDOT temperature limit criteria. Closed-form equations were developed for the three mix design types where the shaft size and total cementitious material content was input. Depending on the equation used, peak temperature, true differential (edge-to-core) temperature, or cage-to-core differential temperature can be estimated. The peak temperature and true differential temperature equations can be used as pre-construction design aids, while the cage-to-core differential temperature prediction can be added to the maximum average cage temperature routinely measured in the field to determine if a given shaft has exceeded the peak temperature limit (ACI and/or FDOT). The error associated with these equations was determined for drilled shafts three feet in diameter or larger with TCC between 560-1060 lb/yd^3 based on the fitted function value and the model determined values. The errors are as follows:

- Cage-to-core differential equations
  - 34% fly ash, +1.9/-0.3°F
  - 60% slag, +2.4/-1.5°F
  - 100% Portland cement, +1.3/-1.1°F
- Edge-to-core differential equations
  - 34% fly ash, +2.6/-1.0°F
  - 60% slag, +2.5/-2.6°F
  - 100% Portland cement, +6.5/-3.9°F
- Peak temperature equations
  - 34% fly ash, +4.6/-2.0°F
  - 60% slag, +4.5/-2.4°F
  - 100% Portland cement, +3.3/-10.9°F

A database of thermal integrity tests for drilled shafts constructed with slag mixes was evaluated using the peak and differential temperature prediction relationships. This database consisted of a total of 70 shafts. Shaft diameters ranged from 42 to 78 inches and total cement contents ranged from 660 to 930 lbs/yd^3. The most frequently occurring shaft diameter was 72 inches; 68 of the 70 shafts were 72 inches or smaller, which were excluded from mass concrete considerations by FDOT specifications at the time of this study (FDOT, 2019c). The average TCC was 760 lbs/yd^3. Figures 5.1 and 5.2 show the edge-to-core differential temperature and peak temperature predictions, respectively. All but one drilled shaft (98.6%) exceeded the ACI differential temperature limit of 35°F. Forty-three shafts (61%) exceeded the ACI peak temperature limit of 158°F and four (6%) exceeded the ACI never-to-exceed peak temperature limit of 185°F. The primary motivation behind these temperature limitations is to prevent long-term durability issues in concrete structures.

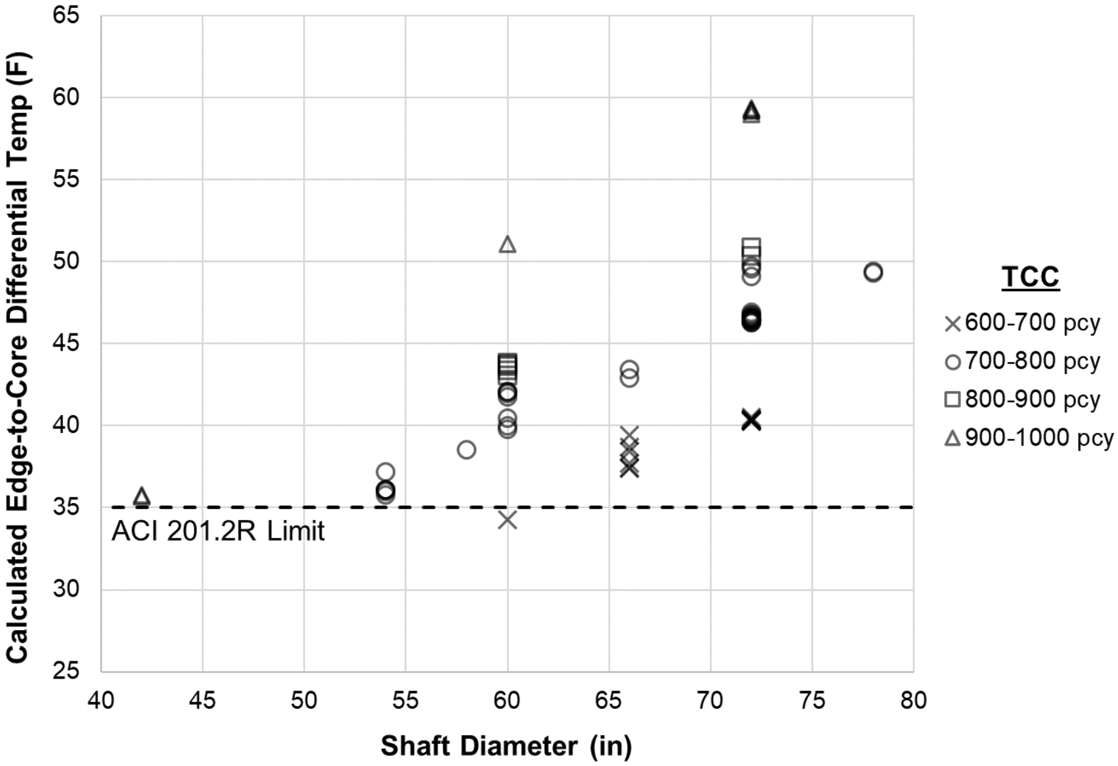


Figure 5.1 Plot presenting edge-to-core differential temperatures calculated from the database of drilled shafts with previously collected thermal data versus shaft diameter organized by TCC.
[This is a plot presenting calculated edge-to-core differential temperatures on the y-axis versus shaft diameter on the x-axis for 70 drilled shafts where thermal data was previously collected (a subset of the data presented in Chapter 2 of this report). Temperatures range from approximately 34°F to 59°F. All drilled shafts in this data subset were constructed with slag blended mixes. This plot also marks the differential temperature limit specified in ACI 201.2R at 35ºF.]

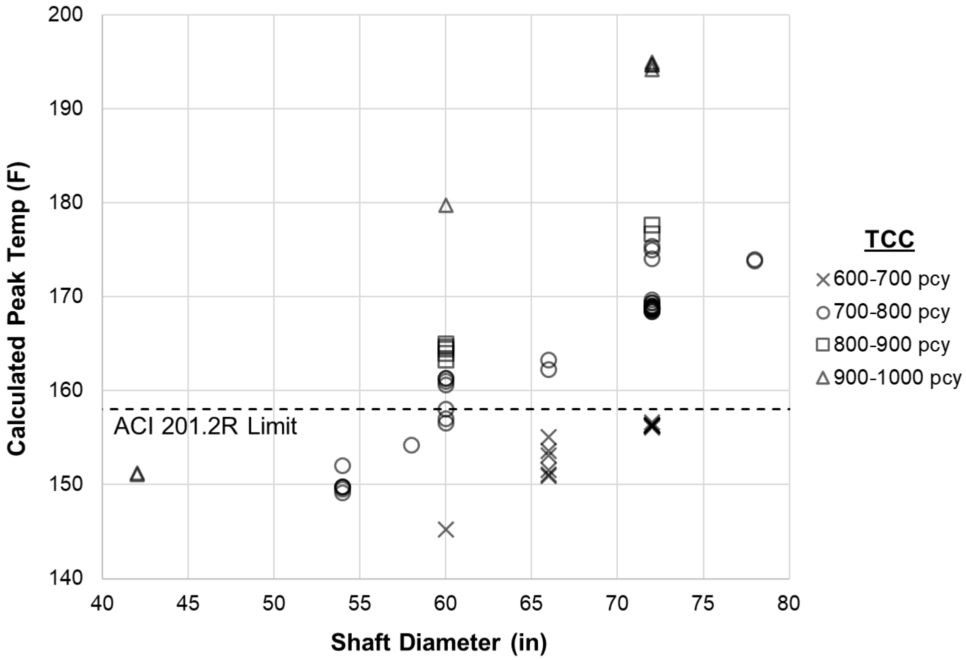
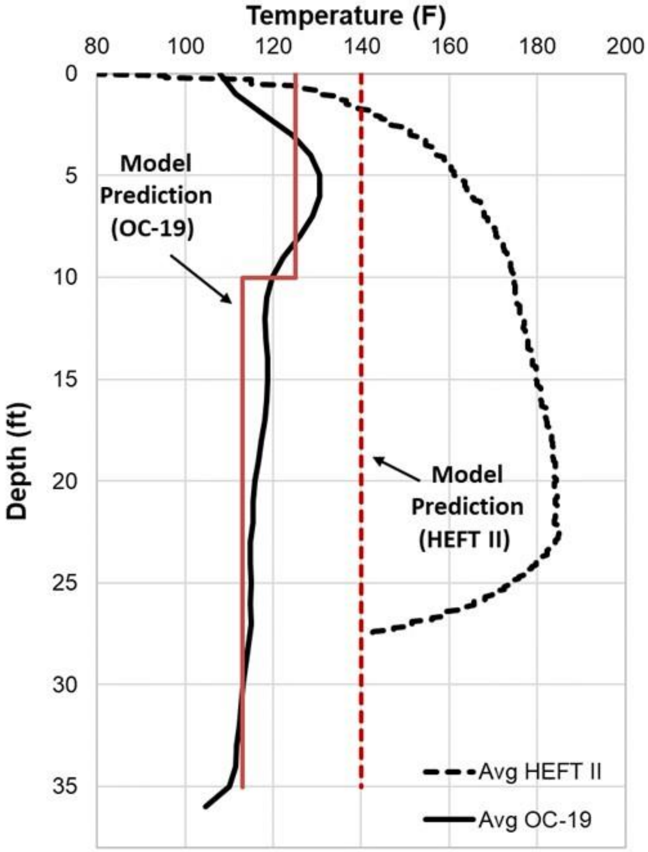


Figure 5.2 Plot presenting peak temperatures calculated from the database of drilled shafts with previously collected thermal data versus shaft diameter organized by TCC.

[This is a plot presenting calculated peak temperatures on the y-axis versus shaft diameter on the x-axis for 70 drilled shafts where thermal data was previously collected (a subset of the data presented in Chapter 2 of this report). Temperatures range from approximately 145°F to 195°F. All drilled shafts in this data subset were constructed with slag blended mixes. This plot also marks the peak temperature limit specified in ACI 201.2R at 158°F.]

In addition to mix design and shaft diameter, cementitious constituent composition also plays a significant role in peak temperature. Figure 5.3 illustrates the average temperature profiles (taken at the reinforcement cage) from the HEFT II shaft (Chapter 2) and OC-19 (Chapter 4); both were 6 feet in diameter, and both were 60% slag mixes. OC-19 had a 7-foot diameter surface casing which made the upper 10 feet of the shaft warmer. Comparing just the hottest portion of the 6-foot diameter regions, the peak average temperatures were 118°F at 15 feet (OC-19) and 184°F at 23 feet (HEFT II). At first glance, the logical explanation for the large difference in cage temperature would be the TCC (660 vs 924 lb/yd^3). However, the peak temperature contours presented in Chapter 4 (Figure 4.4) indicate a 6-foot shaft with 924 lb/yd^3 TCC is predicted to have a peak core temperature of approximately 193°F which is only slightly higher than the measured 184°F average cage temperature. Figure 5.4 shows the modeled across-shaft temperature distribution for six-foot shafts with TCC values ranging from 660lbs/yd^3 (OC-19) to 960lbs/yd^3 (just higher than the 925lbs/yd^3 for the HEFT II shaft). The open diamond-shaped marker denotes the interpolated predicted cage temperature for the hotter shaft to be 145°F, 39°F less than measured. The corollary is the model-predicted core temperature of 193°F is likely to have underpredicted the actual core temperature by at least 39°F making the core >232°F.



HEFT II Mix Design	
Cement	360.0 lb/yd^3
Slag	564.4 lb/yd^3
Water	273.9 lb/yd^3
Coarse Agg	1497.8 lb/yd^3
Fine Agg	915.6 lb/yd^3

OC-19 Mix Design	
Cement	266.1 lb/yd^3
Slag	393.9 lb/yd^3
Water	177.7 lb/yd^3
Coarse Agg	1615.6 lb/yd^3
Fine Agg	1322.2 lb/yd^3

Figure 5.3 Disparate temperature profiles.

[This is a compound figure with a plot on the left where the x-axis is temperature and the y-axis is depth and the data presented includes the measured average cage temperatures for drilled shaft OC-19 with the corresponding model temperatures overlayed as well as the measured average cage temperatures for the HEFT-II drilled shaft with the corresponding model temperatures overlayed. On the right are the concrete mix designs for both drilled shafts.]

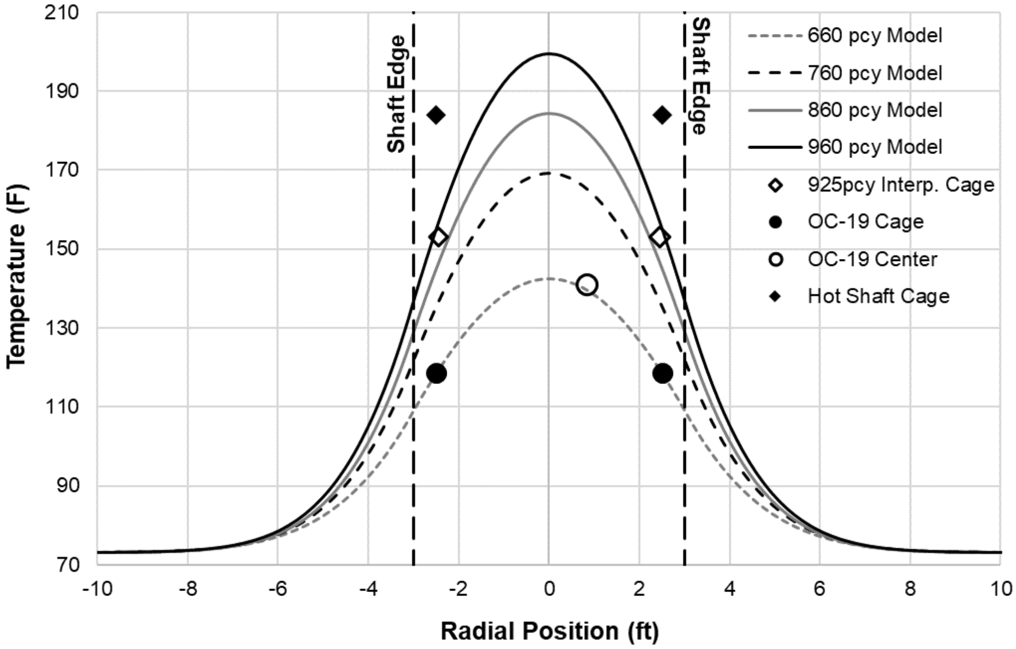


Figure 5.4 Comparison between model data, measured OC-19 data, and measured HEFT II data. *[This is a plot where the x-axis is radial position in feet and the y-axis is temperature and the data presented includes across-shaft modeled temperature distributions for total cementitious contents ranging from 660 lb/yd^3 to 906 lb/yd^3, as well as data points for interpolated cage temperature for a 925 lb/yd^3 mix, measured average cage temperature for drilled shaft OC-19, measured center wire temperature for drilled shaft OC-19, and measured average cage temperature for drilled shaft HEFT-II.]*

The 60% slag model results were based on the cementitious constituent compositions for OC-19 and are representative of the most common shaft mixes presently used in Florida. The mill certifications for the cement and slag used in the HEFT II shaft were not available but were expected to have been quite different. Due to hydration being such a complex process, particularly with slag-blended cements, the differences in physical and chemical characteristics are likely to have drastically affected the heat energy production during curing (Zhu et al., 2022). It is known that alumina content, MgO/Al_2O_3 (M/A) ratio, and slag fineness all contribute to how much or fast heat energy is produced (Zayed et al., 2019). This extreme variation in curing performance gives cause to revisit the HEFT II shaft for core samples and testing. Since the HEFT II shaft construction in 2018, a sufficient amount of time has elapsed for any durability issues such as thermal cracking, delayed ettringite formation, or concrete strength reduction to be revealed.

Variations in slag constituent composition is now being joined by changes in fly ash compositions and definitions. As of 2023, ASTM Committee C09 allows for the use of blended fly ash and bottom ash, resulting in coal ash (ASTM, 2023). This has the potential for significant changes in concrete performance, as bottom ash is known to be generally inert compared to fly ash (Thomas et al., 2017). Without accurate and standardized mill certificate reporting, modeling results cannot be used reliably. With respect to minerology, typically Bogue calculations are used to determine C3S, C2S, C3A, and C4AF, however this can lead to discrepancies in quantification by up to 10%. Quantitative x-ray diffraction is more accurate for quantifying cementitious minerals and can identify specific mineral forms (e.g., calcium sulfate). Further, the α, β, τ parameters on which the modeling results are based do not account for the variability in slag and fly ash constituent compositions that are found in the field today.

Where mass concreting programs are concerned, core and cage temperatures are typically used to determine differential temperature, however the cage-to-core and edge-to-core contour plots show that there can be as much as a 30°F difference between the two. This raises the questions: which is more correct, or are neither correct if a center bar is not centered? Should the differential between the hottest and coldest parts of the shaft (184-80=104°F, Figure 2.10) be considered regardless of where they occur? Or, is the largest temperature gradient (°F/in) most likely more important when identifying cracking stress potential?

To date, the rationales for setting peak and differential temperature limits vary and are likely to continue to be in dispute given the variability of cementitious constituent compositions. This variability can be found in the materials used by the researchers leading up to these conclusions / specifications. This study did not aim to address which of the two temperature criteria are most correct, but rather focused on determining the actual peak and differential temperature in drilled shafts with varied concrete mix designs and from shafts of different diameters. However, the threshold of safety is left to the reviewer when using a given acceptance criteria (FDOT, ACI, or other).

Finally, the current specifications for all concrete elements need to be unified. Drilled shafts should not be exempted from mass concrete specifications, nor should any element; even 30-in diameter elements have been shown to exceed peak temperature limits for both FDOT and ACI.

5.2 Conclusions and Recommendations

Based on the findings of this study the following points can be made:

- Specialized field temperature measurements confirmed the relationship between temperature and radial position across the diameter of a drilled shaft within the reinforcement cage to be parabolic.
- It is possible that the temperature measurements taken by the individual sensors of a thermal probe can be used to calculate temperature gradient across commonly placed access tubes in drilled shafts, however further investigation is needed to confirm this gradient is truly representative of the parabolic slope.

- Based on the predicted edge-to-core differential temperatures and peak temperatures estimated from a database of 70 drilled shafts constructed with concrete mixes using slag-blended cement, most drilled shafts excluded from mass concrete considerations exceed one or both ACI temperature limitations (peak and differential).
- Chemical and physical characteristics of cementitious material play a significant role in heat energy production and should be considered alongside cementitious material replacement level when designing drilled shafts.
- Designer-friendly contour plots and closed-form equations were developed from models to determine when a given project should include a mass concrete control plan. The mill certs for the modeled cementitious materials can be considered typical, not highly reactive, and predicted temperature values should not overpredict field temperature values.
- It is recommended that the HEFT II shaft in Miami, Florida be revisited for core samples and testing to determine if long-term concrete durability has been affected by extreme curing temperatures.
- Further investigation into how differential temperature is determined is recommended, as it is unclear whether differential should be taken between the hottest and coldest parts of a shaft, between core and edge, or if the largest temperature gradient is more effective when identifying cracking stress potential.
- The 35°F differential is exceeded by virtually all drilled shafts, yet a commensurate amount damage or cases have not been seen. A more robust criterion for differential temperature limits is needed.
- Including mill certificates as part of shaft installation plans and/or submittal documents is recommended.
- Mill certs are not presently standardized; standardized mill certificate reporting is recommended for all cementitious material types.
- Sized-based guidelines for mass concrete considerations are obsolete given the increase in total cementitious contents used in recent years, therefore it is recommended that specifications move away from this approach with prioritization on performance-based guidelines.
- Evaluation of all drilled shafts for possible mass concrete considerations is recommended.

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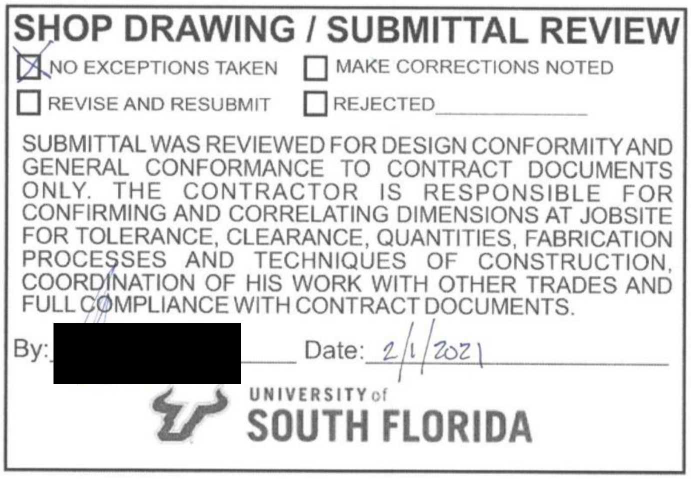
Zhu, H., Mapa, D. G., Lucero, C., Riding, K. A., & Zayed, A. (2022). Effect of Slag Characteristics on Adiabatic Temperature Rise of Blended Concrete. *ACI Materials Journal*, 119(1).

Appendix A: *Judy Genshaft Honors College Drilled Shaft DS-6 Construction Documents*



SHOP DRAWING / SUBMITTAL REVIEW

☒ NO EXCEPTIONS TAKEN ☐ MAKE CORRECTIONS NOTED

☐ REVISE AND RESUBMIT ☐ REJECTED______________

SUBMITTAL WAS REVIEWED FOR DESIGN CONFORMITY AND GENERAL CONFORMANCE TO CONTRACT DOCUMENTS ONLY. THE CONTRACTOR IS RESPONSIBLE FOR CONFIRMING AND CORRELATING DIMENSIONS AT JOBSITE FOR TOLERANCE, CLEARANCE, QUANTITIES, FABRICATION PROCESSES AND TECHNIQUES OF CONSTRUCTION, COORDINATION OF HIS WORK WITH OTHER TRADES AND FULL COMPLIANCE WITH CONTRACT DOCUMENTS.

By: [redacted] Date: 2/1/2021

UNIVERSITY of SOUTH FLORIDA

Figure A.1 Genshaft Honors College concrete mix design submittal page 1.

Submittal #31 63 29-1.0

The Beck Group
220 West 7th Avenue, Suite 200
Tampa, Florida 33602
Phone: (813) 282-3900
Fax: (813) 288-0188

Project: 171685 - University of South Florida Judy Genshaft Honors College
4202 E. Fowler Ave
Tampa, Florida 33620

DM-Drilled Pier

SPEC SECTION:	31 63 29 - DRILLED CONCRETE PIERS		
ISSUE DATE:		**FINAL DUE DATE:**	1/12/2021
TYPE:	Design Mixtures	**REVISION:**	0
RESPONSIBLE CONTRACTOR:	R.W. Harris, Inc.	**RECEIVED FROM:**	Dean Cacio

DESCRIPTION:
Concrete Mix Design: Submit concrete mix designs suitable for method of concrete placement for Engineer and Owner's Testing Laboratory approval prior to pier installation.

ATTACHMENTS:

STAMPS

HCBeck, Ltd.
SUBMITTAL STAMP

REVIEWED AS TO GENERAL COMPLIANCE WITH THE CONTRACT DOCUMENTS. SUBMITTER TO VERIFY DIMENSIONS, QUANTITIES, AND FIELD CONDITIONS FOR PROPER AND COMPLETE PERFORMANCE OF THE SUBMITTED ITEMS. REVIEW DOES NOT RELIEVE SUBMITTER FROM RESPONSIBILITY FOR ERRORS OR DEVIATIONS FROM CONTRACT DOCUMENTS. REVIEW DOES NOT CONSTITUTE APPROVAL OF SAFETY PRECAUTIONS OR OF ANY CONSTRUCTION MEANS, METHODS, TECHNIQUES, SEQUENCES OR PROCEDURES. REVIEW OF A SPECIFIC ITEM SHALL NOT INDICATE APPROVAL OF AN ASSEMBLY OF WHICH THE ITEM IS A COMPONENT.

REVIEWED BY: Charlotte Hart DATE:12/21/2020

- ☐ REJECTED
- ☐ REVISE AND RESUBMIT
- ☑ SUBMITTAL FOR REVIEW
- ☐ SUBMITTAL FOR INFORMATION
- ☐ RESUBMITTAL FOR REVIEW

☐ NO EXCEPTIONS TAKEN ☐ REVISE AND RESUBMIT
🟥 EXCEPTIONS NOTED ☐ SUBMIT SPECIFIED ITEM(s)

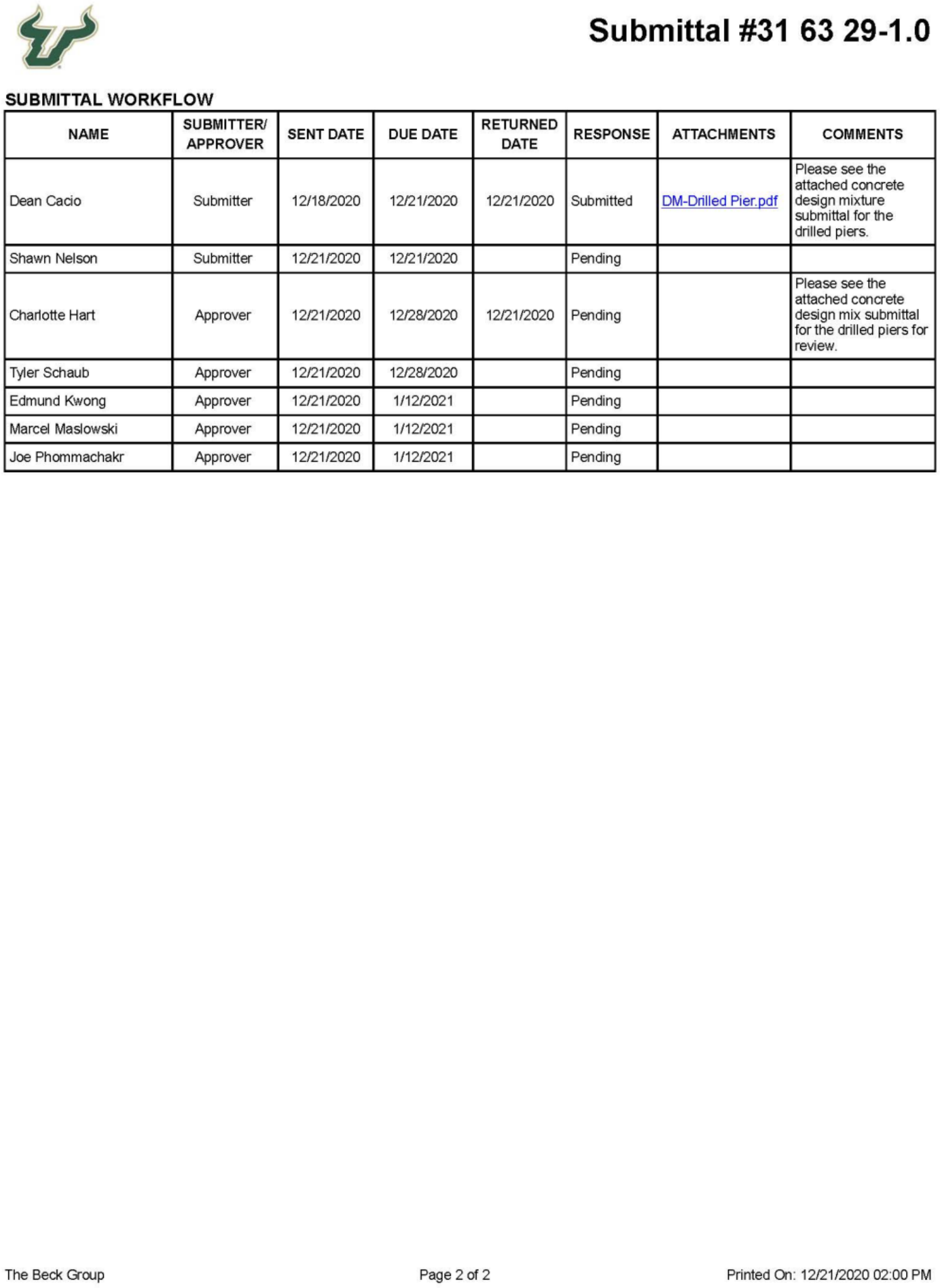
Checking is only for general conformance with design concept of the project and for general compliance with Contract Documents. Contractor is responsible for confirming and correcting dimensions at job sites for information which pertains to fabrication processes or construction techniques and for coordination of work of all trades. Checking of shop drawings shall not relieve the Contractor of responsibility for deviances from requirements of Contract Documents and for errors and omissions in the shop drawings.

BY: Anthony De Furio (WPM) DATE: 01/04/2021

WALTER P MOORE AND ASSOCIATES, INC.

The Beck Group Page 1 of 2 Printed On: 12/21/2020 02:00 PM

Figure A.2 Genshaft Honors College concrete mix design submittal page 2.



Submittal #31 63 29-1.0

SUBMITTAL WORKFLOW

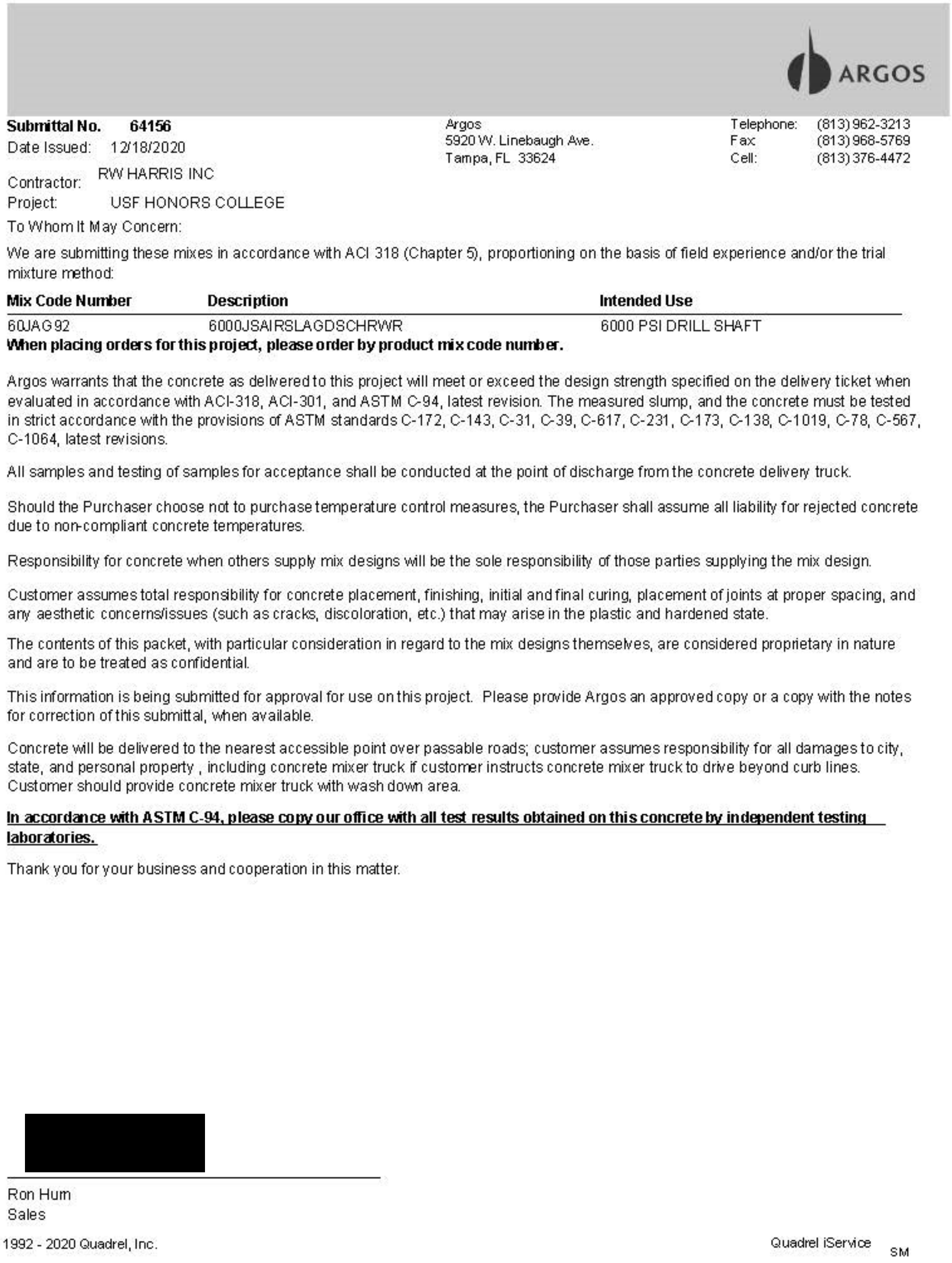
NAME	SUBMITTER/ APPROVER	SENT DATE	DUE DATE	RETURNED DATE	RESPONSE	ATTACHMENTS	COMMENTS
Dean Cacio	Submitter	12/18/2020	12/21/2020	12/21/2020	Submitted	DM-Drilled Pier.pdf	Please see the attached concrete design mixture submittal for the drilled piers.
Shawn Nelson	Submitter	12/21/2020	12/21/2020		Pending		
Charlotte Hart	Approver	12/21/2020	12/28/2020	12/21/2020	Pending		Please see the attached concrete design mix submittal for the drilled piers for review.
Tyler Schaub	Approver	12/21/2020	12/28/2020		Pending		
Edmund Kwong	Approver	12/21/2020	1/12/2021		Pending		
Marcel Maslowski	Approver	12/21/2020	1/12/2021		Pending		
Joe Phommachakr	Approver	12/21/2020	1/12/2021		Pending		

The Beck Group

Page 2 of 2

Printed On: 12/21/2020 02:00 PM

Figure A.3 Genshaft Honors College concrete mix design submittal page 3.



ARGOS

Submittal No. **64156**
Date Issued: 12/18/2020

Argos
5920 W. Linebaugh Ave.
Tampa, FL 33624

Telephone:	(813) 962-3213
Fax:	(813) 968-5769
Cell:	(813) 376-4472

Contractor: RW HARRIS INC
Project: USF HONORS COLLEGE

To Whom It May Concern:

We are submitting these mixes in accordance with ACI 318 (Chapter 5), proportioning on the basis of field experience and/or the trial mixture method:

Mix Code Number	Description	Intended Use
60JAG92	6000JSAIRSLAGDSCHRWR	6000 PSI DRILL SHAFT

When placing orders for this project, please order by product mix code number.

Argos warrants that the concrete as delivered to this project will meet or exceed the design strength specified on the delivery ticket when evaluated in accordance with ACI-318, ACI-301, and ASTM C-94, latest revision. The measured slump, and the concrete must be tested in strict accordance with the provisions of ASTM standards C-172, C-143, C-31, C-39, C-617, C-231, C-173, C-138, C-1019, C-78, C-567, C-1064, latest revisions.

All samples and testing of samples for acceptance shall be conducted at the point of discharge from the concrete delivery truck.

Should the Purchaser choose not to purchase temperature control measures, the Purchaser shall assume all liability for rejected concrete due to non-compliant concrete temperatures.

Responsibility for concrete when others supply mix designs will be the sole responsibility of those parties supplying the mix design.

Customer assumes total responsibility for concrete placement, finishing, initial and final curing, placement of joints at proper spacing, and any aesthetic concerns/issues (such as cracks, discoloration, etc.) that may arise in the plastic and hardened state.

The contents of this packet, with particular consideration in regard to the mix designs themselves, are considered proprietary in nature and are to be treated as confidential.

This information is being submitted for approval for use on this project. Please provide Argos an approved copy or a copy with the notes for correction of this submittal, when available.

Concrete will be delivered to the nearest accessible point over passable roads; customer assumes responsibility for all damages to city, state, and personal property , including concrete mixer truck if customer instructs concrete mixer truck to drive beyond curb lines. Customer should provide concrete mixer truck with wash down area.

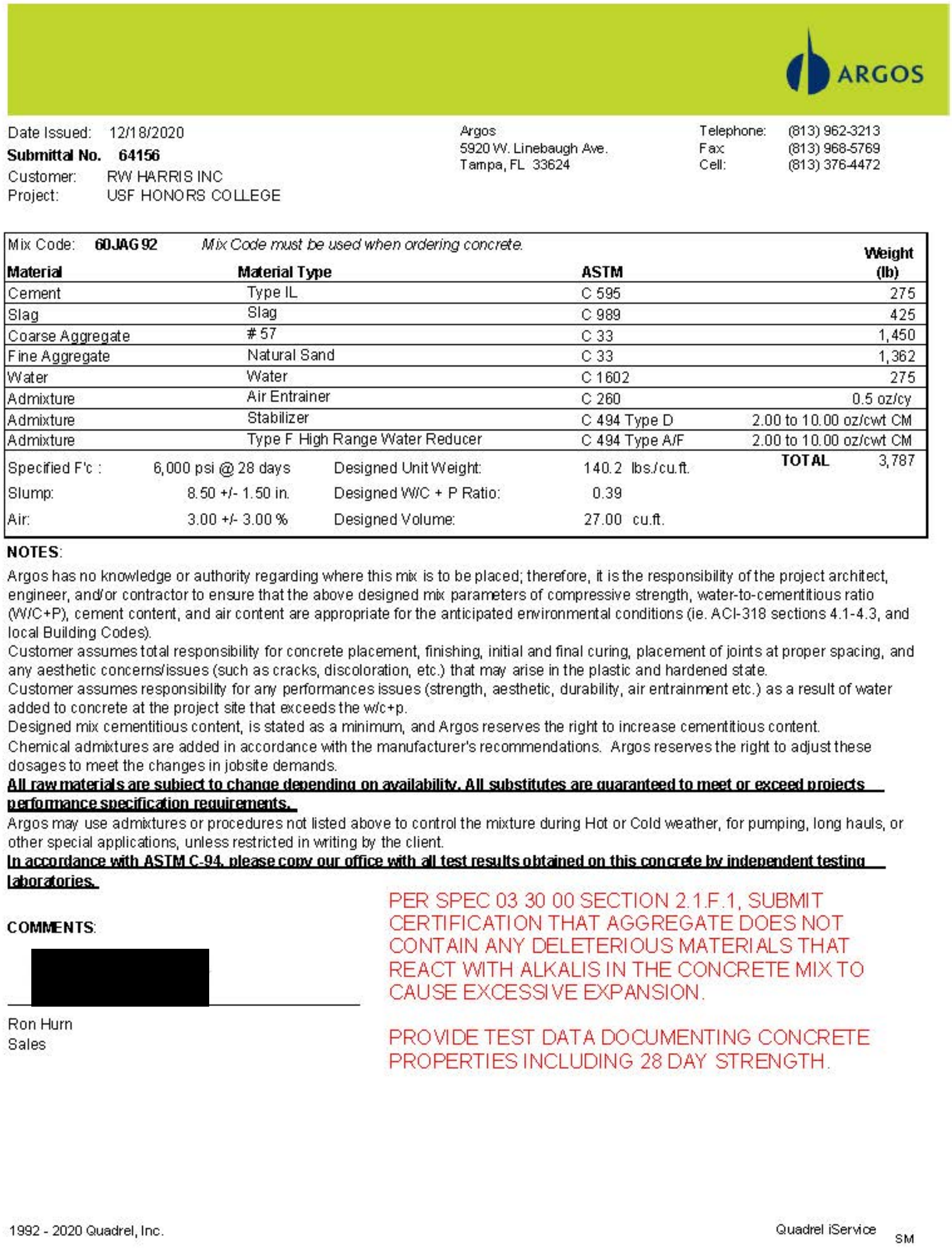
In accordance with ASTM C-94, please copy our office with all test results obtained on this concrete by independent testing laboratories.

Thank you for your business and cooperation in this matter.

[redacted]

Ron Hum
Sales

Figure A.4 Genshaft Honors College concrete mix design submittal page 4.



ARGOS

Date Issued: 12/18/2020
Submittal No. 64156
Customer: RW HARRIS INC
Project: USF HONORS COLLEGE

Argos
5920 W. Linebaugh Ave.
Tampa, FL 33624

Telephone: (813) 962-3213
Fax: (813) 968-5769
Cell: (813) 376-4472

Mix Code: **60JAG92** *Mix Code must be used when ordering concrete.*

Material	Material Type	ASTM	Weight (lb)
Cement	Type IL	C 595	275
Slag	Slag	C 989	425
Coarse Aggregate	# 57	C 33	1,450
Fine Aggregate	Natural Sand	C 33	1,362
Water	Water	C 1602	275
Admixture	Air Entrainer	C 260	0.5 oz/cy
Admixture	Stabilizer	C 494 Type D	2.00 to 10.00 oz/cwt CM
Admixture	Type F High Range Water Reducer	C 494 Type A/F	2.00 to 10.00 oz/cwt CM

Specified F'c :	6,000 psi @ 28 days	Designed Unit Weight:	140.2 lbs./cu.ft.	**TOTAL**	3,787
Slump:	8.50 +/- 1.50 in.	Designed W/C + P Ratio:	0.39		
Air:	3.00 +/- 3.00 %	Designed Volume:	27.00 cu.ft.		

NOTES:

Argos has no knowledge or authority regarding where this mix is to be placed; therefore, it is the responsibility of the project architect, engineer, and/or contractor to ensure that the above designed mix parameters of compressive strength, water-to-cementitious ratio (W/C+P), cement content, and air content are appropriate for the anticipated environmental conditions (ie. ACI-318 sections 4.1-4.3, and local Building Codes).

Customer assumes total responsibility for concrete placement, finishing, initial and final curing, placement of joints at proper spacing, and any aesthetic concerns/issues (such as cracks, discoloration, etc.) that may arise in the plastic and hardened state.

Customer assumes responsibility for any performances issues (strength, aesthetic, durability, air entrainment etc.) as a result of water added to concrete at the project site that exceeds the w/c+p.

Designed mix cementitious content, is stated as a minimum, and Argos reserves the right to increase cementitious content.

Chemical admixtures are added in accordance with the manufacturer's recommendations. Argos reserves the right to adjust these dosages to meet the changes in jobsite demands.

All raw materials are subject to change depending on availability. All substitutes are guaranteed to meet or exceed projects performance specification requirements.

Argos may use admixtures or procedures not listed above to control the mixture during Hot or Cold weather, for pumping, long hauls, or other special applications, unless restricted in writing by the client.

In accordance with ASTM C-94, please copy our office with all test results obtained on this concrete by independent testing laboratories.

COMMENTS:

[redacted]

Ron Hurn
Sales

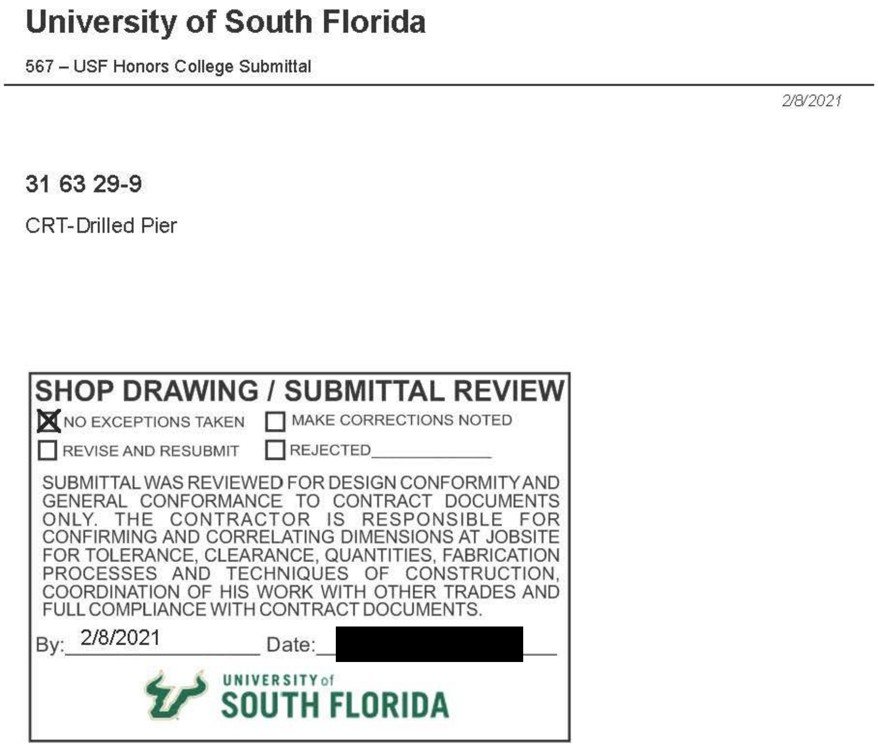
PER SPEC 03 30 00 SECTION 2.1.F.1, SUBMIT CERTIFICATION THAT AGGREGATE DOES NOT CONTAIN ANY DELETERIOUS MATERIALS THAT REACT WITH ALKALIS IN THE CONCRETE MIX TO CAUSE EXCESSIVE EXPANSION.

PROVIDE TEST DATA DOCUMENTING CONCRETE PROPERTIES INCLUDING 28 DAY STRENGTH.

1992 - 2020 Quadrel, Inc.

Quadrel iService SM

Figure A.5 Genshaft Honors College concrete mix design submittal page 5.



University of South Florida

567 – USF Honors College Submittal

2/8/2021

31 63 29-9

CRT-Drilled Pier

SHOP DRAWING / SUBMITTAL REVIEW

☒ NO EXCEPTIONS TAKEN ☐ MAKE CORRECTIONS NOTED

☐ REVISE AND RESUBMIT ☐ REJECTED____________

SUBMITTAL WAS REVIEWED FOR DESIGN CONFORMITY AND GENERAL CONFORMANCE TO CONTRACT DOCUMENTS ONLY. THE CONTRACTOR IS RESPONSIBLE FOR CONFIRMING AND CORRELATING DIMENSIONS AT JOBSITE FOR TOLERANCE, CLEARANCE, QUANTITIES, FABRICATION PROCESSES AND TECHNIQUES OF CONSTRUCTION, COORDINATION OF HIS WORK WITH OTHER TRADES AND FULL COMPLIANCE WITH CONTRACT DOCUMENTS.

By: 2/8/2021 Date: [redacted]

UNIVERSITY of SOUTH FLORIDA

Figure A.6 Genshaft Honors College certification data submittal page 1.

Submittal #31 63 29-9.0

The Beck Group
220 West 7th Avenue, Suite 200
Tampa, Florida 33602
Phone: (813) 282-3900
Fax: (813) 288-0188

Project: 171685 - University of South Florida Judy Genshaft Honors College
4202 E. Fowler Ave
Tampa, Florida 33620

CRT-Drilled Pier

SPEC SECTION:	31 63 29 - DRILLED CONCRETE PIERS		
ISSUE DATE:	1/21/2021	**FINAL DUE DATE:**	2/14/2021
TYPE:	Certificates	**REVISION:**	0
RESPONSIBLE CONTRACTOR:	R.W. Harris, Inc.	**RECEIVED FROM:**	Dean Cacio

DESCRIPTION:
Certification data for concrete sources and design mixtures for drilled piers.

ATTACHMENTS:

STAMPS

HCBeck, Ltd.
SUBMITTAL STAMP

REVIEWED AS TO GENERAL COMPLIANCE WITH THE CONTRACT DOCUMENTS. SUBMITTER TO VERIFY DIMENSIONS, QUANTITIES, AND FIELD CONDITIONS FOR PROPER AND COMPLETE PERFORMANCE OF THE SUBMITTED ITEMS. REVIEW DOES NOT RELIEVE SUBMITTER FROM RESPONSIBILITY FOR ERRORS OR DEVIATIONS FROM CONTRACT DOCUMENTS. REVIEW DOES NOT CONSTITUTE APPROVAL OF SAFETY PRECAUTIONS OR OF ANY CONSTRUCTION MEANS, METHODS, TECHNIQUES, SEQUENCES OR PROCEDURES. REVIEW OF A SPECIFIC ITEM SHALL NOT INDICATE APPROVAL OF AN ASSEMBLY OF WHICH THE ITEM IS A COMPONENT.

REVIEWED BY: Charlotte Hart DATE:1/21/2021

- ☐ REJECTED
- ☐ REVISE AND RESUBMIT
- ☑ SUBMITTAL FOR REVIEW
- ☐ SUBMITTAL FOR INFORMATION
- ☐ RESUBMITTAL FOR REVIEW

■ NO EXCEPTIONS TAKEN ☐ REVISE AND RESUBMIT
☐ EXCEPTIONS NOTED ☐ SUBMIT SPECIFIED ITEM(s)

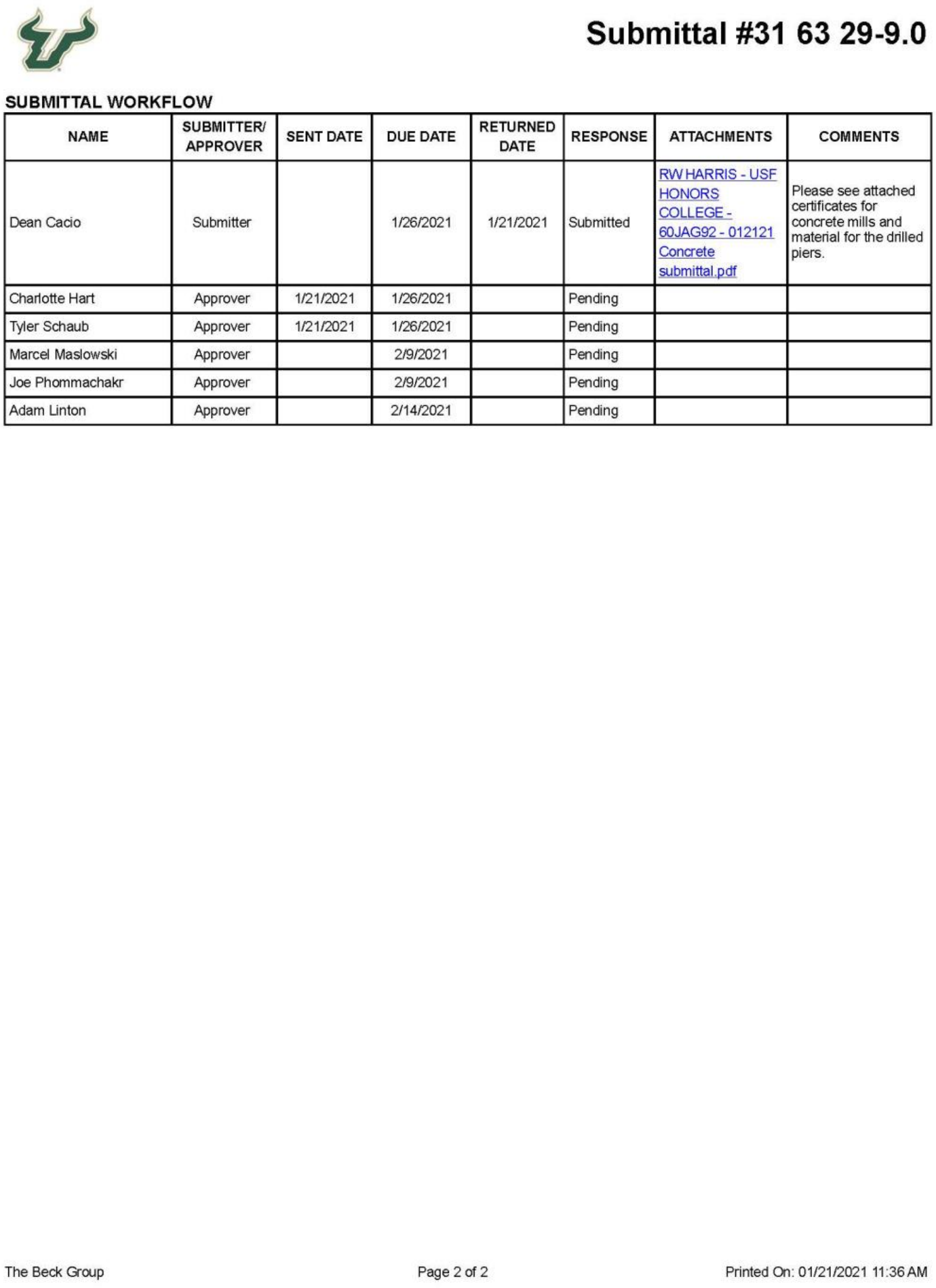
Checking is only for general conformance with design concept of the project and for general compliance with Contract Documents. Contractor is responsible for confirming and correcting dimensions at job sites for information which pertains to fabrication processes or construction techniques and for coordination of work of all trades. Checking of shop drawings shall not relieve the Contractor of responsibility for deviances from requirements of Contract Documents and for errors and omissions in the shop drawings.

BY: Anthony De Furio (WPM) DATE: 01/25/2021

WALTER P MOORE AND ASSOCIATES, INC.

The Beck Group Page 1 of 2 Printed On: 01/21/2021 11:36 AM

Figure A.7 Genshaft Honors College certification data submittal page 2.



Submittal #31 63 29-9.0

SUBMITTAL WORKFLOW

NAME	SUBMITTER/ APPROVER	SENT DATE	DUE DATE	RETURNED DATE	RESPONSE	ATTACHMENTS	COMMENTS
Dean Cacio	Submitter		1/26/2021	1/21/2021	Submitted	RW HARRIS - USF HONORS COLLEGE - 60JAG92 - 012121 Concrete submittal.pdf	Please see attached certificates for concrete mills and material for the drilled piers.
Charlotte Hart	Approver	1/21/2021	1/26/2021		Pending		
Tyler Schaub	Approver	1/21/2021	1/26/2021		Pending		
Marcel Maslowski	Approver		2/9/2021		Pending		
Joe Phommachakr	Approver		2/9/2021		Pending		
Adam Linton	Approver		2/14/2021		Pending		

The Beck Group Page 2 of 2 Printed On: 01/21/2021 11:36 AM

Figure A.8 Genshaft Honors College certification data submittal page 3.

ARGOS

Letter Of Transmittal

01/21/2021 6:08:17AM
Report 249901 *(internal use only)*

Please use the ***submittal number*** *located on the following pages when referring to the set of documents contained within this submittal.*

The following items are included in this mix submittal:

Fla_Argos Newberry Type IL PLC Data Sheet Florida.pdf attachment for Submittal #64156 for Project: USF HONORS COLLEGE

Fla_Argos Slag Mill Certification 011921.pdf attachment for Submittal #64156 for Project: USF HONORS COLLEGE

Fla_ Vulcan Tampa 57 cert ltr 12-20.pdf attachment for Submittal #64156 for Project: USF HONORS COLLEGE

Fla_Vulcan Diamond DOT cert ltr 12-20.pdf attachment for Submittal #64156 for Project: USF HONORS COLLEGE

Fla_Adva Cast 600 Certification.pdf attachment for Submittal #64156 for Project: USF HONORS COLLEGE

Fla_Adva Cast 600 Data Sheet.pdf attachment for Submittal #64156 for Project: USF HONORS COLLEGE

Fla_Darex AEA Certification.pdf attachment for Submittal #64156 for Project: USF HONORS COLLEGE

Fla_Darex AEA Data Sheet.pdf attachment for Submittal #64156 for Project: USF HONORS COLLEGE

Fla_Recover Certification.pdf attachment for Submittal #64156 for Project: USF HONORS COLLEGE

Fla_Recover Data Sheet.pdf attachment for Submittal #64156 for Project: USF HONORS COLLEGE

Fla_Argos Ready Mix Concrete Safety Data Sheet.pdf attachment for Submittal #64156 for Project: USF HONORS COLLEGE

Submittal #64156 for Project: USF HONORS COLLEGE

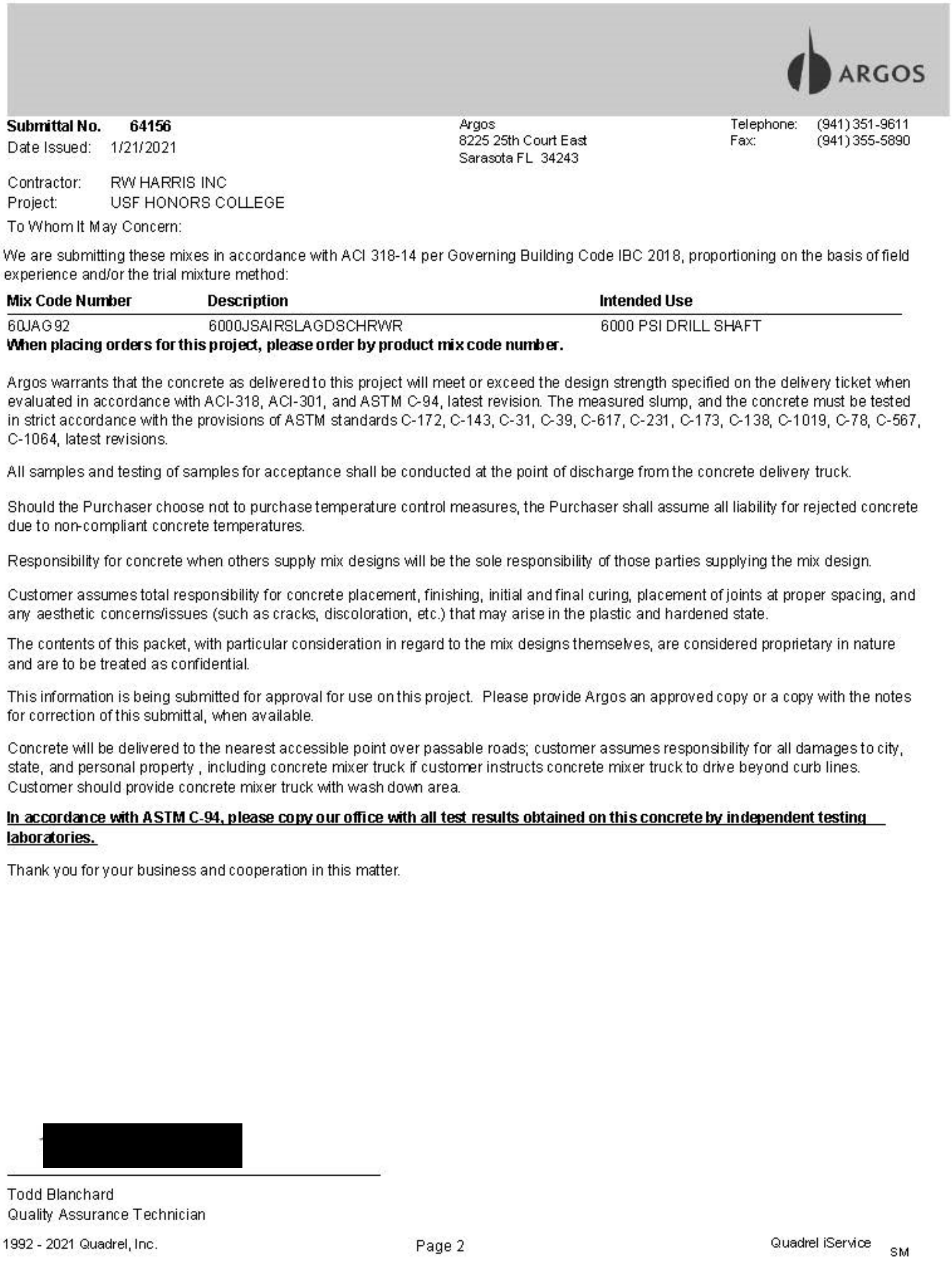
Detailed Data for Submittal #64156

Backup Data for Mix:60JAG92 of Submittal #64156 for Project: USF HONORS COLLEGE

Fla_Argos Newberry IL Mill Certification 011921.pdf attachment for Submittal #64156 for Project: USF HONORS COLLEGE

1992 - 2021 Quadrel, Inc. Page 1 Quadrel iService SM

Figure A.9 Genshaft Honors College certification data submittal page 4.



ARGOS

Submittal No. **64156**
Date Issued: 1/21/2021

Argos
8225 25th Court East
Sarasota FL 34243

Telephone: (941) 351-9611
Fax: (941) 355-5890

Contractor: RW HARRIS INC
Project: USF HONORS COLLEGE

To Whom It May Concern:

We are submitting these mixes in accordance with ACI 318-14 per Governing Building Code IBC 2018, proportioning on the basis of field experience and/or the trial mixture method:

Mix Code Number	**Description**	**Intended Use**
60JAG92	6000JSAIRSLAGDSCHRWR	6000 PSI DRILL SHAFT

When placing orders for this project, please order by product mix code number.

Argos warrants that the concrete as delivered to this project will meet or exceed the design strength specified on the delivery ticket when evaluated in accordance with ACI-318, ACI-301, and ASTM C-94, latest revision. The measured slump, and the concrete must be tested in strict accordance with the provisions of ASTM standards C-172, C-143, C-31, C-39, C-617, C-231, C-173, C-138, C-1019, C-78, C-567, C-1064, latest revisions.

All samples and testing of samples for acceptance shall be conducted at the point of discharge from the concrete delivery truck.

Should the Purchaser choose not to purchase temperature control measures, the Purchaser shall assume all liability for rejected concrete due to non-compliant concrete temperatures.

Responsibility for concrete when others supply mix designs will be the sole responsibility of those parties supplying the mix design.

Customer assumes total responsibility for concrete placement, finishing, initial and final curing, placement of joints at proper spacing, and any aesthetic concerns/issues (such as cracks, discoloration, etc.) that may arise in the plastic and hardened state.

The contents of this packet, with particular consideration in regard to the mix designs themselves, are considered proprietary in nature and are to be treated as confidential.

This information is being submitted for approval for use on this project. Please provide Argos an approved copy or a copy with the notes for correction of this submittal, when available.

Concrete will be delivered to the nearest accessible point over passable roads; customer assumes responsibility for all damages to city, state, and personal property , including concrete mixer truck if customer instructs concrete mixer truck to drive beyond curb lines. Customer should provide concrete mixer truck with wash down area.

In accordance with ASTM C-94, please copy our office with all test results obtained on this concrete by independent testing laboratories.

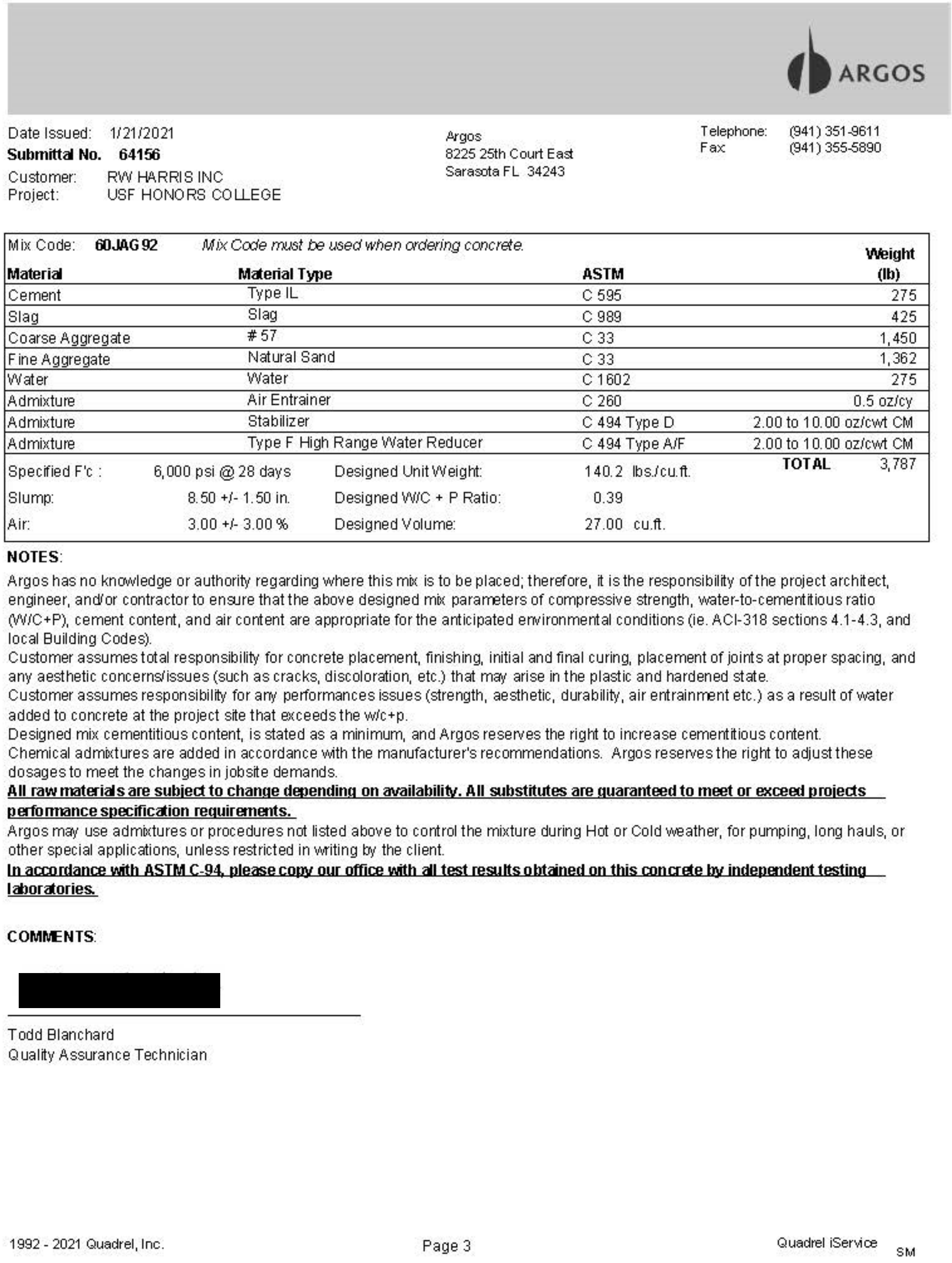
Thank you for your business and cooperation in this matter.

[redacted]

Todd Blanchard
Quality Assurance Technician

1992 - 2021 Quadrel, Inc.　　Page 2　　Quadrel iService SM

Figure A.10 Genshaft Honors College certification data submittal page 5.



ARGOS

Date Issued: 1/21/2021
Submittal No. 64156
Customer: RW HARRIS INC
Project: USF HONORS COLLEGE

Argos
8225 25th Court East
Sarasota FL 34243

Telephone: (941) 351-9611
Fax: (941) 355-5890

Mix Code: **60JAG92** *Mix Code must be used when ordering concrete.*

Material	**Material Type**	**ASTM**	**Weight (lb)**
Cement	Type IL	C 595	275
Slag	Slag	C 989	425
Coarse Aggregate	# 57	C 33	1,450
Fine Aggregate	Natural Sand	C 33	1,362
Water	Water	C 1602	275
Admixture	Air Entrainer	C 260	0.5 oz/cy
Admixture	Stabilizer	C 494 Type D	2.00 to 10.00 oz/cwt CM
Admixture	Type F High Range Water Reducer	C 494 Type A/F	2.00 to 10.00 oz/cwt CM

Specified F'c :	6,000 psi @ 28 days	Designed Unit Weight:	140.2 lbs./cu.ft.	**TOTAL**	3,787
Slump:	8.50 +/- 1.50 in.	Designed W/C + P Ratio:	0.39		
Air:	3.00 +/- 3.00 %	Designed Volume:	27.00 cu.ft.		

NOTES:

Argos has no knowledge or authority regarding where this mix is to be placed; therefore, it is the responsibility of the project architect, engineer, and/or contractor to ensure that the above designed mix parameters of compressive strength, water-to-cementitious ratio (W/C+P), cement content, and air content are appropriate for the anticipated environmental conditions (ie. ACI-318 sections 4.1-4.3, and local Building Codes).

Customer assumes total responsibility for concrete placement, finishing, initial and final curing, placement of joints at proper spacing, and any aesthetic concerns/issues (such as cracks, discoloration, etc.) that may arise in the plastic and hardened state.

Customer assumes responsibility for any performances issues (strength, aesthetic, durability, air entrainment etc.) as a result of water added to concrete at the project site that exceeds the w/c+p.

Designed mix cementitious content, is stated as a minimum, and Argos reserves the right to increase cementitious content.

Chemical admixtures are added in accordance with the manufacturer's recommendations. Argos reserves the right to adjust these dosages to meet the changes in jobsite demands.

All raw materials are subject to change depending on availability. All substitutes are guaranteed to meet or exceed projects performance specification requirements.

Argos may use admixtures or procedures not listed above to control the mixture during Hot or Cold weather, for pumping, long hauls, or other special applications, unless restricted in writing by the client.

In accordance with ASTM C-94, please copy our office with all test results obtained on this concrete by independent testing laboratories.

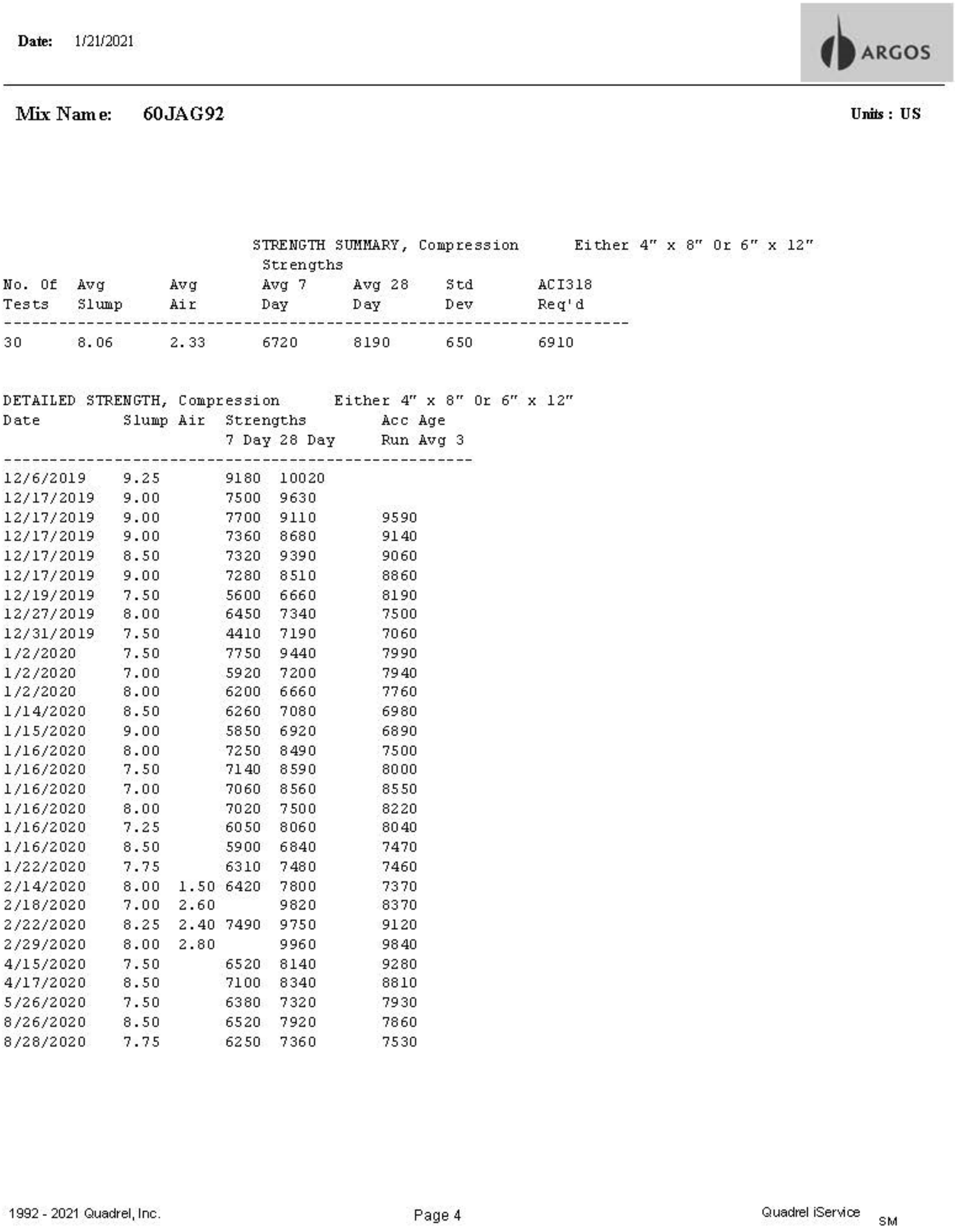
COMMENTS:

[redacted]

Todd Blanchard
Quality Assurance Technician

1992 - 2021 Quadrel, Inc. Page 3 Quadrel iService SM

Figure A.11 Genshaft Honors College certification data submittal page 6.



Date: 1/21/2021

ARGOS

Mix Name: **60JAG92**

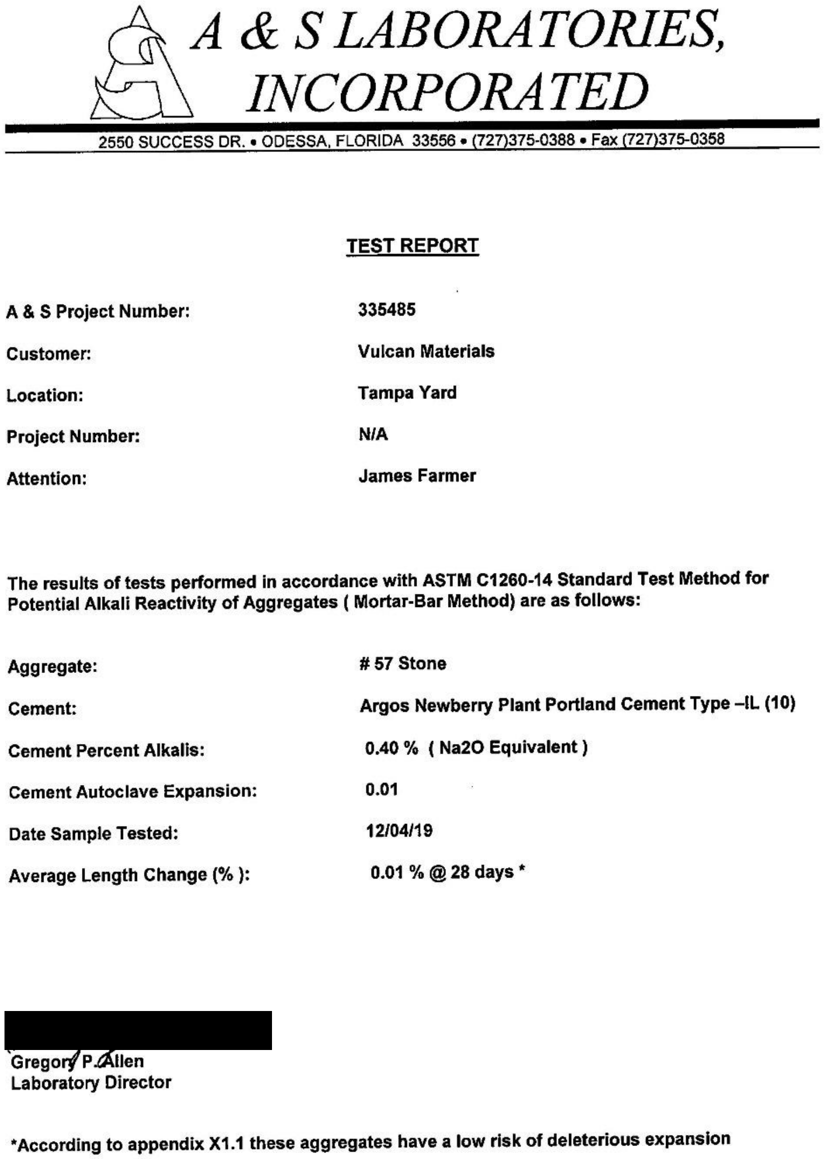
Units : US

```
                            STRENGTH SUMMARY, Compression      Either 4" x 8" Or 6" x 12"
                             Strengths
No. Of  Avg       Avg       Avg 7     Avg 28    Std       ACI318
Tests   Slump     Air       Day       Day       Dev       Req'd
--------------------------------------------------------------------
30      8.06      2.33      6720      8190      650       6910


DETAILED STRENGTH, Compression      Either 4" x 8" Or 6" x 12"
Date         Slump Air  Strengths        Acc Age
                        7 Day 28 Day     Run Avg 3
---------------------------------------------------
12/6/2019    9.25       9180  10020
12/17/2019   9.00       7500  9630
12/17/2019   9.00       7700  9110       9590
12/17/2019   9.00       7360  8680       9140
12/17/2019   8.50       7320  9390       9060
12/17/2019   9.00       7280  8510       8860
12/19/2019   7.50       5600  6660       8190
12/27/2019   8.00       6450  7340       7500
12/31/2019   7.50       4410  7190       7060
1/2/2020     7.50       7750  9440       7990
1/2/2020     7.00       5920  7200       7940
1/2/2020     8.00       6200  6660       7760
1/14/2020    8.50       6260  7080       6980
1/15/2020    9.00       5850  6920       6890
1/16/2020    8.00       7250  8490       7500
1/16/2020    7.50       7140  8590       8000
1/16/2020    7.00       7060  8560       8550
1/16/2020    8.00       7020  7500       8220
1/16/2020    7.25       6050  8060       8040
1/16/2020    8.50       5900  6840       7470
1/22/2020    7.75       6310  7480       7460
2/14/2020    8.00  1.50 6420  7800       7370
2/18/2020    7.00  2.60       9820       8370
2/22/2020    8.25  2.40 7490  9750       9120
2/29/2020    8.00  2.80       9960       9840
4/15/2020    7.50       6520  8140       9280
4/17/2020    8.50       7100  8340       8810
5/26/2020    7.50       6380  7320       7930
8/26/2020    8.50       6520  7920       7860
8/28/2020    7.75       6250  7360       7530
```

1992 - 2021 Quadrel, Inc.   Page 4   Quadrel iService SM

Figure A.12 Genshaft Honors College certification data submittal page 7.



A & S LABORATORIES, INCORPORATED

2550 SUCCESS DR. • ODESSA, FLORIDA 33556 • (727)375-0388 • Fax (727)375-0358

TEST REPORT

A & S Project Number: 335485

Customer: Vulcan Materials

Location: Tampa Yard

Project Number: N/A

Attention: James Farmer

The results of tests performed in accordance with ASTM C1260-14 Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method) are as follows:

Aggregate: # 57 Stone

Cement: Argos Newberry Plant Portland Cement Type –IL (10)

Cement Percent Alkalis: 0.40 % (Na2O Equivalent)

Cement Autoclave Expansion: 0.01

Date Sample Tested: 12/04/19

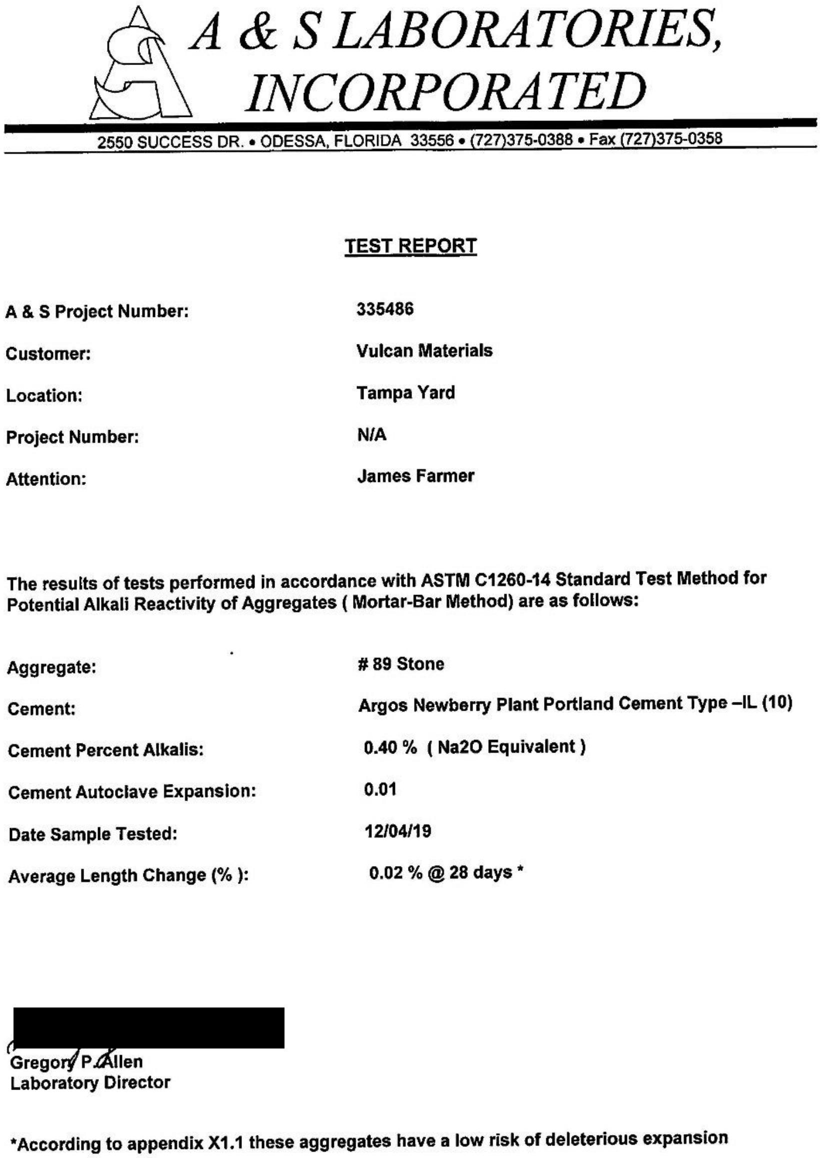
Average Length Change (%): 0.01 % @ 28 days *

[redacted]

Gregory P. Allen
Laboratory Director

*According to appendix X1.1 these aggregates have a low risk of deleterious expansion

Figure A.13 Genshaft Honors College certification data submittal page 8.



A & S LABORATORIES,
INCORPORATED

2550 SUCCESS DR. • ODESSA, FLORIDA 33556 • (727)375-0388 • Fax (727)375-0358

TEST REPORT

A & S Project Number:	**335486**
Customer:	**Vulcan Materials**
Location:	**Tampa Yard**
Project Number:	**N/A**
Attention:	**James Farmer**

The results of tests performed in accordance with ASTM C1260-14 Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method) are as follows:

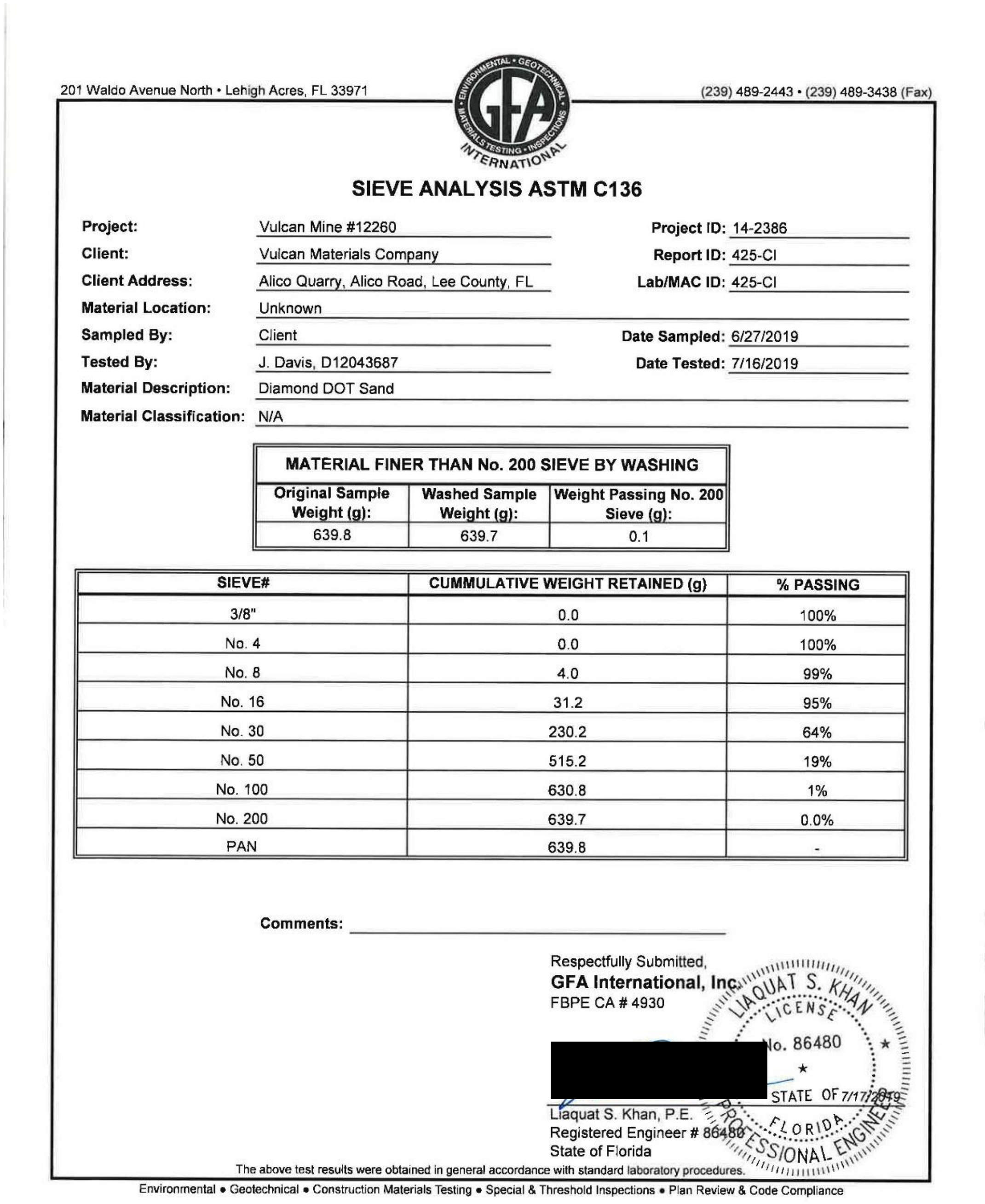
Aggregate:	**# 89 Stone**
Cement:	**Argos Newberry Plant Portland Cement Type –IL (10)**
Cement Percent Alkalis:	**0.40 % (Na2O Equivalent)**
Cement Autoclave Expansion:	**0.01**
Date Sample Tested:	**12/04/19**
Average Length Change (%):	**0.02 % @ 28 days ***

[redacted]

Gregory P. Allen
Laboratory Director

***According to appendix X1.1 these aggregates have a low risk of deleterious expansion**

Figure A.14 Genshaft Honors College certification data submittal page 9.



201 Waldo Avenue North • Lehigh Acres, FL 33971 (239) 489-2443 • (239) 489-3438 (Fax)

GFA INTERNATIONAL

SIEVE ANALYSIS ASTM C136

Project: Vulcan Mine #12260
Project ID: 14-2386
Client: Vulcan Materials Company
Report ID: 425-CI
Client Address: Alico Quarry, Alico Road, Lee County, FL
Lab/MAC ID: 425-CI
Material Location: Unknown
Sampled By: Client
Date Sampled: 6/27/2019
Tested By: J. Davis, D12043687
Date Tested: 7/16/2019
Material Description: Diamond DOT Sand
Material Classification: N/A

MATERIAL FINER THAN No. 200 SIEVE BY WASHING		
Original Sample Weight (g):	**Washed Sample Weight (g):**	**Weight Passing No. 200 Sieve (g):**
639.8	639.7	0.1

SIEVE#	CUMMULATIVE WEIGHT RETAINED (g)	% PASSING
3/8"	0.0	100%
No. 4	0.0	100%
No. 8	4.0	99%
No. 16	31.2	95%
No. 30	230.2	64%
No. 50	515.2	19%
No. 100	630.8	1%
No. 200	639.7	0.0%
PAN	639.8	-

Comments: ______________________

Respectfully Submitted,
GFA International, Inc.
FBPE CA # 4930

[redacted]

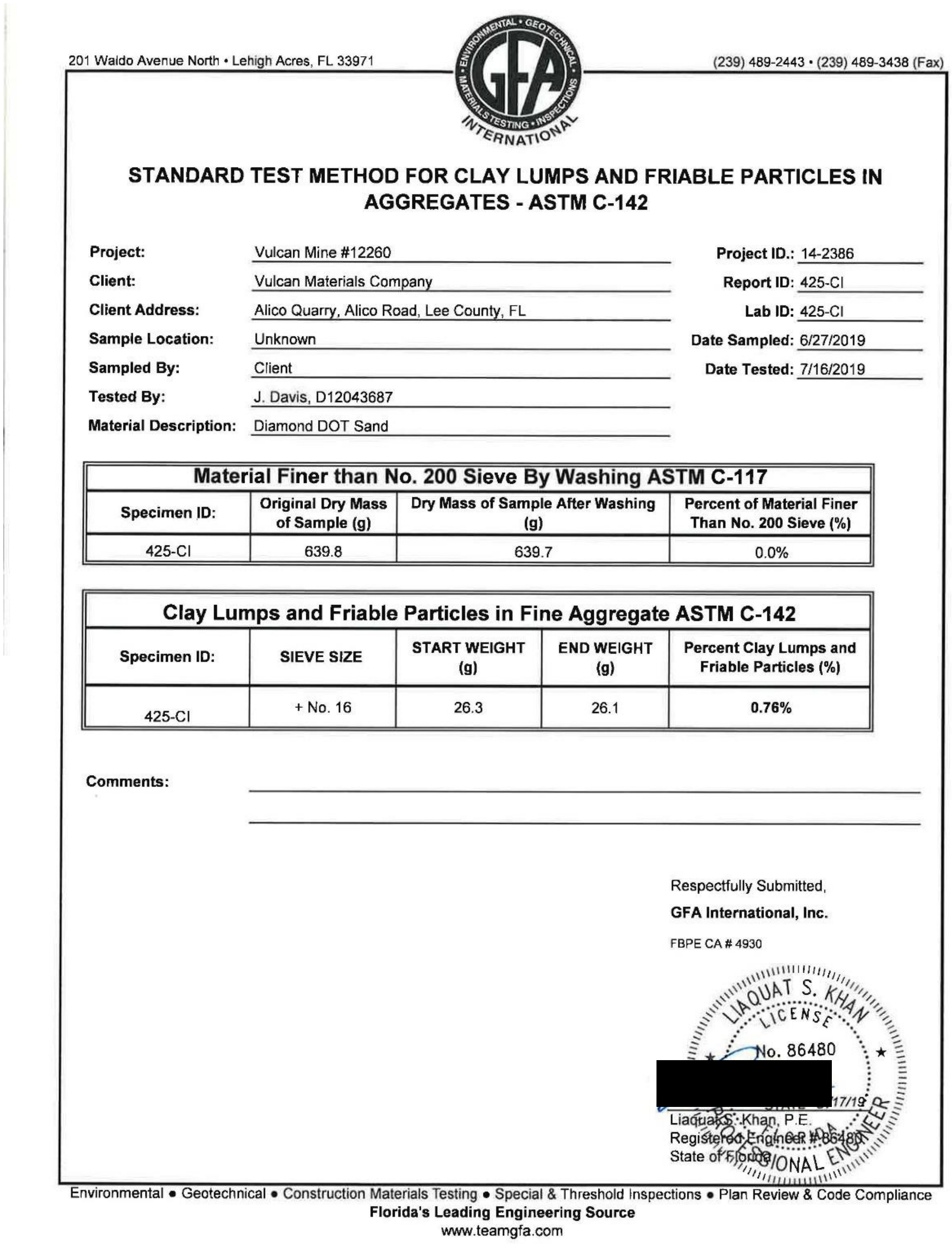
LIAQUAT S. KHAN
No. 86480
7/17/2019

Liaquat S. Khan, P.E.
Registered Engineer # 86480
State of Florida

The above test results were obtained in general accordance with standard laboratory procedures.

Environmental • Geotechnical • Construction Materials Testing • Special & Threshold Inspections • Plan Review & Code Compliance

Figure A.15 Genshaft Honors College certification data submittal page 10.



201 Waldo Avenue North • Lehigh Acres, FL 33971 (239) 489-2443 • (239) 489-3438 (Fax)

STANDARD TEST METHOD FOR CLAY LUMPS AND FRIABLE PARTICLES IN AGGREGATES - ASTM C-142

Project: Vulcan Mine #12260
Project ID.: 14-2386
Client: Vulcan Materials Company
Report ID: 425-CI
Client Address: Alico Quarry, Alico Road, Lee County, FL
Lab ID: 425-CI
Sample Location: Unknown
Date Sampled: 6/27/2019
Sampled By: Client
Date Tested: 7/16/2019
Tested By: J. Davis, D12043687
Material Description: Diamond DOT Sand

Material Finer than No. 200 Sieve By Washing ASTM C-117

Specimen ID:	Original Dry Mass of Sample (g)	Dry Mass of Sample After Washing (g)	Percent of Material Finer Than No. 200 Sieve (%)
425-CI	639.8	639.7	0.0%

Clay Lumps and Friable Particles in Fine Aggregate ASTM C-142

Specimen ID:	SIEVE SIZE	START WEIGHT (g)	END WEIGHT (g)	Percent Clay Lumps and Friable Particles (%)
425-CI	+ No. 16	26.3	26.1	**0.76%**

Comments:

Respectfully Submitted,
GFA International, Inc.
FBPE CA # 4930

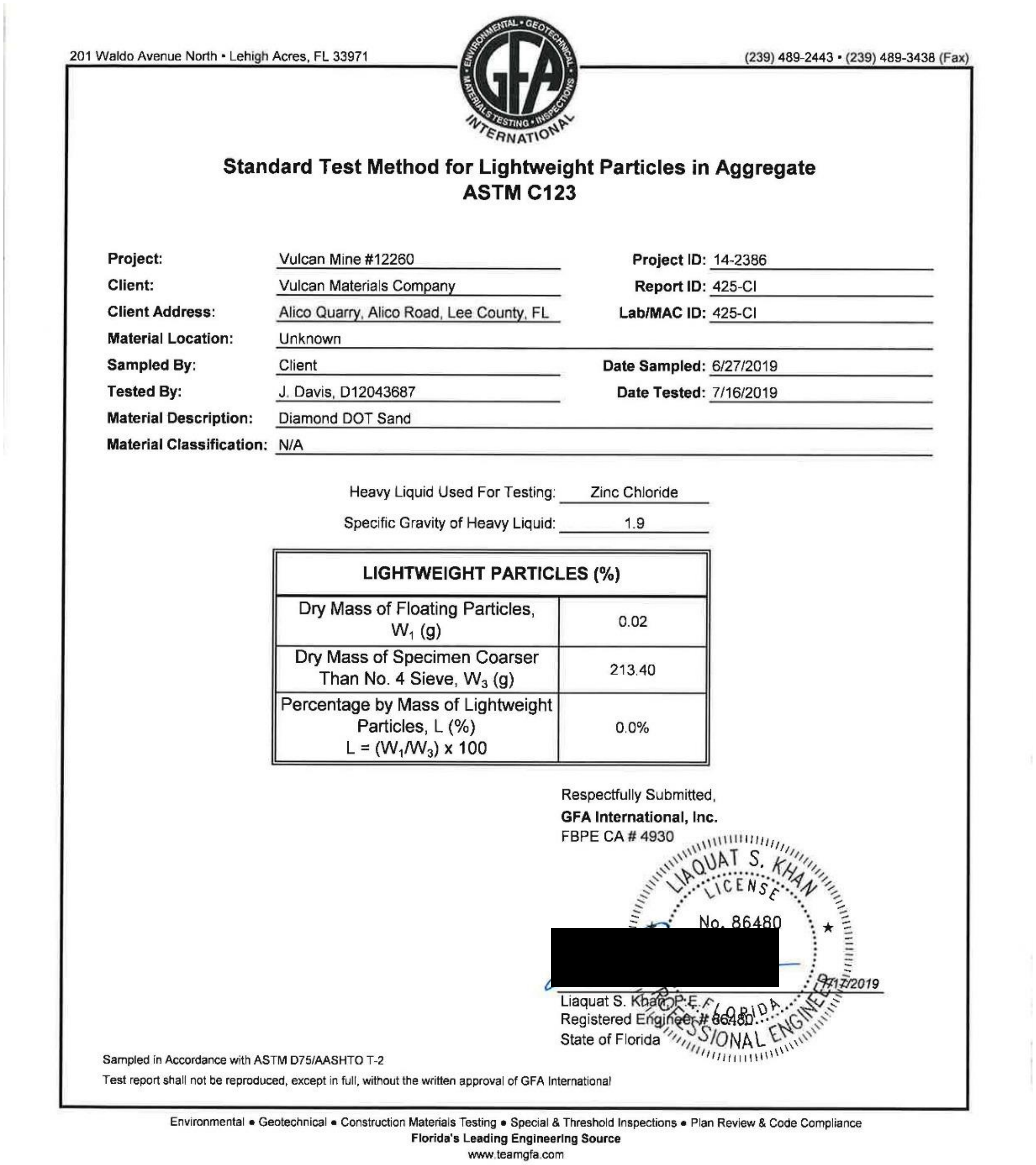
No. 86480

[redacted]

Liaquat S. Khan, P.E.
Registered Engineer #86480
State of Florida

Environmental • Geotechnical • Construction Materials Testing • Special & Threshold Inspections • Plan Review & Code Compliance
Florida's Leading Engineering Source
www.teamgfa.com

Figure A.16 Genshaft Honors College certification data submittal page 11.



201 Waldo Avenue North • Lehigh Acres, FL 33971

(239) 489-2443 • (239) 489-3438 (Fax)

Standard Test Method for Lightweight Particles in Aggregate
ASTM C123

Project: Vulcan Mine #12260
Project ID: 14-2386
Client: Vulcan Materials Company
Report ID: 425-CI
Client Address: Alico Quarry, Alico Road, Lee County, FL
Lab/MAC ID: 425-CI
Material Location: Unknown
Sampled By: Client
Date Sampled: 6/27/2019
Tested By: J. Davis, D12043687
Date Tested: 7/16/2019
Material Description: Diamond DOT Sand
Material Classification: N/A

Heavy Liquid Used For Testing: Zinc Chloride
Specific Gravity of Heavy Liquid: 1.9

LIGHTWEIGHT PARTICLES (%)	
Dry Mass of Floating Particles, W_1 (g)	0.02
Dry Mass of Specimen Coarser Than No. 4 Sieve, W_3 (g)	213.40
Percentage by Mass of Lightweight Particles, L (%) $L = (W_1/W_3) \times 100$	0.0%

Respectfully Submitted,
GFA International, Inc.
FBPE CA # 4930

LIAQUAT S. KHAN
No. 86480

[redacted]

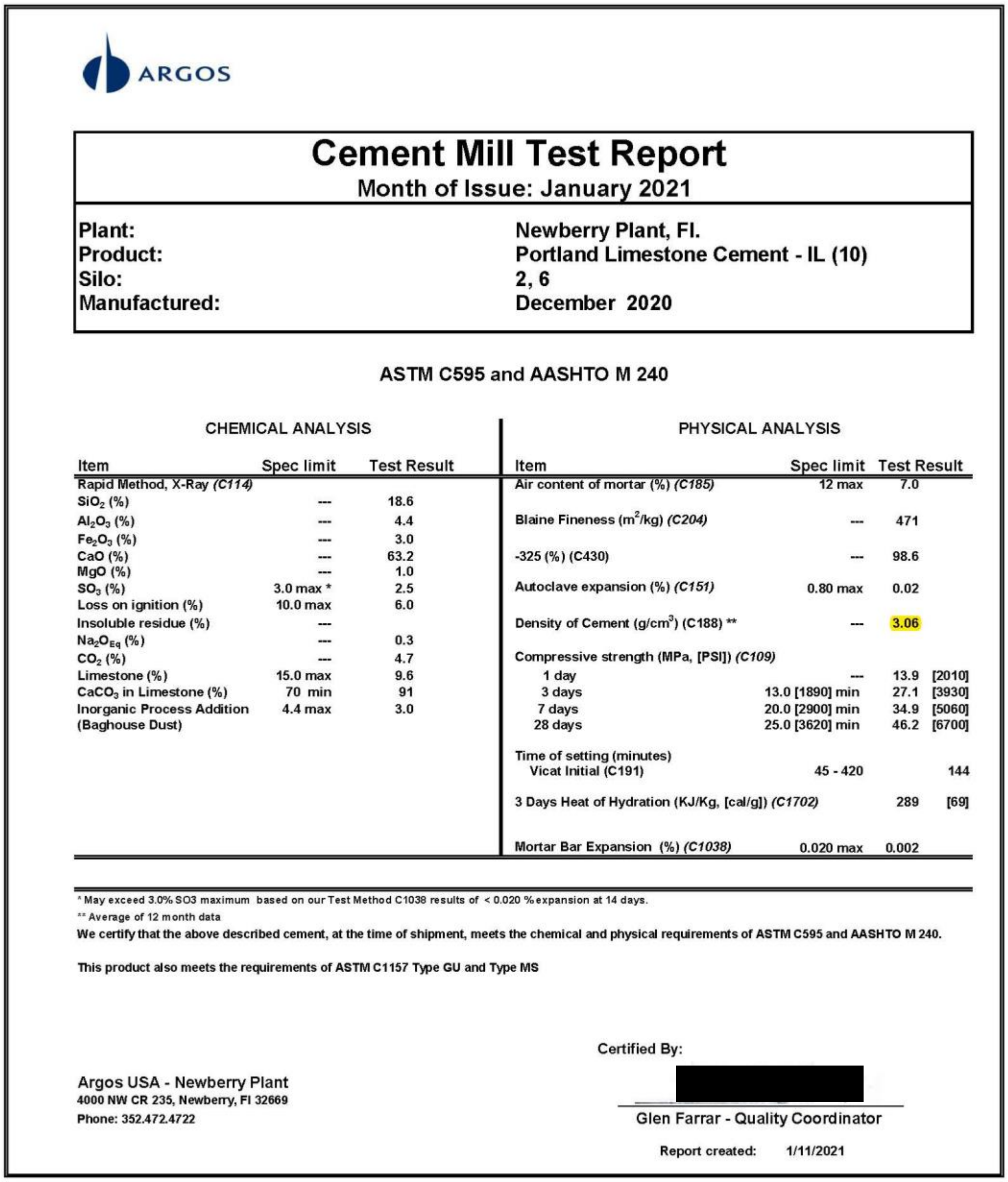
7/17/2019

Liaquat S. Khan, P.E.
Registered Engineer # 86480
State of Florida

Sampled in Accordance with ASTM D75/AASHTO T-2
Test report shall not be reproduced, except in full, without the written approval of GFA International

Environmental • Geotechnical • Construction Materials Testing • Special & Threshold Inspections • Plan Review & Code Compliance
Florida's Leading Engineering Source
www.teamgfa.com

Figure A.17 Genshaft Honors College certification data submittal page 12.



ARGOS

Cement Mill Test Report

Month of Issue: January 2021

Plant: Newberry Plant, Fl.
Product: Portland Limestone Cement - IL (10)
Silo: 2, 6
Manufactured: December 2020

ASTM C595 and AASHTO M 240

CHEMICAL ANALYSIS

Item	Spec limit	Test Result
Rapid Method, X-Ray *(C114)*		
SiO_2 (%)	---	18.6
Al_2O_3 (%)	---	4.4
Fe_2O_3 (%)	---	3.0
CaO (%)	---	63.2
MgO (%)	---	1.0
SO_3 (%)	3.0 max *	2.5
Loss on ignition (%)	10.0 max	6.0
Insoluble residue (%)	---	
Na_2O_{Eq} (%)	---	0.3
CO_2 (%)	---	4.7
Limestone (%)	15.0 max	9.6
$CaCO_3$ in Limestone (%)	70 min	91
Inorganic Process Addition (Baghouse Dust)	4.4 max	3.0

PHYSICAL ANALYSIS

Item	Spec limit	Test Result	
Air content of mortar (%) *(C185)*	12 max	7.0	
Blaine Fineness (m^2/kg) *(C204)*	---	471	
-325 (%) (C430)	---	98.6	
Autoclave expansion (%) *(C151)*	0.80 max	0.02	
Density of Cement (g/cm^3) (C188) **	---	3.06	
Compressive strength (MPa, [PSI]) *(C109)*			
1 day	---	13.9	[2010]
3 days	13.0 [1890] min	27.1	[3930]
7 days	20.0 [2900] min	34.9	[5060]
28 days	25.0 [3620] min	46.2	[6700]
Time of setting (minutes)			
Vicat Initial (C191)	45 - 420	144	
3 Days Heat of Hydration (KJ/Kg, [cal/g]) *(C1702)*		289	[69]
Mortar Bar Expansion (%) *(C1038)*	0.020 max	0.002	

* May exceed 3.0% SO3 maximum based on our Test Method C1038 results of < 0.020 % expansion at 14 days.

** Average of 12 month data

We certify that the above described cement, at the time of shipment, meets the chemical and physical requirements of ASTM C595 and AASHTO M 240.

This product also meets the requirements of ASTM C1157 Type GU and Type MS

Certified By:

[redacted]

Glen Farrar - Quality Coordinator

Argos USA - Newberry Plant
4000 NW CR 235, Newberry, Fl 32669
Phone: 352.472.4722

Report created: 1/11/2021

Figure A.18 Genshaft Honors College certification data submittal page 13.

TYPE IL PORTLAND LIMESTONE CEMENT

ARGOS

For Ready Mix Concrete Use

Argos Type IL portland limestone cement (PLC) is a blended hydraulic cement with up to 15 percent limestone.

It is manufactured with the same materials, additives, equipment, and quality control/quality assurance measures as our Type I/II cement and is manufactured to produce equivalent performance. This facilitates the IL PLC use as a one-to-one substitution for Type I/II cement.

Argos recommends that Type IL PLC cement be used at equal substitution on all ready mix concrete projects allowing use of Type I or Type II cement in S1 exposure class as defined in ACI 318-14.

CONCRETE PERFORMANCE

The table below compares three mixes, each with Type I/II or Type IL cement and with water adjusted to constant slump.

		4000 psi		4000 psi fly ash mix		4000 psi ternary mix	
Parameter	**Units**	**Type I/II**	**Type IL**	**Type I/II**	**Type IL**	**Type I/II**	**Type IL**
Cement	lb/cy	550	550	440	440	275	275
Fly ash	lb/cy	-	-	110	110	110	110
Slag	lb/cy	-	-	-	-	165	165
Water	gal/cy	35	35	34	34	35	35
Water Reducer	oz/cwt	4	4	4	4	4	4
Slump	in	4.5	4.25	4	4.75	4	4.5
Air		1.9	2.2	1.6	1.2	1.5	1.3
1-day strength	psi	2430	2430	1910	1740	1260	1410
3-day strength	psi	4020	3940	3230	3180	2660	2920
7-day strength	psi	4510	4440	3670	3700	3590	3650
28-day strength	psi	5860	5880	5430	5360	6160	6170

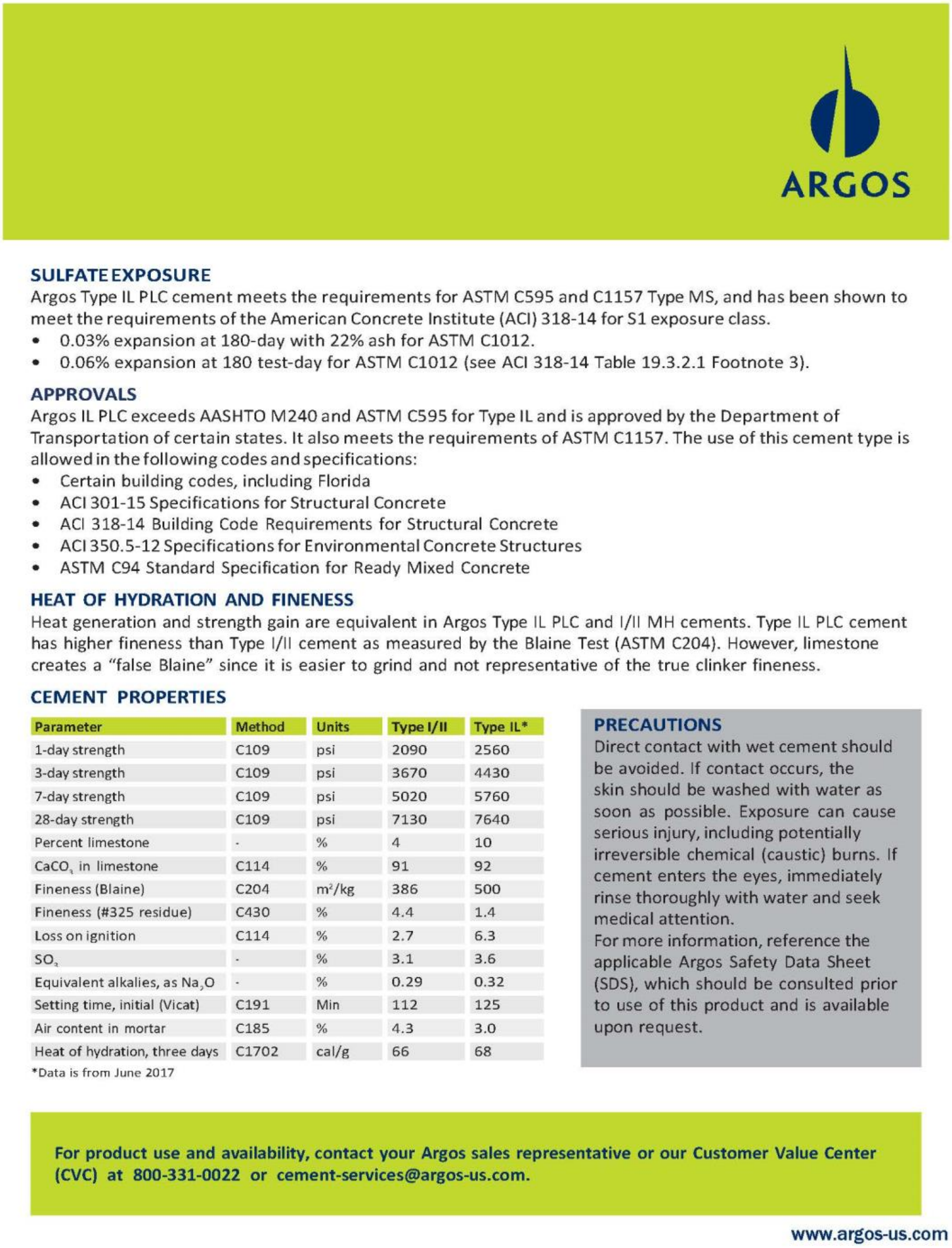
Note: Cement and water weights adjusted to proper yield. No retarder used.

LIMITED WARRANTY

Argos warrants that Argos IL PLC Cement meets the requirements of American Association of State Highway and Transportation Officials (AASHTO) M 240, ASTM C595 and ASTM C1157. Argos makes no other warranty, whether of merchantability or fitness for a particular purpose, with respect to Argos IL PLC Cement.

www.argos-us.com

Figure A.19 Genshaft Honors College certification data submittal page 14.



ARGOS

SULFATE EXPOSURE

Argos Type IL PLC cement meets the requirements for ASTM C595 and C1157 Type MS, and has been shown to meet the requirements of the American Concrete Institute (ACI) 318-14 for S1 exposure class.

- 0.03% expansion at 180-day with 22% ash for ASTM C1012.
- 0.06% expansion at 180 test-day for ASTM C1012 (see ACI 318-14 Table 19.3.2.1 Footnote 3).

APPROVALS

Argos IL PLC exceeds AASHTO M240 and ASTM C595 for Type IL and is approved by the Department of Transportation of certain states. It also meets the requirements of ASTM C1157. The use of this cement type is allowed in the following codes and specifications:

- Certain building codes, including Florida
- ACI 301-15 Specifications for Structural Concrete
- ACI 318-14 Building Code Requirements for Structural Concrete
- ACI 350.5-12 Specifications for Environmental Concrete Structures
- ASTM C94 Standard Specification for Ready Mixed Concrete

HEAT OF HYDRATION AND FINENESS

Heat generation and strength gain are equivalent in Argos Type IL PLC and I/II MH cements. Type IL PLC cement has higher fineness than Type I/II cement as measured by the Blaine Test (ASTM C204). However, limestone creates a "false Blaine" since it is easier to grind and not representative of the true clinker fineness.

CEMENT PROPERTIES

Parameter	Method	Units	Type I/II	Type IL*
1-day strength	C109	psi	2090	2560
3-day strength	C109	psi	3670	4430
7-day strength	C109	psi	5020	5760
28-day strength	C109	psi	7130	7640
Percent limestone	-	%	4	10
$CaCO_3$ in limestone	C114	%	91	92
Fineness (Blaine)	C204	m^2/kg	386	500
Fineness (#325 residue)	C430	%	4.4	1.4
Loss on ignition	C114	%	2.7	6.3
SO_3	-	%	3.1	3.6
Equivalent alkalies, as Na_2O	-	%	0.29	0.32
Setting time, initial (Vicat)	C191	Min	112	125
Air content in mortar	C185	%	4.3	3.0
Heat of hydration, three days	C1702	cal/g	66	68

*Data is from June 2017

PRECAUTIONS

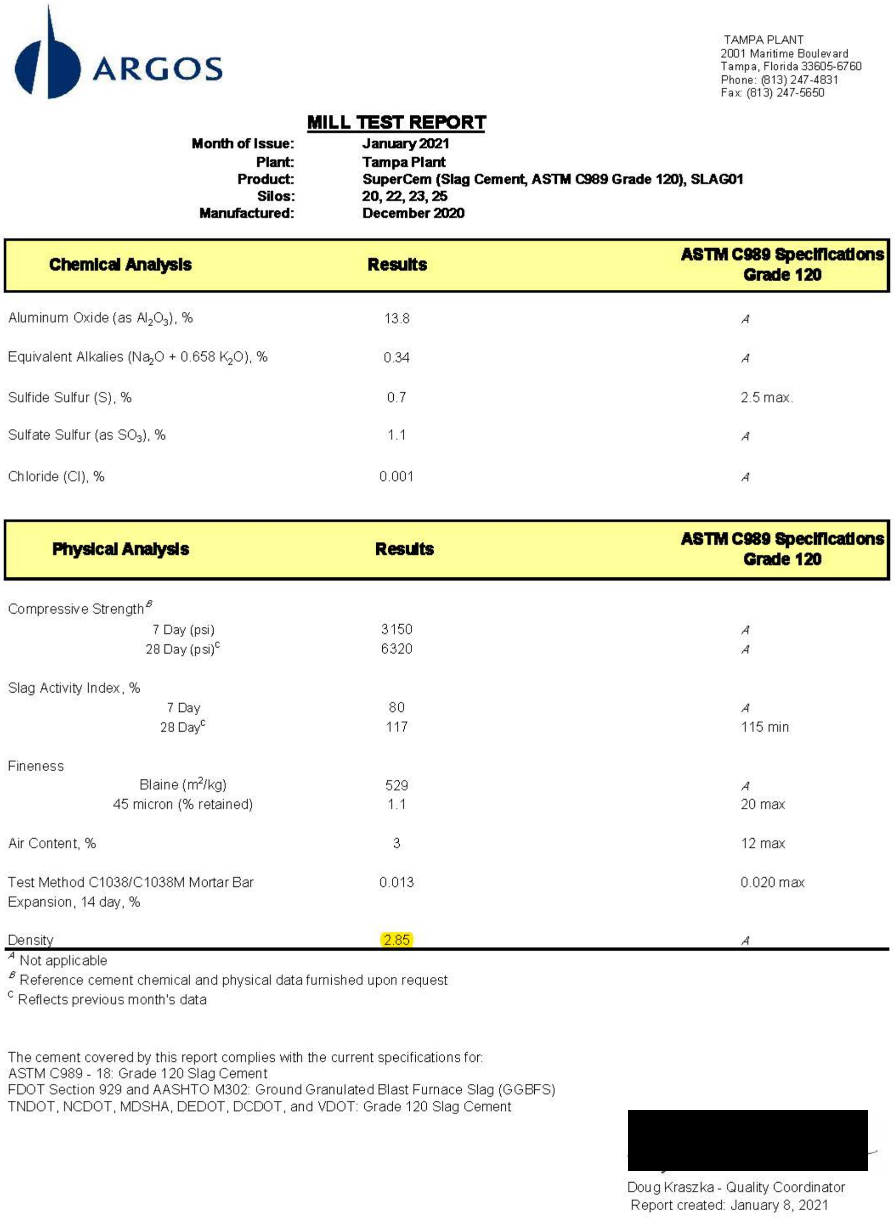
Direct contact with wet cement should be avoided. If contact occurs, the skin should be washed with water as soon as possible. Exposure can cause serious injury, including potentially irreversible chemical (caustic) burns. If cement enters the eyes, immediately rinse thoroughly with water and seek medical attention.

For more information, reference the applicable Argos Safety Data Sheet (SDS), which should be consulted prior to use of this product and is available upon request.

For product use and availability, contact your Argos sales representative or our Customer Value Center (CVC) at 800-331-0022 or cement-services@argos-us.com.

www.argos-us.com

Figure A.20 Genshaft Honors College certification data submittal page 15.



TAMPA PLANT
2001 Maritime Boulevard
Tampa, Florida 33605-6760
Phone: (813) 247-4831
Fax: (813) 247-5650

MILL TEST REPORT

Month of Issue: January 2021
Plant: Tampa Plant
Product: SuperCem (Slag Cement, ASTM C989 Grade 120), SLAG01
Silos: 20, 22, 23, 25
Manufactured: December 2020

Chemical Analysis	Results	ASTM C989 Specifications Grade 120
Aluminum Oxide (as Al_2O_3), %	13.8	A
Equivalent Alkalies (Na_2O + 0.658 K_2O), %	0.34	A
Sulfide Sulfur (S), %	0.7	2.5 max.
Sulfate Sulfur (as SO_3), %	1.1	A
Chloride (Cl), %	0.001	A

Physical Analysis	Results	ASTM C989 Specifications Grade 120
Compressive Strength[B]		
7 Day (psi)	3150	A
28 Day (psi)[C]	6320	A
Slag Activity Index, %		
7 Day	80	A
28 Day[C]	117	115 min
Fineness		
Blaine (m^2/kg)	529	A
45 micron (% retained)	1.1	20 max
Air Content, %	3	12 max
Test Method C1038/C1038M Mortar Bar Expansion, 14 day, %	0.013	0.020 max
Density	2.85	A

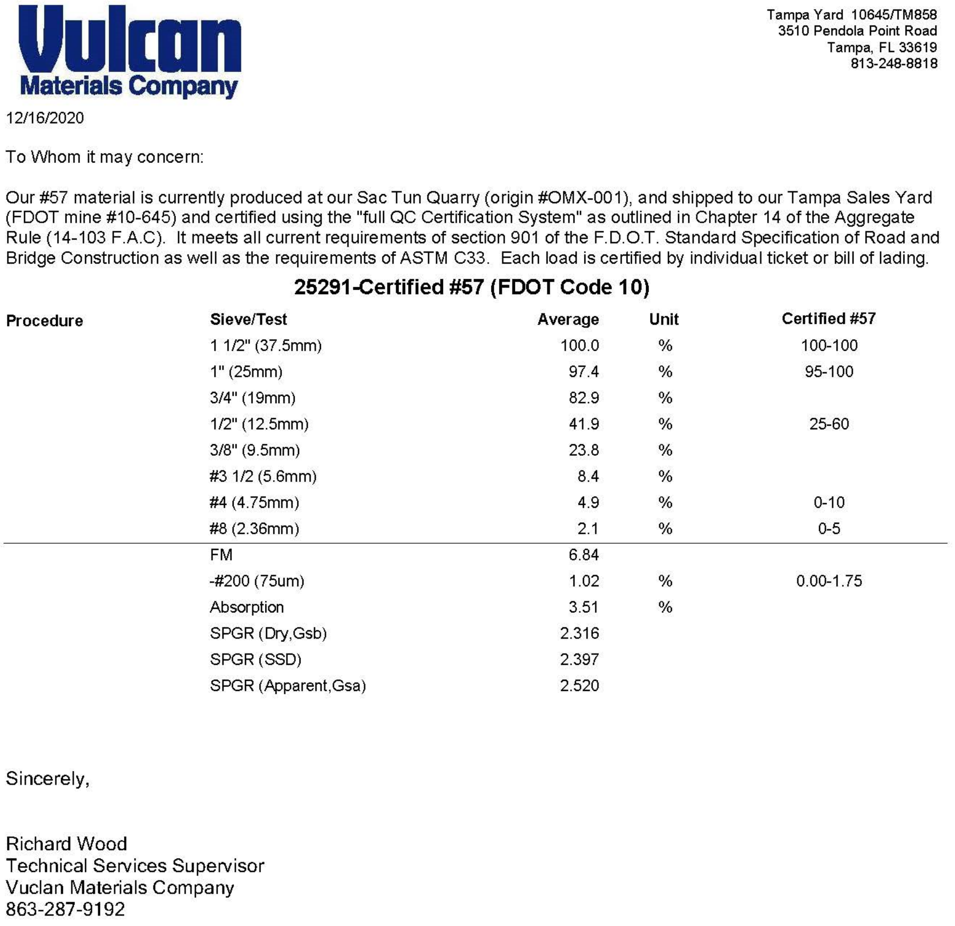
[A] Not applicable
[B] Reference cement chemical and physical data furnished upon request
[C] Reflects previous month's data

The cement covered by this report complies with the current specifications for:
ASTM C989 - 18: Grade 120 Slag Cement
FDOT Section 929 and AASHTO M302: Ground Granulated Blast Furnace Slag (GGBFS)
TNDOT, NCDOT, MDSHA, DEDOT, DCDOT, and VDOT: Grade 120 Slag Cement

[redacted]

Doug Kraszka - Quality Coordinator
Report created: January 8, 2021

Figure A.21 Genshaft Honors College certification data submittal page 16.



Vulcan
Materials Company

Tampa Yard 10645/TM858
3510 Pendola Point Road
Tampa, FL 33619
813-248-8818

12/16/2020

To Whom it may concern:

Our #57 material is currently produced at our Sac Tun Quarry (origin #OMX-001), and shipped to our Tampa Sales Yard (FDOT mine #10-645) and certified using the "full QC Certification System" as outlined in Chapter 14 of the Aggregate Rule (14-103 F.A.C). It meets all current requirements of section 901 of the F.D.O.T. Standard Specification of Road and Bridge Construction as well as the requirements of ASTM C33. Each load is certified by individual ticket or bill of lading.

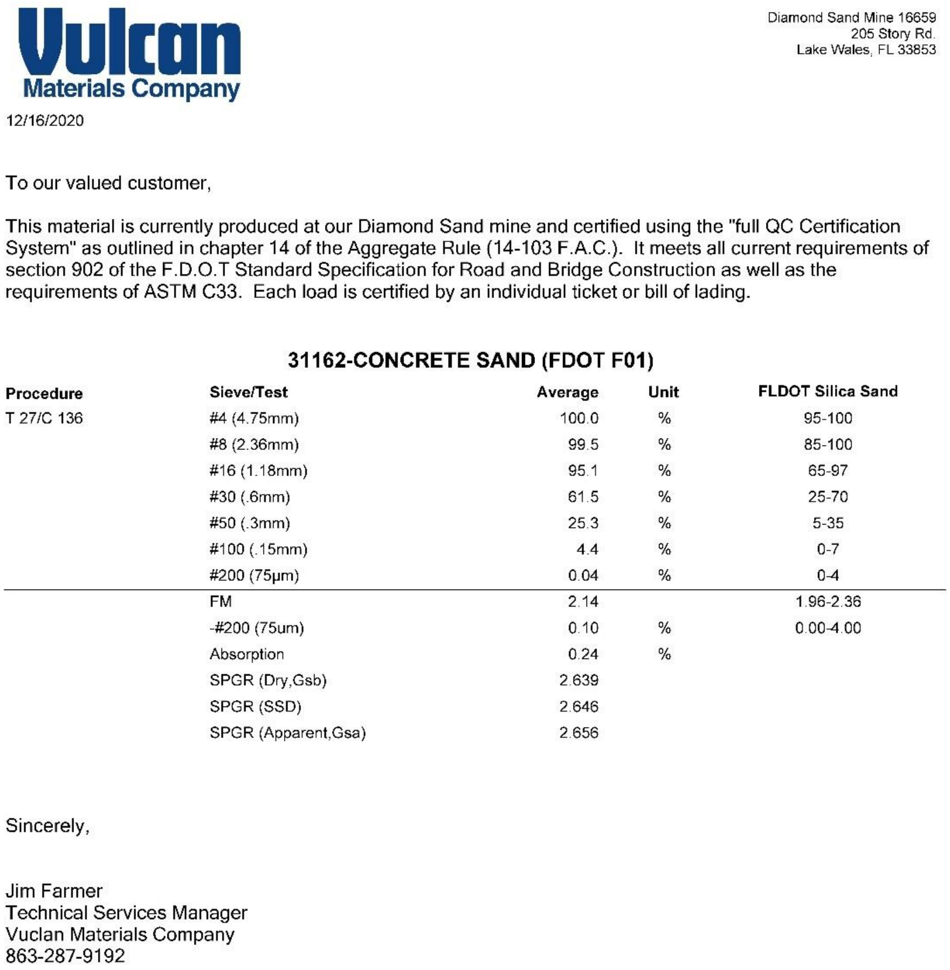
25291-Certified #57 (FDOT Code 10)

Procedure	Sieve/Test	Average	Unit	Certified #57
	1 1/2" (37.5mm)	100.0	%	100-100
	1" (25mm)	97.4	%	95-100
	3/4" (19mm)	82.9	%	
	1/2" (12.5mm)	41.9	%	25-60
	3/8" (9.5mm)	23.8	%	
	#3 1/2 (5.6mm)	8.4	%	
	#4 (4.75mm)	4.9	%	0-10
	#8 (2.36mm)	2.1	%	0-5
	FM	6.84		
	-#200 (75um)	1.02	%	0.00-1.75
	Absorption	3.51	%	
	SPGR (Dry,Gsb)	2.316		
	SPGR (SSD)	2.397		
	SPGR (Apparent,Gsa)	2.520		

Sincerely,

Richard Wood
Technical Services Supervisor
Vuclan Materials Company
863-287-9192

Figure A.22 Genshaft Honors College certification data submittal page 17.



Vulcan
Materials Company

Diamond Sand Mine 16659
205 Story Rd.
Lake Wales, FL 33853

12/16/2020

To our valued customer,

This material is currently produced at our Diamond Sand mine and certified using the "full QC Certification System" as outlined in chapter 14 of the Aggregate Rule (14-103 F.A.C.). It meets all current requirements of section 902 of the F.D.O.T Standard Specification for Road and Bridge Construction as well as the requirements of ASTM C33. Each load is certified by an individual ticket or bill of lading.

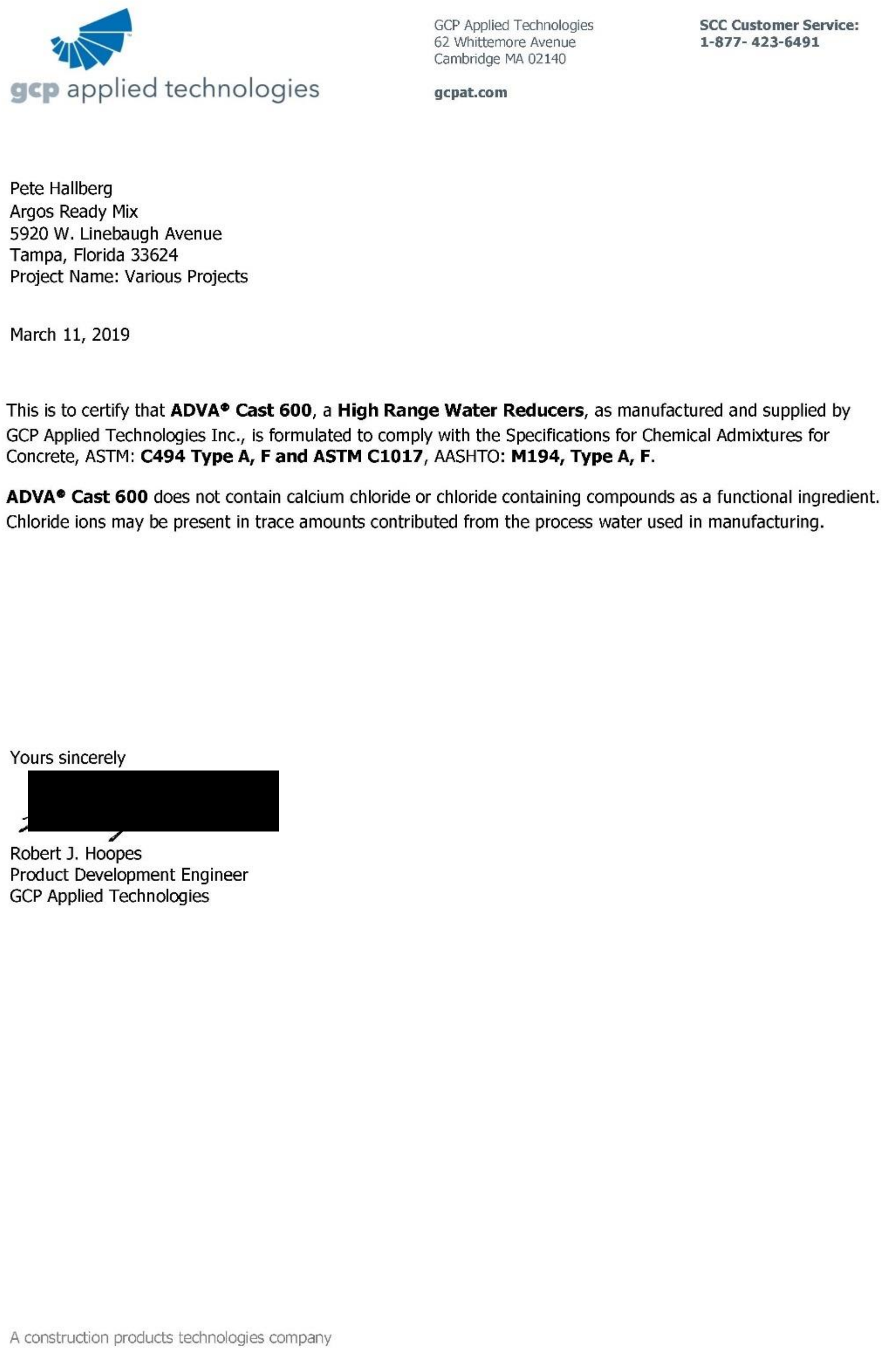
31162-CONCRETE SAND (FDOT F01)

Procedure	Sieve/Test	Average	Unit	FLDOT Silica Sand
T 27/C 136	#4 (4.75mm)	100.0	%	95-100
	#8 (2.36mm)	99.5	%	85-100
	#16 (1.18mm)	95.1	%	65-97
	#30 (.6mm)	61.5	%	25-70
	#50 (.3mm)	25.3	%	5-35
	#100 (.15mm)	4.4	%	0-7
	#200 (75µm)	0.04	%	0-4
	FM	2.14		1.96-2.36
	-#200 (75um)	0.10	%	0.00-4.00
	Absorption	0.24	%	
	SPGR (Dry,Gsb)	2.639		
	SPGR (SSD)	2.646		
	SPGR (Apparent,Gsa)	2.656		

Sincerely,

Jim Farmer
Technical Services Manager
Vuclan Materials Company
863-287-9192

Figure A.23 Genshaft Honors College certification data submittal page 18.



gcp applied technologies

GCP Applied Technologies
62 Whittemore Avenue
Cambridge MA 02140

gcpat.com

SCC Customer Service:
1-877- 423-6491

Pete Hallberg
Argos Ready Mix
5920 W. Linebaugh Avenue
Tampa, Florida 33624
Project Name: Various Projects

March 11, 2019

This is to certify that **ADVA® Cast 600**, a **High Range Water Reducers**, as manufactured and supplied by GCP Applied Technologies Inc., is formulated to comply with the Specifications for Chemical Admixtures for Concrete, ASTM: **C494 Type A, F and ASTM C1017**, AASHTO**: M194, Type A, F**.

ADVA® Cast 600 does not contain calcium chloride or chloride containing compounds as a functional ingredient. Chloride ions may be present in trace amounts contributed from the process water used in manufacturing.

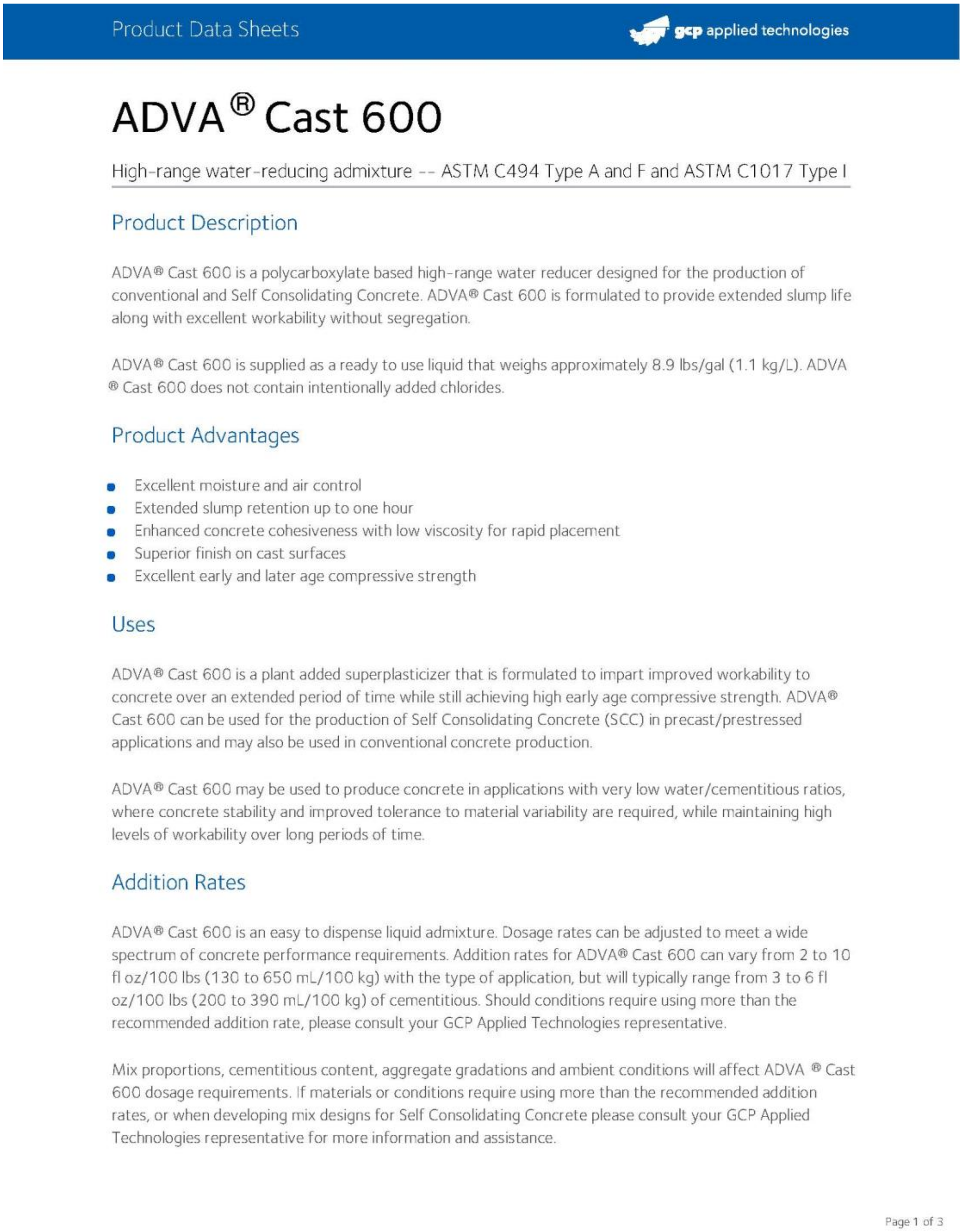
Yours sincerely

[redacted]

Robert J. Hoopes
Product Development Engineer
GCP Applied Technologies

A construction products technologies company

Figure A.24 Genshaft Honors College certification data submittal page 19.



Product Data Sheets

gcp applied technologies

ADVA® Cast 600

High-range water-reducing admixture -- ASTM C494 Type A and F and ASTM C1017 Type I

Product Description

ADVA® Cast 600 is a polycarboxylate based high-range water reducer designed for the production of conventional and Self Consolidating Concrete. ADVA® Cast 600 is formulated to provide extended slump life along with excellent workability without segregation.

ADVA® Cast 600 is supplied as a ready to use liquid that weighs approximately 8.9 lbs/gal (1.1 kg/L). ADVA ® Cast 600 does not contain intentionally added chlorides.

Product Advantages

- Excellent moisture and air control
- Extended slump retention up to one hour
- Enhanced concrete cohesiveness with low viscosity for rapid placement
- Superior finish on cast surfaces
- Excellent early and later age compressive strength

Uses

ADVA® Cast 600 is a plant added superplasticizer that is formulated to impart improved workability to concrete over an extended period of time while still achieving high early age compressive strength. ADVA® Cast 600 can be used for the production of Self Consolidating Concrete (SCC) in precast/prestressed applications and may also be used in conventional concrete production.

ADVA® Cast 600 may be used to produce concrete in applications with very low water/cementitious ratios, where concrete stability and improved tolerance to material variability are required, while maintaining high levels of workability over long periods of time.

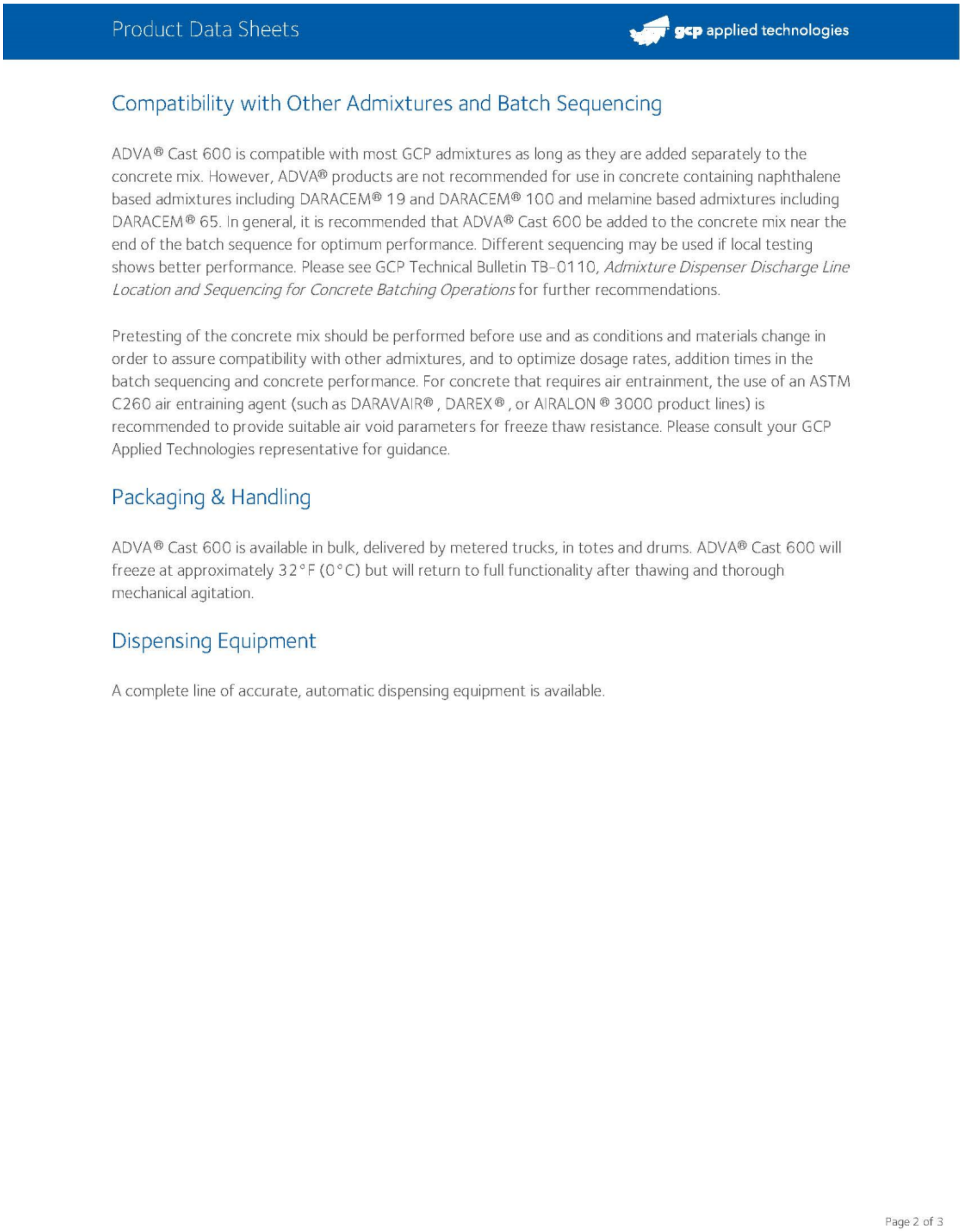
Addition Rates

ADVA® Cast 600 is an easy to dispense liquid admixture. Dosage rates can be adjusted to meet a wide spectrum of concrete performance requirements. Addition rates for ADVA® Cast 600 can vary from 2 to 10 fl oz/100 lbs (130 to 650 mL/100 kg) with the type of application, but will typically range from 3 to 6 fl oz/100 lbs (200 to 390 mL/100 kg) of cementitious. Should conditions require using more than the recommended addition rate, please consult your GCP Applied Technologies representative.

Mix proportions, cementitious content, aggregate gradations and ambient conditions will affect ADVA ® Cast 600 dosage requirements. If materials or conditions require using more than the recommended addition rates, or when developing mix designs for Self Consolidating Concrete please consult your GCP Applied Technologies representative for more information and assistance.

Page 1 of 3

Figure A.25 Genshaft Honors College certification data submittal page 20.



Product Data Sheets

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Compatibility with Other Admixtures and Batch Sequencing

ADVA® Cast 600 is compatible with most GCP admixtures as long as they are added separately to the concrete mix. However, ADVA® products are not recommended for use in concrete containing naphthalene based admixtures including DARACEM® 19 and DARACEM® 100 and melamine based admixtures including DARACEM® 65. In general, it is recommended that ADVA® Cast 600 be added to the concrete mix near the end of the batch sequence for optimum performance. Different sequencing may be used if local testing shows better performance. Please see GCP Technical Bulletin TB-0110, *Admixture Dispenser Discharge Line Location and Sequencing for Concrete Batching Operations* for further recommendations.

Pretesting of the concrete mix should be performed before use and as conditions and materials change in order to assure compatibility with other admixtures, and to optimize dosage rates, addition times in the batch sequencing and concrete performance. For concrete that requires air entrainment, the use of an ASTM C260 air entraining agent (such as DARAVAIR® , DAREX® , or AIRALON ® 3000 product lines) is recommended to provide suitable air void parameters for freeze thaw resistance. Please consult your GCP Applied Technologies representative for guidance.

Packaging & Handling

ADVA® Cast 600 is available in bulk, delivered by metered trucks, in totes and drums. ADVA® Cast 600 will freeze at approximately 32°F (0°C) but will return to full functionality after thawing and thorough mechanical agitation.

Dispensing Equipment

A complete line of accurate, automatic dispensing equipment is available.

Page 2 of 3

Figure A.26 Genshaft Honors College certification data submittal page 21.

Product Data Sheets

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gcpat.com | North America Customer Service: **1 877-4AD-MIX1 (1 877-423-6491)**

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ADVA, AIRALON, DAREX, DARACEM, and DARAVAIR are registered trademarks, which may be registered in the United States and/or other countries, of GCP Applied Technologies, Inc. This trademark list has been compiled using available published information as of the publication date and may not accurately reflect current trademark ownership or status.

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Last Updated: 2018-08-24
gcpat.com/solutions/products/adva-cast-high-range-water-reducers/adva-cast-600

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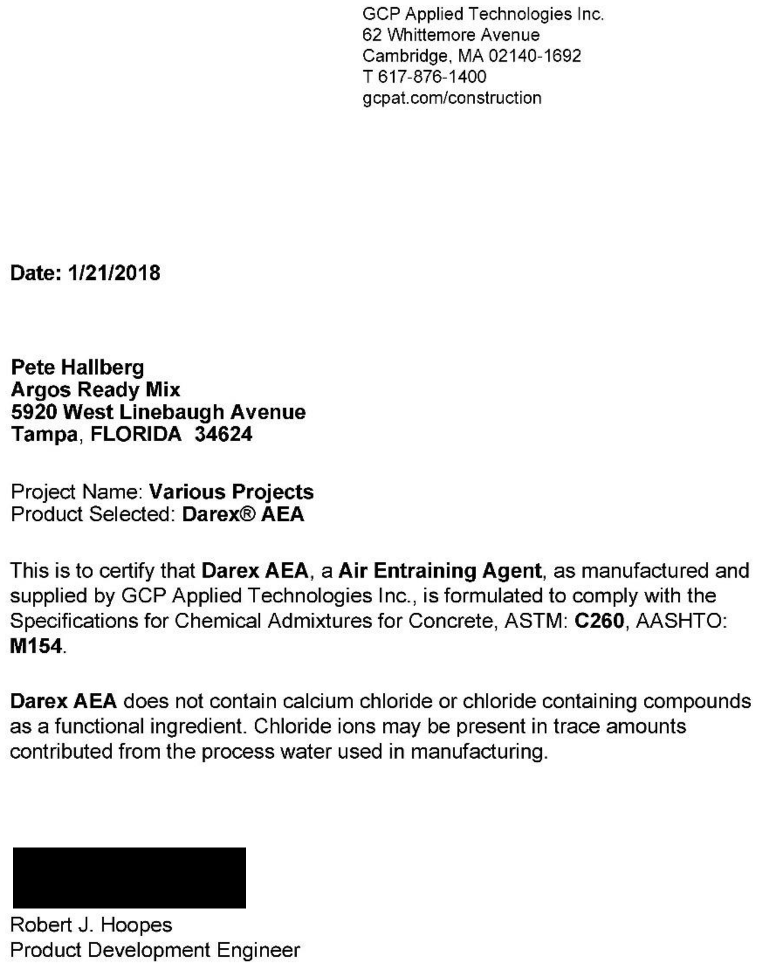
Page 3 of 3

Figure A.27 Genshaft Honors College certification data submittal page 22.



GCP Applied Technologies Inc.
62 Whittemore Avenue
Cambridge, MA 02140-1692
T 617-876-1400
gcpat.com/construction

Date: 1/21/2018

Pete Hallberg
Argos Ready Mix
5920 West Linebaugh Avenue
Tampa, **FLORIDA 34624**

Project Name: **Various Projects**
Product Selected: **Darex® AEA**

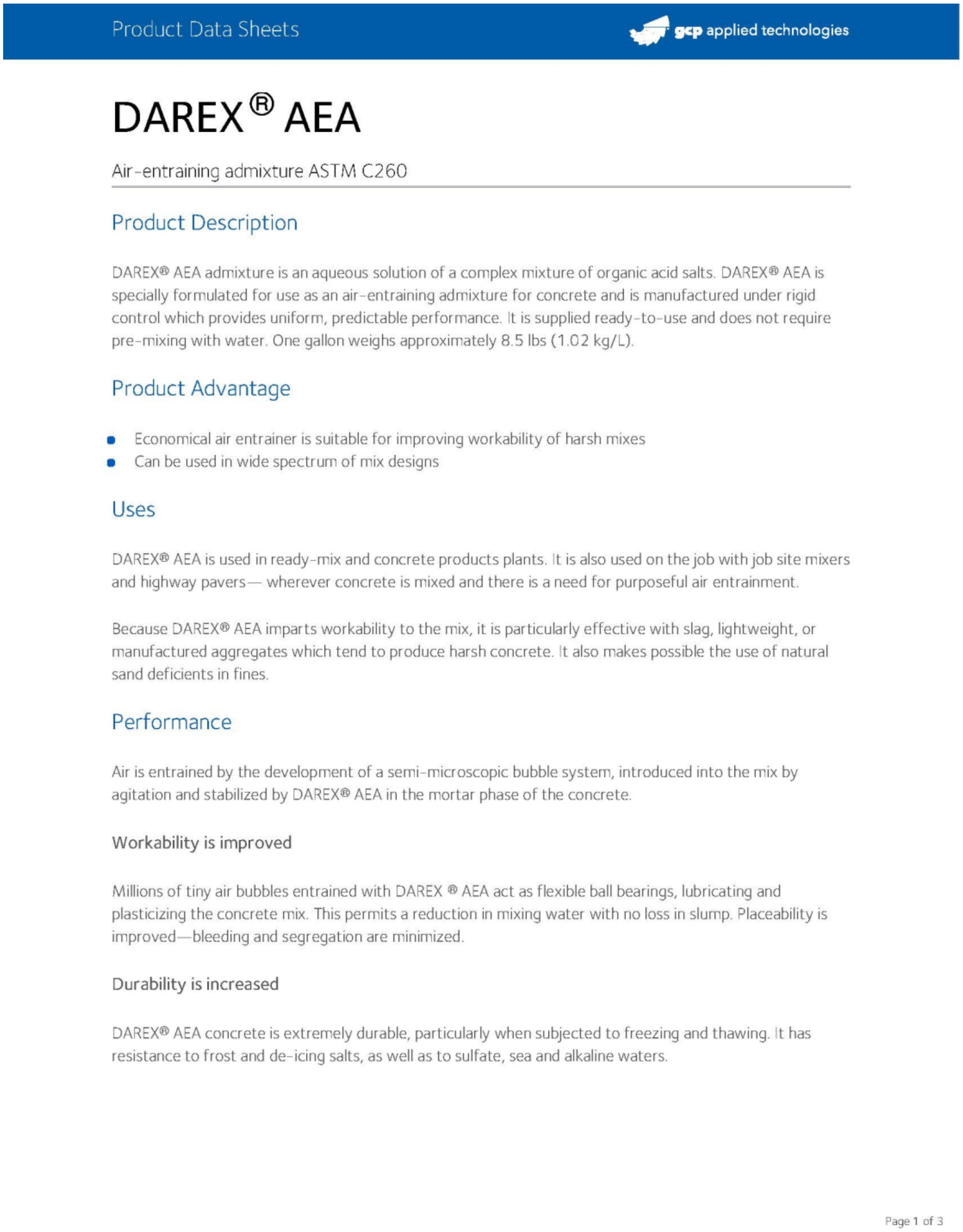
This is to certify that **Darex AEA**, a **Air Entraining Agent**, as manufactured and supplied by GCP Applied Technologies Inc., is formulated to comply with the Specifications for Chemical Admixtures for Concrete, ASTM: **C260**, AASHTO: **M154**.

Darex AEA does not contain calcium chloride or chloride containing compounds as a functional ingredient. Chloride ions may be present in trace amounts contributed from the process water used in manufacturing.

[redacted]

Robert J. Hoopes
Product Development Engineer

Figure A.28 Genshaft Honors College certification data submittal page 23.



Product Data Sheets

gcp applied technologies

DAREX® AEA

Air-entraining admixture ASTM C260

Product Description

DAREX® AEA admixture is an aqueous solution of a complex mixture of organic acid salts. DAREX® AEA is specially formulated for use as an air-entraining admixture for concrete and is manufactured under rigid control which provides uniform, predictable performance. It is supplied ready-to-use and does not require pre-mixing with water. One gallon weighs approximately 8.5 lbs (1.02 kg/L).

Product Advantage

- Economical air entrainer is suitable for improving workability of harsh mixes
- Can be used in wide spectrum of mix designs

Uses

DAREX® AEA is used in ready-mix and concrete products plants. It is also used on the job with job site mixers and highway pavers— wherever concrete is mixed and there is a need for purposeful air entrainment.

Because DAREX® AEA imparts workability to the mix, it is particularly effective with slag, lightweight, or manufactured aggregates which tend to produce harsh concrete. It also makes possible the use of natural sand deficients in fines.

Performance

Air is entrained by the development of a semi-microscopic bubble system, introduced into the mix by agitation and stabilized by DAREX® AEA in the mortar phase of the concrete.

Workability is improved

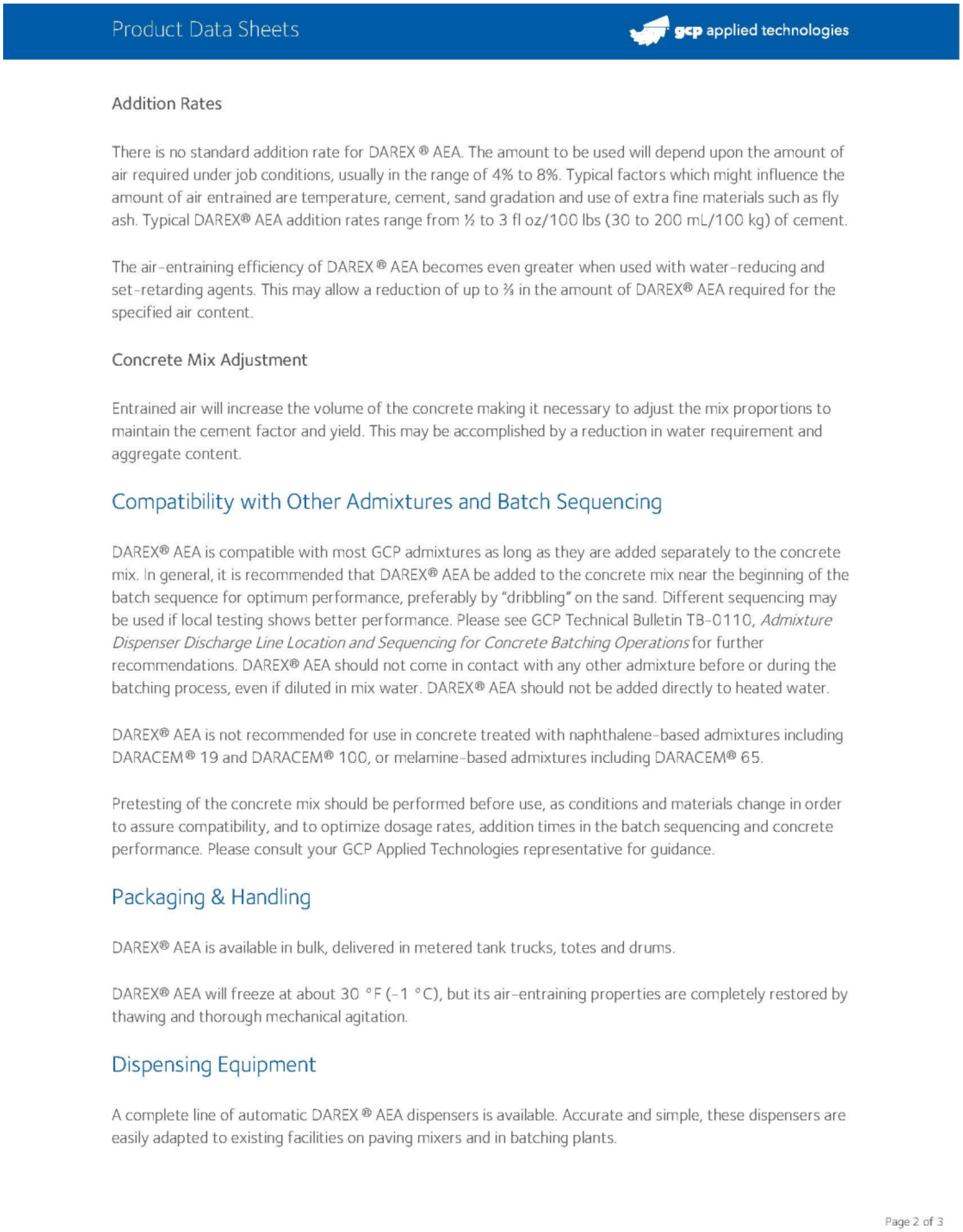
Millions of tiny air bubbles entrained with DAREX ® AEA act as flexible ball bearings, lubricating and plasticizing the concrete mix. This permits a reduction in mixing water with no loss in slump. Placeability is improved—bleeding and segregation are minimized.

Durability is increased

DAREX® AEA concrete is extremely durable, particularly when subjected to freezing and thawing. It has resistance to frost and de-icing salts, as well as to sulfate, sea and alkaline waters.

Page 1 of 3

Figure A.29 Genshaft Honors College certification data submittal page 24.



Product Data Sheets

gcp applied technologies

Addition Rates

There is no standard addition rate for DAREX® AEA. The amount to be used will depend upon the amount of air required under job conditions, usually in the range of 4% to 8%. Typical factors which might influence the amount of air entrained are temperature, cement, sand gradation and use of extra fine materials such as fly ash. Typical DAREX® AEA addition rates range from ½ to 3 fl oz/100 lbs (30 to 200 mL/100 kg) of cement.

The air-entraining efficiency of DAREX® AEA becomes even greater when used with water-reducing and set-retarding agents. This may allow a reduction of up to ⅔ in the amount of DAREX® AEA required for the specified air content.

Concrete Mix Adjustment

Entrained air will increase the volume of the concrete making it necessary to adjust the mix proportions to maintain the cement factor and yield. This may be accomplished by a reduction in water requirement and aggregate content.

Compatibility with Other Admixtures and Batch Sequencing

DAREX® AEA is compatible with most GCP admixtures as long as they are added separately to the concrete mix. In general, it is recommended that DAREX® AEA be added to the concrete mix near the beginning of the batch sequence for optimum performance, preferably by "dribbling" on the sand. Different sequencing may be used if local testing shows better performance. Please see GCP Technical Bulletin TB-0110, *Admixture Dispenser Discharge Line Location and Sequencing for Concrete Batching Operations* for further recommendations. DAREX® AEA should not come in contact with any other admixture before or during the batching process, even if diluted in mix water. DAREX® AEA should not be added directly to heated water.

DAREX® AEA is not recommended for use in concrete treated with naphthalene-based admixtures including DARACEM® 19 and DARACEM® 100, or melamine-based admixtures including DARACEM® 65.

Pretesting of the concrete mix should be performed before use, as conditions and materials change in order to assure compatibility, and to optimize dosage rates, addition times in the batch sequencing and concrete performance. Please consult your GCP Applied Technologies representative for guidance.

Packaging & Handling

DAREX® AEA is available in bulk, delivered in metered tank trucks, totes and drums.

DAREX® AEA will freeze at about 30 °F (-1 °C), but its air-entraining properties are completely restored by thawing and thorough mechanical agitation.

Dispensing Equipment

A complete line of automatic DAREX® AEA dispensers is available. Accurate and simple, these dispensers are easily adapted to existing facilities on paving mixers and in batching plants.

Page 2 of 3

Figure A.30 Genshaft Honors College certification data submittal page 25.

Product Data Sheets

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Specifications

Concrete shall be air entrained concrete, containing 4% to 8% entrained air. The air contents in the concrete shall be determined by the pressure method (ASTM Designation C231) or gravimetric method (ASTM Designation C138). The air-entraining admixture shall be DAREX® AEA, as manufactured by GCP Applied Technologies, or equal. The air-entraining admixture shall be added at the concrete mixer or batching plant in such quantities as to give the specified air contents.

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gcpat.com/solutions/products/darex-aea

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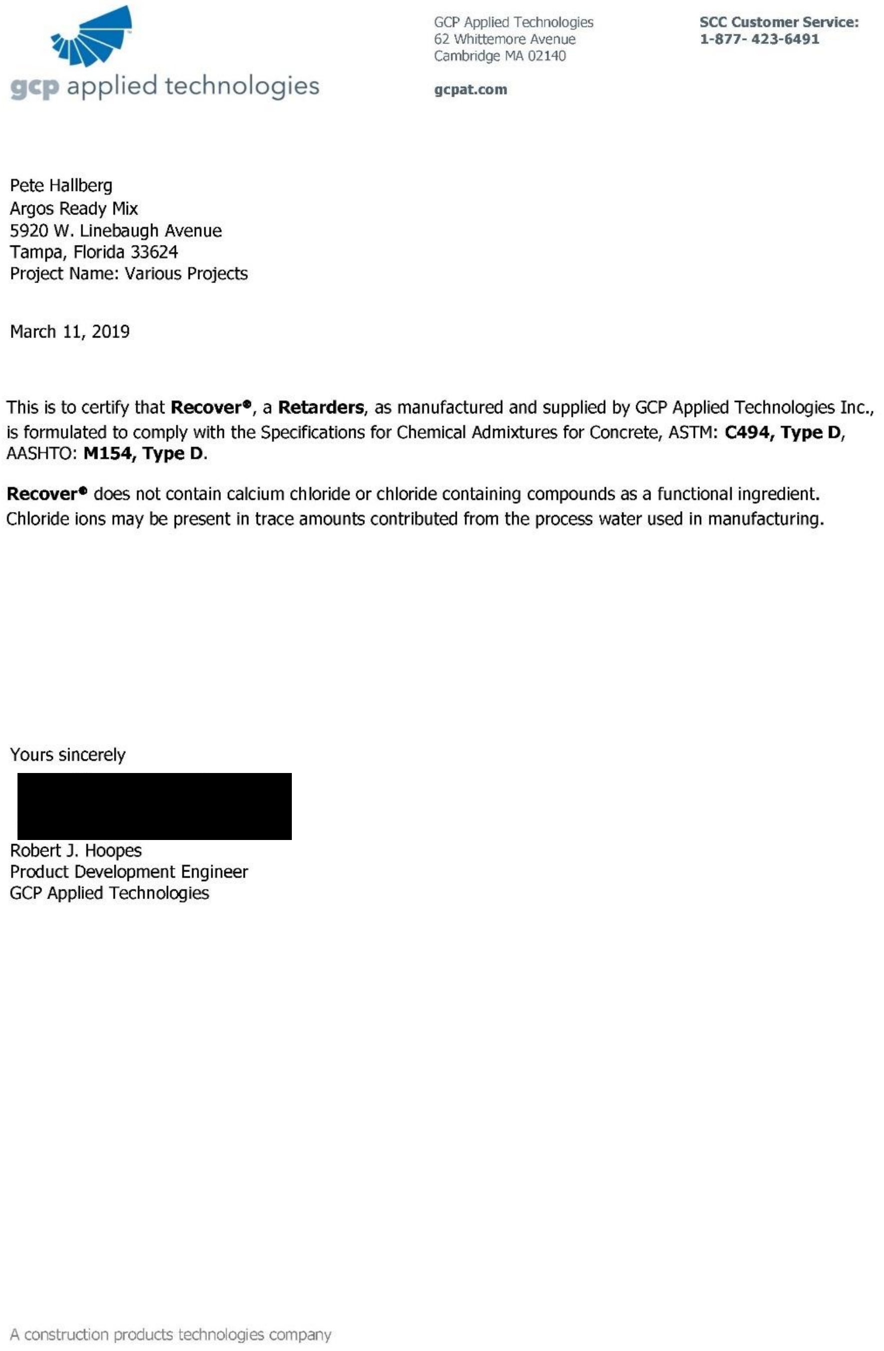
Page 3 of 3

Figure A.31 Genshaft Honors College certification data submittal page 26.



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GCP Applied Technologies
62 Whittemore Avenue
Cambridge MA 02140

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SCC Customer Service:
1-877- 423-6491

Pete Hallberg
Argos Ready Mix
5920 W. Linebaugh Avenue
Tampa, Florida 33624
Project Name: Various Projects

March 11, 2019

This is to certify that **Recover®**, a **Retarders**, as manufactured and supplied by GCP Applied Technologies Inc., is formulated to comply with the Specifications for Chemical Admixtures for Concrete, ASTM: **C494, Type D**, AASHTO: **M154, Type D**.

Recover® does not contain calcium chloride or chloride containing compounds as a functional ingredient. Chloride ions may be present in trace amounts contributed from the process water used in manufacturing.

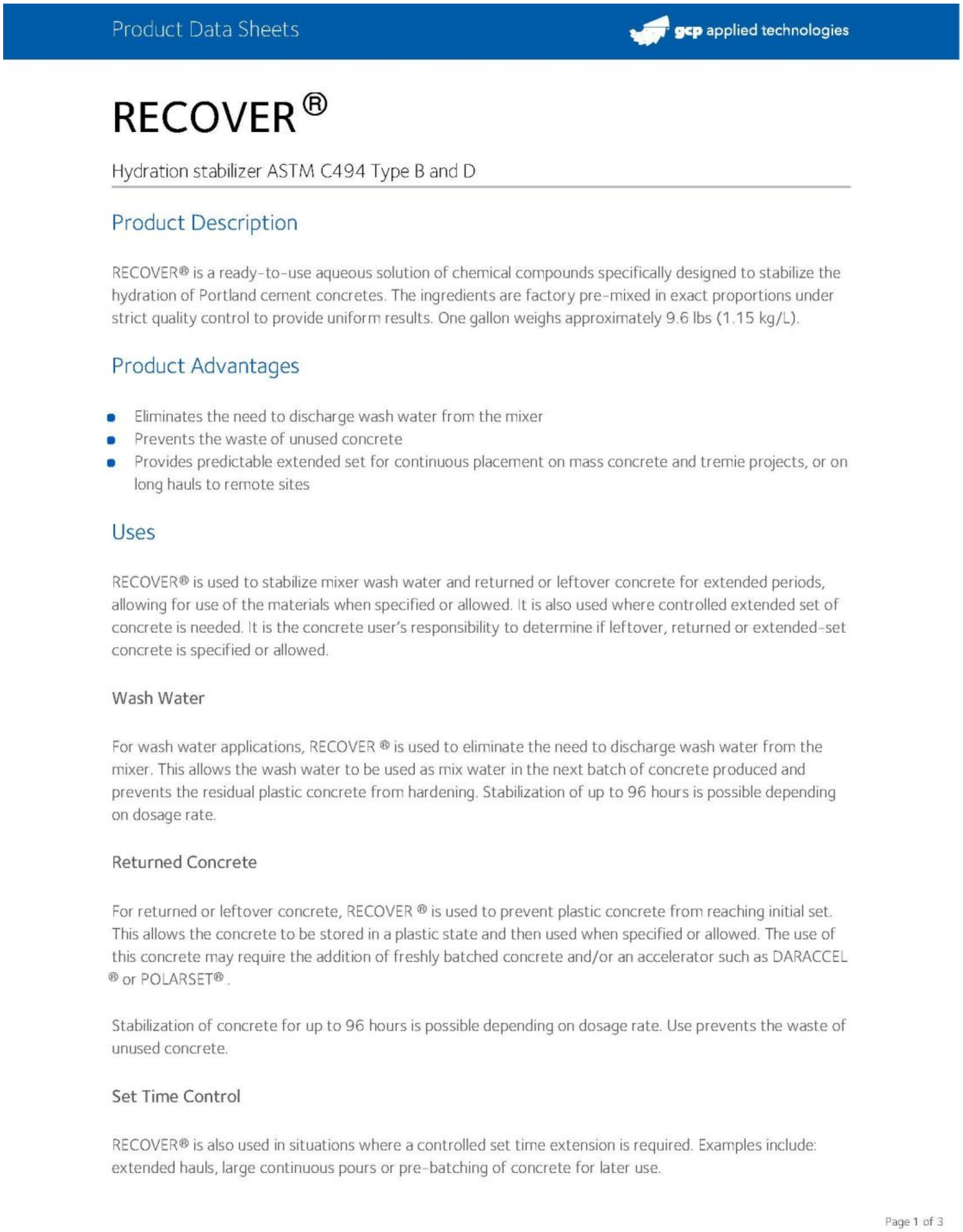
Yours sincerely

[redacted]

Robert J. Hoopes
Product Development Engineer
GCP Applied Technologies

A construction products technologies company

Figure A.32 Genshaft Honors College certification data submittal page 27.



Product Data Sheets

gcp applied technologies

RECOVER®

Hydration stabilizer ASTM C494 Type B and D

Product Description

RECOVER® is a ready-to-use aqueous solution of chemical compounds specifically designed to stabilize the hydration of Portland cement concretes. The ingredients are factory pre-mixed in exact proportions under strict quality control to provide uniform results. One gallon weighs approximately 9.6 lbs (1.15 kg/L).

Product Advantages

- Eliminates the need to discharge wash water from the mixer
- Prevents the waste of unused concrete
- Provides predictable extended set for continuous placement on mass concrete and tremie projects, or on long hauls to remote sites

Uses

RECOVER® is used to stabilize mixer wash water and returned or leftover concrete for extended periods, allowing for use of the materials when specified or allowed. It is also used where controlled extended set of concrete is needed. It is the concrete user's responsibility to determine if leftover, returned or extended-set concrete is specified or allowed.

Wash Water

For wash water applications, RECOVER ® is used to eliminate the need to discharge wash water from the mixer. This allows the wash water to be used as mix water in the next batch of concrete produced and prevents the residual plastic concrete from hardening. Stabilization of up to 96 hours is possible depending on dosage rate.

Returned Concrete

For returned or leftover concrete, RECOVER ® is used to prevent plastic concrete from reaching initial set. This allows the concrete to be stored in a plastic state and then used when specified or allowed. The use of this concrete may require the addition of freshly batched concrete and/or an accelerator such as DARACCEL ® or POLARSET® .

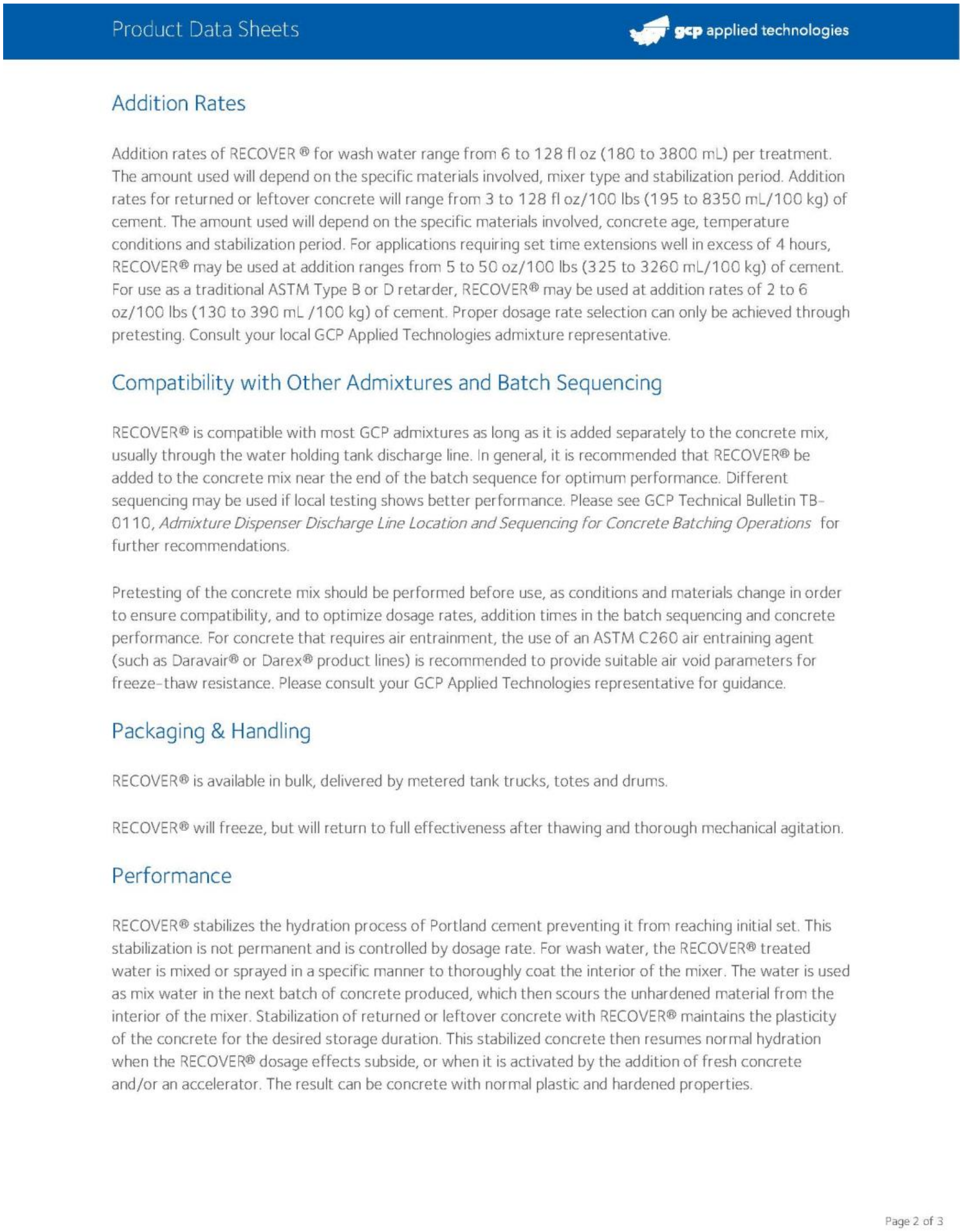
Stabilization of concrete for up to 96 hours is possible depending on dosage rate. Use prevents the waste of unused concrete.

Set Time Control

RECOVER® is also used in situations where a controlled set time extension is required. Examples include: extended hauls, large continuous pours or pre-batching of concrete for later use.

Page 1 of 3

Figure A.33 Genshaft Honors College certification data submittal page 28



Product Data Sheets

gcp applied technologies

Addition Rates

Addition rates of RECOVER ® for wash water range from 6 to 128 fl oz (180 to 3800 mL) per treatment. The amount used will depend on the specific materials involved, mixer type and stabilization period. Addition rates for returned or leftover concrete will range from 3 to 128 fl oz/100 lbs (195 to 8350 mL/100 kg) of cement. The amount used will depend on the specific materials involved, concrete age, temperature conditions and stabilization period. For applications requiring set time extensions well in excess of 4 hours, RECOVER® may be used at addition ranges from 5 to 50 oz/100 lbs (325 to 3260 mL/100 kg) of cement. For use as a traditional ASTM Type B or D retarder, RECOVER® may be used at addition rates of 2 to 6 oz/100 lbs (130 to 390 mL /100 kg) of cement. Proper dosage rate selection can only be achieved through pretesting. Consult your local GCP Applied Technologies admixture representative.

Compatibility with Other Admixtures and Batch Sequencing

RECOVER® is compatible with most GCP admixtures as long as it is added separately to the concrete mix, usually through the water holding tank discharge line. In general, it is recommended that RECOVER® be added to the concrete mix near the end of the batch sequence for optimum performance. Different sequencing may be used if local testing shows better performance. Please see GCP Technical Bulletin TB-0110, *Admixture Dispenser Discharge Line Location and Sequencing for Concrete Batching Operations* for further recommendations.

Pretesting of the concrete mix should be performed before use, as conditions and materials change in order to ensure compatibility, and to optimize dosage rates, addition times in the batch sequencing and concrete performance. For concrete that requires air entrainment, the use of an ASTM C260 air entraining agent (such as Daravair® or Darex® product lines) is recommended to provide suitable air void parameters for freeze-thaw resistance. Please consult your GCP Applied Technologies representative for guidance.

Packaging & Handling

RECOVER® is available in bulk, delivered by metered tank trucks, totes and drums.

RECOVER® will freeze, but will return to full effectiveness after thawing and thorough mechanical agitation.

Performance

RECOVER® stabilizes the hydration process of Portland cement preventing it from reaching initial set. This stabilization is not permanent and is controlled by dosage rate. For wash water, the RECOVER® treated water is mixed or sprayed in a specific manner to thoroughly coat the interior of the mixer. The water is used as mix water in the next batch of concrete produced, which then scours the unhardened material from the interior of the mixer. Stabilization of returned or leftover concrete with RECOVER® maintains the plasticity of the concrete for the desired storage duration. This stabilized concrete then resumes normal hydration when the RECOVER® dosage effects subside, or when it is activated by the addition of fresh concrete and/or an accelerator. The result can be concrete with normal plastic and hardened properties.

Page 2 of 3

Figure A.34 Genshaft Honors College certification data submittal page 29.

Product Data Sheets

gcp applied technologies

Dispensing Equipment

A complete line of GCP dispensing equipment is available for RECOVER ®. This includes the Reach 360TM System which uses an innovative spray wand technology to simplify wash water procedures.

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Last Updated: 2018-08-24
gcpat.com/solutions/products/recover

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Page 3 of 3

Figure A.35 Genshaft Honors College certification data submittal page 30.

SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

1. IDENTIFICATION

Product Identifier	Ready Mix Concrete (Concrete)
Synonyms:	Ready Mix Concrete, Concrete Ready Mix, Portland Cement Concrete, Ready Mix Stucco, Ready Mix grout, Ready Mix, Concrete, Freshly Mixed Concrete, Collodial Concrete, Permeable Concrete, Shotcrete, Gunite, Polymer-Portland Cement Concrete, Colored Concrete, Flowable Fill, Roller-Compacted Concrete, Fiber Reinforced Concrete. Includes Florida Super n Sand Stucco Mix and Florida Super n Sand Masonry Mortar Mix.
Intended use of the product:	Cement is used as a binder in concrete and mortars that are widely used in construction. Cement is distributed in bags, totes and bulk shipment.
Contact:	Argos Cement 3015 Windward Plaza Suite 300 Alpharetta, GA 30005 mheaton@argos-us.com Contact Person: Michael J. Heaton
Contact Information:	CHEMTREC EMERGENCY TELEPHONE NUMBER (24 hrs): (800)424-9300 COMPANY CONTACT (business hours): (678)368-4300 (8 AM-4 PM EST)

2. HAZARD IDENTIFICATION

According to OSHA 29 CFR 1910.1200 HCS

Classification of the Substance or Mixture

Classification (GHS-US):

Skin Corrosion/Irritation	Category 1C	H314
Skin Sensitization	Category 1	H317
Serious Eye Damage/Eye Irritation	Category 1	H318
STOT SE	Category 3	H335
Carcinogenicity	Category 1A	H350
STOT RE	Category 1	H372

Labeling Elements

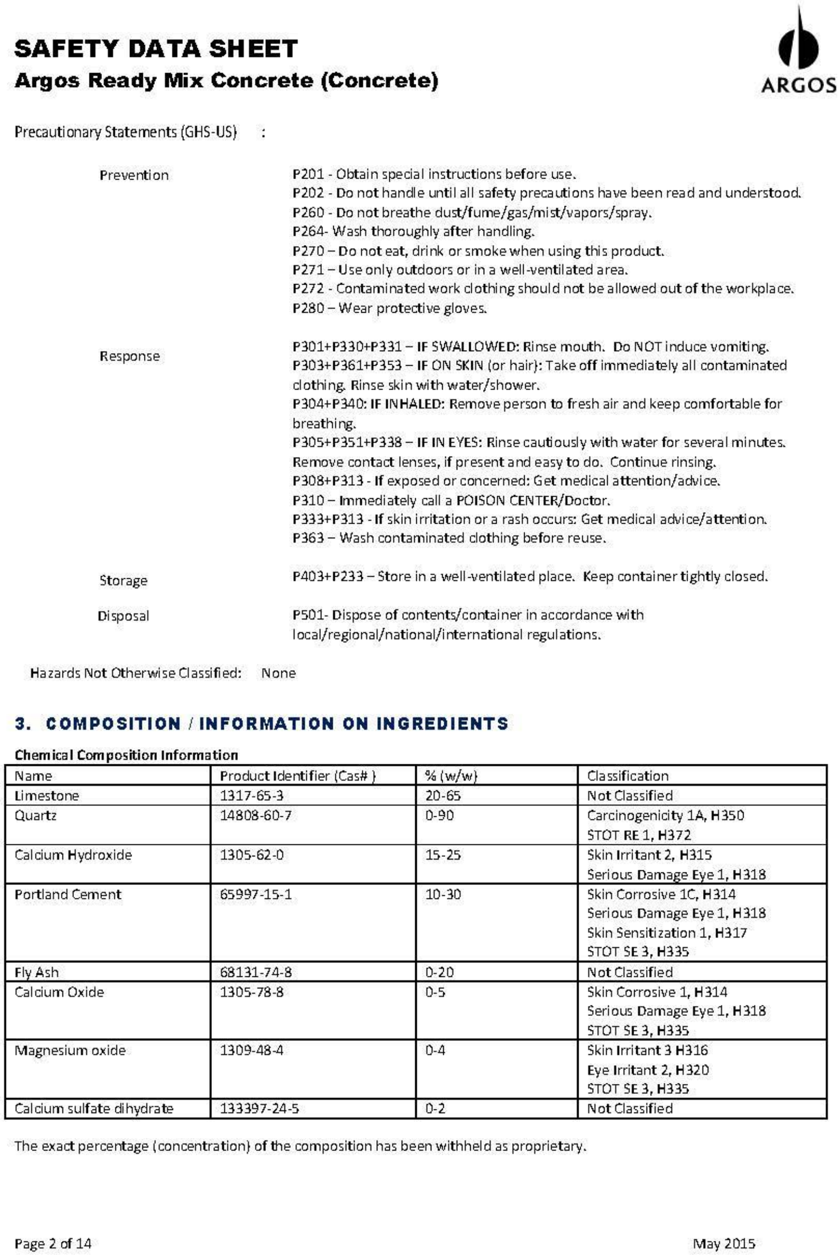
Signal Word (GHS-US) : Danger

Hazard Statements (GHS-US):

H314 – Causes severe skin burns and eye damage.
H317 – May cause an allergic skin reaction.
H318 – Causes serious eye damage.
H335 – May cause respiratory irritation.
H350 – May cause cancer.
H372 – Causes damage to lung through prolonged or repeated exposure inhalation.

Page 1 of 14 May 2015

Figure A.36 Genshaft Honors College certification data submittal page 31.



Precautionary Statements (GHS-US) :

Prevention

P201 - Obtain special instructions before use.
P202 - Do not handle until all safety precautions have been read and understood.
P260 - Do not breathe dust/fume/gas/mist/vapors/spray.
P264- Wash thoroughly after handling.
P270 – Do not eat, drink or smoke when using this product.
P271 – Use only outdoors or in a well-ventilated area.
P272 - Contaminated work clothing should not be allowed out of the workplace.
P280 – Wear protective gloves.

Response

P301+P330+P331 – IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P303+P361+P353 – IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
P304+P340: IF INHALED: Remove person to fresh air and keep comfortable for breathing.
P305+P351+P338 – IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P308+P313 - If exposed or concerned: Get medical attention/advice.
P310 – Immediately call a POISON CENTER/Doctor.
P333+P313 - If skin irritation or a rash occurs: Get medical advice/attention.
P363 – Wash contaminated clothing before reuse.

Storage

P403+P233 – Store in a well-ventilated place. Keep container tightly closed.

Disposal

P501- Dispose of contents/container in accordance with local/regional/national/international regulations.

Hazards Not Otherwise Classified: None

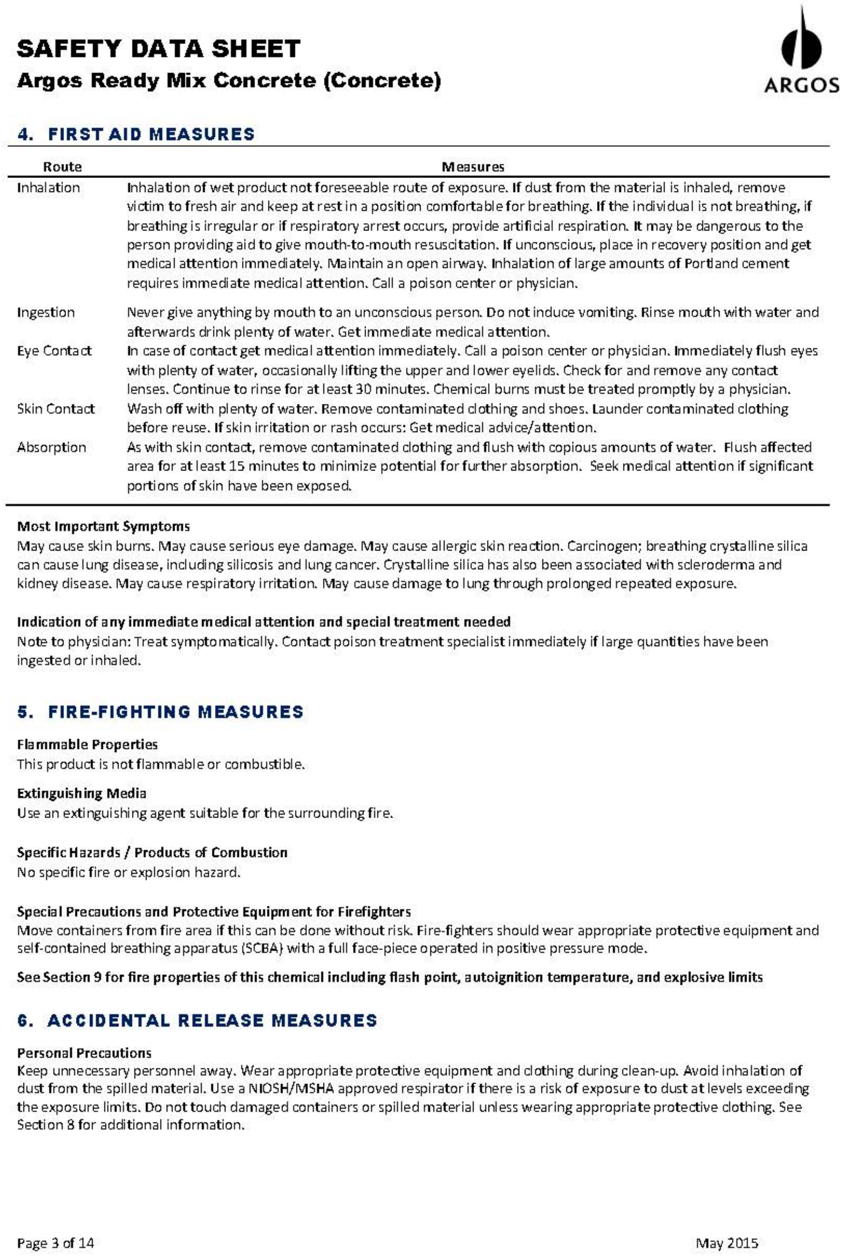
3. COMPOSITION / INFORMATION ON INGREDIENTS

Chemical Composition Information

Name	Product Identifier (Cas#)	% (w/w)	Classification
Limestone	1317-65-3	20-65	Not Classified
Quartz	14808-60-7	0-90	Carcinogenicity 1A, H350 STOT RE 1, H372
Calcium Hydroxide	1305-62-0	15-25	Skin Irritant 2, H315 Serious Damage Eye 1, H318
Portland Cement	65997-15-1	10-30	Skin Corrosive 1C, H314 Serious Damage Eye 1, H318 Skin Sensitization 1, H317 STOT SE 3, H335
Fly Ash	68131-74-8	0-20	Not Classified
Calcium Oxide	1305-78-8	0-5	Skin Corrosive 1, H314 Serious Damage Eye 1, H318 STOT SE 3, H335
Magnesium oxide	1309-48-4	0-4	Skin Irritant 3 H316 Eye Irritant 2, H320 STOT SE 3, H335
Calcium sulfate dihydrate	133397-24-5	0-2	Not Classified

The exact percentage (concentration) of the composition has been withheld as proprietary.

Figure A.37 Genshaft Honors College certification data submittal page 32.



SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

4. FIRST AID MEASURES

Route	Measures
Inhalation	Inhalation of wet product not foreseeable route of exposure. If dust from the material is inhaled, remove victim to fresh air and keep at rest in a position comfortable for breathing. If the individual is not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Inhalation of large amounts of Portland cement requires immediate medical attention. Call a poison center or physician.
Ingestion	Never give anything by mouth to an unconscious person. Do not induce vomiting. Rinse mouth with water and afterwards drink plenty of water. Get immediate medical attention.
Eye Contact	In case of contact get medical attention immediately. Call a poison center or physician. Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 30 minutes. Chemical burns must be treated promptly by a physician.
Skin Contact	Wash off with plenty of water. Remove contaminated clothing and shoes. Launder contaminated clothing before reuse. If skin irritation or rash occurs: Get medical advice/attention.
Absorption	As with skin contact, remove contaminated clothing and flush with copious amounts of water. Flush affected area for at least 15 minutes to minimize potential for further absorption. Seek medical attention if significant portions of skin have been exposed.

Most Important Symptoms

May cause skin burns. May cause serious eye damage. May cause allergic skin reaction. Carcinogen; breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease. May cause respiratory irritation. May cause damage to lung through prolonged repeated exposure.

Indication of any immediate medical attention and special treatment needed

Note to physician: Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

5. FIRE-FIGHTING MEASURES

Flammable Properties

This product is not flammable or combustible.

Extinguishing Media

Use an extinguishing agent suitable for the surrounding fire.

Specific Hazards / Products of Combustion

No specific fire or explosion hazard.

Special Precautions and Protective Equipment for Firefighters

Move containers from fire area if this can be done without risk. Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

See Section 9 for fire properties of this chemical including flash point, autoignition temperature, and explosive limits

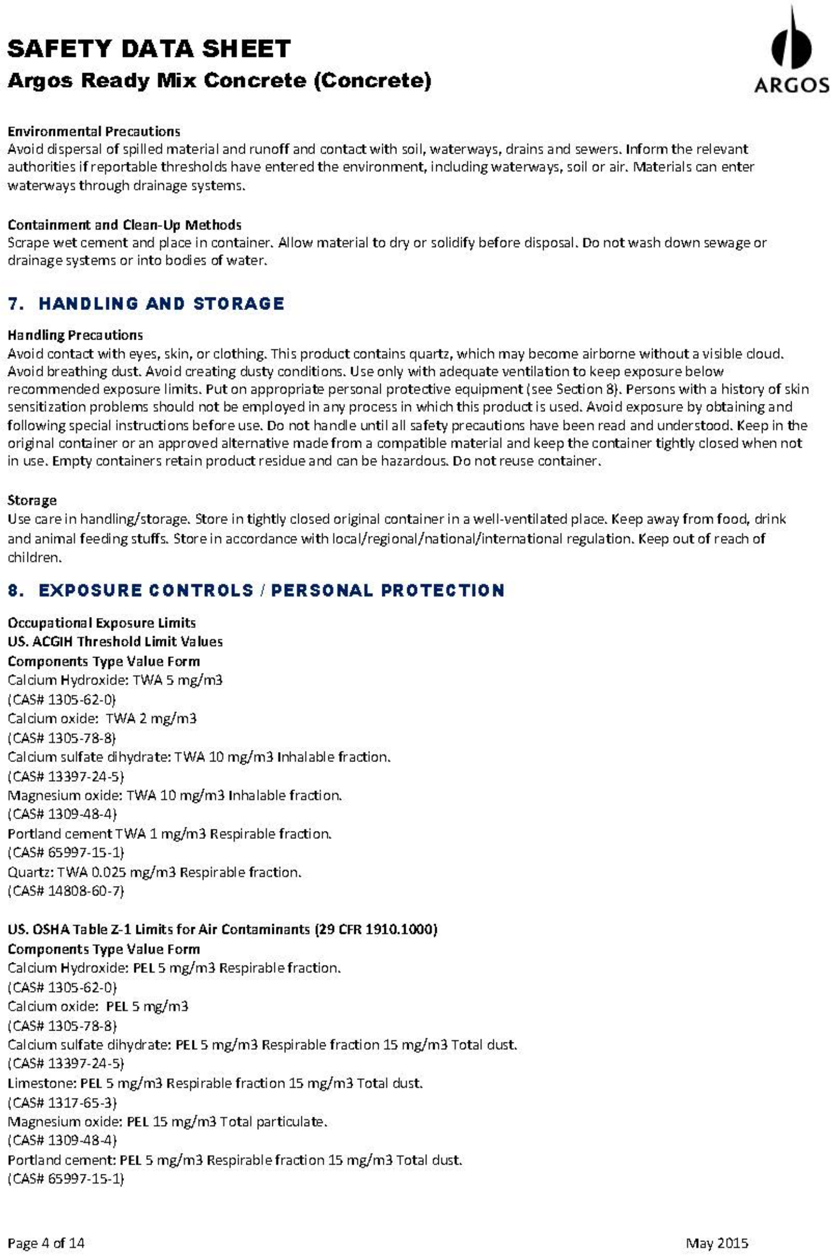
6. ACCIDENTAL RELEASE MEASURES

Personal Precautions

Keep unnecessary personnel away. Wear appropriate protective equipment and clothing during clean-up. Avoid inhalation of dust from the spilled material. Use a NIOSH/MSHA approved respirator if there is a risk of exposure to dust at levels exceeding the exposure limits. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. See Section 8 for additional information.

Page 3 of 14 May 2015

Figure A.38 Genshaft Honors College certification data submittal page 33.



SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

Environmental Precautions

Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if reportable thresholds have entered the environment, including waterways, soil or air. Materials can enter waterways through drainage systems.

Containment and Clean-Up Methods

Scrape wet cement and place in container. Allow material to dry or solidify before disposal. Do not wash down sewage or drainage systems or into bodies of water.

7. HANDLING AND STORAGE

Handling Precautions

Avoid contact with eyes, skin, or clothing. This product contains quartz, which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Put on appropriate personal protective equipment (see Section 8). Persons with a history of skin sensitization problems should not be employed in any process in which this product is used. Avoid exposure by obtaining and following special instructions before use. Do not handle until all safety precautions have been read and understood. Keep in the original container or an approved alternative made from a compatible material and keep the container tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.

Storage

Use care in handling/storage. Store in tightly closed original container in a well-ventilated place. Keep away from food, drink and animal feeding stuffs. Store in accordance with local/regional/national/international regulation. Keep out of reach of children.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational Exposure Limits
US. ACGIH Threshold Limit Values
Components Type Value Form
Calcium Hydroxide: TWA 5 mg/m3
(CAS# 1305-62-0)
Calcium oxide: TWA 2 mg/m3
(CAS# 1305-78-8)
Calcium sulfate dihydrate: TWA 10 mg/m3 Inhalable fraction.
(CAS# 13397-24-5)
Magnesium oxide: TWA 10 mg/m3 Inhalable fraction.
(CAS# 1309-48-4)
Portland cement TWA 1 mg/m3 Respirable fraction.
(CAS# 65997-15-1)
Quartz: TWA 0.025 mg/m3 Respirable fraction.
(CAS# 14808-60-7)

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)
Components Type Value Form
Calcium Hydroxide: PEL 5 mg/m3 Respirable fraction.
(CAS# 1305-62-0)
Calcium oxide: PEL 5 mg/m3
(CAS# 1305-78-8)
Calcium sulfate dihydrate: PEL 5 mg/m3 Respirable fraction 15 mg/m3 Total dust.
(CAS# 13397-24-5)
Limestone: PEL 5 mg/m3 Respirable fraction 15 mg/m3 Total dust.
(CAS# 1317-65-3)
Magnesium oxide: PEL 15 mg/m3 Total particulate.
(CAS# 1309-48-4)
Portland cement: PEL 5 mg/m3 Respirable fraction 15 mg/m3 Total dust.
(CAS# 65997-15-1)

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Figure A.39 Genshaft Honors College certification data submittal page 34.

SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

US. OSHA Table Z-3 (29 CFR 1910.1000)
Components Type Value Form
Portland cement: TWA 50 mppcf
(CAS# 65997-15-1)
Quartz: TWA 0.3 mg/m3 Total dust, 0.1 mg/m3 Respirable, 2.4 mppcf Respirable.
(CAS# 14808-60-7)

Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2)
Components Type Value Form
Calcium Hydroxide: TWA 5 mg/m3
(CAS# 1305-62-0)
Calcium oxide: TWA 2 mg/m3
(CAS# 1305-78-8)
Calcium sulfate dihydrate: TWA 10 mg/m3
(CAS# 13397-24-5)
Limestone: TWA 10 mg/m3
(CAS# 1317-65-3)
Magnesium oxide: TWA 10 mg/m3 Fume.
(CAS# 1309-48-4)
Portland cement: TWA 10 mg/m3
(CAS# 65997-15-1)
Quartz: TWA 0.025 mg/m3 Respirable particles.
(CAS# 14808-60-7)

Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended**)**
Components Type Value Form
Calcium Hydroxide: TWA 5 mg/m3
(CAS# 1305-62-0)
Calcium oxide: TWA 2 mg/m3
(CAS# 1305-78-8)
Calcium sulfate dihydrate: STEL 20 mg/m3 Total dust, TWA 10 mg/m3 Inhalable
(CAS# 13397-24-5)
Limestone: STEL 20 mg/m3 Total dust, TWA 3 mg/m3 Respirable fraction 10 mg/m3 Total dust.
(CAS# 1317-65-3)
Magnesium oxide: STEL 10 mg/m3 Respirable dust and/or fume, TWA 3 mg/m3 Respirable dust and/or fume, 10 mg/m3 Inhalable fume.
(CAS# 1309-48-4)
Portland cement: TWA 3 mg/m3 Respirable fraction, 10 mg/m3 Total dust.
(CAS# 65997-15-1)
Quartz TWA 0.025 mg/m3 Respirable fraction.
(CAS# 14808-60-7)

Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents)
Components Type Value Form
Calcium Hydroxide: TWA 5 mg/m3
(CAS# 1305-62-0)
Calcium oxide: TWA 2 mg/m3
(CAS# 1305-78-8)
Calcium sulfate dihydrate: TWA 10 mg/m3 Inhalable fraction.
(CAS# 13397-24-5)
Magnesium oxide: TWA 10 mg/m3 Inhalable fraction.
(CAS# 1309-48-4)
Portland cement: TWA 10 mg/m3

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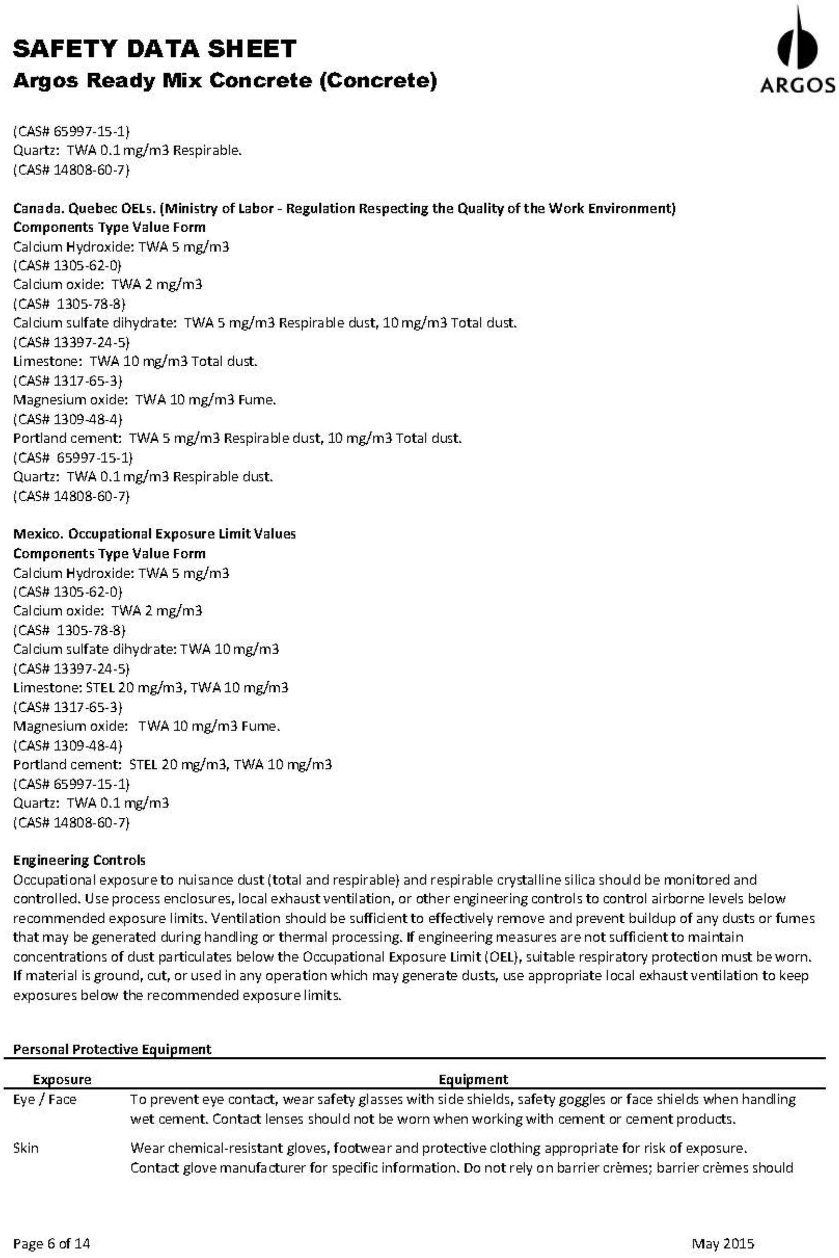
Figure A.40 Genshaft Honors College certification data submittal page 35.



SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

(CAS# 65997-15-1)
Quartz: TWA 0.1 mg/m3 Respirable.
(CAS# 14808-60-7)

Canada. Quebec OELs. (Ministry of Labor - Regulation Respecting the Quality of the Work Environment)
Components Type Value Form
Calcium Hydroxide: TWA 5 mg/m3
(CAS# 1305-62-0)
Calcium oxide: TWA 2 mg/m3
(CAS# 1305-78-8)
Calcium sulfate dihydrate: TWA 5 mg/m3 Respirable dust, 10 mg/m3 Total dust.
(CAS# 13397-24-5)
Limestone: TWA 10 mg/m3 Total dust.
(CAS# 1317-65-3)
Magnesium oxide: TWA 10 mg/m3 Fume.
(CAS# 1309-48-4)
Portland cement: TWA 5 mg/m3 Respirable dust, 10 mg/m3 Total dust.
(CAS# 65997-15-1)
Quartz: TWA 0.1 mg/m3 Respirable dust.
(CAS# 14808-60-7)

Mexico. Occupational Exposure Limit Values
Components Type Value Form
Calcium Hydroxide: TWA 5 mg/m3
(CAS# 1305-62-0)
Calcium oxide: TWA 2 mg/m3
(CAS# 1305-78-8)
Calcium sulfate dihydrate: TWA 10 mg/m3
(CAS# 13397-24-5)
Limestone: STEL 20 mg/m3, TWA 10 mg/m3
(CAS# 1317-65-3)
Magnesium oxide: TWA 10 mg/m3 Fume.
(CAS# 1309-48-4)
Portland cement: STEL 20 mg/m3, TWA 10 mg/m3
(CAS# 65997-15-1)
Quartz: TWA 0.1 mg/m3
(CAS# 14808-60-7)

Engineering Controls

Occupational exposure to nuisance dust (total and respirable) and respirable crystalline silica should be monitored and controlled. Use process enclosures, local exhaust ventilation, or other engineering controls to control airborne levels below recommended exposure limits. Ventilation should be sufficient to effectively remove and prevent buildup of any dusts or fumes that may be generated during handling or thermal processing. If engineering measures are not sufficient to maintain concentrations of dust particulates below the Occupational Exposure Limit (OEL), suitable respiratory protection must be worn. If material is ground, cut, or used in any operation which may generate dusts, use appropriate local exhaust ventilation to keep exposures below the recommended exposure limits.

Personal Protective Equipment

Exposure	Equipment
Eye / Face	To prevent eye contact, wear safety glasses with side shields, safety goggles or face shields when handling wet cement. Contact lenses should not be worn when working with cement or cement products.
Skin	Wear chemical-resistant gloves, footwear and protective clothing appropriate for risk of exposure. Contact glove manufacturer for specific information. Do not rely on barrier crèmes; barrier crèmes should

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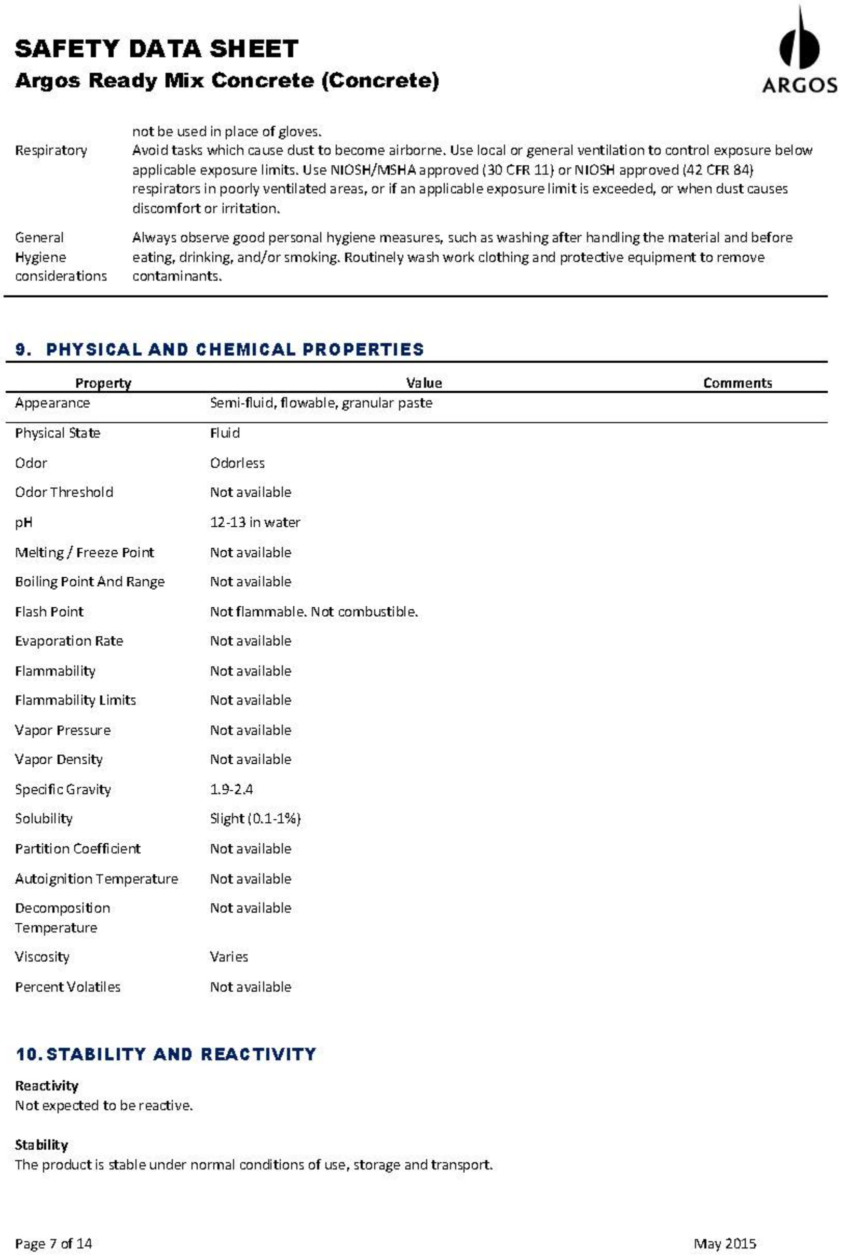
Figure A.41 Genshaft Honors College certification data submittal page 36.



SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

	not be used in place of gloves.
Respiratory	Avoid tasks which cause dust to become airborne. Use local or general ventilation to control exposure below applicable exposure limits. Use NIOSH/MSHA approved (30 CFR 11) or NIOSH approved (42 CFR 84) respirators in poorly ventilated areas, or if an applicable exposure limit is exceeded, or when dust causes discomfort or irritation.
General Hygiene considerations	Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. PHYSICAL AND CHEMICAL PROPERTIES

Property	Value	Comments
Appearance	Semi-fluid, flowable, granular paste	
Physical State	Fluid	
Odor	Odorless	
Odor Threshold	Not available	
pH	12-13 in water	
Melting / Freeze Point	Not available	
Boiling Point And Range	Not available	
Flash Point	Not flammable. Not combustible.	
Evaporation Rate	Not available	
Flammability	Not available	
Flammability Limits	Not available	
Vapor Pressure	Not available	
Vapor Density	Not available	
Specific Gravity	1.9-2.4	
Solubility	Slight (0.1-1%)	
Partition Coefficient	Not available	
Autoignition Temperature	Not available	
Decomposition Temperature	Not available	
Viscosity	Varies	
Percent Volatiles	Not available	

10. STABILITY AND REACTIVITY

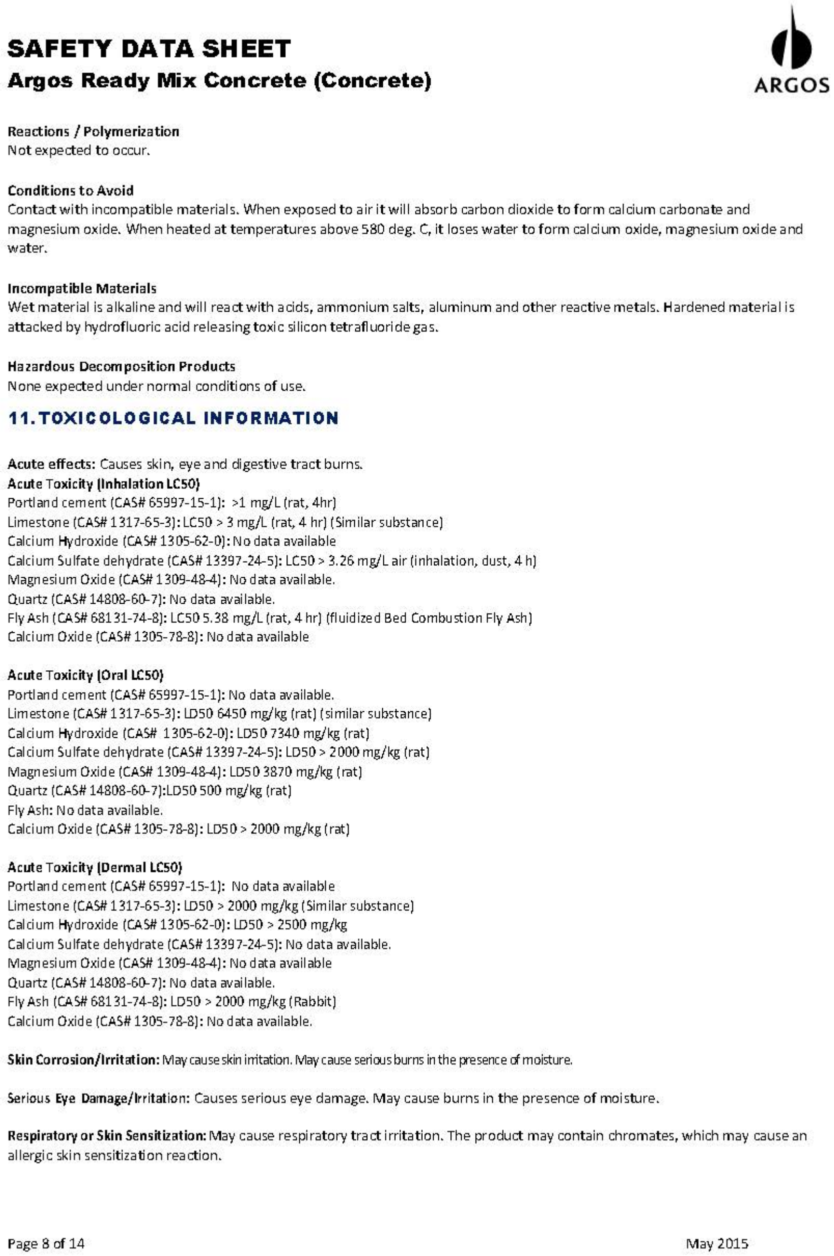
Reactivity

Not expected to be reactive.

Stability

The product is stable under normal conditions of use, storage and transport.

Figure A.42 Genshaft Honors College certification data submittal page 37.



SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

Reactions / Polymerization
Not expected to occur.

Conditions to Avoid
Contact with incompatible materials. When exposed to air it will absorb carbon dioxide to form calcium carbonate and magnesium oxide. When heated at temperatures above 580 deg. C, it loses water to form calcium oxide, magnesium oxide and water.

Incompatible Materials
Wet material is alkaline and will react with acids, ammonium salts, aluminum and other reactive metals. Hardened material is attacked by hydrofluoric acid releasing toxic silicon tetrafluoride gas.

Hazardous Decomposition Products
None expected under normal conditions of use.

11. TOXICOLOGICAL INFORMATION

Acute effects: Causes skin, eye and digestive tract burns.

Acute Toxicity (Inhalation LC50)

Portland cement (CAS# 65997-15-1): >1 mg/L (rat, 4hr)
Limestone (CAS# 1317-65-3): LC50 > 3 mg/L (rat, 4 hr) (Similar substance)
Calcium Hydroxide (CAS# 1305-62-0): No data available
Calcium Sulfate dehydrate (CAS# 13397-24-5): LC50 > 3.26 mg/L air (inhalation, dust, 4 h)
Magnesium Oxide (CAS# 1309-48-4): No data available.
Quartz (CAS# 14808-60-7): No data available.
Fly Ash (CAS# 68131-74-8): LC50 5.38 mg/L (rat, 4 hr) (fluidized Bed Combustion Fly Ash)
Calcium Oxide (CAS# 1305-78-8): No data available

Acute Toxicity (Oral LC50)

Portland cement (CAS# 65997-15-1): No data available.
Limestone (CAS# 1317-65-3): LD50 6450 mg/kg (rat) (similar substance)
Calcium Hydroxide (CAS# 1305-62-0): LD50 7340 mg/kg (rat)
Calcium Sulfate dehydrate (CAS# 13397-24-5): LD50 > 2000 mg/kg (rat)
Magnesium Oxide (CAS# 1309-48-4): LD50 3870 mg/kg (rat)
Quartz (CAS# 14808-60-7):LD50 500 mg/kg (rat)
Fly Ash: No data available.
Calcium Oxide (CAS# 1305-78-8): LD50 > 2000 mg/kg (rat)

Acute Toxicity (Dermal LC50)

Portland cement (CAS# 65997-15-1): No data available
Limestone (CAS# 1317-65-3): LD50 > 2000 mg/kg (Similar substance)
Calcium Hydroxide (CAS# 1305-62-0): LD50 > 2500 mg/kg
Calcium Sulfate dehydrate (CAS# 13397-24-5): No data available.
Magnesium Oxide (CAS# 1309-48-4): No data available
Quartz (CAS# 14808-60-7): No data available.
Fly Ash (CAS# 68131-74-8): LD50 > 2000 mg/kg (Rabbit)
Calcium Oxide (CAS# 1305-78-8): No data available.

Skin Corrosion/Irritation: May cause skin irritation. May cause serious burns in the presence of moisture.

Serious Eye Damage/Irritation: Causes serious eye damage. May cause burns in the presence of moisture.

Respiratory or Skin Sensitization: May cause respiratory tract irritation. The product may contain chromates, which may cause an allergic skin sensitization reaction.

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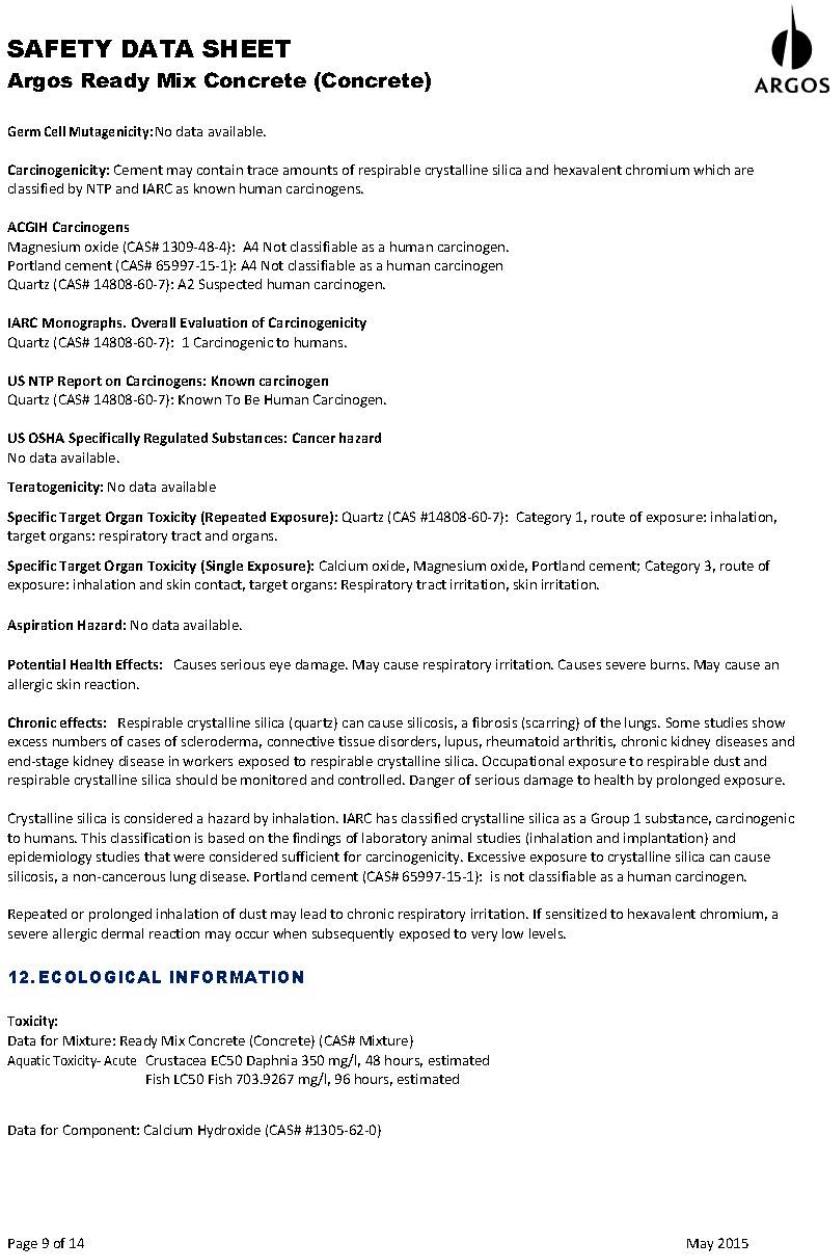
Figure A.43 Genshaft Honors College certification data submittal page 38.



Germ Cell Mutagenicity: No data available.

Carcinogenicity: Cement may contain trace amounts of respirable crystalline silica and hexavalent chromium which are classified by NTP and IARC as known human carcinogens.

ACGIH Carcinogens
Magnesium oxide (CAS# 1309-48-4): A4 Not classifiable as a human carcinogen.
Portland cement (CAS# 65997-15-1): A4 Not classifiable as a human carcinogen
Quartz (CAS# 14808-60-7): A2 Suspected human carcinogen.

IARC Monographs. Overall Evaluation of Carcinogenicity
Quartz (CAS# 14808-60-7): 1 Carcinogenic to humans.

US NTP Report on Carcinogens: Known carcinogen
Quartz (CAS# 14808-60-7): Known To Be Human Carcinogen.

US OSHA Specifically Regulated Substances: Cancer hazard
No data available.

Teratogenicity: No data available

Specific Target Organ Toxicity (Repeated Exposure): Quartz (CAS #14808-60-7): Category 1, route of exposure: inhalation, target organs: respiratory tract and organs.

Specific Target Organ Toxicity (Single Exposure): Calcium oxide, Magnesium oxide, Portland cement; Category 3, route of exposure: inhalation and skin contact, target organs: Respiratory tract irritation, skin irritation.

Aspiration Hazard: No data available.

Potential Health Effects: Causes serious eye damage. May cause respiratory irritation. Causes severe burns. May cause an allergic skin reaction.

Chronic effects: Respirable crystalline silica (quartz) can cause silicosis, a fibrosis (scarring) of the lungs. Some studies show excess numbers of cases of scleroderma, connective tissue disorders, lupus, rheumatoid arthritis, chronic kidney diseases and end-stage kidney disease in workers exposed to respirable crystalline silica. Occupational exposure to respirable dust and respirable crystalline silica should be monitored and controlled. Danger of serious damage to health by prolonged exposure.

Crystalline silica is considered a hazard by inhalation. IARC has classified crystalline silica as a Group 1 substance, carcinogenic to humans. This classification is based on the findings of laboratory animal studies (inhalation and implantation) and epidemiology studies that were considered sufficient for carcinogenicity. Excessive exposure to crystalline silica can cause silicosis, a non-cancerous lung disease. Portland cement (CAS# 65997-15-1): is not classifiable as a human carcinogen.

Repeated or prolonged inhalation of dust may lead to chronic respiratory irritation. If sensitized to hexavalent chromium, a severe allergic dermal reaction may occur when subsequently exposed to very low levels.

12. ECOLOGICAL INFORMATION

Toxicity:
Data for Mixture: Ready Mix Concrete (Concrete) (CAS# Mixture)

Aquatic Toxicity- Acute	Crustacea EC50 Daphnia 350 mg/l, 48 hours, estimated
	Fish LC50 Fish 703.9267 mg/l, 96 hours, estimated

Data for Component: Calcium Hydroxide (CAS# #1305-62-0)

Figure A.44 Genshaft Honors College certification data submittal page 39.

SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

Aquatic Toxicity-Acute	Gasterosteus aculeatus 96 hr LC50 = 457 mg/L Oncorhynchus mykiss 96 hr LC50 = 50.6 mg/L Crangon septemspinosa 96 hr LC50 = 158 mg/L Daphnia magna 48 hr EC50 = 49.1 mg/L Daphnia magna 48 h EC50 > 100 mg/L Danio rerio 96 h LC50 > 11.1 mg/L
Aquatic Toxicity-Chronic	Crangon septemspinosa 14 d NOEC = 32 mg/L
Data for Component:	Calcium sulfate dihydrate (CAS# 13397-24-5)
Aquatic Toxicity-Acute	Fish LC50 Fathead minnow (Pimephales promelas) > 1970 mg/l, 96 hours
Data for Component:	Calcium oxide (CAS#1305-78-8)
Aquatic Toxicity-Acute	Cyprinus carpio 96 hr LC50 = 1070 mg/L
Aquatic Toxicity-Chronic	Tilapia nilotica 46 days NOEC = 100 mg/L
Data for Component:	Quartz (CAS# 14808-60-7)
Aquatic Toxicity- Acute	Daphnia magna 24 hr LL50 > 10000 mg/L Danio rerio 96 hr LL0 = 10000 mg/LDaphnia magna 48 hr EC50 > 100 mg/L (similar substance) Desmodesmus subspicatus 72 hr EC50 > 14 mg/L (similar substance)

Persistence and Degradation: Persistent
Bioaccumulative Potential: Not Bioaccumulative
Mobility in Soil: No data available.
Other Adverse Effects: No data available.
Other Information: No data available.

13. DISPOSAL CONSIDERATIONS

The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Untreated waste should not be released to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe manner. Care should be taken when handling empty containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff, and contact with soil, waterways, drains and sewers.

Dispose in accordance with applicable federal, state, and local regulations. Empty containers may contain product residues. Do not dispose of waste into sewer. This material and its container must be disposed of as hazardous waste.

14. TRANSPORT INFORMATION

US DOT	
UN Identification Number	Not regulated
Proper Shipping Name	Not available
Hazard Class and Packing Group	Not available
Shipping Label	Not available
Placard / Bulk Package	Not available
Emergency Response Guidebook Guide Number	Not available
IATA Cargo	
UN Identification Number	Not regulated
Shipping Name / Description	Not available
Hazard Class and Packing Group	Not available

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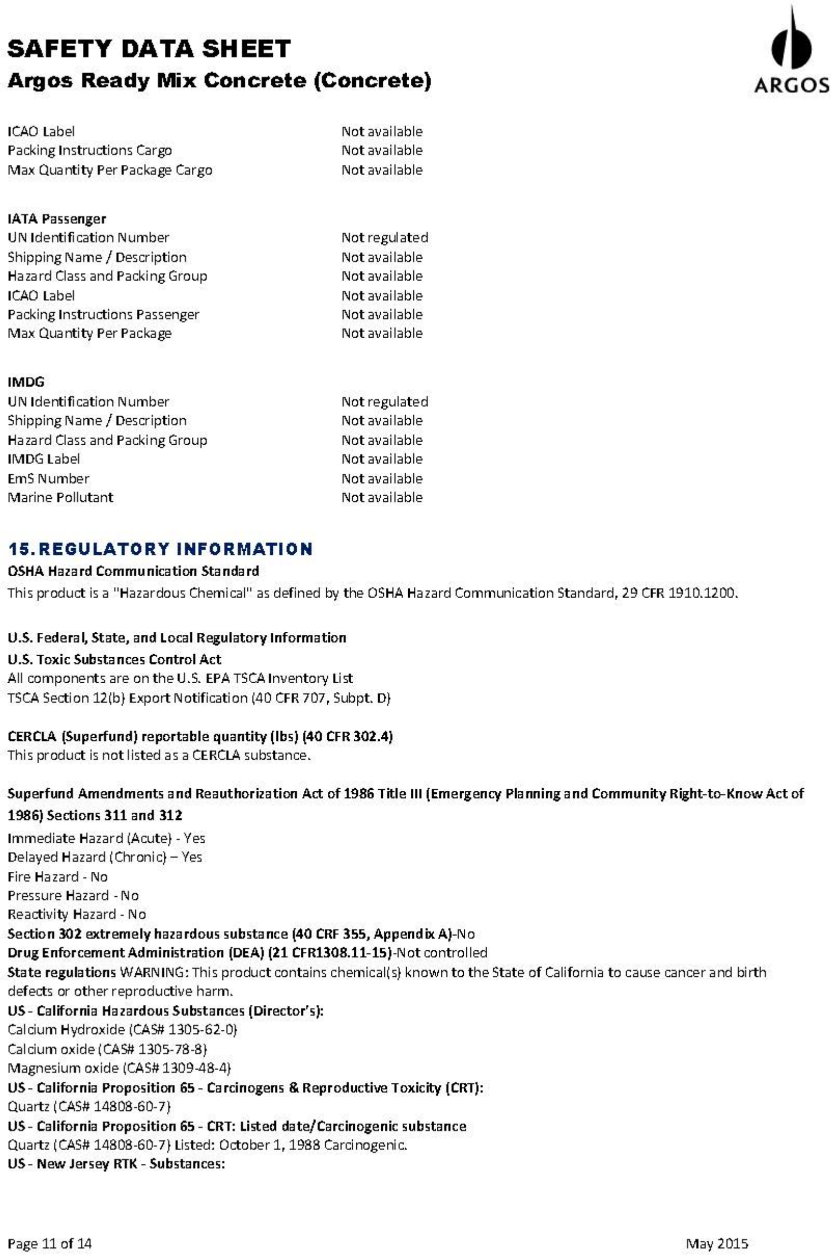
Figure A.45 Genshaft Honors College certification data submittal page 40.



SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

ICAO Label	Not available
Packing Instructions Cargo	Not available
Max Quantity Per Package Cargo	Not available

IATA Passenger

UN Identification Number	Not regulated
Shipping Name / Description	Not available
Hazard Class and Packing Group	Not available
ICAO Label	Not available
Packing Instructions Passenger	Not available
Max Quantity Per Package	Not available

IMDG

UN Identification Number	Not regulated
Shipping Name / Description	Not available
Hazard Class and Packing Group	Not available
IMDG Label	Not available
EmS Number	Not available
Marine Pollutant	Not available

15. REGULATORY INFORMATION

OSHA Hazard Communication Standard

This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

U.S. Federal, State, and Local Regulatory Information

U.S. Toxic Substances Control Act

All components are on the U.S. EPA TSCA Inventory List

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

CERCLA (Superfund) reportable quantity (lbs) (40 CFR 302.4)

This product is not listed as a CERCLA substance.

Superfund Amendments and Reauthorization Act of 1986 Title III (Emergency Planning and Community Right-to-Know Act of 1986) Sections 311 and 312

Immediate Hazard (Acute) - Yes
Delayed Hazard (Chronic) – Yes
Fire Hazard - No
Pressure Hazard - No
Reactivity Hazard - No

Section 302 extremely hazardous substance (40 CRF 355, Appendix A)-No

Drug Enforcement Administration (DEA) (21 CFR1308.11-15)-Not controlled

State regulations WARNING: This product contains chemical(s) known to the State of California to cause cancer and birth defects or other reproductive harm.

US - California Hazardous Substances (Director's):

Calcium Hydroxide (CAS# 1305-62-0)
Calcium oxide (CAS# 1305-78-8)
Magnesium oxide (CAS# 1309-48-4)

US - California Proposition 65 - Carcinogens & Reproductive Toxicity (CRT):

Quartz (CAS# 14808-60-7)

US - California Proposition 65 - CRT: Listed date/Carcinogenic substance

Quartz (CAS# 14808-60-7) Listed: October 1, 1988 Carcinogenic.

US - New Jersey RTK - Substances:

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Figure A.46 Genshaft Honors College certification data submittal page 41.

SAFETY DATA SHEET
Argos Ready Mix Concrete (Concrete)

ARGOS

Calcium Hydroxide (CAS# 1305-62-0)
Calcium oxide (CAS# 1305-78-8) Listed.
Calcium sulfate dihydrate (CAS# 13397-24-5)
Limestone (CAS# 1317-65-3)
Magnesium oxide (CAS# 1309-48-4)
Portland cement (CAS# 65997-15-1)
Quartz (CAS# 14808-60-7)
US - Pennsylvania RTK - Hazardous Substances:
Calcium Hydroxide (CAS# 1305-62-0)
Calcium oxide (CAS# 1305-78-8)
Calcium sulfate dihydrate (CAS# 13397-24-5)
Limestone (CAS# 1317-65-3)
Magnesium oxide (CAS# 1309-48-4)
Portland cement (CAS# 65997-15-1)
Quartz (CAS# 14808-60-7)
US - Pennsylvania RTK - Hazardous Substances: Special hazard
Calcium Hydroxide (CAS# 1305-62-0)
Calcium oxide (CAS# 1305-78-8)
Calcium sulfate dihydrate (CAS# 13397-24-5)
Limestone (CAS# 1317-65-3)
Magnesium oxide (CAS# 1309-48-4)
Portland cement (CAS# 65997-15-1)
Quartz (CAS# 14808-60-7)

Canadian Regulatory Information
This product has been classified in accordance with the hazard criteria of the CPR and the MSDS contains all the information required by the CPR.

WHMIS status
Controlled

WHMIS classification
E – Corrosive

WHMIS labeling

Inventory status	Country(s) or region Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	Yes
Canada	Domestic Substances List (DSL)	No
Canada	Non-Domestic Substances List (NDSL)	Yes
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	Yes
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	No
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	No
Philippines	Philippine Inventory of Chemicals and	No

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Figure A.47 Genshaft Honors College certification data submittal page 42.

SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

	Chemical Substances (PICCS)	
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

**A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)*

16. OTHER INFORMATION

HMIS® Health rating including an * indicates a chronic hazard

HMIS® ratings

Health: 3*

Flammability: 0

Physical hazard: 1

NFPA ratings

Health: 3

Flammability: 0

Instability: 1

Version:2015.05.27

Issue Date

5/27/2015

Prior Issue Date

10/12/2012

Description of Revisions

Revise to meet Globally Harmonized System for chemical hazard communication requirements pursuant to OSHA regulatory revisions 77 FR 17884, March 26, 2012.

Notice to reader

While the information provided in this safety data sheet is believed to provide a useful summary of the hazards of Portland cement as it is commonly used, the sheet cannot anticipate and provide all of the information that might be needed in every situation. Inexperienced product users should obtain proper training before using this product. In particular, the data furnished in this sheet do not address hazards that may be posed by other materials mixed with Portland cement to produce Portland cement products. Users should review other relevant material safety data sheets before working with this Portland cement or working on Portland cement products, for example, Portland cement concrete.

SELLER MAKES NO WARRANTY, EXPRESS OR IMPLIED, CONCERNING THE PRODUCT OR THE MERCHANTABILITY OR FITNESS THEREOF FOR ANY PURPOSE OR CONCERNING THE ACCURACY OF ANY INFORMATION PROVIDED BY **(Name of Company)**, except that the product shall conform to contracted specifications. The information provided herein was believed by the **(Name of Company)** to be accurate at the time of preparation or prepared from sources believed to be reliable, but it is the responsibility of the user to investigate and understand other pertinent sources of information to comply with all laws and procedures applicable to the safe handling and use of product and to determine the suitability of the product for its intended use. Buyer's exclusive remedy shall be for damages and no claim of any kind, whether as to product delivered or for non-delivery of product, and whether based on contract, breach of warranty, negligence, or otherwise shall be greater in amount than the purchase price of the quantity of product in respect of which damages are claimed. In no event shall Seller be liable for incidental or consequential damages, whether Buyer's claim is based on contract, breach of warranty, negligence or otherwise.

Abbreviations

ACGIH — American Conference of Governmental Industrial Hygienists

CAS# — Chemical Abstract Service

CERCLA — Comprehensive Emergency Response and Comprehensive Liability Act

CFR — Code of Federal Regulations

DOT — Department of Transportation

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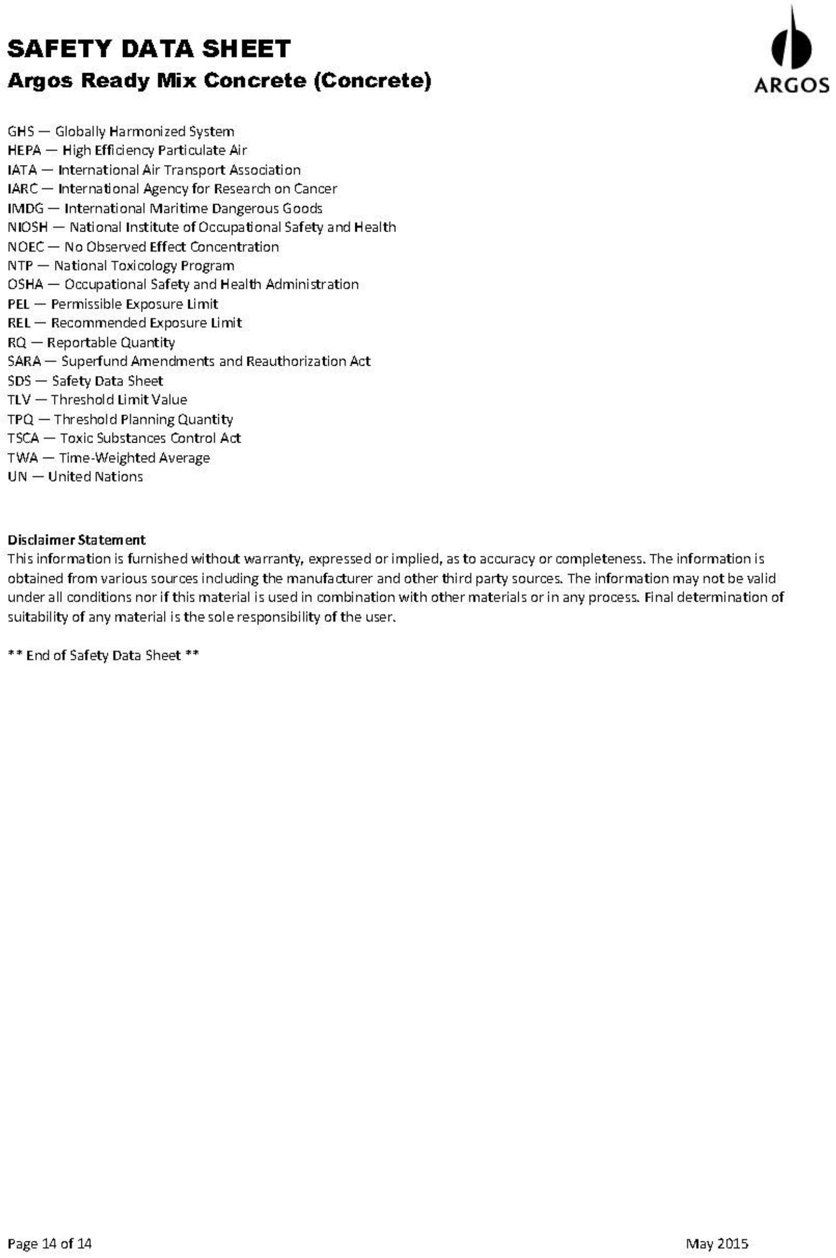
Figure A.48 Genshaft Honors College certification data submittal page 43.



GHS — Globally Harmonized System
HEPA — High Efficiency Particulate Air
IATA — International Air Transport Association
IARC — International Agency for Research on Cancer
IMDG — International Maritime Dangerous Goods
NIOSH — National Institute of Occupational Safety and Health
NOEC — No Observed Effect Concentration
NTP — National Toxicology Program
OSHA — Occupational Safety and Health Administration
PEL — Permissible Exposure Limit
REL — Recommended Exposure Limit
RQ — Reportable Quantity
SARA — Superfund Amendments and Reauthorization Act
SDS — Safety Data Sheet
TLV — Threshold Limit Value
TPQ — Threshold Planning Quantity
TSCA — Toxic Substances Control Act
TWA — Time-Weighted Average
UN — United Nations

Disclaimer Statement

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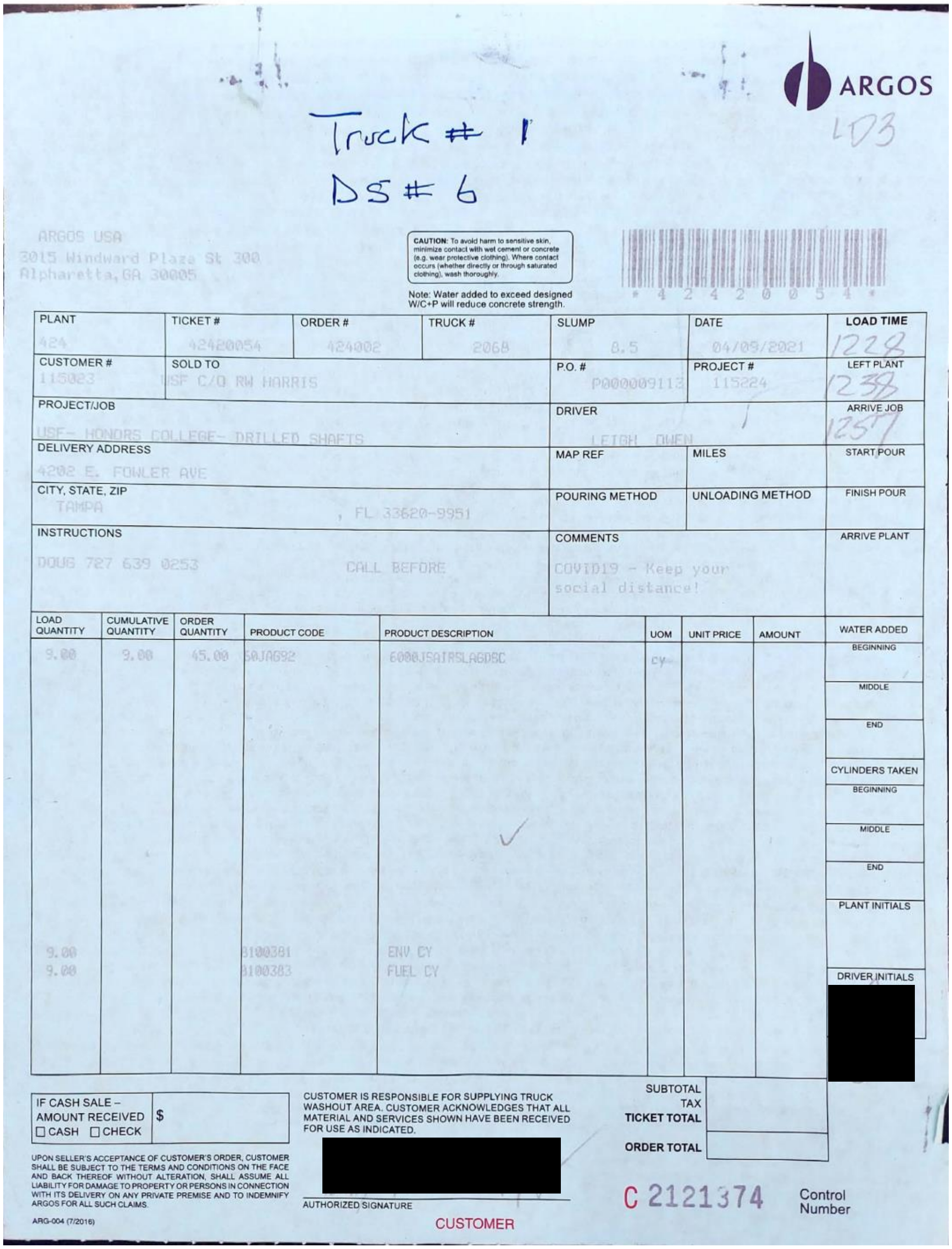
** End of Safety Data Sheet **

Figure A.49 Genshaft Honors College certification data submittal page 44.



ARGOS

LD3

Truck # 1

DS # 6

ARGOS USA
3015 Windward Plaza St 300
Alpharetta, GA 30005

CAUTION: To avoid harm to sensitive skin, minimize contact with wet cement or concrete (e.g. wear protective clothing). Where contact occurs (whether directly or through saturated clothing), wash thoroughly.

Note: Water added to exceed designed W/C+P will reduce concrete strength.

* 4 2 4 2 0 0 5 4 *

PLANT	TICKET #	ORDER #	TRUCK #	SLUMP	DATE	**LOAD TIME**
424	42420054	424002	2068	8.5	04/09/2021	1228

CUSTOMER # 115023

SOLD TO USF C/O RW HARRIS

P.O. # P000009113

PROJECT # 115224

LEFT PLANT 1238

PROJECT/JOB USF- HONORS COLLEGE- DRILLED SHAFTS

DRIVER LEIGH OWEN

ARRIVE JOB 1257

DELIVERY ADDRESS 4202 E. FOWLER AVE

MAP REF

MILES

START POUR

CITY, STATE, ZIP TAMPA , FL 33620-9951

POURING METHOD

UNLOADING METHOD

FINISH POUR

INSTRUCTIONS DOUG 727 639 0253 CALL BEFORE

COMMENTS COVID19 - Keep your social distance!

ARRIVE PLANT

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDER QUANTITY	PRODUCT CODE	PRODUCT DESCRIPTION	UOM	UNIT PRICE	AMOUNT
9.00	9.00	45.00	60JAG92	6000JSAIRSLAGDSC	cy		
9.00			3100381	ENV CY			
9.00			3100383	FUEL CY			

✓

WATER ADDED
BEGINNING
MIDDLE
END

CYLINDERS TAKEN
BEGINNING
MIDDLE
END

PLANT INITIALS

DRIVER INITIALS [redacted]

IF CASH SALE – AMOUNT RECEIVED $
☐ CASH ☐ CHECK

UPON SELLER'S ACCEPTANCE OF CUSTOMER'S ORDER, CUSTOMER SHALL BE SUBJECT TO THE TERMS AND CONDITIONS ON THE FACE AND BACK THEREOF WITHOUT ALTERATION, SHALL ASSUME ALL LIABILITY FOR DAMAGE TO PROPERTY OR PERSONS IN CONNECTION WITH ITS DELIVERY ON ANY PRIVATE PREMISE AND TO INDEMNIFY ARGOS FOR ALL SUCH CLAIMS.

ARG-004 (7/2016)

CUSTOMER IS RESPONSIBLE FOR SUPPLYING TRUCK WASHOUT AREA. CUSTOMER ACKNOWLEDGES THAT ALL MATERIAL AND SERVICES SHOWN HAVE BEEN RECEIVED FOR USE AS INDICATED.

[redacted]

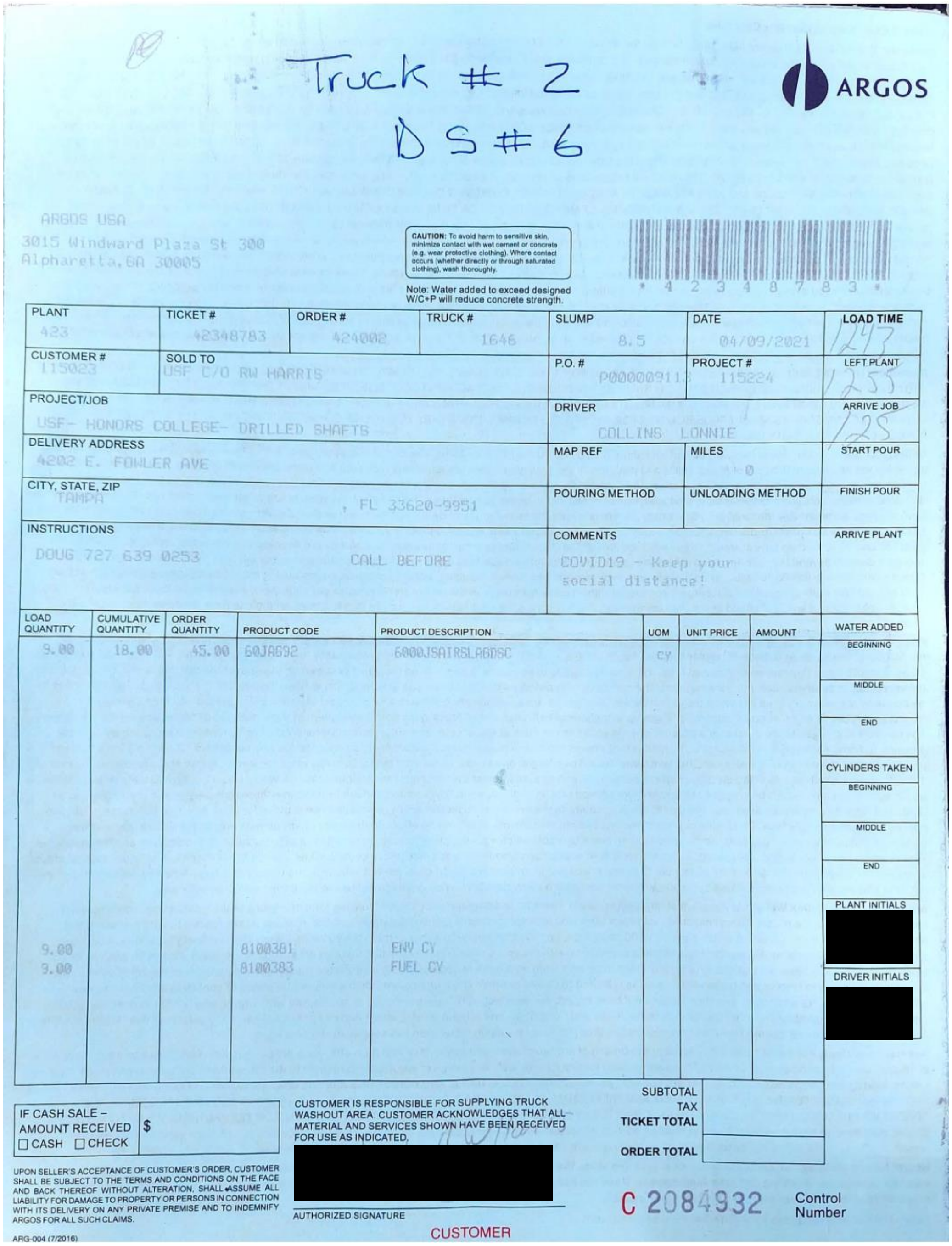
AUTHORIZED SIGNATURE

CUSTOMER

SUBTOTAL
TAX
TICKET TOTAL
ORDER TOTAL

C 2121374 Control Number

Figure A.50 Genshaft Honors College concrete delivery ticket 1.



Truck # 2

DS # 6

ARGOS

ARGOS USA
3015 Windward Plaza St 300
Alpharetta, GA 30005

CAUTION: To avoid harm to sensitive skin, minimize contact with wet cement or concrete (e.g. wear protective clothing). Where contact occurs (whether directly or through saturated clothing), wash thoroughly.

Note: Water added to exceed designed W/C+P will reduce concrete strength.

* 4 2 3 4 8 7 8 3 *

PLANT	TICKET #	ORDER #	TRUCK #	SLUMP	DATE	**LOAD TIME**
423	42348783	424002	1646	8.5	04/09/2021	1243

CUSTOMER # 115023

SOLD TO USF C/O RW HARRIS

P.O. # P000009113

PROJECT # 115224

LEFT PLANT 1255

PROJECT/JOB USF- HONORS COLLEGE- DRILLED SHAFTS

DRIVER COLLINS LONNIE

ARRIVE JOB 125

DELIVERY ADDRESS 4202 E. FOWLER AVE

MAP REF

MILES 0

START POUR

CITY, STATE, ZIP TAMPA , FL 33620-9951

POURING METHOD

UNLOADING METHOD

FINISH POUR

INSTRUCTIONS DOUG 727 639 0253 CALL BEFORE

COMMENTS COVID19 - Keep your social distance!

ARRIVE PLANT

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDER QUANTITY	PRODUCT CODE	PRODUCT DESCRIPTION	UOM	UNIT PRICE	AMOUNT
9.00	18.00	45.00	60JA692	6000JSAIRSLAGDSC	CY		
9.00			8100381	ENV CY			
9.00			8100383	FUEL CY			

WATER ADDED
BEGINNING
MIDDLE
END

CYLINDERS TAKEN
BEGINNING
MIDDLE
END

PLANT INITIALS [redacted]

DRIVER INITIALS [redacted]

IF CASH SALE – AMOUNT RECEIVED $
☐ CASH ☐ CHECK

CUSTOMER IS RESPONSIBLE FOR SUPPLYING TRUCK WASHOUT AREA. CUSTOMER ACKNOWLEDGES THAT ALL MATERIAL AND SERVICES SHOWN HAVE BEEN RECEIVED FOR USE AS INDICATED.

[redacted]

AUTHORIZED SIGNATURE

SUBTOTAL
TAX
TICKET TOTAL
ORDER TOTAL

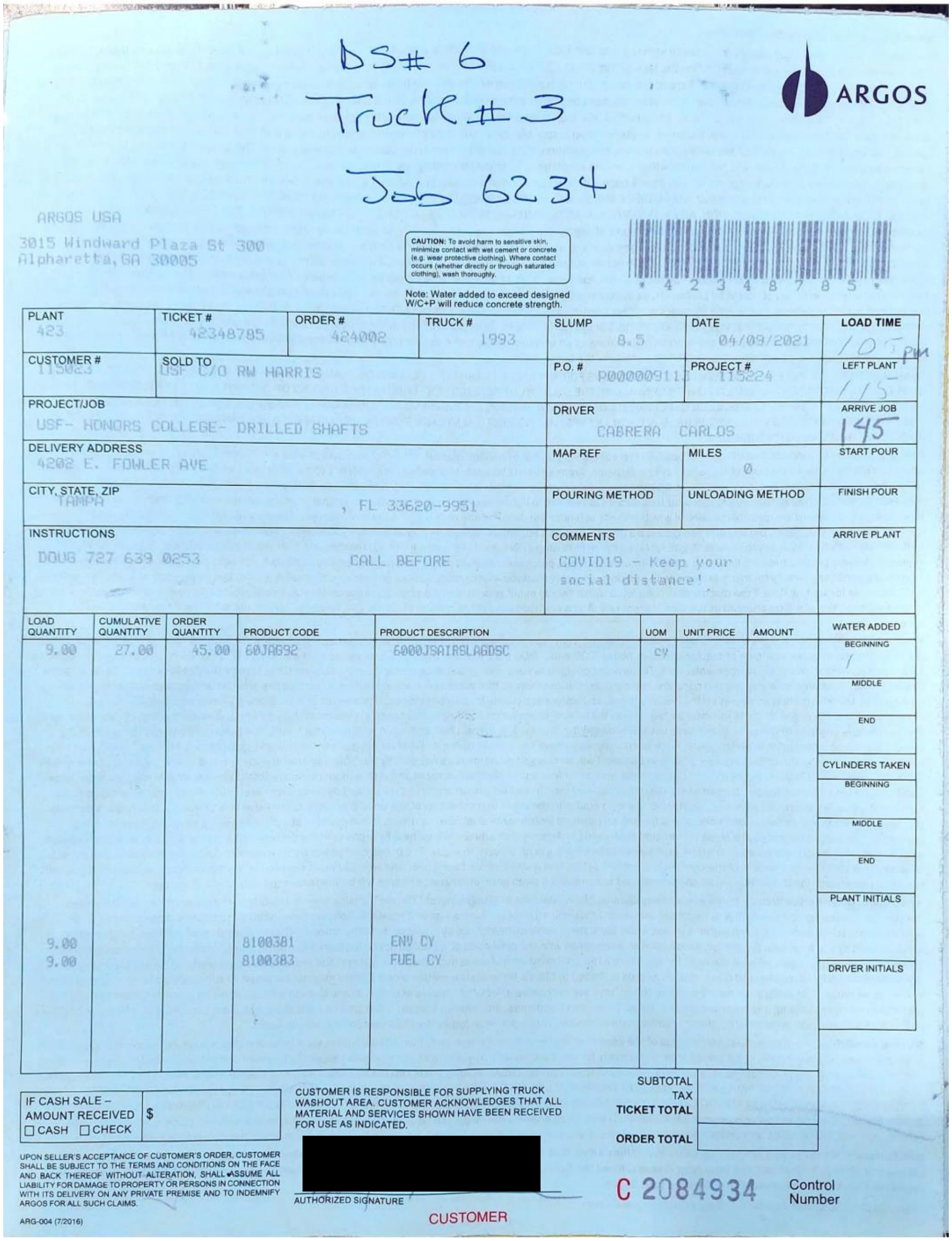
UPON SELLER'S ACCEPTANCE OF CUSTOMER'S ORDER, CUSTOMER SHALL BE SUBJECT TO THE TERMS AND CONDITIONS ON THE FACE AND BACK THEREOF WITHOUT ALTERATION, SHALL ASSUME ALL LIABILITY FOR DAMAGE TO PROPERTY OR PERSONS IN CONNECTION WITH ITS DELIVERY ON ANY PRIVATE PREMISE AND TO INDEMNIFY ARGOS FOR ALL SUCH CLAIMS.

C 2084932 Control Number

CUSTOMER

ARG-004 (7/2016)

Figure A.51 Genshaft Honors College concrete delivery ticket 2.



DS# 6
Truck # 3
Job 6234

ARGOS

ARGOS USA
3015 Windward Plaza St 300
Alpharetta, GA 30005

CAUTION: To avoid harm to sensitive skin, minimize contact with wet cement or concrete (e.g. wear protective clothing). Where contact occurs (whether directly or through saturated clothing), wash thoroughly.

Note: Water added to exceed designed W/C+P will reduce concrete strength.

* 4 2 3 4 8 7 8 5 *

PLANT: 423
TICKET #: 42348785
ORDER #: 424002
TRUCK #: 1993
SLUMP: 8.5
DATE: 04/09/2021
LOAD TIME: 1 05 PM
CUSTOMER #: 115023
SOLD TO: USF C/O RW HARRIS
P.O. #: P00000911
PROJECT #: 115224
LEFT PLANT: 1 15
PROJECT/JOB: USF- HONORS COLLEGE- DRILLED SHAFTS
DRIVER: CABRERA CARLOS
ARRIVE JOB: 145
DELIVERY ADDRESS: 4202 E. FOWLER AVE
MAP REF:
MILES: 0
START POUR:
CITY, STATE, ZIP: TAMPA , FL 33620-9951
POURING METHOD:
UNLOADING METHOD:
FINISH POUR:
INSTRUCTIONS: DOUG 727 639 0253 CALL BEFORE
COMMENTS: COVID19 - Keep your social distance!
ARRIVE PLANT:

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDER QUANTITY	PRODUCT CODE	PRODUCT DESCRIPTION	UOM	UNIT PRICE	AMOUNT
9.00	27.00	45.00	60JAG92	6000JSAIRSLAGDSC	CY		
9.00			8100381	ENV CY			
9.00			8100383	FUEL CY			

WATER ADDED
BEGINNING: /
MIDDLE:
END:

CYLINDERS TAKEN
BEGINNING:
MIDDLE:
END:

PLANT INITIALS:
DRIVER INITIALS:

IF CASH SALE – AMOUNT RECEIVED $
☐ CASH ☐ CHECK

CUSTOMER IS RESPONSIBLE FOR SUPPLYING TRUCK WASHOUT AREA. CUSTOMER ACKNOWLEDGES THAT ALL MATERIAL AND SERVICES SHOWN HAVE BEEN RECEIVED FOR USE AS INDICATED.

SUBTOTAL
TAX
TICKET TOTAL
ORDER TOTAL

UPON SELLER'S ACCEPTANCE OF CUSTOMER'S ORDER, CUSTOMER SHALL BE SUBJECT TO THE TERMS AND CONDITIONS ON THE FACE AND BACK THEREOF WITHOUT ALTERATION, SHALL ASSUME ALL LIABILITY FOR DAMAGE TO PROPERTY OR PERSONS IN CONNECTION WITH ITS DELIVERY ON ANY PRIVATE PREMISE AND TO INDEMNIFY ARGOS FOR ALL SUCH CLAIMS.

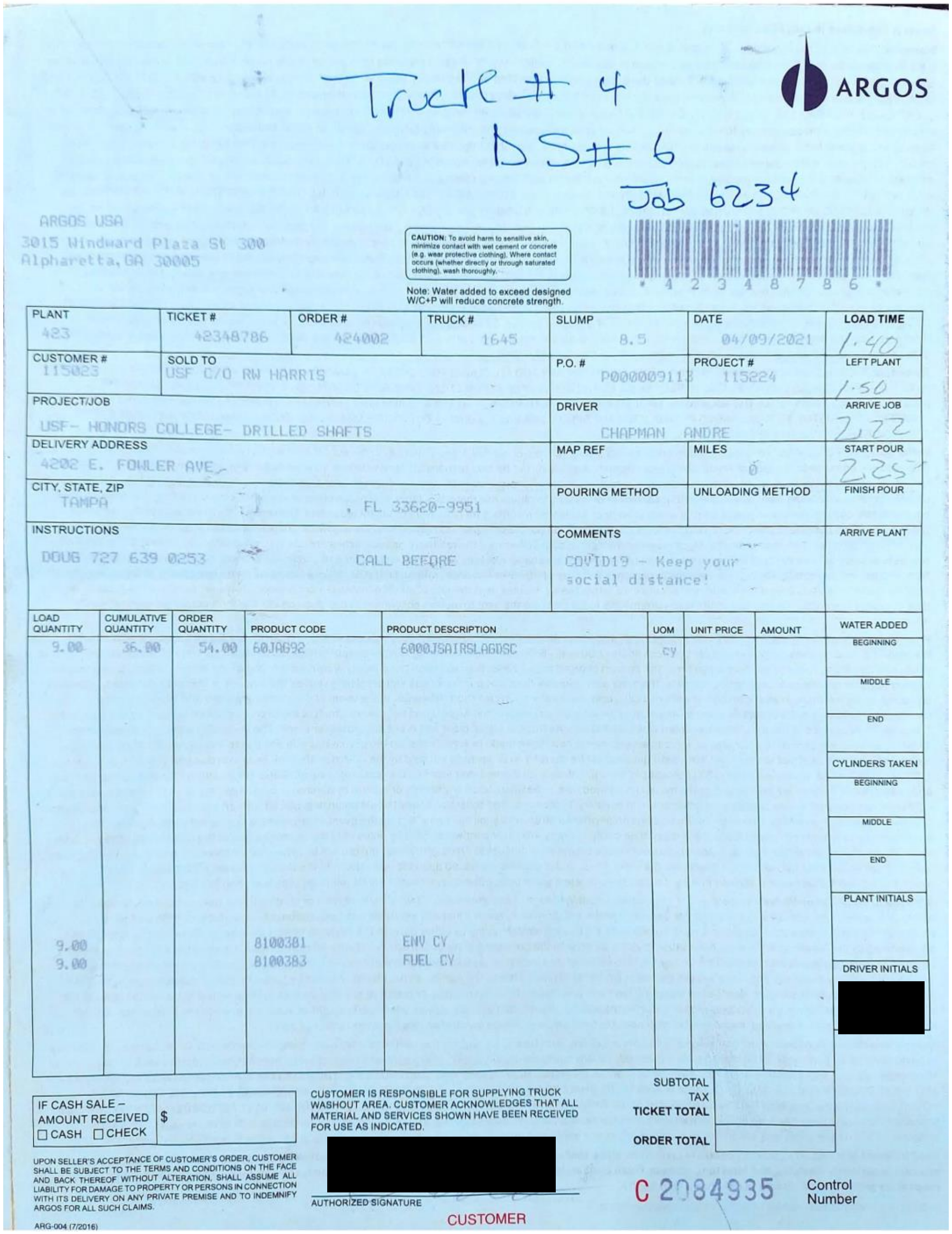
[redacted]
AUTHORIZED SIGNATURE

C 2084934 Control Number

ARG-004 (7/2016)

CUSTOMER

Figure A.52 Genshaft Honors College concrete delivery ticket 3.



Truck # 4

DS # 6

Job 6234

ARGOS

ARGOS USA
3015 Windward Plaza St 300
Alpharetta, GA 30005

CAUTION: To avoid harm to sensitive skin, minimize contact with wet cement or concrete (e.g. wear protective clothing). Where contact occurs (whether directly or through saturated clothing), wash thoroughly.

Note: Water added to exceed designed W/C+P will reduce concrete strength.

42348786

PLANT: 423
TICKET #: 42348786
ORDER #: 424002
TRUCK #: 1645
SLUMP: 8.5
DATE: 04/09/2021
LOAD TIME: 1.40
CUSTOMER #: 115023
SOLD TO: USF C/O RW HARRIS
P.O. #: P000009113
PROJECT #: 115224
LEFT PLANT: 1.50
PROJECT/JOB: USF- HONORS COLLEGE- DRILLED SHAFTS
DRIVER: CHAPMAN ANDRE
ARRIVE JOB: 2.22
DELIVERY ADDRESS: 4202 E. FOWLER AVE
MAP REF:
MILES: 0
START POUR: 2.25
CITY, STATE, ZIP: TAMPA , FL 33620-9951
POURING METHOD:
UNLOADING METHOD:
FINISH POUR:
INSTRUCTIONS: DOUG 727 639 0253 CALL BEFORE
COMMENTS: COVID19 - Keep your social distance!
ARRIVE PLANT:

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDER QUANTITY	PRODUCT CODE	PRODUCT DESCRIPTION	UOM	UNIT PRICE	AMOUNT
9.00	36.00	54.00	60JA692	6000JSAIRSLAGDSC	cy		
9.00			8100381	ENV CY			
9.00			8100383	FUEL CY			

WATER ADDED
BEGINNING
MIDDLE
END

CYLINDERS TAKEN
BEGINNING
MIDDLE
END

PLANT INITIALS

DRIVER INITIALS
[redacted]

IF CASH SALE – AMOUNT RECEIVED $
☐ CASH ☐ CHECK

CUSTOMER IS RESPONSIBLE FOR SUPPLYING TRUCK WASHOUT AREA. CUSTOMER ACKNOWLEDGES THAT ALL MATERIAL AND SERVICES SHOWN HAVE BEEN RECEIVED FOR USE AS INDICATED.

SUBTOTAL
TAX
TICKET TOTAL
ORDER TOTAL

UPON SELLER'S ACCEPTANCE OF CUSTOMER'S ORDER, CUSTOMER SHALL BE SUBJECT TO THE TERMS AND CONDITIONS ON THE FACE AND BACK THEREOF WITHOUT ALTERATION, SHALL ASSUME ALL LIABILITY FOR DAMAGE TO PROPERTY OR PERSONS IN CONNECTION WITH ITS DELIVERY ON ANY PRIVATE PREMISE AND TO INDEMNIFY ARGOS FOR ALL SUCH CLAIMS.

[redacted]

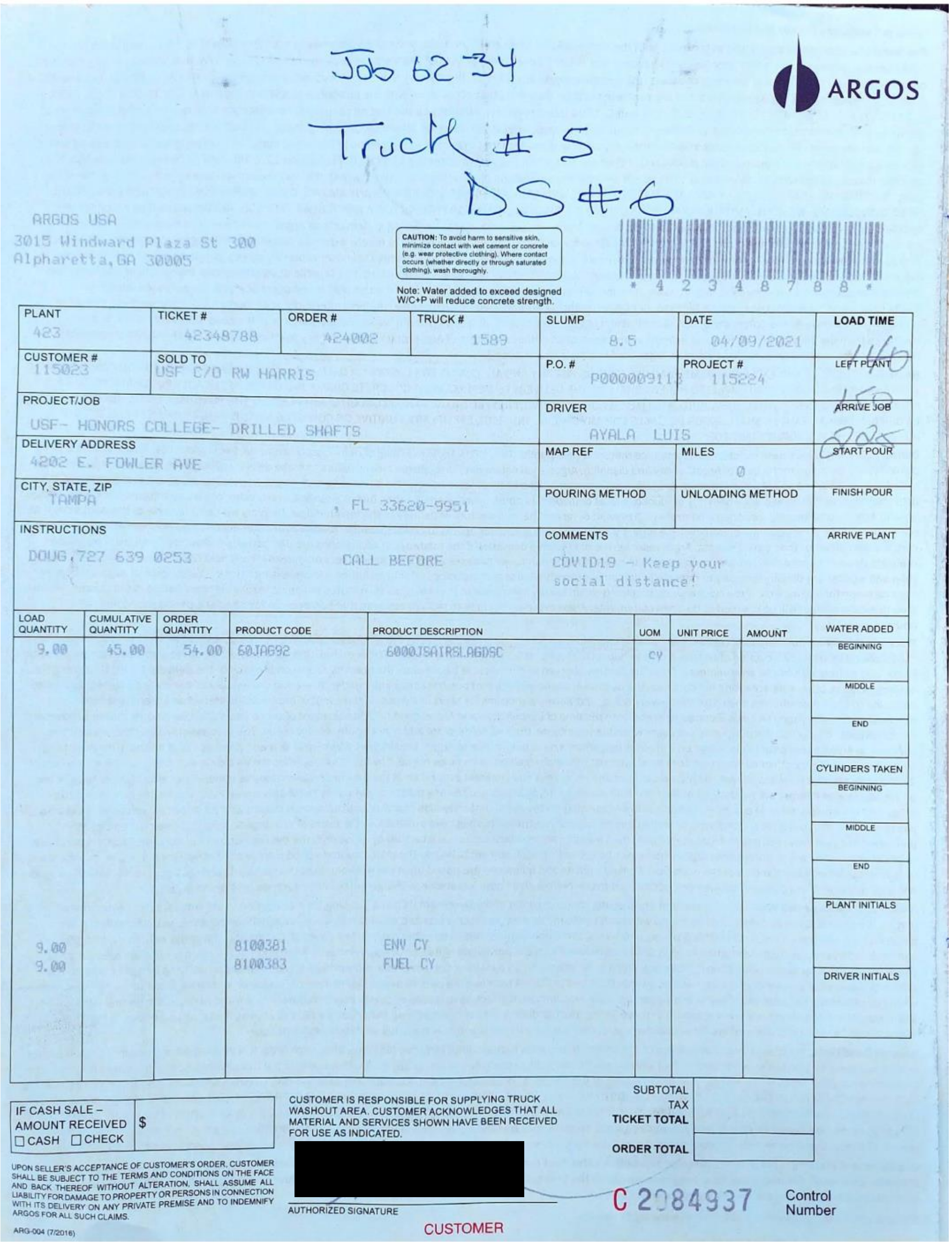
AUTHORIZED SIGNATURE

C 2084935 Control Number

CUSTOMER

ARG-004 (7/2016)

Figure A.53 Genshaft Honors College concrete delivery ticket 4.



Job 62-34

Truck # 5

DS #6

ARGOS

ARGOS USA
3015 Windward Plaza St 300
Alpharetta, GA 30005

CAUTION: To avoid harm to sensitive skin, minimize contact with wet cement or concrete (e.g. wear protective clothing). Where contact occurs (whether directly or through saturated clothing), wash thoroughly.

Note: Water added to exceed designed W/C+P will reduce concrete strength.

* 4 2 3 4 8 7 8 8 *

PLANT: 423
TICKET #: 42348788
ORDER #: 424002
TRUCK #: 1589
SLUMP: 8.5
DATE: 04/09/2021
LOAD TIME
CUSTOMER #: 115023
SOLD TO: USF C/O RW HARRIS
P.O. #: P000009113
PROJECT #: 115224
LEFT PLANT: 140
PROJECT/JOB: USF- HONORS COLLEGE- DRILLED SHAFTS
DRIVER: AYALA LUIS
ARRIVE JOB: 150
DELIVERY ADDRESS: 4202 E. FOWLER AVE
MAP REF:
MILES: 0
START POUR: 225
CITY, STATE, ZIP: TAMPA , FL 33620-9951
POURING METHOD:
UNLOADING METHOD:
FINISH POUR:
INSTRUCTIONS: DOUG,727 639 0253 CALL BEFORE
COMMENTS: COVID19 - Keep your social distance!
ARRIVE PLANT:

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDER QUANTITY	PRODUCT CODE	PRODUCT DESCRIPTION	UOM	UNIT PRICE	AMOUNT
9.00	45.00	54.00	60JA692	6000JSAIRSLAGDSC	cy		
9.00			8100381	ENV CY			
9.00			8100383	FUEL CY			

WATER ADDED
BEGINNING
MIDDLE
END

CYLINDERS TAKEN
BEGINNING
MIDDLE
END

PLANT INITIALS

DRIVER INITIALS

IF CASH SALE – AMOUNT RECEIVED $
☐ CASH ☐ CHECK

CUSTOMER IS RESPONSIBLE FOR SUPPLYING TRUCK WASHOUT AREA. CUSTOMER ACKNOWLEDGES THAT ALL MATERIAL AND SERVICES SHOWN HAVE BEEN RECEIVED FOR USE AS INDICATED.

SUBTOTAL
TAX
TICKET TOTAL
ORDER TOTAL

UPON SELLER'S ACCEPTANCE OF CUSTOMER'S ORDER, CUSTOMER SHALL BE SUBJECT TO THE TERMS AND CONDITIONS ON THE FACE AND BACK THEREOF WITHOUT ALTERATION, SHALL ASSUME ALL LIABILITY FOR DAMAGE TO PROPERTY OR PERSONS IN CONNECTION WITH ITS DELIVERY ON ANY PRIVATE PREMISE AND TO INDEMNIFY ARGOS FOR ALL SUCH CLAIMS.

[redacted]

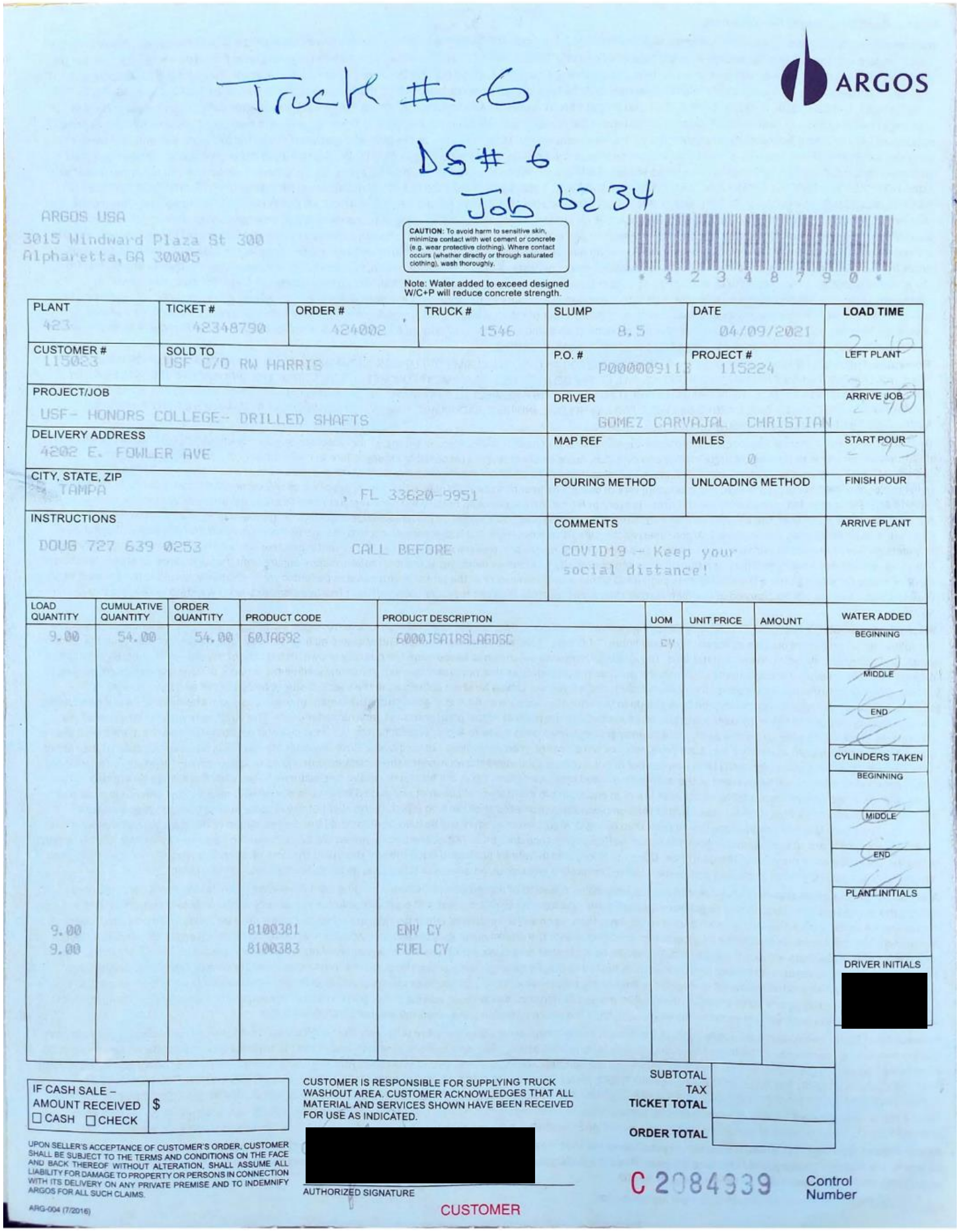
AUTHORIZED SIGNATURE

C 2084937 Control Number

CUSTOMER

ARG-004 (7/2016)

Figure A.54 Genshaft Honors College concrete delivery ticket 5.



Truck # 6

ARGOS

DS # 6
Job 6234

ARGOS USA
3015 Windward Plaza St 300
Alpharetta, GA 30005

CAUTION: To avoid harm to sensitive skin, minimize contact with wet cement or concrete (e.g. wear protective clothing). Where contact occurs (whether directly or through saturated clothing), wash thoroughly.

Note: Water added to exceed designed W/C+P will reduce concrete strength.

* 4 2 3 4 8 7 9 0 *

PLANT: 423
TICKET #: 42348790
ORDER #: 424002
TRUCK #: 1546
SLUMP: 8.5
DATE: 04/09/2021
LOAD TIME: 2:10
CUSTOMER #: 115023
SOLD TO: USF C/O RW HARRIS
P.O. #: P00000911
PROJECT #: 115224
LEFT PLANT: 2:30
PROJECT/JOB: USF- HONORS COLLEGE- DRILLED SHAFTS
DRIVER: GOMEZ CARVAJAL CHRISTIAN
ARRIVE JOB: 2:40
DELIVERY ADDRESS: 4202 E. FOWLER AVE
MAP REF:
MILES: 0
START POUR: 2:45
CITY, STATE, ZIP: TAMPA , FL 33620-9951
POURING METHOD:
UNLOADING METHOD:
FINISH POUR:
INSTRUCTIONS: DOUG 727 639 0253 CALL BEFORE
COMMENTS: COVID19 - Keep your social distance!
ARRIVE PLANT:

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDER QUANTITY	PRODUCT CODE	PRODUCT DESCRIPTION	UOM	UNIT PRICE	AMOUNT
9.00	54.00	54.00	60JAG92	6000JSAIRSLAGDSC	cy		
9.00			8100381	ENV CY			
9.00			8100383	FUEL CY			

WATER ADDED
BEGINNING
MIDDLE
END

CYLINDERS TAKEN
BEGINNING
MIDDLE
END

PLANT INITIALS

DRIVER INITIALS [redacted]

IF CASH SALE – AMOUNT RECEIVED $
☐ CASH ☐ CHECK

CUSTOMER IS RESPONSIBLE FOR SUPPLYING TRUCK WASHOUT AREA. CUSTOMER ACKNOWLEDGES THAT ALL MATERIAL AND SERVICES SHOWN HAVE BEEN RECEIVED FOR USE AS INDICATED.

SUBTOTAL
TAX
TICKET TOTAL
ORDER TOTAL

UPON SELLER'S ACCEPTANCE OF CUSTOMER'S ORDER, CUSTOMER SHALL BE SUBJECT TO THE TERMS AND CONDITIONS ON THE FACE AND BACK THEREOF WITHOUT ALTERATION, SHALL ASSUME ALL LIABILITY FOR DAMAGE TO PROPERTY OR PERSONS IN CONNECTION WITH ITS DELIVERY ON ANY PRIVATE PREMISE AND TO INDEMNIFY ARGOS FOR ALL SUCH CLAIMS.

[redacted]
AUTHORIZED SIGNATURE

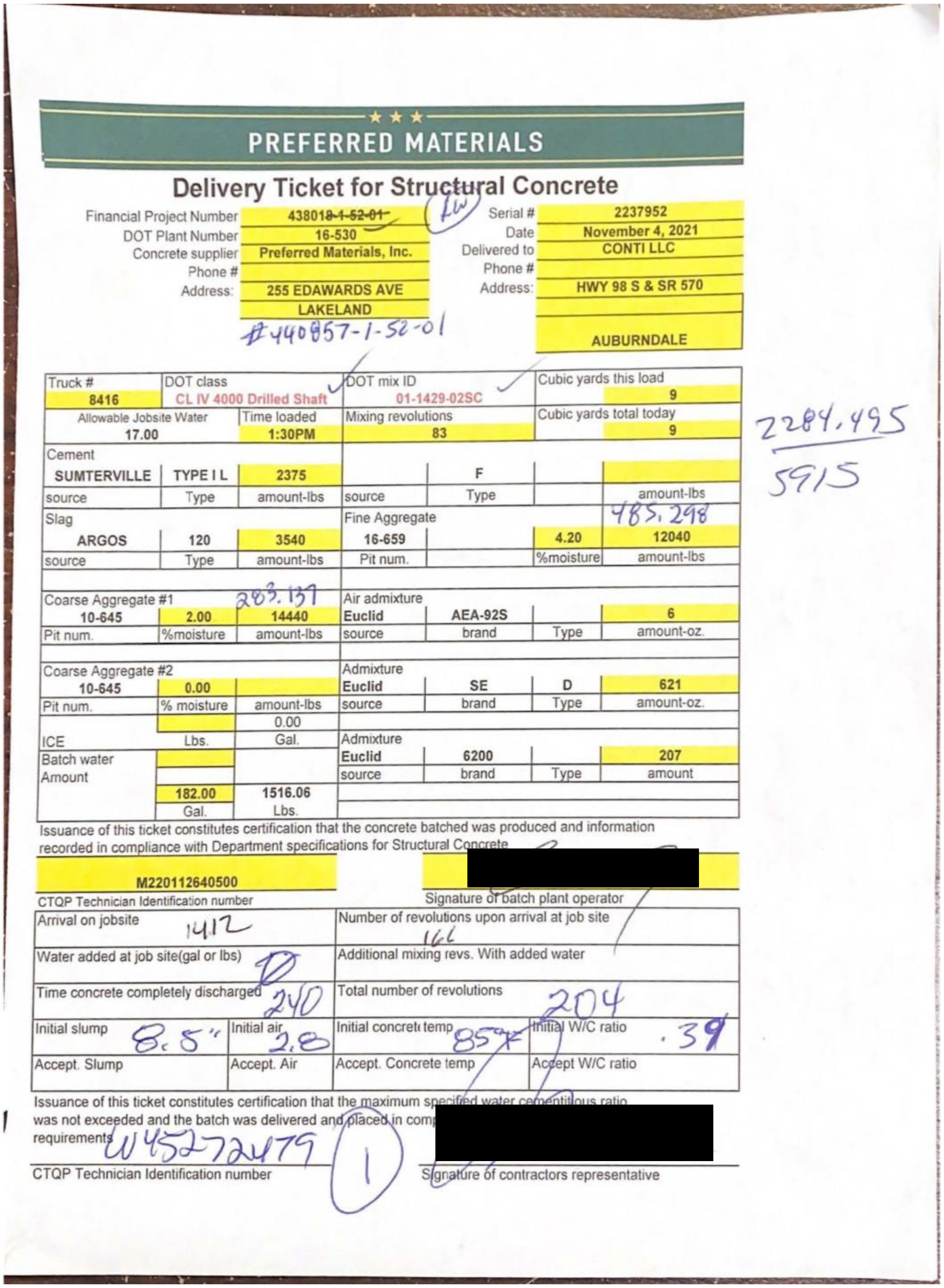
C 2084339 Control Number

ARG-004 (7/2016)

CUSTOMER

Figure A.55 Genshaft Honors College concrete delivery ticket 6.

Appendix B: Polk Parkway Drilled Shaft OC-13 Construction Documents



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

LW

Financial Project Number 43801~~8-1-52-01~~
DOT Plant Number 16-530
Concrete supplier Preferred Materials, Inc.
Phone #
Address: 255 EDAWARDS AVE
LAKELAND

#440857-1-52-01

Serial # 2237952
Date November 4, 2021
Delivered to CONTI LLC
Phone #
Address: HWY 98 S & SR 570
AUBURNDALE

Truck # 8416	DOT class CL IV 4000 Drilled Shaft	DOT mix ID 01-1429-02SC	Cubic yards this load 9
Allowable Jobsite Water 17.00	Time loaded 1:30PM	Mixing revolutions 83	Cubic yards total today 9

2284.495
5915

Cement						
SUMTERVILLE	TYPE I L	2375		F		
source	Type	amount-lbs	source	Type		amount-lbs
Slag			Fine Aggregate			485.298
ARGOS	120	3540	16-659		4.20	12040
source	Type	amount-lbs	Pit num.		%moisture	amount-lbs
Coarse Aggregate #1		283.137	Air admixture			
10-645	2.00	14440	Euclid	AEA-92S		6
Pit num.	%moisture	amount-lbs	source	brand	Type	amount-oz.
Coarse Aggregate #2			Admixture			
10-645	0.00		Euclid	SE	D	621
Pit num.	% moisture	amount-lbs	source	brand	Type	amount-oz.
		0.00				
ICE	Lbs.	Gal.	Admixture			
Batch water Amount			Euclid	6200		207
			source	brand	Type	amount
	182.00	1516.06				
	Gal.	Lbs.				

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural Concrete

M220112640500
CTQP Technician Identification number

[redacted]
Signature of batch plant operator

Arrival on jobsite 1412	Number of revolutions upon arrival at job site 166
Water added at job site(gal or lbs) 0	Additional mixing revs. With added water
Time concrete completely discharged 240	Total number of revolutions 204

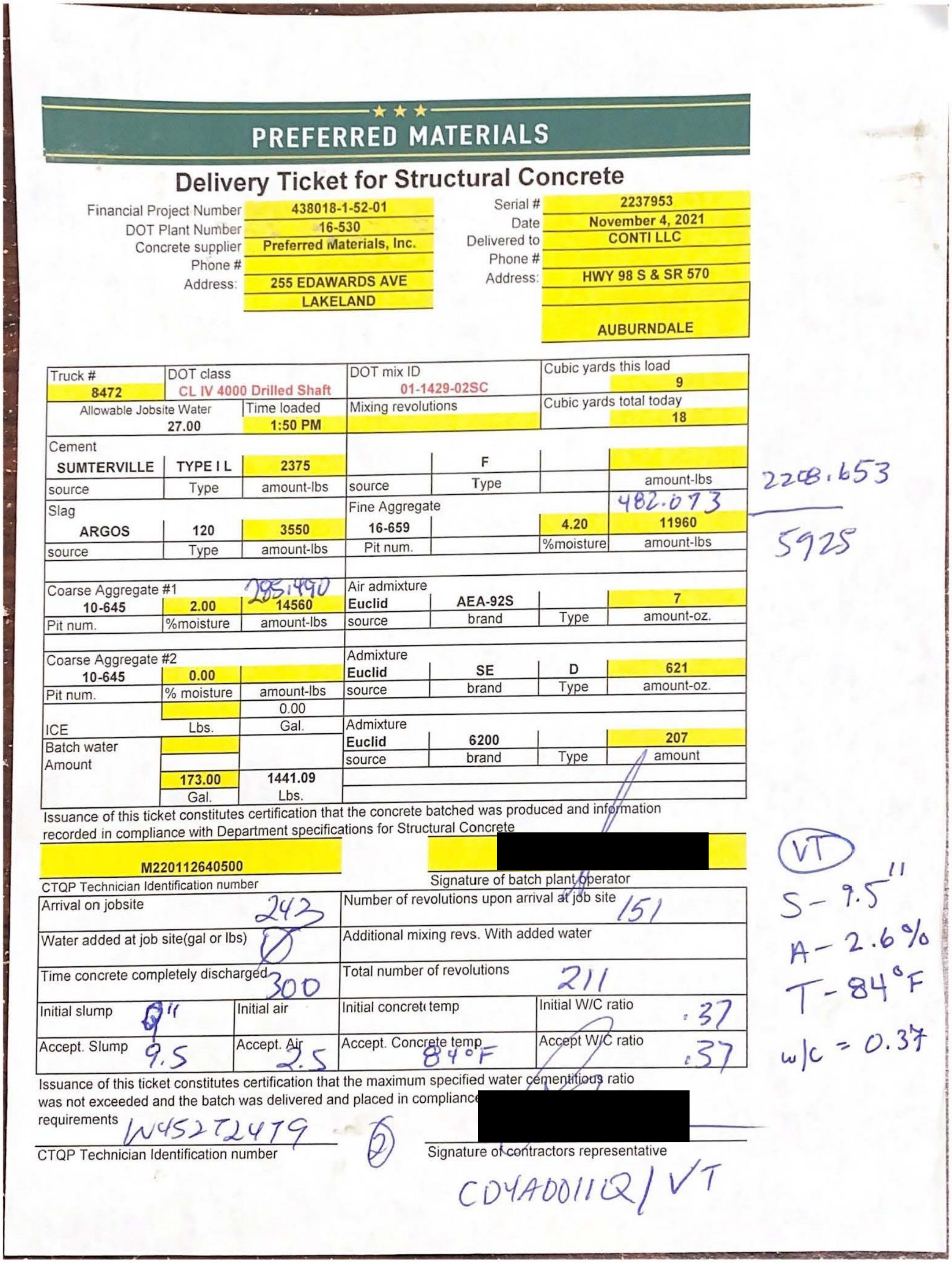
Initial slump 8.5"	Initial air 2.8	Initial concrete temp 85°F	Initial W/C ratio .39
Accept. Slump	Accept. Air	Accept. Concrete temp	Accept W/C ratio

Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in comp [redacted] requirements

W452724179 ①
CTQP Technician Identification number

Signature of contractors representative

Figure B.1 OC-13 concrete delivery ticket 1.



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number 438018-1-52-01
DOT Plant Number 16-530
Concrete supplier Preferred Materials, Inc.
Phone #
Address: 255 EDAWARDS AVE
LAKELAND

Serial # 2237953
Date November 4, 2021
Delivered to CONTI LLC
Phone #
Address: HWY 98 S & SR 570
AUBURNDALE

Truck # 8472	DOT class CL IV 4000 Drilled Shaft	DOT mix ID 01-1429-02SC	Cubic yards this load 9
Allowable Jobsite Water 27.00	Time loaded 1:50 PM	Mixing revolutions	Cubic yards total today 18

Cement		
SUMTERVILLE	TYPE I L	2375
source	Type	amount-lbs
Slag		
ARGOS	120	3550
source	Type	amount-lbs
Coarse Aggregate #1		285.490
10-645	2.00	14560
Pit num.	%moisture	amount-lbs
Coarse Aggregate #2		
10-645	0.00	
Pit num.	% moisture	amount-lbs
		0.00
ICE	Lbs.	Gal.
Batch water Amount		
	173.00	1441.09
	Gal.	Lbs.

	F		
source	Type		amount-lbs
Fine Aggregate			482.073
16-659		4.20	11960
Pit num.		%moisture	amount-lbs
Air admixture			
Euclid	AEA-92S		7
source	brand	Type	amount-oz.
Admixture			
Euclid	SE	D	621
source	brand	Type	amount-oz.
Admixture			
Euclid	6200		207
source	brand	Type	amount

2208.653

5925

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural Concrete

M220112640500
CTQP Technician Identification number

[redacted]
Signature of batch plant operator

Arrival on jobsite 243		Number of revolutions upon arrival at job site 151	
Water added at job site(gal or lbs) 0		Additional mixing revs. With added water	
Time concrete completely discharged 300		Total number of revolutions 211	
Initial slump 9"	Initial air	Initial concrete temp	Initial W/C ratio .37
Accept. Slump 9.5	Accept. Air 2.5	Accept. Concrete temp 84°F	Accept W/C ratio .37

VT
S - 9.5"
A - 2.6%
T - 84°F
w/c = 0.37

Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in compliance [redacted] requirements

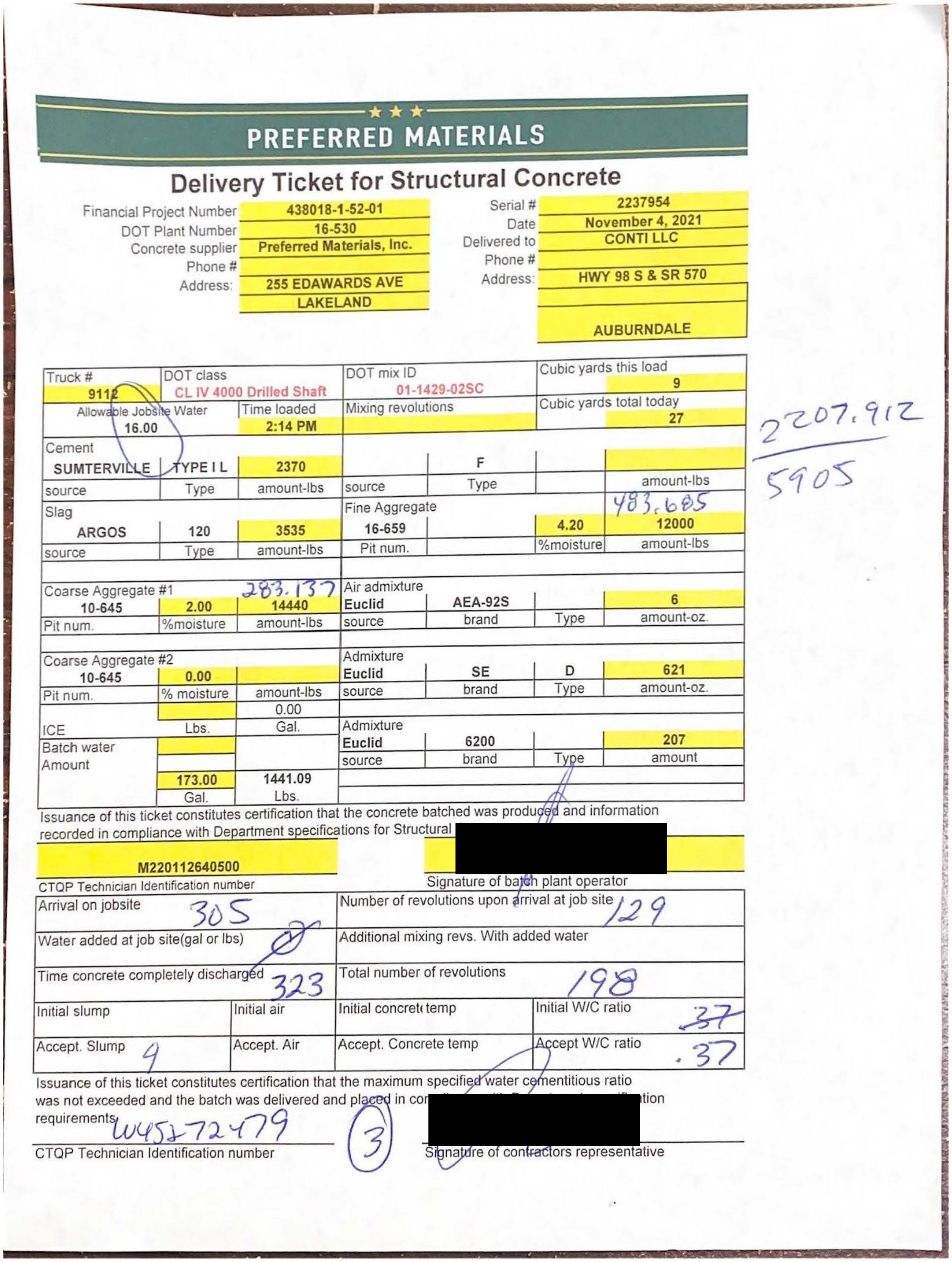
W452T2479
CTQP Technician Identification number

2

Signature of contractors representative

CD4A0011Q / VT

Figure B.2 OC-13 concrete delivery ticket 2.



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number: 438018-1-52-01
DOT Plant Number: 16-530
Concrete supplier: Preferred Materials, Inc.
Phone #:
Address: 255 EDAWARDS AVE
LAKELAND

Serial #: 2237954
Date: November 4, 2021
Delivered to: CONTI LLC
Phone #:
Address: HWY 98 S & SR 570
AUBURNDALE

Truck # 9112	DOT class CL IV 4000 Drilled Shaft	DOT mix ID 01-1429-02SC	Cubic yards this load 9
Allowable Jobsite Water 16.00	Time loaded 2:14 PM	Mixing revolutions	Cubic yards total today 27

2207.912
5905

Cement						
SUMTERVILLE	TYPE I L	2370		F		
source	Type	amount-lbs	source	Type		amount-lbs
Slag			Fine Aggregate			483.685
ARGOS	120	3535	16-659		4.20	12000
source	Type	amount-lbs	Pit num.		%moisture	amount-lbs
Coarse Aggregate #1		283.137	Air admixture			
10-645	2.00	14440	Euclid	AEA-92S		6
Pit num.	%moisture	amount-lbs	source	brand	Type	amount-oz.
Coarse Aggregate #2			Admixture			
10-645	0.00		Euclid	SE	D	621
Pit num.	% moisture	amount-lbs	source	brand	Type	amount-oz.
		0.00				
ICE	Lbs.	Gal.	Admixture			
Batch water Amount			Euclid	6200		207
			source	brand	Type	amount
	173.00	1441.09				
	Gal.	Lbs.				

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural [redacted]

M220112640500
CTQP Technician Identification number

Signature of batch plant operator

Arrival on jobsite 305		Number of revolutions upon arrival at job site 129	
Water added at job site(gal or lbs) 0		Additional mixing revs. With added water	
Time concrete completely discharged 323		Total number of revolutions 198	
Initial slump	Initial air	Initial concrete temp	Initial W/C ratio ~~.37~~
Accept. Slump 9	Accept. Air	Accept. Concrete temp	Accept W/C ratio .37

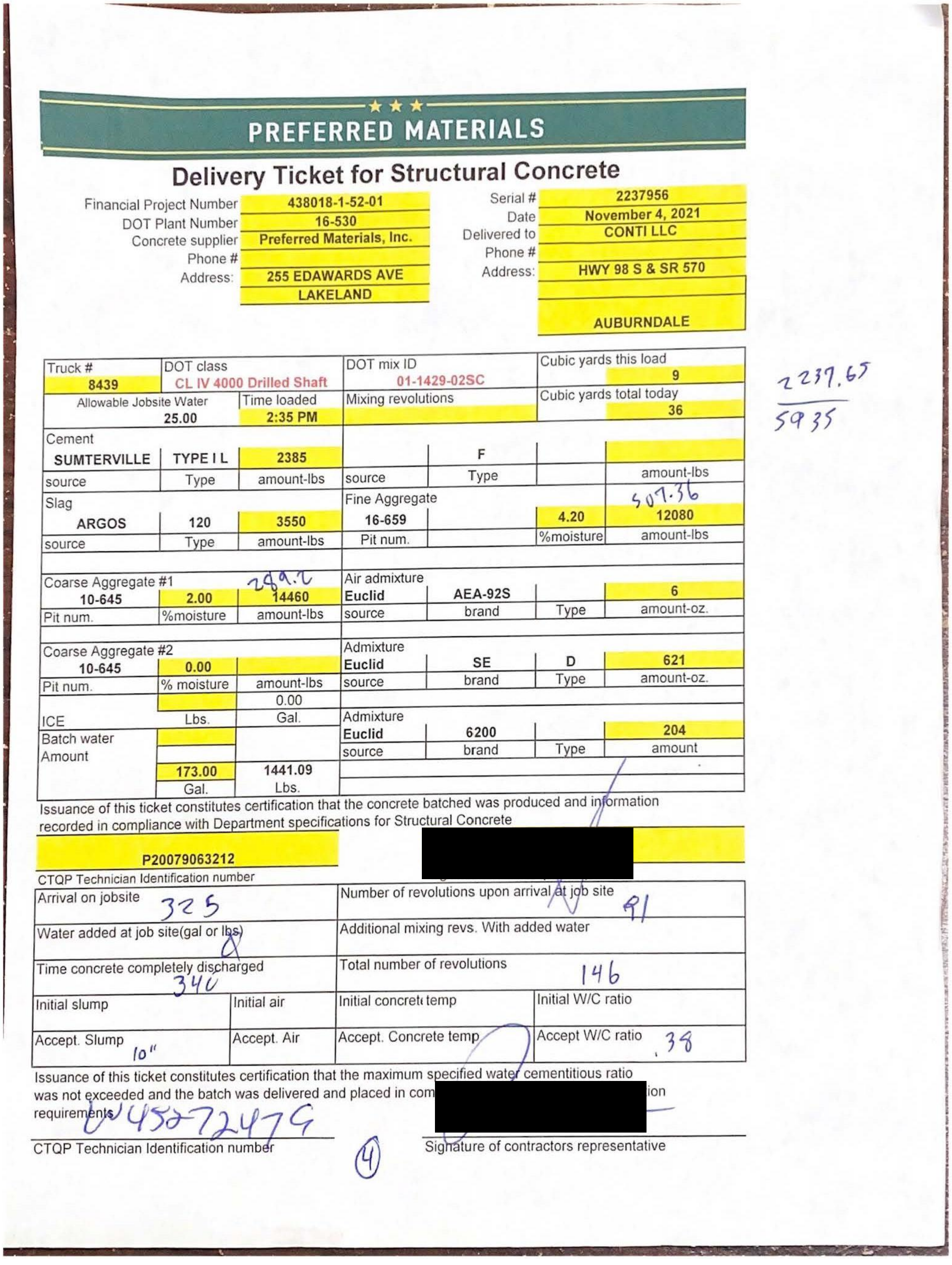
Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in cor [redacted] tion requirements

W4517 2479
CTQP Technician Identification number

③

Signature of contractors representative

Figure B.3 OC-13 concrete delivery ticket 3.



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number 438018-1-52-01
DOT Plant Number 16-530
Concrete supplier Preferred Materials, Inc.
Phone #
Address: 255 EDAWARDS AVE
LAKELAND

Serial # 2237956
Date November 4, 2021
Delivered to CONTI LLC
Phone #
Address: HWY 98 S & SR 570
AUBURNDALE

Truck # 8439	DOT class CL IV 4000 Drilled Shaft	DOT mix ID 01-1429-02SC	Cubic yards this load 9
Allowable Jobsite Water 25.00	Time loaded 2:35 PM	Mixing revolutions	Cubic yards total today 36

2237.65
5935

Cement						
SUMTERVILLE	TYPE I L	2385		F		
source	Type	amount-lbs	source	Type		amount-lbs
Slag			Fine Aggregate			507.36
ARGOS	120	3550	16-659		4.20	12080
source	Type	amount-lbs	Pit num.		%moisture	amount-lbs
Coarse Aggregate #1		289.2	Air admixture			
10-645	2.00	14460	Euclid	AEA-92S		6
Pit num.	%moisture	amount-lbs	source	brand	Type	amount-oz.
Coarse Aggregate #2			Admixture			
10-645	0.00		Euclid	SE	D	621
Pit num.	% moisture	amount-lbs	source	brand	Type	amount-oz.
		0.00				
ICE	Lbs.	Gal.	Admixture			
Batch water Amount			Euclid	6200		204
			source	brand	Type	amount
	173.00	1441.09				
	Gal.	Lbs.				

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural Concrete

P20079063212 [redacted]
CTQP Technician Identification number

Arrival on jobsite 325		Number of revolutions upon arrival at job site 91	
Water added at job site(gal or lbs) 0		Additional mixing revs. With added water	
Time concrete completely discharged 340		Total number of revolutions 146	
Initial slump	Initial air	Initial concrete temp	Initial W/C ratio
Accept. Slump 10"	Accept. Air	Accept. Concrete temp	Accept W/C ratio .38

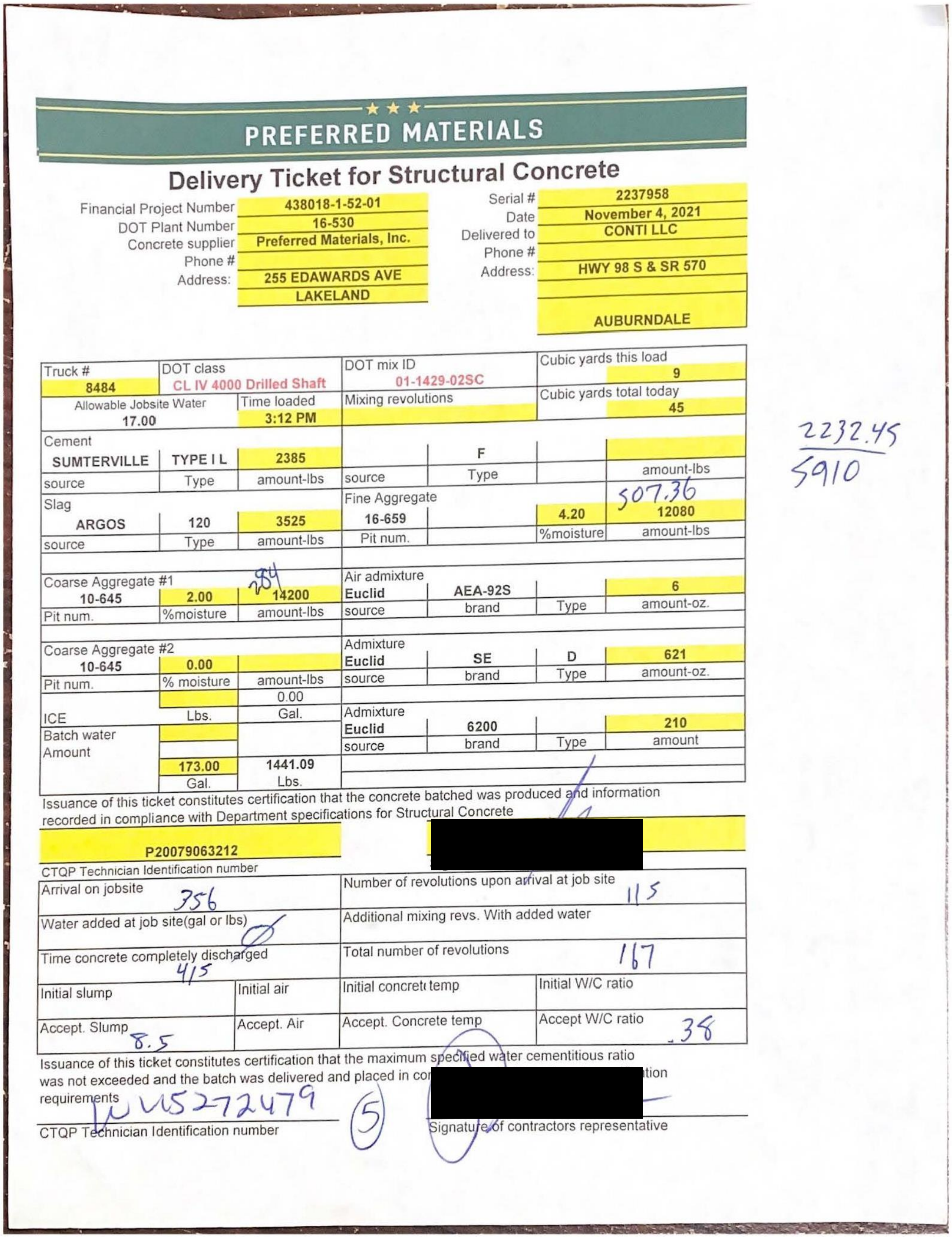
Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in com[redacted]ion requirements

W45272479
CTQP Technician Identification number

④

Signature of contractors representative

Figure B.4 OC-13 concrete delivery ticket 4.



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number	438018-1-52-01	Serial #	2237958
DOT Plant Number	16-530	Date	November 4, 2021
Concrete supplier	Preferred Materials, Inc.	Delivered to	CONTI LLC
Phone #		Phone #	
Address:	255 EDAWARDS AVE LAKELAND	Address:	HWY 98 S & SR 570 AUBURNDALE

Truck # 8484	DOT class CL IV 4000 Drilled Shaft			DOT mix ID 01-1429-02SC		Cubic yards this load 9	
Allowable Jobsite Water 17.00		Time loaded 3:12 PM		Mixing revolutions		Cubic yards total today 45	
Cement							
SUMTERVILLE	TYPE I L	2385			F		
source	Type	amount-lbs		source	Type		amount-lbs
Slag				Fine Aggregate			507.36
ARGOS	120	3525		16-659		4.20	12080
source	Type	amount-lbs		Pit num.		%moisture	amount-lbs
Coarse Aggregate #1		284		Air admixture			
10-645	2.00	14200		Euclid	AEA-92S		6
Pit num.	%moisture	amount-lbs		source	brand	Type	amount-oz.
Coarse Aggregate #2				Admixture			
10-645	0.00			Euclid	SE	D	621
Pit num.	% moisture	amount-lbs		source	brand	Type	amount-oz.
		0.00					
ICE	Lbs.	Gal.		Admixture			
Batch water Amount				Euclid	6200		210
				source	brand	Type	amount
	173.00	1441.09					
	Gal.	Lbs.					

2232.45
5910

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural Concrete

P20079063212

CTQP Technician Identification number

[redacted]

Arrival on jobsite 356		Number of revolutions upon arrival at job site 115	
Water added at job site(gal or lbs) 0		Additional mixing revs. With added water	
Time concrete completely discharged 415		Total number of revolutions 167	
Initial slump	Initial air	Initial concrete temp	Initial W/C ratio
Accept. Slump 8.5	Accept. Air	Accept. Concrete temp	Accept W/C ratio .38

Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in co [redacted] tion requirements

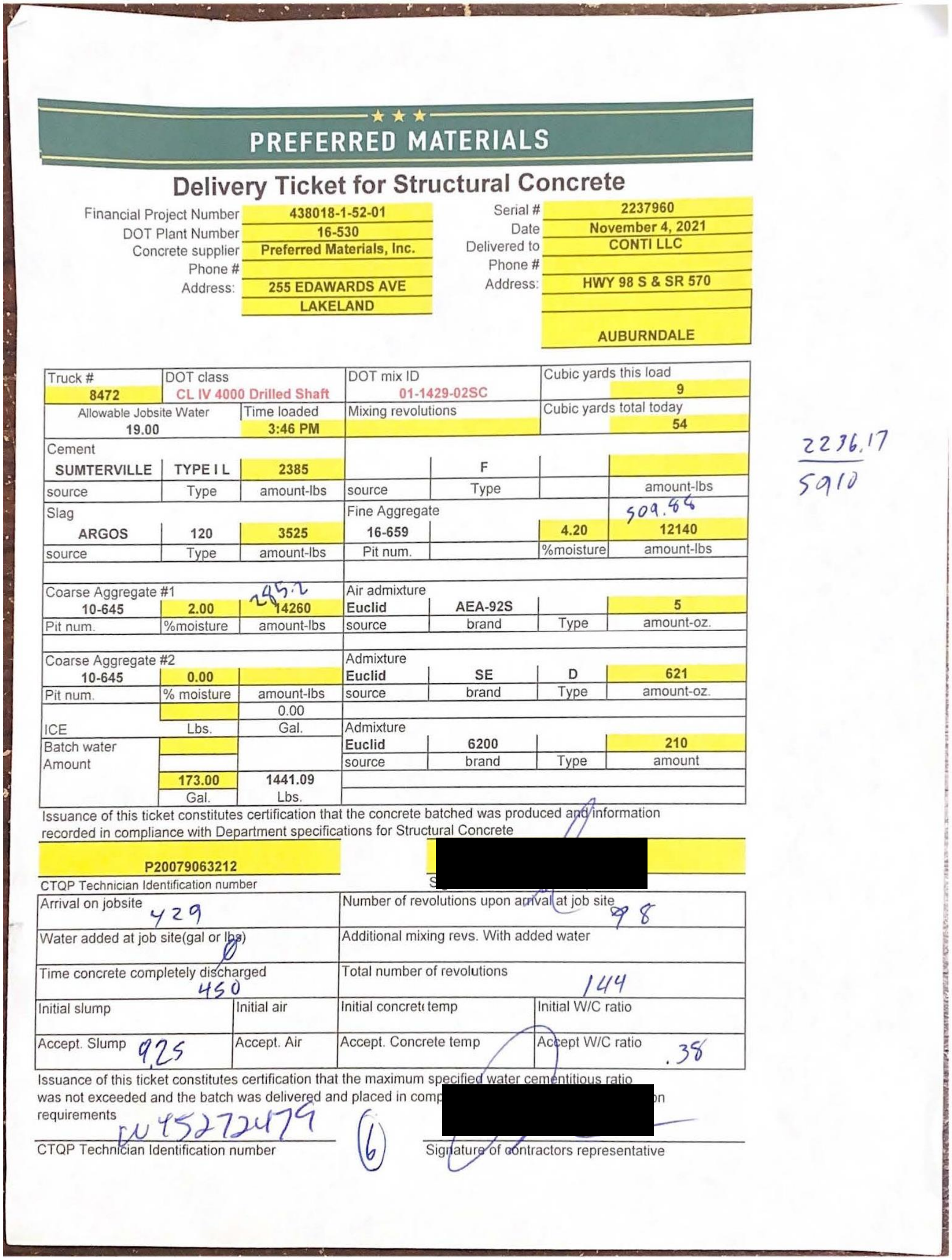
WW5272479

CTQP Technician Identification number

⑤

Signature of contractors representative

Figure B.5 OC-13 concrete delivery ticket 5.



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number: 438018-1-52-01
DOT Plant Number: 16-530
Concrete supplier: Preferred Materials, Inc.
Phone #:
Address: 255 EDAWARDS AVE
LAKELAND

Serial #: 2237960
Date: November 4, 2021
Delivered to: CONTI LLC
Phone #:
Address: HWY 98 S & SR 570

AUBURNDALE

Truck #: 8472
DOT class: CL IV 4000 Drilled Shaft
DOT mix ID: 01-1429-02SC
Cubic yards this load: 9
Allowable Jobsite Water: 19.00
Time loaded: 3:46 PM
Mixing revolutions:
Cubic yards total today: 54

2236.17
5910

Cement						
SUMTERVILLE	TYPE I L	2385		F		
source	Type	amount-lbs	source	Type		amount-lbs
Slag			Fine Aggregate			509.84
ARGOS	120	3525	16-659		4.20	12140
source	Type	amount-lbs	Pit num.		%moisture	amount-lbs
Coarse Aggregate #1		295.2	Air admixture			
10-645	2.00	14260	Euclid	AEA-92S		5
Pit num.	%moisture	amount-lbs	source	brand	Type	amount-oz.
Coarse Aggregate #2			Admixture			
10-645	0.00		Euclid	SE	D	621
Pit num.	% moisture	amount-lbs	source	brand	Type	amount-oz.
		0.00				
ICE	Lbs.	Gal.	Admixture			
Batch water Amount			Euclid	6200		210
			source	brand	Type	amount
	173.00	1441.09				
	Gal.	Lbs.				

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural Concrete

P20079063212
CTQP Technician Identification number

[redacted]

Arrival on jobsite 429		Number of revolutions upon arrival at job site 98	
Water added at job site(gal or lbs) 0		Additional mixing revs. With added water	
Time concrete completely discharged 450		Total number of revolutions 144	
Initial slump	Initial air	Initial concret temp	Initial W/C ratio
Accept. Slump 9.25	Accept. Air	Accept. Concrete temp	Accept W/C ratio .38

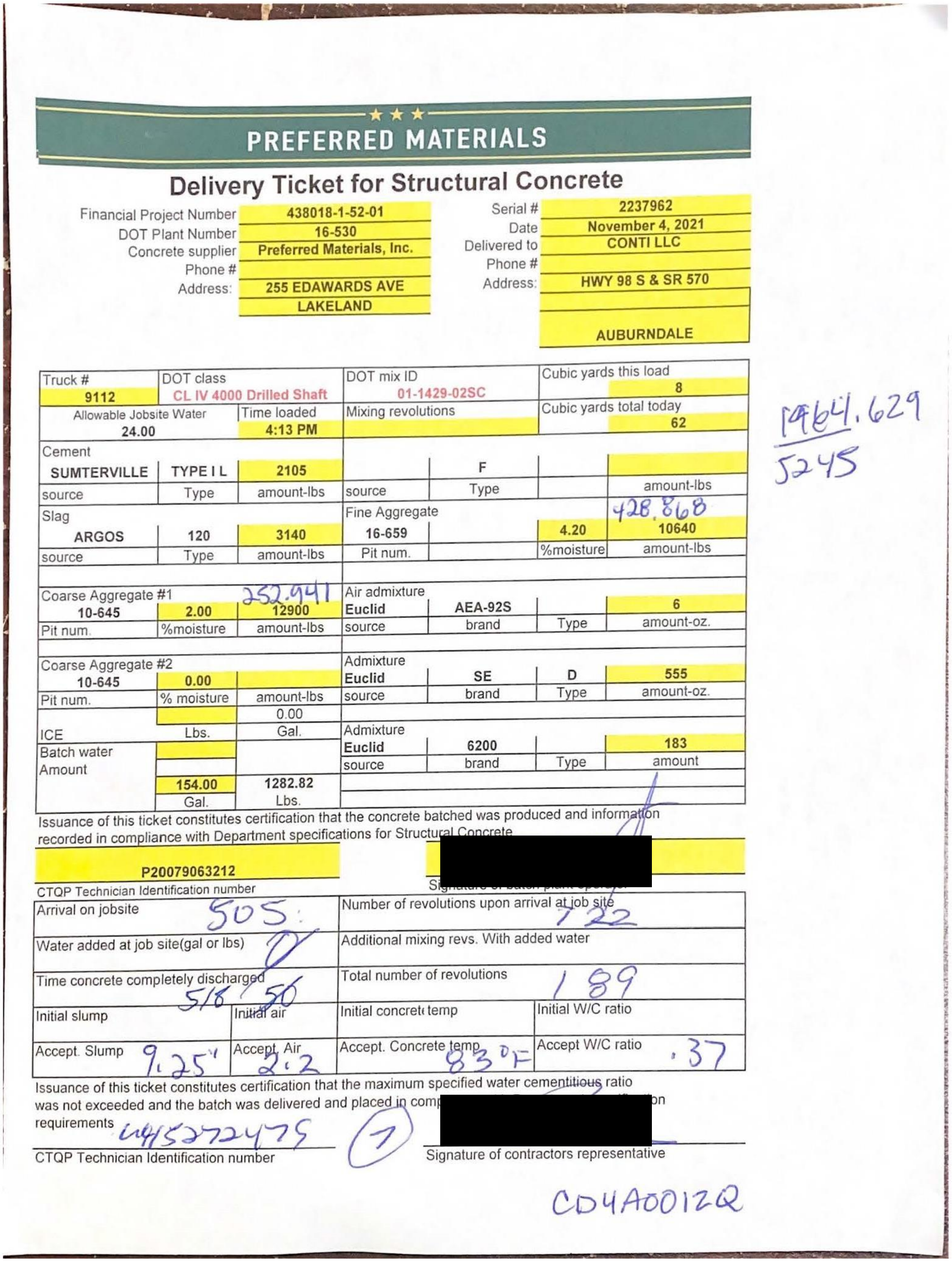
Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in comp [redacted] on requirements

CW45272479
CTQP Technician Identification number

⑥

Signature of contractors representative

Figure B.6 OC-13 concrete delivery ticket 6.



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number	438018-1-52-01	Serial #	2237962
DOT Plant Number	16-530	Date	November 4, 2021
Concrete supplier	Preferred Materials, Inc.	Delivered to	CONTI LLC
Phone #		Phone #	
Address:	255 EDAWARDS AVE LAKELAND	Address:	HWY 98 S & SR 570 AUBURNDALE

Truck # 9112	DOT class CL IV 4000 Drilled Shaft	DOT mix ID 01-1429-02SC	Cubic yards this load 8
Allowable Jobsite Water 24.00	Time loaded 4:13 PM	Mixing revolutions	Cubic yards total today 62

1964.629

5245

Cement						
SUMTERVILLE	TYPE I L	2105		F		
source	Type	amount-lbs	source	Type		amount-lbs
Slag			Fine Aggregate			428.868
ARGOS	120	3140	16-659		4.20	10640
source	Type	amount-lbs	Pit num.		%moisture	amount-lbs
Coarse Aggregate #1		252.941	Air admixture			
10-645	2.00	12900	Euclid	AEA-92S		6
Pit num.	%moisture	amount-lbs	source	brand	Type	amount-oz.
Coarse Aggregate #2			Admixture			
10-645	0.00		Euclid	SE	D	555
Pit num.	% moisture	amount-lbs	source	brand	Type	amount-oz.
		0.00				
ICE	Lbs.	Gal.	Admixture			
Batch water Amount			Euclid	6200		183
			source	brand	Type	amount
	154.00	1282.82				
	Gal.	Lbs.				

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural Concrete

P20079063212

CTQP Technician Identification number

[redacted]

Arrival on jobsite 505:		Number of revolutions upon arrival at job site 722	
Water added at job site(gal or lbs) 0		Additional mixing revs. With added water	
Time concrete completely discharged 5/8 / 50		Total number of revolutions 189	
Initial slump	Initial air	Initial concrete temp	Initial W/C ratio
Accept. Slump 9.25"	Accept. Air 2.2	Accept. Concrete temp 83 °F	Accept W/C ratio .37

Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in comp[redacted]on requirements

445272475

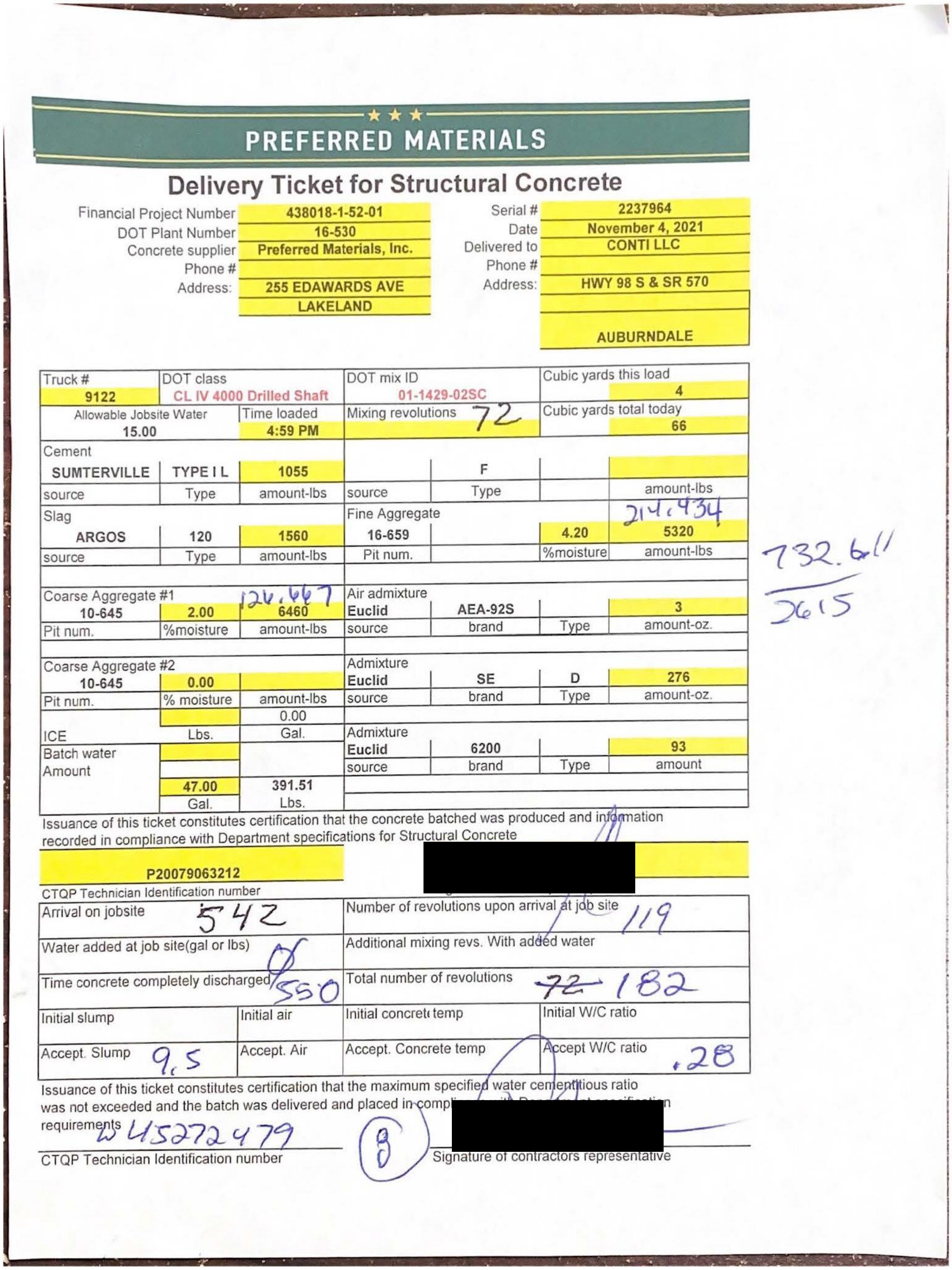
CTQP Technician Identification number

(7)

Signature of contractors representative

CD4A0012Q

Figure B.7 OC-13 concrete delivery ticket 7.



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number	438018-1-52-01	Serial #	2237964
DOT Plant Number	16-530	Date	November 4, 2021
Concrete supplier	Preferred Materials, Inc.	Delivered to	CONTI LLC
Phone #		Phone #	
Address:	255 EDAWARDS AVE LAKELAND	Address:	HWY 98 S & SR 570 AUBURNDALE

Truck # 9122	DOT class CL IV 4000 Drilled Shaft	DOT mix ID 01-1429-02SC	Cubic yards this load 4
Allowable Jobsite Water 15.00	Time loaded 4:59 PM	Mixing revolutions 72	Cubic yards total today 66

Cement						
SUMTERVILLE	TYPE I L	1055		F		
source	Type	amount-lbs	source	Type		amount-lbs
Slag			Fine Aggregate			214.434
ARGOS	120	1560	16-659		4.20	5320
source	Type	amount-lbs	Pit num.		%moisture	amount-lbs
Coarse Aggregate #1		126.667	Air admixture			
10-645	2.00	6460	Euclid	AEA-92S		3
Pit num.	%moisture	amount-lbs	source	brand	Type	amount-oz.
Coarse Aggregate #2			Admixture			
10-645	0.00		Euclid	SE	D	276
Pit num.	% moisture	amount-lbs	source	brand	Type	amount-oz.
		0.00				
ICE	Lbs.	Gal.	Admixture			
Batch water Amount			Euclid	6200		93
			source	brand	Type	amount
	47.00	391.51				
	Gal.	Lbs.				

732.611

2615

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural Concrete

P20079063212 [redacted]

CTQP Technician Identification number

Arrival on jobsite 542		Number of revolutions upon arrival at job site 119	
Water added at job site(gal or lbs) 0		Additional mixing revs. With added water	
Time concrete completely discharged 550		Total number of revolutions ~~72~~ 182	
Initial slump	Initial air	Initial concrete temp	Initial W/C ratio
Accept. Slump 9.5	Accept. Air	Accept. Concrete temp	Accept W/C ratio .28

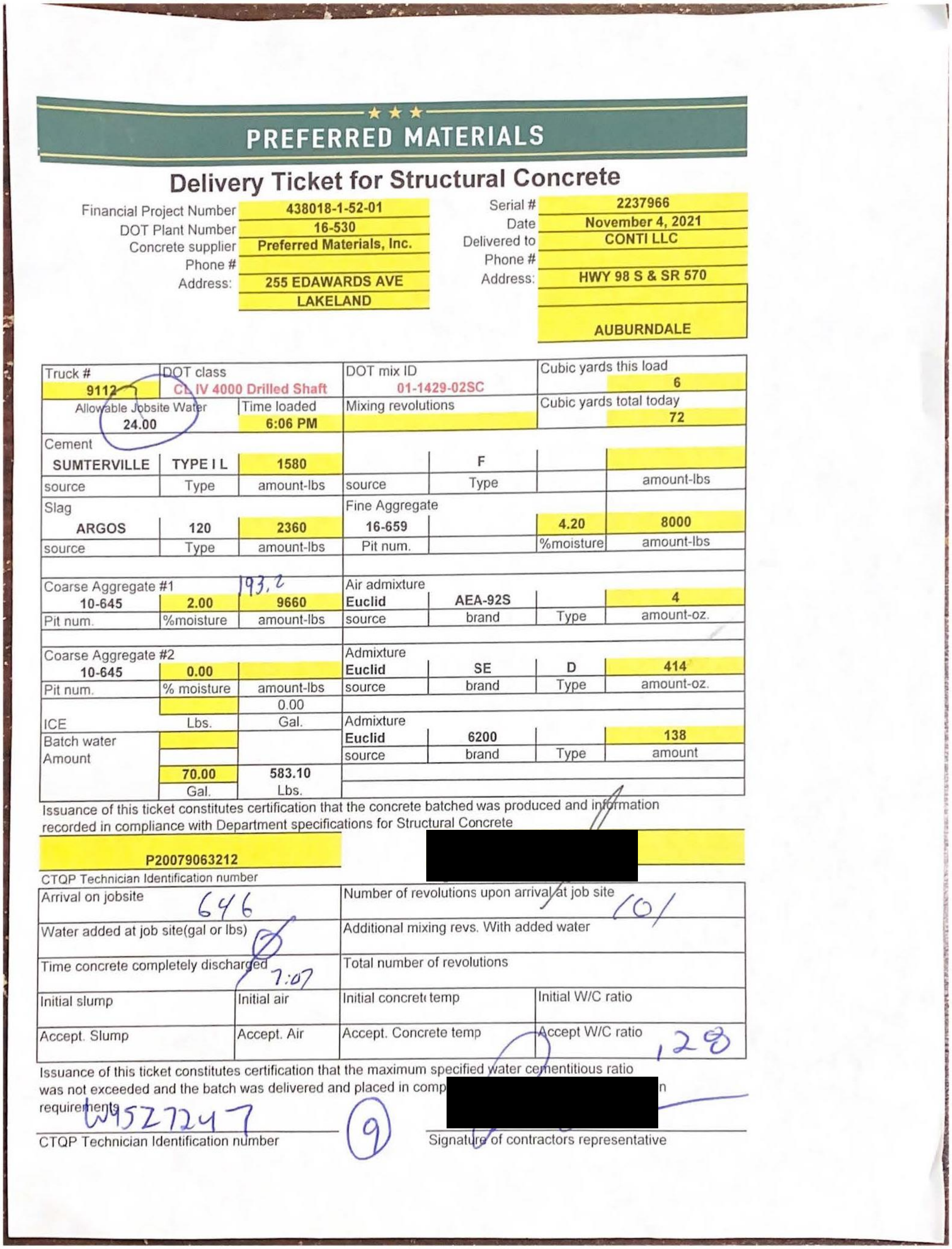
Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in compl [redacted] n requirements

W 45272479 (8)

CTQP Technician Identification number

Signature of contractors representative

Figure B.8 OC-13 concrete delivery ticket 8.



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number 438018-1-52-01
DOT Plant Number 16-530
Concrete supplier Preferred Materials, Inc.
Phone #
Address: 255 EDAWARDS AVE
LAKELAND

Serial # 2237966
Date November 4, 2021
Delivered to CONTI LLC
Phone #
Address: HWY 98 S & SR 570
AUBURNDALE

Truck # 9112
DOT class CL IV 4000 Drilled Shaft
DOT mix ID 01-1429-02SC
Cubic yards this load 6
Allowable Jobsite Water 24.00
Time loaded 6:06 PM
Mixing revolutions
Cubic yards total today 72

Cement

SUMTERVILLE	TYPE I L	1580		F		
source	Type	amount-lbs	source	Type		amount-lbs

Slag / Fine Aggregate

ARGOS	120	2360	16-659		4.20	8000
source	Type	amount-lbs	Pit num.		%moisture	amount-lbs

Coarse Aggregate #1 / Air admixture

		193,2				
10-645	2.00	9660	Euclid	AEA-92S		4
Pit num.	%moisture	amount-lbs	source	brand	Type	amount-oz.

Coarse Aggregate #2 / Admixture

10-645	0.00		Euclid	SE	D	414
Pit num.	% moisture	amount-lbs	source	brand	Type	amount-oz.

		0.00				
ICE	Lbs.	Gal.	Admixture			
Batch water Amount			Euclid	6200		138
			source	brand	Type	amount
	70.00	583.10				
	Gal.	Lbs.				

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural Concrete

P20079063212 [redacted]
CTQP Technician Identification number

Arrival on jobsite 646		Number of revolutions upon arrival at job site 101	
Water added at job site(gal or lbs) 0		Additional mixing revs. With added water	
Time concrete completely discharged 7:07		Total number of revolutions	
Initial slump	Initial air	Initial concrete temp	Initial W/C ratio
Accept. Slump	Accept. Air	Accept. Concrete temp	Accept W/C ratio ,128

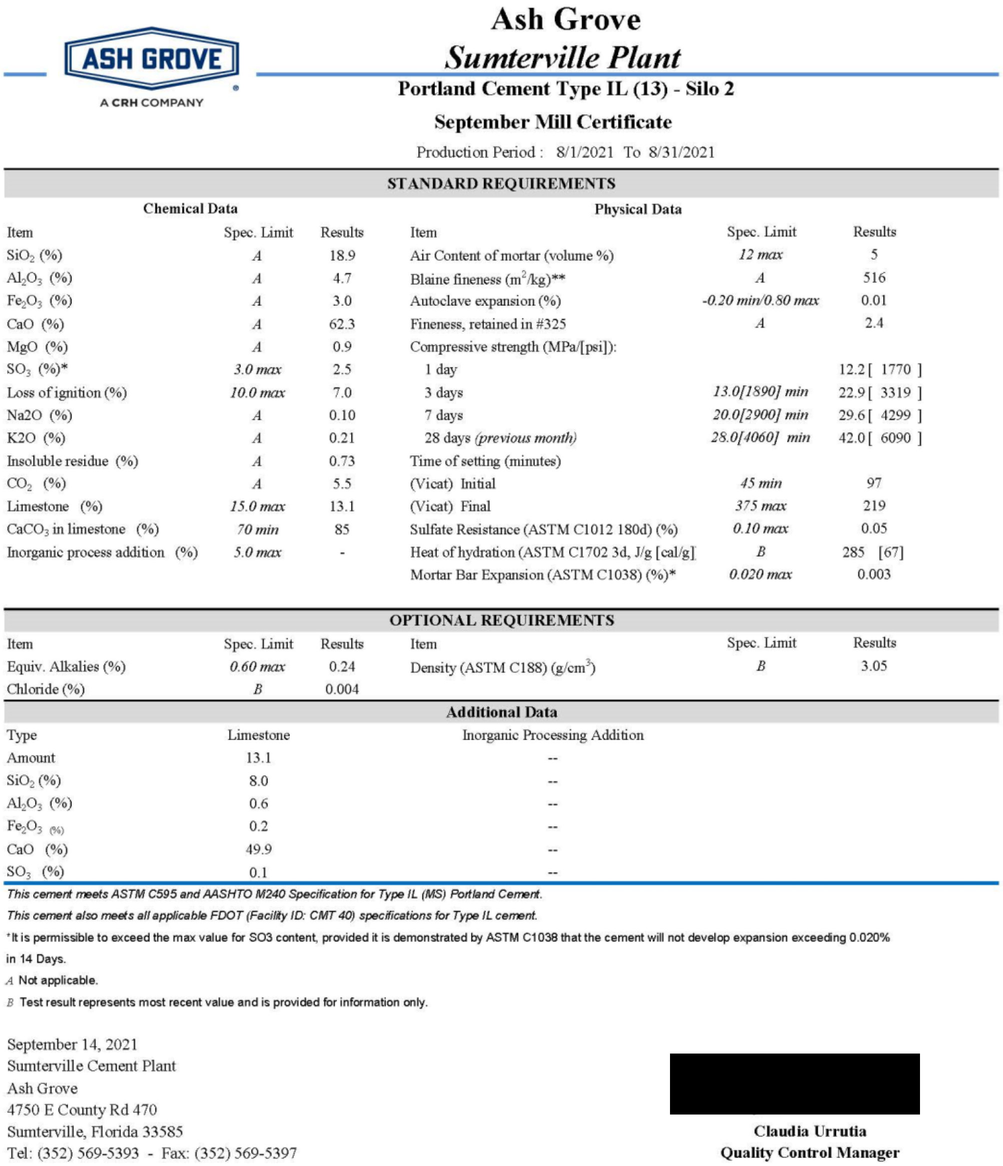
Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in comp[redacted]n requirements

W9527247 ⑨

CTQP Technician Identification number

Signature of contractors representative

Figure B.9 OC-13 concrete delivery ticket 9.



ASH GROVE
A CRH COMPANY

Ash Grove

Sumterville Plant

Portland Cement Type IL (13) - Silo 2

September Mill Certificate

Production Period : 8/1/2021 To 8/31/2021

STANDARD REQUIREMENTS

Chemical Data			**Physical Data**		
Item	Spec. Limit	Results	Item	Spec. Limit	Results
SiO_2 (%)	*A*	18.9	Air Content of mortar (volume %)	*12 max*	5
Al_2O_3 (%)	*A*	4.7	Blaine fineness (m^2/kg)**	*A*	516
Fe_2O_3 (%)	*A*	3.0	Autoclave expansion (%)	*-0.20 min/0.80 max*	0.01
CaO (%)	*A*	62.3	Fineness, retained in #325	*A*	2.4
MgO (%)	*A*	0.9	Compressive strength (MPa/[psi]):		
SO_3 (%)*	*3.0 max*	2.5	1 day		12.2 [1770]
Loss of ignition (%)	*10.0 max*	7.0	3 days	*13.0[1890] min*	22.9 [3319]
Na2O (%)	*A*	0.10	7 days	*20.0[2900] min*	29.6 [4299]
K2O (%)	*A*	0.21	28 days *(previous month)*	*28.0[4060] min*	42.0 [6090]
Insoluble residue (%)	*A*	0.73	Time of setting (minutes)		
CO_2 (%)	*A*	5.5	(Vicat) Initial	*45 min*	97
Limestone (%)	*15.0 max*	13.1	(Vicat) Final	*375 max*	219
$CaCO_3$ in limestone (%)	*70 min*	85	Sulfate Resistance (ASTM C1012 180d) (%)	*0.10 max*	0.05
Inorganic process addition (%)	*5.0 max*	-	Heat of hydration (ASTM C1702 3d, J/g [cal/g]	*B*	285 [67]
			Mortar Bar Expansion (ASTM C1038) (%)*	*0.020 max*	0.003

OPTIONAL REQUIREMENTS

Item	Spec. Limit	Results	Item	Spec. Limit	Results
Equiv. Alkalies (%)	*0.60 max*	0.24	Density (ASTM C188) (g/cm^3)	*B*	3.05
Chloride (%)	*B*	0.004			

Additional Data

Type	Limestone	Inorganic Processing Addition
Amount	13.1	--
SiO_2 (%)	8.0	--
Al_2O_3 (%)	0.6	--
Fe_2O_3 (%)	0.2	--
CaO (%)	49.9	--
SO_3 (%)	0.1	--

This cement meets ASTM C595 and AASHTO M240 Specification for Type IL (MS) Portland Cement.

This cement also meets all applicable FDOT (Facility ID: CMT 40) specifications for Type IL cement.

*It is permissible to exceed the max value for SO3 content, provided it is demonstrated by ASTM C1038 that the cement will not develop expansion exceeding 0.020% in 14 Days.

A Not applicable.

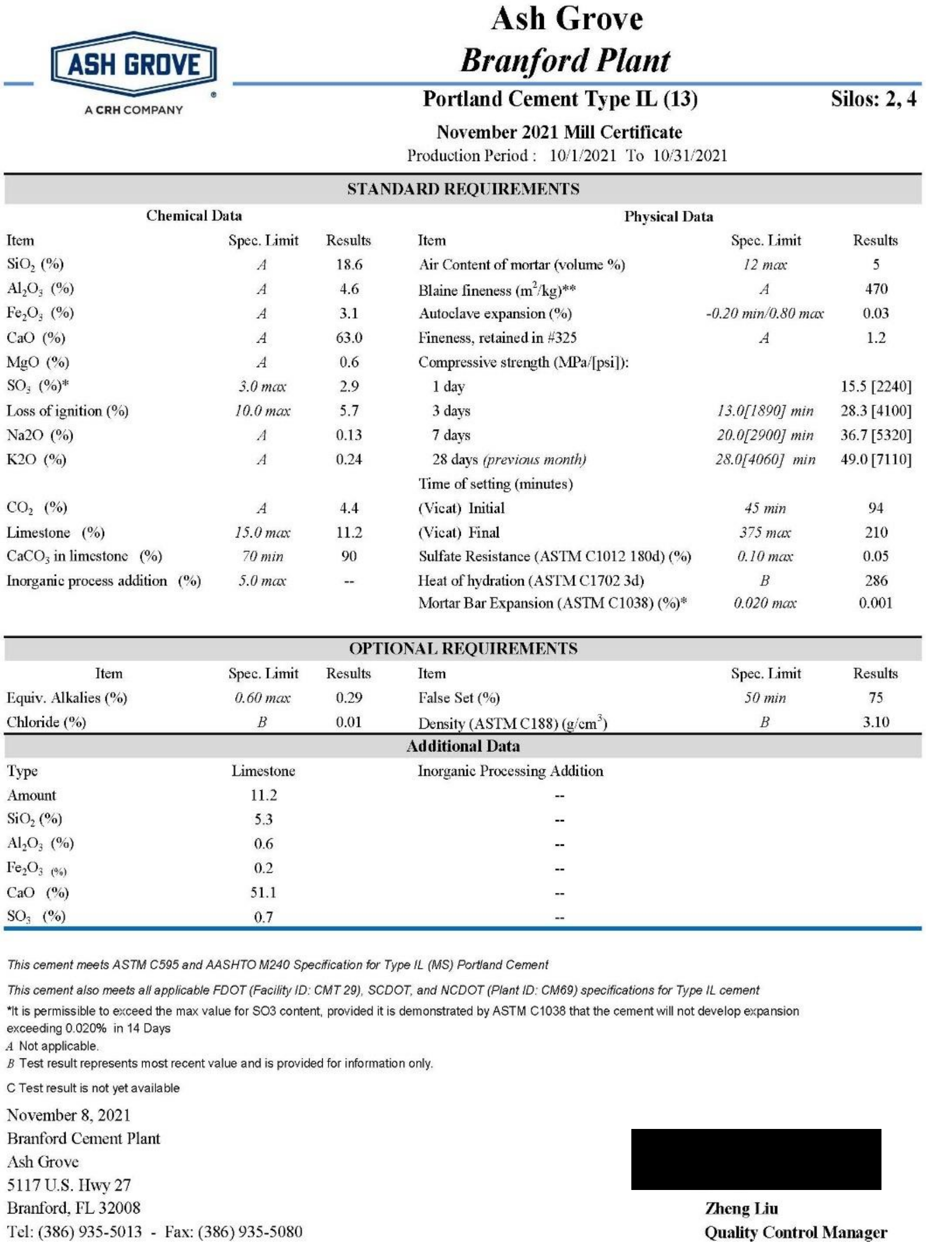
B Test result represents most recent value and is provided for information only.

September 14, 2021
Sumterville Cement Plant
Ash Grove
4750 E County Rd 470
Sumterville, Florida 33585
Tel: (352) 569-5393 - Fax: (352) 569-5397

[redacted]

Claudia Urrutia
Quality Control Manager

Figure B.10 OC-13 Type IL cement Sumterville Plant mill certificate.



Ash Grove

Branford Plant

Portland Cement Type IL (13) **Silos: 2, 4**

November 2021 Mill Certificate

Production Period : 10/1/2021 To 10/31/2021

STANDARD REQUIREMENTS

Chemical Data			Physical Data		
Item	Spec. Limit	Results	Item	Spec. Limit	Results
SiO_2 (%)	*A*	18.6	Air Content of mortar (volume %)	*12 max*	5
Al_2O_3 (%)	*A*	4.6	Blaine fineness (m^2/kg)**	*A*	470
Fe_2O_3 (%)	*A*	3.1	Autoclave expansion (%)	*-0.20 min/0.80 max*	0.03
CaO (%)	*A*	63.0	Fineness, retained in #325	*A*	1.2
MgO (%)	*A*	0.6	Compressive strength (MPa/[psi]):		
SO_3 (%)*	*3.0 max*	2.9	1 day		15.5 [2240]
Loss of ignition (%)	*10.0 max*	5.7	3 days	*13.0[1890] min*	28.3 [4100]
Na2O (%)	*A*	0.13	7 days	*20.0[2900] min*	36.7 [5320]
K2O (%)	*A*	0.24	28 days *(previous month)*	*28.0[4060] min*	49.0 [7110]
			Time of setting (minutes)		
CO_2 (%)	*A*	4.4	(Vicat) Initial	*45 min*	94
Limestone (%)	*15.0 max*	11.2	(Vicat) Final	*375 max*	210
$CaCO_3$ in limestone (%)	*70 min*	90	Sulfate Resistance (ASTM C1012 180d) (%)	*0.10 max*	0.05
Inorganic process addition (%)	*5.0 max*	--	Heat of hydration (ASTM C1702 3d)	*B*	286
			Mortar Bar Expansion (ASTM C1038) (%)*	*0.020 max*	0.001

OPTIONAL REQUIREMENTS

Item	Spec. Limit	Results	Item	Spec. Limit	Results
Equiv. Alkalies (%)	*0.60 max*	0.29	False Set (%)	*50 min*	75
Chloride (%)	*B*	0.01	Density (ASTM C188) (g/cm^3)	*B*	3.10

Additional Data

Type	Limestone	Inorganic Processing Addition
Amount	11.2	--
SiO_2 (%)	5.3	--
Al_2O_3 (%)	0.6	--
Fe_2O_3 (%)	0.2	--
CaO (%)	51.1	--
SO_3 (%)	0.7	--

This cement meets ASTM C595 and AASHTO M240 Specification for Type IL (MS) Portland Cement

This cement also meets all applicable FDOT (Facility ID: CMT 29), SCDOT, and NCDOT (Plant ID: CM69) specifications for Type IL cement

*It is permissible to exceed the max value for SO3 content, provided it is demonstrated by ASTM C1038 that the cement will not develop expansion exceeding 0.020% in 14 Days

A Not applicable.

B Test result represents most recent value and is provided for information only.

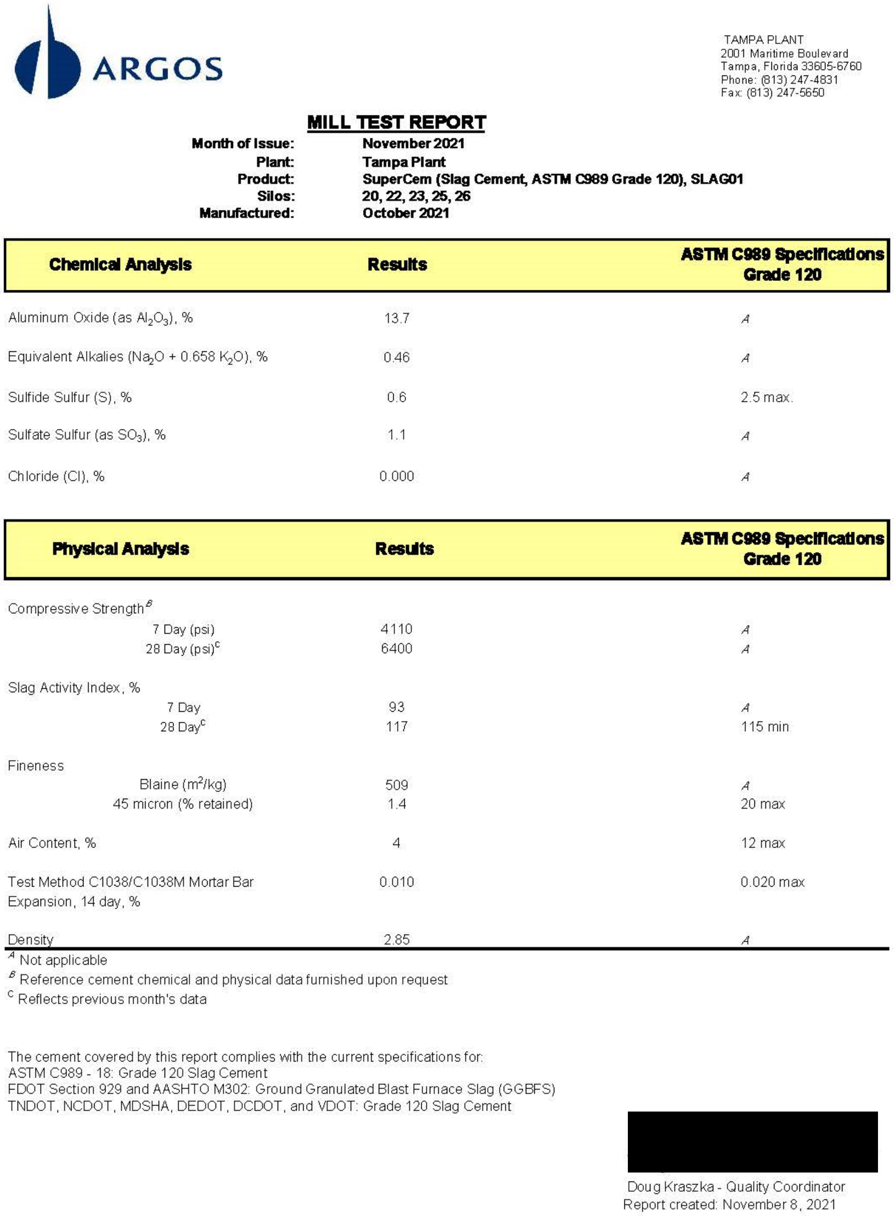
C Test result is not yet available

November 8, 2021
Branford Cement Plant
Ash Grove
5117 U.S. Hwy 27
Branford, FL 32008
Tel: (386) 935-5013 - Fax: (386) 935-5080

[redacted]

Zheng Liu
Quality Control Manager

Figure B.11 OC-13 Type IL cement Branford Plant mill certificate.



TAMPA PLANT
2001 Maritime Boulevard
Tampa, Florida 33605-6760
Phone: (813) 247-4831
Fax: (813) 247-5650

MILL TEST REPORT

Month of Issue:	**November 2021**
Plant:	**Tampa Plant**
Product:	**SuperCem (Slag Cement, ASTM C989 Grade 120), SLAG01**
Silos:	**20, 22, 23, 25, 26**
Manufactured:	**October 2021**

Chemical Analysis	Results	ASTM C989 Specifications Grade 120
Aluminum Oxide (as Al_2O_3), %	13.7	A
Equivalent Alkalies (Na_2O + 0.658 K_2O), %	0.46	A
Sulfide Sulfur (S), %	0.6	2.5 max.
Sulfate Sulfur (as SO_3), %	1.1	A
Chloride (Cl), %	0.000	A

Physical Analysis	Results	ASTM C989 Specifications Grade 120
Compressive Strength[B]		
7 Day (psi)	4110	A
28 Day (psi)[C]	6400	A
Slag Activity Index, %		
7 Day	93	A
28 Day[C]	117	115 min
Fineness		
Blaine (m^2/kg)	509	A
45 micron (% retained)	1.4	20 max
Air Content, %	4	12 max
Test Method C1038/C1038M Mortar Bar Expansion, 14 day, %	0.010	0.020 max
Density	2.85	A

[A] Not applicable
[B] Reference cement chemical and physical data furnished upon request
[C] Reflects previous month's data

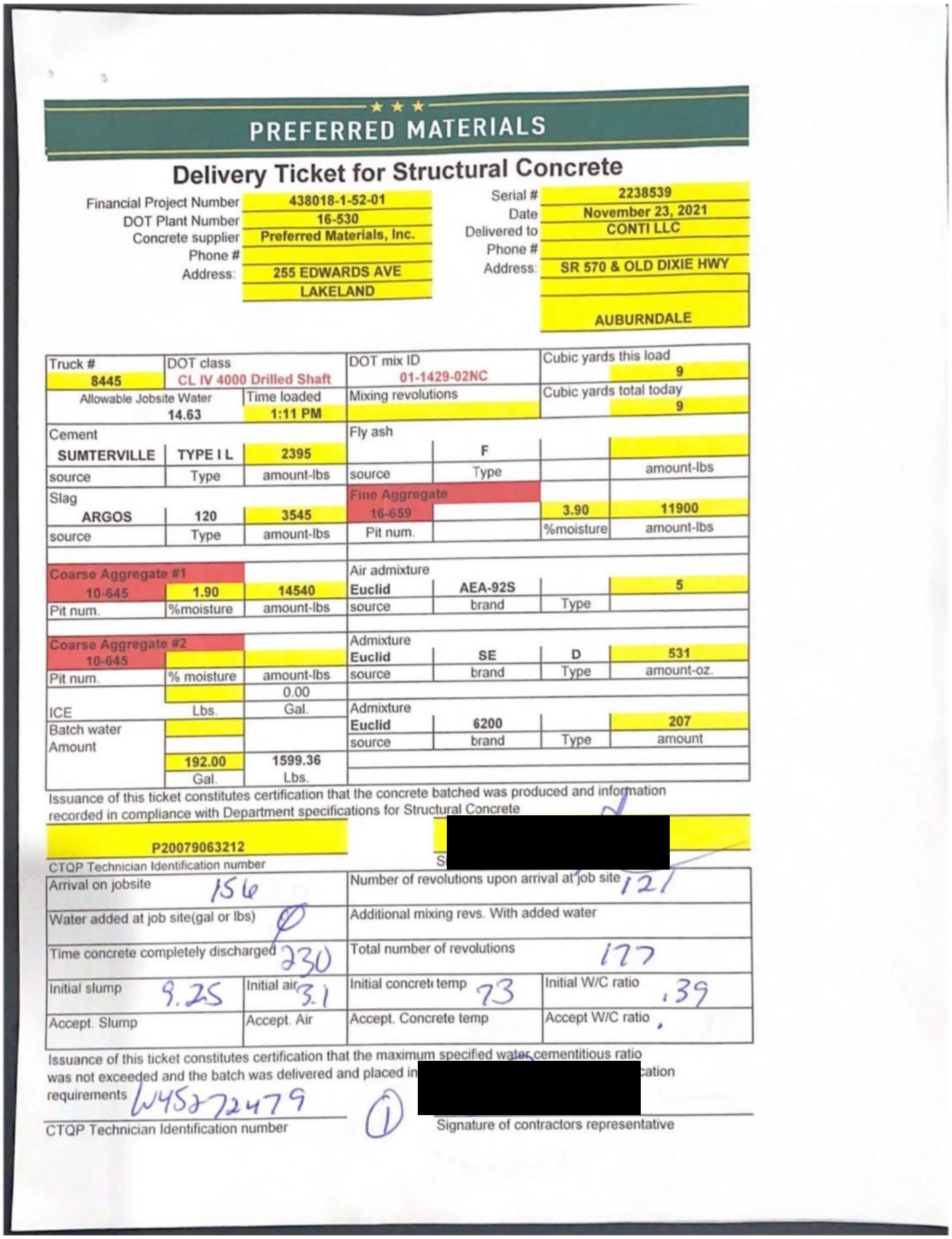
The cement covered by this report complies with the current specifications for:
ASTM C989 - 18: Grade 120 Slag Cement
FDOT Section 929 and AASHTO M302: Ground Granulated Blast Furnace Slag (GGBFS)
TNDOT, NCDOT, MDSHA, DEDOT, DCDOT, and VDOT: Grade 120 Slag Cement

[redacted]

Doug Kraszka - Quality Coordinator
Report created: November 8, 2021

Figure B.12 OC-13 slag mill certificate.

Appendix C: I-4 Drilled Shaft OC-19 Construction Documents



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number: 438018-1-52-01
DOT Plant Number: 16-530
Concrete supplier: Preferred Materials, Inc.
Phone #:
Address: 255 EDWARDS AVE
LAKELAND

Serial #: 2238539
Date: November 23, 2021
Delivered to: CONTI LLC
Phone #:
Address: SR 570 & OLD DIXIE HWY
AUBURNDALE

Truck #: 8445
DOT class: CL IV 4000 Drilled Shaft
DOT mix ID: 01-1429-02NC
Cubic yards this load: 9
Allowable Jobsite Water: 14.63
Time loaded: 1:11 PM
Mixing revolutions:
Cubic yards total today: 9

Cement			
SUMTERVILLE	TYPE I L	2395	
source	Type	amount-lbs	
Slag			
ARGOS	120	3545	
source	Type	amount-lbs	
Coarse Aggregate #1			
10-645	1.90	14540	
Pit num.	%moisture	amount-lbs	
Coarse Aggregate #2			
10-645			
Pit num.	% moisture	amount-lbs	
		0.00	
ICE	Lbs.	Gal.	
Batch water Amount			
	192.00	1599.36	
	Gal.	Lbs.	

Fly ash			
	F		
source	Type		amount-lbs
Fine Aggregate			
16-659		3.90	11900
Pit num.		%moisture	amount-lbs
Air admixture			
Euclid	AEA-92S		5
source	brand	Type	
Admixture			
Euclid	SE	D	531
source	brand	Type	amount-oz.
Admixture			
Euclid	6200		207
source	brand	Type	amount

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural Concrete

P20079063212
CTQP Technician Identification number

S[redacted]

Arrival on jobsite 156		Number of revolutions upon arrival at job site 121	
Water added at job site(gal or lbs) 0		Additional mixing revs. With added water	
Time concrete completely discharged 230		Total number of revolutions 177	
Initial slump 9.25	Initial air 3.1	Initial concrete temp 73	Initial W/C ratio .39
Accept. Slump	Accept. Air	Accept. Concrete temp	Accept W/C ratio .

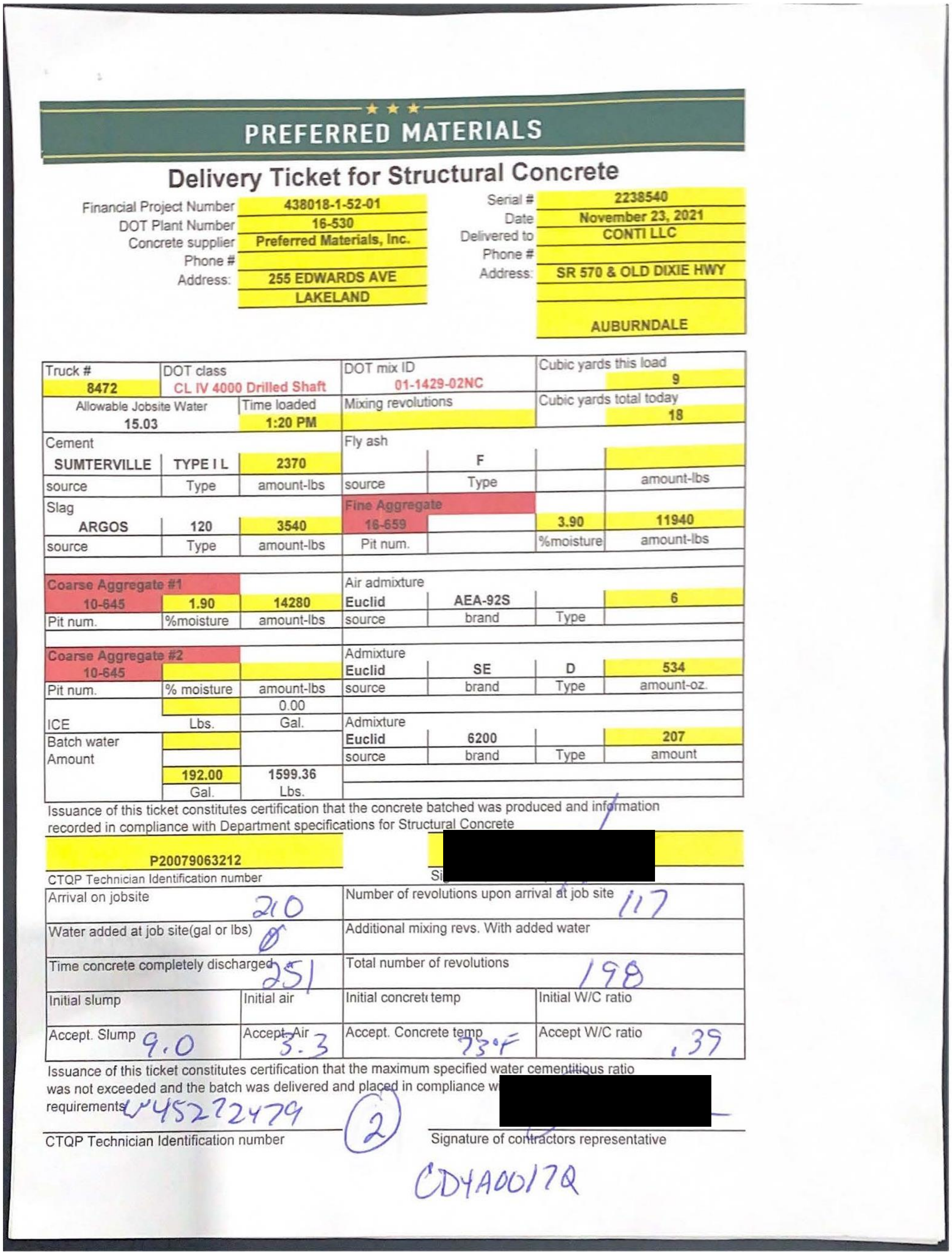
Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in [redacted]cation requirements

W4572479
CTQP Technician Identification number

①

Signature of contractors representative

Figure C.1 OC-19 concrete delivery ticket 1.



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number: 438018-1-52-01
DOT Plant Number: 16-530
Concrete supplier: Preferred Materials, Inc.
Phone #:
Address: 255 EDWARDS AVE
LAKELAND

Serial #: 2238540
Date: November 23, 2021
Delivered to: CONTI LLC
Phone #:
Address: SR 570 & OLD DIXIE HWY
AUBURNDALE

Truck # 8472	DOT class CL IV 4000 Drilled Shaft	DOT mix ID 01-1429-02NC	Cubic yards this load 9
Allowable Jobsite Water 15.03	Time loaded 1:20 PM	Mixing revolutions	Cubic yards total today 18

Cement			Fly ash			
SUMTERVILLE	TYPE I L	2370		F		
source	Type	amount-lbs	source	Type		amount-lbs
Slag			Fine Aggregate			
ARGOS	120	3540	16-659		3.90	11940
source	Type	amount-lbs	Pit num.		%moisture	amount-lbs
Coarse Aggregate #1			Air admixture			
10-645	1.90	14280	Euclid	AEA-92S		6
Pit num.	%moisture	amount-lbs	source	brand	Type	
Coarse Aggregate #2			Admixture			
10-645			Euclid	SE	D	534
Pit num.	% moisture	amount-lbs	source	brand	Type	amount-oz.
		0.00				
ICE	Lbs.	Gal.	Admixture			
Batch water Amount			Euclid	6200		207
			source	brand	Type	amount
	192.00	1599.36				
	Gal.	Lbs.				

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural Concrete

P20079063212
CTQP Technician Identification number

Si[redacted]

Arrival on jobsite 210	Number of revolutions upon arrival at job site 117
Water added at job site(gal or lbs) 0	Additional mixing revs. With added water
Time concrete completely discharged 251	Total number of revolutions 198

Initial slump	Initial air	Initial concrete temp	Initial W/C ratio
Accept. Slump 9.0	Accept. Air 3.3	Accept. Concrete temp 73°F	Accept W/C ratio .39

Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in compliance wi[redacted] requirements

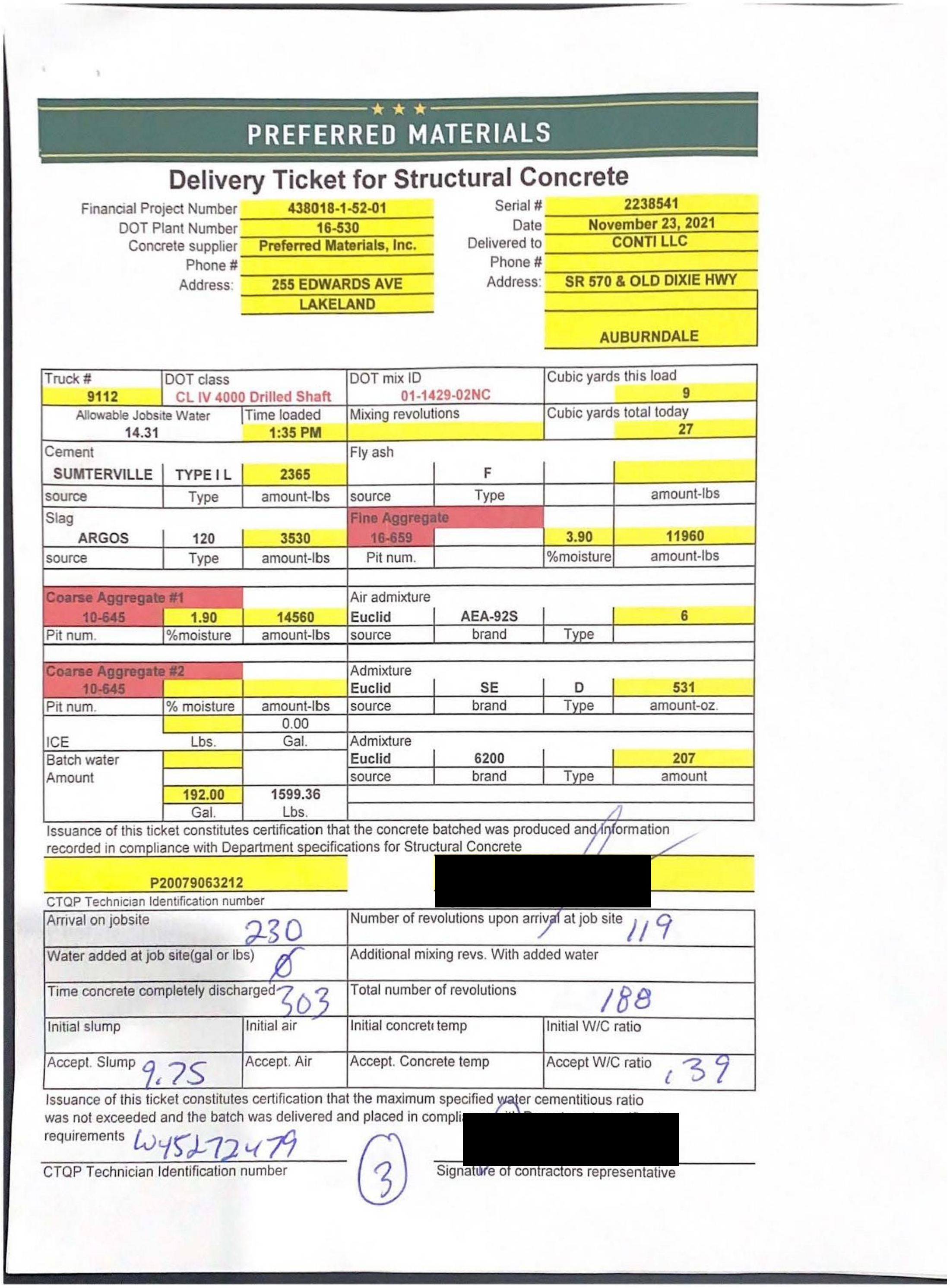
V45272479 ②

CTQP Technician Identification number

Signature of contractors representative

CD4A0017Q

Figure C.2 OC-19 concrete delivery ticket 2.



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number 438018-1-52-01
DOT Plant Number 16-530
Concrete supplier Preferred Materials, Inc.
Phone #
Address: 255 EDWARDS AVE
LAKELAND

Serial # 2238541
Date November 23, 2021
Delivered to CONTI LLC
Phone #
Address: SR 570 & OLD DIXIE HWY
AUBURNDALE

Truck # 9112	DOT class CL IV 4000 Drilled Shaft		DOT mix ID 01-1429-02NC		Cubic yards this load 9	
Allowable Jobsite Water 14.31		Time loaded 1:35 PM	Mixing revolutions		Cubic yards total today 27	
Cement			Fly ash			
SUMTERVILLE	TYPE I L	2365		F		
source	Type	amount-lbs	source	Type		amount-lbs
Slag			Fine Aggregate			
ARGOS	120	3530	16-659		3.90	11960
source	Type	amount-lbs	Pit num.		%moisture	amount-lbs
Coarse Aggregate #1			Air admixture			
10-645	1.90	14560	Euclid	AEA-92S		6
Pit num.	%moisture	amount-lbs	source	brand	Type	
Coarse Aggregate #2			Admixture			
10-645			Euclid	SE	D	531
Pit num.	% moisture	amount-lbs	source	brand	Type	amount-oz.
		0.00				
ICE	Lbs.	Gal.	Admixture			
Batch water			Euclid	6200		207
Amount			source	brand	Type	amount
	192.00	1599.36				
	Gal.	Lbs.				

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural Concrete

P20079063212 [redacted]

CTQP Technician Identification number

Arrival on jobsite 230		Number of revolutions upon arrival at job site 119	
Water added at job site(gal or lbs) 0		Additional mixing revs. With added water	
Time concrete completely discharged 303		Total number of revolutions 188	
Initial slump	Initial air	Initial concrete temp	Initial W/C ratio
Accept. Slump 9.75	Accept. Air	Accept. Concrete temp	Accept W/C ratio .39

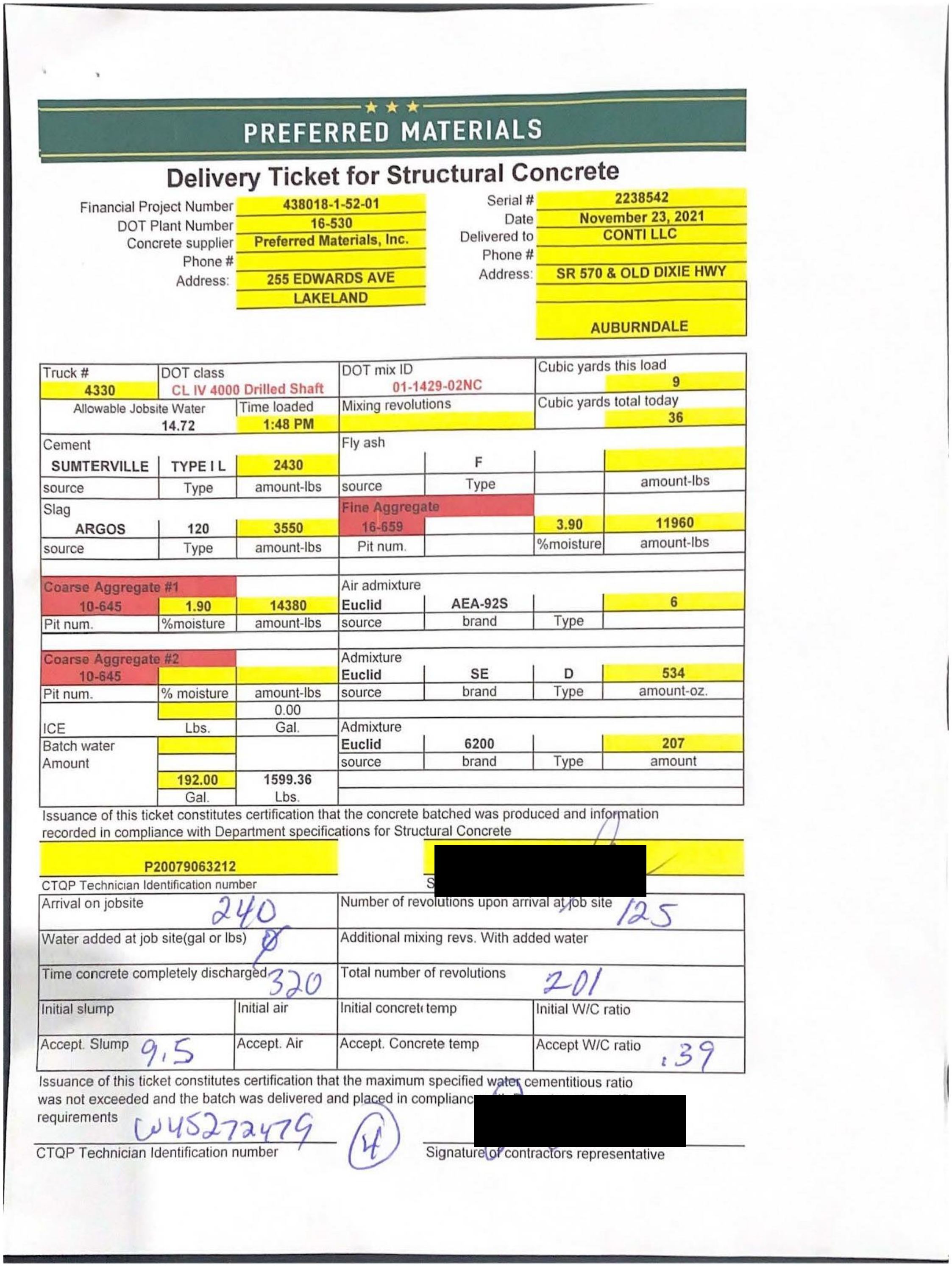
Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in compli [redacted] requirements W45272479

③

CTQP Technician Identification number

Signature of contractors representative

Figure C.3 OC-19 concrete delivery ticket 3.



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number 438018-1-52-01
DOT Plant Number 16-530
Concrete supplier Preferred Materials, Inc.
Phone #
Address: 255 EDWARDS AVE
LAKELAND

Serial # 2238542
Date November 23, 2021
Delivered to CONTI LLC
Phone #
Address: SR 570 & OLD DIXIE HWY

AUBURNDALE

Truck # 4330	DOT class CL IV 4000 Drilled Shaft		DOT mix ID 01-1429-02NC			Cubic yards this load 9
Allowable Jobsite Water 14.72		Time loaded 1:48 PM	Mixing revolutions			Cubic yards total today 36
Cement			Fly ash			
SUMTERVILLE	TYPE I L	2430		F		
source	Type	amount-lbs	source	Type		amount-lbs
Slag			Fine Aggregate			
ARGOS	120	3550	16-659		3.90	11960
source	Type	amount-lbs	Pit num.		%moisture	amount-lbs
Coarse Aggregate #1			Air admixture			
10-645	1.90	14380	Euclid	AEA-92S		6
Pit num.	%moisture	amount-lbs	source	brand	Type	
Coarse Aggregate #2			Admixture			
10-645			Euclid	SE	D	534
Pit num.	% moisture	amount-lbs	source	brand	Type	amount-oz.
		0.00				
ICE	Lbs.	Gal.	Admixture			
Batch water			Euclid	6200		207
Amount			source	brand	Type	amount
	192.00	1599.36				
	Gal.	Lbs.				

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural Concrete

P20079063212
CTQP Technician Identification number

[redacted]

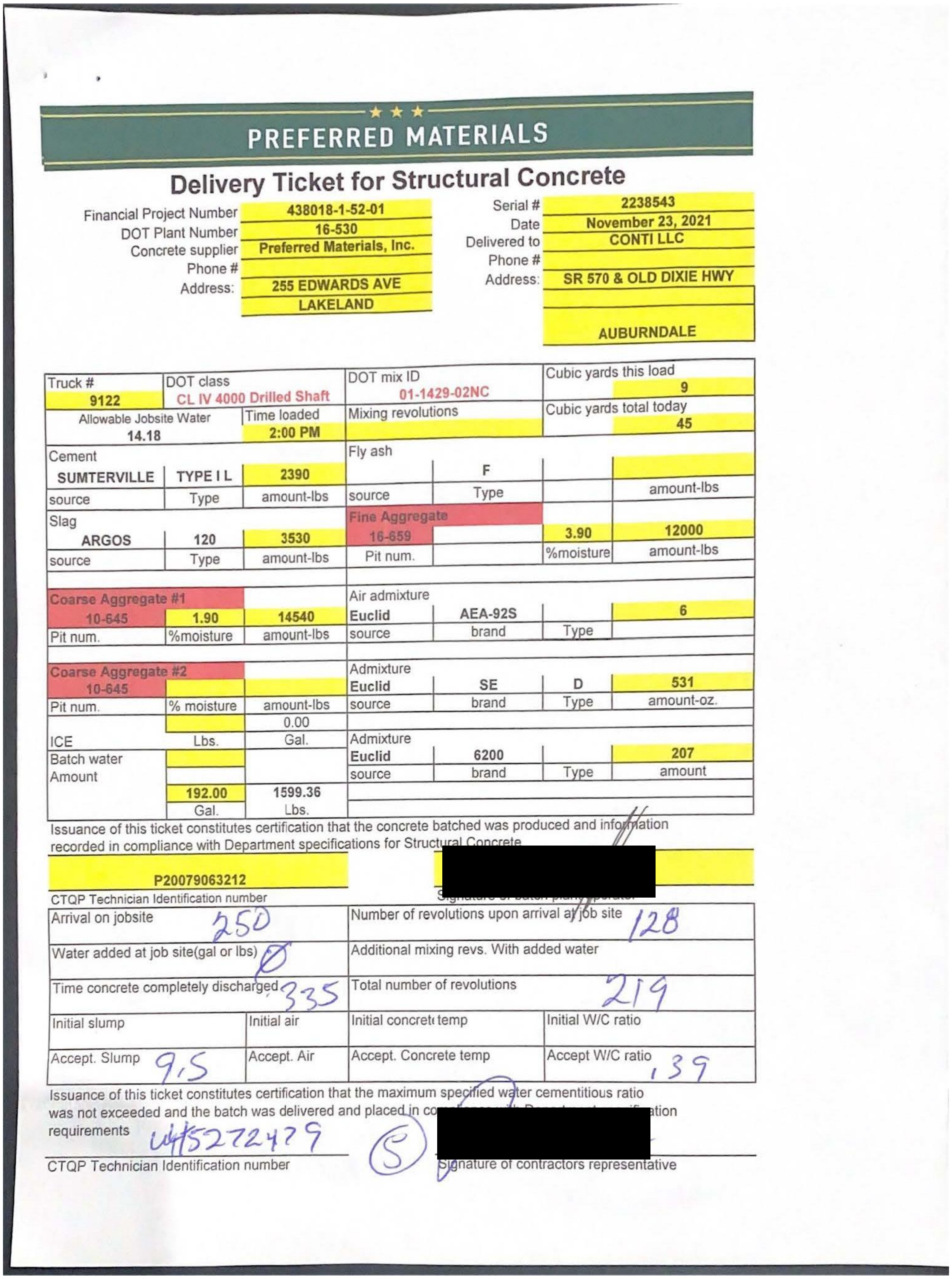
Arrival on jobsite 240		Number of revolutions upon arrival at job site 125	
Water added at job site(gal or lbs) 0		Additional mixing revs. With added water	
Time concrete completely discharged 320		Total number of revolutions 201	
Initial slump	Initial air	Initial concrete temp	Initial W/C ratio
Accept. Slump 9.5	Accept. Air	Accept. Concrete temp	Accept W/C ratio .39

Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in complianc [redacted] requirements

W45272479 ④
CTQP Technician Identification number

Signature of contractors representative

Figure C.4 OC-19 concrete delivery ticket 4.



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number: 438018-1-52-01
DOT Plant Number: 16-530
Concrete supplier: Preferred Materials, Inc.
Phone #:
Address: 255 EDWARDS AVE
LAKELAND

Serial #: 2238543
Date: November 23, 2021
Delivered to: CONTI LLC
Phone #:
Address: SR 570 & OLD DIXIE HWY

AUBURNDALE

Truck # 9122	DOT class CL IV 4000 Drilled Shaft	DOT mix ID 01-1429-02NC	Cubic yards this load 9
Allowable Jobsite Water 14.18	Time loaded 2:00 PM	Mixing revolutions	Cubic yards total today 45

Cement			Fly ash			
SUMTERVILLE	TYPE I L	2390		F		
source	Type	amount-lbs	source	Type		amount-lbs
Slag			Fine Aggregate			
ARGOS	120	3530	16-659		3.90	12000
source	Type	amount-lbs	Pit num.		%moisture	amount-lbs
Coarse Aggregate #1			Air admixture			
10-645	1.90	14540	Euclid	AEA-92S		6
Pit num.	%moisture	amount-lbs	source	brand	Type	
Coarse Aggregate #2			Admixture			
10-645			Euclid	SE	D	531
Pit num.	% moisture	amount-lbs	source	brand	Type	amount-oz.
		0.00				
ICE	Lbs.	Gal.	Admixture			
Batch water Amount			Euclid	6200		207
			source	brand	Type	amount
	192.00	1599.36				
	Gal.	Lbs.				

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural Concrete

P20079063212
CTQP Technician Identification number

[redacted]

Arrival on jobsite 250		Number of revolutions upon arrival at job site 128	
Water added at job site(gal or lbs) 0		Additional mixing revs. With added water	
Time concrete completely discharged 335		Total number of revolutions 219	
Initial slump	Initial air	Initial concrete temp	Initial W/C ratio
Accept. Slump 9.5	Accept. Air	Accept. Concrete temp	Accept W/C ratio .39

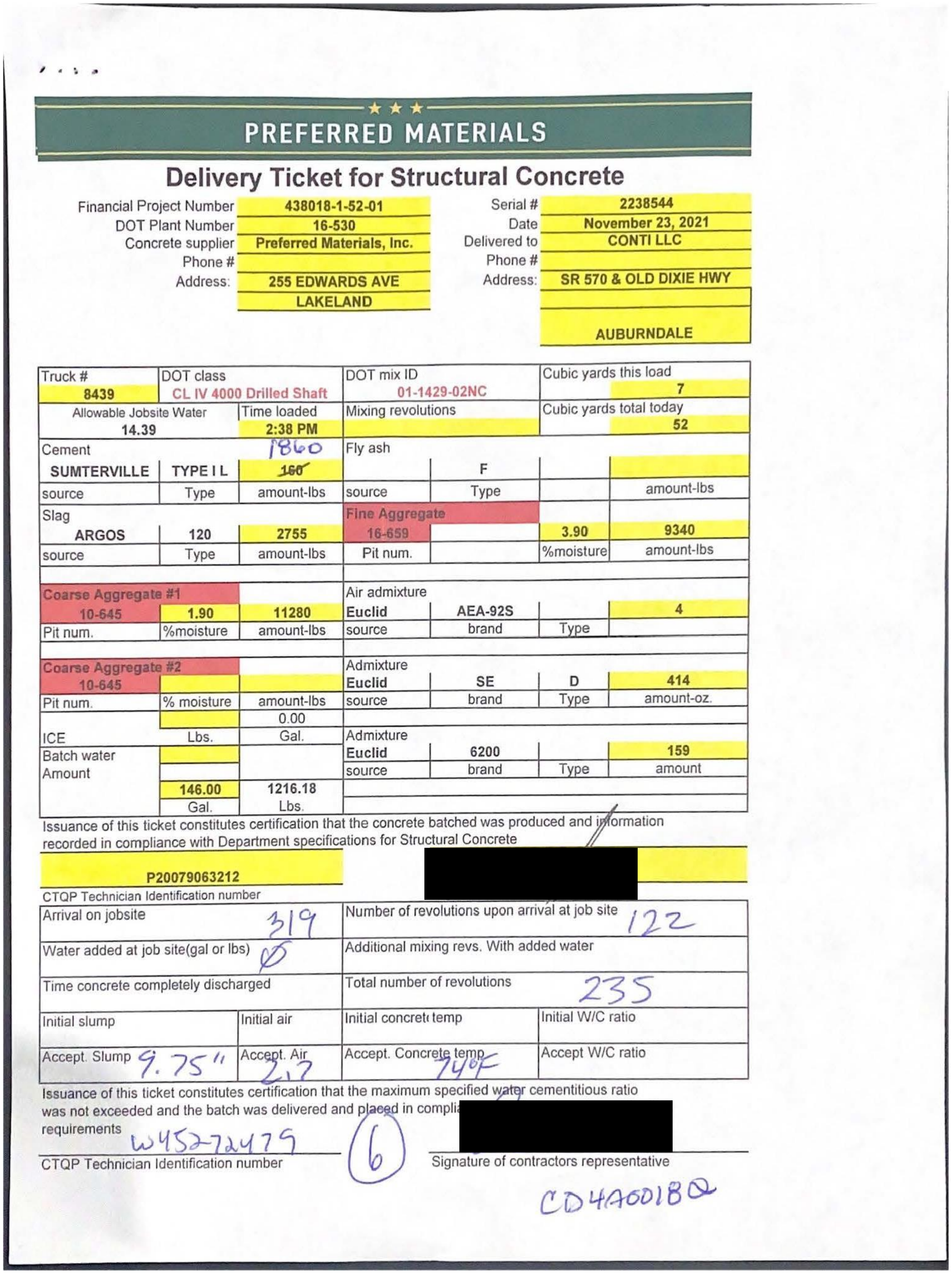
Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in co[redacted]ation requirements

U45272479
CTQP Technician Identification number

Ⓢ

Signature of contractors representative

Figure C.5 OC-19 concrete delivery ticket 5.



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number	438018-1-52-01	Serial #	2238544
DOT Plant Number	16-530	Date	November 23, 2021
Concrete supplier	Preferred Materials, Inc.	Delivered to	CONTI LLC
Phone #		Phone #	
Address:	255 EDWARDS AVE LAKELAND	Address:	SR 570 & OLD DIXIE HWY AUBURNDALE

Truck # 8439	DOT class CL IV 4000 Drilled Shaft		DOT mix ID 01-1429-02NC		Cubic yards this load 7	
Allowable Jobsite Water 14.39		Time loaded 2:38 PM	Mixing revolutions		Cubic yards total today 52	
Cement		1860	Fly ash			
SUMTERVILLE	TYPE I L	~~160~~		F		
source	Type	amount-lbs	source	Type		amount-lbs
Slag			Fine Aggregate			
ARGOS	120	2755	16-659		3.90	9340
source	Type	amount-lbs	Pit num.		%moisture	amount-lbs
Coarse Aggregate #1			Air admixture			
10-645	1.90	11280	Euclid	AEA-92S		4
Pit num.	%moisture	amount-lbs	source	brand	Type	
Coarse Aggregate #2			Admixture			
10-645			Euclid	SE	D	414
Pit num.	% moisture	amount-lbs	source	brand	Type	amount-oz.
		0.00				
ICE	Lbs.	Gal.	Admixture			
Batch water			Euclid	6200		159
Amount			source	brand	Type	amount
	146.00	1216.18				
	Gal.	Lbs.				

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structural Concrete

P20079063212 [redacted]

CTQP Technician Identification number

Arrival on jobsite 319		Number of revolutions upon arrival at job site 122	
Water added at job site(gal or lbs) 0		Additional mixing revs. With added water	
Time concrete completely discharged		Total number of revolutions 235	
Initial slump	Initial air	Initial concrete temp	Initial W/C ratio
Accept. Slump 9.75"	Accept. Air 2.7	Accept. Concrete temp 74°F	Accept W/C ratio

Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in compli[redacted] requirements

W45272479

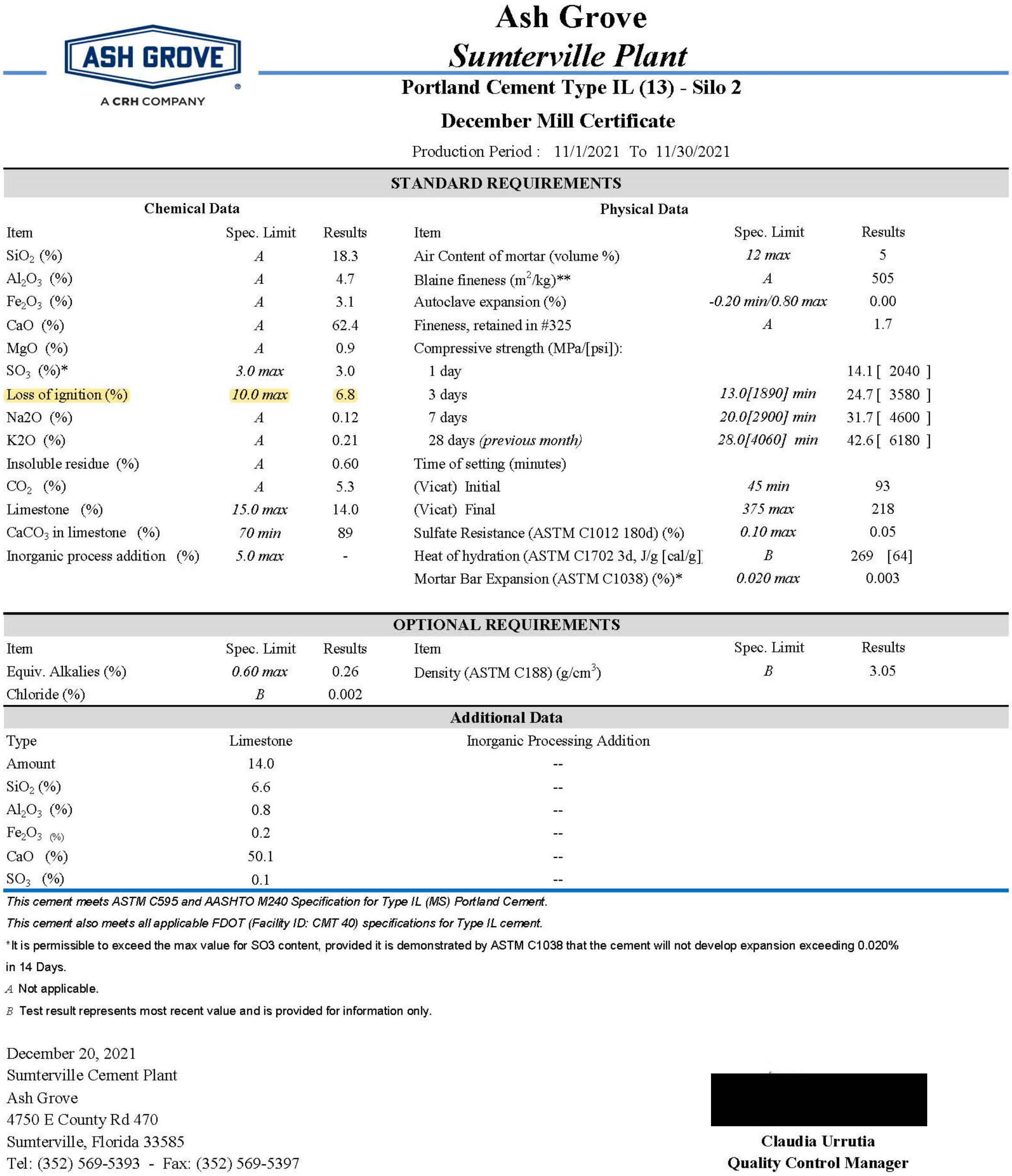
CTQP Technician Identification number

(6)

Signature of contractors representative

CD4A001BQ

Figure C.6 OC-19 concrete delivery ticket 6.



Ash Grove
Sumterville Plant

Portland Cement Type IL (13) - Silo 2

December Mill Certificate

Production Period : 11/1/2021 To 11/30/2021

STANDARD REQUIREMENTS

Chemical Data			Physical Data		
Item	Spec. Limit	Results	Item	Spec. Limit	Results
SiO_2 (%)	*A*	18.3	Air Content of mortar (volume %)	*12 max*	5
Al_2O_3 (%)	*A*	4.7	Blaine fineness (m^2/kg)**	*A*	505
Fe_2O_3 (%)	*A*	3.1	Autoclave expansion (%)	*-0.20 min/0.80 max*	0.00
CaO (%)	*A*	62.4	Fineness, retained in #325	*A*	1.7
MgO (%)	*A*	0.9	Compressive strength (MPa/[psi]):		
SO_3 (%)*	*3.0 max*	3.0	1 day		14.1 [2040]
Loss of ignition (%)	*10.0 max*	6.8	3 days	*13.0[1890] min*	24.7 [3580]
Na2O (%)	*A*	0.12	7 days	*20.0[2900] min*	31.7 [4600]
K2O (%)	*A*	0.21	28 days *(previous month)*	*28.0[4060] min*	42.6 [6180]
Insoluble residue (%)	*A*	0.60	Time of setting (minutes)		
CO_2 (%)	*A*	5.3	(Vicat) Initial	*45 min*	93
Limestone (%)	*15.0 max*	14.0	(Vicat) Final	*375 max*	218
$CaCO_3$ in limestone (%)	*70 min*	89	Sulfate Resistance (ASTM C1012 180d) (%)	*0.10 max*	0.05
Inorganic process addition (%)	*5.0 max*	-	Heat of hydration (ASTM C1702 3d, J/g [cal/g]	*B*	269 [64]
			Mortar Bar Expansion (ASTM C1038) (%)*	*0.020 max*	0.003

OPTIONAL REQUIREMENTS

Item	Spec. Limit	Results	Item	Spec. Limit	Results
Equiv. Alkalies (%)	*0.60 max*	0.26	Density (ASTM C188) (g/cm^3)	*B*	3.05
Chloride (%)	*B*	0.002			

Additional Data

Type	Limestone	Inorganic Processing Addition
Amount	14.0	--
SiO_2 (%)	6.6	--
Al_2O_3 (%)	0.8	--
Fe_2O_3 (%)	0.2	--
CaO (%)	50.1	--
SO_3 (%)	0.1	--

This cement meets ASTM C595 and AASHTO M240 Specification for Type IL (MS) Portland Cement.

This cement also meets all applicable FDOT (Facility ID: CMT 40) specifications for Type IL cement.

*It is permissible to exceed the max value for SO3 content, provided it is demonstrated by ASTM C1038 that the cement will not develop expansion exceeding 0.020% in 14 Days.

A Not applicable.

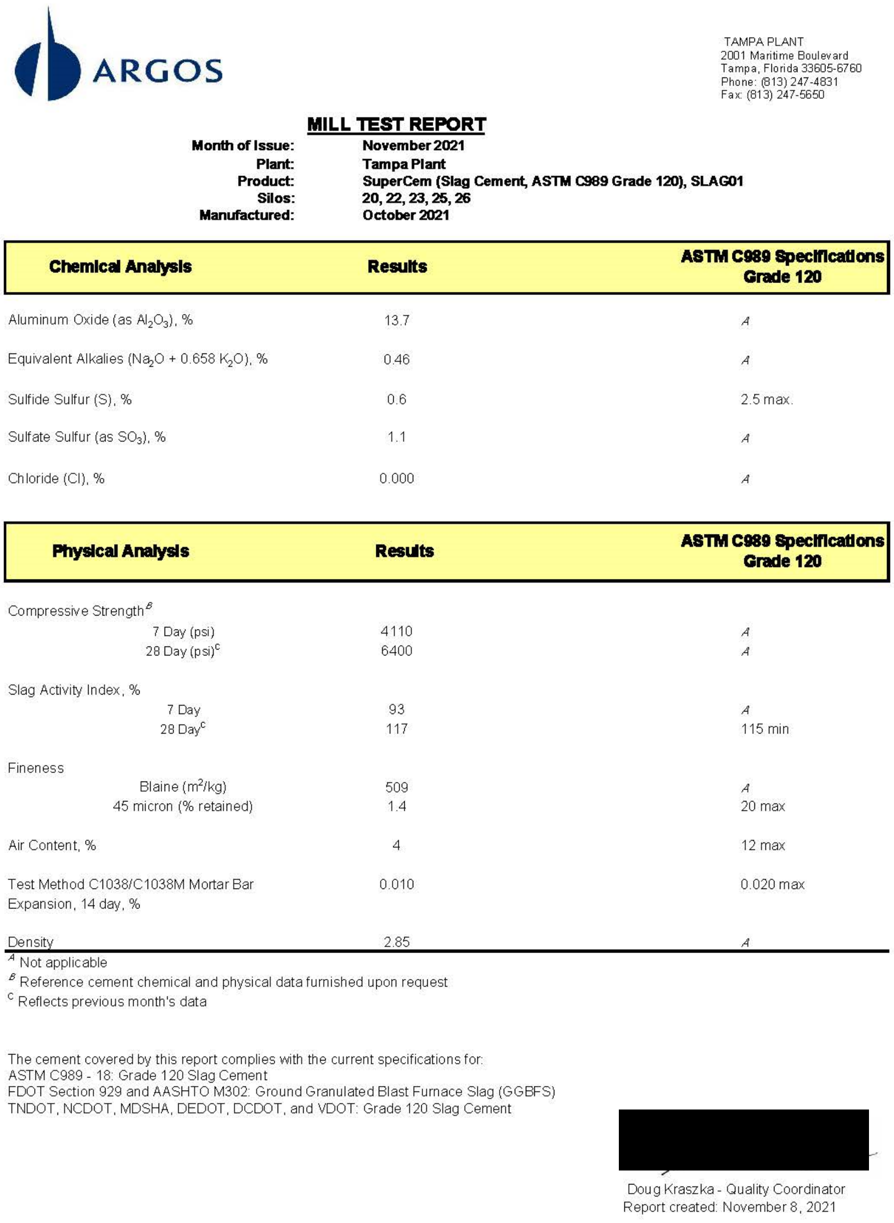
B Test result represents most recent value and is provided for information only.

December 20, 2021
Sumterville Cement Plant
Ash Grove
4750 E County Rd 470
Sumterville, Florida 33585
Tel: (352) 569-5393 - Fax: (352) 569-5397

[redacted]

Claudia Urrutia
Quality Control Manager

Figure C.7 OC-19 Type IL cement mill certificate.



ARGOS

TAMPA PLANT
2001 Maritime Boulevard
Tampa, Florida 33605-6760
Phone: (813) 247-4831
Fax: (813) 247-5650

MILL TEST REPORT

Month of Issue: **November 2021**
Plant: **Tampa Plant**
Product: **SuperCem (Slag Cement, ASTM C989 Grade 120), SLAG01**
Silos: **20, 22, 23, 25, 26**
Manufactured: **October 2021**

Chemical Analysis	**Results**	**ASTM C989 Specifications Grade 120**
Aluminum Oxide (as Al_2O_3), %	13.7	*A*
Equivalent Alkalies (Na_2O + 0.658 K_2O), %	0.46	*A*
Sulfide Sulfur (S), %	0.6	2.5 max.
Sulfate Sulfur (as SO_3), %	1.1	*A*
Chloride (Cl), %	0.000	*A*

Physical Analysis	**Results**	**ASTM C989 Specifications Grade 120**
Compressive Strength^{B}		
7 Day (psi)	4110	*A*
28 Day (psi)^{C}	6400	*A*
Slag Activity Index, %		
7 Day	93	*A*
28 Day^{C}	117	115 min
Fineness		
Blaine (m^2/kg)	509	*A*
45 micron (% retained)	1.4	20 max
Air Content, %	4	12 max
Test Method C1038/C1038M Mortar Bar Expansion, 14 day, %	0.010	0.020 max
Density	2.85	*A*

[A] Not applicable

[B] Reference cement chemical and physical data furnished upon request

[C] Reflects previous month's data

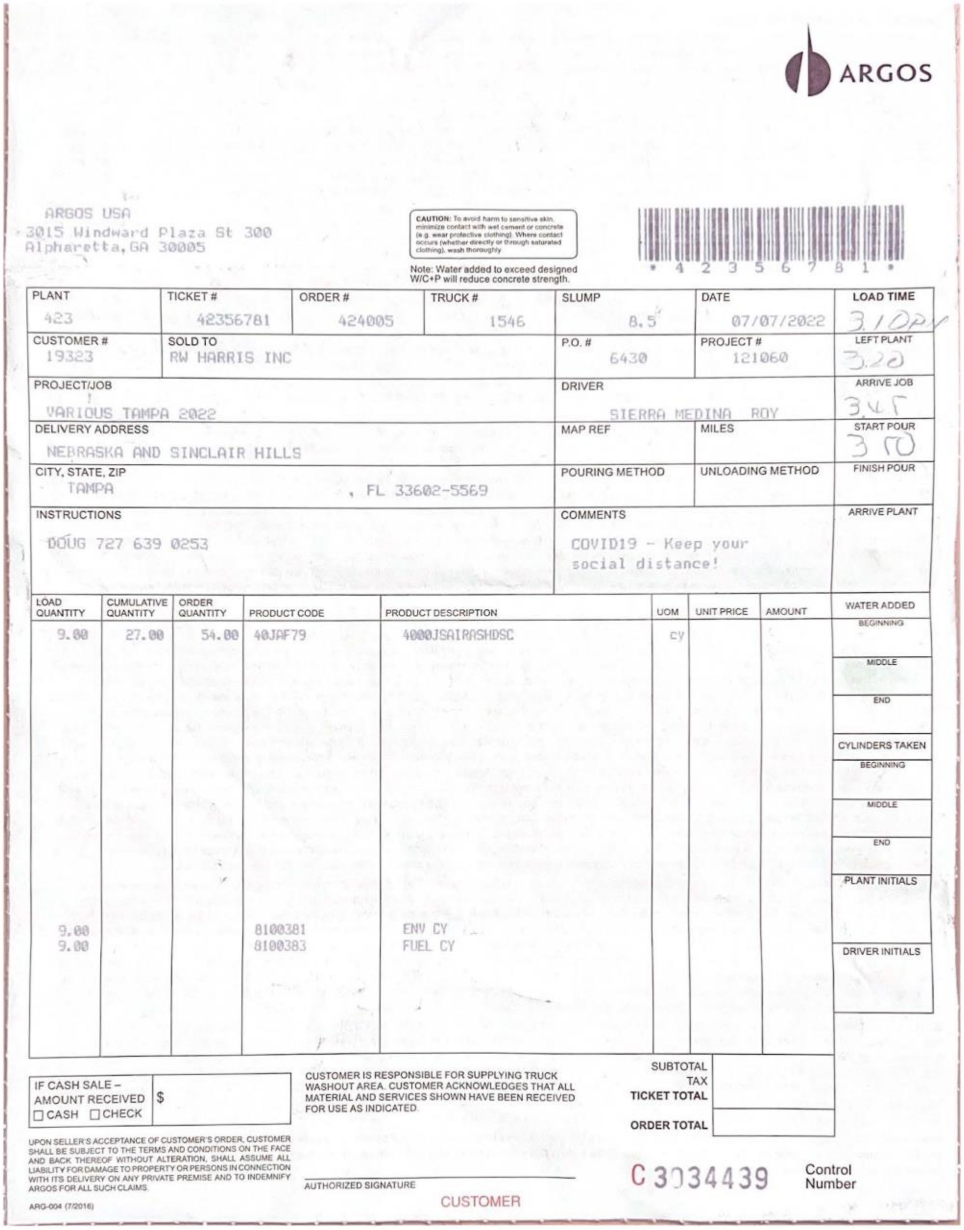
The cement covered by this report complies with the current specifications for:
ASTM C989 - 18: Grade 120 Slag Cement
FDOT Section 929 and AASHTO M302: Ground Granulated Blast Furnace Slag (GGBFS)
TNDOT, NCDOT, MDSHA, DEDOT, DCDOT, and VDOT: Grade 120 Slag Cement

[redacted]

Doug Kraszka - Quality Coordinator
Report created: November 8, 2021

Figure C.8 OC-19 slag mill certificate.

Appendix D: N. Florida and Sinclair Hills Drilled Shaft Construction Documents



ARGOS

ARGOS USA
3015 Windward Plaza St 300
Alpharetta, GA 30005

CAUTION: To avoid harm to sensitive skin, minimize contact with wet cement or concrete (e.g. wear protective clothing). Where contact occurs (whether directly or through saturated clothing), wash thoroughly.

Note: Water added to exceed designed W/C+P will reduce concrete strength.

* 4 2 3 5 6 7 8 1 *

PLANT	TICKET #	ORDER #	TRUCK #	SLUMP	DATE	LOAD TIME
423	42356781	424005	1546	8.5	07/07/2022	3.10PM

CUSTOMER # 19323

SOLD TO RW HARRIS INC

P.O. # 6430

PROJECT # 121060

LEFT PLANT 3.20

PROJECT/JOB VARIOUS TAMPA 2022

DRIVER SIERRA MEDINA ROY

ARRIVE JOB 345

DELIVERY ADDRESS NEBRASKA AND SINCLAIR HILLS

MAP REF

MILES

START POUR 350

CITY, STATE, ZIP TAMPA , FL 33602-5569

POURING METHOD

UNLOADING METHOD

FINISH POUR

INSTRUCTIONS DOUG 727 639 0253

COMMENTS COVID19 - Keep your social distance!

ARRIVE PLANT

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDER QUANTITY	PRODUCT CODE	PRODUCT DESCRIPTION	UOM	UNIT PRICE	AMOUNT
9.00	27.00	54.00	40JAF79	4000JSAIRASHDSC	cy		
9.00			8100381	ENV CY			
9.00			8100383	FUEL CY			

WATER ADDED
BEGINNING
MIDDLE
END

CYLINDERS TAKEN
BEGINNING
MIDDLE
END

PLANT INITIALS

DRIVER INITIALS

IF CASH SALE – AMOUNT RECEIVED $
☐ CASH ☐ CHECK

CUSTOMER IS RESPONSIBLE FOR SUPPLYING TRUCK WASHOUT AREA. CUSTOMER ACKNOWLEDGES THAT ALL MATERIAL AND SERVICES SHOWN HAVE BEEN RECEIVED FOR USE AS INDICATED.

SUBTOTAL
TAX
TICKET TOTAL
ORDER TOTAL

UPON SELLER'S ACCEPTANCE OF CUSTOMER'S ORDER, CUSTOMER SHALL BE SUBJECT TO THE TERMS AND CONDITIONS ON THE FACE AND BACK THEREOF WITHOUT ALTERATION, SHALL ASSUME ALL LIABILITY FOR DAMAGE TO PROPERTY OR PERSONS IN CONNECTION WITH ITS DELIVERY ON ANY PRIVATE PREMISE AND TO INDEMNIFY ARGOS FOR ALL SUCH CLAIMS.

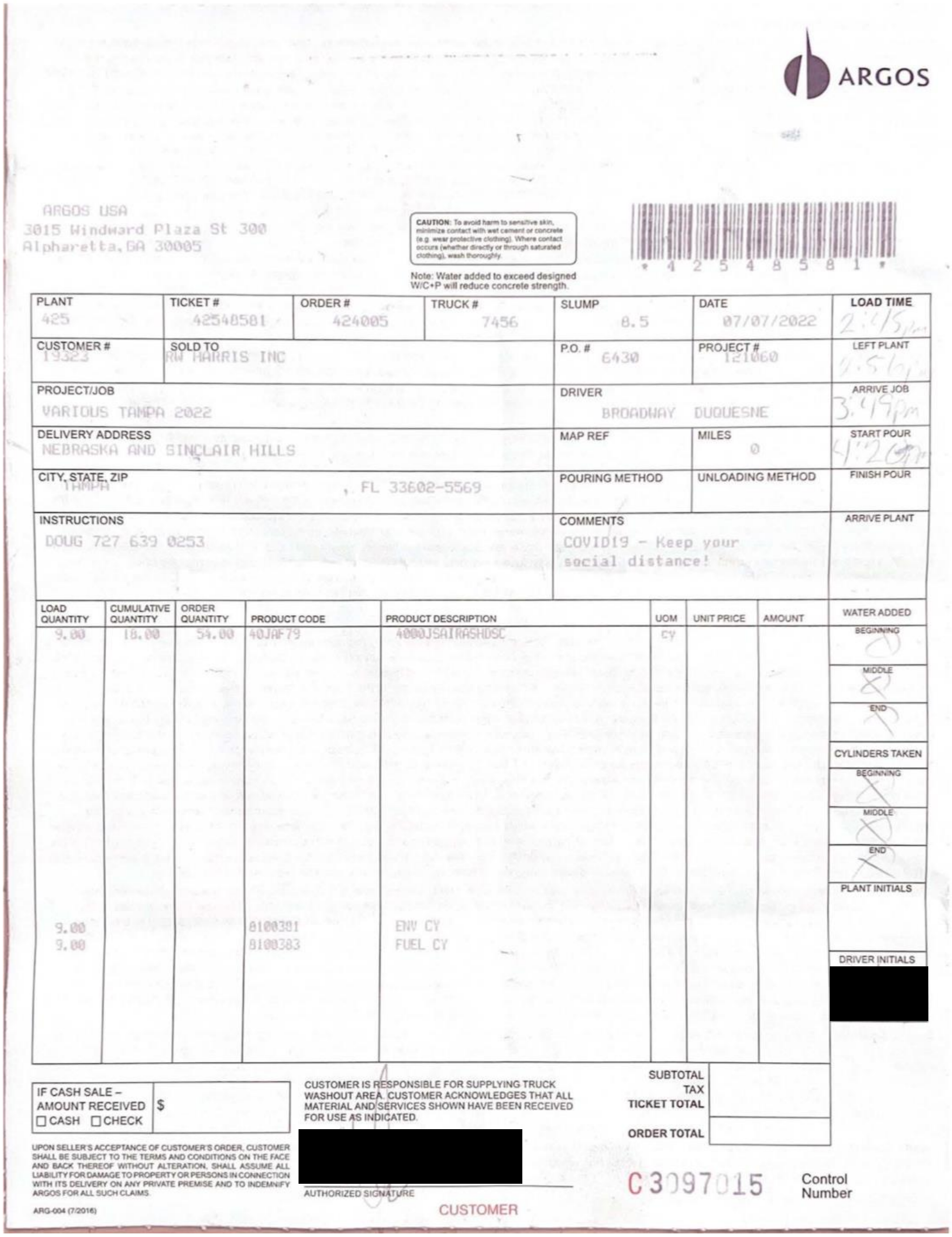
AUTHORIZED SIGNATURE

C 3034439 Control Number

CUSTOMER

ARG-004 (7/2016)

Figure D.1 Sinclair Hills drilled shaft concrete delivery ticket 1.



ARGOS

ARGOS USA
3015 Windward Plaza St 300
Alpharetta, GA 30005

CAUTION: To avoid harm to sensitive skin, minimize contact with wet cement or concrete (e.g. wear protective clothing). Where contact occurs (whether directly or through saturated clothing), wash thoroughly.

Note: Water added to exceed designed W/C+P will reduce concrete strength.

* 4 2 5 4 8 5 8 1 *

PLANT: 425
TICKET #: 42548581
ORDER #: 424005
TRUCK #: 7456
SLUMP: 8.5
DATE: 07/07/2022
LOAD TIME: 2:45pm
CUSTOMER #: 19323
SOLD TO: RW HARRIS INC
P.O. #: 6430
PROJECT #: 121060
LEFT PLANT: 2:56pm
PROJECT/JOB: VARIOUS TAMPA 2022
DRIVER: BROADWAY DUQUESNE
ARRIVE JOB: 3:49pm
DELIVERY ADDRESS: NEBRASKA AND SINCLAIR HILLS
MAP REF:
MILES: 0
START POUR: 4:20pm
CITY, STATE, ZIP: TAMPA, FL 33602-5569
POURING METHOD:
UNLOADING METHOD:
FINISH POUR:
INSTRUCTIONS: DOUG 727 639 0253
COMMENTS: COVID19 - Keep your social distance!
ARRIVE PLANT:

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDER QUANTITY	PRODUCT CODE	PRODUCT DESCRIPTION	UOM	UNIT PRICE	AMOUNT
9.00	18.00	54.00	40JAF79	4000JSAIRASHDSC	CY		
9.00			8100381	ENV CY			
9.00			8100383	FUEL CY			

WATER ADDED
BEGINNING
MIDDLE
END

CYLINDERS TAKEN
BEGINNING
MIDDLE
END

PLANT INITIALS

DRIVER INITIALS
[redacted]

IF CASH SALE – AMOUNT RECEIVED $
☐ CASH ☐ CHECK

UPON SELLER'S ACCEPTANCE OF CUSTOMER'S ORDER, CUSTOMER SHALL BE SUBJECT TO THE TERMS AND CONDITIONS ON THE FACE AND BACK THEREOF WITHOUT ALTERATION, SHALL ASSUME ALL LIABILITY FOR DAMAGE TO PROPERTY OR PERSONS IN CONNECTION WITH ITS DELIVERY ON ANY PRIVATE PREMISE AND TO INDEMNIFY ARGOS FOR ALL SUCH CLAIMS.

ARG-004 (7/2016)

CUSTOMER IS RESPONSIBLE FOR SUPPLYING TRUCK WASHOUT AREA. CUSTOMER ACKNOWLEDGES THAT ALL MATERIAL AND SERVICES SHOWN HAVE BEEN RECEIVED FOR USE AS INDICATED.

[redacted]

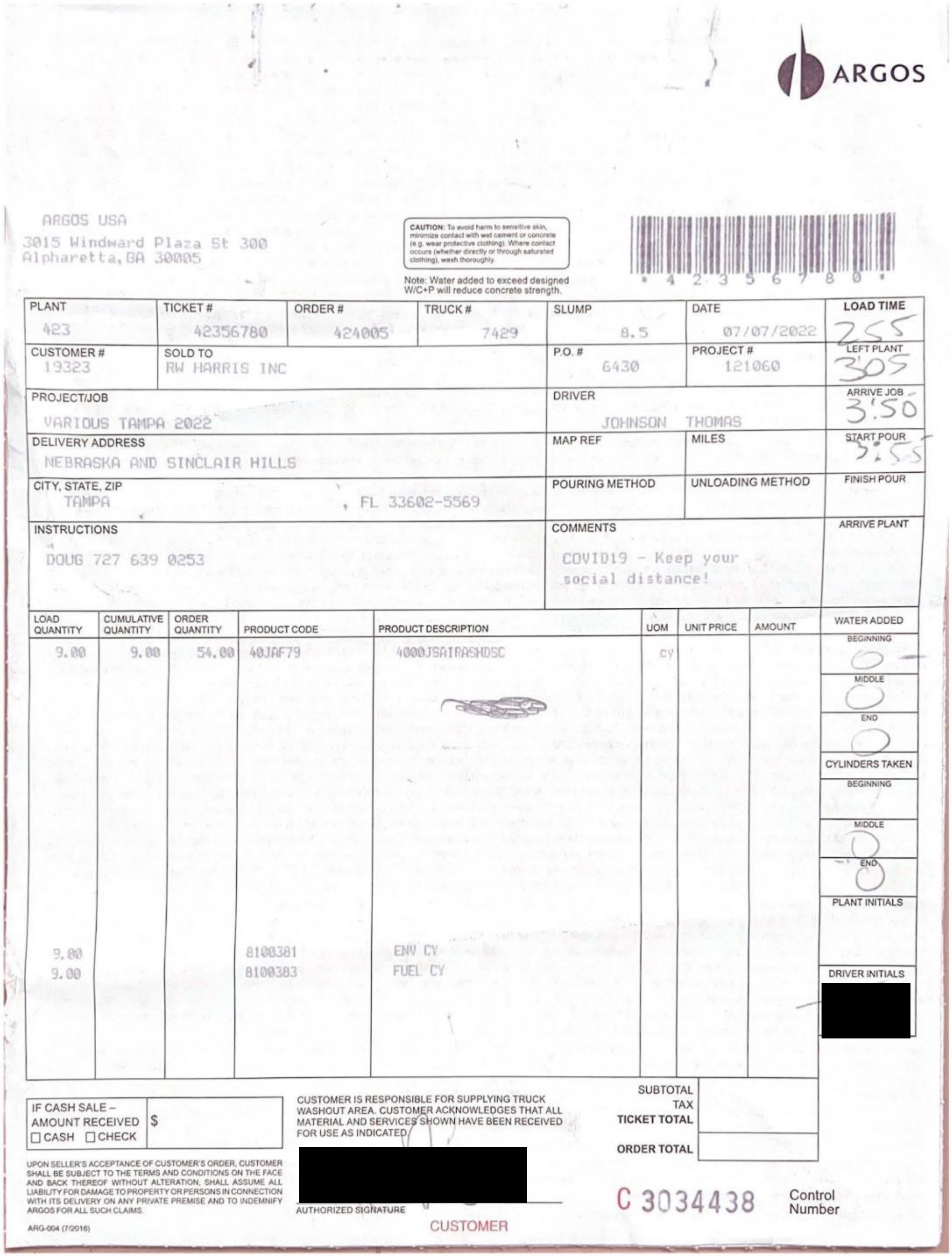
AUTHORIZED SIGNATURE

CUSTOMER

SUBTOTAL
TAX
TICKET TOTAL
ORDER TOTAL

C3097015 Control Number

Figure D.2 Sinclair Hills drilled shaft concrete delivery ticket 2.



ARGOS

ARGOS USA
3015 Windward Plaza St 300
Alpharetta, GA 30005

CAUTION: To avoid harm to sensitive skin, minimize contact with wet cement or concrete (e.g. wear protective clothing). Where contact occurs (whether directly or through saturated clothing), wash thoroughly.

Note: Water added to exceed designed W/C+P will reduce concrete strength.

* 4 2 3 5 6 7 8 0 *

PLANT: 423
TICKET #: 42356780
ORDER #: 424005
TRUCK #: 7429
SLUMP: 8.5
DATE: 07/07/2022
LOAD TIME: 255
CUSTOMER #: 19323
SOLD TO: RW HARRIS INC
P.O. #: 6430
PROJECT #: 121060
LEFT PLANT: 305
PROJECT/JOB: VARIOUS TAMPA 2022
DRIVER: JOHNSON THOMAS
ARRIVE JOB: 3:50
DELIVERY ADDRESS: NEBRASKA AND SINCLAIR HILLS
MAP REF:
MILES:
START POUR: 3:55
CITY, STATE, ZIP: TAMPA , FL 33602-5569
POURING METHOD:
UNLOADING METHOD:
FINISH POUR:
INSTRUCTIONS: DOUG 727 639 0253
COMMENTS: COVID19 - Keep your social distance!
ARRIVE PLANT:

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDER QUANTITY	PRODUCT CODE	PRODUCT DESCRIPTION	UOM	UNIT PRICE	AMOUNT
9.00	9.00	54.00	40JAF79	4000JSAIRASHDSC	CY		
9.00			8100381	ENV CY			
9.00			8100383	FUEL CY			

WATER ADDED
BEGINNING: 0
MIDDLE: 0
END: 0

CYLINDERS TAKEN
BEGINNING:
MIDDLE: 0
END: 0

PLANT INITIALS:

DRIVER INITIALS: [redacted]

IF CASH SALE – AMOUNT RECEIVED $
☐ CASH ☐ CHECK

CUSTOMER IS RESPONSIBLE FOR SUPPLYING TRUCK WASHOUT AREA. CUSTOMER ACKNOWLEDGES THAT ALL MATERIAL AND SERVICES SHOWN HAVE BEEN RECEIVED FOR USE AS INDICATED.

SUBTOTAL
TAX
TICKET TOTAL
ORDER TOTAL

UPON SELLER'S ACCEPTANCE OF CUSTOMER'S ORDER, CUSTOMER SHALL BE SUBJECT TO THE TERMS AND CONDITIONS ON THE FACE AND BACK THEREOF WITHOUT ALTERATION, SHALL ASSUME ALL LIABILITY FOR DAMAGE TO PROPERTY OR PERSONS IN CONNECTION WITH ITS DELIVERY ON ANY PRIVATE PREMISE AND TO INDEMNIFY ARGOS FOR ALL SUCH CLAIMS.

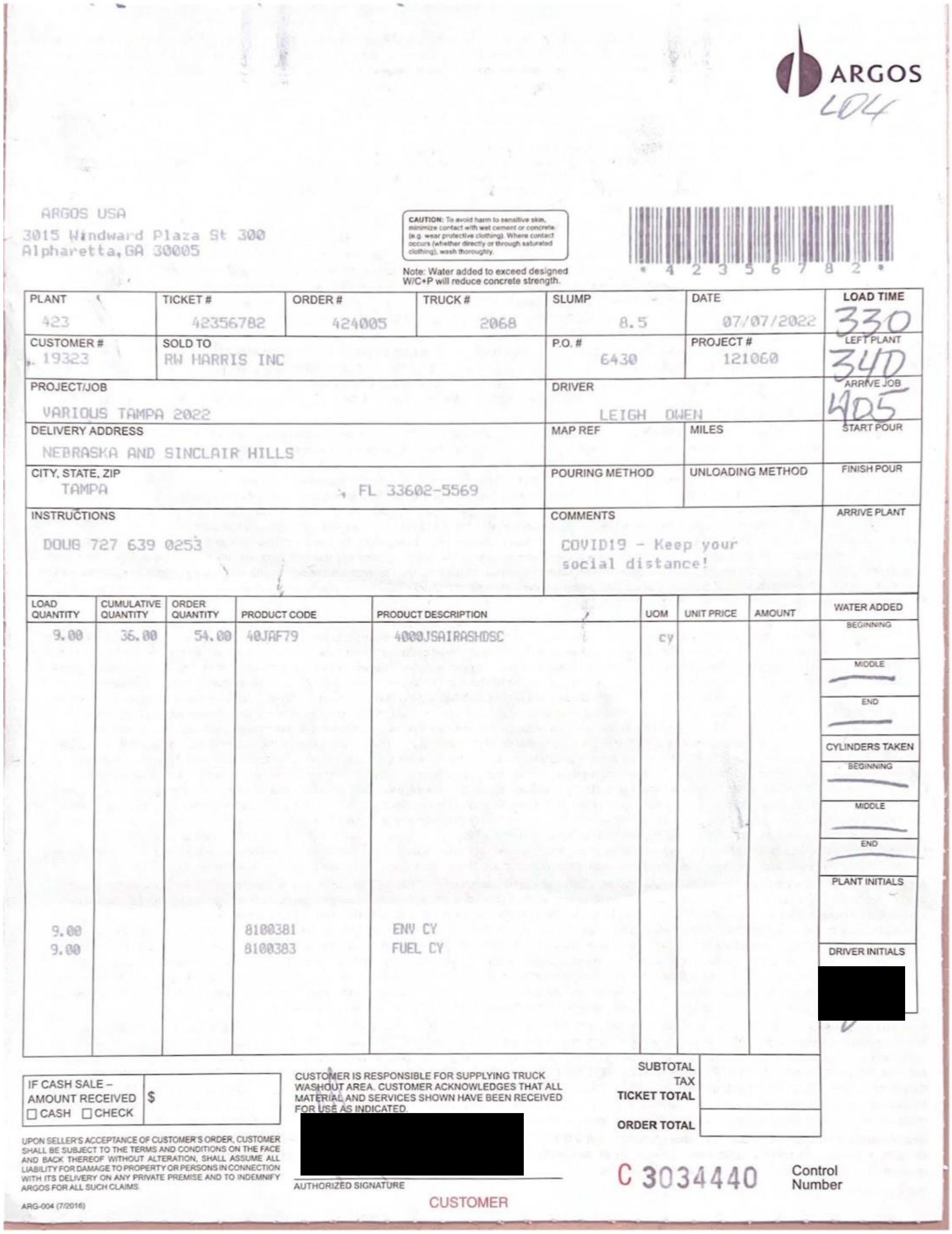
[redacted]
AUTHORIZED SIGNATURE

C 3034438 Control Number

ARG-004 (7/2016)

CUSTOMER

Figure D.3 Sinclair Hills drilled shaft concrete delivery ticket 3.



ARGOS

404

ARGOS USA
3015 Windward Plaza St 300
Alpharetta, GA 30005

CAUTION: To avoid harm to sensitive skin, minimize contact with wet cement or concrete (e.g. wear protective clothing). Where contact occurs (whether directly or through saturated clothing), wash thoroughly.

Note: Water added to exceed designed W/C+P will reduce concrete strength.

* 4 2 3 5 6 7 8 2 *

PLANT	TICKET #	ORDER #	TRUCK #	SLUMP	DATE	LOAD TIME
423	42356782	424005	2068	8.5	07/07/2022	330

CUSTOMER #: 19323
SOLD TO: RW HARRIS INC
P.O. #: 6430
PROJECT #: 121060
LEFT PLANT: 340
PROJECT/JOB: VARIOUS TAMPA 2022
DRIVER: LEIGH OWEN
ARRIVE JOB: 405
DELIVERY ADDRESS: NEBRASKA AND SINCLAIR HILLS
MAP REF:
MILES:
START POUR:
CITY, STATE, ZIP: TAMPA , FL 33602-5569
POURING METHOD:
UNLOADING METHOD:
FINISH POUR:
INSTRUCTIONS: DOUG 727 639 0253
COMMENTS: COVID19 - Keep your social distance!
ARRIVE PLANT:

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDER QUANTITY	PRODUCT CODE	PRODUCT DESCRIPTION	UOM	UNIT PRICE	AMOUNT
9.00	36.00	54.00	40JAF79	4000JSAIRASHDSC	cy		
9.00			8100381	ENV CY			
9.00			8100383	FUEL CY			

WATER ADDED
BEGINNING
MIDDLE
END

CYLINDERS TAKEN
BEGINNING
MIDDLE
END

PLANT INITIALS

DRIVER INITIALS [redacted]

IF CASH SALE – AMOUNT RECEIVED $
☐ CASH ☐ CHECK

UPON SELLER'S ACCEPTANCE OF CUSTOMER'S ORDER, CUSTOMER SHALL BE SUBJECT TO THE TERMS AND CONDITIONS ON THE FACE AND BACK THEREOF WITHOUT ALTERATION, SHALL ASSUME ALL LIABILITY FOR DAMAGE TO PROPERTY OR PERSONS IN CONNECTION WITH ITS DELIVERY ON ANY PRIVATE PREMISE AND TO INDEMNIFY ARGOS FOR ALL SUCH CLAIMS.

ARG-004 (7/2016)

CUSTOMER IS RESPONSIBLE FOR SUPPLYING TRUCK WASHOUT AREA. CUSTOMER ACKNOWLEDGES THAT ALL MATERIAL AND SERVICES SHOWN HAVE BEEN RECEIVED FOR USE AS INDICATED.

[redacted]

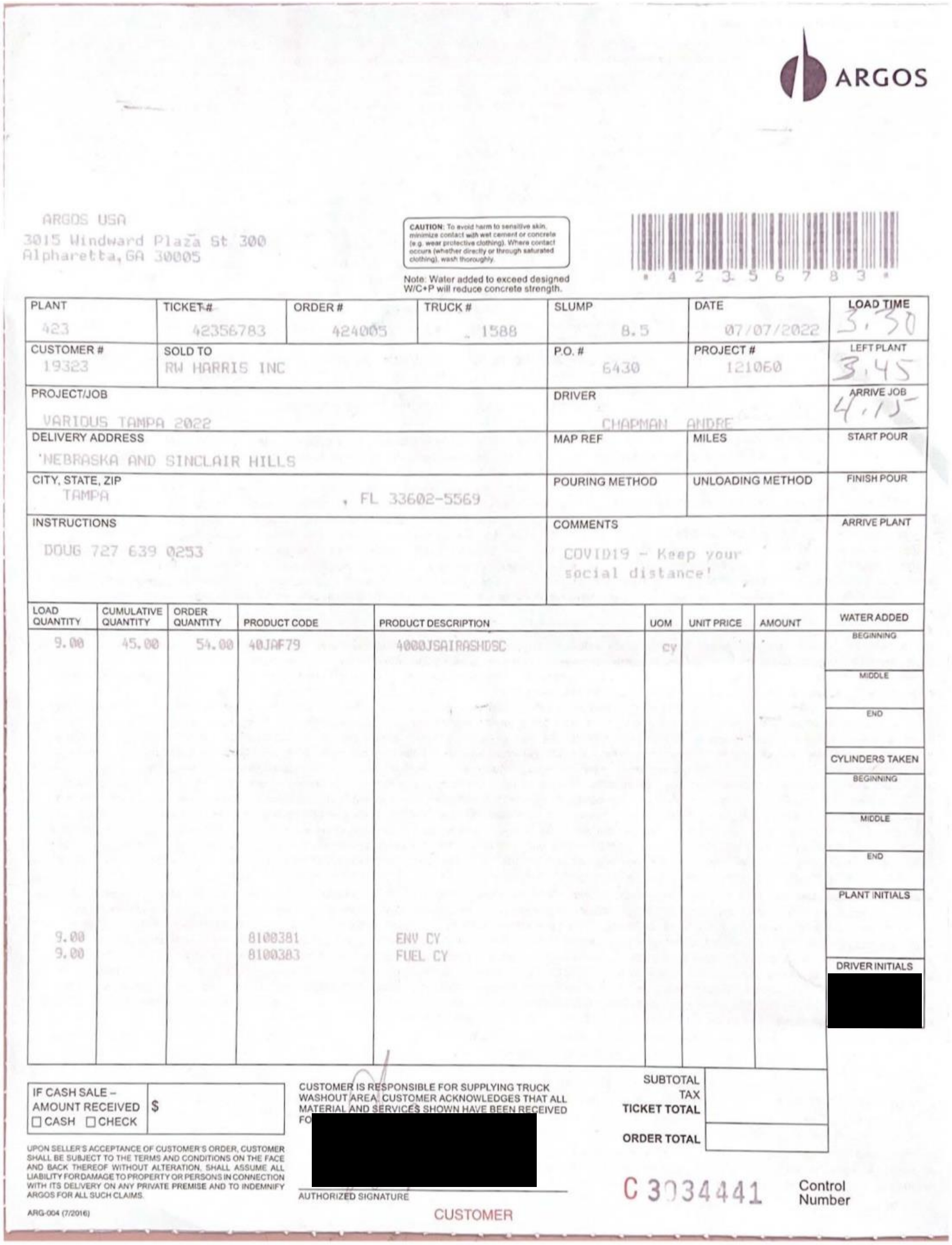
AUTHORIZED SIGNATURE

CUSTOMER

SUBTOTAL
TAX
TICKET TOTAL
ORDER TOTAL

C 3034440 Control Number

Figure D.4 Sinclair Hills drilled shaft concrete delivery ticket 4.



ARGOS

ARGOS USA
3015 Windward Plaza St 300
Alpharetta, GA 30005

CAUTION: To avoid harm to sensitive skin, minimize contact with wet cement or concrete (e.g. wear protective clothing). Where contact occurs (whether directly or through saturated clothing), wash thoroughly.

Note: Water added to exceed designed W/C+P will reduce concrete strength.

* 4 2 3 5 6 7 8 3 *

PLANT	TICKET #	ORDER #	TRUCK #	SLUMP	DATE	LOAD TIME
423	42356783	424005	1588	8.5	07/07/2022	3:30

CUSTOMER #: 19323
SOLD TO: RW HARRIS INC
P.O. #: 6430
PROJECT #: 121060
LEFT PLANT: 3:45
PROJECT/JOB: VARIOUS TAMPA 2022
DRIVER: CHAPMAN ANDRE
ARRIVE JOB: 4:15
DELIVERY ADDRESS: 'NEBRASKA AND SINCLAIR HILLS
MAP REF:
MILES:
START POUR:
CITY, STATE, ZIP: TAMPA , FL 33602-5569
POURING METHOD:
UNLOADING METHOD:
FINISH POUR:
INSTRUCTIONS: DOUG 727 639 0253
COMMENTS: COVID19 - Keep your social distance!
ARRIVE PLANT:

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDER QUANTITY	PRODUCT CODE	PRODUCT DESCRIPTION	UOM	UNIT PRICE	AMOUNT
9.00	45.00	54.00	40JAF79	4000JSAIRASHDSC	cy		
9.00			8100381	ENV CY			
9.00			8100383	FUEL CY			

WATER ADDED
BEGINNING
MIDDLE
END

CYLINDERS TAKEN
BEGINNING
MIDDLE
END

PLANT INITIALS

DRIVER INITIALS [redacted]

IF CASH SALE – AMOUNT RECEIVED $
☐ CASH ☐ CHECK

UPON SELLER'S ACCEPTANCE OF CUSTOMER'S ORDER, CUSTOMER SHALL BE SUBJECT TO THE TERMS AND CONDITIONS ON THE FACE AND BACK THEREOF WITHOUT ALTERATION, SHALL ASSUME ALL LIABILITY FOR DAMAGE TO PROPERTY OR PERSONS IN CONNECTION WITH ITS DELIVERY ON ANY PRIVATE PREMISE AND TO INDEMNIFY ARGOS FOR ALL SUCH CLAIMS.

ARG-004 (7/2016)

CUSTOMER IS RESPONSIBLE FOR SUPPLYING TRUCK WASHOUT AREA. CUSTOMER ACKNOWLEDGES THAT ALL MATERIAL AND SERVICES SHOWN HAVE BEEN RECEIVED FO[redacted]

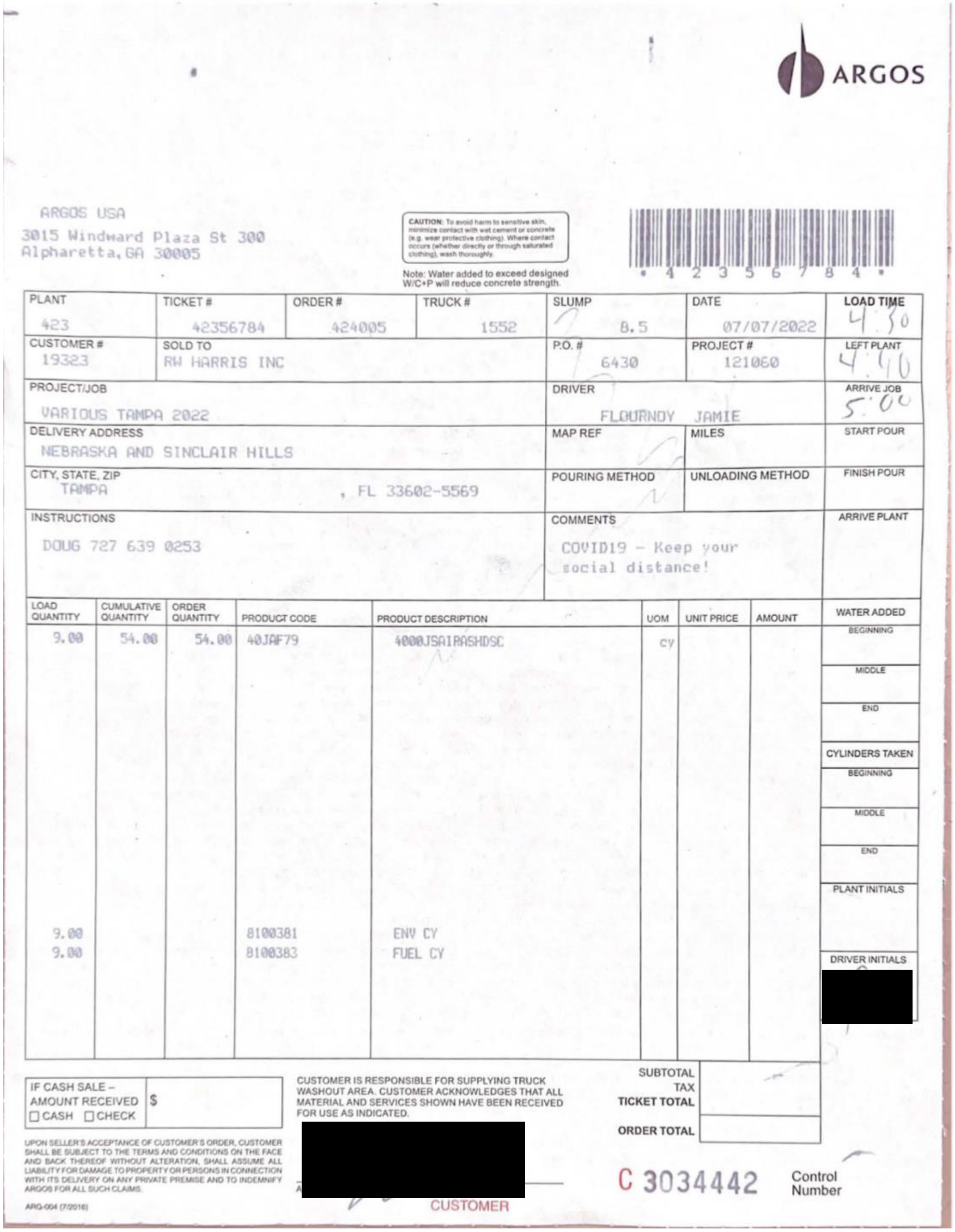
AUTHORIZED SIGNATURE

SUBTOTAL
TAX
TICKET TOTAL
ORDER TOTAL

C 3034441 Control Number

CUSTOMER

Figure D.5 Sinclair Hills drilled shaft concrete delivery ticket 5.



ARGOS

ARGOS USA
3015 Windward Plaza St 300
Alpharetta, GA 30005

CAUTION: To avoid harm to sensitive skin, minimize contact with wet cement or concrete (e.g. wear protective clothing). Where contact occurs (whether directly or through saturated clothing), wash thoroughly.

Note: Water added to exceed designed W/C+P will reduce concrete strength.

* 4 2 3 5 6 7 8 4 *

PLANT: 423
TICKET #: 42356784
ORDER #: 424005
TRUCK #: 1552
SLUMP: 8.5
DATE: 07/07/2022
LOAD TIME: 4:30
CUSTOMER #: 19323
SOLD TO: RW HARRIS INC
P.O. #: 6430
PROJECT #: 121060
LEFT PLANT: 4:40
PROJECT/JOB: VARIOUS TAMPA 2022
DRIVER: FLOURNOY JAMIE
ARRIVE JOB: 5:00
DELIVERY ADDRESS: NEBRASKA AND SINCLAIR HILLS
MAP REF:
MILES:
START POUR:
CITY, STATE, ZIP: TAMPA , FL 33602-5569
POURING METHOD:
UNLOADING METHOD:
FINISH POUR:
INSTRUCTIONS: DOUG 727 639 0253
COMMENTS: COVID19 - Keep your social distance!
ARRIVE PLANT:

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDER QUANTITY	PRODUCT CODE	PRODUCT DESCRIPTION	UOM	UNIT PRICE	AMOUNT
9.00	54.00	54.00	40JAF79	4000JSAIRASHDSC	cy		
9.00			8100381	ENV CY			
9.00			8100383	FUEL CY			

WATER ADDED
BEGINNING
MIDDLE
END

CYLINDERS TAKEN
BEGINNING
MIDDLE
END

PLANT INITIALS

DRIVER INITIALS [redacted]

IF CASH SALE – AMOUNT RECEIVED $
☐ CASH ☐ CHECK

CUSTOMER IS RESPONSIBLE FOR SUPPLYING TRUCK WASHOUT AREA. CUSTOMER ACKNOWLEDGES THAT ALL MATERIAL AND SERVICES SHOWN HAVE BEEN RECEIVED FOR USE AS INDICATED.

SUBTOTAL
TAX
TICKET TOTAL
ORDER TOTAL

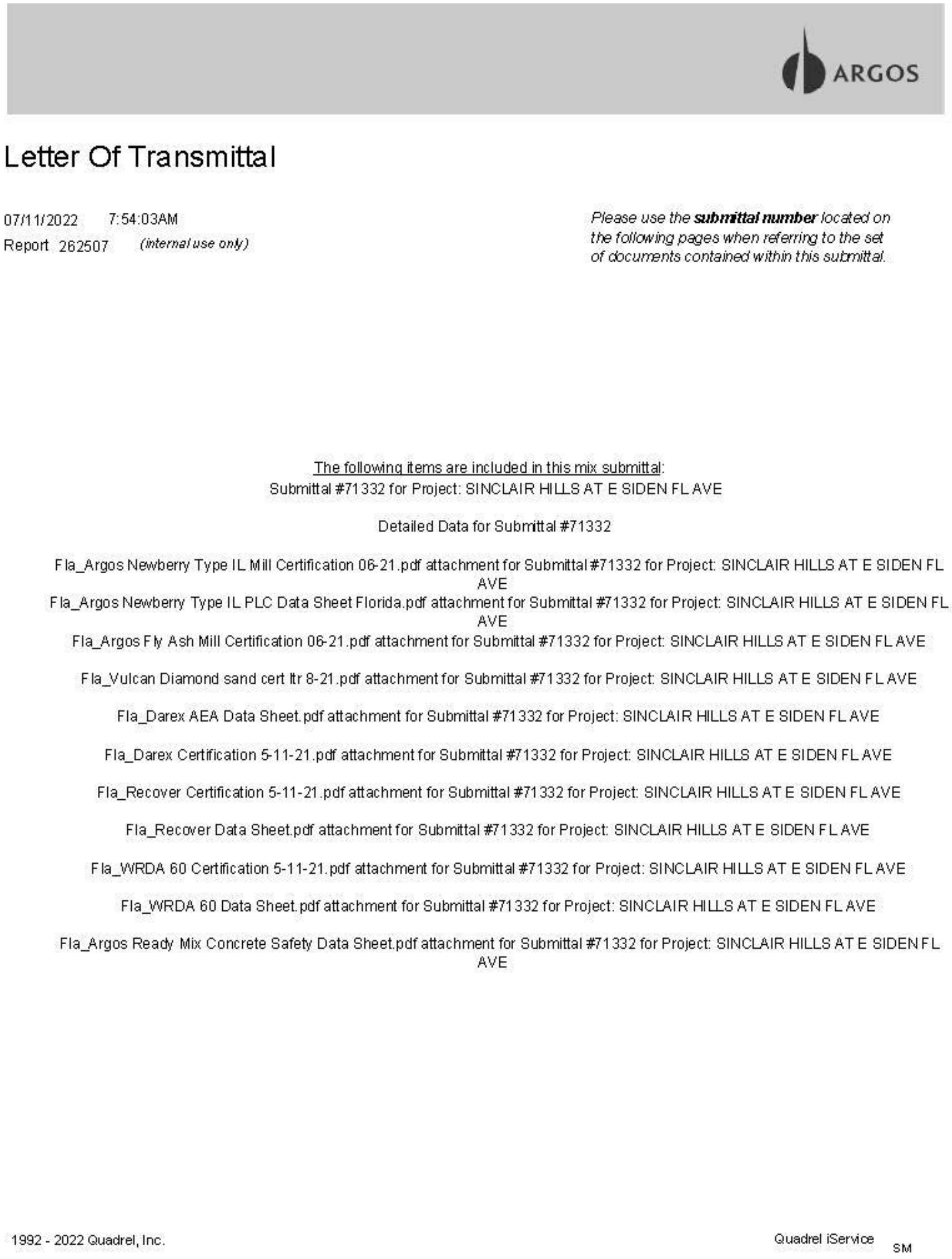
UPON SELLER'S ACCEPTANCE OF CUSTOMER'S ORDER, CUSTOMER SHALL BE SUBJECT TO THE TERMS AND CONDITIONS ON THE FACE AND BACK THEREOF WITHOUT ALTERATION, SHALL ASSUME ALL LIABILITY FOR DAMAGE TO PROPERTY OR PERSONS IN CONNECTION WITH ITS DELIVERY ON ANY PRIVATE PREMISE AND TO INDEMNIFY ARGOS FOR ALL SUCH CLAIMS.

[redacted]
CUSTOMER

C 3034442 Control Number

ARG-004 (7/2016)

Figure D.6 Sinclair Hills drilled shaft concrete delivery ticket 6.



ARGOS

Letter Of Transmittal

07/11/2022 7:54:03AM
Report 262507 *(internal use only)*

*Please use the **submittal number** located on the following pages when referring to the set of documents contained within this submittal.*

The following items are included in this mix submittal:
Submittal #71332 for Project: SINCLAIR HILLS AT E SIDEN FL AVE

Detailed Data for Submittal #71332

Fla_Argos Newberry Type IL Mill Certification 06-21.pdf attachment for Submittal #71332 for Project: SINCLAIR HILLS AT E SIDEN FL AVE

Fla_Argos Newberry Type IL PLC Data Sheet Florida.pdf attachment for Submittal #71332 for Project: SINCLAIR HILLS AT E SIDEN FL AVE

Fla_Argos Fly Ash Mill Certification 06-21.pdf attachment for Submittal #71332 for Project: SINCLAIR HILLS AT E SIDEN FL AVE

Fla_Vulcan Diamond sand cert ltr 8-21.pdf attachment for Submittal #71332 for Project: SINCLAIR HILLS AT E SIDEN FL AVE

Fla_Darex AEA Data Sheet.pdf attachment for Submittal #71332 for Project: SINCLAIR HILLS AT E SIDEN FL AVE

Fla_Darex Certification 5-11-21.pdf attachment for Submittal #71332 for Project: SINCLAIR HILLS AT E SIDEN FL AVE

Fla_Recover Certification 5-11-21.pdf attachment for Submittal #71332 for Project: SINCLAIR HILLS AT E SIDEN FL AVE

Fla_Recover Data Sheet.pdf attachment for Submittal #71332 for Project: SINCLAIR HILLS AT E SIDEN FL AVE

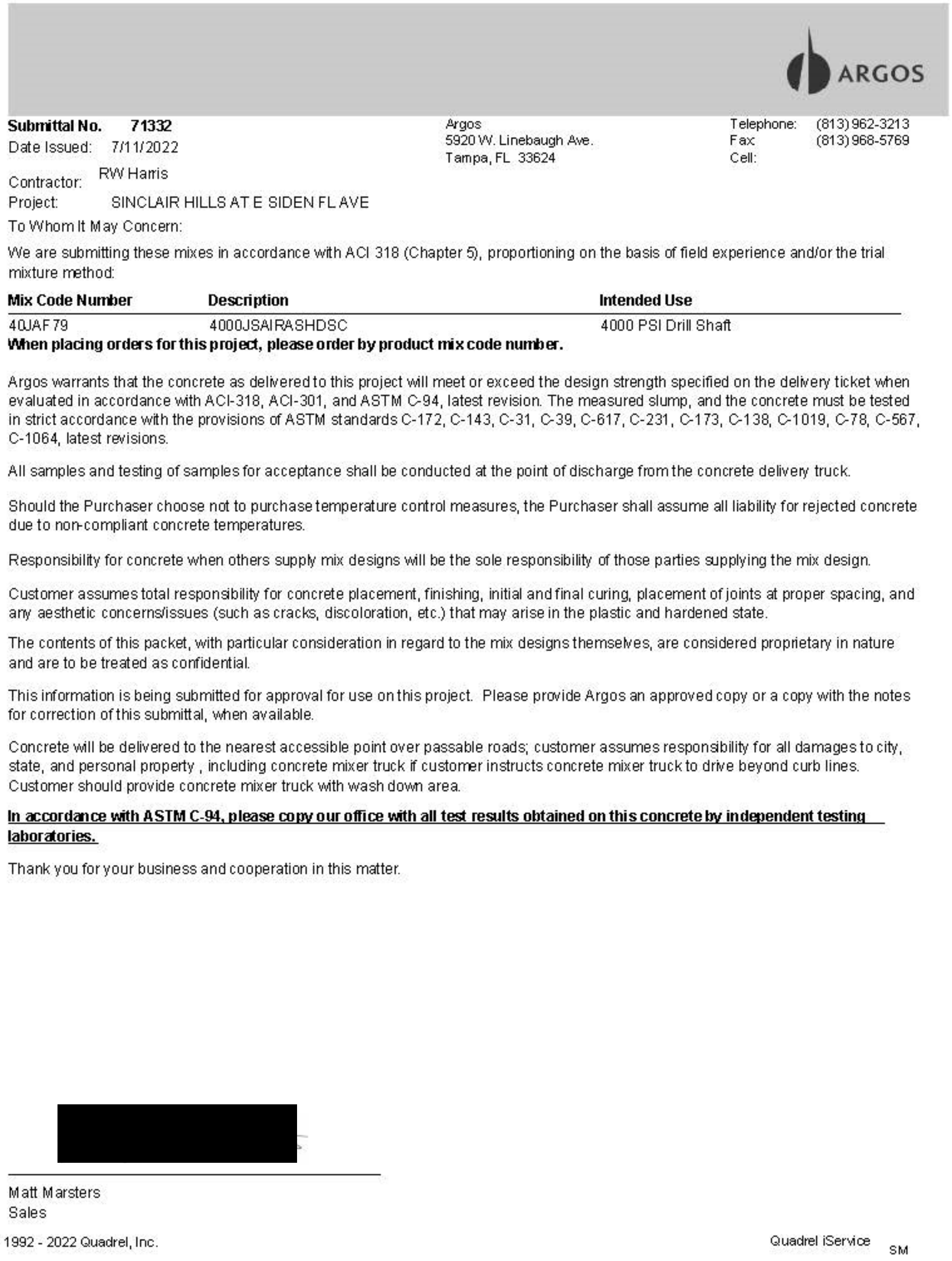
Fla_WRDA 60 Certification 5-11-21.pdf attachment for Submittal #71332 for Project: SINCLAIR HILLS AT E SIDEN FL AVE

Fla_WRDA 60 Data Sheet.pdf attachment for Submittal #71332 for Project: SINCLAIR HILLS AT E SIDEN FL AVE

Fla_Argos Ready Mix Concrete Safety Data Sheet.pdf attachment for Submittal #71332 for Project: SINCLAIR HILLS AT E SIDEN FL AVE

1992 - 2022 Quadrel, Inc. Quadrel iService SM

Figure D.7 Sinclair Hills drilled shaft certification data submittal page 1.



ARGOS

Submittal No. **71332**
Date Issued: 7/11/2022

Argos
5920 W. Linebaugh Ave.
Tampa, FL 33624

Telephone: (813) 962-3213
Fax: (813) 968-5769
Cell:

Contractor: RW Harris
Project: SINCLAIR HILLS AT E SIDEN FL AVE

To Whom It May Concern:

We are submitting these mixes in accordance with ACI 318 (Chapter 5), proportioning on the basis of field experience and/or the trial mixture method:

Mix Code Number	Description	Intended Use
40JAF79	4000JSAIRASHDSC	4000 PSI Drill Shaft

When placing orders for this project, please order by product mix code number.

Argos warrants that the concrete as delivered to this project will meet or exceed the design strength specified on the delivery ticket when evaluated in accordance with ACI-318, ACI-301, and ASTM C-94, latest revision. The measured slump, and the concrete must be tested in strict accordance with the provisions of ASTM standards C-172, C-143, C-31, C-39, C-617, C-231, C-173, C-138, C-1019, C-78, C-567, C-1064, latest revisions.

All samples and testing of samples for acceptance shall be conducted at the point of discharge from the concrete delivery truck.

Should the Purchaser choose not to purchase temperature control measures, the Purchaser shall assume all liability for rejected concrete due to non-compliant concrete temperatures.

Responsibility for concrete when others supply mix designs will be the sole responsibility of those parties supplying the mix design.

Customer assumes total responsibility for concrete placement, finishing, initial and final curing, placement of joints at proper spacing, and any aesthetic concerns/issues (such as cracks, discoloration, etc.) that may arise in the plastic and hardened state.

The contents of this packet, with particular consideration in regard to the mix designs themselves, are considered proprietary in nature and are to be treated as confidential.

This information is being submitted for approval for use on this project. Please provide Argos an approved copy or a copy with the notes for correction of this submittal, when available.

Concrete will be delivered to the nearest accessible point over passable roads; customer assumes responsibility for all damages to city, state, and personal property , including concrete mixer truck if customer instructs concrete mixer truck to drive beyond curb lines. Customer should provide concrete mixer truck with wash down area.

In accordance with ASTM C-94, please copy our office with all test results obtained on this concrete by independent testing laboratories.

Thank you for your business and cooperation in this matter.

[redacted]

Matt Marsters
Sales

Figure D.8 Sinclair Hills drilled shaft certification data submittal page 2.

Date Issued: 7/11/2022
Submittal No. 71332
Customer: RW Harris
Project: SINCLAIR HILLS AT E SIDEN FL AVE

Argos
5920 W. Linebaugh Ave.
Tampa, FL 33624

Telephone: (813) 962-3213
Fax: (813) 968-5769
Cell:

Mix Code: **40JAF79** *Mix Code must be used when ordering concrete.*

Material	**Material Type**	**ASTM**	**Weight (lb)**
Cement	Type IL	C 595	564
Fly Ash	Fly Ash F	C 618	140
Coarse Aggregate	# 57	C33	1,614
Fine Aggregate	Natural Sand	C 33	1,324
Water	Water	C 1602	283
Admixture	Air Entrainer	C 260	2.5 oz/cy
Admixture	Stabilizer	C 494 Type D	1.00 to 15.00 oz/cwt CM
Admixture	Type A & D Water Reducer	C 494 Type A/D	1.00 to 15.00 oz/cwt CM

Specified F'c :	4,000 psi @ 28 days	Designed Unit Weight:	145.3 lbs./cu.ft.	**TOTAL** 3,925
Slump:	8.50 +/- 1.50 in.	Designed W/C + P Ratio:	0.40	
Air:	3.00 +/- 1.50 %	Designed Volume:	27.02 cu.ft.	

NOTES:

Argos has no knowledge or authority regarding where this mix is to be placed; therefore, it is the responsibility of the project architect, engineer, and/or contractor to ensure that the above designed mix parameters of compressive strength, water-to-cementitious ratio (W/C+P), cement content, and air content are appropriate for the anticipated environmental conditions (ie. ACI-318 sections 4.1-4.3, and local Building Codes).

Customer assumes total responsibility for concrete placement, finishing, initial and final curing, placement of joints at proper spacing, and any aesthetic concerns/issues (such as cracks, discoloration, etc.) that may arise in the plastic and hardened state.

Customer assumes responsibility for any performances issues (strength, aesthetic, durability, air entrainment etc.) as a result of water added to concrete at the project site that exceeds the w/c+p.

Designed mix cementitious content, is stated as a minimum, and Argos reserves the right to increase cementitious content.

Chemical admixtures are added in accordance with the manufacturer's recommendations. Argos reserves the right to adjust these dosages to meet the changes in jobsite demands.

All raw materials are subject to change depending on availability. All substitutes are guaranteed to meet or exceed projects performance specification requirements.

Argos may use admixtures or procedures not listed above to control the mixture during Hot or Cold weather, for pumping, long hauls, or other special applications, unless restricted in writing by the client.

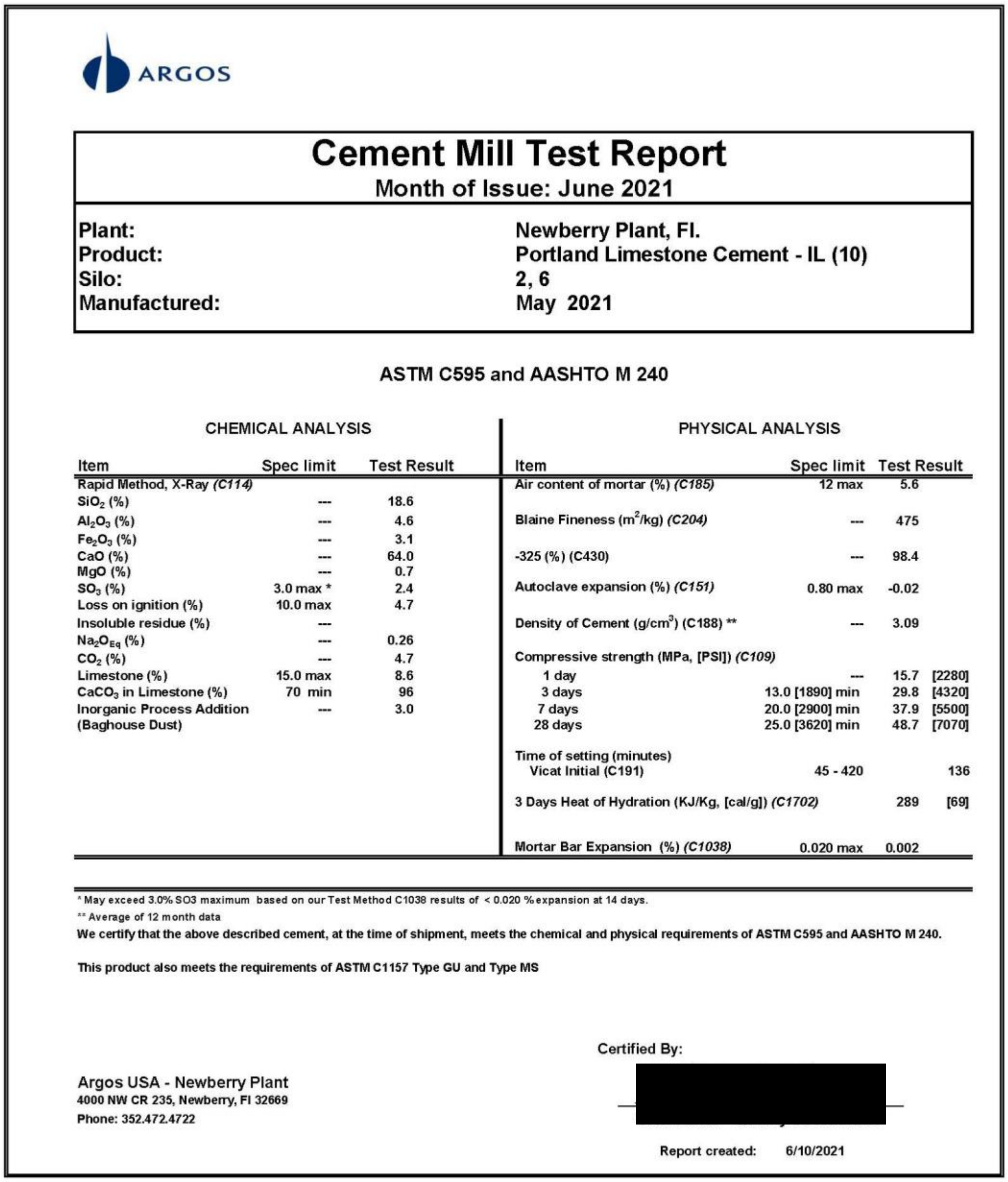
In accordance with ASTM C-94, please copy our office with all test results obtained on this concrete by independent testing laboratories.

COMMENTS:

[redacted]

Matt Marsters
Sales

Figure D.9 Sinclair Hills drilled shaft certification data submittal page 3.



ARGOS

Cement Mill Test Report

Month of Issue: June 2021

Plant:	**Newberry Plant, Fl.**
Product:	**Portland Limestone Cement - IL (10)**
Silo:	**2, 6**
Manufactured:	**May 2021**

ASTM C595 and AASHTO M 240

CHEMICAL ANALYSIS

Item	Spec limit	Test Result
Rapid Method, X-Ray *(C114)*		
SiO_2 (%)	---	18.6
Al_2O_3 (%)	---	4.6
Fe_2O_3 (%)	---	3.1
CaO (%)	---	64.0
MgO (%)	---	0.7
SO_3 (%)	3.0 max *	2.4
Loss on ignition (%)	10.0 max	4.7
Insoluble residue (%)	---	
Na_2O_{Eq} (%)	---	0.26
CO_2 (%)	---	4.7
Limestone (%)	15.0 max	8.6
$CaCO_3$ in Limestone (%)	70 min	96
Inorganic Process Addition (Baghouse Dust)	---	3.0

PHYSICAL ANALYSIS

Item	Spec limit	Test Result	
Air content of mortar (%) *(C185)*	12 max	5.6	
Blaine Fineness (m^2/kg) *(C204)*	---	475	
-325 (%) (C430)	---	98.4	
Autoclave expansion (%) *(C151)*	0.80 max	-0.02	
Density of Cement (g/cm^3) (C188) **	---	3.09	
Compressive strength (MPa, [PSI]) *(C109)*			
1 day	---	15.7	[2280]
3 days	13.0 [1890] min	29.8	[4320]
7 days	20.0 [2900] min	37.9	[5500]
28 days	25.0 [3620] min	48.7	[7070]
Time of setting (minutes)			
Vicat Initial (C191)	45 - 420		136
3 Days Heat of Hydration (KJ/Kg, [cal/g]) *(C1702)*		289	[69]
Mortar Bar Expansion (%) *(C1038)*	0.020 max	0.002	

* May exceed 3.0% SO3 maximum based on our Test Method C1038 results of < 0.020 % expansion at 14 days.

** Average of 12 month data

We certify that the above described cement, at the time of shipment, meets the chemical and physical requirements of ASTM C595 and AASHTO M 240.

This product also meets the requirements of ASTM C1157 Type GU and Type MS

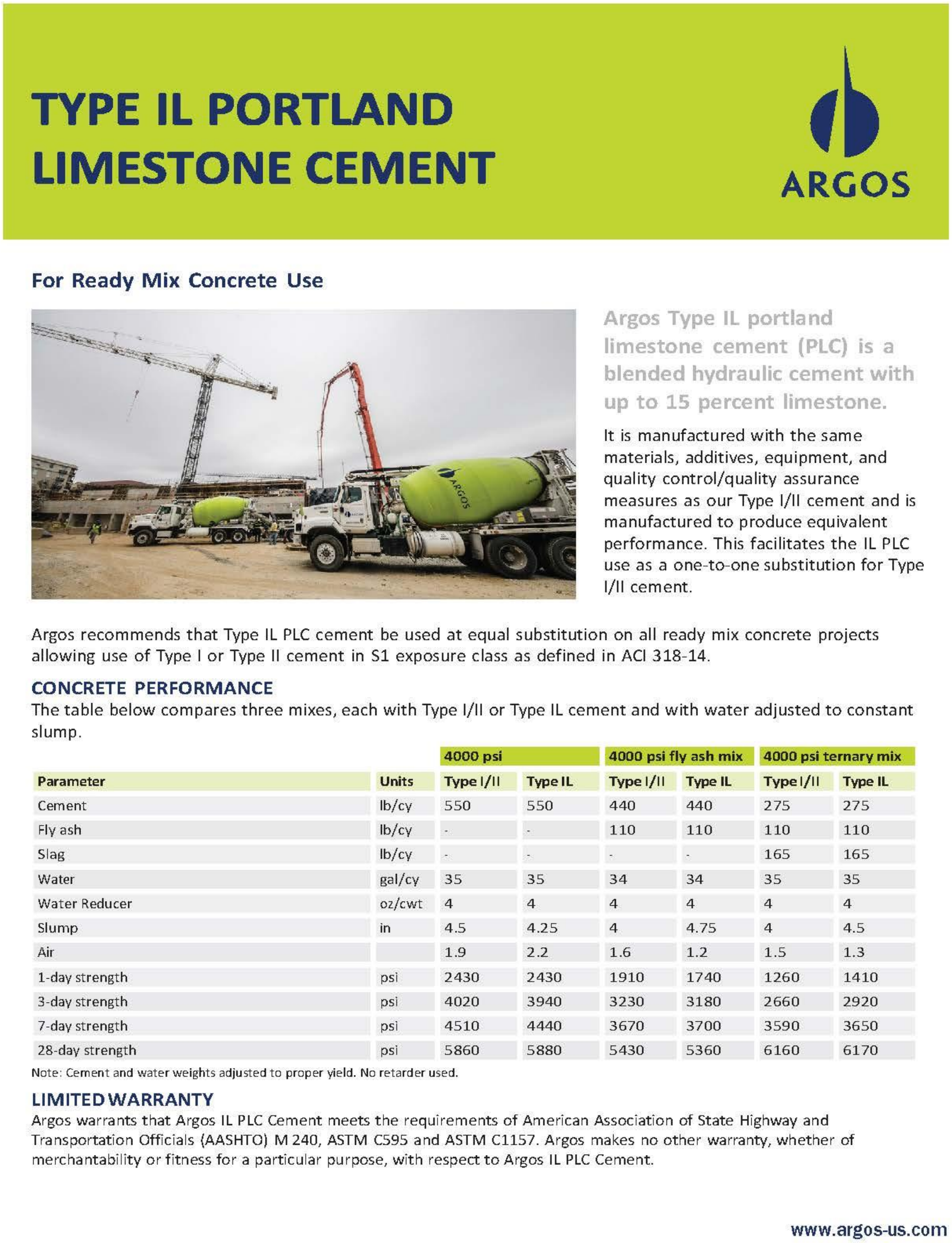
Certified By:

[redacted]

Argos USA - Newberry Plant
4000 NW CR 235, Newberry, Fl 32669
Phone: 352.472.4722

Report created: 6/10/2021

Figure D.10 Sinclair Hills drilled shaft certification data submittal page 4.



TYPE IL PORTLAND LIMESTONE CEMENT

ARGOS

For Ready Mix Concrete Use

Argos Type IL portland limestone cement (PLC) is a blended hydraulic cement with up to 15 percent limestone.

It is manufactured with the same materials, additives, equipment, and quality control/quality assurance measures as our Type I/II cement and is manufactured to produce equivalent performance. This facilitates the IL PLC use as a one-to-one substitution for Type I/II cement.

Argos recommends that Type IL PLC cement be used at equal substitution on all ready mix concrete projects allowing use of Type I or Type II cement in S1 exposure class as defined in ACI 318-14.

CONCRETE PERFORMANCE

The table below compares three mixes, each with Type I/II or Type IL cement and with water adjusted to constant slump.

		4000 psi		4000 psi fly ash mix		4000 psi ternary mix	
Parameter	**Units**	**Type I/II**	**Type IL**	**Type I/II**	**Type IL**	**Type I/II**	**Type IL**
Cement	lb/cy	550	550	440	440	275	275
Fly ash	lb/cy	-	-	110	110	110	110
Slag	lb/cy	-	-	-	-	165	165
Water	gal/cy	35	35	34	34	35	35
Water Reducer	oz/cwt	4	4	4	4	4	4
Slump	in	4.5	4.25	4	4.75	4	4.5
Air		1.9	2.2	1.6	1.2	1.5	1.3
1-day strength	psi	2430	2430	1910	1740	1260	1410
3-day strength	psi	4020	3940	3230	3180	2660	2920
7-day strength	psi	4510	4440	3670	3700	3590	3650
28-day strength	psi	5860	5880	5430	5360	6160	6170

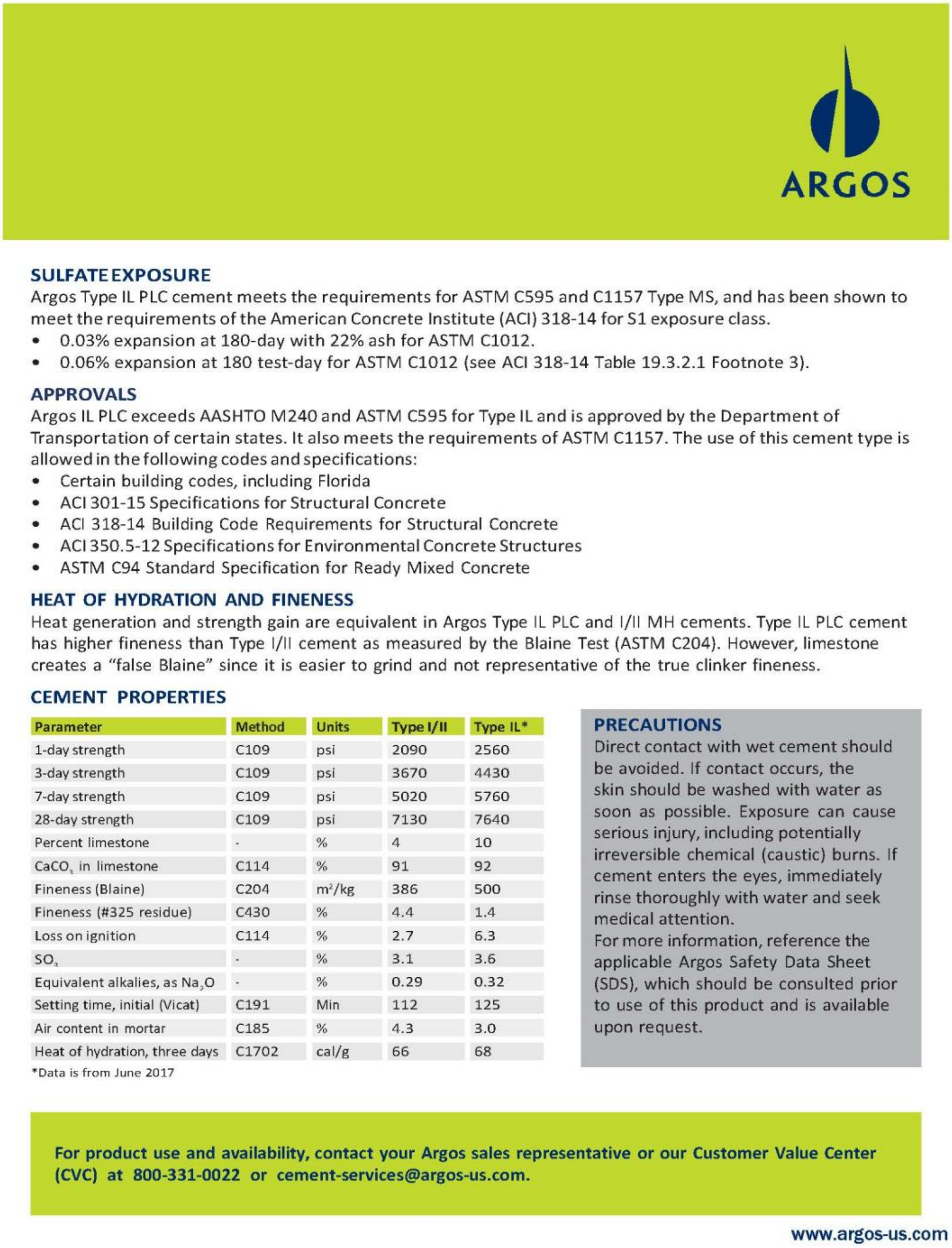
Note: Cement and water weights adjusted to proper yield. No retarder used.

LIMITED WARRANTY

Argos warrants that Argos IL PLC Cement meets the requirements of American Association of State Highway and Transportation Officials (AASHTO) M 240, ASTM C595 and ASTM C1157. Argos makes no other warranty, whether of merchantability or fitness for a particular purpose, with respect to Argos IL PLC Cement.

www.argos-us.com

Figure D.11 Sinclair Hills drilled shaft certification data submittal page 5.



ARGOS

SULFATE EXPOSURE

Argos Type IL PLC cement meets the requirements for ASTM C595 and C1157 Type MS, and has been shown to meet the requirements of the American Concrete Institute (ACI) 318-14 for S1 exposure class.

- 0.03% expansion at 180-day with 22% ash for ASTM C1012.
- 0.06% expansion at 180 test-day for ASTM C1012 (see ACI 318-14 Table 19.3.2.1 Footnote 3).

APPROVALS

Argos IL PLC exceeds AASHTO M240 and ASTM C595 for Type IL and is approved by the Department of Transportation of certain states. It also meets the requirements of ASTM C1157. The use of this cement type is allowed in the following codes and specifications:

- Certain building codes, including Florida
- ACI 301-15 Specifications for Structural Concrete
- ACI 318-14 Building Code Requirements for Structural Concrete
- ACI 350.5-12 Specifications for Environmental Concrete Structures
- ASTM C94 Standard Specification for Ready Mixed Concrete

HEAT OF HYDRATION AND FINENESS

Heat generation and strength gain are equivalent in Argos Type IL PLC and I/II MH cements. Type IL PLC cement has higher fineness than Type I/II cement as measured by the Blaine Test (ASTM C204). However, limestone creates a "false Blaine" since it is easier to grind and not representative of the true clinker fineness.

CEMENT PROPERTIES

Parameter	Method	Units	Type I/II	Type IL*
1-day strength	C109	psi	2090	2560
3-day strength	C109	psi	3670	4430
7-day strength	C109	psi	5020	5760
28-day strength	C109	psi	7130	7640
Percent limestone	-	%	4	10
$CaCO_3$ in limestone	C114	%	91	92
Fineness (Blaine)	C204	m^2/kg	386	500
Fineness (#325 residue)	C430	%	4.4	1.4
Loss on ignition	C114	%	2.7	6.3
SO_3	-	%	3.1	3.6
Equivalent alkalies, as Na_2O	-	%	0.29	0.32
Setting time, initial (Vicat)	C191	Min	112	125
Air content in mortar	C185	%	4.3	3.0
Heat of hydration, three days	C1702	cal/g	66	68

*Data is from June 2017

PRECAUTIONS

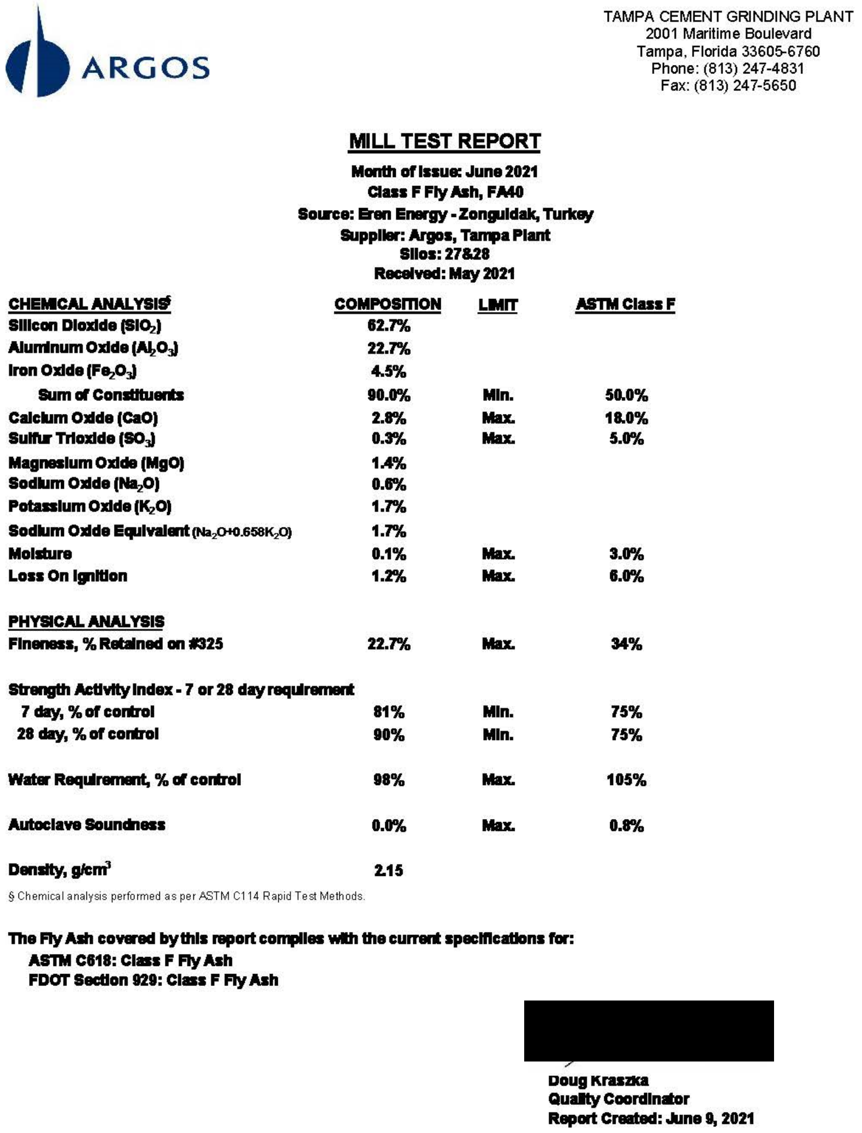
Direct contact with wet cement should be avoided. If contact occurs, the skin should be washed with water as soon as possible. Exposure can cause serious injury, including potentially irreversible chemical (caustic) burns. If cement enters the eyes, immediately rinse thoroughly with water and seek medical attention.

For more information, reference the applicable Argos Safety Data Sheet (SDS), which should be consulted prior to use of this product and is available upon request.

For product use and availability, contact your Argos sales representative or our Customer Value Center (CVC) at 800-331-0022 or cement-services@argos-us.com.

www.argos-us.com

Figure D.12 Sinclair Hills drilled shaft certification data submittal page 6.



ARGOS

TAMPA CEMENT GRINDING PLANT
2001 Maritime Boulevard
Tampa, Florida 33605-6760
Phone: (813) 247-4831
Fax: (813) 247-5650

MILL TEST REPORT

Month of Issue: June 2021
Class F Fly Ash, FA40
Source: Eren Energy - Zonguldak, Turkey
Supplier: Argos, Tampa Plant
Silos: 27&28
Received: May 2021

CHEMICAL ANALYSIS[§]	COMPOSITION	LIMIT	ASTM Class F
Silicon Dioxide (SiO_2)	62.7%		
Aluminum Oxide (Al_2O_3)	22.7%		
Iron Oxide (Fe_2O_3)	4.5%		
Sum of Constituents	90.0%	Min.	50.0%
Calcium Oxide (CaO)	2.8%	Max.	18.0%
Sulfur Trioxide (SO_3)	0.3%	Max.	5.0%
Magnesium Oxide (MgO)	1.4%		
Sodium Oxide (Na_2O)	0.6%		
Potassium Oxide (K_2O)	1.7%		
Sodium Oxide Equivalent (Na_2O+0.658K_2O)	1.7%		
Moisture	0.1%	Max.	3.0%
Loss On Ignition	1.2%	Max.	6.0%
PHYSICAL ANALYSIS			
Fineness, % Retained on #325	22.7%	Max.	34%
Strength Activity Index - 7 or 28 day requirement			
7 day, % of control	81%	Min.	75%
28 day, % of control	90%	Min.	75%
Water Requirement, % of control	98%	Max.	105%
Autoclave Soundness	0.0%	Max.	0.8%
Density, g/cm³	2.15		

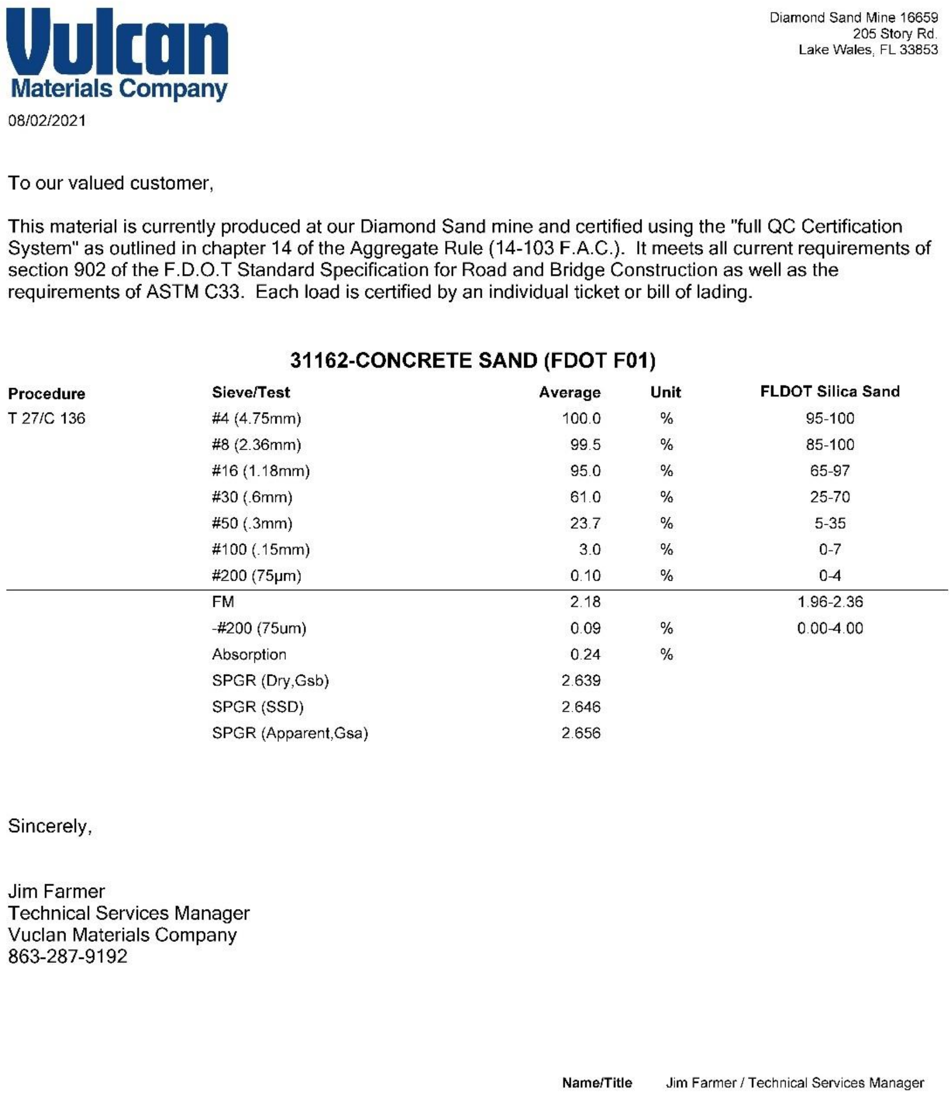
§ Chemical analysis performed as per ASTM C114 Rapid Test Methods.

The Fly Ash covered by this report complies with the current specifications for:
ASTM C618: Class F Fly Ash
FDOT Section 929: Class F Fly Ash

[redacted]

Doug Kraszka
Quality Coordinator
Report Created: June 9, 2021

Figure D.13 Sinclair Hills drilled shaft certification data submittal page 7.



Vulcan
Materials Company

Diamond Sand Mine 16659
205 Story Rd.
Lake Wales, FL 33853

08/02/2021

To our valued customer,

This material is currently produced at our Diamond Sand mine and certified using the "full QC Certification System" as outlined in chapter 14 of the Aggregate Rule (14-103 F.A.C.). It meets all current requirements of section 902 of the F.D.O.T Standard Specification for Road and Bridge Construction as well as the requirements of ASTM C33. Each load is certified by an individual ticket or bill of lading.

31162-CONCRETE SAND (FDOT F01)

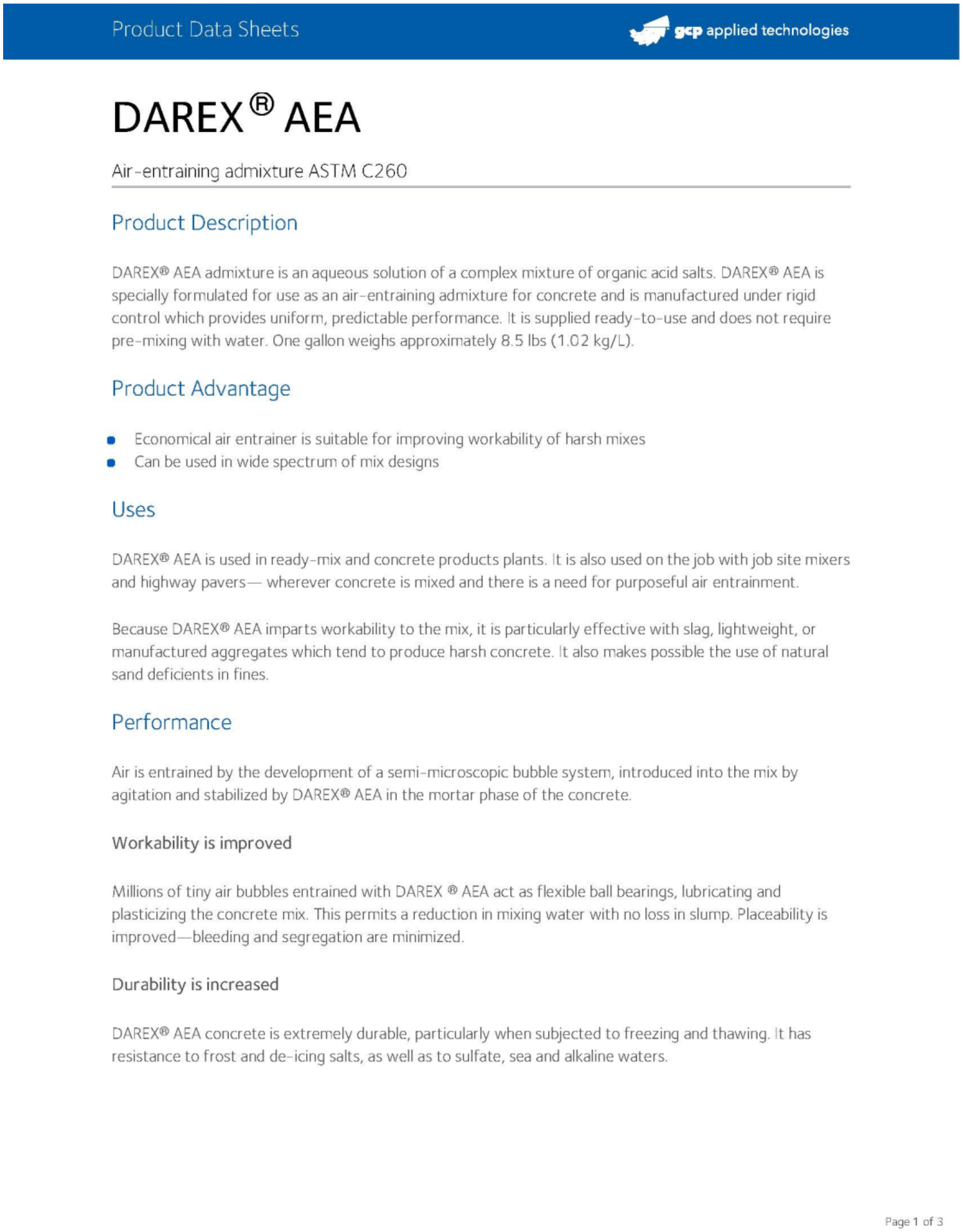
Procedure	**Sieve/Test**	**Average**	**Unit**	**FLDOT Silica Sand**
T 27/C 136	#4 (4.75mm)	100.0	%	95-100
	#8 (2.36mm)	99.5	%	85-100
	#16 (1.18mm)	95.0	%	65-97
	#30 (.6mm)	61.0	%	25-70
	#50 (.3mm)	23.7	%	5-35
	#100 (.15mm)	3.0	%	0-7
	#200 (75µm)	0.10	%	0-4
	FM	2.18		1.96-2.36
	-#200 (75um)	0.09	%	0.00-4.00
	Absorption	0.24	%	
	SPGR (Dry,Gsb)	2.639		
	SPGR (SSD)	2.646		
	SPGR (Apparent,Gsa)	2.656		

Sincerely,

Jim Farmer
Technical Services Manager
Vuclan Materials Company
863-287-9192

Name/Title Jim Farmer / Technical Services Manager

Figure D.14 Sinclair Hills drilled shaft certification data submittal page 8.



Product Data Sheets

gcp applied technologies

DAREX® AEA

Air-entraining admixture ASTM C260

Product Description

DAREX® AEA admixture is an aqueous solution of a complex mixture of organic acid salts. DAREX® AEA is specially formulated for use as an air-entraining admixture for concrete and is manufactured under rigid control which provides uniform, predictable performance. It is supplied ready-to-use and does not require pre-mixing with water. One gallon weighs approximately 8.5 lbs (1.02 kg/L).

Product Advantage

- Economical air entrainer is suitable for improving workability of harsh mixes
- Can be used in wide spectrum of mix designs

Uses

DAREX® AEA is used in ready-mix and concrete products plants. It is also used on the job with job site mixers and highway pavers— wherever concrete is mixed and there is a need for purposeful air entrainment.

Because DAREX® AEA imparts workability to the mix, it is particularly effective with slag, lightweight, or manufactured aggregates which tend to produce harsh concrete. It also makes possible the use of natural sand deficients in fines.

Performance

Air is entrained by the development of a semi-microscopic bubble system, introduced into the mix by agitation and stabilized by DAREX® AEA in the mortar phase of the concrete.

Workability is improved

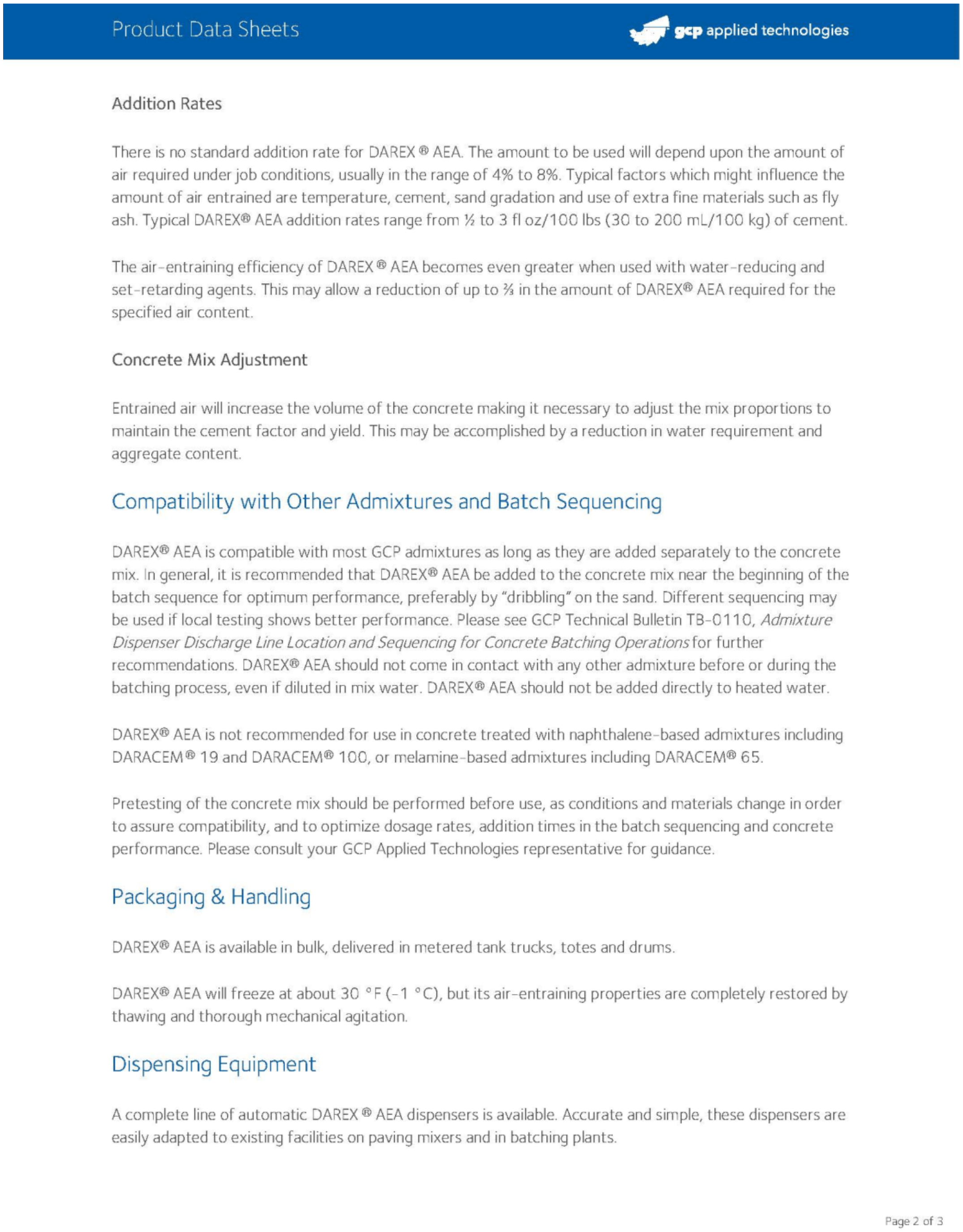
Millions of tiny air bubbles entrained with DAREX ® AEA act as flexible ball bearings, lubricating and plasticizing the concrete mix. This permits a reduction in mixing water with no loss in slump. Placeability is improved—bleeding and segregation are minimized.

Durability is increased

DAREX® AEA concrete is extremely durable, particularly when subjected to freezing and thawing. It has resistance to frost and de-icing salts, as well as to sulfate, sea and alkaline waters.

Page 1 of 3

Figure D.15 Sinclair Hills drilled shaft certification data submittal page 9.



Product Data Sheets

gcp applied technologies

Addition Rates

There is no standard addition rate for DAREX ® AEA. The amount to be used will depend upon the amount of air required under job conditions, usually in the range of 4% to 8%. Typical factors which might influence the amount of air entrained are temperature, cement, sand gradation and use of extra fine materials such as fly ash. Typical DAREX® AEA addition rates range from ½ to 3 fl oz/100 lbs (30 to 200 mL/100 kg) of cement.

The air-entraining efficiency of DAREX ® AEA becomes even greater when used with water-reducing and set-retarding agents. This may allow a reduction of up to ⅔ in the amount of DAREX® AEA required for the specified air content.

Concrete Mix Adjustment

Entrained air will increase the volume of the concrete making it necessary to adjust the mix proportions to maintain the cement factor and yield. This may be accomplished by a reduction in water requirement and aggregate content.

Compatibility with Other Admixtures and Batch Sequencing

DAREX® AEA is compatible with most GCP admixtures as long as they are added separately to the concrete mix. In general, it is recommended that DAREX® AEA be added to the concrete mix near the beginning of the batch sequence for optimum performance, preferably by "dribbling" on the sand. Different sequencing may be used if local testing shows better performance. Please see GCP Technical Bulletin TB-0110, *Admixture Dispenser Discharge Line Location and Sequencing for Concrete Batching Operations* for further recommendations. DAREX® AEA should not come in contact with any other admixture before or during the batching process, even if diluted in mix water. DAREX® AEA should not be added directly to heated water.

DAREX® AEA is not recommended for use in concrete treated with naphthalene-based admixtures including DARACEM® 19 and DARACEM® 100, or melamine-based admixtures including DARACEM® 65.

Pretesting of the concrete mix should be performed before use, as conditions and materials change in order to assure compatibility, and to optimize dosage rates, addition times in the batch sequencing and concrete performance. Please consult your GCP Applied Technologies representative for guidance.

Packaging & Handling

DAREX® AEA is available in bulk, delivered in metered tank trucks, totes and drums.

DAREX® AEA will freeze at about 30 °F (-1 °C), but its air-entraining properties are completely restored by thawing and thorough mechanical agitation.

Dispensing Equipment

A complete line of automatic DAREX ® AEA dispensers is available. Accurate and simple, these dispensers are easily adapted to existing facilities on paving mixers and in batching plants.

Page 2 of 3

Figure D.16 Sinclair Hills drilled shaft certification data submittal page 10.

Specifications

Concrete shall be air entrained concrete, containing 4% to 8% entrained air. The air contents in the concrete shall be determined by the pressure method (ASTM Designation C231) or gravimetric method (ASTM Designation C138). The air-entraining admixture shall be DAREX® AEA, as manufactured by GCP Applied Technologies, or equal. The air-entraining admixture shall be added at the concrete mixer or batching plant in such quantities as to give the specified air contents.

gcpat.com | North America Customer Service: 1 877-4AD-MIX1 (1 877-423-6491)

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

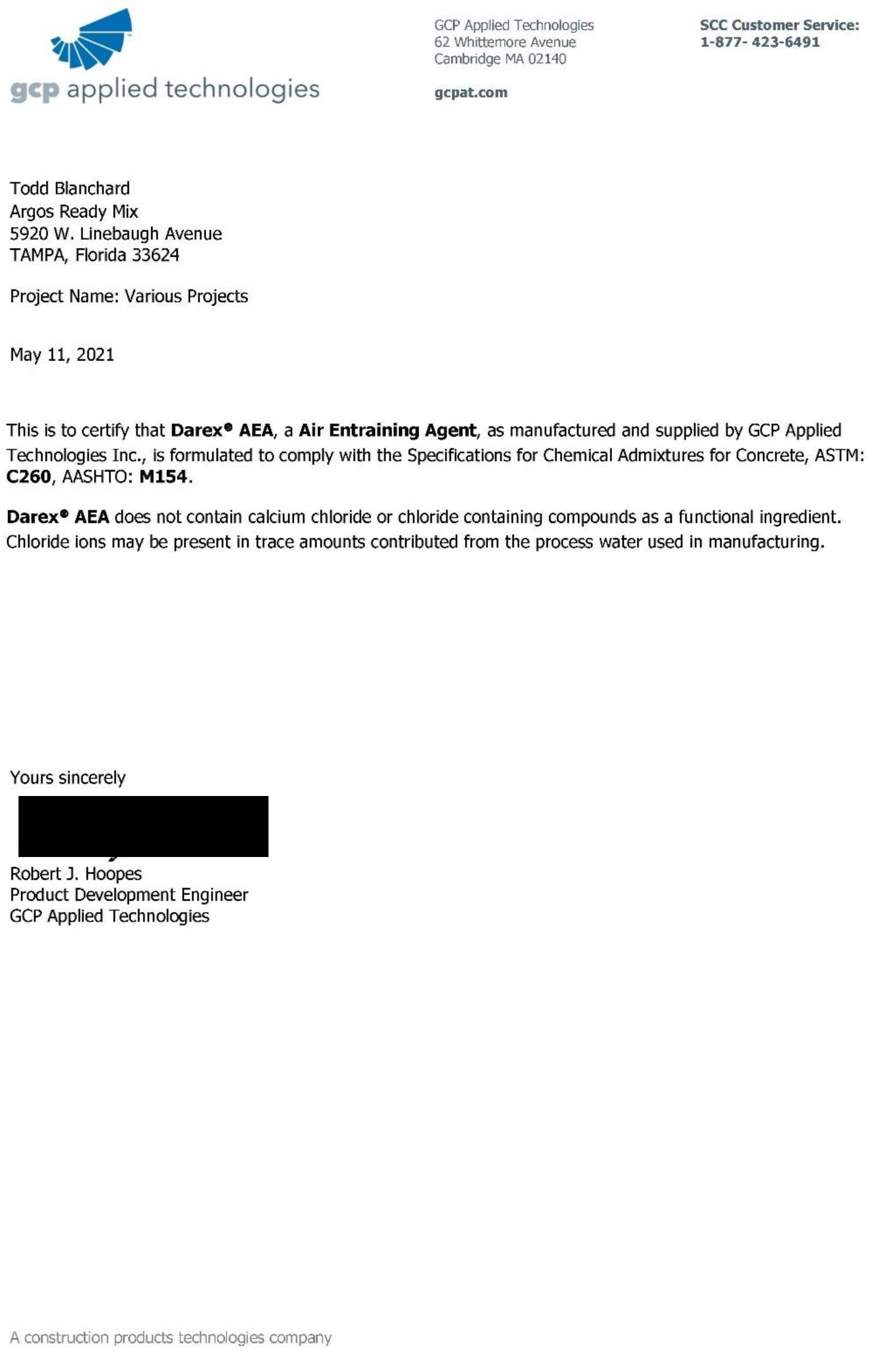
In Canada, GCP Canada, Inc., 294 Clements Road, West, Ajax, Ontario, Canada L1S 3C6.

This document is only current as of the last updated date stated below and is valid only for use in the United States. It is important that you always refer to the currently available information at the URL below to provide the most current product information at the time of use. Additional literature such as Contractor Manuals, Technical Bulletins, Detail Drawings and detailing recommendations and other relevant documents are also available on www.gcpat.com. Information found on other websites must not be relied upon, as they may not be up-to-date or applicable to the conditions in your location and we do not accept any responsibility for their content. If there are any conflicts or if you need more information, please contact GCP Customer Service.

Last Updated: 2018-08-24
gcpat.com/solutions/products/darex-aea

gcp applied technologies

Figure D.17 Sinclair Hills drilled shaft certification data submittal page 11.



gcp applied technologies

GCP Applied Technologies
62 Whittemore Avenue
Cambridge MA 02140

gcpat.com

SCC Customer Service:
1-877- 423-6491

Todd Blanchard
Argos Ready Mix
5920 W. Linebaugh Avenue
TAMPA, Florida 33624

Project Name: Various Projects

May 11, 2021

This is to certify that **Darex® AEA**, a **Air Entraining Agent**, as manufactured and supplied by GCP Applied Technologies Inc., is formulated to comply with the Specifications for Chemical Admixtures for Concrete, ASTM: **C260**, AASHTO: **M154**.

Darex® AEA does not contain calcium chloride or chloride containing compounds as a functional ingredient. Chloride ions may be present in trace amounts contributed from the process water used in manufacturing.

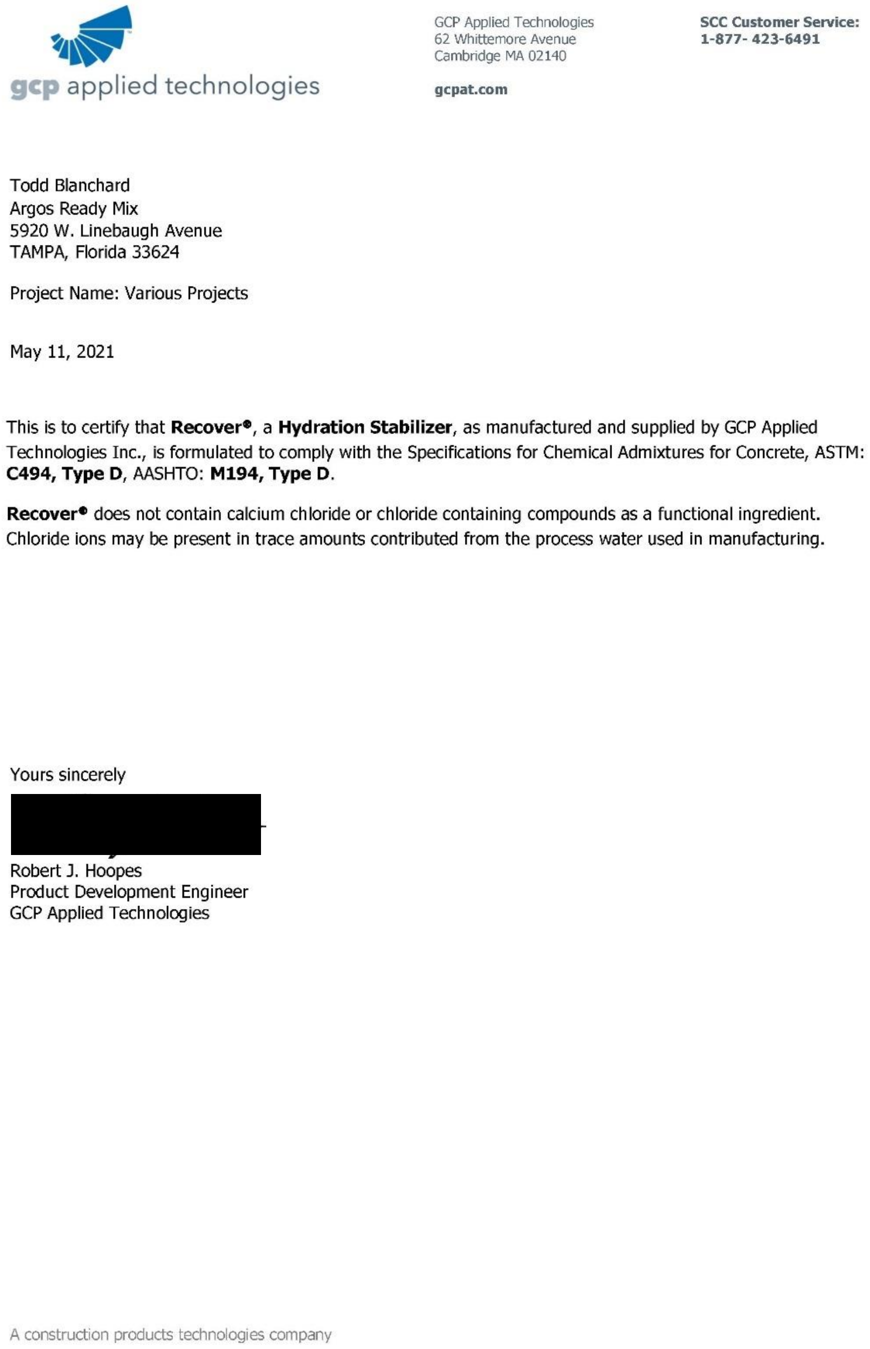
Yours sincerely

[redacted]

Robert J. Hoopes
Product Development Engineer
GCP Applied Technologies

A construction products technologies company

Figure D.18 Sinclair Hills drilled shaft certification data submittal page 12.



GCP Applied Technologies
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Cambridge MA 02140

gcpat.com

SCC Customer Service:
1-877- 423-6491

Todd Blanchard
Argos Ready Mix
5920 W. Linebaugh Avenue
TAMPA, Florida 33624

Project Name: Various Projects

May 11, 2021

This is to certify that **Recover®**, a **Hydration Stabilizer**, as manufactured and supplied by GCP Applied Technologies Inc., is formulated to comply with the Specifications for Chemical Admixtures for Concrete, ASTM: **C494, Type D**, AASHTO: **M194, Type D**.

Recover® does not contain calcium chloride or chloride containing compounds as a functional ingredient. Chloride ions may be present in trace amounts contributed from the process water used in manufacturing.

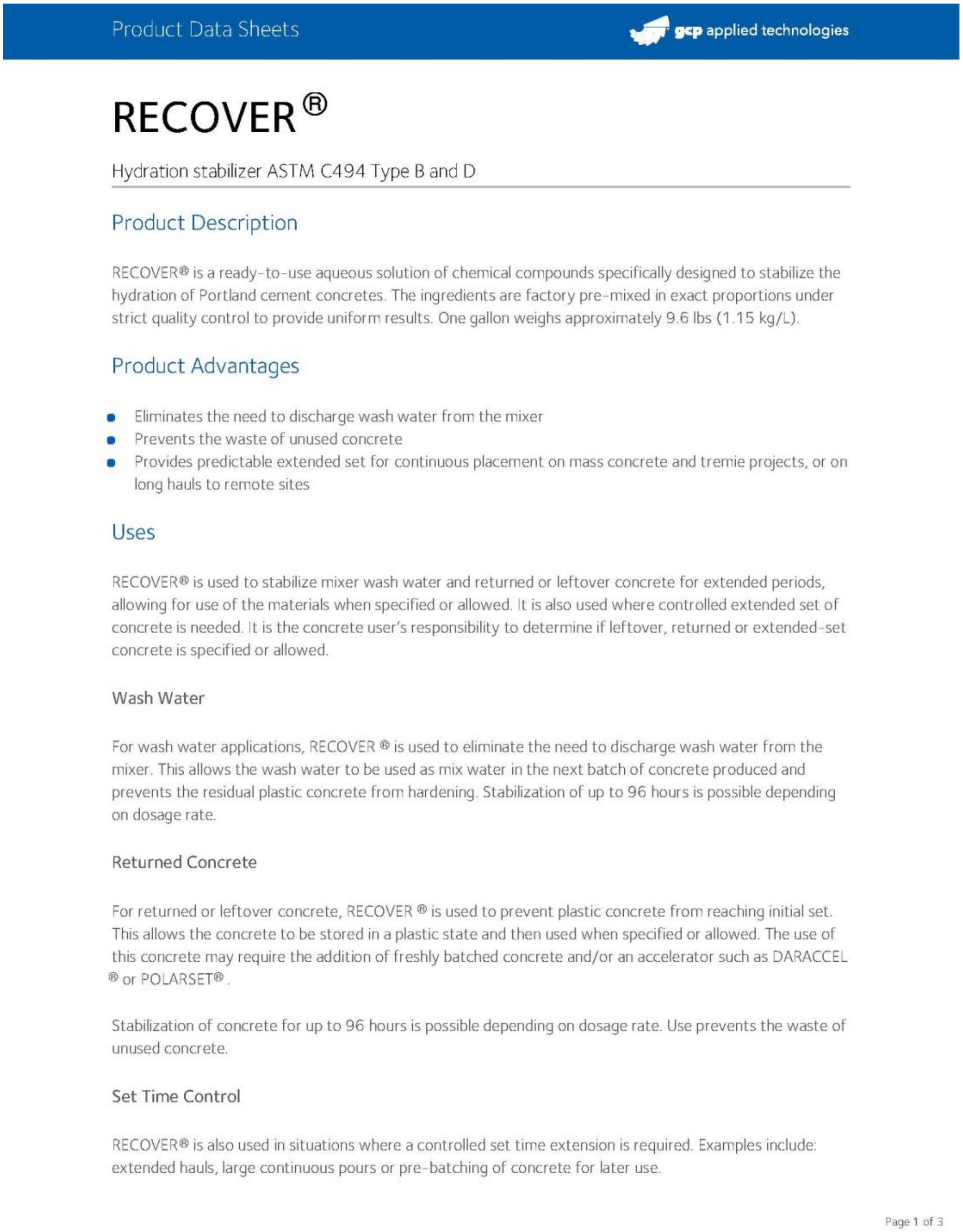
Yours sincerely

[redacted]

Robert J. Hoopes
Product Development Engineer
GCP Applied Technologies

A construction products technologies company

Figure D.19 Sinclair Hills drilled shaft certification data submittal page 13.



Product Data Sheets

gcp applied technologies

RECOVER®

Hydration stabilizer ASTM C494 Type B and D

Product Description

RECOVER® is a ready-to-use aqueous solution of chemical compounds specifically designed to stabilize the hydration of Portland cement concretes. The ingredients are factory pre-mixed in exact proportions under strict quality control to provide uniform results. One gallon weighs approximately 9.6 lbs (1.15 kg/L).

Product Advantages

- Eliminates the need to discharge wash water from the mixer
- Prevents the waste of unused concrete
- Provides predictable extended set for continuous placement on mass concrete and tremie projects, or on long hauls to remote sites

Uses

RECOVER® is used to stabilize mixer wash water and returned or leftover concrete for extended periods, allowing for use of the materials when specified or allowed. It is also used where controlled extended set of concrete is needed. It is the concrete user's responsibility to determine if leftover, returned or extended-set concrete is specified or allowed.

Wash Water

For wash water applications, RECOVER ® is used to eliminate the need to discharge wash water from the mixer. This allows the wash water to be used as mix water in the next batch of concrete produced and prevents the residual plastic concrete from hardening. Stabilization of up to 96 hours is possible depending on dosage rate.

Returned Concrete

For returned or leftover concrete, RECOVER ® is used to prevent plastic concrete from reaching initial set. This allows the concrete to be stored in a plastic state and then used when specified or allowed. The use of this concrete may require the addition of freshly batched concrete and/or an accelerator such as DARACCEL ® or POLARSET® .

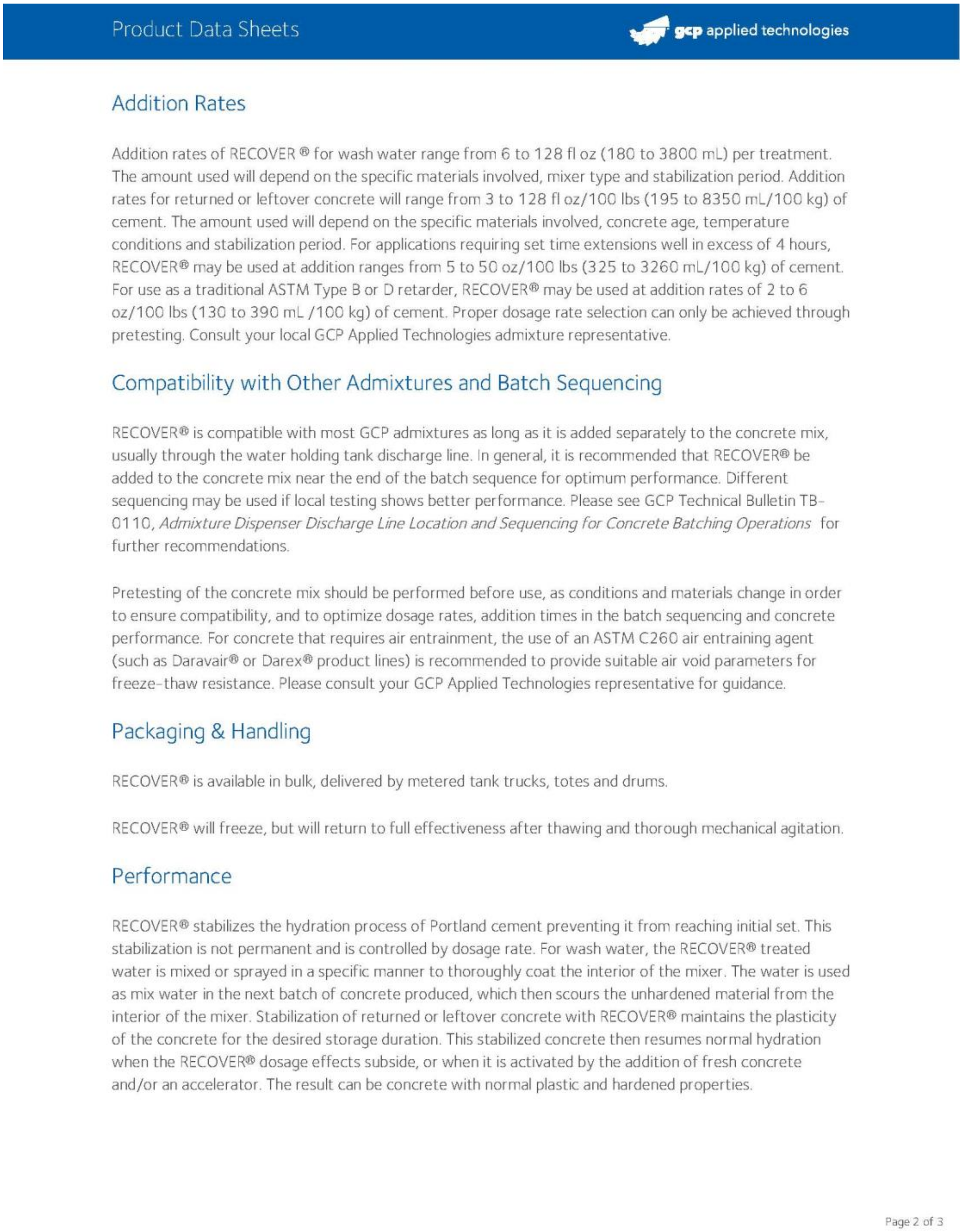
Stabilization of concrete for up to 96 hours is possible depending on dosage rate. Use prevents the waste of unused concrete.

Set Time Control

RECOVER® is also used in situations where a controlled set time extension is required. Examples include: extended hauls, large continuous pours or pre-batching of concrete for later use.

Page 1 of 3

Figure D.20 Sinclair Hills drilled shaft certification data submittal page 14.



Addition Rates

Addition rates of RECOVER ® for wash water range from 6 to 128 fl oz (180 to 3800 mL) per treatment. The amount used will depend on the specific materials involved, mixer type and stabilization period. Addition rates for returned or leftover concrete will range from 3 to 128 fl oz/100 lbs (195 to 8350 mL/100 kg) of cement. The amount used will depend on the specific materials involved, concrete age, temperature conditions and stabilization period. For applications requiring set time extensions well in excess of 4 hours, RECOVER® may be used at addition ranges from 5 to 50 oz/100 lbs (325 to 3260 mL/100 kg) of cement. For use as a traditional ASTM Type B or D retarder, RECOVER® may be used at addition rates of 2 to 6 oz/100 lbs (130 to 390 mL /100 kg) of cement. Proper dosage rate selection can only be achieved through pretesting. Consult your local GCP Applied Technologies admixture representative.

Compatibility with Other Admixtures and Batch Sequencing

RECOVER® is compatible with most GCP admixtures as long as it is added separately to the concrete mix, usually through the water holding tank discharge line. In general, it is recommended that RECOVER® be added to the concrete mix near the end of the batch sequence for optimum performance. Different sequencing may be used if local testing shows better performance. Please see GCP Technical Bulletin TB-0110, *Admixture Dispenser Discharge Line Location and Sequencing for Concrete Batching Operations* for further recommendations.

Pretesting of the concrete mix should be performed before use, as conditions and materials change in order to ensure compatibility, and to optimize dosage rates, addition times in the batch sequencing and concrete performance. For concrete that requires air entrainment, the use of an ASTM C260 air entraining agent (such as Daravair® or Darex® product lines) is recommended to provide suitable air void parameters for freeze-thaw resistance. Please consult your GCP Applied Technologies representative for guidance.

Packaging & Handling

RECOVER® is available in bulk, delivered by metered tank trucks, totes and drums.

RECOVER® will freeze, but will return to full effectiveness after thawing and thorough mechanical agitation.

Performance

RECOVER® stabilizes the hydration process of Portland cement preventing it from reaching initial set. This stabilization is not permanent and is controlled by dosage rate. For wash water, the RECOVER® treated water is mixed or sprayed in a specific manner to thoroughly coat the interior of the mixer. The water is used as mix water in the next batch of concrete produced, which then scours the unhardened material from the interior of the mixer. Stabilization of returned or leftover concrete with RECOVER® maintains the plasticity of the concrete for the desired storage duration. This stabilized concrete then resumes normal hydration when the RECOVER® dosage effects subside, or when it is activated by the addition of fresh concrete and/or an accelerator. The result can be concrete with normal plastic and hardened properties.

Figure D.21 Sinclair Hills drilled shaft certification data submittal page 15.

Product Data Sheets

gcp applied technologies

Dispensing Equipment

A complete line of GCP dispensing equipment is available for RECOVER ® . This includes the Reach 360TM System which uses an innovative spray wand technology to simplify wash water procedures.

gcpat.com | North America Customer Service: 1 877-4AD-MIX1 (1 877-423-6491)

We hope the information here will be helpful. It is based on data and knowledge considered to be true and accurate, and is offered for consideration, investigation and verification by the user, but we do not warrant the results to be obtained. Please read all statements, recommendations, and suggestions in conjunction with our conditions of sale, which apply to all goods supplied by us. No statement, recommendation, or suggestion is intended for any use that would infringe any patent, copyright, or other third party right.

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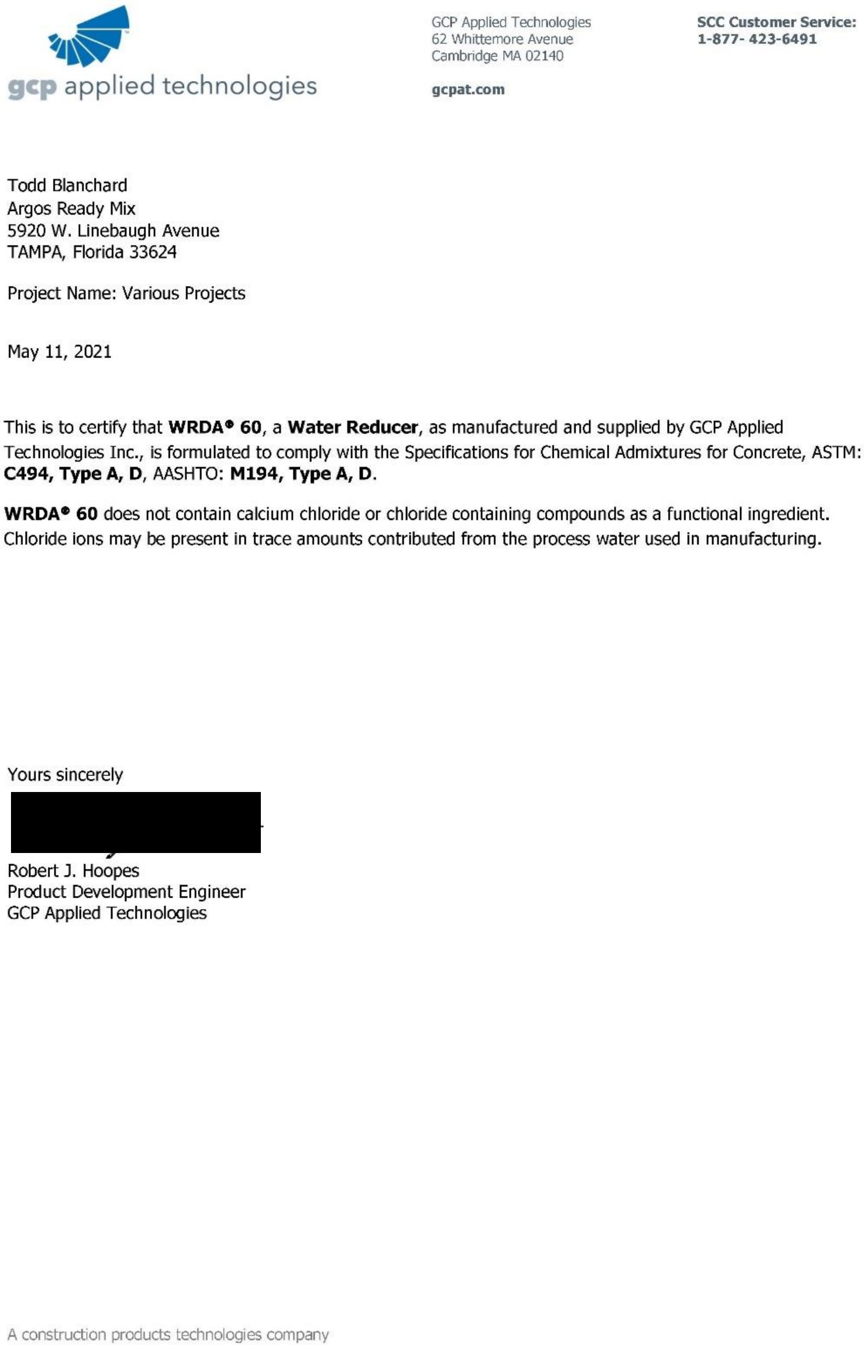
Last Updated: 2018-08-24
gcpat.com/solutions/products/recover

gcp applied technologies

Page 3 of 3

Figure D.22 Sinclair Hills drilled shaft certification data submittal page 16.



gcp applied technologies

GCP Applied Technologies
62 Whittemore Avenue
Cambridge MA 02140

gcpat.com

SCC Customer Service:
1-877- 423-6491

Todd Blanchard
Argos Ready Mix
5920 W. Linebaugh Avenue
TAMPA, Florida 33624

Project Name: Various Projects

May 11, 2021

This is to certify that **WRDA® 60**, a **Water Reducer**, as manufactured and supplied by GCP Applied Technologies Inc., is formulated to comply with the Specifications for Chemical Admixtures for Concrete, ASTM: **C494, Type A, D**, AASHTO: **M194, Type A, D**.

WRDA® 60 does not contain calcium chloride or chloride containing compounds as a functional ingredient. Chloride ions may be present in trace amounts contributed from the process water used in manufacturing.

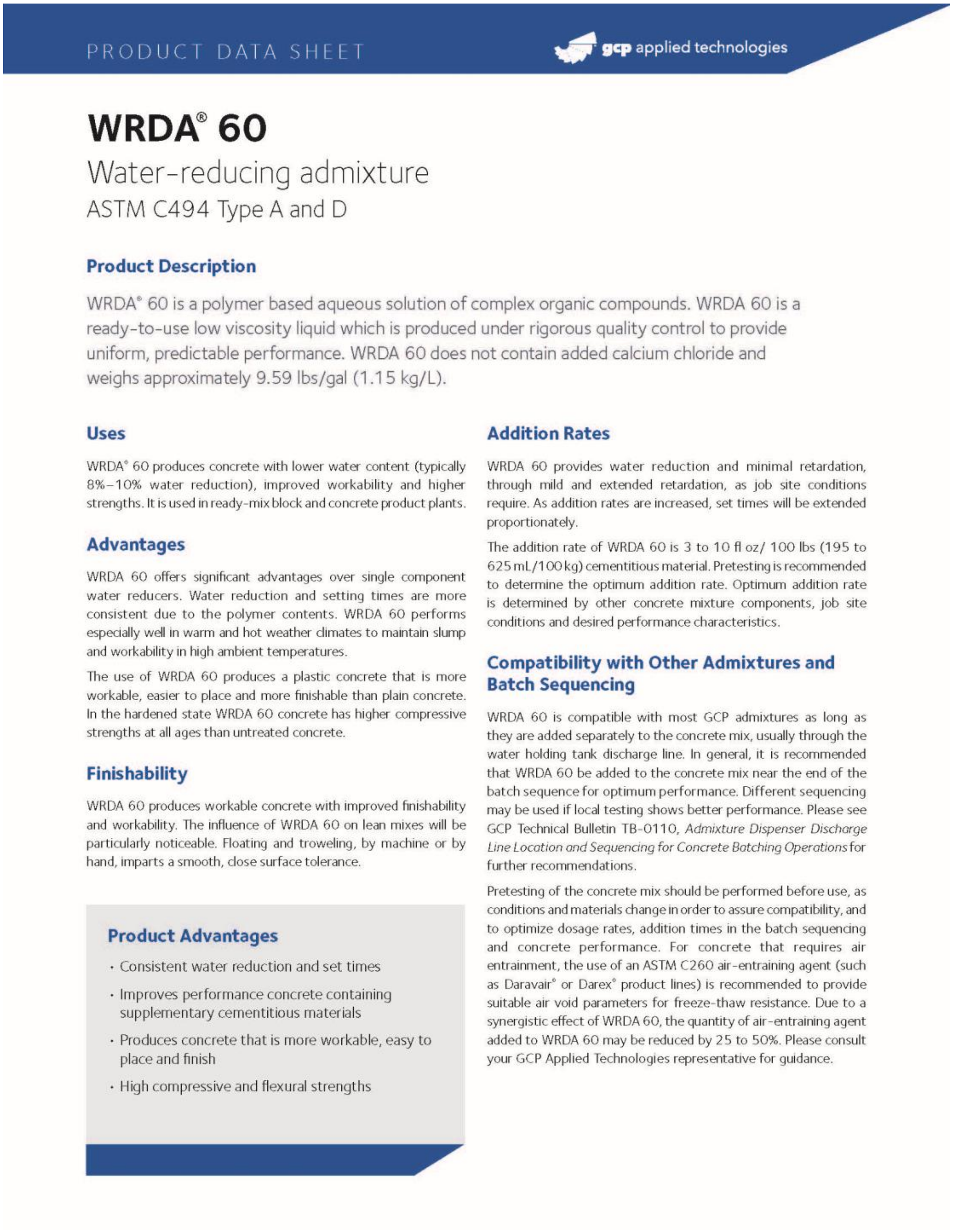
Yours sincerely

[redacted]

Robert J. Hoopes
Product Development Engineer
GCP Applied Technologies

A construction products technologies company

Figure D.23 Sinclair Hills drilled shaft certification data submittal page 17.



PRODUCT DATA SHEET

gcp applied technologies

WRDA® 60

Water-reducing admixture

ASTM C494 Type A and D

Product Description

WRDA® 60 is a polymer based aqueous solution of complex organic compounds. WRDA 60 is a ready-to-use low viscosity liquid which is produced under rigorous quality control to provide uniform, predictable performance. WRDA 60 does not contain added calcium chloride and weighs approximately 9.59 lbs/gal (1.15 kg/L).

Uses

WRDA® 60 produces concrete with lower water content (typically 8%–10% water reduction), improved workability and higher strengths. It is used in ready-mix block and concrete product plants.

Advantages

WRDA 60 offers significant advantages over single component water reducers. Water reduction and setting times are more consistent due to the polymer contents. WRDA 60 performs especially well in warm and hot weather climates to maintain slump and workability in high ambient temperatures.

The use of WRDA 60 produces a plastic concrete that is more workable, easier to place and more finishable than plain concrete. In the hardened state WRDA 60 concrete has higher compressive strengths at all ages than untreated concrete.

Finishability

WRDA 60 produces workable concrete with improved finishability and workability. The influence of WRDA 60 on lean mixes will be particularly noticeable. Floating and troweling, by machine or by hand, imparts a smooth, close surface tolerance.

Product Advantages

- Consistent water reduction and set times
- Improves performance concrete containing supplementary cementitious materials
- Produces concrete that is more workable, easy to place and finish
- High compressive and flexural strengths

Addition Rates

WRDA 60 provides water reduction and minimal retardation, through mild and extended retardation, as job site conditions require. As addition rates are increased, set times will be extended proportionately.

The addition rate of WRDA 60 is 3 to 10 fl oz/ 100 lbs (195 to 625 mL/100 kg) cementitious material. Pretesting is recommended to determine the optimum addition rate. Optimum addition rate is determined by other concrete mixture components, job site conditions and desired performance characteristics.

Compatibility with Other Admixtures and Batch Sequencing

WRDA 60 is compatible with most GCP admixtures as long as they are added separately to the concrete mix, usually through the water holding tank discharge line. In general, it is recommended that WRDA 60 be added to the concrete mix near the end of the batch sequence for optimum performance. Different sequencing may be used if local testing shows better performance. Please see GCP Technical Bulletin TB-0110, *Admixture Dispenser Discharge Line Location and Sequencing for Concrete Batching Operations* for further recommendations.

Pretesting of the concrete mix should be performed before use, as conditions and materials change in order to assure compatibility, and to optimize dosage rates, addition times in the batch sequencing and concrete performance. For concrete that requires air entrainment, the use of an ASTM C260 air-entraining agent (such as Daravair® or Darex® product lines) is recommended to provide suitable air void parameters for freeze-thaw resistance. Due to a synergistic effect of WRDA 60, the quantity of air-entraining agent added to WRDA 60 may be reduced by 25 to 50%. Please consult your GCP Applied Technologies representative for guidance.

Figure D.24 Sinclair Hills drilled shaft certification data submittal page 18.

Packaging & Handling

WRDA 60 is available in bulk, delivered by metered tank trucks, totes and drums.

WRDA 60 will freeze at about 28 °F (-2 °C) but will return to full strength after thawing and thorough mechanical agitation.

Dispensing Equipment

A complete line of accurate, automatic dispensing equipment is available. WRDA 60 may be introduced into the mix on the sand or in the mix water.

Specifications

Concrete shall be designed in accordance with *Standard Recommended Practice for Selecting Proportions for Concrete,* ACI 211.

The water-reducing admixture shall be WRDA 60 as manufactured by GCP Applied Technologies, or approved equal. The admixture shall not contain calcium chloride. It shall meet the requirements of *Specification for Chemical Admixtures for Concrete* ASTM Designation C494 as a Type D admixture when used at an addition rate of 3 to 10 fl oz/100 lbs (190 to 625 mL/100 kg) of cementitious material. WRDA 60 is NSF Std. 61 certified when used at a maximum addition rate of 6 fl oz/100 lbs (390 mL/100 kg) of cementitious material.

The admixture shall be delivered as a ready-to-use liquid product and shall require no mixing at the batching plant or job site.

gcpat.com | North America Customer Service: 1-877-4AD-MIX1 (1-877-423-6491)

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

In Canada, 294 Clements Road, West, Ajax, Ontario, Canada L1S 3C6.

GCP0083 DW-24-1216

gcp applied technologies

Figure D.25 Sinclair Hills drilled shaft certification data submittal page 19.

SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

1. IDENTIFICATION

Product Identifier: Ready Mix Concrete (Concrete)

Synonyms: Ready Mix Concrete, Concrete Ready Mix, Portland Cement Concrete, Ready Mix Stucco, Ready Mix grout, Ready Mix, Concrete, Freshly Mixed Concrete, Collodial Concrete, Permeable Concrete, Shotcrete, Gunite, Polymer-Portland Cement Concrete, Colored Concrete, Flowable Fill, Roller-Compacted Concrete, Fiber Reinforced Concrete. Includes Florida Super n Sand Stucco Mix and Florida Super n Sand Masonry Mortar Mix.

Intended use of the product: Cement is used as a binder in concrete and mortars that are widely used in construction. Cement is distributed in bags, totes and bulk shipment.

Contact:
Argos Cement
3015 Windward Plaza
Suite 300
Alpharetta, GA 30005
mheaton@argos-us.com
Contact Person: Michael J. Heaton

Contact Information:
CHEMTREC EMERGENCY TELEPHONE NUMBER (24 hrs): (800)424-9300
COMPANY CONTACT (business hours): (678)368-4300 (8 AM-4 PM EST)

2. HAZARD IDENTIFICATION

According to OSHA 29 CFR 1910.1200 HCS

Classification of the Substance or Mixture

Classification (GHS-US):

Skin Corrosion/Irritation	Category 1C	H314
Skin Sensitization	Category 1	H317
Serious Eye Damage/Eye Irritation	Category 1	H318
STOT SE	Category 3	H335
Carcinogenicity	Category 1A	H350
STOT RE	Category 1	H372

Labeling Elements

Signal Word (GHS-US) : Danger

Hazard Statements (GHS-US):
H314 – Causes severe skin burns and eye damage.
H317 – May cause an allergic skin reaction.
H318 – Causes serious eye damage.
H335 – May cause respiratory irritation.
H350 – May cause cancer.
H372 – Causes damage to lung through prolonged or repeated exposure inhalation.

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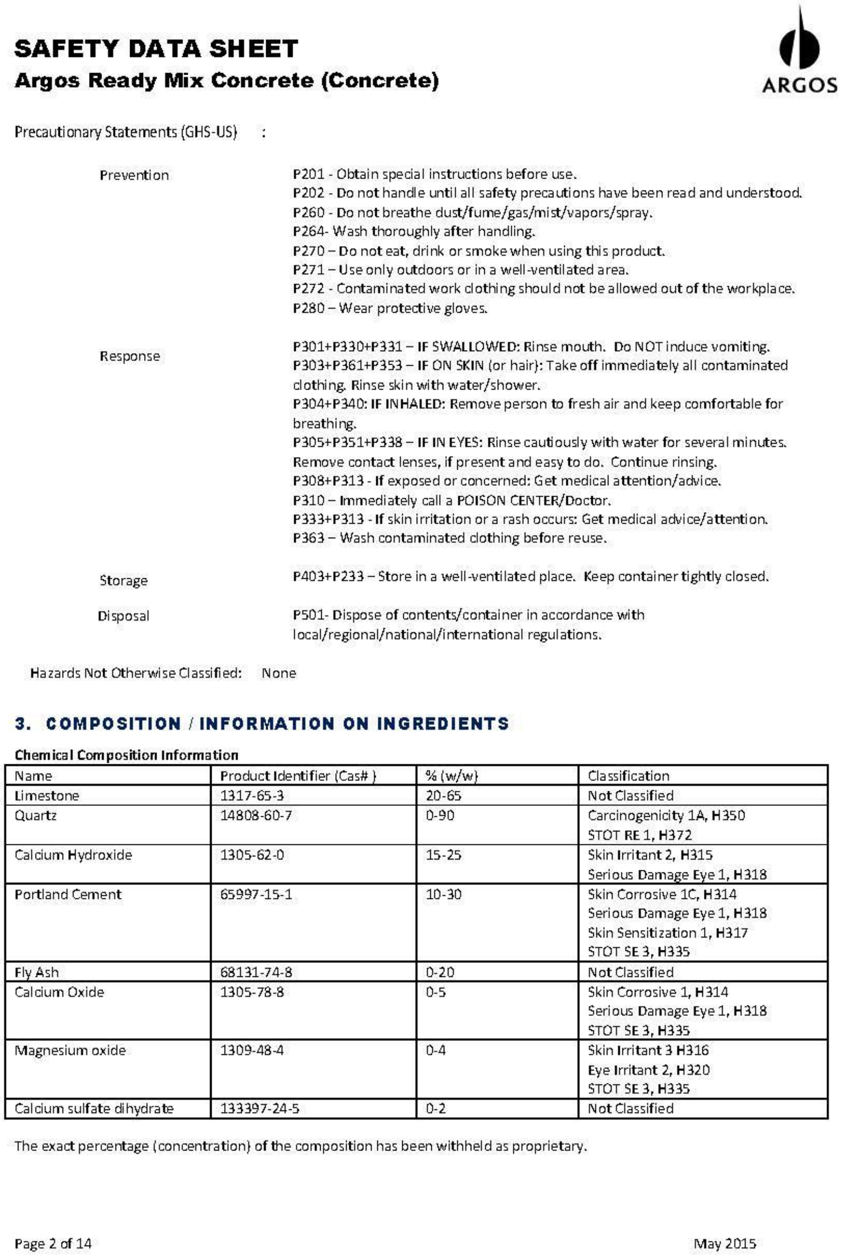
Figure D.26 Sinclair Hills drilled shaft certification data submittal page 20.



SAFETY DATA SHEET
Argos Ready Mix Concrete (Concrete)

ARGOS

Precautionary Statements (GHS-US) :

Prevention
P201 - Obtain special instructions before use.
P202 - Do not handle until all safety precautions have been read and understood.
P260 - Do not breathe dust/fume/gas/mist/vapors/spray.
P264- Wash thoroughly after handling.
P270 – Do not eat, drink or smoke when using this product.
P271 – Use only outdoors or in a well-ventilated area.
P272 - Contaminated work clothing should not be allowed out of the workplace.
P280 – Wear protective gloves.

Response
P301+P330+P331 – IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P303+P361+P353 – IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
P304+P340: IF INHALED: Remove person to fresh air and keep comfortable for breathing.
P305+P351+P338 – IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P308+P313 - If exposed or concerned: Get medical attention/advice.
P310 – Immediately call a POISON CENTER/Doctor.
P333+P313 - If skin irritation or a rash occurs: Get medical advice/attention.
P363 – Wash contaminated clothing before reuse.

Storage
P403+P233 – Store in a well-ventilated place. Keep container tightly closed.

Disposal
P501- Dispose of contents/container in accordance with local/regional/national/international regulations.

Hazards Not Otherwise Classified: None

3. COMPOSITION / INFORMATION ON INGREDIENTS

Chemical Composition Information

Name	Product Identifier (Cas#)	% (w/w)	Classification
Limestone	1317-65-3	20-65	Not Classified
Quartz	14808-60-7	0-90	Carcinogenicity 1A, H350 STOT RE 1, H372
Calcium Hydroxide	1305-62-0	15-25	Skin Irritant 2, H315 Serious Damage Eye 1, H318
Portland Cement	65997-15-1	10-30	Skin Corrosive 1C, H314 Serious Damage Eye 1, H318 Skin Sensitization 1, H317 STOT SE 3, H335
Fly Ash	68131-74-8	0-20	Not Classified
Calcium Oxide	1305-78-8	0-5	Skin Corrosive 1, H314 Serious Damage Eye 1, H318 STOT SE 3, H335
Magnesium oxide	1309-48-4	0-4	Skin Irritant 3 H316 Eye Irritant 2, H320 STOT SE 3, H335
Calcium sulfate dihydrate	133397-24-5	0-2	Not Classified

The exact percentage (concentration) of the composition has been withheld as proprietary.

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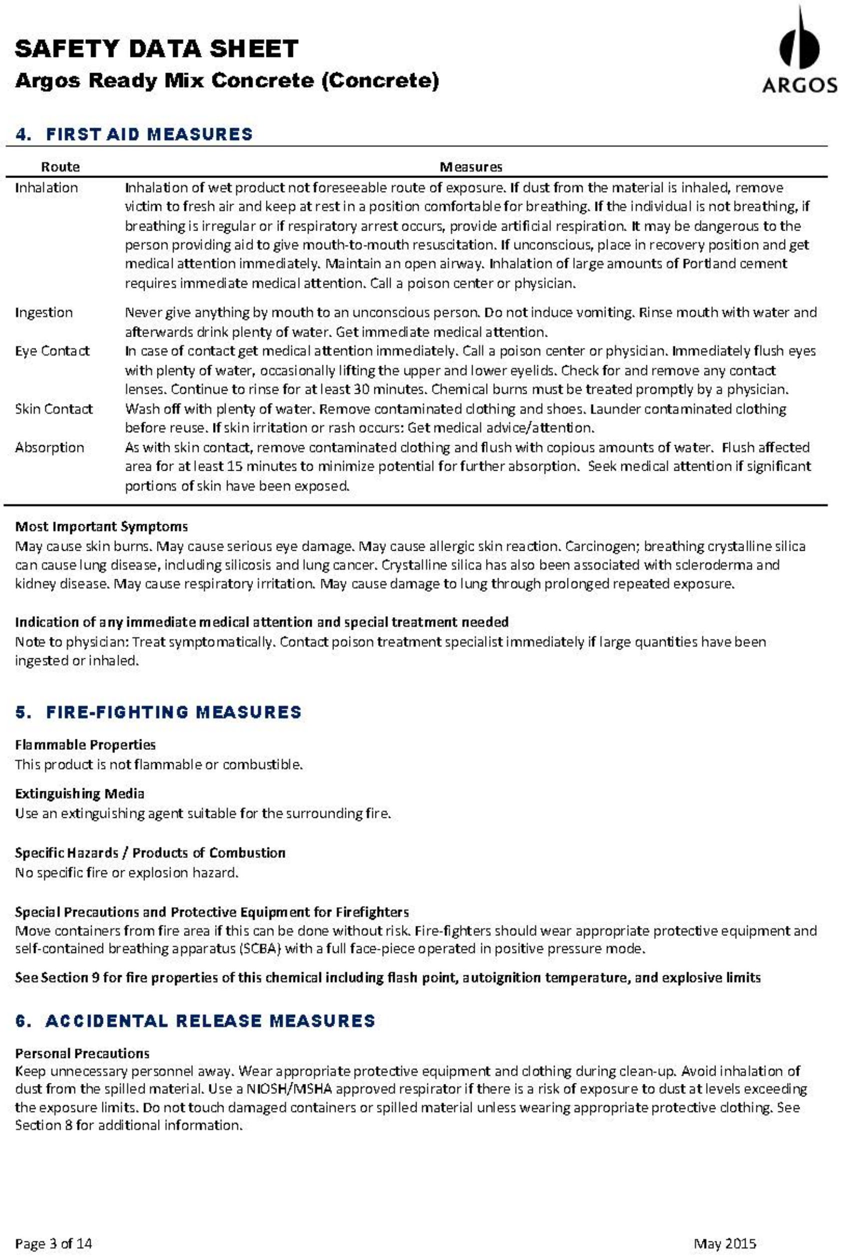
Figure D.27 Sinclair Hills drilled shaft certification data submittal page 21.



SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

4. FIRST AID MEASURES

Route	Measures
Inhalation	Inhalation of wet product not foreseeable route of exposure. If dust from the material is inhaled, remove victim to fresh air and keep at rest in a position comfortable for breathing. If the individual is not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Inhalation of large amounts of Portland cement requires immediate medical attention. Call a poison center or physician.
Ingestion	Never give anything by mouth to an unconscious person. Do not induce vomiting. Rinse mouth with water and afterwards drink plenty of water. Get immediate medical attention.
Eye Contact	In case of contact get medical attention immediately. Call a poison center or physician. Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 30 minutes. Chemical burns must be treated promptly by a physician.
Skin Contact	Wash off with plenty of water. Remove contaminated clothing and shoes. Launder contaminated clothing before reuse. If skin irritation or rash occurs: Get medical advice/attention.
Absorption	As with skin contact, remove contaminated clothing and flush with copious amounts of water. Flush affected area for at least 15 minutes to minimize potential for further absorption. Seek medical attention if significant portions of skin have been exposed.

Most Important Symptoms

May cause skin burns. May cause serious eye damage. May cause allergic skin reaction. Carcinogen; breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease. May cause respiratory irritation. May cause damage to lung through prolonged repeated exposure.

Indication of any immediate medical attention and special treatment needed

Note to physician: Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

5. FIRE-FIGHTING MEASURES

Flammable Properties

This product is not flammable or combustible.

Extinguishing Media

Use an extinguishing agent suitable for the surrounding fire.

Specific Hazards / Products of Combustion

No specific fire or explosion hazard.

Special Precautions and Protective Equipment for Firefighters

Move containers from fire area if this can be done without risk. Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

See Section 9 for fire properties of this chemical including flash point, autoignition temperature, and explosive limits

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions

Keep unnecessary personnel away. Wear appropriate protective equipment and clothing during clean-up. Avoid inhalation of dust from the spilled material. Use a NIOSH/MSHA approved respirator if there is a risk of exposure to dust at levels exceeding the exposure limits. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. See Section 8 for additional information.

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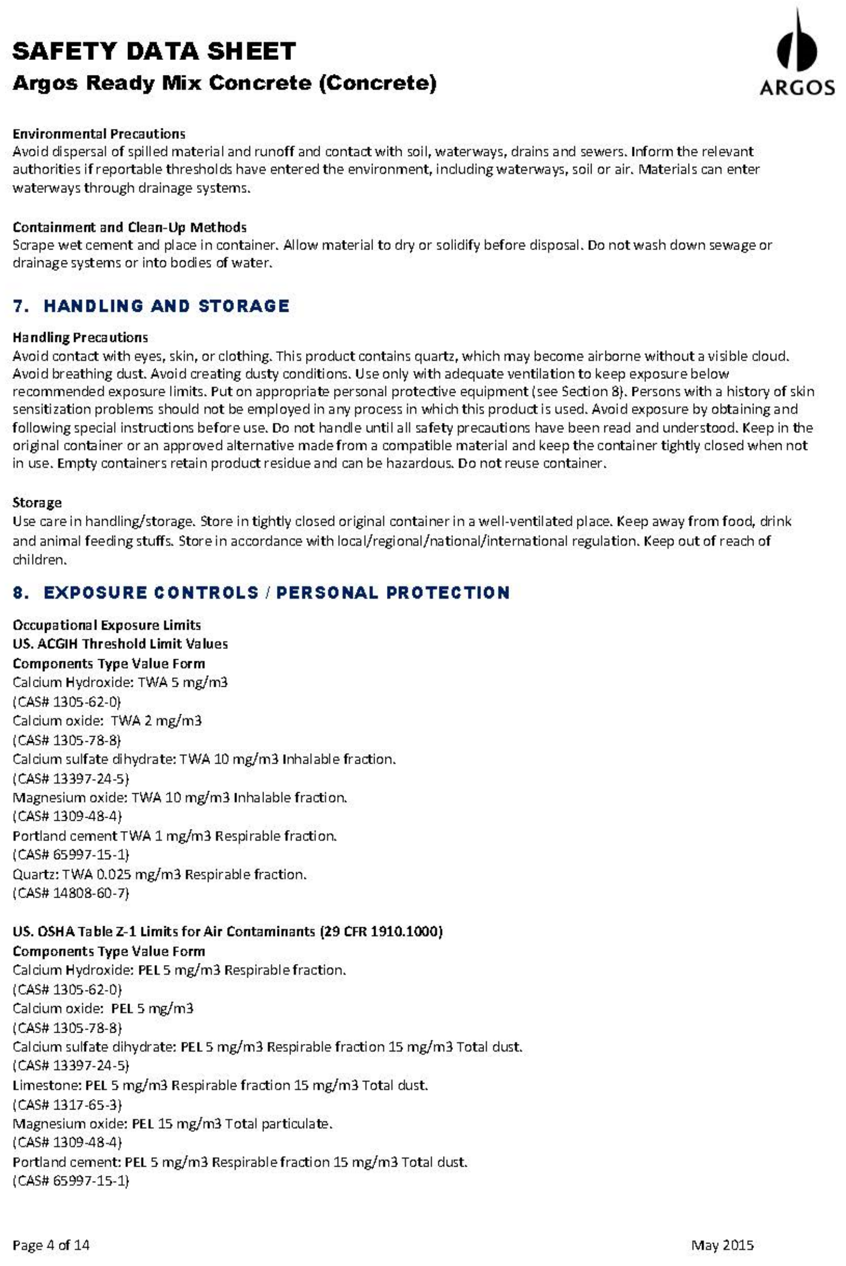
Figure D.28 Sinclair Hills drilled shaft certification data submittal page 22



SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

Environmental Precautions

Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if reportable thresholds have entered the environment, including waterways, soil or air. Materials can enter waterways through drainage systems.

Containment and Clean-Up Methods

Scrape wet cement and place in container. Allow material to dry or solidify before disposal. Do not wash down sewage or drainage systems or into bodies of water.

7. HANDLING AND STORAGE

Handling Precautions

Avoid contact with eyes, skin, or clothing. This product contains quartz, which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Put on appropriate personal protective equipment (see Section 8). Persons with a history of skin sensitization problems should not be employed in any process in which this product is used. Avoid exposure by obtaining and following special instructions before use. Do not handle until all safety precautions have been read and understood. Keep in the original container or an approved alternative made from a compatible material and keep the container tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.

Storage

Use care in handling/storage. Store in tightly closed original container in a well-ventilated place. Keep away from food, drink and animal feeding stuffs. Store in accordance with local/regional/national/international regulation. Keep out of reach of children.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational Exposure Limits

US. ACGIH Threshold Limit Values

Components Type Value Form

Calcium Hydroxide: TWA 5 mg/m3
(CAS# 1305-62-0)
Calcium oxide: TWA 2 mg/m3
(CAS# 1305-78-8)
Calcium sulfate dihydrate: TWA 10 mg/m3 Inhalable fraction.
(CAS# 13397-24-5)
Magnesium oxide: TWA 10 mg/m3 Inhalable fraction.
(CAS# 1309-48-4)
Portland cement TWA 1 mg/m3 Respirable fraction.
(CAS# 65997-15-1)
Quartz: TWA 0.025 mg/m3 Respirable fraction.
(CAS# 14808-60-7)

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)

Components Type Value Form

Calcium Hydroxide: PEL 5 mg/m3 Respirable fraction.
(CAS# 1305-62-0)
Calcium oxide: PEL 5 mg/m3
(CAS# 1305-78-8)
Calcium sulfate dihydrate: PEL 5 mg/m3 Respirable fraction 15 mg/m3 Total dust.
(CAS# 13397-24-5)
Limestone: PEL 5 mg/m3 Respirable fraction 15 mg/m3 Total dust.
(CAS# 1317-65-3)
Magnesium oxide: PEL 15 mg/m3 Total particulate.
(CAS# 1309-48-4)
Portland cement: PEL 5 mg/m3 Respirable fraction 15 mg/m3 Total dust.
(CAS# 65997-15-1)

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Figure D.29 Sinclair Hills drilled shaft certification data submittal page 23.

SAFETY DATA SHEET
Argos Ready Mix Concrete (Concrete)

ARGOS

US. OSHA Table Z-3 (29 CFR 1910.1000)
Components Type Value Form
Portland cement: TWA 50 mppcf
(CAS# 65997-15-1)
Quartz: TWA 0.3 mg/m3 Total dust, 0.1 mg/m3 Respirable, 2.4 mppcf Respirable.
(CAS# 14808-60-7)

Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2)
Components Type Value Form
Calcium Hydroxide: TWA 5 mg/m3
(CAS# 1305-62-0)
Calcium oxide: TWA 2 mg/m3
(CAS# 1305-78-8)
Calcium sulfate dihydrate: TWA 10 mg/m3
(CAS# 13397-24-5)
Limestone: TWA 10 mg/m3
(CAS# 1317-65-3)
Magnesium oxide: TWA 10 mg/m3 Fume.
(CAS# 1309-48-4)
Portland cement: TWA 10 mg/m3
(CAS# 65997-15-1)
Quartz: TWA 0.025 mg/m3 Respirable particles.
(CAS# 14808-60-7)

Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended)
Components Type Value Form
Calcium Hydroxide: TWA 5 mg/m3
(CAS# 1305-62-0)
Calcium oxide: TWA 2 mg/m3
(CAS# 1305-78-8)
Calcium sulfate dihydrate: STEL 20 mg/m3 Total dust, TWA 10 mg/m3 Inhalable
(CAS# 13397-24-5)
Limestone: STEL 20 mg/m3 Total dust, TWA 3 mg/m3 Respirable fraction 10 mg/m3 Total dust.
(CAS# 1317-65-3)
Magnesium oxide: STEL 10 mg/m3 Respirable dust and/or fume, TWA 3 mg/m3 Respirable dust and/or fume, 10 mg/m3 Inhalable fume.
(CAS# 1309-48-4)
Portland cement: TWA 3 mg/m3 Respirable fraction, 10 mg/m3 Total dust.
(CAS# 65997-15-1)
Quartz TWA 0.025 mg/m3 Respirable fraction.
(CAS# 14808-60-7)

Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents)
Components Type Value Form
Calcium Hydroxide: TWA 5 mg/m3
(CAS# 1305-62-0)
Calcium oxide: TWA 2 mg/m3
(CAS# 1305-78-8)
Calcium sulfate dihydrate: TWA 10 mg/m3 Inhalable fraction.
(CAS# 13397-24-5)
Magnesium oxide: TWA 10 mg/m3 Inhalable fraction.
(CAS# 1309-48-4)
Portland cement: TWA 10 mg/m3

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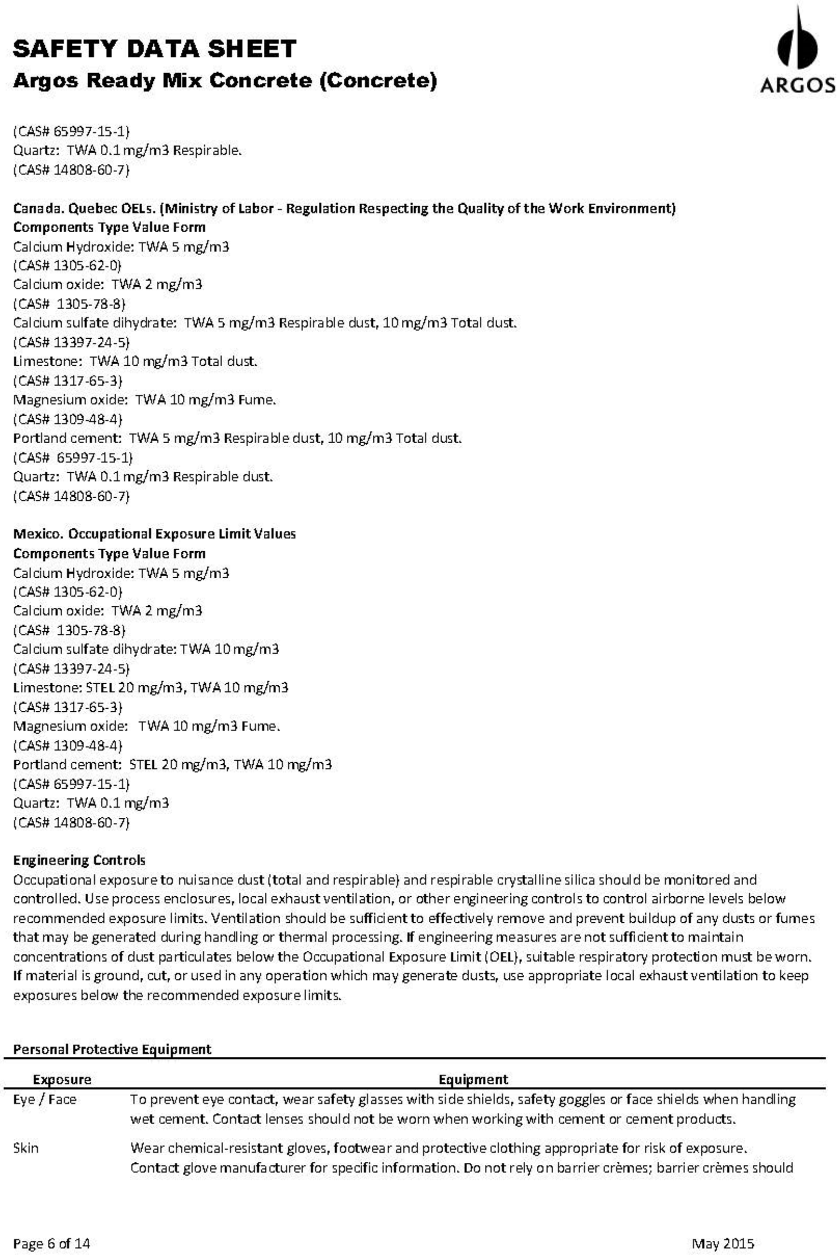
Figure D.30 Sinclair Hills drilled shaft certification data submittal page 24.



SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

(CAS# 65997-15-1)
Quartz: TWA 0.1 mg/m3 Respirable.
(CAS# 14808-60-7)

Canada. Quebec OELs. (Ministry of Labor - Regulation Respecting the Quality of the Work Environment)
Components Type Value Form
Calcium Hydroxide: TWA 5 mg/m3
(CAS# 1305-62-0)
Calcium oxide: TWA 2 mg/m3
(CAS# 1305-78-8)
Calcium sulfate dihydrate: TWA 5 mg/m3 Respirable dust, 10 mg/m3 Total dust.
(CAS# 13397-24-5)
Limestone: TWA 10 mg/m3 Total dust.
(CAS# 1317-65-3)
Magnesium oxide: TWA 10 mg/m3 Fume.
(CAS# 1309-48-4)
Portland cement: TWA 5 mg/m3 Respirable dust, 10 mg/m3 Total dust.
(CAS# 65997-15-1)
Quartz: TWA 0.1 mg/m3 Respirable dust.
(CAS# 14808-60-7)

Mexico. Occupational Exposure Limit Values
Components Type Value Form
Calcium Hydroxide: TWA 5 mg/m3
(CAS# 1305-62-0)
Calcium oxide: TWA 2 mg/m3
(CAS# 1305-78-8)
Calcium sulfate dihydrate: TWA 10 mg/m3
(CAS# 13397-24-5)
Limestone: STEL 20 mg/m3, TWA 10 mg/m3
(CAS# 1317-65-3)
Magnesium oxide: TWA 10 mg/m3 Fume.
(CAS# 1309-48-4)
Portland cement: STEL 20 mg/m3, TWA 10 mg/m3
(CAS# 65997-15-1)
Quartz: TWA 0.1 mg/m3
(CAS# 14808-60-7)

Engineering Controls

Occupational exposure to nuisance dust (total and respirable) and respirable crystalline silica should be monitored and controlled. Use process enclosures, local exhaust ventilation, or other engineering controls to control airborne levels below recommended exposure limits. Ventilation should be sufficient to effectively remove and prevent buildup of any dusts or fumes that may be generated during handling or thermal processing. If engineering measures are not sufficient to maintain concentrations of dust particulates below the Occupational Exposure Limit (OEL), suitable respiratory protection must be worn. If material is ground, cut, or used in any operation which may generate dusts, use appropriate local exhaust ventilation to keep exposures below the recommended exposure limits.

Personal Protective Equipment

Exposure	Equipment
Eye / Face	To prevent eye contact, wear safety glasses with side shields, safety goggles or face shields when handling wet cement. Contact lenses should not be worn when working with cement or cement products.
Skin	Wear chemical-resistant gloves, footwear and protective clothing appropriate for risk of exposure. Contact glove manufacturer for specific information. Do not rely on barrier crèmes; barrier crèmes should

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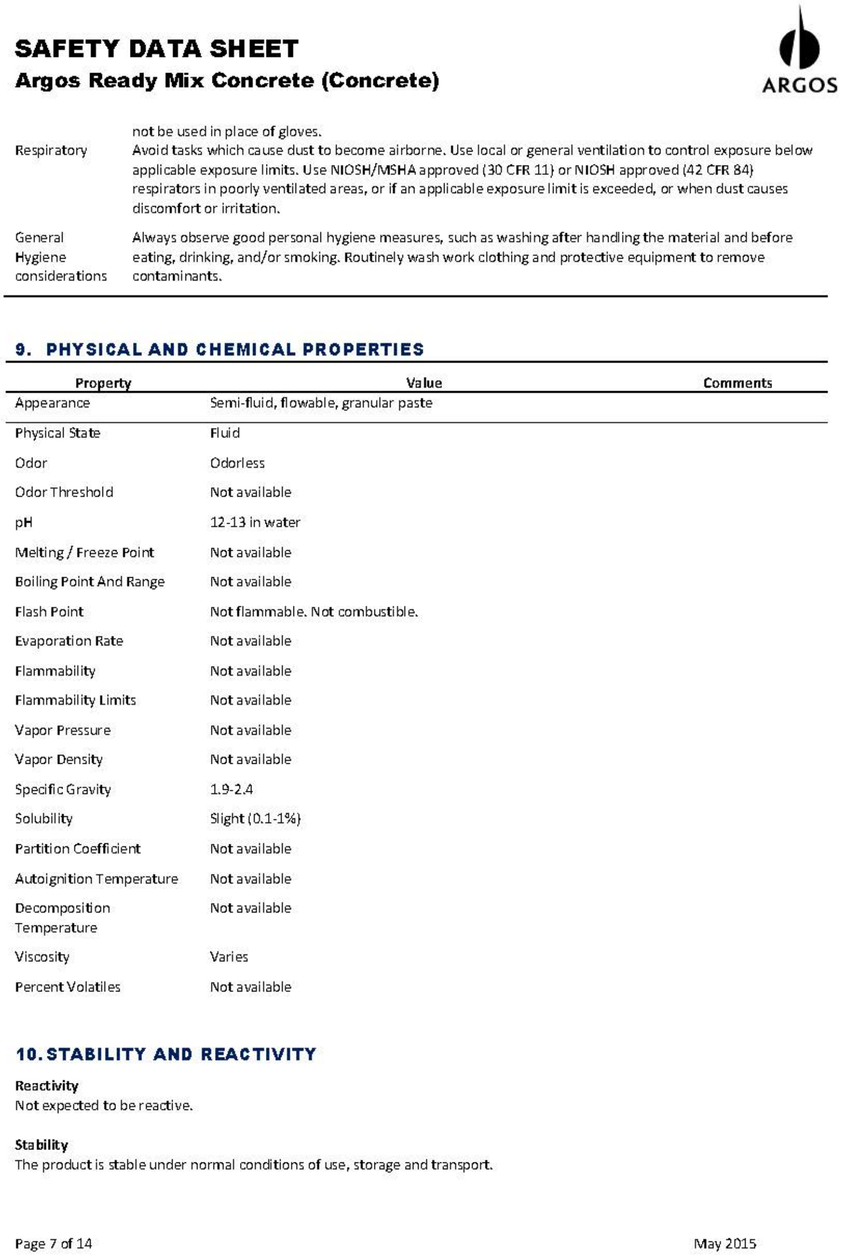
Figure D.31 Sinclair Hills drilled shaft certification data submittal page 25.



SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

	not be used in place of gloves.
Respiratory	Avoid tasks which cause dust to become airborne. Use local or general ventilation to control exposure below applicable exposure limits. Use NIOSH/MSHA approved (30 CFR 11) or NIOSH approved (42 CFR 84) respirators in poorly ventilated areas, or if an applicable exposure limit is exceeded, or when dust causes discomfort or irritation.
General Hygiene considerations	Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. PHYSICAL AND CHEMICAL PROPERTIES

Property	Value	Comments
Appearance	Semi-fluid, flowable, granular paste	
Physical State	Fluid	
Odor	Odorless	
Odor Threshold	Not available	
pH	12-13 in water	
Melting / Freeze Point	Not available	
Boiling Point And Range	Not available	
Flash Point	Not flammable. Not combustible.	
Evaporation Rate	Not available	
Flammability	Not available	
Flammability Limits	Not available	
Vapor Pressure	Not available	
Vapor Density	Not available	
Specific Gravity	1.9-2.4	
Solubility	Slight (0.1-1%)	
Partition Coefficient	Not available	
Autoignition Temperature	Not available	
Decomposition Temperature	Not available	
Viscosity	Varies	
Percent Volatiles	Not available	

10. STABILITY AND REACTIVITY

Reactivity

Not expected to be reactive.

Stability

The product is stable under normal conditions of use, storage and transport.

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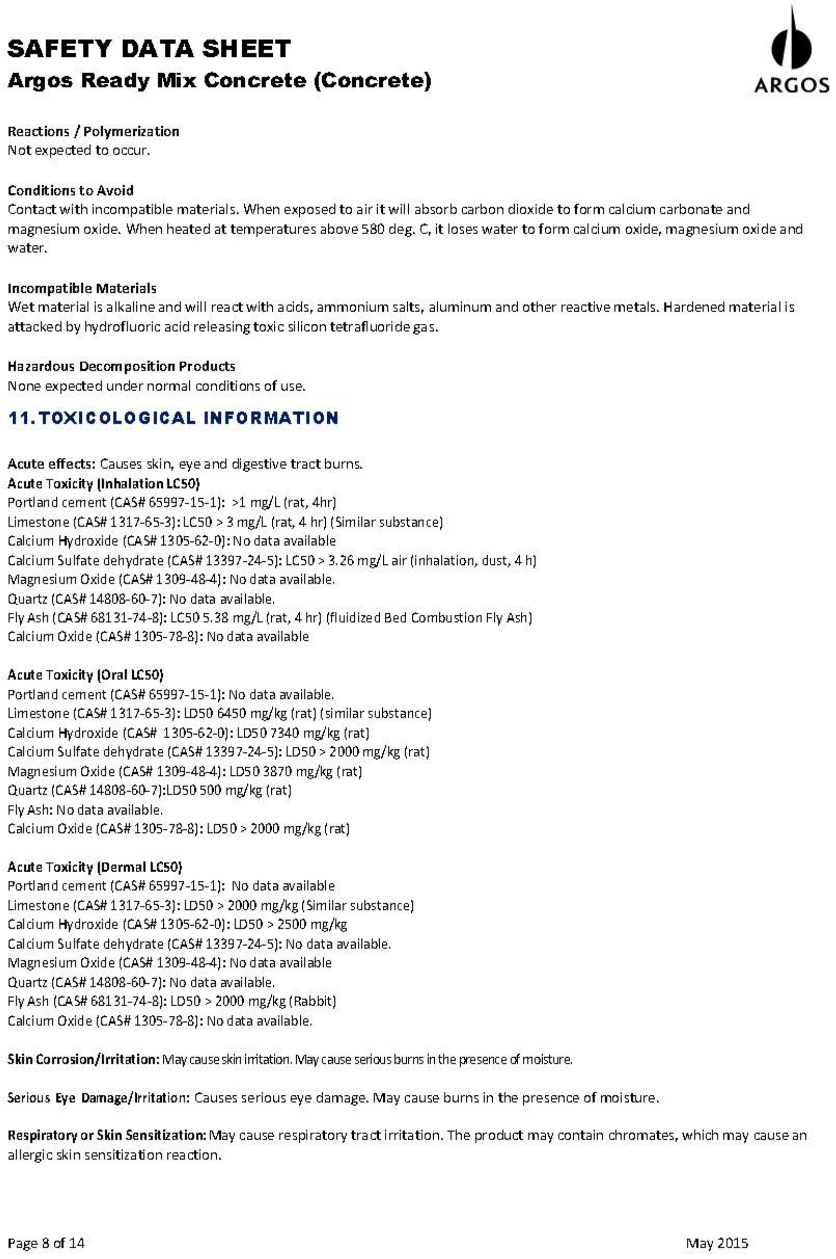
Figure D.32 Sinclair Hills drilled shaft certification data submittal page 26.



Reactions / Polymerization
Not expected to occur.

Conditions to Avoid
Contact with incompatible materials. When exposed to air it will absorb carbon dioxide to form calcium carbonate and magnesium oxide. When heated at temperatures above 580 deg. C, it loses water to form calcium oxide, magnesium oxide and water.

Incompatible Materials
Wet material is alkaline and will react with acids, ammonium salts, aluminum and other reactive metals. Hardened material is attacked by hydrofluoric acid releasing toxic silicon tetrafluoride gas.

Hazardous Decomposition Products
None expected under normal conditions of use.

11. TOXICOLOGICAL INFORMATION

Acute effects: Causes skin, eye and digestive tract burns.

Acute Toxicity (Inhalation LC50)
Portland cement (CAS# 65997-15-1): >1 mg/L (rat, 4hr)
Limestone (CAS# 1317-65-3): LC50 > 3 mg/L (rat, 4 hr) (Similar substance)
Calcium Hydroxide (CAS# 1305-62-0): No data available
Calcium Sulfate dehydrate (CAS# 13397-24-5): LC50 > 3.26 mg/L air (inhalation, dust, 4 h)
Magnesium Oxide (CAS# 1309-48-4): No data available.
Quartz (CAS# 14808-60-7): No data available.
Fly Ash (CAS# 68131-74-8): LC50 5.38 mg/L (rat, 4 hr) (fluidized Bed Combustion Fly Ash)
Calcium Oxide (CAS# 1305-78-8): No data available

Acute Toxicity (Oral LC50)
Portland cement (CAS# 65997-15-1): No data available.
Limestone (CAS# 1317-65-3): LD50 6450 mg/kg (rat) (similar substance)
Calcium Hydroxide (CAS# 1305-62-0): LD50 7340 mg/kg (rat)
Calcium Sulfate dehydrate (CAS# 13397-24-5): LD50 > 2000 mg/kg (rat)
Magnesium Oxide (CAS# 1309-48-4): LD50 3870 mg/kg (rat)
Quartz (CAS# 14808-60-7):LD50 500 mg/kg (rat)
Fly Ash: No data available.
Calcium Oxide (CAS# 1305-78-8): LD50 > 2000 mg/kg (rat)

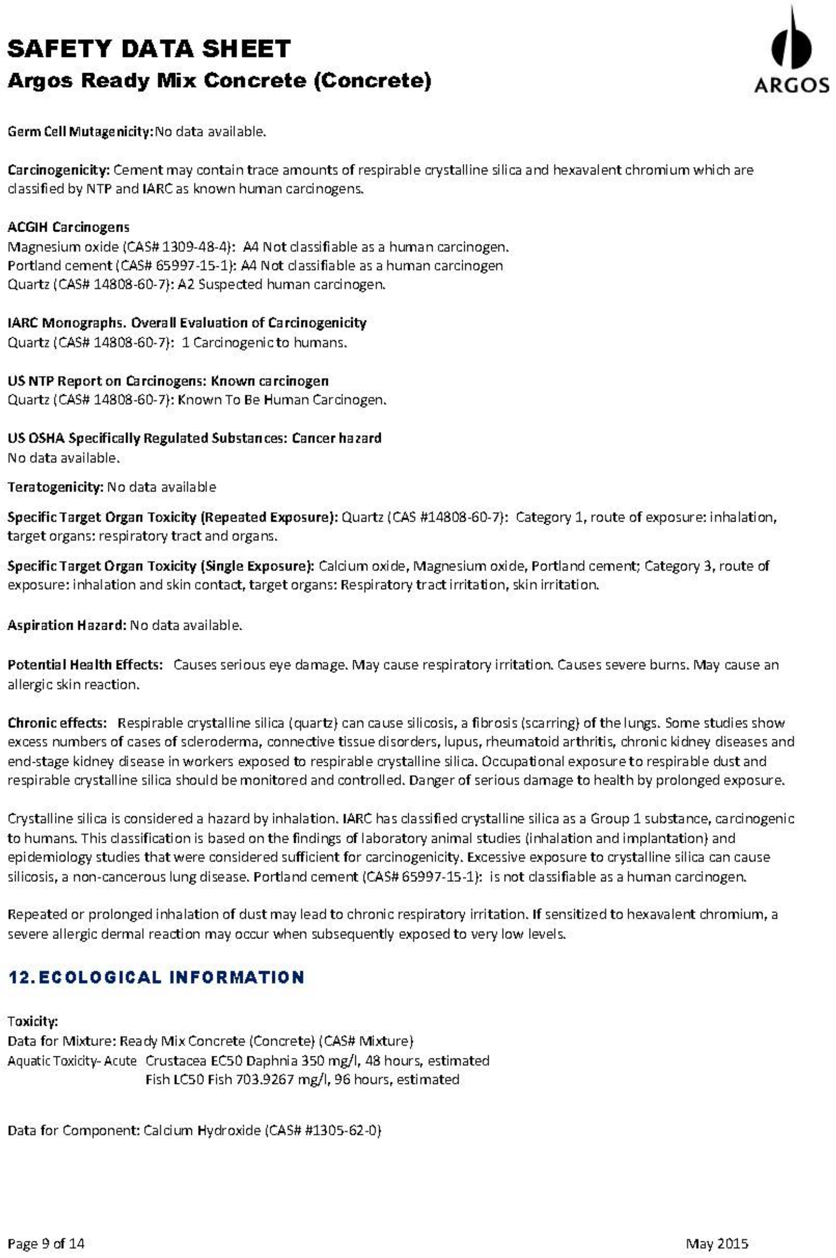
Acute Toxicity (Dermal LC50)
Portland cement (CAS# 65997-15-1): No data available
Limestone (CAS# 1317-65-3): LD50 > 2000 mg/kg (Similar substance)
Calcium Hydroxide (CAS# 1305-62-0): LD50 > 2500 mg/kg
Calcium Sulfate dehydrate (CAS# 13397-24-5): No data available.
Magnesium Oxide (CAS# 1309-48-4): No data available
Quartz (CAS# 14808-60-7): No data available.
Fly Ash (CAS# 68131-74-8): LD50 > 2000 mg/kg (Rabbit)
Calcium Oxide (CAS# 1305-78-8): No data available.

Skin Corrosion/Irritation: May cause skin irritation. May cause serious burns in the presence of moisture.

Serious Eye Damage/Irritation: Causes serious eye damage. May cause burns in the presence of moisture.

Respiratory or Skin Sensitization: May cause respiratory tract irritation. The product may contain chromates, which may cause an allergic skin sensitization reaction.

Figure D.33 Sinclair Hills drilled shaft certification data submittal page 27.



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ARGOS

Germ Cell Mutagenicity: No data available.

Carcinogenicity: Cement may contain trace amounts of respirable crystalline silica and hexavalent chromium which are classified by NTP and IARC as known human carcinogens.

ACGIH Carcinogens
Magnesium oxide (CAS# 1309-48-4): A4 Not classifiable as a human carcinogen.
Portland cement (CAS# 65997-15-1): A4 Not classifiable as a human carcinogen
Quartz (CAS# 14808-60-7): A2 Suspected human carcinogen.

IARC Monographs. Overall Evaluation of Carcinogenicity
Quartz (CAS# 14808-60-7): 1 Carcinogenic to humans.

US NTP Report on Carcinogens: Known carcinogen
Quartz (CAS# 14808-60-7): Known To Be Human Carcinogen.

US OSHA Specifically Regulated Substances: Cancer hazard
No data available.

Teratogenicity: No data available

Specific Target Organ Toxicity (Repeated Exposure): Quartz (CAS #14808-60-7): Category 1, route of exposure: inhalation, target organs: respiratory tract and organs.

Specific Target Organ Toxicity (Single Exposure): Calcium oxide, Magnesium oxide, Portland cement; Category 3, route of exposure: inhalation and skin contact, target organs: Respiratory tract irritation, skin irritation.

Aspiration Hazard: No data available.

Potential Health Effects: Causes serious eye damage. May cause respiratory irritation. Causes severe burns. May cause an allergic skin reaction.

Chronic effects: Respirable crystalline silica (quartz) can cause silicosis, a fibrosis (scarring) of the lungs. Some studies show excess numbers of cases of scleroderma, connective tissue disorders, lupus, rheumatoid arthritis, chronic kidney diseases and end-stage kidney disease in workers exposed to respirable crystalline silica. Occupational exposure to respirable dust and respirable crystalline silica should be monitored and controlled. Danger of serious damage to health by prolonged exposure.

Crystalline silica is considered a hazard by inhalation. IARC has classified crystalline silica as a Group 1 substance, carcinogenic to humans. This classification is based on the findings of laboratory animal studies (inhalation and implantation) and epidemiology studies that were considered sufficient for carcinogenicity. Excessive exposure to crystalline silica can cause silicosis, a non-cancerous lung disease. Portland cement (CAS# 65997-15-1): is not classifiable as a human carcinogen.

Repeated or prolonged inhalation of dust may lead to chronic respiratory irritation. If sensitized to hexavalent chromium, a severe allergic dermal reaction may occur when subsequently exposed to very low levels.

12. ECOLOGICAL INFORMATION

Toxicity:
Data for Mixture: Ready Mix Concrete (Concrete) (CAS# Mixture)

Aquatic Toxicity- Acute	Crustacea EC50 Daphnia 350 mg/l, 48 hours, estimated
	Fish LC50 Fish 703.9267 mg/l, 96 hours, estimated

Data for Component: Calcium Hydroxide (CAS# #1305-62-0)

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Figure D.34 Sinclair Hills drilled shaft certification data submittal page 28.

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Aquatic Toxicity-Acute	Gasterosteus aculeatus 96 hr LC50 = 457 mg/L Oncorhynchus mykiss 96 hr LC50 = 50.6 mg/L Crangon septemspinosa 96 hr LC50 = 158 mg/L Daphnia magna 48 hr EC50 = 49.1 mg/L Daphnia magna 48 h EC50 > 100 mg/L Danio rerio 96 h LC50 > 11.1 mg/L
Aquatic Toxicity-Chronic	Crangon septemspinosa 14 d NOEC = 32 mg/L
Data for Component:	Calcium sulfate dihydrate (CAS# 13397-24-5)
Aquatic Toxicity-Acute	Fish LC50 Fathead minnow (Pimephales promelas) > 1970 mg/l, 96 hours
Data for Component:	Calcium oxide (CAS#1305-78-8)
Aquatic Toxicity-Acute	Cyprinus carpio 96 hr LC50 = 1070 mg/L
Aquatic Toxicity-Chronic	Tilapia nilotica 46 days NOEC = 100 mg/L
Data for Component:	Quartz (CAS# 14808-60-7)
Aquatic Toxicity- Acute	Daphnia magna 24 hr LL50 > 10000 mg/L Danio rerio 96 hr LL0 = 10000 mg/LDaphnia magna 48 hr EC50 > 100 mg/L (similar substance) Desmodesmus subspicatus 72 hr EC50 > 14 mg/L (similar substance)

Persistence and Degradation: Persistent
Bioaccumulative Potential: Not Bioaccumulative
Mobility in Soil: No data available.
Other Adverse Effects: No data available.
Other Information: No data available.

13. DISPOSAL CONSIDERATIONS

The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Untreated waste should not be released to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe manner. Care should be taken when handling empty containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff, and contact with soil, waterways, drains and sewers.

Dispose in accordance with applicable federal, state, and local regulations. Empty containers may contain product residues. Do not dispose of waste into sewer. This material and its container must be disposed of as hazardous waste.

14. TRANSPORT INFORMATION

US DOT	
UN Identification Number	Not regulated
Proper Shipping Name	Not available
Hazard Class and Packing Group	Not available
Shipping Label	Not available
Placard / Bulk Package	Not available
Emergency Response Guidebook Guide Number	Not available
IATA Cargo	
UN Identification Number	Not regulated
Shipping Name / Description	Not available
Hazard Class and Packing Group	Not available

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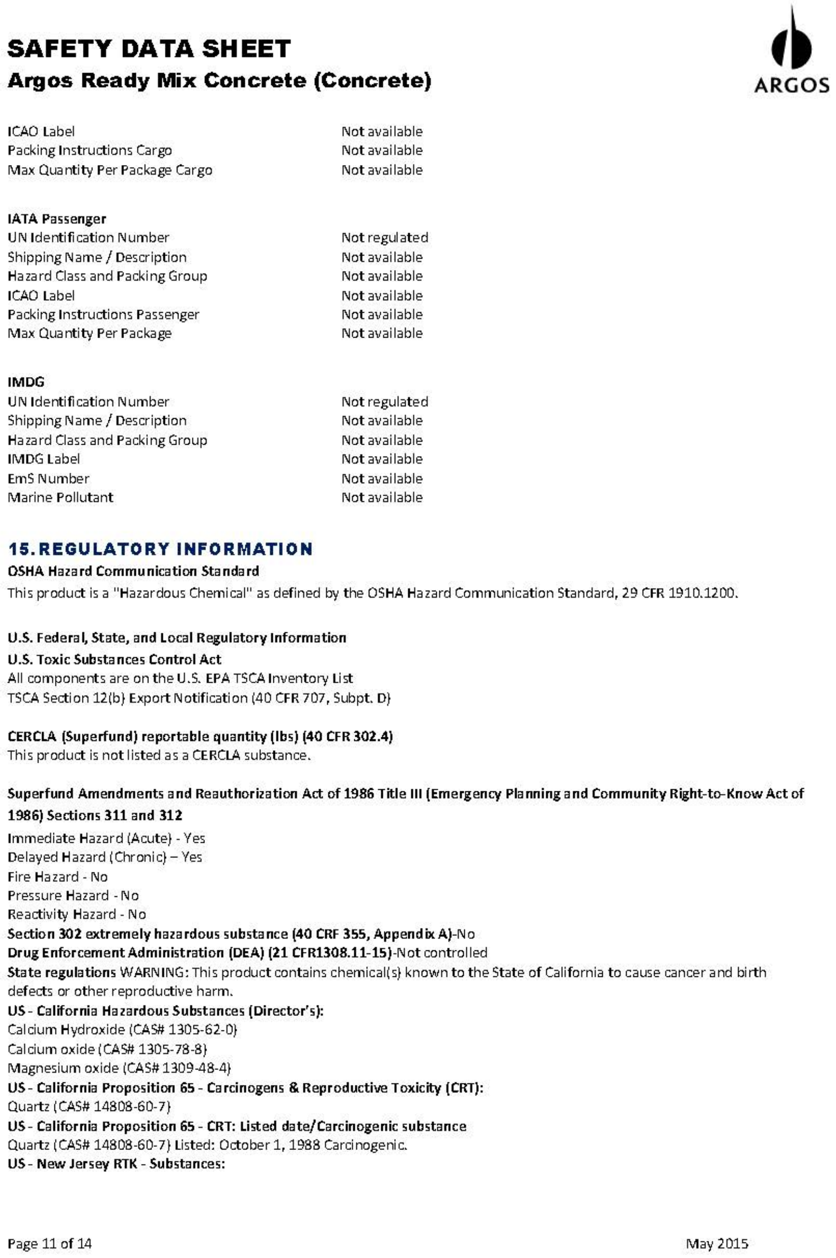
Figure D.35 Sinclair Hills drilled shaft certification data submittal page 29.



SAFETY DATA SHEET
Argos Ready Mix Concrete (Concrete)

ARGOS

ICAO Label	Not available
Packing Instructions Cargo	Not available
Max Quantity Per Package Cargo	Not available

IATA Passenger

UN Identification Number	Not regulated
Shipping Name / Description	Not available
Hazard Class and Packing Group	Not available
ICAO Label	Not available
Packing Instructions Passenger	Not available
Max Quantity Per Package	Not available

IMDG

UN Identification Number	Not regulated
Shipping Name / Description	Not available
Hazard Class and Packing Group	Not available
IMDG Label	Not available
EmS Number	Not available
Marine Pollutant	Not available

15. REGULATORY INFORMATION

OSHA Hazard Communication Standard

This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

U.S. Federal, State, and Local Regulatory Information

U.S. Toxic Substances Control Act

All components are on the U.S. EPA TSCA Inventory List
TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

CERCLA (Superfund) reportable quantity (lbs) (40 CFR 302.4)

This product is not listed as a CERCLA substance.

Superfund Amendments and Reauthorization Act of 1986 Title III (Emergency Planning and Community Right-to-Know Act of 1986) Sections 311 and 312

Immediate Hazard (Acute) - Yes
Delayed Hazard (Chronic) – Yes
Fire Hazard - No
Pressure Hazard - No
Reactivity Hazard - No
Section 302 extremely hazardous substance (40 CRF 355, Appendix A)-No
Drug Enforcement Administration (DEA) (21 CFR1308.11-15)-Not controlled
State regulations WARNING: This product contains chemical(s) known to the State of California to cause cancer and birth defects or other reproductive harm.
US - California Hazardous Substances (Director's):
Calcium Hydroxide (CAS# 1305-62-0)
Calcium oxide (CAS# 1305-78-8)
Magnesium oxide (CAS# 1309-48-4)
US - California Proposition 65 - Carcinogens & Reproductive Toxicity (CRT):
Quartz (CAS# 14808-60-7)
US - California Proposition 65 - CRT: Listed date/Carcinogenic substance
Quartz (CAS# 14808-60-7) Listed: October 1, 1988 Carcinogenic.
US - New Jersey RTK - Substances:

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Figure D.36 Sinclair Hills drilled shaft certification data submittal page 30.

SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

Calcium Hydroxide (CAS# 1305-62-0)
Calcium oxide (CAS# 1305-78-8) Listed.
Calcium sulfate dihydrate (CAS# 13397-24-5)
Limestone (CAS# 1317-65-3)
Magnesium oxide (CAS# 1309-48-4)
Portland cement (CAS# 65997-15-1)
Quartz (CAS# 14808-60-7)

US - Pennsylvania RTK - Hazardous Substances:

Calcium Hydroxide (CAS# 1305-62-0)
Calcium oxide (CAS# 1305-78-8)
Calcium sulfate dihydrate (CAS# 13397-24-5)
Limestone (CAS# 1317-65-3)
Magnesium oxide (CAS# 1309-48-4)
Portland cement (CAS# 65997-15-1)
Quartz (CAS# 14808-60-7)

US - Pennsylvania RTK - Hazardous Substances: Special hazard

Calcium Hydroxide (CAS# 1305-62-0)
Calcium oxide (CAS# 1305-78-8)
Calcium sulfate dihydrate (CAS# 13397-24-5)
Limestone (CAS# 1317-65-3)
Magnesium oxide (CAS# 1309-48-4)
Portland cement (CAS# 65997-15-1)
Quartz (CAS# 14808-60-7)

Canadian Regulatory Information

This product has been classified in accordance with the hazard criteria of the CPR and the MSDS contains all the information required by the CPR.

WHMIS status

Controlled

WHMIS classification

E – Corrosive

WHMIS labeling

Inventory status	**Country(s) or region Inventory name**	**On inventory (yes/no)***
Australia	Australian Inventory of Chemical Substances (AICS)	Yes
Canada	Domestic Substances List (DSL)	No
Canada	Non-Domestic Substances List (NDSL)	Yes
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	Yes
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	No
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	No
Philippines	Philippine Inventory of Chemicals and	No

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May 2015

Figure D.37 Sinclair Hills drilled shaft certification data submittal page 31.

SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

ARGOS

	Chemical Substances (PICCS)	
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

**A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)*

16. OTHER INFORMATION

HMIS® Health rating including an * indicates a chronic hazard

HMIS® ratings

Health: 3*
Flammability: 0
Physical hazard: 1

NFPA ratings

Health: 3
Flammability: 0
Instability: 1

Version:2015.05.27

Issue Date
5/27/2015
Prior Issue Date
10/12/2012

Description of Revisions

Revise to meet Globally Harmonized System for chemical hazard communication requirements pursuant to OSHA regulatory revisions 77 FR 17884, March 26, 2012.

Notice to reader

While the information provided in this safety data sheet is believed to provide a useful summary of the hazards of Portland cement as it is commonly used, the sheet cannot anticipate and provide all of the information that might be needed in every situation. Inexperienced product users should obtain proper training before using this product. In particular, the data furnished in this sheet do not address hazards that may be posed by other materials mixed with Portland cement to produce Portland cement products. Users should review other relevant material safety data sheets before working with this Portland cement or working on Portland cement products, for example, Portland cement concrete.

SELLER MAKES NO WARRANTY, EXPRESS OR IMPLIED, CONCERNING THE PRODUCT OR THE MERCHANTABILITY OR FITNESS THEREOF FOR ANY PURPOSE OR CONCERNING THE ACCURACY OF ANY INFORMATION PROVIDED BY **(Name of Company)**, except that the product shall conform to contracted specifications. The information provided herein was believed by the **(Name of Company)** to be accurate at the time of preparation or prepared from sources believed to be reliable, but it is the responsibility of the user to investigate and understand other pertinent sources of information to comply with all laws and procedures applicable to the safe handling and use of product and to determine the suitability of the product for its intended use. Buyer's exclusive remedy shall be for damages and no claim of any kind, whether as to product delivered or for non-delivery of product, and whether based on contract, breach of warranty, negligence, or otherwise shall be greater in amount than the purchase price of the quantity of product in respect of which damages are claimed. In no event shall Seller be liable for incidental or consequential damages, whether Buyer's claim is based on contract, breach of warranty, negligence or otherwise.

Abbreviations

ACGIH — American Conference of Governmental Industrial Hygienists
CAS# — Chemical Abstract Service
CERCLA — Comprehensive Emergency Response and Comprehensive Liability Act
CFR — Code of Federal Regulations
DOT — Department of Transportation

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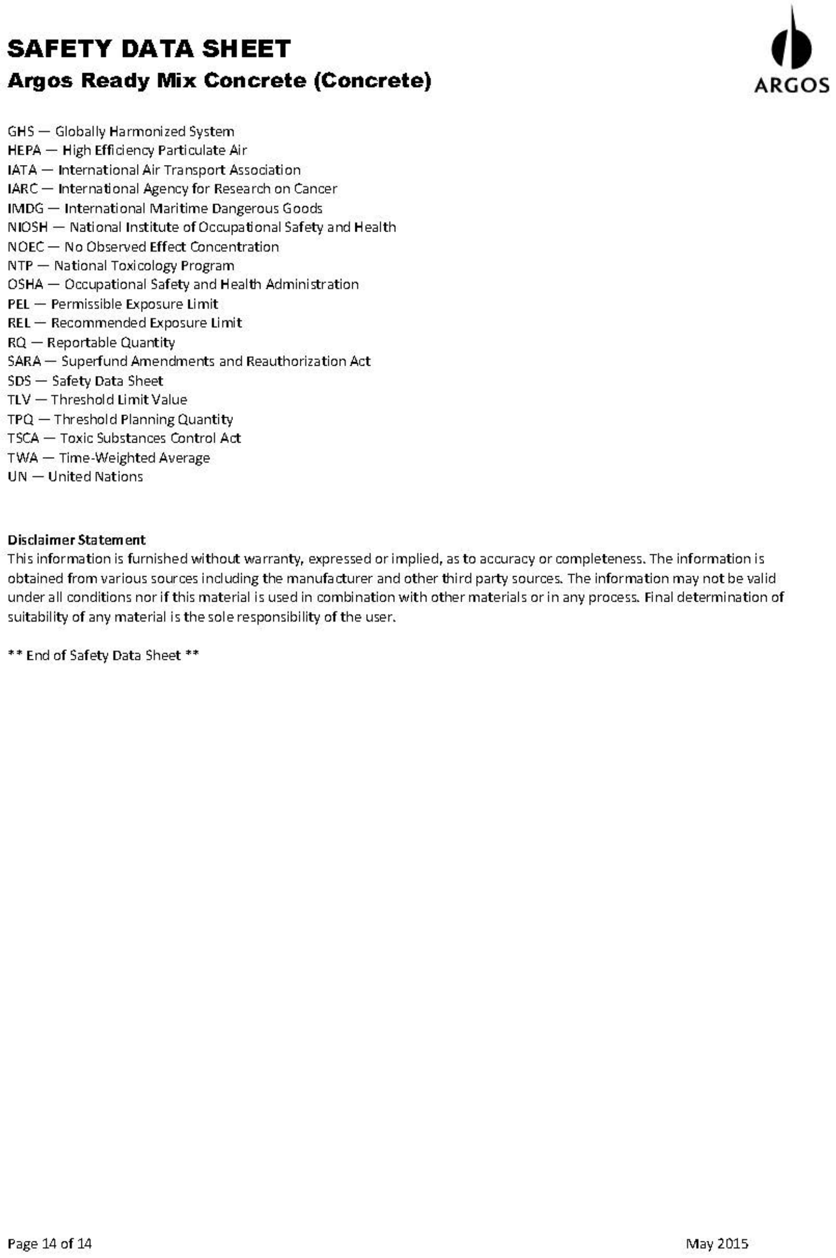
Figure D.38 Sinclair Hills drilled shaft certification data submittal page 32.



SAFETY DATA SHEET

Argos Ready Mix Concrete (Concrete)

GHS — Globally Harmonized System
HEPA — High Efficiency Particulate Air
IATA — International Air Transport Association
IARC — International Agency for Research on Cancer
IMDG — International Maritime Dangerous Goods
NIOSH — National Institute of Occupational Safety and Health
NOEC — No Observed Effect Concentration
NTP — National Toxicology Program
OSHA — Occupational Safety and Health Administration
PEL — Permissible Exposure Limit
REL — Recommended Exposure Limit
RQ — Reportable Quantity
SARA — Superfund Amendments and Reauthorization Act
SDS — Safety Data Sheet
TLV — Threshold Limit Value
TPQ — Threshold Planning Quantity
TSCA — Toxic Substances Control Act
TWA — Time-Weighted Average
UN — United Nations

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

** End of Safety Data Sheet **

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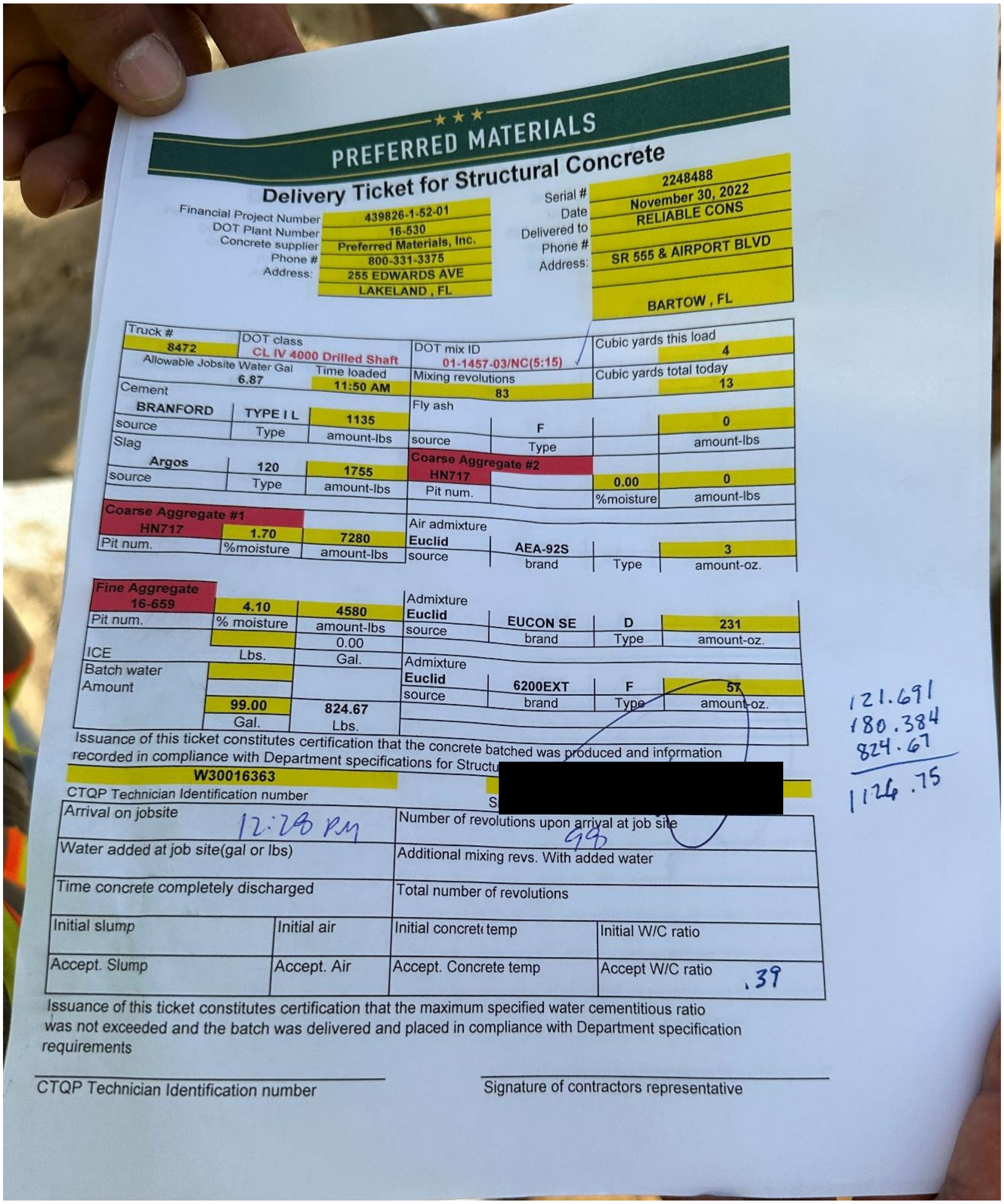
Figure D.39 Sinclair Hills drilled shaft certification data submittal page 33.

Appendix E: US 17 Drilled Shaft 1-4 Construction Documents



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number 439826-1-52-01
DOT Plant Number 16-530
Concrete supplier Preferred Materials, Inc.
Phone # 800-331-3375
Address: 255 EDWARDS AVE
LAKELAND , FL

Serial # 2248488
Date November 30, 2022
Delivered to RELIABLE CONS
Phone #
Address: SR 555 & AIRPORT BLVD
BARTOW , FL

Truck # 8472
DOT class CL IV 4000 Drilled Shaft
DOT mix ID 01-1457-03/NC(5:15) ✓
Cubic yards this load 4
Allowable Jobsite Water Gal 6.87
Time loaded 11:50 AM
Mixing revolutions 83
Cubic yards total today 13

Cement
BRANFORD source; TYPE I L Type; 1135 amount-lbs

Fly ash
source; F Type; 0 amount-lbs

Slag
Argos source; 120 Type; 1755 amount-lbs

Coarse Aggregate #2
HN717 Pit num.; 0.00 %moisture; 0 amount-lbs

Coarse Aggregate #1
HN717 Pit num.; 1.70 %moisture; 7280 amount-lbs

Air admixture
Euclid source; AEA-92S brand; Type; 3 amount-oz.

Fine Aggregate
16-659 Pit num.; 4.10 % moisture; 4580 amount-lbs

Admixture
Euclid source; EUCON SE brand; D Type; 231 amount-oz.

ICE Lbs.; 0.00 Gal.

Admixture
Euclid source; 6200EXT brand; F Type; 57 amount-oz.

Batch water Amount 99.00 Gal.; 824.67 Lbs.

121.691
180.384
824.67
1126.75

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Structu [redacted]

W30016363
CTQP Technician Identification number

S

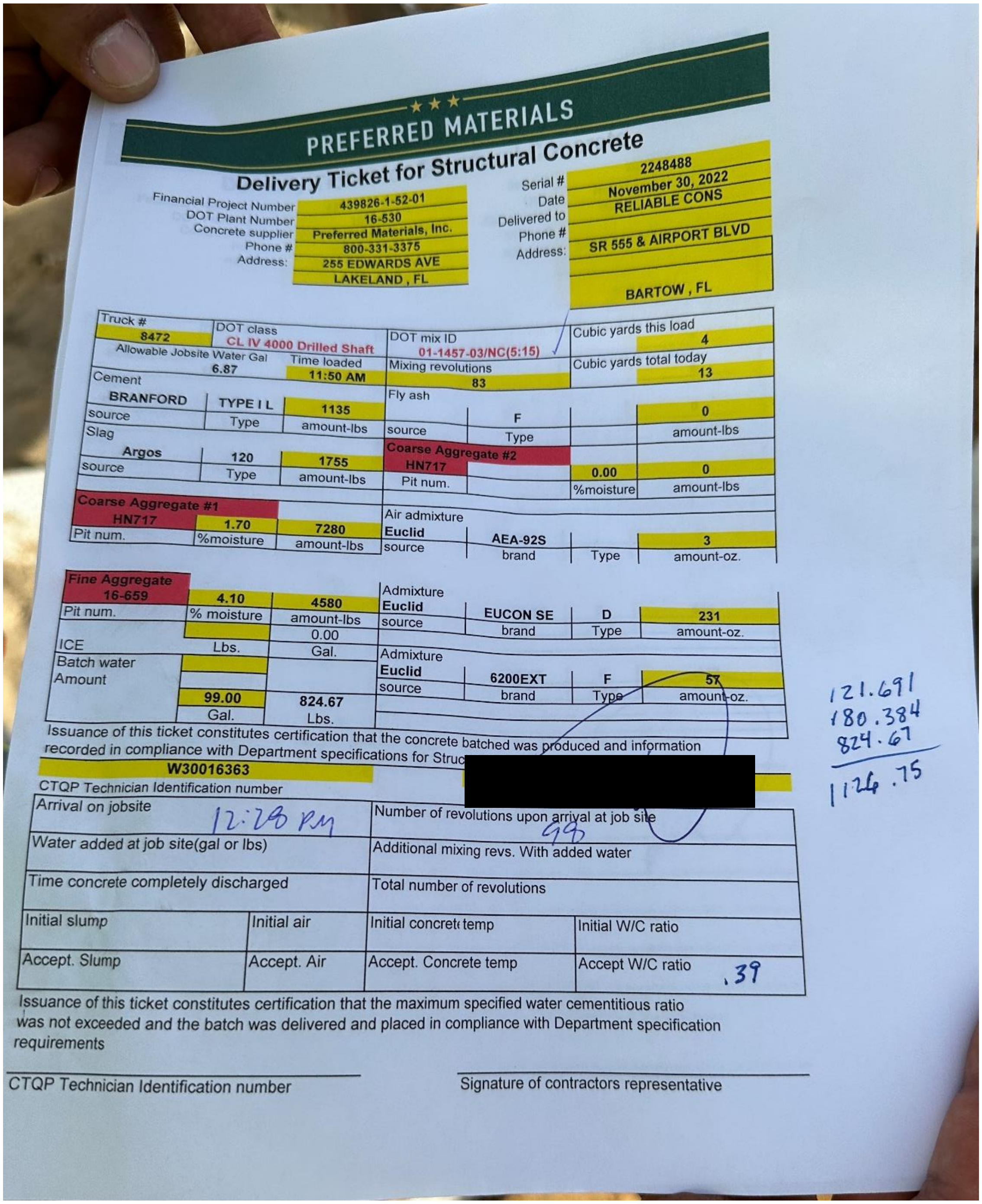
Arrival on jobsite 12:28 PM
Number of revolutions upon arrival at job site 99
Water added at job site(gal or lbs)
Additional mixing revs. With added water
Time concrete completely discharged
Total number of revolutions
Initial slump
Initial air
Initial concret temp
Initial W/C ratio
Accept. Slump
Accept. Air
Accept. Concrete temp
Accept W/C ratio .39

Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in compliance with Department specification requirements

CTQP Technician Identification number

Signature of contractors representative

Figure E.1 Bartow drilled shaft 1-4 concrete delivery ticket 1.



PREFERRED MATERIALS

Delivery Ticket for Structural Concrete

Financial Project Number	439826-1-52-01	Serial #	2248488
DOT Plant Number	16-530	Date	November 30, 2022
Concrete supplier	Preferred Materials, Inc.	Delivered to	RELIABLE CONS
Phone #	800-331-3375	Phone #	
Address:	255 EDWARDS AVE LAKELAND , FL	Address:	SR 555 & AIRPORT BLVD BARTOW , FL

Truck # 8472	DOT class CL IV 4000 Drilled Shaft	DOT mix ID 01-1457-03/NC(5:15)	Cubic yards this load 4
Allowable Jobsite Water Gal 6.87	Time loaded 11:50 AM	Mixing revolutions 83	Cubic yards total today 13

Cement

source	Type	amount-lbs
BRANFORD	TYPE I L	1135

Fly ash

source	Type		amount-lbs
	F		0

Slag

source	Type	amount-lbs
Argos	120	1755

Coarse Aggregate #2

Pit num.		%moisture	amount-lbs
HN717		0.00	0

Coarse Aggregate #1

Pit num.	%moisture	amount-lbs
HN717	1.70	7280

Air admixture

source	brand	Type	amount-oz.
Euclid	AEA-92S		3

Fine Aggregate

Pit num.	% moisture	amount-lbs
16-659	4.10	4580

Admixture

source	brand	Type	amount-oz.
Euclid	EUCON SE	D	231

ICE	Lbs.	0.00 Gal.
Batch water Amount	99.00 Gal.	824.67 Lbs.

Admixture

source	brand	Type	amount-oz.
Euclid	6200EXT	F	57

121.691
180.384
824.67
1126.75

Issuance of this ticket constitutes certification that the concrete batched was produced and information recorded in compliance with Department specifications for Struc [redacted]

W30016363
CTQP Technician Identification number

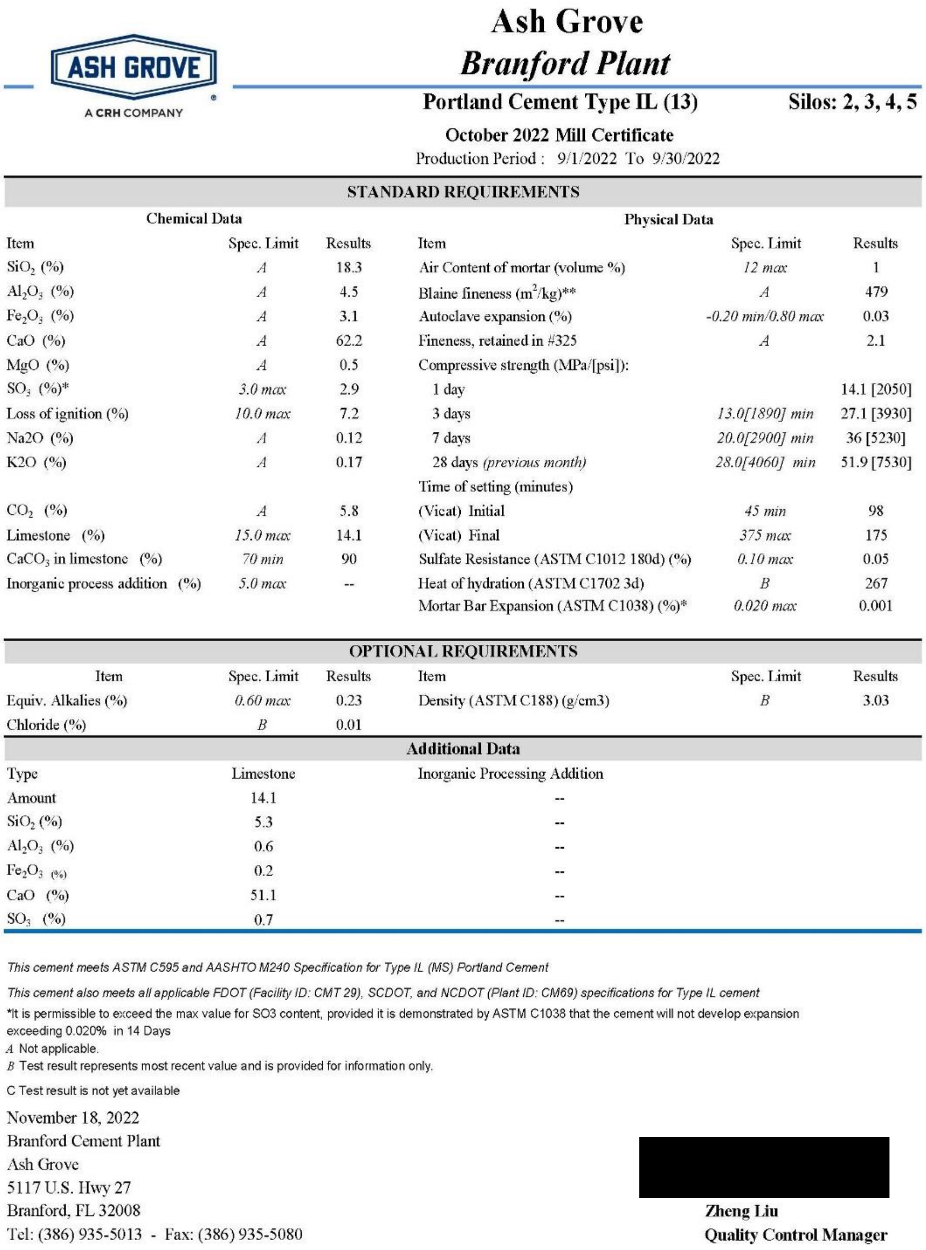
Arrival on jobsite 12:28 PM		Number of revolutions upon arrival at job site 99	
Water added at job site(gal or lbs)		Additional mixing revs. With added water	
Time concrete completely discharged		Total number of revolutions	
Initial slump	Initial air	Initial concrete temp	Initial W/C ratio
Accept. Slump	Accept. Air	Accept. Concrete temp	Accept W/C ratio .39

Issuance of this ticket constitutes certification that the maximum specified water cementitious ratio was not exceeded and the batch was delivered and placed in compliance with Department specification requirements

CTQP Technician Identification number

Signature of contractors representative

Figure E.2 Bartow drilled shaft 1-4 concrete delivery ticket 2.



Ash Grove

Branford Plant

Portland Cement Type IL (13) **Silos: 2, 3, 4, 5**

October 2022 Mill Certificate

Production Period : 9/1/2022 To 9/30/2022

STANDARD REQUIREMENTS

Chemical Data			Physical Data		
Item	Spec. Limit	Results	Item	Spec. Limit	Results
SiO_2 (%)	*A*	18.3	Air Content of mortar (volume %)	*12 max*	1
Al_2O_3 (%)	*A*	4.5	Blaine fineness (m^2/kg)**	*A*	479
Fe_2O_3 (%)	*A*	3.1	Autoclave expansion (%)	*-0.20 min/0.80 max*	0.03
CaO (%)	*A*	62.2	Fineness, retained in #325	*A*	2.1
MgO (%)	*A*	0.5	Compressive strength (MPa/[psi]):		
SO_3 (%)*	*3.0 max*	2.9	1 day		14.1 [2050]
Loss of ignition (%)	*10.0 max*	7.2	3 days	*13.0[1890] min*	27.1 [3930]
Na2O (%)	*A*	0.12	7 days	*20.0[2900] min*	36 [5230]
K2O (%)	*A*	0.17	28 days *(previous month)*	*28.0[4060] min*	51.9 [7530]
			Time of setting (minutes)		
CO_2 (%)	*A*	5.8	(Vicat) Initial	*45 min*	98
Limestone (%)	*15.0 max*	14.1	(Vicat) Final	*375 max*	175
$CaCO_3$ in limestone (%)	*70 min*	90	Sulfate Resistance (ASTM C1012 180d) (%)	*0.10 max*	0.05
Inorganic process addition (%)	*5.0 max*	--	Heat of hydration (ASTM C1702 3d)	*B*	267
			Mortar Bar Expansion (ASTM C1038) (%)*	*0.020 max*	0.001

OPTIONAL REQUIREMENTS

Item	Spec. Limit	Results	Item	Spec. Limit	Results
Equiv. Alkalies (%)	*0.60 max*	0.23	Density (ASTM C188) (g/cm3)	*B*	3.03
Chloride (%)	*B*	0.01			

Additional Data

Type	Limestone	Inorganic Processing Addition
Amount	14.1	--
SiO_2 (%)	5.3	--
Al_2O_3 (%)	0.6	--
Fe_2O_3 (%)	0.2	--
CaO (%)	51.1	--
SO_3 (%)	0.7	--

This cement meets ASTM C595 and AASHTO M240 Specification for Type IL (MS) Portland Cement

This cement also meets all applicable FDOT (Facility ID: CMT 29), SCDOT, and NCDOT (Plant ID: CM69) specifications for Type IL cement

*It is permissible to exceed the max value for SO3 content, provided it is demonstrated by ASTM C1038 that the cement will not develop expansion exceeding 0.020% in 14 Days

A Not applicable.

B Test result represents most recent value and is provided for information only.

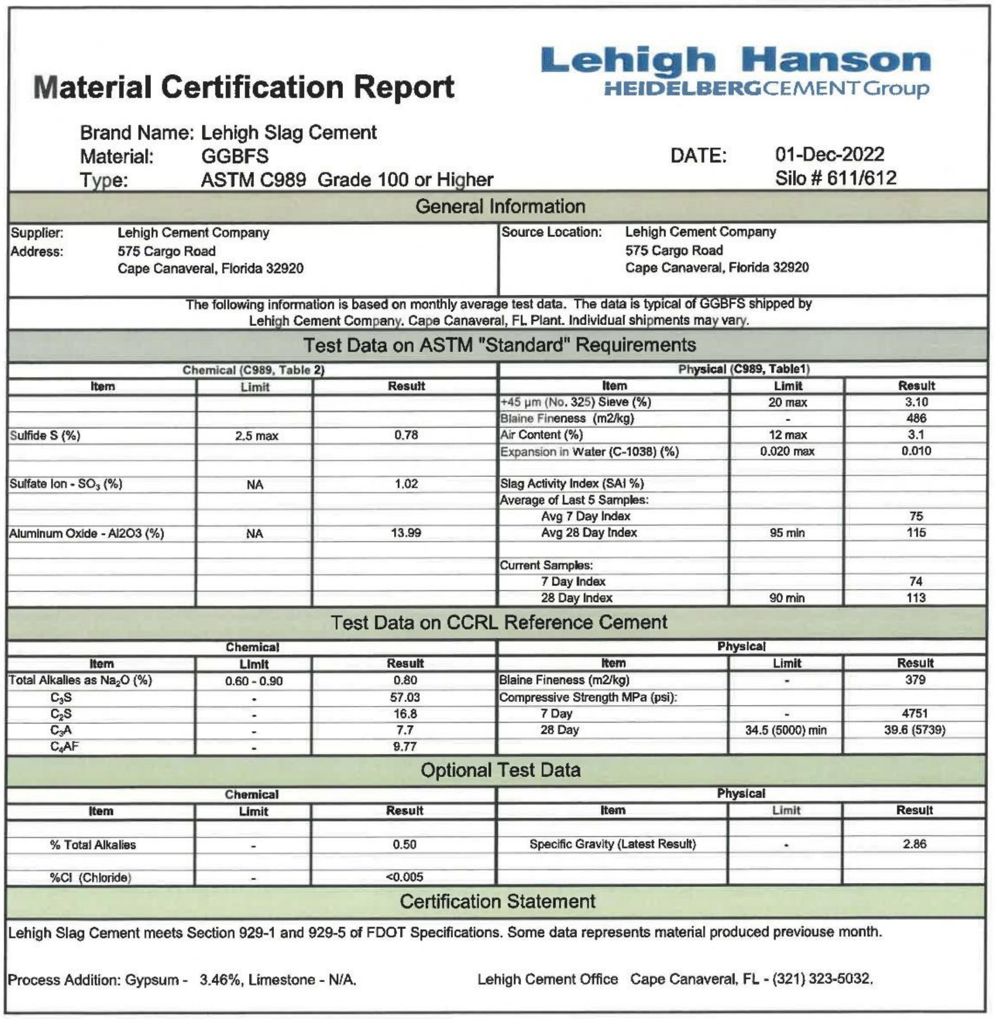
C Test result is not yet available

November 18, 2022
Branford Cement Plant
Ash Grove
5117 U.S. Hwy 27
Branford, FL 32008
Tel: (386) 935-5013 - Fax: (386) 935-5080

[redacted]

Zheng Liu
Quality Control Manager

Figure E.3 Bartow drilled shaft 1-4 Type IL cement mill certificate.



Material Certification Report

Lehigh Hanson
HEIDELBERGCEMENT Group

Brand Name: Lehigh Slag Cement
Material: GGBFS
Type: ASTM C989 Grade 100 or Higher

DATE: 01-Dec-2022
Silo # 611/612

General Information

Supplier: Lehigh Cement Company
Address: 575 Cargo Road
Cape Canaveral, Florida 32920

Source Location: Lehigh Cement Company
575 Cargo Road
Cape Canaveral, Florida 32920

The following information is based on monthly average test data. The data is typical of GGBFS shipped by Lehigh Cement Company. Cape Canaveral, FL Plant. Individual shipments may vary.

Test Data on ASTM "Standard" Requirements

Chemical (C989, Table 2)			Physical (C989, Table1)		
Item	**Limit**	**Result**	**Item**	**Limit**	**Result**
			+45 µm (No. 325) Sieve (%)	20 max	3.10
			Blaine Fineness (m2/kg)	-	486
Sulfide S (%)	2.5 max	0.78	Air Content (%)	12 max	3.1
			Expansion in Water (C-1038) (%)	0.020 max	0.010
Sulfate Ion - SO_3 (%)	NA	1.02	Slag Activity Index (SAI %)		
			Average of Last 5 Samples:		
			Avg 7 Day Index		75
Aluminum Oxide - Al2O3 (%)	NA	13.99	Avg 28 Day Index	95 min	115
			Current Samples:		
			7 Day Index		74
			28 Day Index	90 min	113

Test Data on CCRL Reference Cement

Chemical			Physical		
Item	**Limit**	**Result**	**Item**	**Limit**	**Result**
Total Alkalies as Na_2O (%)	0.60 - 0.90	0.80	Blaine Fineness (m2/kg)	-	379
C_3S	-	57.03	Compressive Strength MPa (psi):		
C_2S	-	16.8	7 Day	-	4751
C_3A	-	7.7	28 Day	34.5 (5000) min	39.6 (5739)
C_4AF	-	9.77			

Optional Test Data

Chemical			Physical		
Item	**Limit**	**Result**	**Item**	**Limit**	**Result**
% Total Alkalies	-	0.50	Specific Gravity (Latest Result)	-	2.86
%Cl (Chloride)	-	<0.005			

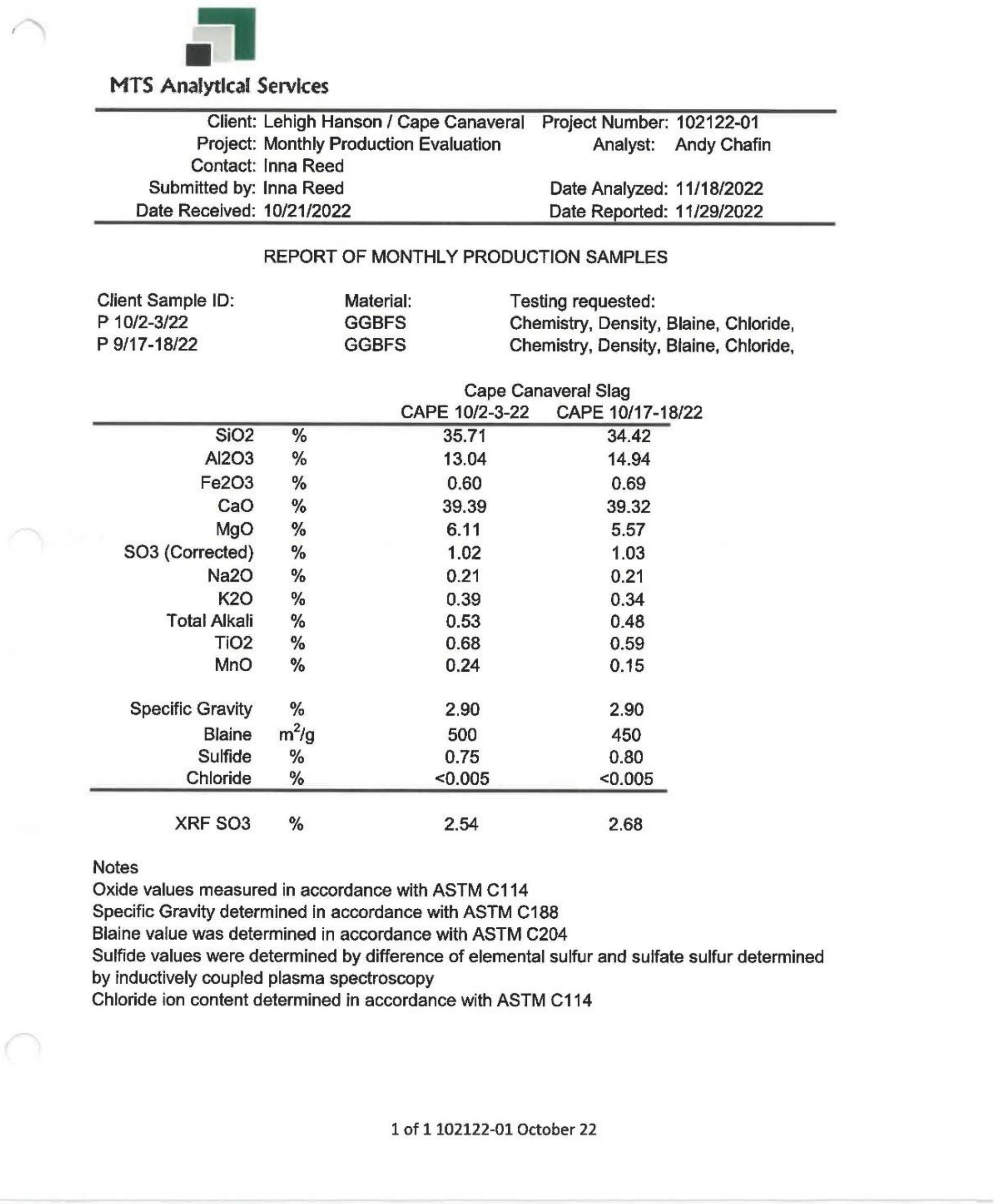
Certification Statement

Lehigh Slag Cement meets Section 929-1 and 929-5 of FDOT Specifications. Some data represents material produced previouse month.

Process Addition: Gypsum - 3.46%, Limestone - N/A.

Lehigh Cement Office Cape Canaveral, FL - (321) 323-5032.

Figure E.4 Bartow drilled shaft 1-4 Lehigh slag mill certificate page 1.



MTS Analytical Services

Client: Lehigh Hanson / Cape Canaveral
Project: Monthly Production Evaluation
Contact: Inna Reed
Submitted by: Inna Reed
Date Received: 10/21/2022

Project Number: 102122-01
Analyst: Andy Chafin
Date Analyzed: 11/18/2022
Date Reported: 11/29/2022

REPORT OF MONTHLY PRODUCTION SAMPLES

Client Sample ID:	Material:	Testing requested:
P 10/2-3/22	GGBFS	Chemistry, Density, Blaine, Chloride,
P 9/17-18/22	GGBFS	Chemistry, Density, Blaine, Chloride,

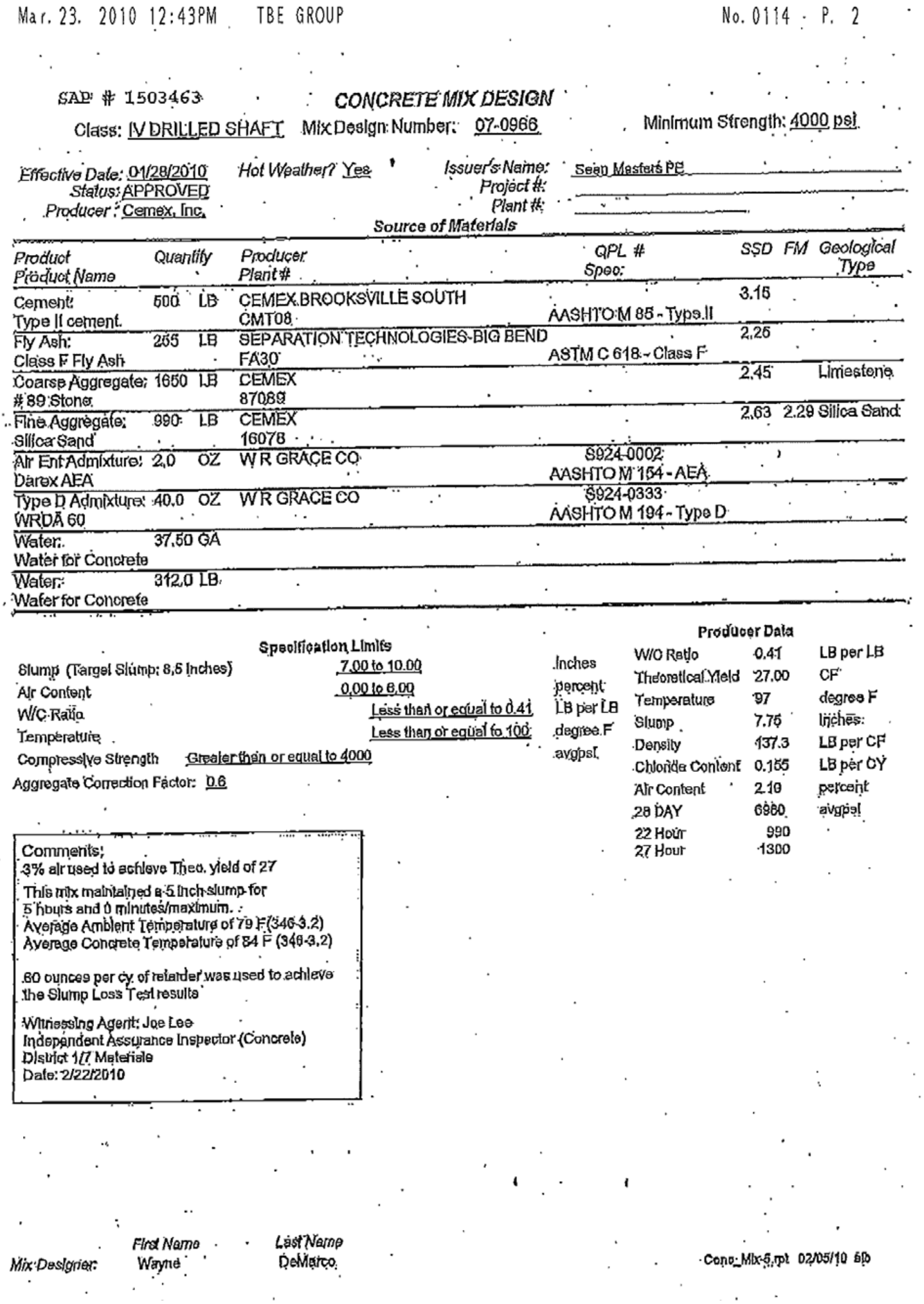
		Cape Canaveral Slag	
		CAPE 10/2-3-22	CAPE 10/17-18/22
SiO2	%	35.71	34.42
Al2O3	%	13.04	14.94
Fe2O3	%	0.60	0.69
CaO	%	39.39	39.32
MgO	%	6.11	5.57
SO3 (Corrected)	%	1.02	1.03
Na2O	%	0.21	0.21
K2O	%	0.39	0.34
Total Alkali	%	0.53	0.48
TiO2	%	0.68	0.59
MnO	%	0.24	0.15
Specific Gravity	%	2.90	2.90
Blaine	m^2/g	500	450
Sulfide	%	0.75	0.80
Chloride	%	<0.005	<0.005
XRF SO3	%	2.54	2.68

Notes
Oxide values measured in accordance with ASTM C114
Specific Gravity determined in accordance with ASTM C188
Blaine value was determined in accordance with ASTM C204
Sulfide values were determined by difference of elemental sulfur and sulfate sulfur determined by inductively coupled plasma spectroscopy
Chloride ion content determined in accordance with ASTM C114

1 of 1 102122-01 October 22

Figure E.5 Bartow drilled shaft 1-4 Lehigh slag mill certificate page 2.

Appendix F: 34% Fly Ash (Class F) Model Concrete Mix Design and Mill Certificates



Mar. 23. 2010 12:43PM TBE GROUP No. 0114 P. 2

SAP # 1503463

CONCRETE MIX DESIGN

Class: IV DRILLED SHAFT Mix Design Number: 07-0966 Minimum Strength: 4000 psi

Effective Date: 01/28/2010
Status: APPROVED
Producer: Cemex, Inc.

Hot Weather? Yes

Issuer's Name: Sean Masters PE
Project #:
Plant #:

Source of Materials

Product Product Name	Quantity	Producer Plant #	QPL # Spec:	SSD	FM	Geological Type
Cement: Type II cement.	500 LB	CEMEX BROOKSVILLE SOUTH CMT08	AASHTO M 85 - Type II	3.15		
Fly Ash: Class F Fly Ash	255 LB	SEPARATION TECHNOLOGIES-BIG BEND FA30	ASTM C 618 - Class F	2.25		
Coarse Aggregate: # 89 Stone	1650 LB	CEMEX 87089		2.45		Limestone
Fine Aggregate: Silica Sand	990 LB	CEMEX 16078		2.63	2.29	Silica Sand
Air Ent Admixture: Darex AEA	2,0 OZ	W R GRACE CO	S924-0002 AASHTO M 154 - AEA			
Type D Admixture: WRDA 60	40.0 OZ	W R GRACE CO	S924-0333 AASHTO M 194 - Type D			
Water: Water for Concrete	37,50 GA					
Water: Water for Concrete	312,0 LB					

Specification Limits

Slump (Target Slump: 8,5 Inches)	7.00 to 10.00	Inches
Air Content	0.00 to 6.00	percent
W/C Ratio	Less than or equal to 0.41	LB per LB
Temperature	Less than or equal to 100	degree F
Compressive Strength	Greater then or equal to 4000	avgpsi

Aggregate Correction Factor: 0.6

Producer Data

W/C Ratio	0.41	LB per LB
Theoretical Yield	27.00	CF
Temperature	97	degree F
Slump	7.75	Inches
Density	137.3	LB per CF
Chloride Content	0.155	LB per CY
Air Content	2.10	percent
28 DAY	6980	avgpsi
22 Hour	990	
27 Hour	1300	

Comments:
3% air used to achieve Theo. yield of 27

This mix maintained a 5 inch slump for
5 hours and 0 minutes/maximum.
Average Ambient Temperature of 79 F (346-3.2)
Average Concrete Temperature of 84 F (346-3.2)

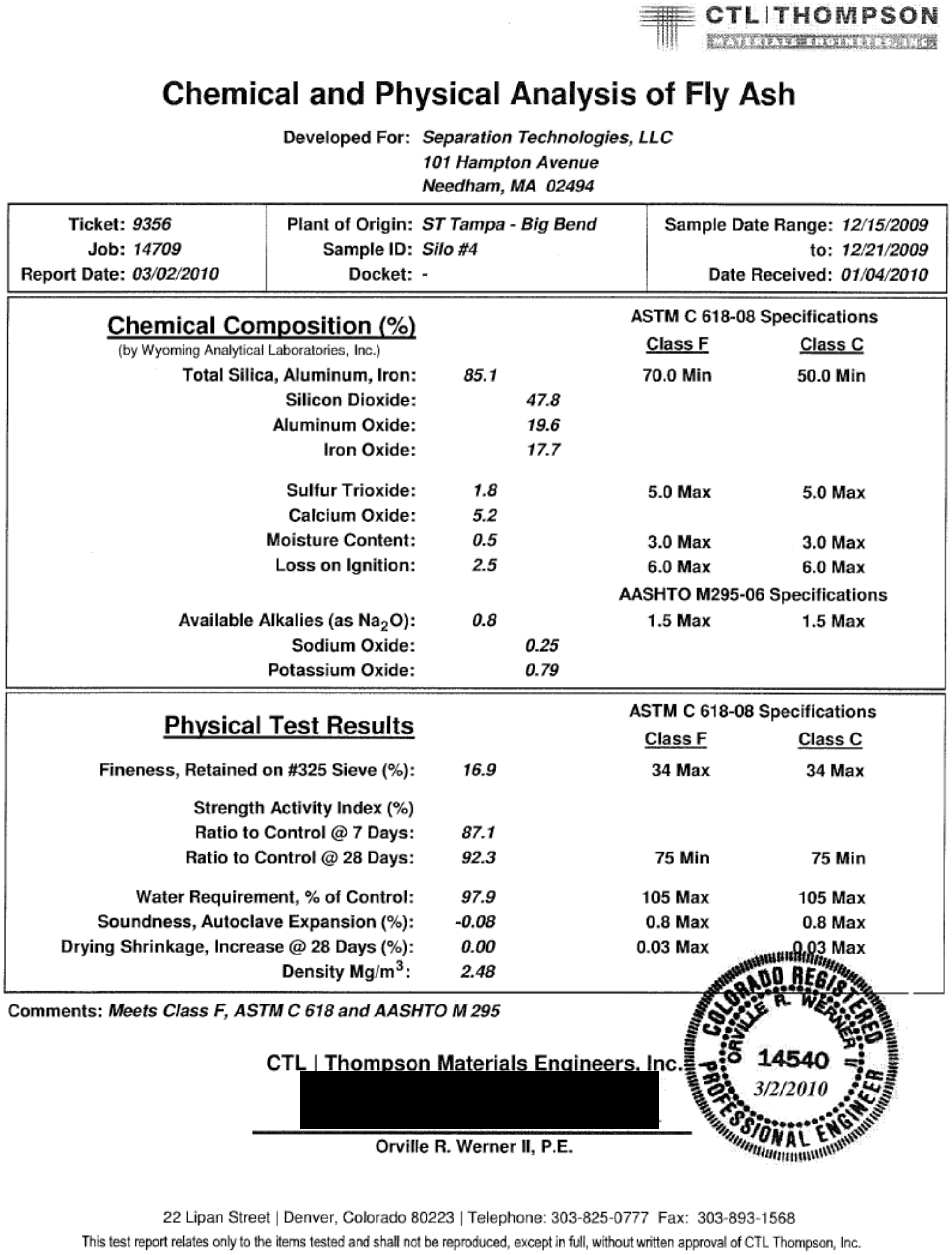
.60 ounces per cy. of retarder was used to achieve
the Slump Loss Test results

Witnessing Agent: Joe Lee
Independent Assurance Inspector (Concrete)
District 1/7 Materials
Date: 2/22/2010

Mix Designer: First Name Wayne Last Name DeMarco

Conc_Mix-5.rpt 02/05/10 6b

Figure F.1 34% Fly Ash Model concrete mix design.



CTL | THOMPSON
MATERIALS ENGINEERS, INC.

Chemical and Physical Analysis of Fly Ash

Developed For: *Separation Technologies, LLC*
101 Hampton Avenue
Needham, MA 02494

Ticket: *9356*
Job: *14709*
Report Date: *03/02/2010*

Plant of Origin: *ST Tampa - Big Bend*
Sample ID: *Silo #4*
Docket: -

Sample Date Range: *12/15/2009*
to: *12/21/2009*
Date Received: *01/04/2010*

Chemical Composition (%) (by Wyoming Analytical Laboratories, Inc.)			**ASTM C 618-08 Specifications**	
			Class F	**Class C**
Total Silica, Aluminum, Iron:	*85.1*		**70.0 Min**	**50.0 Min**
Silicon Dioxide:		*47.8*		
Aluminum Oxide:		*19.6*		
Iron Oxide:		*17.7*		
Sulfur Trioxide:	*1.8*		**5.0 Max**	**5.0 Max**
Calcium Oxide:	*5.2*			
Moisture Content:	*0.5*		**3.0 Max**	**3.0 Max**
Loss on Ignition:	*2.5*		**6.0 Max**	**6.0 Max**
			AASHTO M295-06 Specifications	
Available Alkalies (as Na_2O):	*0.8*		**1.5 Max**	**1.5 Max**
Sodium Oxide:		*0.25*		
Potassium Oxide:		*0.79*		

Physical Test Results		**ASTM C 618-08 Specifications**	
		Class F	**Class C**
Fineness, Retained on #325 Sieve (%):	*16.9*	**34 Max**	**34 Max**
Strength Activity Index (%)			
Ratio to Control @ 7 Days:	*87.1*		
Ratio to Control @ 28 Days:	*92.3*	**75 Min**	**75 Min**
Water Requirement, % of Control:	*97.9*	**105 Max**	**105 Max**
Soundness, Autoclave Expansion (%):	*-0.08*	**0.8 Max**	**0.8 Max**
Drying Shrinkage, Increase @ 28 Days (%):	*0.00*	**0.03 Max**	**0.03 Max**
Density Mg/m^3:	*2.48*		

Comments: *Meets Class F, ASTM C 618 and AASHTO M 295*

CTL | Thompson Materials Engineers, Inc.

[redacted]

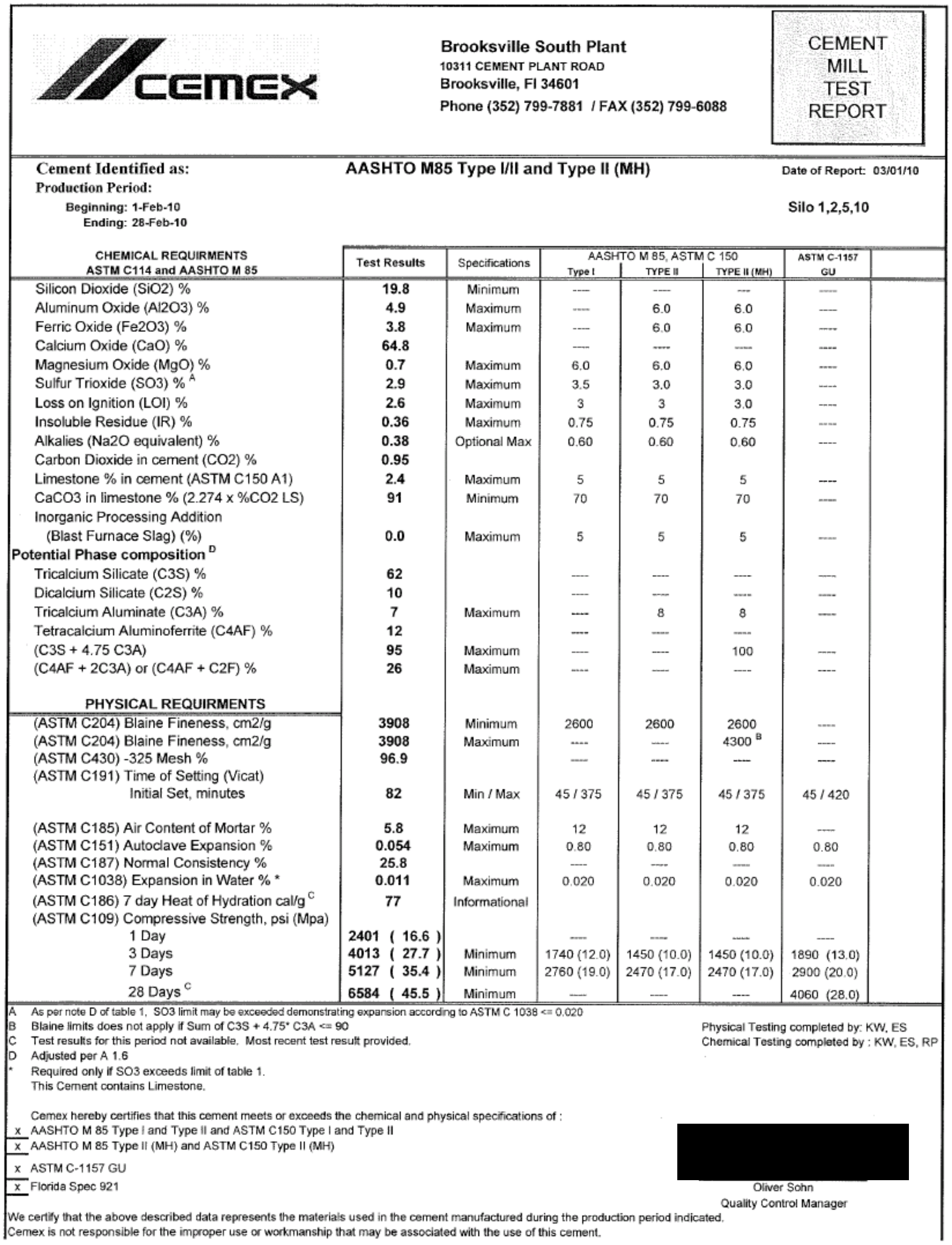
Orville R. Werner II, P.E.

14540
3/2/2010

22 Lipan Street | Denver, Colorado 80223 | Telephone: 303-825-0777 Fax: 303-893-1568

This test report relates only to the items tested and shall not be reproduced, except in full, without written approval of CTL Thompson, Inc.

Figure F.2 34% Fly Ash Model mill certificate for Class F Fly Ash.



Brooksville South Plant
10311 CEMENT PLANT ROAD
Brooksville, Fl 34601
Phone (352) 799-7881 / FAX (352) 799-6088

CEMENT
MILL
TEST
REPORT

Cement Identified as: **AASHTO M85 Type I/II and Type II (MH)**

Date of Report: 03/01/10

Production Period:
Beginning: 1-Feb-10
Ending: 28-Feb-10

Silo 1,2,5,10

CHEMICAL REQUIRMENTS ASTM C114 and AASHTO M 85	Test Results	Specifications	AASHTO M 85, ASTM C 150			ASTM C-1157
			Type I	TYPE II	TYPE II (MH)	GU
Silicon Dioxide (SiO2) %	**19.8**	Minimum	----	----	---	----
Aluminum Oxide (Al2O3) %	**4.9**	Maximum	----	6.0	6.0	----
Ferric Oxide (Fe2O3) %	**3.8**	Maximum	----	6.0	6.0	----
Calcium Oxide (CaO) %	**64.8**		----	----	----	----
Magnesium Oxide (MgO) %	**0.7**	Maximum	6.0	6.0	6.0	----
Sulfur Trioxide (SO3) % ^{A}	**2.9**	Maximum	3.5	3.0	3.0	----
Loss on Ignition (LOI) %	**2.6**	Maximum	3	3	3.0	----
Insoluble Residue (IR) %	**0.36**	Maximum	0.75	0.75	0.75	----
Alkalies (Na2O equivalent) %	**0.38**	Optional Max	0.60	0.60	0.60	----
Carbon Dioxide in cement (CO2) %	**0.95**					
Limestone % in cement (ASTM C150 A1)	**2.4**	Maximum	5	5	5	----
CaCO3 in limestone % (2.274 x %CO2 LS)	**91**	Minimum	70	70	70	----
Inorganic Processing Addition (Blast Furnace Slag) (%)	**0.0**	Maximum	5	5	5	----
Potential Phase composition ^{D}						
Tricalcium Silicate (C3S) %	**62**		----	----	----	----
Dicalcium Silicate (C2S) %	**10**		----	----	----	----
Tricalcium Aluminate (C3A) %	**7**	Maximum	----	8	8	----
Tetracalcium Aluminoferrite (C4AF) %	**12**		----	----	----	
(C3S + 4.75 C3A)	**95**	Maximum	----	----	100	----
(C4AF + 2C3A) or (C4AF + C2F) %	**26**	Maximum	----	----	----	----
PHYSICAL REQUIRMENTS						
(ASTM C204) Blaine Fineness, cm2/g	**3908**	Minimum	2600	2600	2600	----
(ASTM C204) Blaine Fineness, cm2/g	**3908**	Maximum	----	----	4300 ^{B}	----
(ASTM C430) -325 Mesh %	**96.9**		----	----	----	----
(ASTM C191) Time of Setting (Vicat) Initial Set, minutes	**82**	Min / Max	45 / 375	45 / 375	45 / 375	45 / 420
(ASTM C185) Air Content of Mortar %	**5.8**	Maximum	12	12	12	----
(ASTM C151) Autoclave Expansion %	**0.054**	Maximum	0.80	0.80	0.80	0.80
(ASTM C187) Normal Consistency %	**25.8**		----	----	----	----
(ASTM C1038) Expansion in Water % *	**0.011**	Maximum	0.020	0.020	0.020	0.020
(ASTM C186) 7 day Heat of Hydration cal/g ^{C}	**77**	Informational				
(ASTM C109) Compressive Strength, psi (Mpa)						
1 Day	**2401 (16.6)**		----	----	----	----
3 Days	**4013 (27.7)**	Minimum	1740 (12.0)	1450 (10.0)	1450 (10.0)	1890 (13.0)
7 Days	**5127 (35.4)**	Minimum	2760 (19.0)	2470 (17.0)	2470 (17.0)	2900 (20.0)
28 Days ^{C}	**6584 (45.5)**	Minimum	----	----	----	4060 (28.0)

A As per note D of table 1, SO3 limit may be exceeded demonstrating expansion according to ASTM C 1038 <= 0.020
B Blaine limits does not apply if Sum of C3S + 4.75* C3A <= 90
C Test results for this period not available. Most recent test result provided.
D Adjusted per A 1.6
* Required only if SO3 exceeds limit of table 1.
This Cement contains Limestone.

Physical Testing completed by: KW, ES
Chemical Testing completed by : KW, ES, RP

Cemex hereby certifies that this cement meets or exceeds the chemical and physical specifications of :

x AASHTO M 85 Type I and Type II and ASTM C150 Type I and Type II
x AASHTO M 85 Type II (MH) and ASTM C150 Type II (MH)
x ASTM C-1157 GU
x Florida Spec 921

[redacted]

Oliver Sohn
Quality Control Manager

We certify that the above described data represents the materials used in the cement manufactured during the production period indicated.
Cemex is not responsible for the improper use or workmanship that may be associated with the use of this cement.

Figure F.3 34% Fly Ash Model mill certificate for Type II Portland Cement.