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New Technology-Based Approach to Advance Higher Volume Fly Ash Concrete with Acceptable Performance

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New Technology-Based Approach to Advance Higher Volume Fly Ash Concrete With Acceptable Performance

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Abstract

The use of fly ash in concrete has received significant attention over recent years due to environmental concerns regarding its disposal and potential for use as a cementitious material with its ability to provide significant benefits to concrete. While fly ash content less than 25% of total cementitious content is routinely used in concrete, high-volume fly ash (HVFA) concrete is not common due to perceived lower early-age strengths. The objective of this study was to demonstrate using maturity based techniques that the beneficial effects of high in-place temperature may be able to compensate for the slower rate of strength gain in HVFA concrete that is typically observed when tested under standard laboratory temperature conditions. In addition, different methods (match-cured cylinders, pullout testing) were used to estimate the early-age in-place strength of HVFA concrete to confirm the maturity predicted strengths. The results have shown that the standard and field-cured cylinder strengths underestimate the in-place concrete strength. Higher in-place temperatures due to the mass characteristics of structural elements resulted in increased early age in-place strengths, adequate for construction scheduling, as measured by match-cured cylinders, pullout testing, and the maturity approach.

Keywords: Concrete, Fly Ash, Supplementary Cementitious Materials, Maturity, Pullout Test.

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EXECUTIVE SUMMARY

A major obstacle that limits the widespread use of High-Volume Fly Ash (HVFA) concrete is its lower early-age strength as documented in research studies conducted in the laboratory with standard cured strength specimens. The objective of this study was to demonstrate, using maturity-based techniques that the actual in-place strength of HVFA concrete in a structure is higher than that indicated by strength measured on field-cured cylinders due to the higher in-place temperature resulting from the slower dissipation of heat of hydration due to the greater mass of structural members. The in-place strength of concrete in the structure can be determined by monitoring its temperature history over time, calculating the maturity, and by estimating the in-place strength from the pre-calibrated strength-maturity relationship. The maturity concept assumes hydraulic cement concrete of the same maturity will have similar strengths, regardless of the combination of time and temperature yielding the maturity. Maturity concepts are well established for Portland cement concretes but they are not so established for HVFA concrete mixtures containing chemical admixtures. The Arrhenius and Nurse-Saul maturity functions are commonly used to establish the maturity index. The Arrhenius maturity function is considered more accurate and was used in this study. The Arrhenius maturity function requires the use of mixture-specific activation energy to improve predictions of strength. The activation energy quantifies the temperature sensitivity of the concrete mixture.

An initial task was to determine the activation energy of each of the concrete mixtures using the procedure outlined in ASTM C1074. Various fly ashes (Class C and Class F fly ash meeting the standard ASTM C618) with multiple dosages (20% to 50% by mass of cementitious materials) were used in this study. Activation energies of these mixtures were determined. Some unexpected trends of strength based on curing temperature were observed for these fly ashes mixtures. The fly ash mixtures cured at elevated temperatures demonstrated higher long-term strengths than anticipated in comparison to the strength of specimens cured at lower temperatures.

The next step was to develop strength-maturity relationships in the laboratory for four of the concrete mixtures. Additionally, pullout load versus compressive strength correlations were developed. To validate the strength predictions based on maturity, four concrete blocks and slabs were prepared in the field during the period of October to December, when the ambient temperature ranged from 15.5^{o}C (60^{o}F) to 7.5^{o}C (45^{o}F). The in-place compressive strength of the concrete blocks and slabs were predicted based on the following approaches:

1. Match-cured cylinders;
2. Pullout testing using the pullout versus compressive strength relationship previously developed;
3. Maturity based on the activation energy and strength-maturity relationship previously measured; and
4. Field-cured cylinders.

Compressive strength of the concrete mixtures using standard-cured cylinders was tested at several ages.

Based on this study the following preliminary conclusions are made:

1. Match-cured compressive strength data have clearly demonstrated that HVFA concretes in actual structural members achieve much higher early-age strengths than the strength indicated by testing field-cured cylinders. This observation will allow for further mixture optimization and possibly increased content of fly ash without negative impact on construction operations.

2. A maturity-based approach has been developed to estimate in-place strength in the actual structure from temperature measurement with time.

CHAPTER 1 – INTRODUCTION

The 2006 fly ash use survey conducted by the American Coal Ash Association (ACAA, 2006) indicates that 45% of the 72.4 million tons of fly ash produced was beneficially utilized. However, this still results in a majority (55%) to be disposed, typically in landfills. The 2006 survey also indicates that 59% of the beneficially used fly ash was used in cement and concrete applications. Since ready mixed concrete represents the single largest market for fly ash, it can offer the largest potential for **increased fly ash** utilization. Estimated ready mixed concrete production in the U.S. in 2007 was 415 million cubic yards (NRMCA, 2008).

There is a large body of research and literature on the development and use of High-Volume Fly Ash (HVFA) concrete. In spite of that, the actual use of high-volumes of fly ash (> 30% of total cementitious materials content) in ready mixed concrete is limited. Surveys (PCA and NRMCA 2000-2003, Obla et. al 2003) suggest that the average fly ash content in all ready mixed concrete is still about 10% of total cementitious materials content even though some producers may be using an average fly ash content as high as 30% in summer months and certain applications. Please note that when fly ash is used in ready mixed concrete, the reported average according to the survey is actually 20%. Since only about half of all ready mixed concrete contains fly ash (37% contains only Portland cement and the rest contain Portland, slag and other supplementary cementitious material blends) the average fly ash content in all ready mixed concrete effectively drops to 10%. *If the average fly ash content in all ready mixed concrete were increased to 20%, this would increase the overall fly ash utilization from 45% to 71% thereby far exceeding CBRC's 2010 goal of 50% fly ash utilization*! In order to achieve the average of 20% fly ash use in all ready mixed concrete all year around, it may be necessary to use 50% or more fly ash in certain applications. However, many contractors and producers cite the low rate of strength gain and delayed -setting times as the primary reasons for not using higher volumes of fly ash in concrete.

This project addresses one of the two major obstacles - rate of strength gain. Using the maturity-based approach demonstrates that HVFA concrete in the structural members has sufficient early-age strengths to allow for optimized construction scheduling, such as formwork removal and post-tensioning. The basic approach to this study is the premise that while the strength measured using laboratory or field-cured cylinders of HVFA concrete mixtures are low, the actual strengths in the structural members are likely to be higher. This is because the larger mass of most concrete structural members, compared to cylindrical specimens, allows for greater retention of heat of hydration that allows for a faster rate of strength gain. Essentially, HVFA concrete is penalized when construction operations such as formwork removal are not based on in-place strengths but on tests on field-cured cylinders.

The challenge is then to accurately estimate the concrete strength in the structure. The maturity method can be used for this purpose (Saul 1951, Freiesleben and Pederson 1977, Carino 1984). The in-place strength of concrete in the structure can be estimated by monitoring its temperature history over time, calculating the maturity, and by estimating the in-place strength from the pre-calibrated strength-maturity relationship. The maturity concept assumes that hydraulic cement concrete of the same maturity will have similar strengths, regardless of the combination of time and temperature yielding the maturity. Maturity concepts are well established for Portland cement concretes but have not been validated for HVFA concrete mixtures containing chemical admixtures (Schindler 2004, Carino 2004). The Arrhenius and Nurse-Saul maturity functions are most commonly used to calculate the maturity index. The Arrhenius maturity function is considered more accurate and was used in this project. The Arrhenius maturity function requires the use of mixture-specific activation energy to yield most accurate results. The activation energy quantifies the temperature sensitivity of the concrete mixture (Schindler 2004).

This project consists of five different tasks:

The first task involved training and material preparation. The graduate student received training in the various concrete and mortar testing. NRMCA senior laboratory technician, Laboratory Manager, and Mr. Gary Mullings conducted this training.

The second task was the determination of the activation energy of each of the concrete mixtures using the procedure outlined in ASTM C1074. Various kinds of fly ashes (Class C and Class F fly ash meeting the standard ASTM C618) with multiple dosages (20% to 50% by mass of cementitious materials) were used and the activation energies of the resulting concrete mixtures were evaluated.

The third task was to develop strength-maturity relationships in the laboratory for the concrete mixtures. Ready mixed concrete from a concrete plant was used for this task. Concrete cylinders (4 in. x 8 in.) were cast and cured in lime-saturated water baths at a temperature of 23.0°C (73°F) and tested in compression at 1, 2, 4, 7, 14, and 28 days. Compressive strengths are plotted as a function of equivalent age at 23.0°C (73°F). The best-fit relationship of this strength versus maturity data is the strength-maturity relationship to be used for estimating in-place strength in the large-scale specimens made with that specific mixture. In addition, compressive strength versus pullout load relationships were also developed. Eight (8) in. concrete cubes were cast, with one pullout insert placed on each of the four side faces (barring top and bottom) of the cube. Pullout tests were conducted at the same time that cylinder compressive strengths were measured. The resulting data were used to establish the strength-pullout load relationships that was used to confirm the estimated in-place strength estimated from the maturity method.

The fourth task consisted of field validation where four concrete blocks and two concrete slabs were prepared in the field with multiple embedded temperature sensors during the period of October to December, when the ambient temperature ranged from 15.5°C (60°F) to 7.5°C (45°F). Ready mixed concrete from a concrete plant was used for this task. The temperature sensors inside the blocks and the slabs documented the temperature as a function of age. Equivalent ages (relative to a reference temperature of 23.0°C

(73°F)) can be calculated using the Arrhenius (Equivalent age) maturity function with the mixture-specific activation energy determined in the previous tasks. From the equivalent ages and the previously established strength-maturity relationships, the in-place strength of the structural members was estimated. Pullout tests (ACI 228, 2003) were performed on the blocks and slabs and the data were analyzed statistically to arrive at reliable estimates of the in-place compressive strength. The match-cured cylinders were cured with proprietary equipment to follow the temperature of the structural members and subsequently tested to obtain an estimate of the true in-place strength. The pullout tests and match-cured cylinder tests were used to confirm and validate the in-place strength predicted by the maturity method. Additionally, standard lab-cured and field-cured concrete cylinders were tested at specific ages and these strengths were compared to the in-place strengths estimated by the maturity method at those ages.

The fifth task consisted of developing thermal signatures of various HVFA concrete mixtures using Semi-Adiabatic Calorimetry. This portion of the study was conducted at Auburn University using the same materials in the other tasks. The results show the effect of the different fly ash contents on the rate of hydration, total heat of hydration, setting, and to some extent the degree of hydration. These results will be useful to understand the heat evolution process of HVFA concrete mixtures. Additionally, the calorimetry results can also be used as input to simulation programs to estimate the in-place temperature development of concrete structural members with varying dimensions and boundary conditions. The Concrete Works program models the temperature profile in concrete members (see www.texasconcreteworks.com) and can be used to obtain an estimate of in-place temperature profiles and gradients of concrete members. The model provides a visual 2-D animation temperature profile throughout the element as hydration progresses.

Based on this study the following principal conclusions are made:

1. The match-cured cylinder strength data demonstrated clearly that HVFA concretes in actual structures have much higher early-age strengths than obtained from testing standard-cured cylinders. This means that HVFA concrete mixture proportions may be further optimized (use of lower total cementitious material contents, increase the quantity of fly ash, and increase the *w/cm*) without negative effects on construction operations that require attainment of specified in-place strength at early ages.

2. A maturity-based approach is applicable to estimate the early-age concrete strength in structures made with HVFA concretes. This requires determining the applicable activation energy for the specific cementitious mixture, developing the strength-maturity relationship, and recording the in-place temperature history.

CHAPTER 2 – BACKGROUND

2.1 Maturity Method

It has been well documented (Nurse 1949, Saul 1951, Carino 1991) that the strength of well-cured and consolidated concrete is a function of its age and curing temperature. The effects of time and temperature can be combined into one constant, called maturity, which is indicative of the concrete strength. In 1951, Saul concluded that the maturity concept could be effectively used to define the strength development of a concrete cured at any temperature above the datum temperature. Equation 1, commonly referred to as Nurse-Saul function, is a simple mathematical function to define maturity with respect to a datum temperature. Datum temperature (T_o) is the lowest temperature at which strength gain in concrete is observed. Generally, the value of the datum temperature is taken as 10^{o}C (14^{o}F), but for more precision it should be established for a particular concrete mixture. Equation 1 is used to convert the actual time temperature history to a maturity index also called the "Time Temperature Factor" (TTF). Saul (1951) presented the following principle, known as the maturity rule:

"Concrete of the same mix at the same maturity has approximately the same strength whatever combination of the temperature and time go to make up the maturity."

$$M = \sum_{0}^{t} \left(T - T_o\right)\Delta t \qquad \textbf{Equation 1}$$

where,

M = maturity index, °C-hours (or °C-days),
T = average concrete temperature, °C, during the time interval Δt,
T_o = datum temperature (usually taken to be -10 °C),
t = elapsed time (hours or days), and
Δt = time interval (hours or days).

The Nurse-Saul maturity function has gained widespread acceptance in the concrete industry because of its simplicity in combining the effects of time and temperature to estimate strength development of hydraulic cement concrete. Apart from its simplicity the Nurse-Saul maturity has few drawbacks (Carino 2004); it is only valid provided the concrete temperature did not reach about 50^{o}C (122^{o}F) within two hours or about 100^{o}C (212^{o}F) within the first six hours after the concrete is mixed. The major deficiency of the Nurse-Saul maturity function is that the rate of strength gain is assumed a linear function of curing temperature, which has been shown to be invalid for a wide range of temperature (Carino 2004). Therefore, the Nurse-Saul maturity function can overestimate or underestimate the effect of temperature on the rate of strength gain.

Since the first breakthrough in maturity concepts, many other maturity functions have been developed and proposed. Freiesleben Hansen and Pedersen (1977) suggested another maturity function based on the concept of Arrhenius equation. The Arrhenius equation defines the chemical reaction between two reactants and is a function of activation energy and the reaction temperature. The activation energy is defined as the minimum energy necessary for a specific chemical reaction to occur. The Arrhenius approach is a more sound technical basis and experimental studies conducted have confirmed that it captures the time-temperature dependence of concrete more appropriately (Carino 2004).

Equation 2 represents the Arrhenius maturity function that can be used to compute the maturity index in terms of an equivalent age. Equivalent age represents the duration of the curing period at the reference temperature that would result in the same maturity when the concrete is cured at any other temperature. The exponential part of the equation is an age conversion factor used to convert the actual temperature history to the temperature history at the reference temperature. The reference temperature values that have been used in Europe and the US are 20°C (68°F) and 23°C (73°F), respectively.

$$t_e = \sum_0^t e^{\frac{-E}{R}\left(\frac{1}{T}-\frac{1}{T_r}\right)} \cdot \Delta t \qquad \textbf{Equation 2}$$

where

t_e = the equivalent age at the reference temperature (hours),
E = apparent activation energy (J/mol),
R = universal gas constant (8.314 J/mol-K),
T = average absolute temperature of the concrete during interval Δt, (Kelvin), and
T_r = absolute reference temperature, (Kelvin).
Δt = time interval (hours or days).

Much like the datum temperature in the Nurse-Saul approach, the activation energy is mixture specific and has to be established for a specific concrete mixture prior to using the Arrhenius maturity function for estimating in-place strengths. The equivalent age, maturity function was opted in this study because it better captures the non-linear effect of temperature on the rate of strength development (Carino 2004).

ASTM C1074 provides procedures for both the Nurse-Saul and the Arrhenius approaches for computing the maturity index from the measured temperature history of the concrete. It also provides a technique for calculating the datum temperature as well as the activation energy from strength development data collected at various isothermal temperatures.

Strength predictions using the maturity method should be validated by other in-place tests that measure the in-place compressive strength (Carino 2004). In this project pullout tests, (ASTM C900) and match-cured cylinder tests were conducted as the validation methods. (Upadhyaya et al. 2007).

2.2 Pullout Test

Pullout test is a non-destructive test method used to measure the pullout force required to displace a metal insert from a concrete structure (ASTM C900). The probe has an enlarged head of 1 in. diameter and is placed at a depth of 1 in. from the surface of the concrete specimen. The probe is pulled against a 2.16 in. diameter counter pressure disc applied on the surface as shown in Figure 2.1. A compression strut develops in the concrete between the enlarged head and the counter pressure disc during the process. A correlation is established between measured pullout force and compressive strength of cylindrical specimens in laboratory. The correlation is used to estimate the in-place concrete strength from the results of the pullout test. Pullout force can also be correlated to different uniaxial strength properties of concrete.

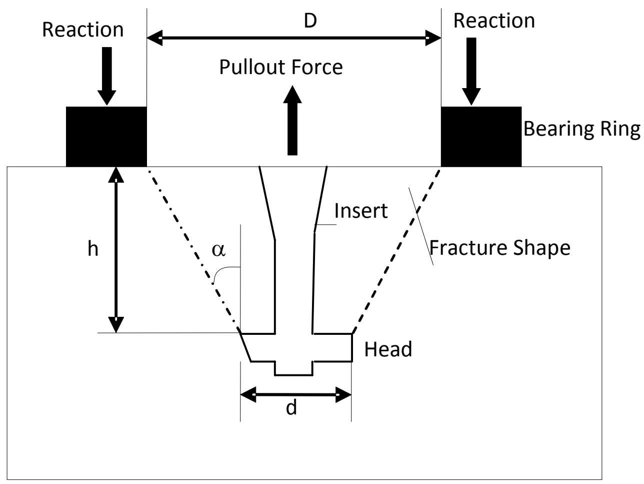


Figure 2.1 Pullout setup (Carino 2004)

2.3 Match Curing

It is well known that for members of larger mass that the rate of hydration of concrete will be accelerated due to higher in-place temperatures, which will also lead to accelerated rate of in-place strength development. Field-cured cylinders do not provide reliable estimates of the in-place compressive strength because of the mass effect. Match curing is therefore used to match the temperature curing history of molded cylinders to that of the in-place structural concrete member. The match curing system used in this project was called "Sure Cure". The Sure Cure system consists of a micro-controller, the match cure cylinders and a Type-T thermocouple. The micro controller uses software that controls the temperature of the cylinders in the molds based on the temperature in the structure measured by the thermocouple. Thus, the concrete cylinders in the match cure molds experience the same temperature history as that of the structural member.

2.4 Push out Cylinders

Push out cylinder is a method that allows one to cure a molded cylinder in-place (ASTM C873), and they are pushed out of concrete element and tested in a compression testing machine. In-place cylinders are placed within the concrete structure to make sure they experience the same temperature and curing conditions as the structure. However, in some cases, these cylinders do not experience the same temperature history as the structure. In this research project, a 6 in. diameter plastic mold was installed in the slab form work before the concrete pour. After the concrete was poured in the slab, 4 in. diameter concrete specimens were prepared in the plastic molds and kept in these 6 in. molds casted within the slab. The area between the 6 in. and 4 in. mold was filled with fine sand to allow some heat transfer between the slab and concrete cylinders. Push out were only used for 50% FA-A mixture slab because of the logistics.

CHAPTER 3 – EXPERIMENTAL WORK – MORTAR

Activation Energy is a key parameter for the equivalent age maturity model. To evaluate this parameter mortar testing was conducted. ASTM C1074 recommends preparation of 2 in. mortar cubes for evaluation of datum temperature and activation energy.

3.1 Materials

The following materials were used in the project for the mortar preparation at the NRMCA research laboratory:
ASTM C150 Type I Portland cement, Lot# 8124
ASTM C618 Class C and Class F Fly Ash, Lot# 8125, Lot #8126
ASTM C33 Natural Sand, Lot # 8127
ASTM C33 No. 57 Crushed Limestone Coarse Aggregate, Lot #7998
ASTM C494/C494M: Polycarboxylate based Type F High Range Water Reducer, Lot # 8128

Table 3.1 lists the chemical properties of various cementitious materials used in this project, fly ashes were selected that varied in terms of the percentage of the CaO content, and the range of CaO is representative of that found across the United States. The following three fly ashes were used:

1. Class F fly ash with a CaO content of 1.0%, identified as FA-A in this report,
2. Class F fly ash with a CaO content of 13.3%, identified as FA-B in this report, and
3. Class C fly ash with a CaO content of 23.44%, identified as FA-C in this report.

The following sources of fly ash and high-range water-reducing (HRWR) admixture were used:

- FA-A was supplied by STI, Baltimore, MD,
- FA-B and FA-C were donated by Boral Material Technologies Inc., and
- HRWR admixture was ViscoCrete 2100 supplied by Sika Corporation.

Table 3.2 includes the measured physical properties of the fine and coarse aggregates. The relative density (specific gravity), absorption of coarse and fine aggregates were measured by ASTM C127 and ASTM C128 respectively; sieve analysis of both aggregates was measured by ASTM C136; bulk density (dry rodded unit weight) of coarse aggregate was measured by ASTM C29/C29M.

Table 3.1 Chemical and physical properties of cement and fly ash (ASTM C 150, ASTM C618)

Item	Cement	FA-A	FA-B	FA-C
Silicon dioxide (SiO_2), %	20.50	59.40	55.58	38.48
Aluminium dioxide (Al_2O_3), %	5.00	30.30	18.96	20.64
Iron Oxide (Fe_2O_3), %	3.30	2.80	4.52	5.46
Sum of SiO_2, Al_2O_3, Fe_2O_3, %	28.80	92.50	79.06	64.58
Calcium Oxide (CaO), %	62.70	1.00	13.29	23.44
Magnesium (MgO), %	3.80	-	3.01	4.10
Sulfur trioxide (SO_3), %	2.90	0.10	0.53	1.69
Potassium Oxide (K_2O), %	-	0.64	0.83	0.61
Loss of Ignition, %	0.85	1.30	0.22	0.27
Insoluble Residue, %	0.29	-	-	-
Fineness 45mm sieve, % retained	8.2	26.40	23.75	10.75
Blaine (Specific Surface) $m^{2/}kg$	368	-	-	-
Specific Gravity	3.15	-	2.47	2.61
Setting Time-Vicat Initial (minutes)	130	-	-	-
Air Content %	7.50	-	-	-
Compressive strength, 3 days, psi	3790	-	-	-
Compressive strength, 7 days, psi	4910	-	-	-
Strength Activity Index with Portland Cement at 7 days, % Control	-	77.30	84.90	88.60
Strength Activity Index with Portland Cement at 28 days, % Control	-	78.30	84.10	94.60
Water Required, % Control	-	98.30	95.00	91.70
Autoclave Expansion %	0.14	-0.04	-0.01	-0.01
Available Alkali (as Na_2O), %	0.55	0.50	0.86	1.95
Tricalcium Silicate (C_3S), %	53.0%	-	-	-
Tricalcium Aluminate (C_3A), %	8.0%	-	-	-

Table 3.2 Gradation and properties of aggregates (ASTM C 136)

Sieve Sizes	Percentage Passing	
	Coarse Aggregate	**Fine Aggregate**
	No.57	-
1 ½	100.0	0.0
1	100.0	0.0
¾	92.0	0.0
½	49.0	0.0
3/8	28.0	100.0
No. 4	5.0	99.0
No. 8	1.0	84.0
No. 16	0.0	70.0
No. 30	0.0	52.0
No. 50	0.0	20.0
No. 100	0.0	3.0
No. 200	1.0	-
Fineness Modulus	-	2.73
Specific Gravity(SSD)	2.84	2.59
Absorption, %	0.3	1.3
Dry rodded unit weight, lb/ft^3	105.9	N/A

3.2 Mixing Mortar

ASTM C1074 recommends preparation of 2 in. mortar cubes for evaluation of datum temperature and activation energy. Four different temperatures (7.5^{o}C (45^{o}F), 21.0^{o}C (70^{o}F), 38.0^{o}C (100^{o}F), and 49.0^{o}C (120^{o}F)) were selected for mixing and curing the mortar cubes. Prior to batching, all the materials (cement, fly ash, fine aggregates, HRWR, and water) were preconditioned at respective temperature, to assure that the mortars were maintained as close as possible to the desired curing temperature. Mortar mixtures were proportioned to match specific concrete mixtures according to ASTM C1074 Annex A1.

3.3 Mortar Testing

3.3.1 Fresh Mortar Tests

These tests were done for all the batches and curing conditions. Fresh mortar tests were conducted in accordance to the following ASTM Standards:
ASTM C1437: Flow test, and
ASTM C185: Air content and density
ASTM C403/C403M. Setting time by penetration resistance

For determination of setting time, mortar specimens were prepared and cast as specified in ASTM C403/C403M. After casting, specimens were submerged in water baths as recommended by ASTM C1074 Annex A1. The specimens were carefully removed from the water bath and excess water was removed before making the penetration measurements on the specimen in accordance to ASTM C403/C403M.

3.3.2 Hardened Mortar Tests

The primary objective of this portion of the study was to determine the activation energy of mixtures based on the type and quantity of fly ash. ASTM C1074 Annex A1 mentions that the activation energy can be obtained by analyzing compressive strength data obtained from 2-in. mortar cubes and the results are applicable to the concrete. Around 1000 2-in. mortar cubes were prepared and tested in compression.

As per ASTM C1074, mortar cubes were molded and tested in compression in accordance with ASTM C109/C109M. Cube specimens were cured at 4 different isothermal curing conditions (7.5^{o}C (45^{o}F), 21.0^{o}C (70^{o}F), 38.0^{o}C (100^{o}F), and 49.0^{o}C (120^{o}F)). For each batch, 20 mortar cubes were prepared and tested at 6 different ages. For each testing age three 2-in. mortar cubes were tested and the average value was recorded for the analysis. These cubes were tested in a 300-kip capacity compression testing machine, which was setup at a maximum load range of 30-kip for compression testing.

After casting, the cubes were submerged in lime-saturated water baths maintained at the specified curing temperatures. Temperature sensors (iButton®), as shown in Figure 3.1, were cast in the center of two mortar cube for each condition during molding of cubes to maintain a record of the curing temperature. A wire was soldered to both ends of an iButton® to allow for interface with a computer using a RJ-11 connector, and coated with plasti dip to protect it from moisture. The iButton has an internal data logger and information is transferred between the iButton and a PC with the program "One-wire Viewer". The average temperature of the two cubes is reported. The purpose of these sensors was to measure the isothermal curing temperature that the cubes were cured under for the entire period of curing. These two mortar cubes were not tested for strength.

Figure 3.1 Temperature sensor (iButton®)

3.4 Mixture Proportions

Six mortar mixtures were prepared. The mortar mixtures were proportioned so that the fine aggregate-to-cementitious materials ratio (by mass) is the same as the coarse aggregate-to-cementititious materials ratio of the concrete mixtures under investigation. This is consistent with the recommendations in Annex A1 of C1074. The concrete mixture proportions are provided in Table A.1 of Appendix A. Table 3.3 summarizes the mortar mixture proportions that correspond to the yield-adjusted concrete mixture proportions of Table A.1 of Appendix A. (In this project the concrete testing was conducted prior to the mortar testing and therefore the yield-adjusted concrete mixture proportions were used to prepare the mortar mixtures.)

Table 3.3 Mortar mixture proportions (2-inch cubes –ASTM C1074)

Item	Control Mixture	20% FA-A	35% FA-C	35% FA-B	35% FA-A	50% FA-A
Cement (gram)	1876	1551	1357	1371	1199	1101
Fly Ash (gram)	0.0	388	740	739	710	1066
Fine Aggregate (gram)	7136	7110	7250	7185	7087	7036
Water (gram)	1052	988	889	894	960	848
HRWR Admixture (oz/cwt)	2.1	3	5.1	5	6.7	7.1
w/cm	0.56	0.51	0.42	0.43	0.51	0.39

Multiple trials were made for some of the mixtures because of unusual behavior in the measured compressive strength results of mortar cubes for those mixtures.Table 3.4 tabulates the list of trials and curing temperatures for those trials. Some of the trials were repeated for only two temperatures as indicated in Table 3.4. As described in ASTM C1074, at least three curing temperatures are needed to determine the activation energy (AE). Two approaches were used to group the data together to quantify AE values for mixtures as described below.

1. For the trial for which strength versus age data was not available at three temperatures, data from the other trials were used for the third temperature. Eg: Mixture 50% FA-A Trial 3 has two curing temperatures and results for curing at a third temperature were not available, so data from Trial 2 was used to obtain at least three temperatures. These AE values are termed as individual AE values later in the report. For each trial, one AE value is reported. Eg: control mix will have two AE values one for each trial.

2. All the computed rate constants were grouped together for one particular mixture irrespective of which trial it belonged to and one AE value was calculated. These AE values are termed as combined AE values.

Table 3.4 Curing temperatures used for multiple trials

Mixture	Trial	Curing Temperature			
		7.5°C (45°F)	21.0°C (70°F)	38.0°C (100°F)	49.0°C (120°F)
Control	1	X	X	X	X
	2	X	X		X
20% FA-A	1	X	X	X	X
35% FA-A	1	X	X	X	X
	2	X	X		X
	3		X		X
50% FA-A	1	X	X	X	X
	2	X	X		X
	3		X		X
	4		X		X
35% FA-B	1	X	X	X	X
	2		X		X
35% FA-C	1	X	X	X	X
	2		X		X
	3		X		X

Note: X denotes the temperatures at which compressive testing was performed

3.5 Discussion of Test Results

3.5.1 Fresh Mortar Properties

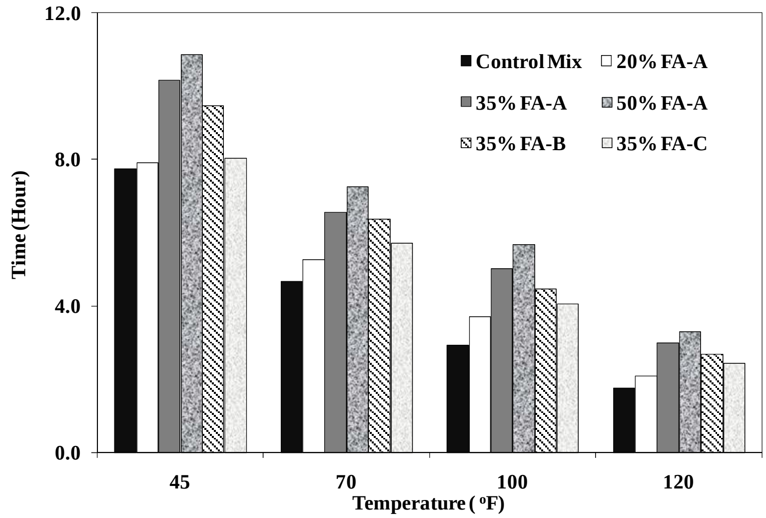
Table 3.5 summarizes the average recorded curing temperature for mortar cubes. Trials are marked as Trial 1 to Trail 4 depending on the number of trials for each mixture, as defined in Table 3.4. It can be observed that the isothermal conditions are closely matched for the 4 different curing conditions. Table 3.6 presents the initial and final seting times for the six mortar mixtures and these data are graphically presented in Figure 3.2. As expected, the figure clearly shows that the setting times decrease as the curing temperature increases for all the mixtures.

Table 3.5 Average curing temperature for mortar cubes

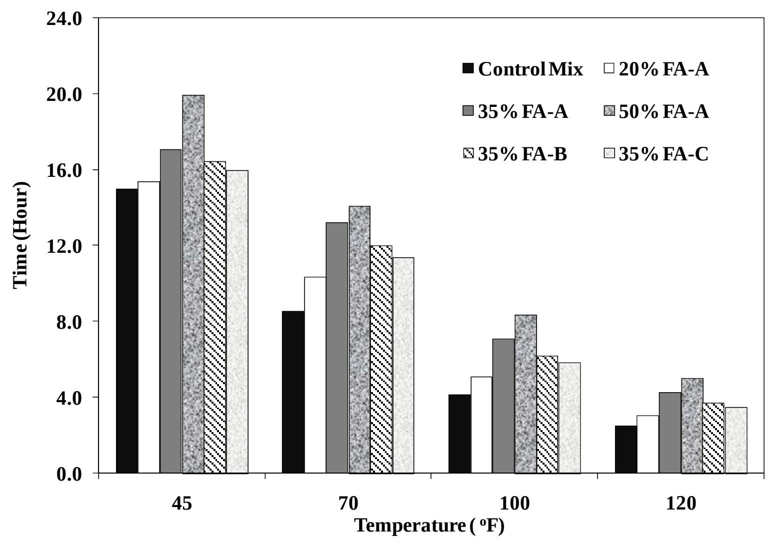
Mixture	Trial	Curing Temperature 7.5°C (45°F)	21.0°C (70°F)	38.0°C (100°F)	49.0°C (120°F)
Control	1	43.2	72.0	99.3	121.2
	2	43.3	75.2		121.3
20% FA-A	1	44.3	72.5	99.4	121.2
35% FA-A	1	44.2	72.0	97.4	120.1
	2	46.2	73.4		118.2
	3		71.2		121.5
50% FA-A	1	44.3	71.4	98.6	120.2
	2	42.6	75.5		122.0
	3		71.6		120.6
	4		70.1		121.0
35% FA-B	1	42.8	72.1	99.8	120.3
	2		74.6		118.9
35% FA-C	1	45.0	72.9	99.3	121.1
	2		74.9		119.4
	3		70.00		118.4

Table 3.6 Setting times for mortar mixtures (ASTM C403)

Mixture	Setting Time (hours)							
	T_c = 7.5°C (45°F)		T_c = 21.0°C (70°F)		T_c = 38°C (100°F)		T_c = 49.0°C (120°F)	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Control Mixture	7.8	15.0	4.7	8.5	2.9	4.1	1.8	2.5
35%FA-C	8.0	16.0	5.7	11.4	4.1	5.9	2.4	3.5
35%FA-B	9.5	16.4	6.4	12.0	4.5	6.2	2.7	3.7
20% FA-A	7.9	15.4	5.3	10.4	3.7	5.1	2.1	3.0
35% FA-A	10.2	17.1	6.6	13.2	5.0	7.1	3.0	4.2
50% FA-A	10.9	19.9	7.3	14.1	5.7	8.4	3.3	5.0



(a-Initial setting time)



(b-Final Setting time)

Figure 3.2 Setting times of mortar mixtures

Table 3.7 to Table 3.10 presents the flow results for the various mortar mixtures. It can be generally observed that the flow of the mixtures decreases as the mixing temperatures increase. At the higher temperature, the hydration reaction is faster compared to mixtures mixed at lower temperature, which means the free water will be bound faster and cause the workability of these mixtures to decrease.

Table 3.7 Flow results for mortar mixtures-trial I (ASTM C1437)

Mixture	Flow(%)-Trial I			
	T_c = 7.5°C (45°F)	T_c = 21.0°C (70°F)	T_c = 38°C (100°F)	T_c = 49.0°C (120°F)
Control Mixture	108	102	80	81
35%FA-C	100	96	112	109
35%FA-B	100	99	101	102
20% FA-A	102	98	99	98
35% FA-A	106	109	105	111
50% FA-A	100	103	101	101

Table 3.8 Flow results for mortar mixtures-trial II (ASTM C1437)

Mixture	Flow-Trial (%) II		
	T_c = 7.5°C (45°F)	T_c = 21.0°C (70°F)	T_c = 49.0°C (120°F)
Control Mixture	112.5	108	81
35%FA-C	-	113	92
35%FA-B	-	113.5	102
20% FA-A	-	-	-
35% FA-A	120	113.5	107.5
50% FA-A	119.5	102	98.5

Table 3.9 Flow results for mortar mixtures-trial II (ASTM C1437)

Mixture	Flow-Trial (%) III	
	T_c = 21.0°C (70°F)	T_c = 49.0°C (120°F)
35%FA-C	112	93
35% FA-A	111.5	105.5
50% FA-A	106	96.5

Table 3.10 Flow results for mortar mixtures-trial IV (ASTM C1437)

Mixture	Flow-Trial (%) IV	
	T_c = 21.0°C (70°F)	T_c = 49.0°C (120°F)
50% FA-A	104.5	99.0

The air content and density results for all trials are presented from Table 3.11 to Table 3.13. The interpretation of the tables shows that the density values of the mixtures increase as the mixing temperature increases and vice versa for the air content. At higher temperatures air voids are less stable and hence the total air content values are expected to be slightly lower. Note that a 2% reduction in air in the mortar translates to about 1% reduction in air content for the concrete mixture.

Table 3.11 Air content and density for mortar mixtures-trial II (ASTM C185)

Mixture	Trial II					
	T_c = 7.5°C (45°F)		T_c = 21.0°C (70°F)		T_c = 49.0°C (120°F)	
	Density (g/mL)	Air (%)	Density (g/mL)	Air (%)	Density (g/mL)	Air (%)
Control Mixture	2.10	6.99	2.11	6.76	2.12	5.93
35%FA-C	-	-	2.11	8.16	2.15	6.28
35%FA-B	-	-	2.10	8.78	2.15	6.13
20% FA-A	-	-	-	-	-	-
35% FA-A	2.05	8.49	2.08	7.78	2.09	6.49
50% FA-A	2.08	7.98	2.08	7.85	2.16	4.39

Table 3.12 Air content and density for mortar mixtures-trial III (ASTM C185)

Mixture	Trial III			
	T_c = 49.0°C (120°F)		T_c = 49.0°C (120°F)	
	Density (g/mL)	Air (%)	Density (g/mL)	Air (%)
35%FA-C	2.31	8.68	2.40	6.57
35% FA-A	2.10	8.10	2.32	6.63
50% FA-A	2.16	7.65	2.20	4.96.

Table 3.13 Air content and density for mortar mixtures-trial IV (ASTM C185)

Mixture	Trial IV			
	T_c = 49.0°C (120°F)		T_c = 49.0°C (120°F)	
	Density (g/mL)	Air (%)	Density (g/mL)	Air (%)
50% FA-A	2.21	8.10	2.40	4.42

3.5.2. Compressive Strength

At each testing age the maturity was established based on the temperature history recorded by the temperature sensors. The testing ages of the cubes were selected based on the measured final setting time obtained for each specific mixtures. The first test age was selected such that the compressive strength of the mortar cubes was around 200 psi -400 psi. It was important to capture the strength development of the mixtures at early ages. After the age of the first test was obtained, subsequent tests were performed at twice the testing age of the previous test. The last testing age was selected to correspond to an equivalent age of 28 days at the reference curing temperature of 23°C (73 °F) and was calculated by assuming an activation energy value. For example: for 49.0°C (120°F) curing temperature the last testing age was around 7 days, which corresponds to an equivalent age of 28 days at 23°C (73°F).

The average compressive strength values of 2-in. mortar cubes are reported in Appendix B from Table B.1 to Table B.15. These results include the test results obtained for all six mixtures cured at the four different isothermal curing temperatures of 45°F, 70°F, 100°F and 120°F. From the results, it is observed that at elevated temperatures mortar cubes showed higher compressive strength at later ages compared to mortar cubes cured at lower temperatures, which is an unexpected behavior for cementitious mixtures. Figure 3.3 and Figure 3.4 show such behavior for the 35% FA-A mixture and 35% FA-C respectively. Carino (2004) describes that concrete mixtures cured at elevated temperatures will have lower strength at later ages compared to the specimens cured at lower temperatures. This unexpected behavior was the reason for conducting several testing trials in order to verify this trend.

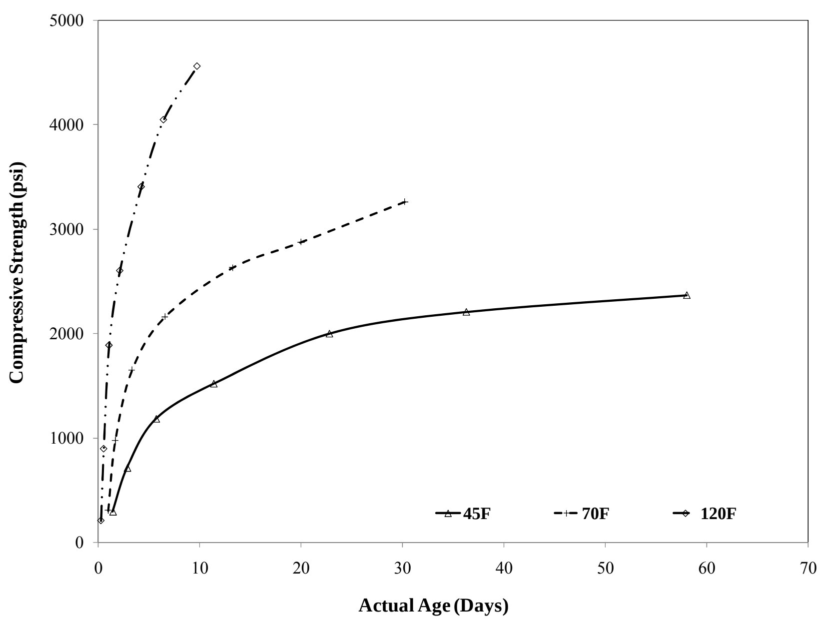


Figure 3.3 Compressive strength vs. actual age (35% FA-A mixture)

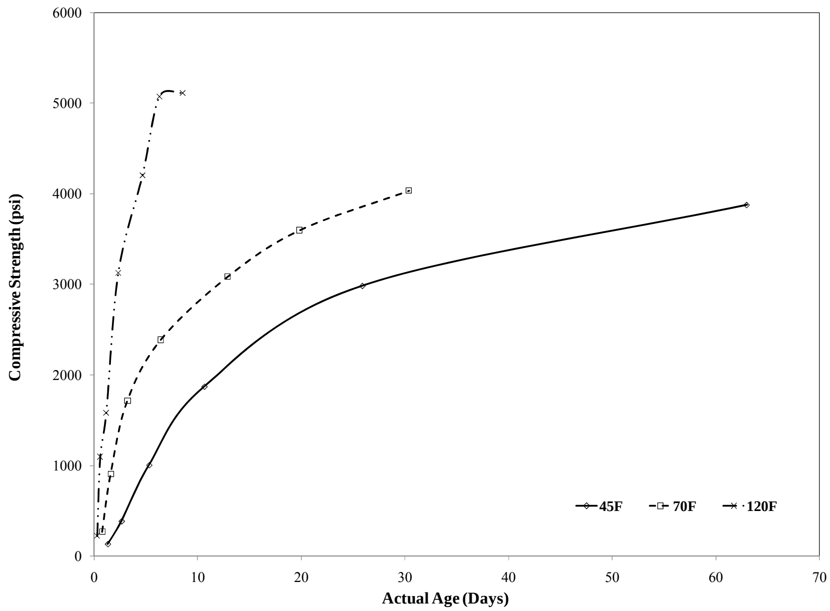


Figure 3.4 Compressive strength vs. actual age (35% FA-C mixture)

3.5.3. Calculation of Activation Energy

In order to calculate the activation energy values, the natural logarithms of rate constant values are plotted as a function of reciprocal of absolute temperature (curing temperature in Kelvin). The best-fit straight line is determined. The activation energy is the negative value of the slope divided by the universal gas constant. More details on how to calculate the activation energy is in ASTM C1074 Annex A1.

Activation energy (AE) was determined using strength age data for the various mixtures. After the strength data for various mixtures are obtained, strength is plotted as a function of curing age for each curing temperature. In ASTM C1074 a hyperbolicmodel, Equation 3 is suggested to characterize the compressive strength-age relationship. In this approach, t_0 was substituted with the final setting time measured for each batch of mortar

$$S(t) = S_u(t)\frac{k(T)\times\left(t - t_{fs}\right)}{1 + k(T)\times\left(t - t_{fs}\right)}$$ **Equation 3**

where,
- $S(t)$ = compressive strength (psi),
- $S_u(t)$ = limiting strength (psi),
- $k(T)$ = rate constant (1/days),
- t = testing age (days), and
- t_{fs} = final setting time (days).

Least square regression analysis was used to determine the best-fit values for S_u, and k(T) summarizes the computed rate constants for the various trials and curing temperatures.

Figure 3.5 to Figure 3.10 shows the graphical representation of rate constant versus curing temperature for all the mixtures and trials. The continuous line in each plot is the best fit curve for rate constant versus curing temperature from which the activation energy is calculated. The correlation coefficient (R^2) values are reasonably good with the exception for two mixtures that had R^2 values of 0.71 (35% FA-C), and 0.61 (35% FA-A). This suggests that the reaction rate for these mixtures may not fit Arrhenius theory, and a modified approach might be needed to capture this unusual effect for high-volume fly ash concrete. Figure 3.11 (a-f) illustrates the Arrhenius plots for all the mixtures and trials. Table 3.15 presents the computed apparent activation energy (AE) values for the various mixtures. The activation energies are summarized considering the data from each "individual" trial, as well as using the "combined" results of all trials. For the in-place strength estimation the activation energy of combined trials has been used as it is considered more accurate.

Table 3.14 Best fit regression constants

Mixture	Trial	Curing Temperature							
		45 °F		70 °F		100 °F		120 °F	
		S_u (psi)	k_t (day^{-1})	S_u (psi)	k_t (day^{-1})	S_u (psi)	k_t (day^{-1})	S_u (psi)	k_t (day^{-1})
Control	1	4329	0.240	4778	0.636	4517	1.539	3933	2.450
	2	4669	0.203	4216	0.648			3777	1.973
20% FA-A	1	5850	0.093	5336	0.405	5225	0.928	5409	1.422
35% FA-A	1	2662	0.156	3448	0.410	4652	0.457	5867	0.404
	2	2581	0.161	3435	0.310			5254	0.542
	3			3779	0.290			5849	0.309
50% FA-A	1	5358	0.085	5762	0.175	8125	0.441	7987	0.677
	2	5924	0.096	5762	0.289			7465	0.772
	3			7033	0.133			7473	0.666
	4			6423	0.221			8519	0.343
35% FA-B	1	5018	0.117	4945	0.436	4509	0.459	4992	1.269
	2			4972	0.325			6404	0.686
35% FA-C	1	5023	0.056	5256	0.198	6851	0.138	9015	0.335
	2			4580	0.194			7149	0.335
	3			4686	0.013			7021	0.039

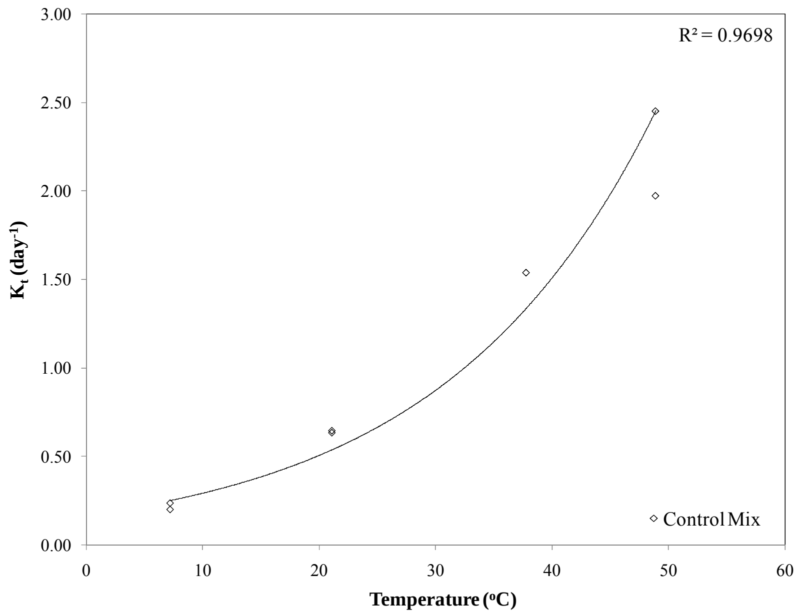


Figure 3.5 Rate constant vs. temperature-control mixture (AE-41400l J /mol)

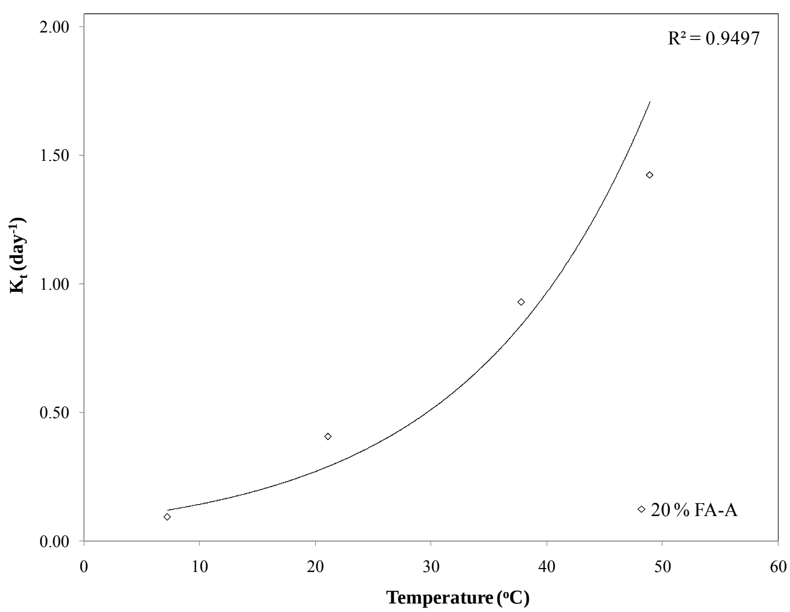


Figure 3.6 Rate constant vs. temperature-20% FA-A (AE-48100 J /mol)

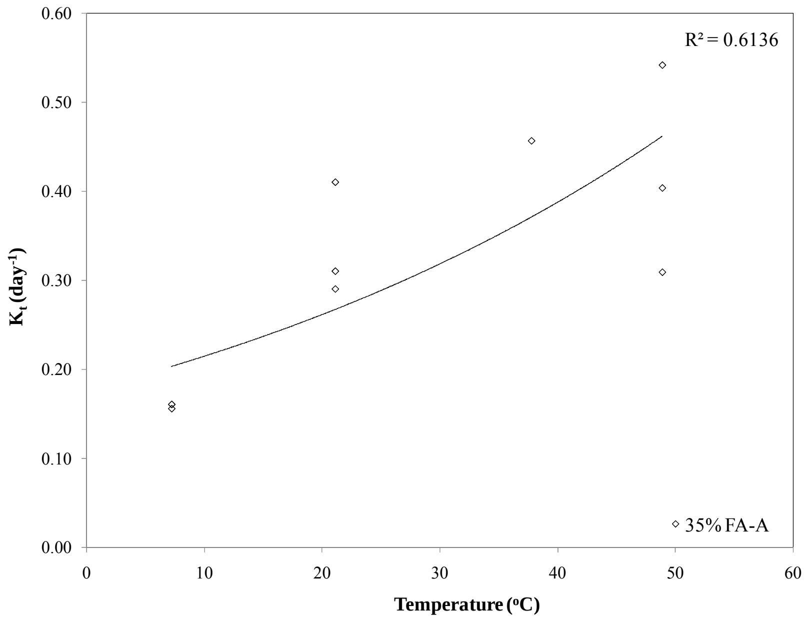


Figure 3.7 Rate constant vs. temperature-35% FA-A (AE-l5600 J /mol)

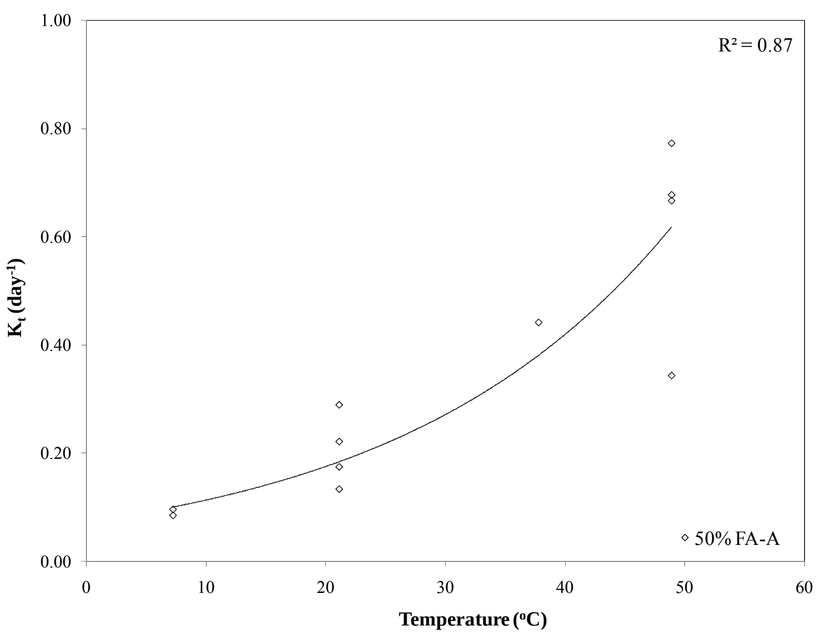


Figure 3.8 Rate constant vs. temperature-50% FA-A (AE-33400 J /mol)

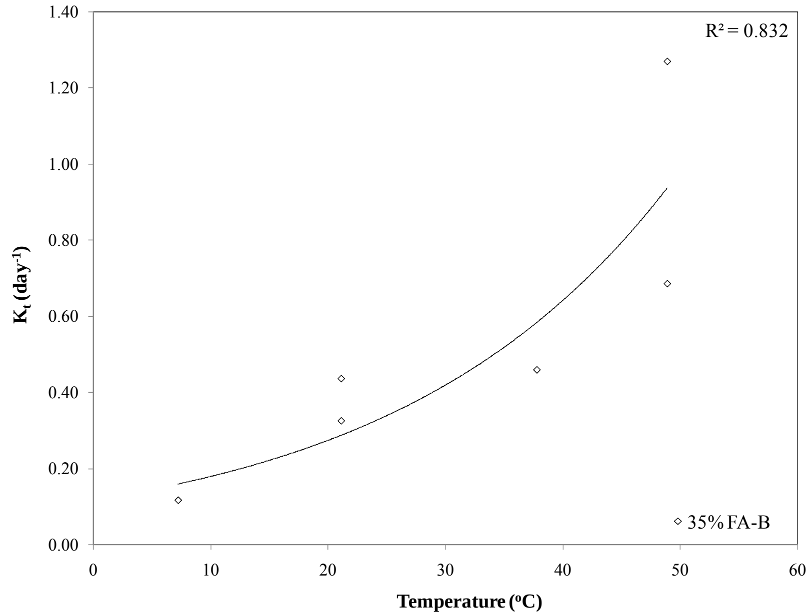


Figure 3.9 Rate constant vs. temperature-35% FA-B (AE-33000 J /mol)

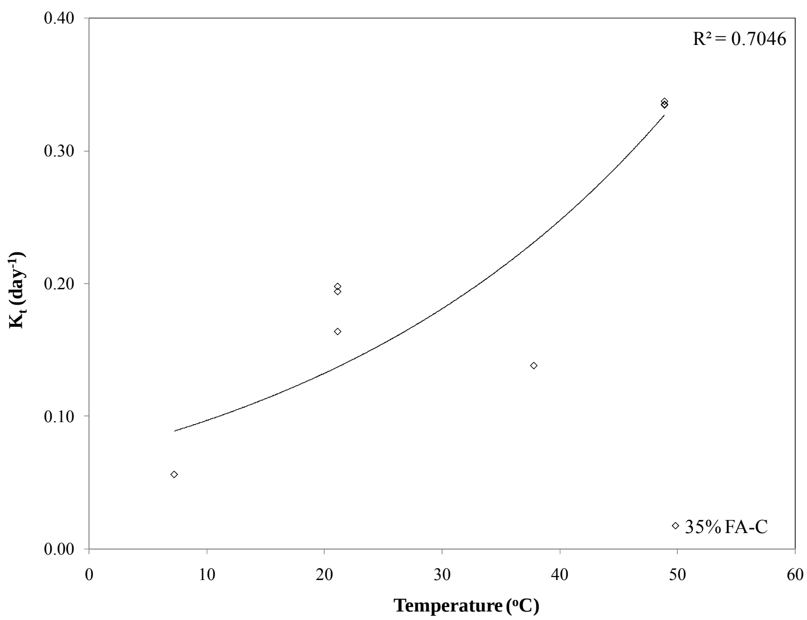
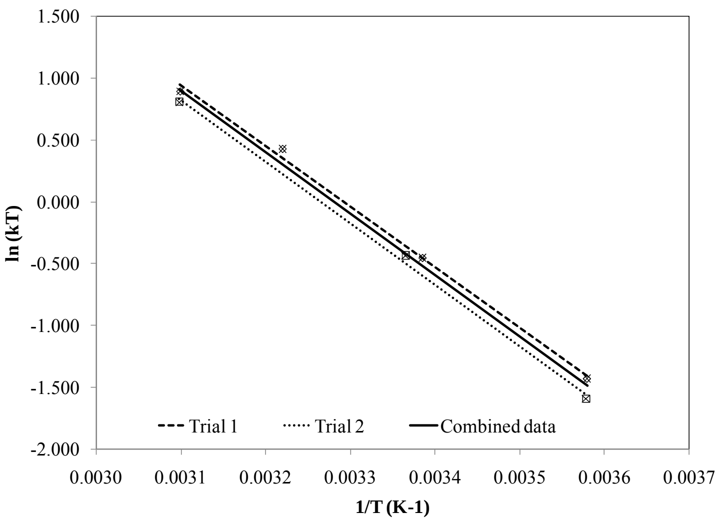
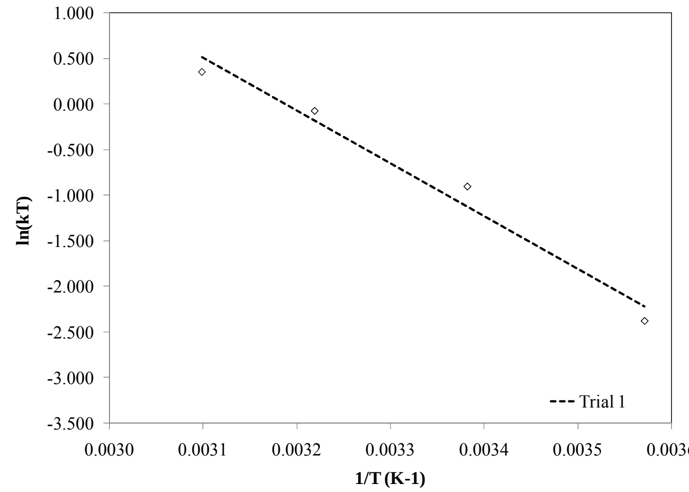


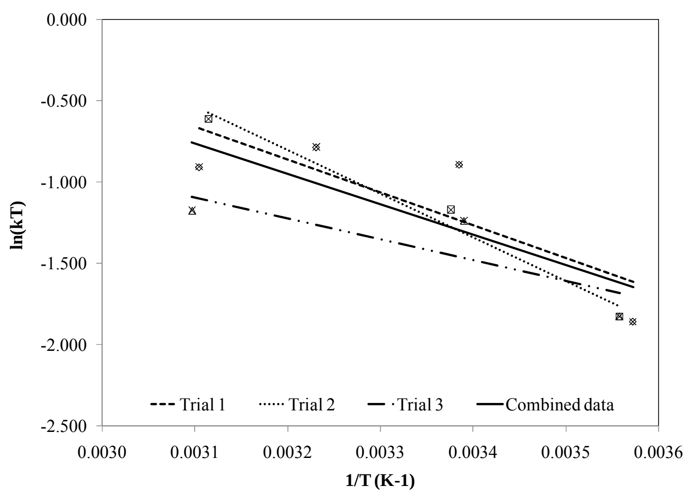
Figure 3.10 Rate constant vs. temperature-35% FA-C (AE-28300l J /mol)



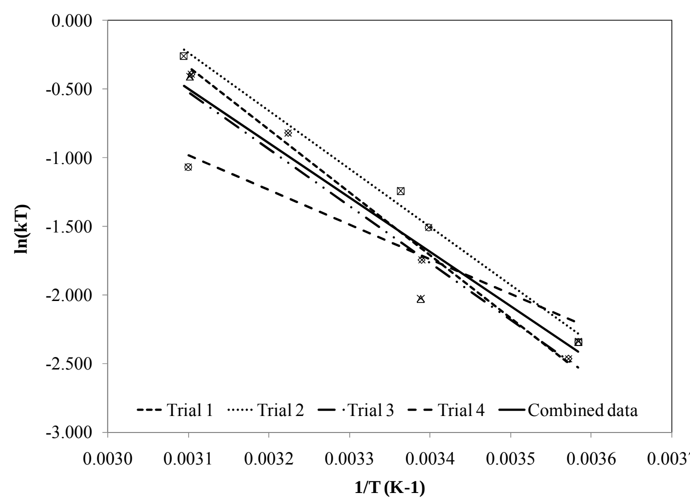
(a-Control mixture)



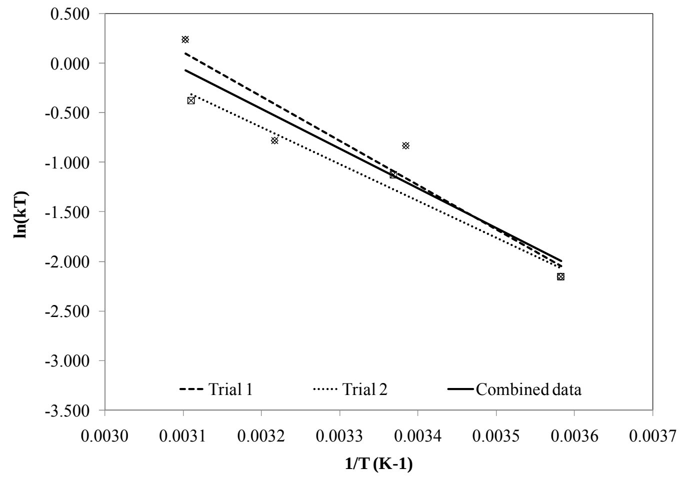
(b-20% FA-A)

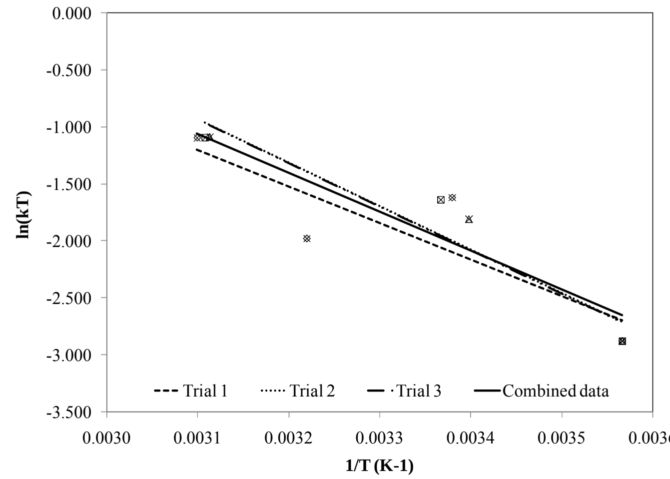


(c-35% FA-A)



(d-50% FA-A)





(e-35% FA-B) (f-35% FA-C)

Figure 3.11 Arrhenius plots for the various mixtures

Table 3.15 Calculated activation energies (ASTM C1074)

Mixture	AE (J/mol)	AE_1 (J/mol)	AE_2 (J/mol)	AE_3 (J/mol)	AE_4 (J/mol)
Control	41400	40900	41500		
20% FA-A	48100				
35% FA-A	15600	16900	22400	10700	
50% FA-A	33400	38000	35300	34500	21800
35% FA-B	33000	37100	31000		
35% FA-C	28300	26700	31700	31700	

AE= Activation Energy calculated based on combined data set

AE_i = Activation Energy calculated based for each of the trials, i = 1 through 4

CHAPTER 4 – EXPERIMENTAL WORK – CONCRETE

4.1 Materials

The same materials were used for concrete and mortar batches; the physical and chemical properties of the materials used for concrete field and laboratory testing are presented in Table 3.1and Table 3.2 in Chapter 3.

4.2 Mixing Concrete

These non-air-entrained concrete mixtures had a target slump of 5 to 7 in. Type F HRWR was used in the concrete mixture to achieve the target slump. The concrete was mixed in a dry batch ready mixed concrete plant, which means all the materials were batched into the concrete truck mixer and mixed in the truck mixer. The concrete was delivered to the NRMCA research facility which was located about 20 minutes from the concrete plant. The plant only stored Fly ash FA-A, which required that Fly ash FA-C be added to the ready mixed concrete truck at the NRMCA laboratory followed by additional mixing. HRWR was also added as needed at the laboratory to attain target slump.

4.3 Concrete Testing

Concrete tests were conducted in accordance with ASTM standards. The NRMCA Research Laboratory participates in proficiency sample testing of the Cement and Concrete Reference Laboratory (CCRL), is inspected biannually for conformance to the requirements of ASTM C1077, and maintains its accreditation under the AASHTO Laboratory Accreditation Program.

4.3.1 Fresh Concrete Tests

All concrete batches were tested in accordance with ASTM standards for slump (ASTM C143/C143M), air content (ASTM C231), density (ASTM C138/C138M), and temperature (ASTM C1064/C1064M).

4.3.2 Hardened Concrete Tests

Compressive Strength Tests:

Compressive strength tests for concrete mixtures were conducted in accordance with ASTM C39/C39M. Specimen size used was 4 x 8 in. cylindrical specimens. Neoprene caps in accordance with ASTM C1231/C1231M of 70 durometer hardness were used to cap the test specimens. Three types of curing were followed:

1. Standard-cured test specimens were transferred to the 100% humidity room [23^{o}C (73 ^{o}F)] as soon as they were cast, demolded at 24 hours and cured until the test age.

Cylinders were tested at an age of 1, 2, 4, 7, 14, and 28 days. Strength test results reported are the average of 3 test cylinders tested at the same age. Temperature sensors were placed in two of the concrete cylinders. The average temperature data were used to establish the strength-maturity relationship for each mixture.

2. Field-cured cylinders were also tested at an age of 2, 4, and 7 days. Compressive strength test results reported are the average of 3 test cylinders for field-cured cylinders tested at the same age. Two additional concrete cylinders were casted with temperature sensor (iButtons) at the center to compare the temperature development with that structure. These concrete specimens with temperature sensors were not tested for compressive strength, and were only used to recording temperature.

3. Match-cured cylinders were also tested at an age of 2, 4, and 7 days. The match curing process used is shown in Figure 4.1. Compressive Strength test results reported are the average of 2 test cylinders tested at the same age. Two additional concrete cylinders were cast with a temperature sensor (iButton) at the center to compare the temperature development with that structure. These concrete specimens with temperature sensors were not tested for compressive strength.

Figure 4.1 Match cure system showing 8 match-cured cylinder molds connected to a micro-controller computer

Pullout Tests:

Wooden 8-in. cube molds shown in Figure 4.2 were used for developing the correlations between pullout load and compressive strength of companion cylinders. Testing was conducted at six ages (1, 2, 4, 7, 14, and 28 days). Early stripping inserts were used in the 8-in. concrete cubes, one pullout insert was used in each side of the four faces to eliminate the possibility of any radial cracking propagation affecting the results during the pullout test (Figure 4.3). A LOK-test machine was used to perform the pullout test, as shown in Figure 4.4. Pullout force test result reported is the average of 8 pullout test at same age from 2 cubes. An additional cube was made to record the temperature of these specimens; therefore, 13 cubes were prepared for each mixture. Temperature sensors (iButtons) were placed in one of the cubes at a height of 1 in. from the bottom surface of the cube at the center of the surface. The temperature data were used to compare the temperature development of the cubes and cylinders. These molds were fabricated with wood and coated with waterproofing paint and varnish. Before filling the concrete, the wooden cube molds were coated with form oil to prevent the concrete from adhering to the molds. A correlation between the pullout load and compressive strength was determined for each mixture. This correlation was used to estimate the in-place strength at locations where the pullout test on the concrete members was performed.

Figure 4.2 Custom 8 × 8 × 8-in. cube mold

Figure 4.3 Cube molds with pullout inserts at the centers of the 4 side faces

Figure 4.4 Pullout equipment

Concrete Blocks:

Concrete blocks of dimension 2 × 2 × 6-ft were used to simulate the in-place strength development of HVFA mixtures under field conditions. The 2 × 2 × 6-ft wooden forms, shown in Figure 4.5, were designed to incorporate 12 pullout inserts on each side of the longer faces (24 total). The minimum distance between 2 inserts was kept in accordance to ASTM C900, which states that the minimum clear distance between two inserts should be eight times the head diameter, and the minimum clear distance between the edge and the insert should be four times the head diameter. Inserts were installed at 145-mm clear distance center to center, and 115-mm from the edge, to eliminate any potential effects of radial cracking from one test to the next. The inserts extended a distance of 1 in. into the concrete surface. The blocks were also designed to allow the research team to perform very early pullout tests before the forms were removed. This was done by creating a small access window on specific locations of the block mold as shown in Figure 4.4.

Figure 4.5 Field block with pullout inserts and temperature sensors

Four 2 × 2 × 6-ft concrete blocks were prepared, one for each of the four different concrete mixtures. Temperature sensors (iButtons) were installed in eight different locations in each concrete block. Appendix A, Figure A.3 shows the locations of temperature sensors. Temperature of concrete elements should be measured at critical locations within a structure since a variable temperature gradient may be observed in relation to the specific location, Appendix E shows the plots for temperature profile within the block. One thermocouple was also installed at 1 in. from the surface of the block, which was needed for the match cure cylinders to replicate the same thermal profile as the block. The temperature profile from iButton (denoted by P4 in Figure A.3) located at a depth of 1 in. from the surface was used to calculate the equivalent age of the block. Whenever maturity is used to perform critical formwork removal operations it is customary for the temperature sensor to be placed at a depth of 1 in. from the concrete surface.   It should be observed that the temperature sensor for the maturity (P4 in Figure A.3), the thermocouple for match-cured cylinder tests, and the pullout inserts extended to a depth of 1 in. from the concrete surface. The blocks were placed in two lifts with each layer being consolidated using an internal vibrator. As soon as the blocks were struck off, they were covered with a plastic sheet. A commercially used black curing blanket about

20-mil-thick was used to cover the blocks. The curing blanket was kept over the plastic sheet in order to provide some additional insulation to the blocks during the curing process. Figure 4.6 shows the concrete block being cured.

The pullout test on the concrete blocks was conducted in accordance to ASTM C900, at three different concrete ages (2, 4, and 7 days). Testing at an age of 2 days was conducted with the side forms still on the blocks, so access for the pullout test was obtained through a 100-mm diameter opening in the form as shown in Figure 4.5. The formwork of each block was removed at a concrete age of 3 days. After the forms were removed, the block was cured using plastic sheeting and curing blankets. At each testing age, eight pullout tests were conducted at randomly selected locations on the block, with the requirement that four tests be performed on each of the two longer faces of the block. This approach was used to eliminate the effect of variability due to different curing conditions and hydration that the sides of the block may experience. The average of these eight tests was calculated and used to estimate the in-place compressive strength at that age using the pre-determined pullout load versus strength correlation.

Figure 4.6 Concrete block curing in field.

The pullout tests and match-cured cylinder test results were used to validate the in-place strengths predicted by maturity. Field cured cylinders were also tested as a point of comparison since this approach is currently the most commonly used technique to determine the in-place compressive strength.

Slab tests:

In addition to the concrete blocks, two 8 ft × 8 ft × 7 in. slab (Figure 4.7), were prepared for the control (Portland cement mixture) and the 50% fly ash mixtures. The slabs had 24 floating inserts and 5 temperature sensors at different locations. The sensor for maturity calculation (denoted by P4, inFigure A.4 of Appendix A) was located at a depth of 2 in. from the top surface around the middle third of the slab. This sensor was located two in. below the surface to have the same depth below the surface as the average depth of concrete tested when a floating pullout insert is tested. Refer to Figure A.4 in Appendix A for detailed geometry of the slab and the location of iButtons and the thermocouple used to drive the match-cured cylinders. For the 50% FA-A mixture the in-place cylinders were used in lieu of the match-cured cylinders, due to logistics issues. For the 50% FA-A mixture concrete block and slab were casted at the same day so the match cure system was used for the block.

Figure 4.8 illustrates the test slab with the floating inserts and cast-in-place cylinders. The pullout test was conducted in accordance with ASTM C900 at three ages (2, 4, and 7 days) by testing eight pullout inserts at each age. The compressive strength of the field-cured and match-cured cylinders was also evaluated at the same three ages as for the slab pullout testing, and using three replicates. For the control mixture, the match cure system was used to evaluate the in-place strength. On the other hand, for the 50 % FA-A mixture, two cast-in-place cylinders were tested at each age and the average value was recorded. The temperature data were also recorded in order to compute the maturity development at various locations. With the calculated maturity and the predetermined strength-maturity relationship, the in-place strength development could be estimated.

Figure 4.7 Concrete slab with cast-in-place cylinders and temperature sensors

Figure 4.8 Slabs with cast-in-place cylinders, floating inserts and field cure cylinders (The red marking are the pullout inserts, field-cured cylinders are placed outside the slab and the cast-in-place cylinders are within the slab)

The concrete blocks and slabs were cast at NRMCA's research facility in ambient exposure conditions during the period of October to December. Table 4.1 tabulates the placement dates and average ambient temperature during the first 96 hours after placing the concrete in the block. The block and slab of the control mixture were cast on different dates, Figure E.1 in Appendix E shows the plot of ambient outside temperature for the first 96 hours during curing process.

Table 4.1 Placement of concrete for blocks and slabs- over the first 96 hours

Mixtures	Block	Slab	Placement Date	Average Ambient Temperature (^{o}F)
35% FA-C	X		10-05-2006	59.0
35% FA-A	X		10-26-2006	50.0
Control	X		11-03-2006	42.0
Control		X	11-20-2006	43.0
50% FA-A	X	X	11-28-2006	55.0

4.4 Mixture Proportions

All the concrete mixtures were non-air-entrained and the Type HRWR dosage was adjusted to attain a target slump of 5 to 7 in. The yield adjusted concrete mixture proportions used are summarized in Table 4.2. The water and cementitious contents were generally accurate except for Mixture 35%FA-A which had a much lower cementitious materials content and higher water content presumably due to a batching error at the concrete plant. To achieve sufficient strength at early ages for fly ash concrete, the water-cementitious materials ratio (w/cm) was decreased and a HRWR was added to achieve desired workability.

Table 4.2 Yield adjusted concrete mixture proportions

Item	Control Mixture	35% FA-C	35% FA-A	50% FA-A
Cement (lb/yd^3)	510	363	331	308
Fly Ash (lb/yd^3)	0	198	196	298
Coarse Aggregate (lb/yd^3)	1940	1940	1956	1967
Fine Aggregate(lb/yd^3)	1298	1321	1268	1297
Water(lb/yd^3)	286	238	265	237
HRWR Admixture (oz/cwt)	2.1	5.1	6.7	7.1
w/cm	0.56	0.42	0.50	0.39

4.5 Discussion of Test Results

4.5.1 Fresh Concrete Properties

Fresh concrete properties are reported in Table 4.3.

Table 4.3 Fresh concrete properties

Parameter	**Mixture ID**				
	Control (Block)	**Control (Slab)**	**35%FA-A (Block)**	**50%FA-A (Block & Slab)**	**35%FA-C (Block)**
Slump (in.)	6.0	6.0	8.25	8.5	8.0
Concrete Temp. (°F)	55	58	55	57	72
Total Air Content (%)	2.4	3.4	1.1	1.1	1.7
Density (lb/ft^3)	149.8	150.1	149.8	153.0	143.3

4.5.2 Standard-Cured Strength Results and Strength-Maturity Relationship

Compressive strength testing of standard-cured 4 x 8 in. concrete cylinders was performed to develop the Strength-Maturity relationship for the four mixtures listed in Table 4.3. Table C.1 to Table C.6 in Appendix C summarizes the compressive strength results for the standard-cured cylinders. The equivalent age maturity function was used to compute the maturity index. The activation energies used to convert the actual ages to equivalent age at the reference temperature of 23^{o}C (73^{o}F) for each mixture are average AE values (labeled as AE) of the corresponding mixture and is provided inTable 3.15. Table 4.4 to Table 4.7 tabulates the compressive strength results of standard-cured cylinders for all the four concrete mixtures. These tables also show the computed equivalent age based on the measured temperature profile of the concrete cylinders. Resulting strength versus equivalent age relationships were plotted and the best-fit hyperbolic functions are shown in Figure 4.9 to Figure 4.12.

Table 4.4 Control mixture

Age (Days)	Eq. Age @23^{o}C (Days)	Strength (psi)
1	0.84	1023
2	1.64	1714
4	3.25	2449
7	5.81	2692
14	12.26	3470
28	24.96	4378

Table 4.5 35% FA-A mixture

Age (Days)	Eq. Age @23^{o}C (Days)	Strength (psi)
1	0.95	699
2	1.90	1034
4	3.78	1402
7	6.62	1820
14	13.05	2609
28	26.54	3505

Table 4.6 50% FA-A mixture

Age (Days)	Eq. Age @23^{o}C (Days)	Strength (psi)
1	0.98	1039
2	1.94	1662
4	3.80	2372
7	6.59	2832
14	12.79	3668
28	25.33	4811

Table 4.7 35% FA-C mixture

Age (Days)	Eq. Age @23^{o}C (Days)	Strength (psi)
1	0.98	807
2	1.94	1781
4	3.88	2822
7	6.79	3503
14	13.29	4104
28	26.15	5212

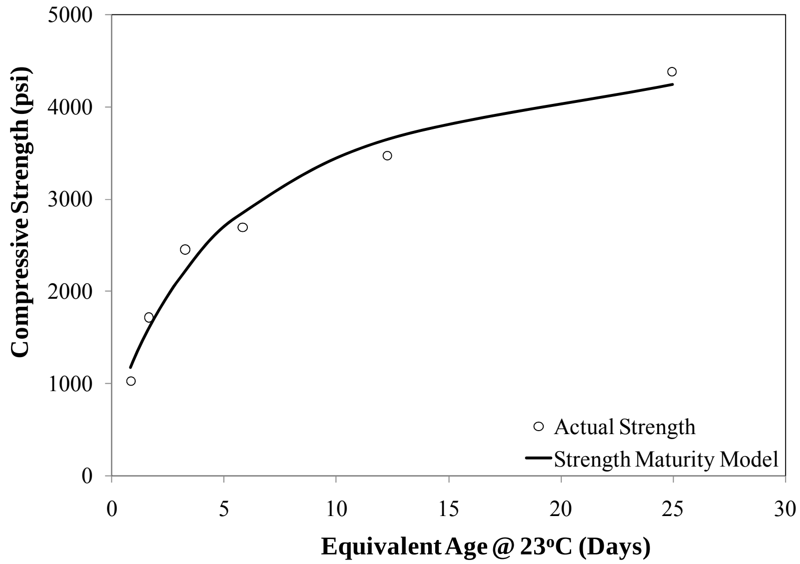


Figure 4.9 Maturity model- control mixture

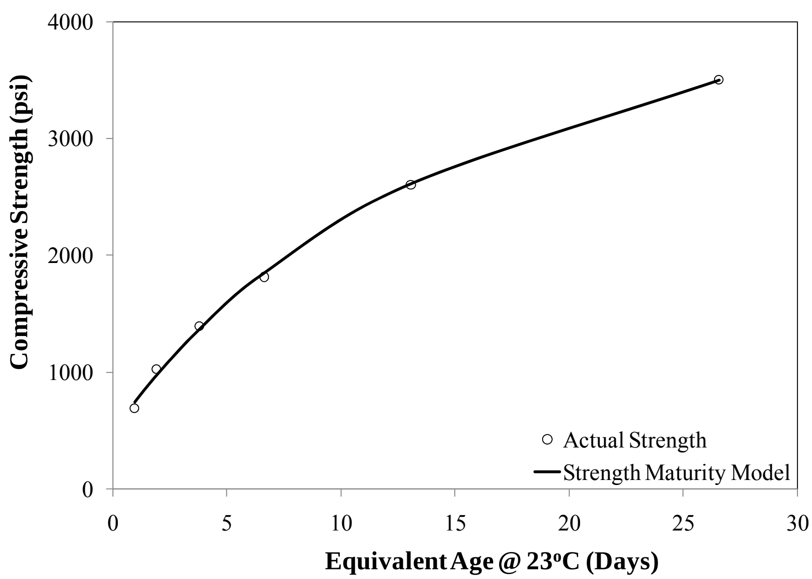


Figure 4.10 Maturity model- 35% FA-A mixture

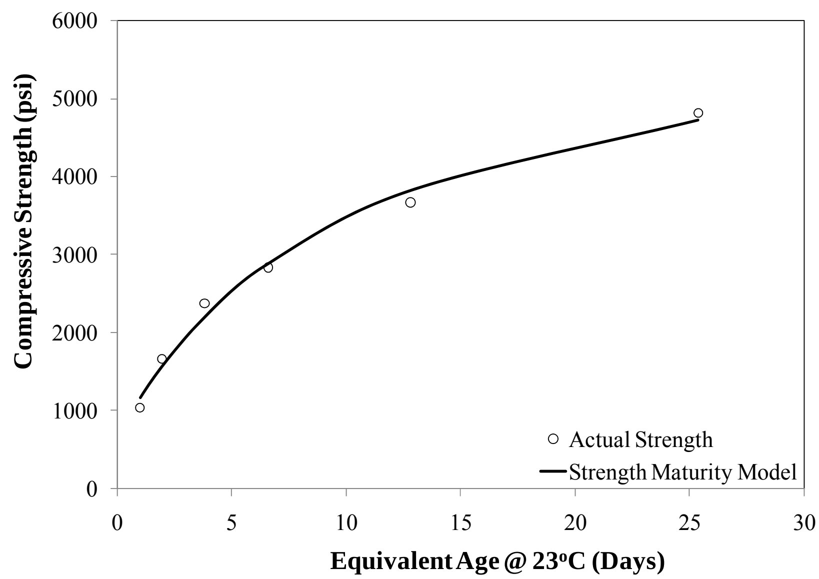


Figure 4.11 Maturity model- 50% FA-A mixture

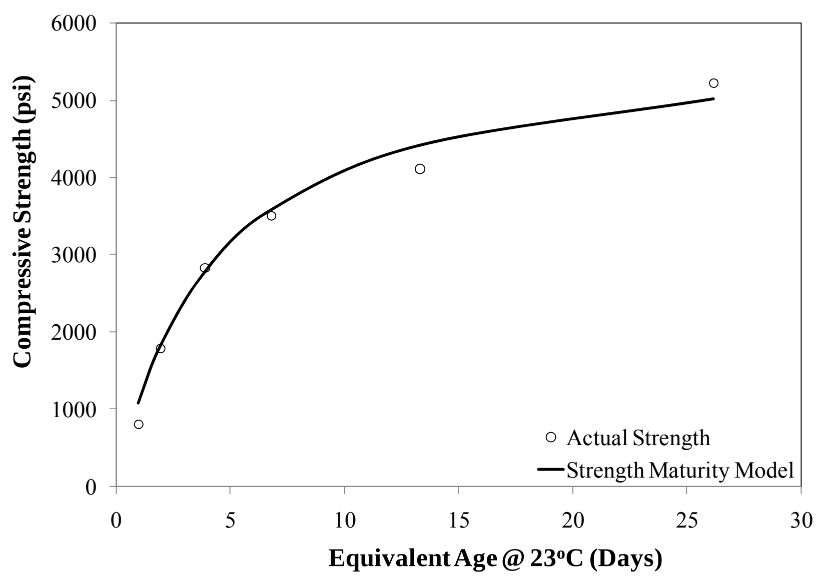


Figure 4.12 Maturity model- 35% FA-C mixture

The hyperbolic function accurately characterized the strength-maturity relationship for all mixtures. Strength-Maturity plots shown in Figure 4.9 to Figure 4.12 are later used to estimate the in-place compressive strengths of the concrete blocks and slabs that were constructed with the same mixtures placed under field conditions.

4.5.3 Pullout Force Test Results and Pullout Force Versus Strength Correlation

The pullout test is used during construction to evaluate the in-place compressive strength of concrete structural elements at any given time. This section will detail the pullout test results and correlations with compressive strength for the different mixtures used in this research. Appendix D summarizes the pullout results for laboratory and field cure specimens. Pullout force results of standard cure cubes are tabulated in Table D.1 to Table D.10 in Appendix D, and these results are used to develop a correlation between pullout force and compressive strength. The compressive strength and pullout force plots are presented in Appendix D from Figure D.1 to Figure D.4. It is noted that the compressive strength increases as an exponential function of the pullout force. This relationship can be described by Equation 4, where a and b are regression constants (ACI 228.1R-03).

$$C = a \times P^{b} \qquad \text{Equation 4}$$

Equation 4 can also be rewritten in a log transformation, as shown in Equation 5, which when plotted on log-log axes will provide a straight line relationship:

$$\log(C) = \log(a) + b \times \log(P) \qquad \text{Equation 5}$$

where, C = Compressive strength (psi),
P = Pullout force (kN), and
a, b = Regression constants, and a is in psi.

Figure D.1 to Figure D.4 Appendix D contain the plots of compressive strength versus the pullout force for all the concrete mixtures. In each graph is also shown the data scatter for the pullout test results for each testing age. The strength-pullout force relationships are based on the average pullout force (from eight measurements) and the average compressive strength. The strength relationship constants are tabulated in Table 4.8 for each mixture

Table 4.8 Regression constants for strength relationship

	a(psi)	b	R^2(%)
Control	85.63	1.20	99.5
35% FA-A	60.73	1.30	99.5
50% FA-A	46.72	1.36	99.1
35% FA-C	84.21	1.22	98.4

From Figure D.1 to Figure D.4 it is observed that there is a good correlation between compressive strength and pullout force for individual mixtures. Further investigation was conducted to explore the possibility of having a single strength relationship for all mixtures. This new relationship, calibrated for all the mixtures tested in this study, is shown in Equation 6 and had an R^2 of 97.4%.

$$C = 67.14 \times P^{1.24} \qquad \text{Equation 6}$$

Equation 7 is the relationship recommended by the manufacturer of the pullout testing apparatus to obtain the compressive strength from a known pullout force. This relationship was also used to estimate the compressive strength and compare them with pullout-strength correlation developed in this project.

$$C = 100 \times P^{1.12} \qquad \text{Equation 7}$$

Where:

C= Compressive strength, psi
P= Pullout Force, kN

Figure 4.13 to Figure 4.16 shows the estimated versus measured strength plots for each concrete mixture. In each plot the compressive strength is estimated from the pullout load using the above three equations. It is clearly observed from the figures that manufacturer's recommended equation relationship does not provide a good estimate of the compressive strength. Correlation developed for each specific mixture provides a more accurate estimate of the measured compressive strength, and is subsequently used to estimate the strength of field-cured concrete element.

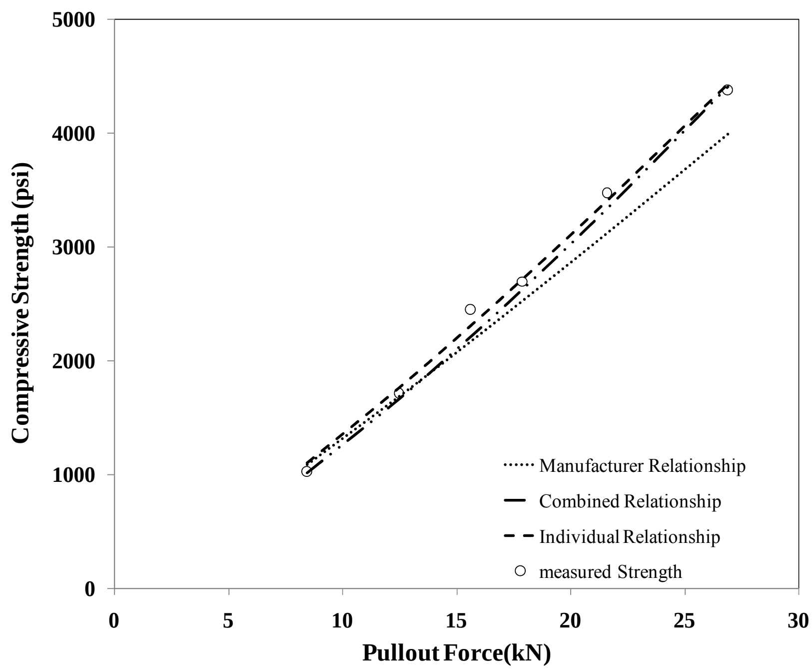


Figure 4.13 Compressive strength vs. pullout force relationship-control mixture

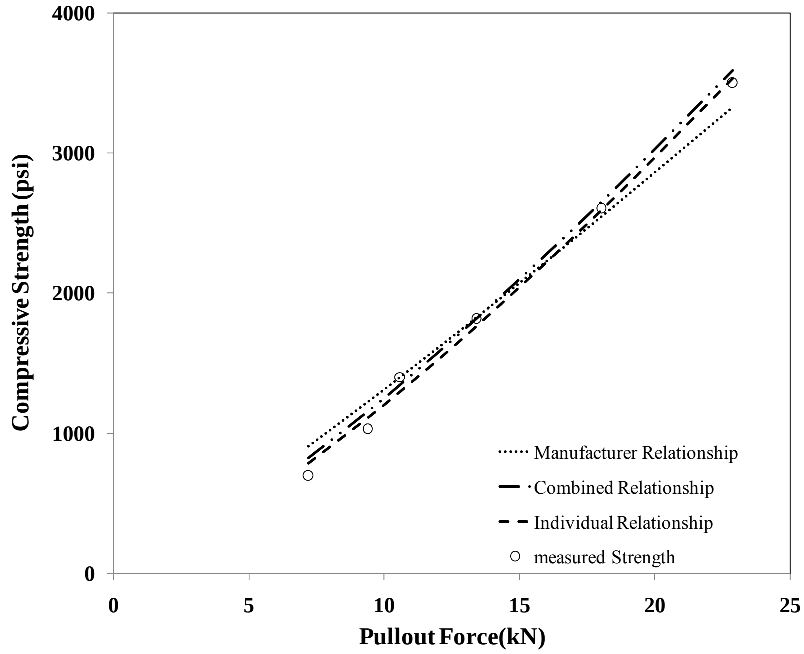


Figure 4.14 Compressive strength vs. pullout force relationship-35% FA-A mixture

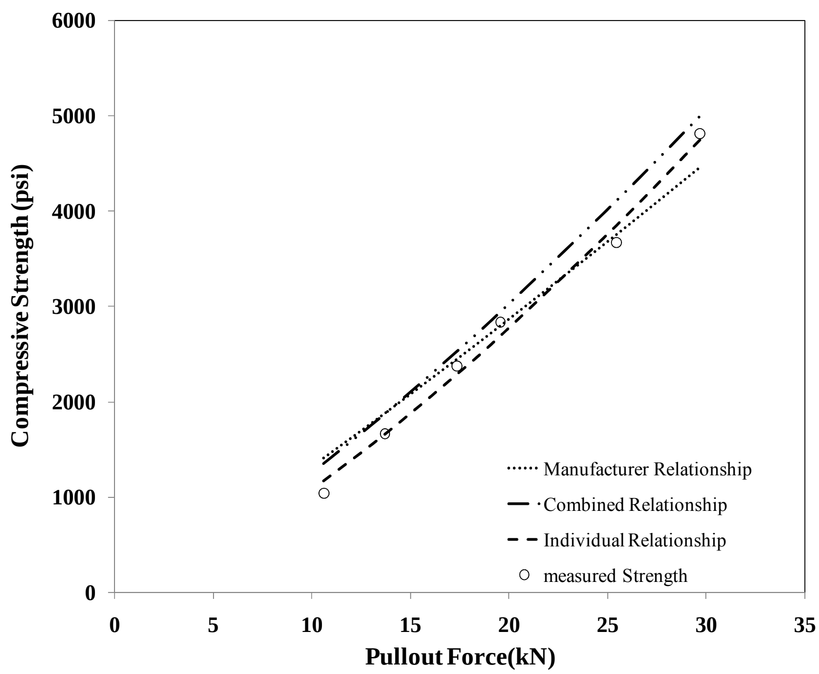


Figure 4.15 Compressive strength vs. pullout force relationship-50% FA-A mixture

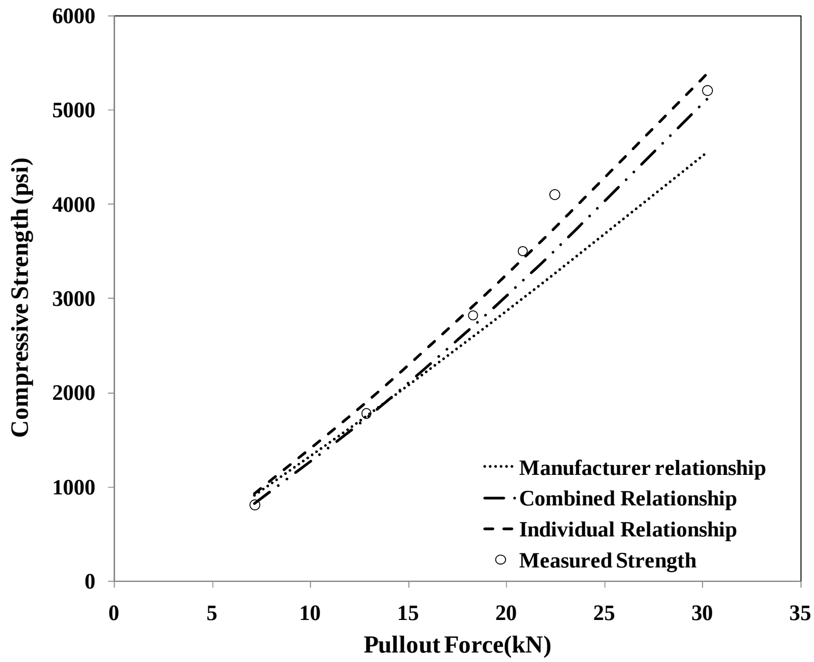


Figure 4.16 Compressive strength vs. pullout force relationship-35% FA-C mixture

<u>4.5.4 In-Place Strength Estimates Based on Field-Cured and Match-Cured Cylinder Strengths</u>

It is well known that concrete cured at higher temperature will gain early-age strength more rapidly than when it is cured at lower temperatures. Higher temperature means faster rate of chemical reaction and thus faster rate of strength gain. Figure E.2 to Figure E.11 in Appendix E show the temperature profile based on different curing conditions. As it can be observed from the temperature profiles the match-cured cylinders, which replicate the actual temperature profile of the structural element (block and slab) experience higher temperatures compared to the field-cured and standard-cured cylinders. Figure 4.17 to Figure 4.21 show the compressive strength plots for the various curing conditions of the four mixtures, including the data from the block and slab concrete elements. From the data collected from the comparative experiments it can be concluded that compressive strength measured using field or standard-cured cylinders do not accurately represent the conditions of the block and slabs and thus underestimate the in-place compressive strengths of the structural concrete elements.

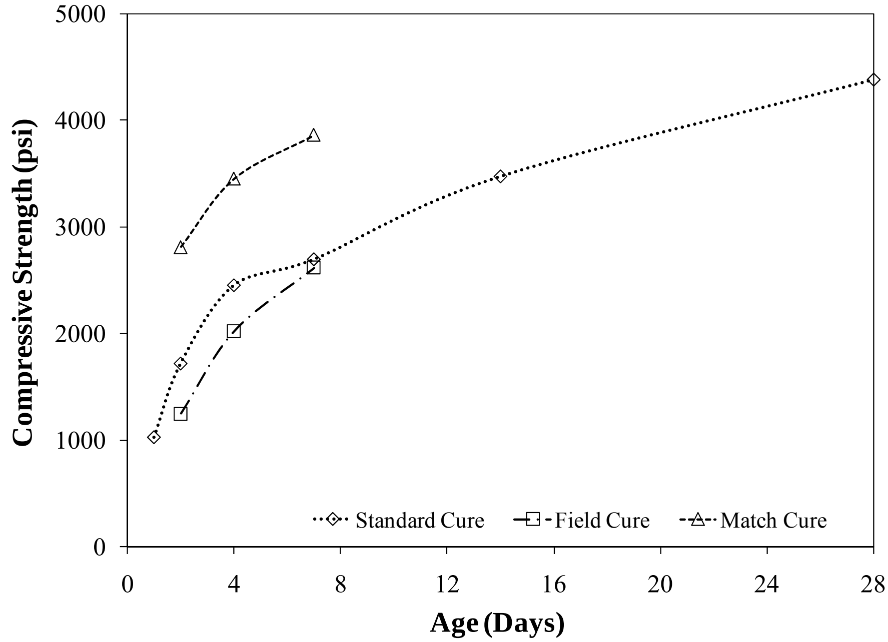


Figure 4.17 Compressive strength vs. age for different curing conditions (Control mixture-block)

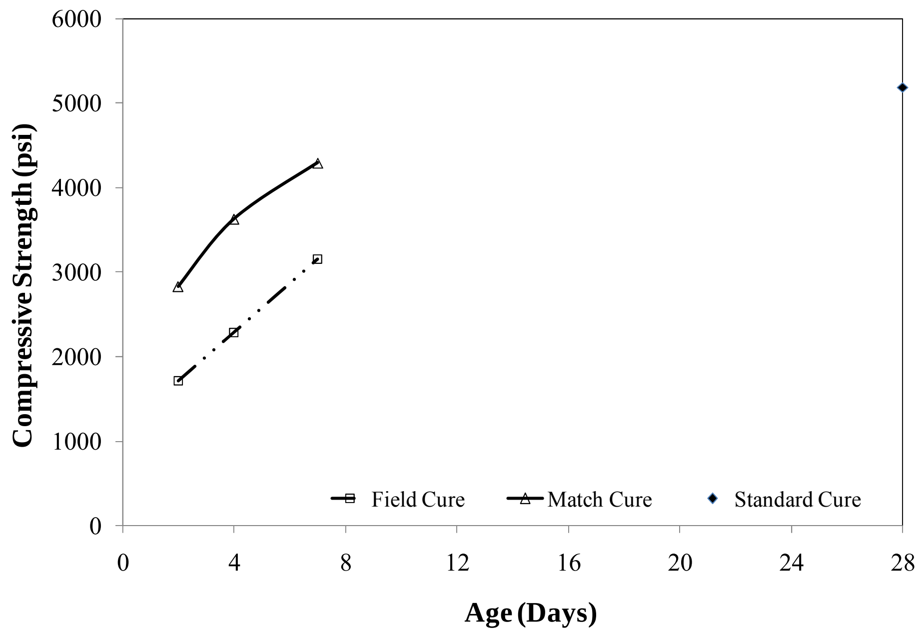


Figure 4.18 Compressive strength vs. age for different curing conditions (Control mixture-slab)

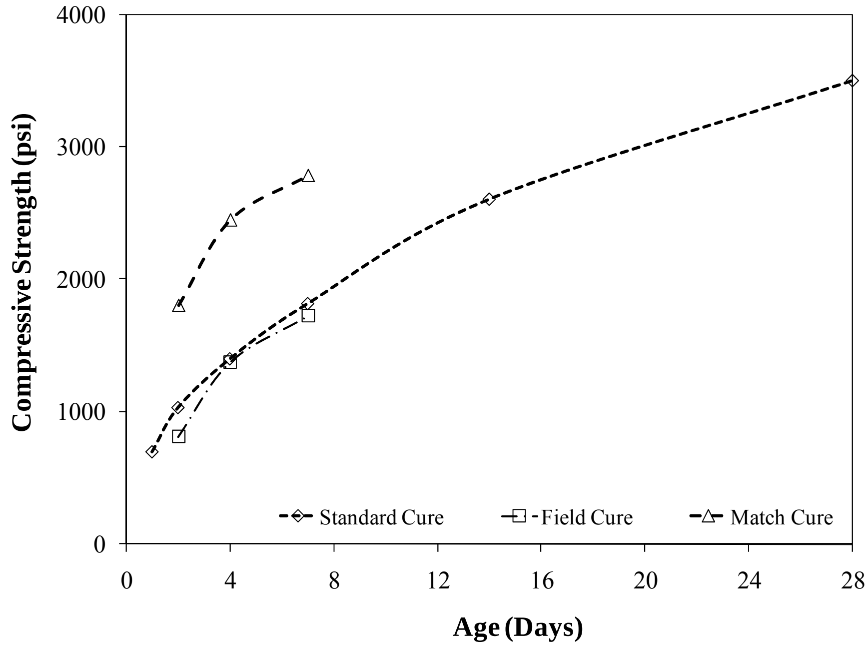


Figure 4.19 Compressive strength vs. age for different curing conditions (35% FA-A mixture-block)

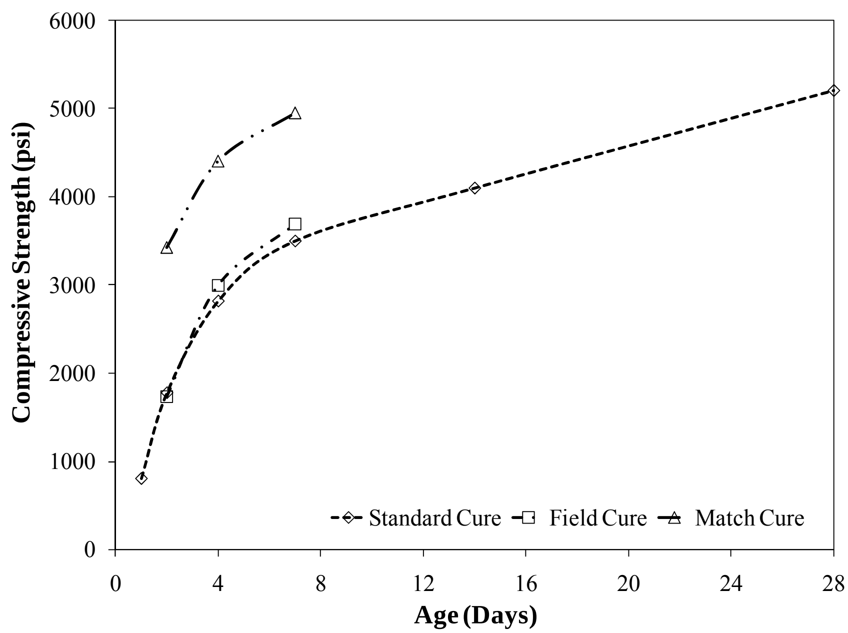


Figure 4.20 Compressive strength vs. age for different curing conditions (35% FA-C mixture-block)

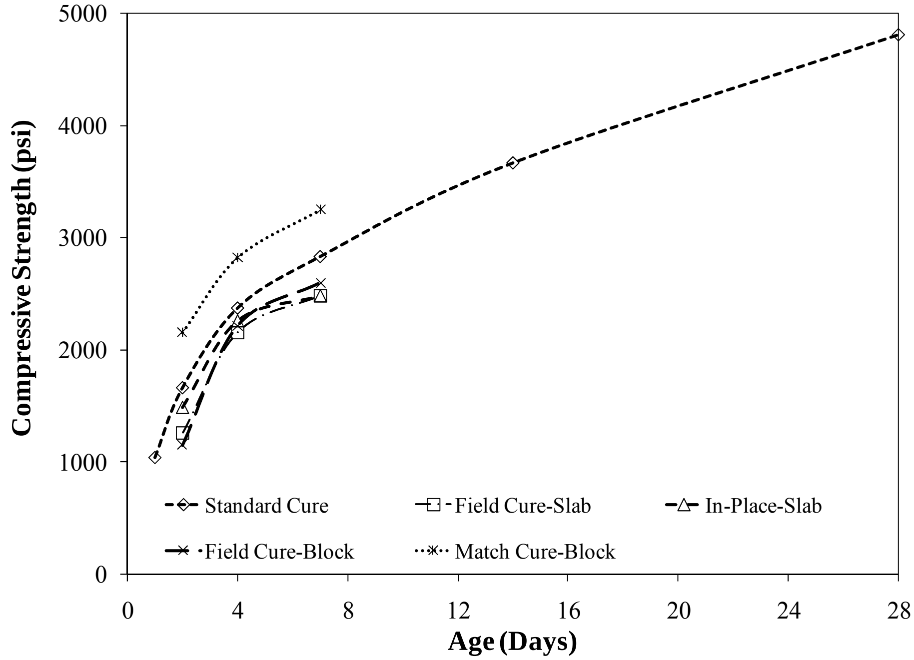


Figure 4.21 Compressive strength vs. age for different curing conditions (50% FA-A mixture-slab and block)

4.5.5 In-Place Strength Estimates Based on Pullout and Maturity

The maturity method and the pullout test were used to estimate the in-place strengths of the concrete in the field block specimens and the field slabs. These estimates were compared with the strengths of match-cured cylinders, which were assumed to represent the best estimates of actual in-place strength. The strengths of the field-cured cylinders were also included in this comparison.

In-place temperature histories (see Appendix E) were recorded using iButton temperature data loggers located 1 in. from the block surface (Sensor P4 in Figure A.3) and 2 in. from the slab surface (Sensor P4 in Figure A.4). These measured temperature histories were converted to equivalent age using Equation 2 and the computed activation energies for each specific mixture. After equivalent age was calculated, the predetermined strength-maturity relationships (Figure 4.9 to Figure 4.12) were used to estimate the in-place strength at the location of the iButton data loggers at test ages of 2, 4, and 7 days. The measured average pullout loads were converted to estimates of in-place compressive strengths using the pullout-strength correlations developed earlier for each mixture (see Figure 4.13 to Figure 4.16).

Table E.1 shows the equivalent ages at each test age and the estimated in-place strengths based on the maturity method and the pullout test. Table E.2 compares the strengths of the match-cured cylinders with the strengths of the field-cured cylinders and with the estimated strengths based on the maturity method and pullout test. The values in the parentheses are the percentage difference in strength compared with the corresponding strength of the match-cured cylinders. Figure 4.22 to Figure 4.25 show these strength comparisons for the four blocks and Figures 4.26 and 4.27 show the comparisons for the two slabs. Table E3 summarizes the average percent difference between the match-cured cylinders and in-place strength estimations by field-cured cylinders, maturity method, and pullout tests.

In general, the estimated strengths based on the pullout test and the maturity method were lower than the strengths of the match-cured cylinders by 15 to 20%. The field-cured cylinders, on the other hand, resulted in 20 to 50 % lower strengths in most cases. The lower strengths of the field-cured cylinders can be explained by their lower in-place temperatures compared with the temperatures recorded by the iButton data loggers. Estimated strengths from pullout tests and maturity were generally in good agreement. It was noted that even though the thermocouple used to drive the match-cured cylinders and the iButton data loggers used to calculate equivalent age for the maturity method were close to each other, the thermocouple temperatures were consistently higher. At each test age, the match-cured cylinders were, therefore, at a higher equivalent age than was used to estimate strength from the strength-maturity relationship. This may account for some of the consistently lower estimated strengths based on maturity. Other factors for the differences are proposed in the following discussion of the results for each mixture.

Control mixture—For the slab, the estimated strengths based on the maturity method were considerably lower (40 %) than the match-cured cylinder strengths. The slab was cast from a different batch than the block. The 28-day standard-cured cylinder strength for the slab concrete was 5180 psi compared with 4380 psi for the block concrete (see Table C.1). Thus the slab concrete was stronger than the block concrete. In estimating the in-place strength of the slab, the strength-maturity relationship for the block was used. This result reinforces the known limitation of the maturity method, which is that it is not able to account for batching errors. Another observation is that at the test age of 7 days, the equivalent age of the slab was only 4.5 days because of the low in-place temperature. For the block, at 7 days the equivalent age of the block was 8.5 days. This can explain why at 7 days, the estimated strengths of the block and slab based on the pullout test were similar even though the potential strength of the slab concrete was higher. At the test age of 7 days, the strength of the match-cured cylinders was 3860 psi which is greater than the 14-day strength of 3470 psi for the standard-cured cylinders (see Table 4.4). Thus the match-cured cylinders may have systematically greater strength than the standard cylinders after accounting for the effects of maturity. This premise requires additional investigation.

35 % FA-A mixture—At the test age of 7days, the equivalent age of the block was 7.1 days. The 7-day strength of the standard-cured cylinder was 1820 psi (see Table 4.4). The estimated strength for the maturity method (1925 psi) is consistent with this value, but the match-cured strength is significantly higher at 2790 psi. A possible explanation may be related to the maximum in-place temperature in the block, which was about 91 ºF. The mortar tests discussed in Chapter 3 showed that when mortar cubes were cured at 100 ºF, the estimated long-term strength was greater than for room-temperature curing. This apparent strength enhancement due to higher early age temperature in the fly ash mixtures may explain why the match-cured cylinders were stronger than estimated from the strength maturity relationship. But this does not explain why the estimated strength based on the pullout test was lower (1800 psi at 7 days). A possible effect may be related to the thermal strains introduced in the surface layer after formwork was removed at 3 days. More study is needed to confirm this suggestion.

50 % FA-A mixture—At test ages of 2, 4, and 7 days, the computed equivalent ages of the block specimens were 2.4, 4.6 and 6.6 days, while for the slab the corresponding values were 1.6, 3.2, and 5.1 days. Thus the slab temperatures were lower than standard temperature. For the block, the match-cured cylinder strengths were considerably greater than the estimated strengths based on the maturity method. This may again be attributed to the strength-enhancing effect of the higher early-age temperature in the block, which reached 91 ºF. At the 7-day test age, the match-cured cylinder strength was 3250 psi. On the other hand, the 7-day standard-cured strength was 2830 psi (see Table 4.4). For the slab, because the in-place temperatures were not above the standard temperature, the strength-enhancement due to high temperature was absent. As a result there was reasonable agreement between the match-cured cylinder strengths and the estimated strength based on maturity (see Table E.2). The estimated strengths based on the pullout test were in good agreement with the strengths of the match-cured cylinders at the 2-day test age. At 4 and 7 days, the estimated strengths from pullout were considerably less than the match-cured cylinders. Again, this could be related to thermal strains that reduce the pullout resistance in the surface layer, but this premise needs to be studied further.

35 % FA-C mixture—The in-place temperature used to calculate equivalent age of the block reached a maximum value of 111 ºF. At test ages of 2, 4, and 7 days, the equivalent ages for the block were 3.7, 6.4, and 9.6 days. The standard-cured cylinder strength at 7 days was 3500 psi, while the match-cured cylinder strength at an equivalent age of 6.4 days was 4400 psi. Thus the enhancing effect of high temperature on long-term strength appears to be present, and this would explain why the estimated strengths based on maturity are consistently lower than the match-cured cylinder strengths. At the 2-day test age, the estimated strength from the pullout test is close to the match-cured cylinder strength. At 4 and 7-day test ages, however, the estimated strengths from the pullout test are considerably lower than the match-cured cylinders. This is consistent with the behavior in all the other cases.

Summary—Figures 4.22 to Figure 4.27 compare the various estimates of in-place strength as a function of the equivalent age at the time of testing based on the iButton data and the activation energies of the various mixtures. In general, the field-cured cylinders resulted in the lowest strengths because of their lower in-place temperatures. The match-cured cylinder strengths were assumed to be the best estimates of in-place strength, but these strengths were consistently higher than the estimates based on the maturity method or the pullout test. Two factors have been suggested for this behavior:

- There may be a systematic effect related to the nature of the match-cured specimens (degree of consolidation and drying effect) that results in a higher apparent strength.
- The higher in-place temperature of the match-cured cylinders may have introduced the strength enhancing effect that was observed in the mortar specimens cured at elevated temperatures.

Both of these proposed factors require additional study. Finally, the lower estimated strengths based on the pullout test may be related to tensile strains introduced into the surface concrete due to thermal gradients and moisture gradients. This suggestion also requires additional study.

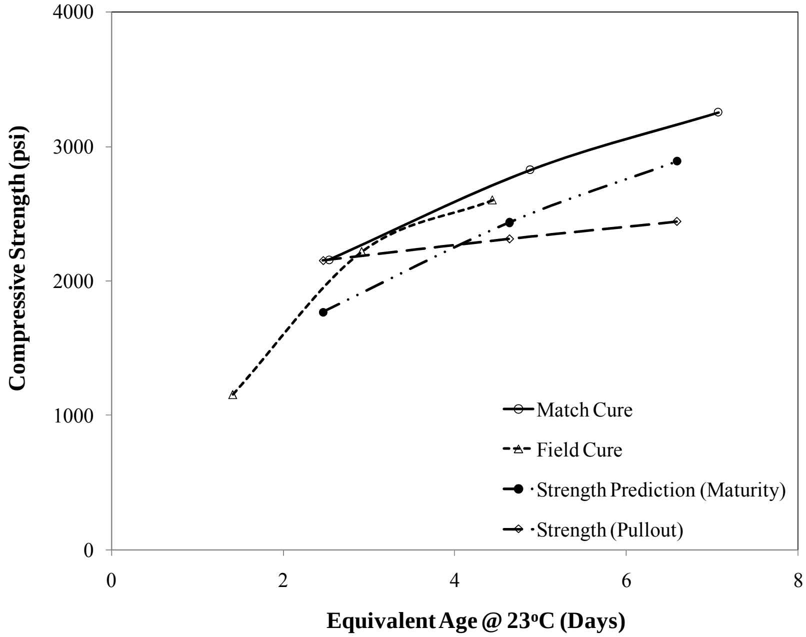


Figure 4.22 Comparison of strength obtained from various methods vs. equivalent age (Control-mixture block)

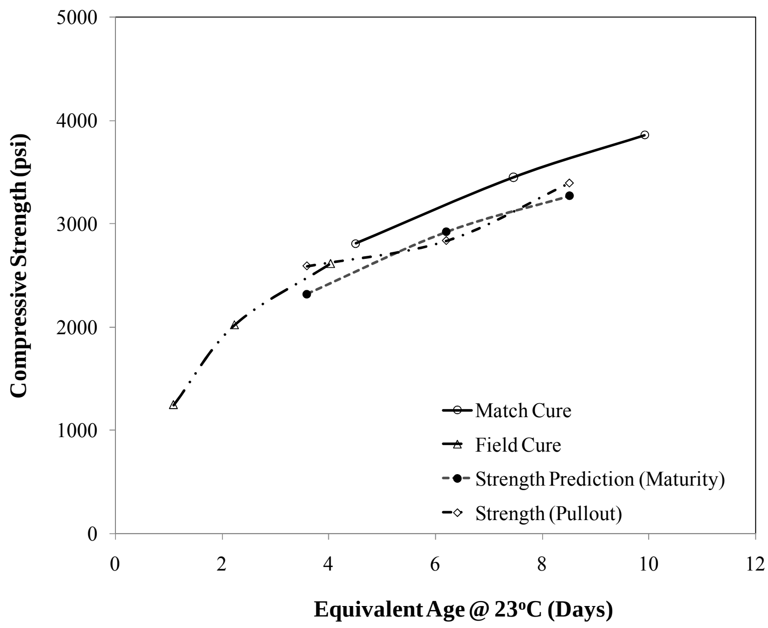


Figure 4.23 Comparison of strength obtained from various methods vs. equivalent age (50% FA-A-block)

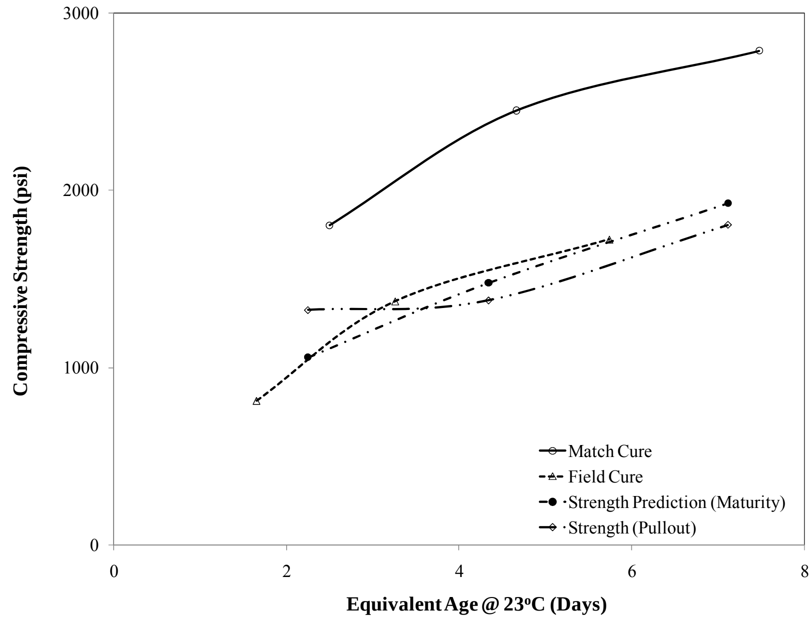


Figure 4.24 Comparison of strength obtained from various methods vs. equivalent age (35% FA-A block)

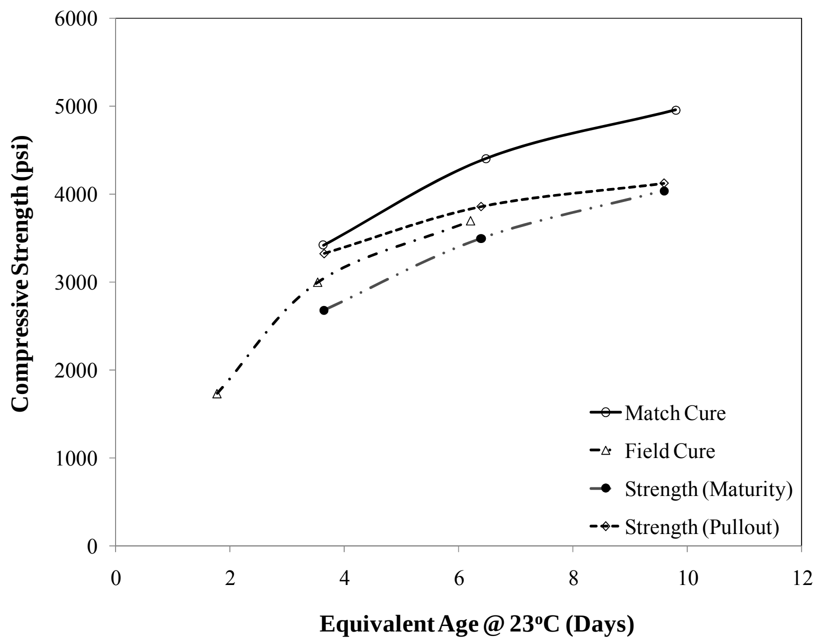


Figure 4.25 Comparison of strength obtained from various methods vs. equivalent age (35% FA-C block)

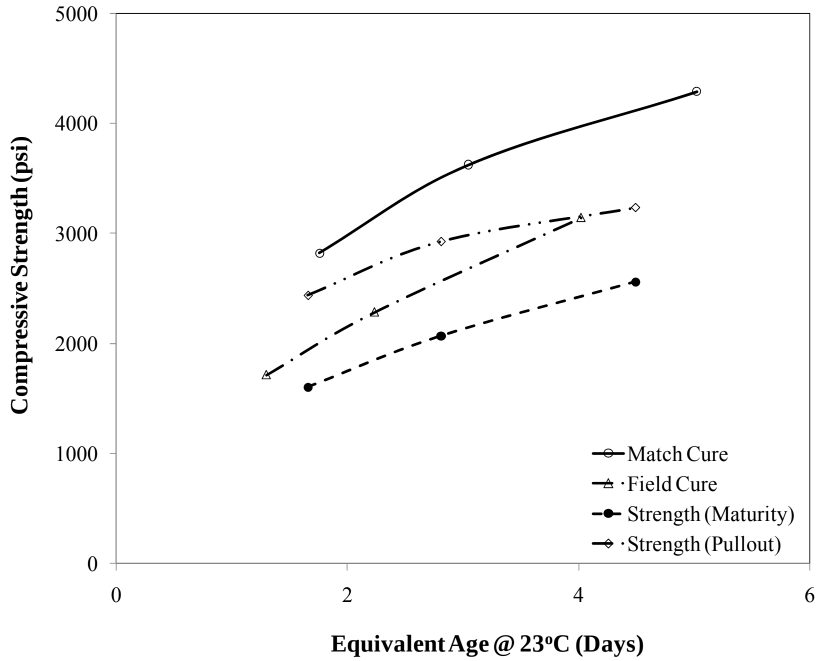


Figure 4.26 Comparison of strength obtained from various methods vs. equivalent age (Control mixture-slab)

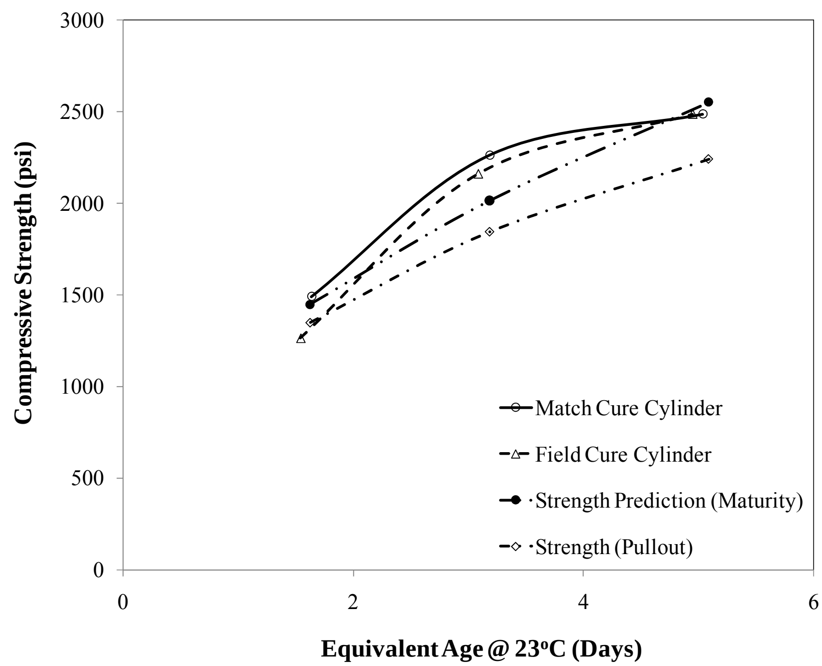


Figure 4.27 Comparison of strength obtained from various methods vs. equivalent age (50% FA-A-slab)

CHAPTER 5 – SEMI-ADIABATIC CALORIMETRY TESTING

The curing temperature of the concrete is arguably the variable that has the most significant effect on the rate of hydration. In this section, the maturity method is used to account for the effect of temperature and time on the rate of hydration. The equivalent age maturity function shown in Equation 8, as developed by Freiesleben and Pedersen (1977), is widely accepted as the most accurate maturity formulation.

$$t_e(T_r) = \sum_0^t \exp\left(\frac{E}{R}\left(\frac{1}{273+T_r} - \frac{1}{273+T_c}\right)\right)\cdot\Delta t$$ **Equation 6**

where, $t_e(T_r)$ = equivalent age at the reference curing temperature (hours),
Δt = chronological time interval (hours),
T_c = average concrete temperature during the time interval, Δt, (°C),
T_r = constant reference temperature (°C),
E = activation energy (J/mol), and
R = universal gas constant (8.3144 J/mol/K).

The hydration reaction of Portland cement is an exothermic process, and the total amount of heat generated may affect the in-place performance of some structures. The total heat released during hydration is a function of the composition of cementitious materials, amount of cementitious materials, and the water-cementitious material ratio of the mixture. In the remainder of this section, models to quantify the total heat of hydration, degree of hydration, temperature sensitivity, and the temperature associated with the hydration of concrete are presented.

5.1 Quantifying the Total Heat of Hydration of the Cementitious Materials

The total heat of hydration (at 100% hydration) can be estimated directly from the cement chemistry (Bogue 1947). Each of the cement constituents have been found to have a unique heat of hydration and the total heat of hydration of the cement at complete hydration (H_{cem}) can be quantified as shown in Equation 9.

Equation 7

$$H_{cem} = 500\,p_{C_3S} + 260\,p_{C_2S} + 866\,p_{C_3A} + 420\,p_{C_4AF} + 624\,p_{SO_3} + 1186\,p_{FreeCaO} + 850\,p_{MgO}$$

where, H_{cem} = total heat of hydration of the cement (J/g), and
p_i = weight ratio of i-th compound in terms of the total cement content.

The calcium oxide (CaO) of the fly ash has been used as an indicator of its cementitious characteristics and the amount of heat that it may contribute during hydration with Portland cement (Schindler and Folliard 2005). With knowledge of the total cementitious materials content (C_c), and the heat of hydration (H_u) per unit weight of all the cementitious materials, the ultimate heat of hydration (H_T) for combinations of cement and fly ash at 100% hydration can be modeled as shown in Equations 10 and 11.

$$H_T = H_u \cdot C_c \qquad \textbf{Equation 8}$$

where, H_T = total ultimate heat of hydration of the concrete (J/m^3),
C_c = cementitious materials content (g/m^3), and
H_u = total heat of hydration of cementitious materials at 100% hydration (J/g), defined as follows:

$$H_u = H_{cem} \cdot p_{cem} + 1800 \cdot p_{FACaO} \cdot p_{FA} \qquad \textbf{Equation 9}$$

where, p_{cem} = cement weight ratio in terms of total cementitious content,
p_{FA} = fly ash weight ratio in terms of total cementitious content, and
p_{FACaO} = fly ash CaO weight ratio in terms of the total fly ash content.

5.2 Quantifying the Degree of Hydration Development

The degree of hydration (α) is a measure of the extent of the hydration reactions between the cementitious materials and the water, and is defined as the ratio between the quantity of hydrated cementitious material and that total hydrated amount on complete hydration of the original cementitious material. The degree of hydration is a function of time, with α varying between 0%, at the start of hydration, and 100% when hydration is fully completed. In reality, not all of the cementitious material always hydrates, and a degree of hydration of 100% may never be reached (Mills 1966). The degree of hydration versus equivalent age relationship is used to characterize the hydration behavior of a specific concrete mixture at the reference temperature (T_r).

In this study, the indirect method of estimating the degree of hydration based on the heat development that occurs during hydration is used. It has been shown that the heat released divided by the total heat available provides a good measure of the degree of hydration (Van Breugel 1997), and this is mathematically express as follows:

$$\alpha(t) = \frac{H(t)}{H_T} \qquad \textbf{Equation 10}$$

where, $\alpha(t)$ = degree of hydration at time, t, and
$H(t)$ = cumulative heat of hydration released at time, t, (J/m^3).

Once test data of the degree of hydration development have experimentally been determined, the data can be represented by a best-fit mathematical model. The exponential formulation shown in Eq. 13 has been shown to accurately represent the s-shape of the hydration development (Schindler and Folliard 2005)

$$\alpha(t_e) = \alpha_u \cdot \exp\left(-\left[\frac{\tau}{t_e}\right]^{\beta}\right) \qquad \textbf{Equation 11}$$

where, $\alpha(t_e)$ = the degree of hydration at equivalent age, t_e,
τ = hydration time parameter (hours),
β = hydration shape parameter, and

α_u = ultimate degree of hydration.

5.3 Temperature Sensitivity of Cementitious Materials

In the equivalent age maturity method, the activation energy defines the temperature sensitivity of a concrete mixture. By using the equivalent age maturity approach, the rate of hydration at any specific temperature can be determined from a known rate of hydration at the reference temperature. It has been shown that the activation energy (*E*) for strength and hydration prediction purposes may be very different. Schindler (2004) evaluated the temperature sensitivity of the hydration process over a temperature range of 4.4°C to 40.6°C and developed the activation energy model shown in Equation 14.

.

$$E = 22{,}100 \cdot p_{C_3A}{}^{0.30} \cdot p_{C_4AF}{}^{0.25} \cdot Blaine^{0.35} \cdot \left(1 - 1.05 \cdot p_{FA} \cdot \left(1 - \frac{p_{FACaO}}{0.40}\right)\right) \quad \textbf{Equation 12}$$

where, p_{C3A} = weight ratio of C_3A in terms of the total cement content,
p_{C4AF} = weight ratio of C_4AF in terms of the total cement content, and
Blaine = Blaine value, specific surface area of cement (m^2/kg).

5.4 Modeling the Heat Generation and Temperature Associated with Hydration

The temperature development in a concrete specimen curing under adiabatic conditions (where there is no heat transfer to the environment) can be determined with Eq. 15 (Jonasson et al. 1995).

$$\frac{dT}{dt} = \frac{Q_H}{\rho \cdot c_p} = \frac{dH}{dt}\left(\frac{1}{\rho \cdot c_p}\right) \quad \textbf{Equation 13}$$

where, T = temperature of the concrete (°C),
ρ = concrete density (kg/m^3),
c_p = concrete specific heat capacity (J/kg/°C),
Q_H = rate of heat generation (W/m^3), and
H = heat of hydration of the concrete (J/m^3), equal to $H_T \cdot C_c \cdot \alpha$.

The rate of heat generation heat, Q_H, is dependent on the degree of hydration. The degree of hydration is a function of the time and temperature history, which can be characterized by the equivalent age maturity function. With this approach, the adiabatic temperature rise of the concrete specimen can be evaluated at discrete times after batching. By using the equivalent age maturity method and the exponential formulation to quantify the degree of hydration (Equation 13), the rate of heat generation, at time *t*, can be determined as shown in Equation 16 (Schindler and Folliard 2005).

$$Q_H(t) = H_u \cdot C_c \cdot \left(\frac{\tau}{t_e}\right)^{\beta} \cdot \left(\frac{\beta}{t_e}\right) \cdot \alpha(t_e) \cdot \exp\left(\frac{E}{R}\left(\frac{1}{273+T_r} - \frac{1}{273+T_c}\right)\right) \quad \textbf{Equation 14}$$

5.5 Experimental Work

Semi-adiabatic calorimetry was used in this study to quantify the hydration development of various cementitious systems. There is currently no standardized ASTM test method for semi-adiabatic calorimetry; however, the test was performed based on the draft test procedure of RILEM TCE-119 (1998). Tests were performed on six mixture proportions—as listed inTable 5.1, and each test was performed over approximately a six-day period. These six mixture proportions match those used during the field work performed during this project. A standard cement source was chosen, and the type and dosage level of the SCMs used with the cement were changed. The following three fly ashes were used: 1) low-lime Class F fly ash, 2) intermediate-lime Class F fly ash, and 3) Class C fly ash. These three fly ashes are identified by the letter A, B, and C, respectively, in Table 5.1.

Table 5.1 Mixture proportions used for semi-adiabatic testing

Item	Mixture ID					
	Control	**20%FA-A**	**35%FA**	**50%FA-A**	**35%FA-B**	**35%FA-C**
Cement, lbs/yd^3	510	424	331	308	371	363
Fly Ash, lbs/yd^3	0	106	196	298	200	198
Water, lbs/yd^3	286	270	265	237	242	238
Coarse Agg. SSD, lbs/yd^3	1,946	1,950	1,962	1,973	1,950	1,946
Fine Agg. SSD, lbs/yd^3	1,319	1,302	1,273	1,232	1,335	1,369
Target Total Air Content, %	3	3	3	3	3	3
HRWR Admixture, oz/yd^3	10.7	15.9	35.3	43.0	28.5	28.6
w / cm	0.56	0.51	0.51	0.39	0.43	0.43
Fly ash ID	-	FA-A	FA-A	FA-A	FA-B	FA-C
Fly ash CaO Content (%)	-	1.2	1.2	1.2	13.3	23.4

The batch size was 1.5 ft^3 and the concrete was made under laboratory conditions. The following tests were performed on each batch to ensure that the concrete was acceptable: slump, fresh concrete temperature, total air content, fresh concrete unit weight, and the 28-day compressive strength. Three, moist-cured, cylinders were tested at 28 days to verify the concrete's strength potential.

With semi-adiabatic calorimetry, a small amount of heat loss is allowed to occur over time. Therefore, the temperature development is not as high as it would be under fully adiabatic conditions. Due to the elevated temperatures reached during hydration, most of the hydration is completed in a short period of time (7 days). A disadvantage of the semi-adiabatic test method is that the true adiabatic heat development has to be calculated from the test results, and losses associated with the test have to be accounted for. Once the test data are collected, the degree of hydration can be computed based on heat transfer principles and with the heat of hydration model previously document in Equations 10, 12, 13, and 15. The result can thus be affected by inaccurate assumptions of activation energy (temperature sensitivity) and material properties such as thermal conductivity, specific heat, and density. These results will show the effect of all the mixture proportions on the rate of hydration, total heat of hydration, setting, and to some extent the degree of hydration.

These results will be useful to show how the addition of various amounts and types of fly ashes alter the hydration process of these mixtures.

5.6 Test Data and Discussion of Results

The concrete quality control tests that were performed on each batch are summarized in Table 5.2. Note that all fresh properties were acceptable and similar for the six batches. It can also be seen from Table 5.2 that the 28-day strength of Mixture 35% FA-B was more than 1,200 psi lower than that of Mixtures 35% FA-A and 35% FA-C. It is unusual that the strength of Mixture 35% FA-B is lower than that of Mixture 35% FA-A, simply since mixture 35% FA-B had a lower w/cm that Mixture 35% FA-A.

Table 5.2 Quality control data collected for batches produced for semi-adiabatic testing

Parameter	Mixture ID					
	Control	20%FA-A	35%FA-A	50%FA-A	35%FA-B	35%FA-C
Slump (in.)	7.5	7.5	6	8	6.5	6
Concrete Temp. (°F)	74	74	72	73	71	74
Total Air Content (%)	2.25	2.5	2	2	2	2
Unit Weight (lb/ft^3)	150.4	152.5	154.6	154.5	155.2	154.8
28-day Comp. Strength (psi)	5,190	5,370	6,260	6,070	4,970	6,550

Table 5.3 provides a summary of the best-fit hydration parameters that were obtained from the semi-adiabatic test data. The activation energy values listed in Table 5.3 were determined with the activation energy model shown in Equation 15. A reference temperature of 22.8°C (73°F) was used during the back-calculation of the hydration parameters. The hydration parameters are of the expected order of magnitude, except for the ultimate degree of hydration for Mixture 35% FA-B; this is also the mixture that exhibited a lower than expected 28-day compressive strength. The ultimate degree of hydration for a mixture made with these materials and proportions should be in the range of 0.75 to 0.90. The increase in the hydration time parameter, τ, for Mixture 35% FA-C relative to any of the other mixtures indicates that a retardation of the hydration reaction has occurred. This retardation would correspond to an increase in initial and final setting times, which is typical for Class C fly ash mixtures. The hydration parameters listed in Figure 5.3 can be used to model the in-place temperature development with a heat transfer model that is appropriate for the specific member size and boundary conditions.

Table 5.3 Best-fit hydration parameters obtained from semi-adiabatic testing (T_r = 22.8°C)

Parameter	Mixture ID					
	Control	20%FA-A	35%FA-A	50%FA-A	35%FA-B	35%FA-C
E-value for Hydration (kJ/mol)	46.1	36.4	28.1	22.3	29.2	29.1
Total Heat of Hydration (J/kg)	488	394	314	258	401	464
Slope Parameter, β	0.785	1.024	1.000	1.100	0.990	0.899
Time Parameter, τ (hours)	17.8	13.3	13.7	13.4	13.0	24.6
Ultimate DOH, α_u	0.913	0.854	0.770	0.837	0.579	0.855

The semi-adiabatic calorimetry test results are summarized in Figure 5.1 to Figure 5.4. Figure 5.1 and Figure 5.2 can be used to evaluate the effect that changes in fly ash A proportions and w/cm will have on the hydration behavior. The proportions of these mixtures do not allow one to only evaluate the effect of an increase in the dosage of fly ash A. This is because an increase in *w/cm* was required to achieve realistic rates and levels of compressive strength gain. It may be seen in Figure 5.1 that there is a significant reduction in cumulative heat of hydration as the replacement level of fly ash A is increased. This trend is true even though in general the w/cm was decrease as the replacement level of fly ash A was increased. It is also significant to note that the mixtures made with fly ash A all have 28-day strengths that exceed that of the control mixture, yet they generate much less heat and this would be advantageous in mass concrete applications. It can be seen from Figure 5.1 that the cumulative heat of hydration development of Mixture 35% FA-A and 50% FA-A are very similar. These mixtures also had similar strength levels. The rate of hydration for Mixture 35% FA-A and 50% FA-A are very similar, as shown in Figure 5.2. This would be an indication that the decrease in w/cm to change from a 35% to a 50% replacement level produced mixtures with very similar hydration kinetics.

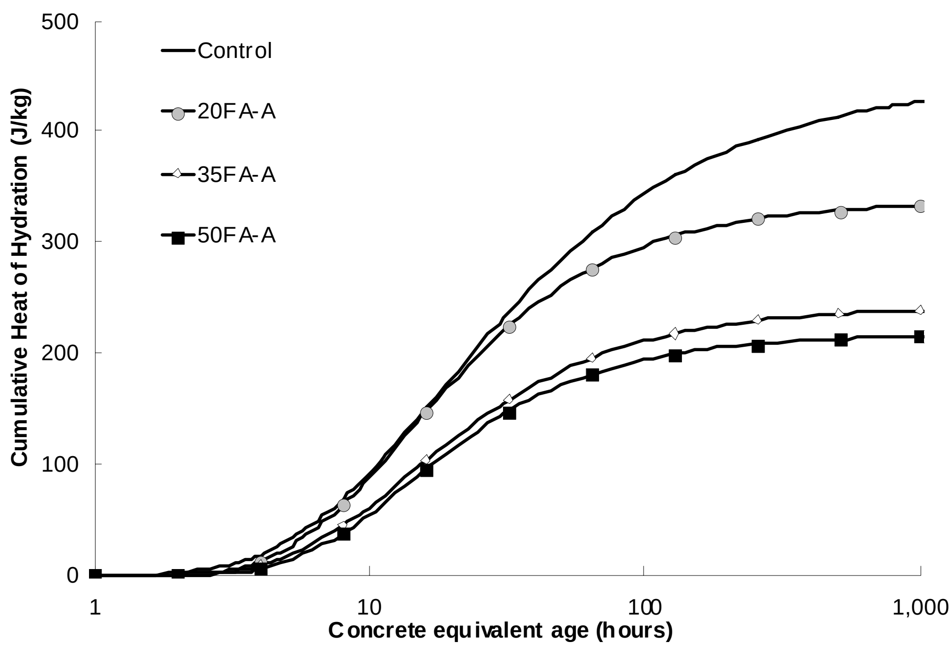


Figure 5.1 Effect of change in fly ash A proportions and w/cm on cumulative heat of hydration development

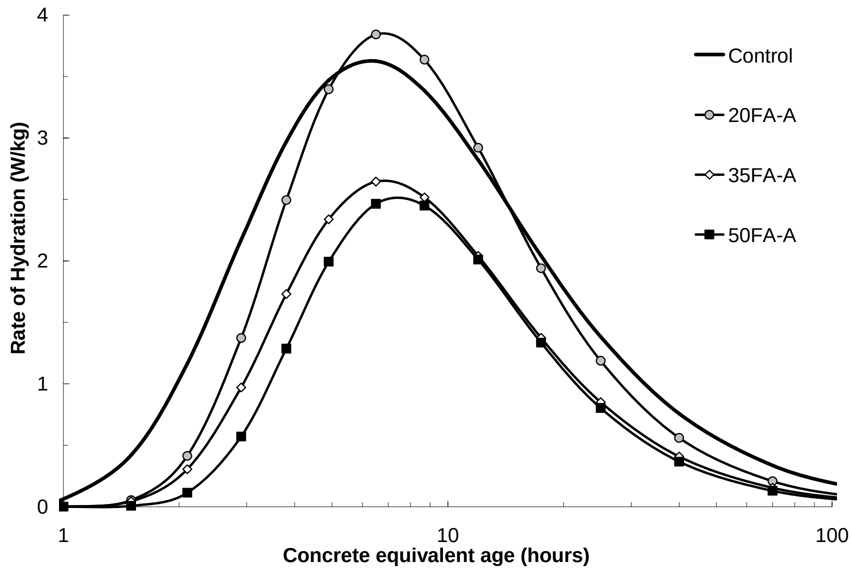


Figure 5.2 Effect of change in fly ash A proportions and w/cm on rate of hydration

Figure 5.3 and Figure 5.4 can be used to evaluate the effect that a change in fly ash type and w/cm will have on the hydration behavior. A comparison of the cumulative heat of hydration of the Control mixture and Mixture 35% FA-C as shown in Figure 5.3 reveals that the Class C fly ash retarded setting of the mixture and it only slightly reduced the cumulative heat of hydration. The retardation effect when the Class C fly ash (35%FA-C) is used can clearly be seen on the rate of hydration graph shown in Figure 5.4. Fly ash A and B did not retard setting much and both significantly reduce the cumulative heat of hydration. The cumulative heat of hydration of Mixture 35%FA-B appears to be lower than expected; and this issue was mentioned when the hydration parameters were discussed. The data shown in Figure 5.3 and Figure 5.4 show that the total heat of hydration of the cementitious system is significantly reduced with the use of a replacement of 35% Class F. The data in Figure 5.3 indicates that Class F fly ash has little contribution to the early-age heat development.

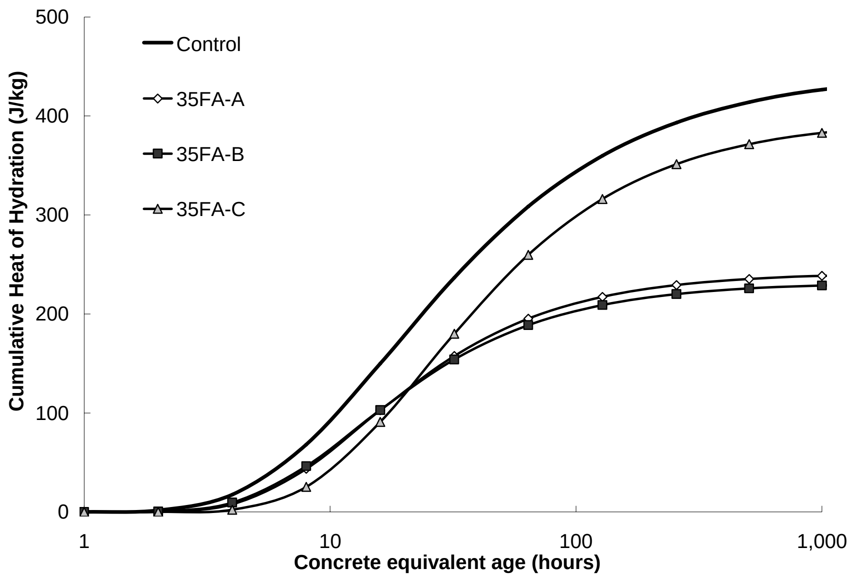


Figure 5.3 Effect of change in fly ash type and w/cm on cumulative heat of hydration development

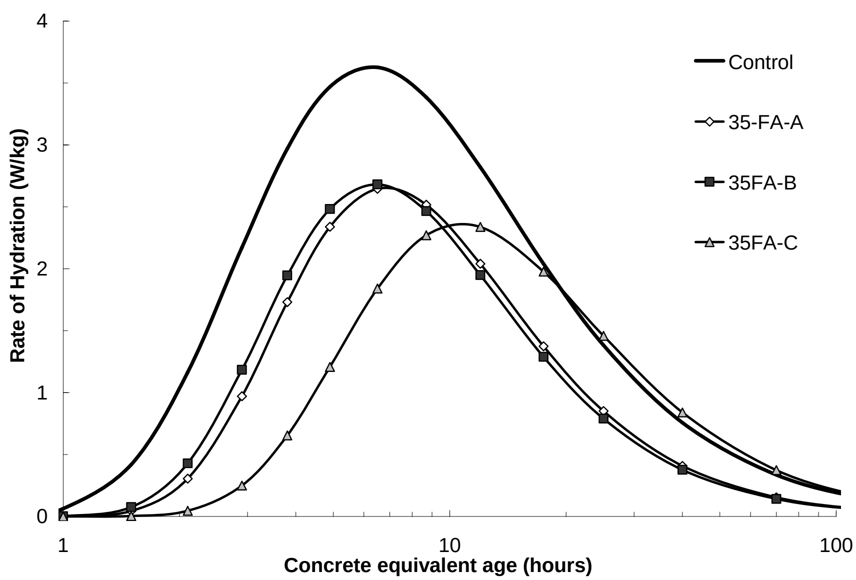


Figure 5.4 Effect of change in fly ash type and w/cm on rate of hydration

CHAPTER 6 – CONCLUSIONS

The following are conclusions from this study:

1) As would be expected, compressive strengths obtained from field-cured and standard-cured cylinders do not provide accurate estimates of in-place strengths for concrete structures. This study investigated the applicability of using match-cured cylinders, the maturity method, and the pullout test to obtain more accurate estimates of the in-place concrete strength in structural members made with high-volume fly ash (HVFA) concretes.

2) The match-cured cylinder strength data demonstrated clearly that HVFA concretes in actual structures have much higher early-age strengths than obtained from testing standard-cured cylinders. This means that HVFA concrete mixture proportions may be further optimized (use of lower total cementitious material contents, increase the quantity of fly ash, and increase the *w/cm*) without negative effects on construction operations that require attainment of specified in-place strength at early ages.

3) Pullout test results have excellent correlations with compressive strength of cylinders for the HVFA concrete mixtures considered. While it is recommended that the correlation be developed for each specific concrete mixture, the results of this study show that the correlation is not affected greatly by the amount of fly ash and the *w/cm*.

4) Estimated strengths based on maturity method and the pullout test method were 15 to 20% lower compared with match-cured cylinder strengths at early ages of 2 to 7 days. However, these were more accurate than field-cured cylinder strengths, which were about 20 to 50% lower. The higher strengths of the match-cured cylinders may be related to a systematic effect due to the nature of the specimens compared with standard molded cylinders. For the HVFA mixtures, the added effect discussed in the next conclusion may have increased the apparent long-term strength for match curing.

5) Mortar cubes of HVFA mixtures have shown increased long-term strengths when cured at higher temperatures compared with cubes cured at the standard temperature. Further investigation is needed to better understand this unusual behavior and improve the strength estimation by the maturity method.

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APPENDIX A

Appendix A summarizes the details of the testing plan adopted for this project.

The HVFA concrete mixtures included in this study are shown inTable A.1.

Table A.1 Mixture proportions

Item	Control	20%FA-A	35%FA-A	50%FA-A	35%FA-B	35%FA-C
Type I cement (pcy)	500	424	371	300	371	371
Fly ash (pcy)	0	106	200	300	200	200
Total Cementitious	500	530	571	600	571	571
Fly ash (%)	0%	20%	35%	50%	35%	35%
Water (pcy)	290	270	242	216	242	242
w/cm	0.58	0.51	0.42	0.36	0.42	0.42
w/c	0.58	0.64	0.65	0.72	0.65	0.65
Type A WR(oz/cy)	4 oz	4 oz	4 oz	4 oz	4 oz	4 oz
Type F HRWR (oz/cy)	0	0	Adjust	Adjust	Adjust	Adjust
Lab-Concrete	X		X	X		X
Field-Block	X		X	X		X
Field-Slab	X			X		
Lab-Mortar	X	X	X	X	X	X

The target slump will be 4 to 6 in.

Task 2. Activation Energy (ASTM C1074).
Objectives:

- Establish the activation energy of the different cementitious systems.
- Examine whether there is a relationship between the activation energy and the amount of fly ash.

a. Mixtures:

Six (6) mortar mixtures will be used for this study

i. Portland cement only
ii. Class F fly ash at 3 levels (20, 35, 50 % of total cementitious material)
iii. Intermediate (10%) and high (25%) lime Class C fly ash at 35% only

b. Fly ash concrete mixtures are proportioned so that early strength at 3 and 7 days will be comparable to that of the Portland cement control mixture. The target strength value for the control mixture will be between 4000-5000 psi. The mortar mixtures will be proportioned so that the ratios of FA/C are the same as the ratios of CA/C in the corresponding concretes, as recommended in Annex A1 of ASTM C1074.

c. Mortars will be mixed and cured at 4 temperatures (7.2°C (45°F), 21°C (70°F), 37.8°C (100°F), and 48.9°C (120 °F)). The mortar cubes will be cured in lime-saturated water baths.

d. Mortar cubes will be tested for compressive strength at 6 different ages. These ages are equivalent ages based on curing at 23°C (73°F), the ages are 1, 2, 4, 7, 14, and 28 days.

Table A.2 Initial activation energy

Mixture Proportion	Initial activation energy
Control: Portland Cement Only	40,000 J/mol
20% Class F Ash	38,000 J/mol
35% Class F Ash	32,000 J/mol
50% Class F Ash	28,000 J/mol
35% Class C Ash (Cao=10%)	34,000 J/mol
35% Class C Ash (Cao=25%)	36,000 J/mol

e. Total of sixteen (24) 2-in. cubes will be made per batch

i. 3 cubes for each age (3 × 6 =18)
ii. 2 cubes with one iButtons sensor each will be prepared to record mortar temperature.
iii. 4 extra cubes

f. Cube temperature will be recorded with an iButton sensor at 60-min interval.

g. Cubes will be tested for compressive strength at each age in accordance with ASTM C109.

h. Strength-age relationship will be determined by regression analysis.

i. Determine k values by fitting the following equation to the strength-age data for each curing temperature.

$$S(t) = S_u \frac{k(T) \times (t - t_o)}{1 + k(t - t_o)} \quad \mathbf{15}$$

S(t) = Compressive strength at age *t*
k(T) = Initial slope of strength-age curve divided by S_u (the rate constant for initial strength development)
t_o = Age when strength development is assumed to begin

S_u = Limiting strength

j. Regression analysis will be used to calculate best-fit values for S_u, t_o, and k.

k. Plot the natural logarithm of the *k*-values as a function of the reciprocal absolute temperature (degrees Kelvin). Determine the best-fitting straight line through the four points. The negative of the slope of the line is the value of the activation energy divided by the gas constant.

$$\ln k(T) = \ln(a) - E_a / RT \quad \textbf{16}$$

<u>Task 3. Strength-Maturity (Equivalent Age) Relationship and Pullout Test Strength Relationship.</u>

Objectives:

- Establish the strength-maturity relationships for each concrete mixture.
- Establish the relationship between pullout strength and cylinder strength for each concrete mixture.

a. Four mixtures will be tested to establish the strength maturity relationship at standard temperature. (Table 1)

   i. Portland cement mixture
   ii. 35 and 50% Class F fly ash mixture
   iii. 35% Class C fly ash (25% lime) mixture

b. 4 in. by 8 in. concrete cylinders will be prepared and cured in accordance with ASTM C192/C192 M.

c. Three (3) cylinders will be tested at each age (1, 2, 4, 7, 14, 28 days). Two cylinders in each mixture will have embedded sensor (mid-depth) to obtain the temperature-age relationship (for use in calculating equivalent age).

d. Cylinders will be cured in lime-saturated water bath at 73^{o}F. Specimen will be put in the water bath immediately after casting.

e. Perform compressive strength tests at ages of 1, 2, 4, 7, and 14, and 28 days according to ASTM C39/C39M. Test three specimens at each age and compute the average strength. Unbonded neoprene pads will be used to cap the specimens.

f. Plot the average compressive strength as a function of equivalent age at 73^{o}F**.** The activation energy values obtained in Task 1 and the measured temperature histories will be used to calculate the equivalent ages at each test age.

Pullout Test Correlation (ASTM C900)

a. 8-in. concrete cubes will be cast with 4 pullout inserts per cube, one on each of the 4 vertical faces (Figure A.1).

b. Four mixtures will be used to obtain the relationship between pullout strength and cylinder compressive strength (Table 1)

   i) Portland cement mixture
   ii) 35 and 50% Class F fly ash mixtures
   iii) 35% Class C fly ash (25% lime) mixture

c. Eight pullout tests (2 cubes) will be performed at the same time as the cylinder compressive strength tests (1, 2, 4, 7, 14, 28 days). Twelve cubes per mixture will be prepared. One iButton sensor 1 in. from the bottom of the mold (at the center of the horizontal plane of the cube) will be embedded in each of the two 28-day cubes. The average of these two will be used for our comparison/maturity calculations.

d. Cure the cubes in the same water bath as the cylinders. Pullout mold will be put into bath right after casting. Strip molds 24 hours after casting[1].

e. When compressive strength tests are performed in step (c), perform 8 pullout tests at the same time.

f. Results from these tests will be used to establish the strength relationship for the pullout test. The procedures in ACI 228.1R will be used to obtain the strength relationship.

g. The pullout strength relationships will be examined to determine whether there is a unique relationship applicable to all mixtures, or if each mixture requires a unique relationship. Compare the relationships with the manufacturer's recommended relationship.

[1]We will do a 50% trial mix and see if strength at 24 hours is adequate for stripping. If yes, we will strip; If Not we will skip 1 day test for that mix and start at 2 days.

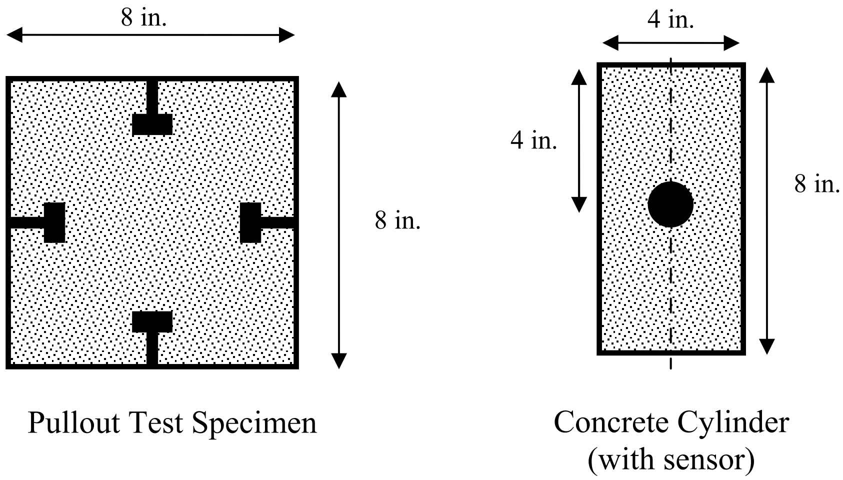

Figure A.1 Specimens for task 3

<u>Task 4. Field Testing</u>

<u>Objectives:</u>

- To simulate the use of maturity method and pullout test to estimate early-age in-place strength of HVFA mixtures.
- To compare estimated strengths by maturity and pullout testing with strength based on temperature-matched curing (Figure A.2).
- To demonstrate that in-place strength development of HVFA mixtures will be greater than that of standard-cured cylinders.

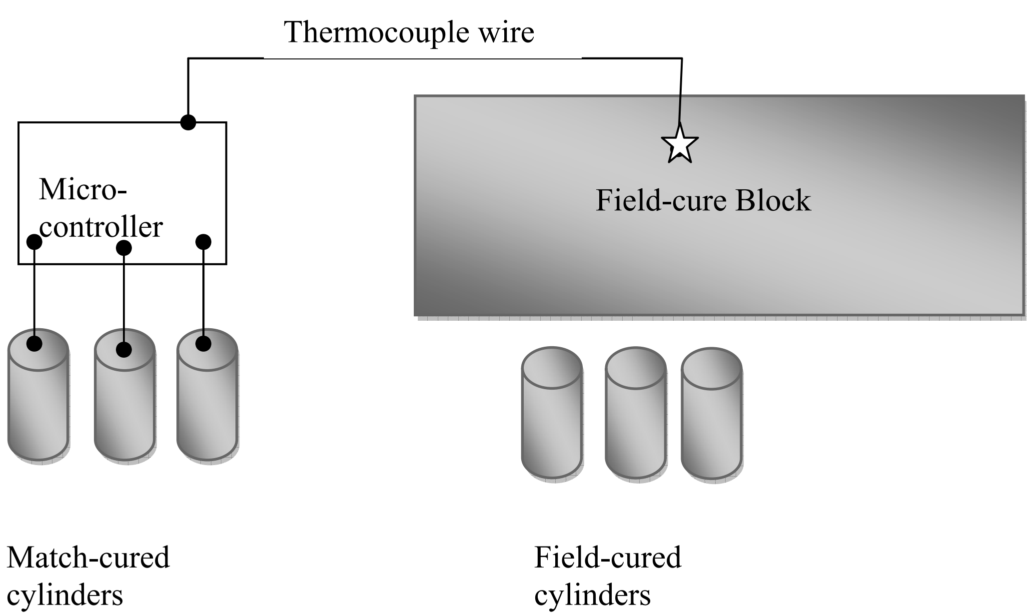

Figure A.2 Schematic of field testing

Part 1: Concrete block (mass concrete)

a. One 2 ft by 2 ft by 6 ft block will be cast for each mixture with seven temperature sensors inside each block (Figure A.3). Thermocouple sensor will be used to drive a temperature-matched curing system.

b. A temperature-matched curing system will be used to obtain the best-estimate of the actual in-place compressive strength at different ages. Eight cylinders will be prepared for temperature-matched curing. At actual ages of 2, 4, and 7 days, six (6) temperature-matched cylinders will be tested. We will need to test 2 cylinders at each age. One cylinder will have an iButton sensor to measure the concrete temperature. This cylinder should not be tested for strength. We will thus have one spare that could be tested at an age where the two breaks are not close to each other. The average cylinder strength will represent the actual in-place strength.

c. Ten additional 4 in. by 8 in. cylinders will be prepared when each block is cast. Nine cylinders will be field-cured according to ASTM C31/C31M and three replicates will be tested at each age of 2, 4, and 7 days. One cylinder will be cast with an iButton sensor at mid-depth to monitor temperature of field cure cylinder.

d. Twenty four pullout inserts will be cast at the mid-depth of block mold in accordance to ASTM C900. Eight pullout tests/age will be performed exactly at the same age at which the match-cured and field-cured cylinders are tested. All pullout inserts will be randomly placed at the same elevation.

e. Two days pullout strength will be tested through the access panels while the form work is still attached, to simulate the actual field test (Early stripping). Block molds will be stripped after 3days to do a pullout test using conventional way for other 2 ages (4 and 7 days). Block will be cured using waterproof cover and curing blanket all the time to provide good curing of the concrete.

f. Four mixtures will be used for the field concrete blocks along with field companion cylinders
   i. Portland cement mixture
   ii. 35 and 50% Class F fly ash mixture
   iii. 35% Class C fly ash (25% lime) mixture

g. Eight iButtons will be placed in each concrete block to monitor temperature of the specimen with age (Figure A.3).The temperature-match- cured cylinders will follow the temperature history of the thermocouple sensor with 1.0 in. cover and placed at mid-depth of the block, as shown in Figure A.3 (denoted by a star).

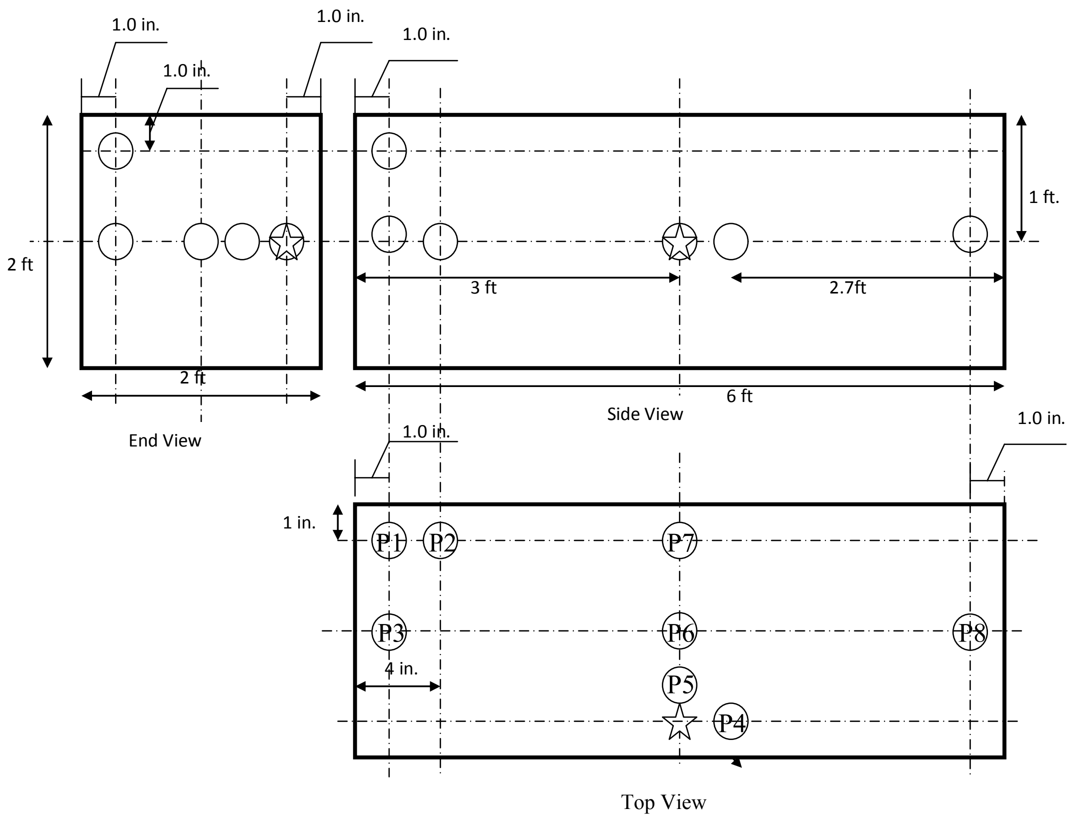

Figure A.3 Concrete bock and temperature sensor locations
(P4 is used for maturity calculations)

h. Use the strength-maturity relationship and the pullout strength relationship to estimate the in-place concrete strength and compare with the strength of the temperature match-cured cylinders.

Part 2: Concrete slab (pavement)

a. One concrete slab of size 8 ft. by 8 ft by 7 in. for each of the two mixtures shown in Table A.1 will be cast.

b. Mixtures for concrete slabs.

   i. Portland cement mixture
   ii. 50% Class F fly ash mixture

c. Concrete cylinders will be prepared for temperature-matched curing, field curing, and standard curing as was done for the concrete block tests.

d. Twenty four pullout test inserts will be floated into the top of each slab with accordance to ASTM C900.

e. Five iButtons shown in Figure A.4 will be used in each slab to record temperature of the slab. Two temperature sensors will be placed at mid depth, and other two sensors will be embedded at 2 in. from the top surface. The thermocouple sensor will be used to drive the temperature-matched curing system.

f. At actual ages of 2, 4, and 7 days, cylinders (field-cured and match-cured) will be tested for compressive strength. At the same ages, 8 pullouts tests will be conducted. Concrete strength estimated based on the strength maturity relationship and the pullout test strength relationship would be compared with the measured compressive strength of the match-cured cylinders.

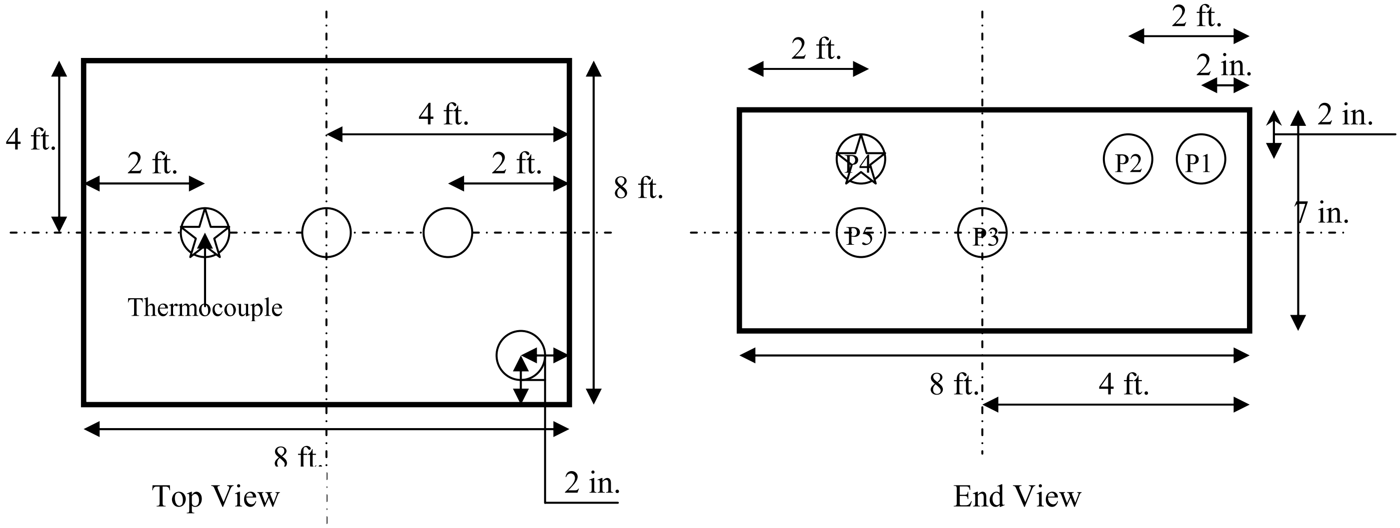

Figure A.4 Concrete slab and temperature sensor locations
(P4 is used for maturity calculations)

APPENDIX B

Appendix B summarizes the compressive strength results on 2 in. mortar cubes.

Table B.1 Compressive strength -trial 1 (Control mixture)

Temp (^oF)	Age (Days)	Strength (psi)	COV(%)
45	1.25	915	5.4
	2.50	1442	1.3
	4.99	2117	3.9
	9.98	2863	0.7
	26.24	3555	1.3
	69.00	4302	0.6
70	0.71	1100	0.5
	1.42	2021	2.3
	2.84	2872	1.9
	5.69	3513	0.9
	13.21	3919	1.0
	30.70	4953	2.4
100	0.34	1006	2.5
	0.69	2188	5.8
	1.37	2846	1.4
	2.75	3354	0.5
	5.92	3975	2.2
	12.77	3975	2.2
120	0.21	523	3.0
	0.41	1931	0.2
	0.82	2531	2.3
	1.65	3052	5.4

Table B.2 Compressive strength -trial 2 (Control mixture)

Temp (^oF)	Age (Days)	Strength (psi)	COV (%)
	0.94	228	1.1
	1.87	1015	3.0
45	3.74	1877	0.8
	7.48	2776	1.6
	14.97	3328	5.0
	32.14	3845	6.8
	69.00	4582	1.8
	0.43	318	3.8
	0.85	1259	0.6
70	1.7	1902	3.0
	3.41	2767	1.4
	6.82	3220	3.8
	14.47	3652	0.6
	30.71	4289	4.5
	0.19	241	1.3
	0.36	1401	0.2
120	0.71	2179	4.0
	1.41	2692	6.3
	2.82	3156	1.7
	4.59	3293	0.9
	7.48	3620	5.2

Table B.3 Compressive strength -trial 1 (20% FA-A)

Temp (^oF)	Age (Days)	Strength (psi)	COV (%)
45	1.28	268	0.5
	2.56	1067	1.3
	5.12	1896	1.7
	10.23	2513	4.0
	25.99	4100	0.8
	66	5077	0.5
70	0.86	1088	1.9
	1.73	1956	3.3
	3.45	2842	1.1
	6.9	3654	2.2
	14.52	4428	3.1
	30.56	5166	2.2
100	0.42	1017	0.7
	0.84	2088	1.5
	1.69	2869	4.5
	3.37	3807	2.8
	6.69	4309	2.4
	13.28	5066	1.9
120	0.25	925	5.8
	0.51	1978	4.1
	1.01	2990	0.3
	2.02	3648	1.5
	4.02	4788	0.9

Table B.4 Compressive strength –trial 1 (35% FA-A)

Temp (^oF)	Age (Days)	Strength (psi)	COV (%)
45	1.42	262	5.9
	2.85	708	2.0
	5.69	1213	1.0
	11.38	1579	4.8
	25.69	2096	0.3
	58.00	2438	3.3
70	1.10	942	2.0
	2.20	1558	2.8
	4.41	1954	1.6
	8.81	2371	0.8
	16.30	2745	1.3
	30.14	3628	0.4
100	0.59	1083	0.6
	1.18	1641	2.0
	2.36	2150	0.5
	4.71	2656	1.8
	8.39	3430	1.1
	14.94	4498	1.2
120	0.35	750	1.6
	0.71	1369	0.4
	1.41	1833	1.8
	2.83	2646	2.9
	5.25	4172	1.9

Table B.5 Compressive strength –trial 2 (35% FA-A)

Temp (^oF)	Age (Days)	Strength (psi)	COV (%)
45	1.42	296	11.2
	2.84	715	5.5
	5.69	1185	1.2
	11.37	1521	1.3
	22.76	2000	9.2
	36.27	2208	2.6
70	58.02	2368	0.5
	0.95	305	0.6
	1.65	975	2.0
	3.30	1650	0.5
	6.55	2160	1.8
	13.22	2630	1.1
	19.96	2875	1.1
	30.20	3261	1.1
120	0.26	209	5.3
	0.53	896	2.3
	1.06	1886	5.6
	2.12	2600	1.6
	4.24	3403	1.4
	6.43	4045	0.3
	9.74	4558	4.1

Table B.6 Compressive strength –trial 3 (35% FA-A)

Temp (^oF)	Age (Days)	Strength (psi)	COV (%)
70	0.83	225	7.8
	1.65	1063	8.3
	3.30	1638	0.1
	6.60	2338	0.7
	30.14	3420	4.3
	94.11	4938	0.7
	0.26	325	10.8
	0.53	819	9.7
120	1.07	1394	1.9
	2.12	2196	2.1
	4.55	3269	4.5
	9.75	4125	0.3
	26.03	5400	0.1

Table B.7 Compressive strength –trial 1 (50% FA-A)

Temp (^oF)	Age (Days)	Strength (psi)	COV(%)
45	1.66	335	4.6
	3.32	879	1.6
	6.64	1900	2.4
	13.29	2646	2.2
	26.54	3709	3.7
70	1.18	1083	0.6
	2.35	1846	0.3
	4.71	2948	0.3
	9.41	4050	1.8
	16.77	5069	1.4
	29.87	6210	3.7
100	0.70	1621	1.9
	1.40	2750	1.9
	2.79	3975	0.6
	5.58	5328	4.4
	9.50	6546	4.4
	16.16	7344	2.1
120	0.42	1274	2.4
	0.84	2543`	3.5
	1.67	3708	3.7
	3.35	5344	1.1
	6.10	6523	0.8

Table B.8 Compressive strength –trial 2 (50% FA-A)

Temp (^oF)	Age (Days)	Strength (psi)	COV(%)
45	1.50	305	11.4
	2.98	1068	2.6
	5.95	2051	1.5
	11.95	2946	5.1
	23.91	4061	2.5
	35.57	4588	1.4
	53.50	4965	0.7
70	0.94	762	1.9
	1.88	1760	1.3
	3.80	2760	0.7
	7.58	3642	3.2
	14.96	4430	4.4
	29.86	5430	0.1
120	0.26	502	9.0
	0.50	1627	1.3
	1.00	2883	2.4
	2.00	3966	3.1
	4.02	5631	0.5
	6.69	6388	2.7
	11.12	6620	0.1

Table B.9 Compressive strength –trial 3 (50% FA-A)

Temp (^oF)	Age (Days)	Strength (psi)	COV(%)
70	0.47	235	12.2
	0.94	792	3.9
	1.88	1625	0.7
	4.05	2473	1.4
	10.54	3575	3.2
	29.92	5143	4.6
	90.95	6958	0.2
120	0.26	425	15.5
	0.52	1423	3.6
	1.04	2668	5.7
	2.08	3880	2.9
	4.82	5896	3.3
	11.12	6479	4.7

Table B.10 Compressive strength –trial 4 (50% FA-A)

Temp (^{o}F)	Age (Days)	Strength (psi)	COV(%)
	0.47	160	2.2
	0.95	838	2.1
70	1.89	1613	1.0
	3.76	2400	2.2
	30.09	5613	2.2
	93.00	7313	8.4
	0.26	505	1.4
120	0.51	1331	0.6
	1.04	2306	0.3
	2.08	2751	3.9
	4.80	5118	3.9
	11.08	6975	0.7
	30.1	7688	2.9

Table B.11 Compressive strength –trial 1 (35% FA-B)

Temp (^oF)	Age (Days)	Strength (psi)	COV(%)
45	1.37	286	2.4
	2.74	917	2.0
	5.48	1788	1.2
	10.96	2854	0.9
	25.64	3683	1.2
70	1.00	1155	3.9
	2.00	2042	1.2
	4.01	2838	0.7
	8.01	3600	4.9
	15.58	4269	0.3
	30.28	4778	2.1
100	0.52	673	1.4
	1.03	1308	1.1
	2.07	2050	1.2
	4.13	2688	1.2
	7.71	3374	3.6
	14.37	4090	1.6
120	0.31	802	1.1
	0.62	1823	3.2
	1.24	2908	3.2
	2.48	3718	0.4

Table B.12 Compressive strength –trial 2 (35% FA-B)

Temp (^oF)	Age (Days)	Strength (psi)	COV(%)
70	0.65	396	7.7
	1.3	1221	1.6
	2.6	2118	2.3
	5.21	2893	2.1
	10.37	3538	0.8
	17.65	4088	2.8
	30.28	4818	1.2
120	0.26	250	4.3
	0.53	1558	2.4
	1.05	2550	1.7
	2.11	3444	3.4
	4.20	4551	0.4
	6.20	5188	2.5
	9.12	5654	2.2

Table B.13 Compressive strength –trial 1 (35% FA-C)

Temp (^oF)	Age (Days)	Strength (psi)	COV(%)
45	1.33	132	0.5
	2.66	384	2.0
	5.33	1004	0.7
	10.65	1871	1.0
	25.91	2983	0.4
	63.00	3877	1.3
70	0.86	363	5.9
	1.73	1167	1.6
	3.45	2033	0.3
	6.90	2872	2.4
	14.52	3666	1.5
	30.56	4657	0.7
100	0.49	133	2.8
	0.98	671	1.0
	1.95	1493	1.0
	3.90	2196	1.1
	7.34	3332	1.2
	13.81	4516	1.1
120	0.29	207	3.6
	0.59	1050	2.7
	1.17	2494	0.4
	2.34	3729	1.6
	4.47	5341	3.0

Table B.14 Compressive strength –trial 2 (35% FA-C)

Temp (^oF)	Age (Days)	Strength (psi)	COV(%)
70	0.80	268	6.1
	1.62	904	0.7
	3.22	1713	3.8
	6.43	2385	1.6
	12.90	3084	2.9
	19.82	3597	0.5
	30.388	4035	2.2
120	0.29	223	3.3
	0.59	1096	1.7
	1.16	1580	3.9
	2.33	3127	3.1
	4.68	4204	1.7
	6.32	5075	5.9
	8.53	5113	0.2

Table B.15 Compressive strength –trial 3 (35% FA-C)

Temp (^oF)	Age (Days)	Strength (psi)	COV(%)
70	0.80	156	6.1
	1.60	750	0.7
	3.22	1536	3.8
	6.48	2256	1.6
	30.44	3906	2.9
	92.04	5444	0.5
120	0.29	184	2.8
	0.58	750	0.0
	1.17	1675	5.2
	2.34	2838	9.3
	4.46	4494	0.1
	8.54	5263	0.3
	23.96	6090	0.0

APPENDIX C

Appendix C summarizes compressive strength test results for field and laboratory testing.

Table C.1 Compressive strength –standard cure concrete cylinders-block (Control mixture)

Age (Days)	Standard Cure (psi)	COV (%)	Field Cure (psi)	COV(%)	Match Cure (psi)	COV(%)
1	1023	5.0				
2	1714	2.0	1249	2.1	2810	0.2
4	2449	3.1	2021	3.6	3452	0.2
7	2692	2.2	2615	4.2	3861	2.1
14	3470	5.5				
28	4378	2.1				

Table C.2 Compressive strength concrete cylinders-slab (Control mixture)

Age (Days)	Standard Cure (psi)	COV(%)	Field Cure(psi)	COV(%)	Match Cure (psi)	COV(%)
1						
2			1717	3.1	2825	1.3
4			2288	13.3	3625	3.4
7			3148	2.3	4289	0.6
14						
28	5182	4.4				

Table C.3Compressive strength -concrete cylinders-block (35% FA-A)

Age (Days)	Standard Cure (psi)	COV (%)	Field Cure (psi)	COV (%)	Match Cure (psi)	COV (%)
1	699	2.3				
2	1034	3.0	813	1.0	1802	4.2
4	1402	3.2	1374	2.2	2450	3.1
7	1820	5.5	1722	11.1	2786	5.3
14	2609	3.1				
28	3505	2.1				

Table C.4 Compressive strength -concrete cylinders-block (50% FA-A)

Age (days)	Standard Cure (psi)	COV (%)	Field Cure (psi)	COV (%)	Match Cure (psi)	COV(%)
1	1039	5.1				
2	1662	2.7	1155	2.3	2156	0.8
4	2372	3.7	2216	1.5	2823	1.0
7	2832	1.1	2599	0.1	3251	3.2
14	3668	1.2				
28	4811	0.4				

Table C.5 Compressive strength -concrete cylinders-slab (50% FA-A)

Age (Days)	Field Cure (psi)	COV (%)	In-Place (psi)	COV (%)
2	1263	2.1	1491	3.6
4	2159	1.1	2262	1.4
7	2485	0.6	2545	3.3

Table C.6 Compressive strength -concrete cylinders-block (35% FA-C)

Age (Days)	Standard Cure (psi)	COV (%)	Field Cure (psi)	COV (%)	Match Cure(psi)	COV (%)
1	807	1.8				
2	1781	6.1	1732	4.4	3422	3.2
4	2822	3.9	2998	1.3	4405	0.1
7	3503	0.2	3695	1.4	4953	1.71
14	4104	2.5				
28	5212	1.2				

APPENDIX D

This Appendix D summarizes the results for pullout force on 8 in. concrete cube and field cure blocks and slabs. The plot for compressive strength vs. pullout force for standard cure 8 in. concrete cube are also shown with best fit exponential equation used for strength vs. pullout force correlations. Finally, the calculated pullout forces for the blocks and slabs are converted to compressive strength estimates using the developed pullout load-compressive strength correlations (Figures D.1 to D.4)

Table D.1 Pullout force on 8 in. cube concrete specimen (Control mixture)

Age (Days)	Pullout Force (kN)	COV(%)
1	8.45	15.4
2	12.50	8.4
4	15.63	5.4
7	17.90	3.3
14	21.61	4.7
28	26.89	8.0

Table D.2 Pullout force on 8in. cube concrete specimen (35% FA-A)

Age (Days)	Pullout Force (kN)	COV (%)
1	7.19	6.9
2	9.40	17.8
4	10.59	5.9
7	13.41	6.9
14	18.03	9.1
28	22.86	4.3

Table D.3 Pullout force on 8in. cube concrete specimen (50% FA-A)

Age (Days)	Pullout Force (kN)	COV (%)
1	10.44	21.9
2	13.97	17.8
4	17.36	15.1
7	19.58	12.3
14	25.45	11.2
28	29.69	7.9

Table D.4 Pullout force on 8in. cube concrete specimen (35% FA-C)

Age (Days)	Pullout Force (kN)	COV (%)
1	7.16	14.0
2	12.86	11.0
4	18.30	8.7
7	20.84	4.2
14	22.49	6.1
28	30.28	7.1

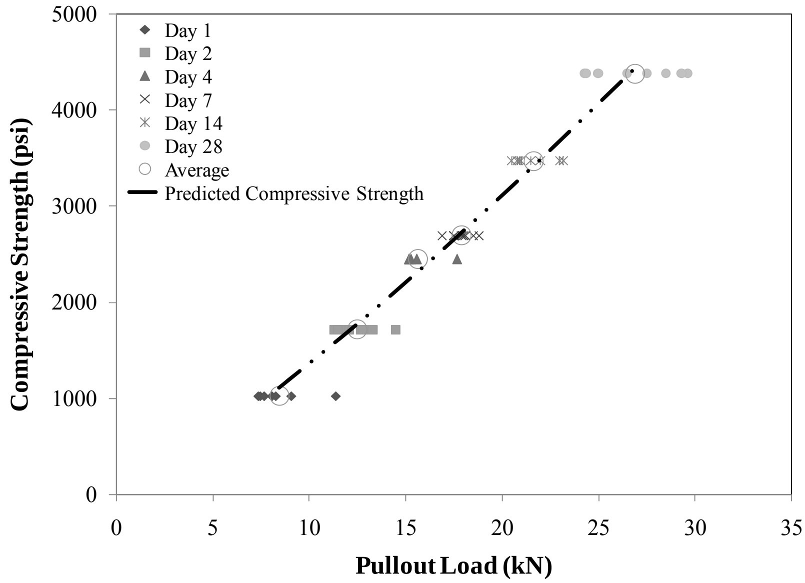

Figure D.1 Strength vs. pullout force (Control mixture)

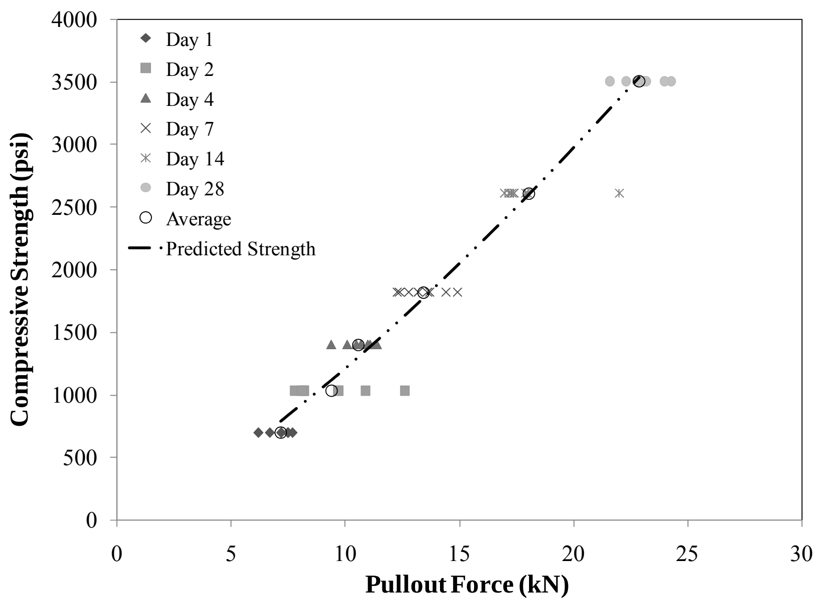

Figure D.2 Strength vs. pullout force (35% FA-A)

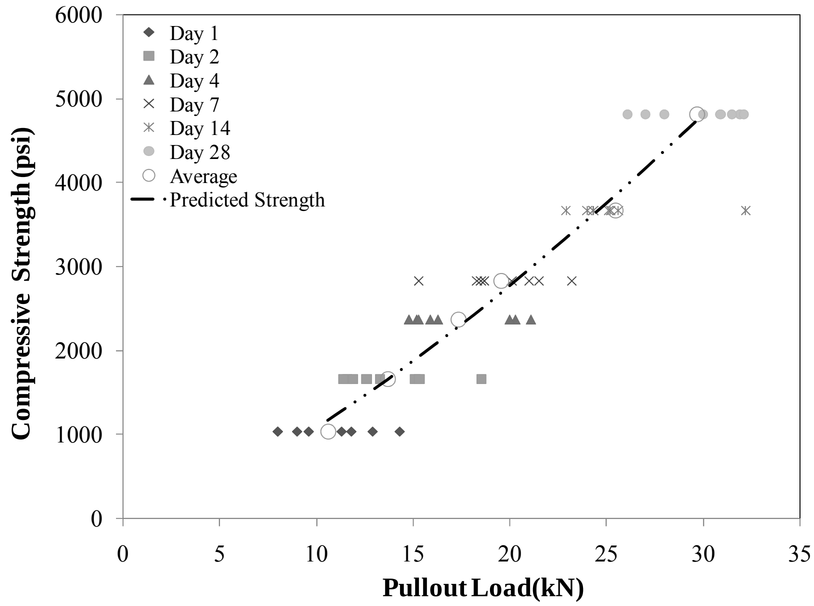

Figure D.3 Strength vs. pullout force (50% FA-A)

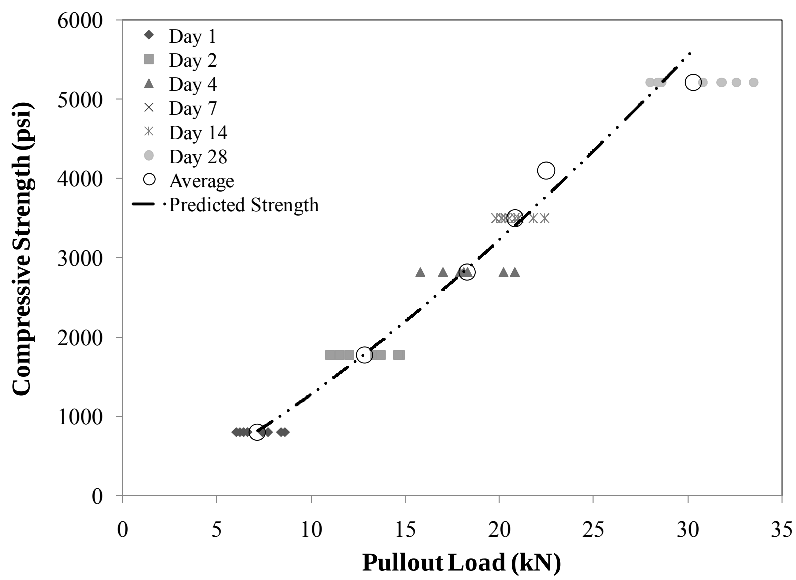

Figure D.4 Strength vs. pullout force (35% FA-C)

Table D.5 Pullout force on concrete block field-cured (Control mixture)

Age (Days)	Pullout Force (kN)	COV (%)	Estimated Strength (psi)
2	17.175	6.7	2590
4	18.525	3.7	2836
7	21.525	4.2	3395

Table D.6 Pullout force on concrete slab field-cured (Control mixture)

Age (Days)	Pullout Force (kN)	COV(%)	Estimated Strength (psi)
2	16.33	7.5	2437
4	19.03	4.7	2928
7	20.69	9.1	3237

Table D.7 Pullout force on concrete block field-cured (35% FA-A)

Age (days)	Pullout Force (kN)	COV(%)	Estimated Strength (psi)
2	10.75	4.2	1325
4	11.09	5.7	1379
7	13.64	9.1	1804

Table D.8 Pullout force on concrete block field-cured (50% FA-A)

Age (Days)	Pullout Force (kN)	COV (%)	Estimated Strength (psi)
2	16.60	16.4	2151
4	17.50	16.7	2311
7	18.21	10.4	2441

Table D.9 Pullout force on concrete slab field-cured (50% FA-A)

Age (Days)	Pullout Force (kN)	COV (%)	Estimated Strength (psi)
2	11.79	6.7	1349
4	14.83	7.4	1844
7	17.10	5.7	2240

Table D.10 Pullout force on concrete block field-cured (35% FA-C)

Age (Days)	Pullout Force (kN)	COV (%)	Estimated Strength (psi)
2	20.35	5.3	3325
4	22.99	2.8	3858
7	24.28	12.0	4123

APPENDIX E

This appendix helps understand the strength estimations from maturity. For each of the 6 field tested cases (4 blocks and 2 slabs) corresponding temperature vs. age profiles are presented as two plots:

1. Figure A.4 in Appendix A for the block and slab respectively

2. The second plot shows the temperature profiles inside the following four scenarios – standard-cured cylinders, field-cured cylinders, match-cured cylinders and iButtons closest to the thermocouple use for match curing.
This is followed by the strength predictions from maturity for each of the 6 cases.

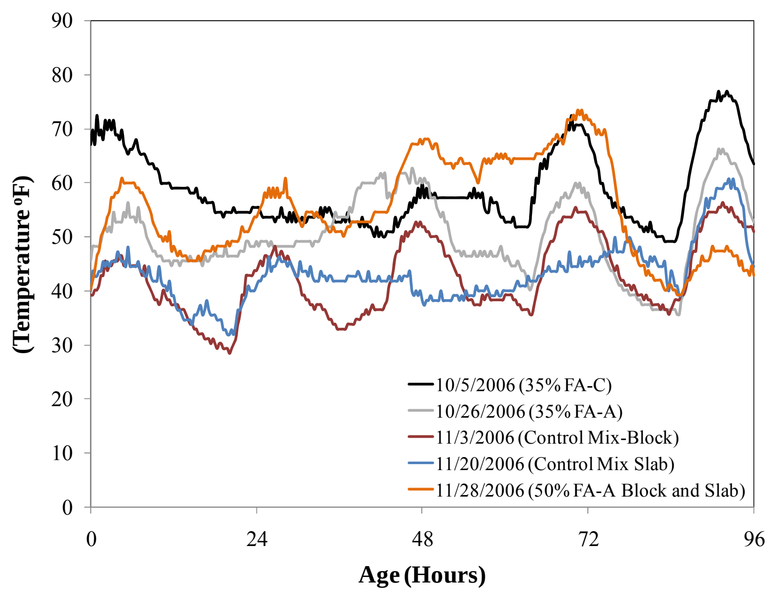

Figure E.1 Ambient temperature profile during field testing from October to November

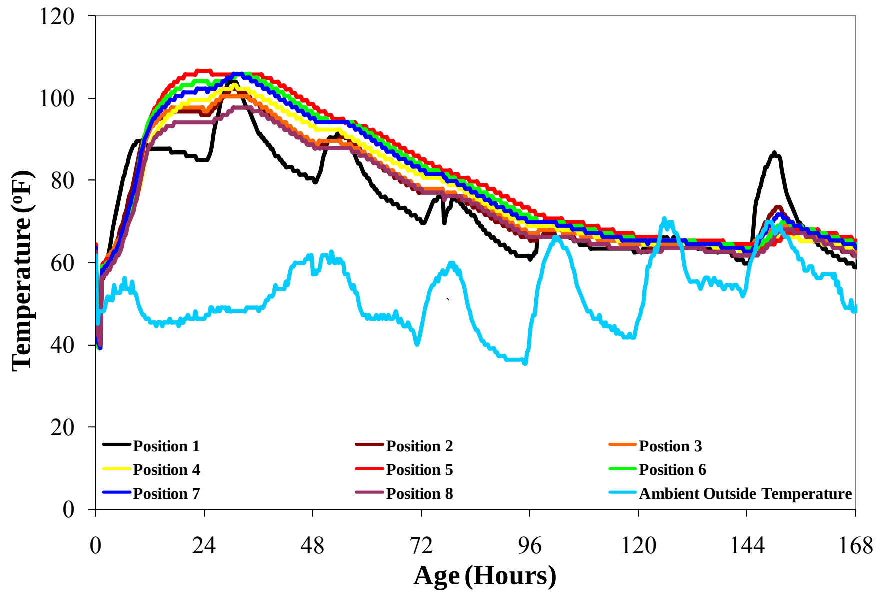

Figure E.2 Temperature profile of block (Control mixture)

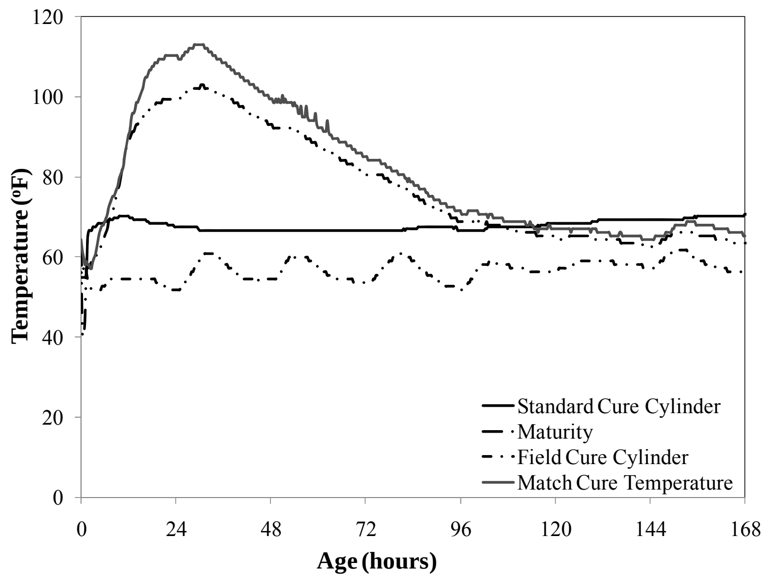

Figure E.3 Temperature profile control mixture

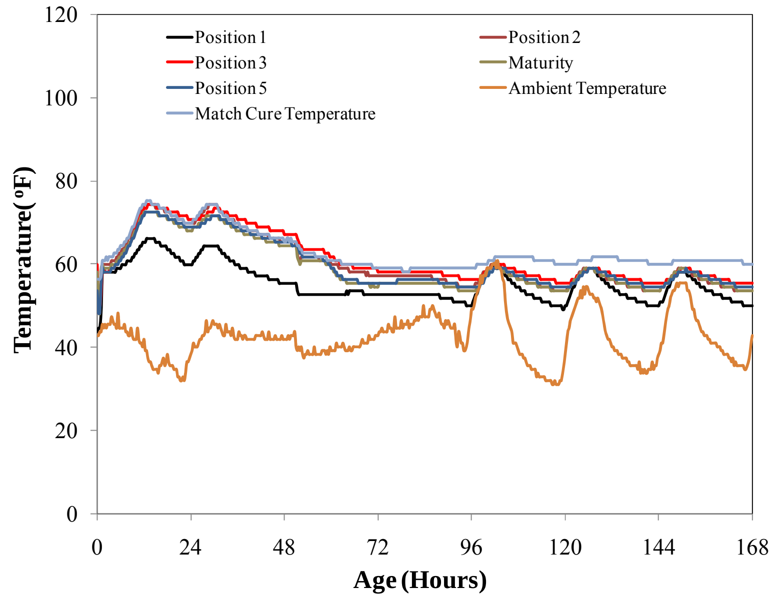

Figure E.4 Temperature profile of slab (Control mixture)

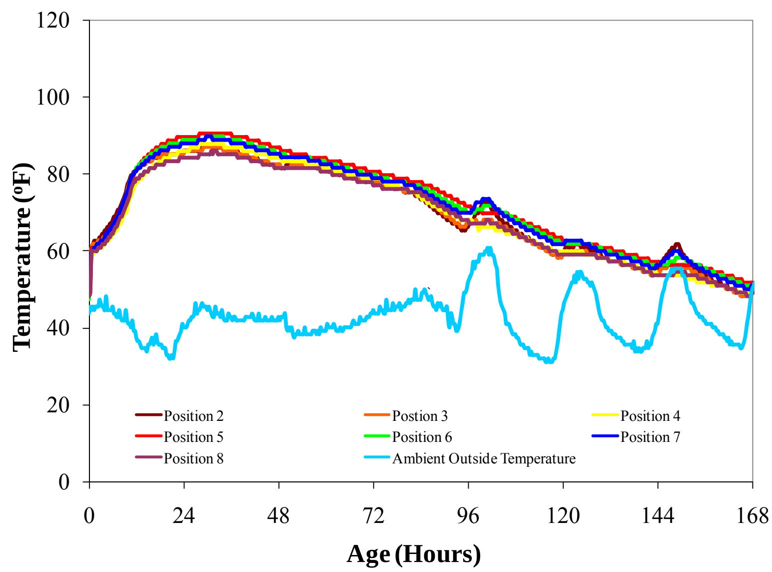

Figure E.5 Temperature profile of block (50% FA-A)

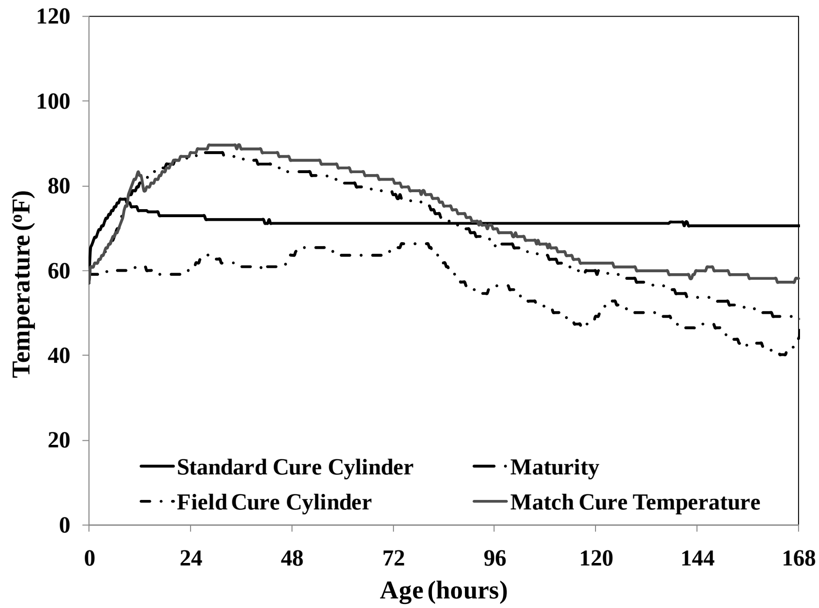

Figure E.6 Temperature profile 50% FA-A

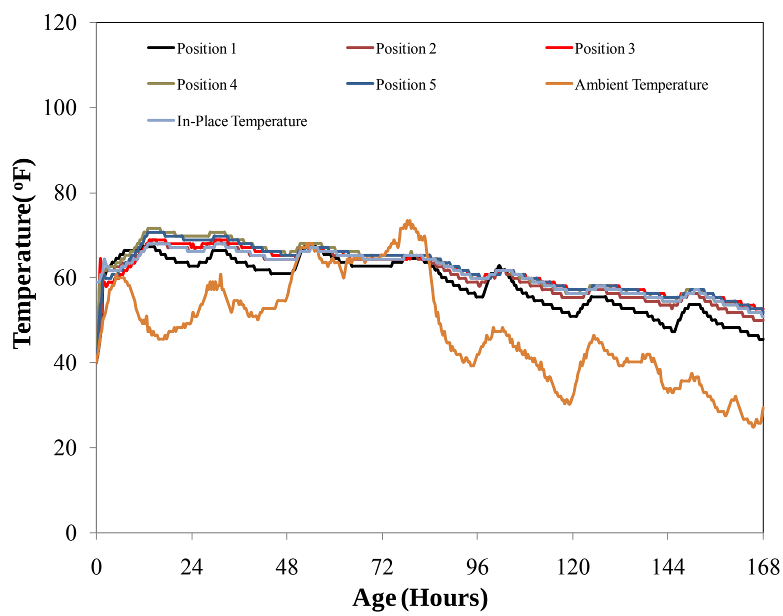

Figure E.7.Temperature profile of Slab (50% FA-A)

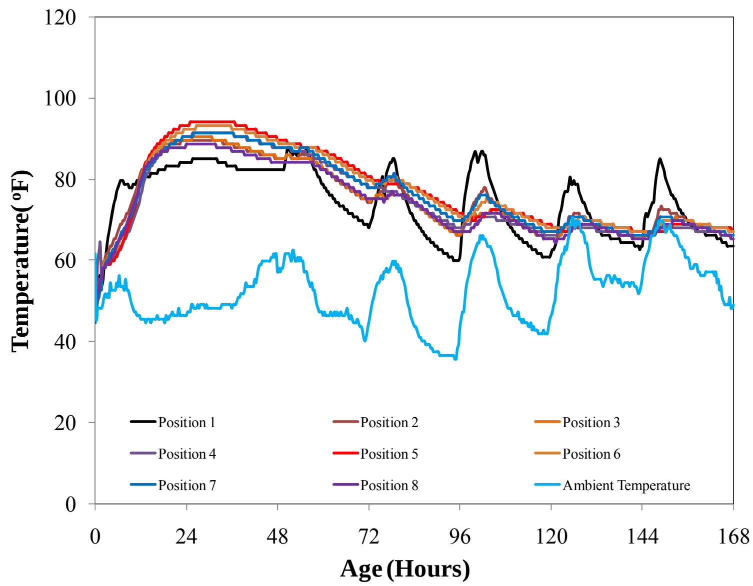

Figure E.8 Temperature profile of block (35% FA-A)

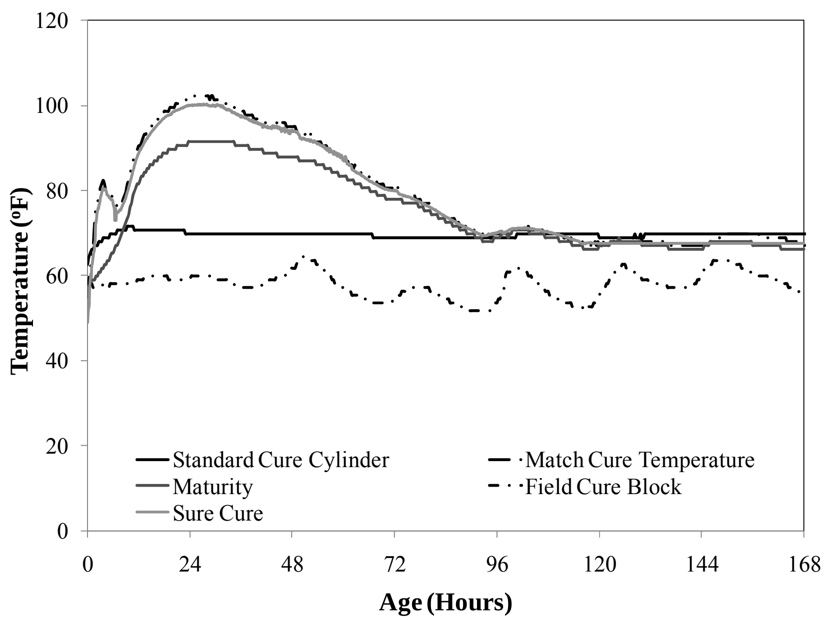

Figure E.9.Temperature profile 35% FA-A

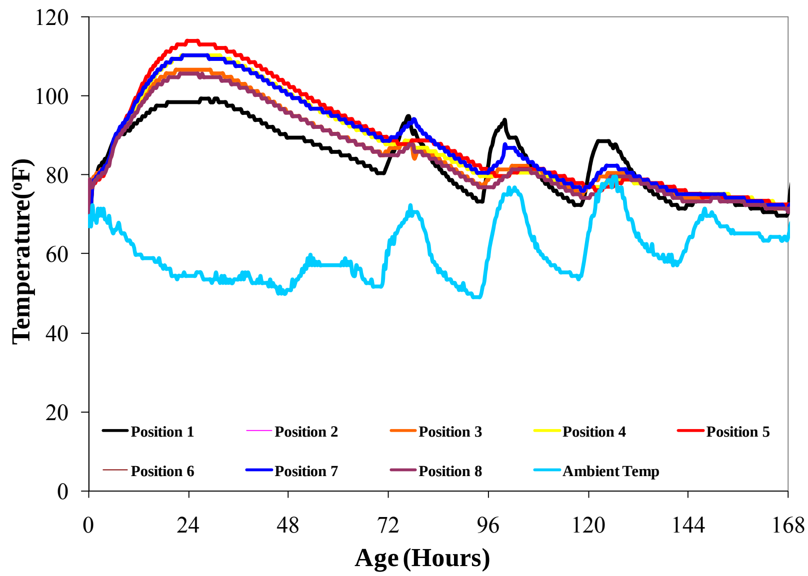

Figure E.10 Temperature profile of block (35% FA-C)

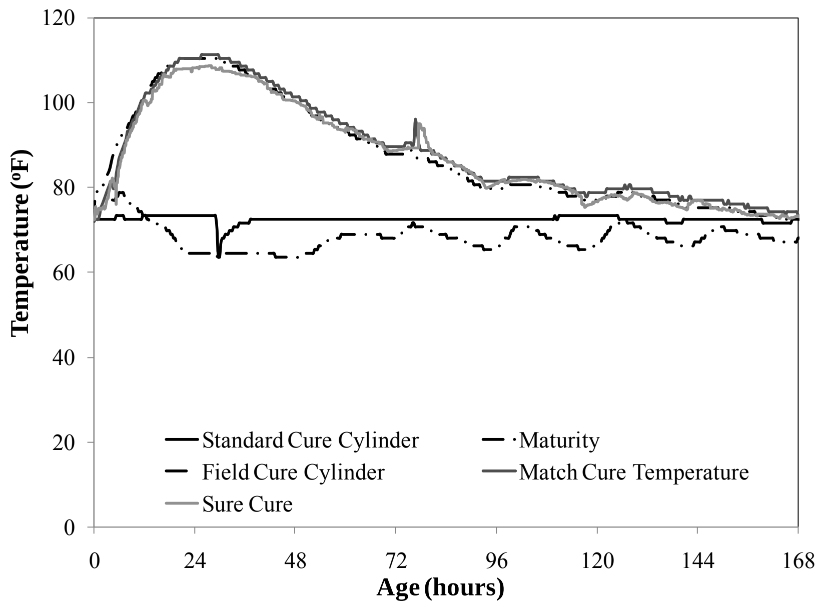

Figure E.11 Temperature profile 35% FA-C

Table E.1 Strength prediction using maturity and pullout correlation

Mixture	Concrete Element	Actual Age (Days)	Equivalent Age (23^{o}C) (days)	Strength Prediction Maturity Method (psi)	Pullout Load (kN)	Strength Prediction Pullout Correlation (psi)
Control Mixture	Block	2	3.60	2322	17.2	2590
		4	6.21	2922	18.5	2836
		7	8.51	3271	21.5	3395
	Slab	2	1.7	1605	16.3	2437
		4	2.8	2069	19.0	2928
		7	4.5	2561	20.7	3237
35% FA-A	Block	2	2.2	1058	10.8	1325
		4	4.3	1477	11.1	1379
		7	7.1	1925	13.6	1804
50% FA-A	Block	2	2.4	1769	16.6	2151
		4	4.6	2434	17.5	2311
		7	6.6	2887	18.2	2441
	Slab	2	1.6	1448	11.8	1349
		4	3.2	2014	14.8	1844
		7	5.1	2550	17.1	2240
35% FA-C	Block	2	3.7	2685	20.4	3325
		4	6.4	3496	23.0	3858
		7	9.6	4035	24.3	4123

Table E.2 Strength comparison between various curing condition and predicted strength

Mixture	Concrete Element	Actual Age (Days)	Match Cure Strength (psi)	Strength Prediction Maturity Method (psi)*	Strength Prediction Pullout Correlation (psi)*	Field Cure (psi)*
Control Mixture	**Block**	2	2810	2322 (-17.4)	2590 (-7.8)	1249 (-55.6)
		4	3452	2922 (-15.4)	2836 (-17.8)	2021 (-41.5)
		7	3861	3271 (-15.3)	3395 (-12.1)	2615 (-32.3)
	Slab	2	2825	1605 (-43.2)	2437 (-13.7)	1717 (-39.2)
		4	3625	2069 (-42.9)	2928 (-19.2)	2288 (-36.9)
		7	4289	2561 (-40.3)	3237 (-24.5)	3148 (-26.6)
35% FA-A	**Block**	2	1802	1058 (-41.3)	1325 (-26.5)	813 (-54.9)
		4	2450	1477 (-39.7)	1379 (-43.7)	1374 (-43.9)
		7	2786	1925 (-30.9)	1804 (-35.2)	1722 (-38.2)
50% FA-A	**Block**	2	2156	1769 (-17.9)	2151 (-0.2)	1155 (-46.4)
		4	2823	2434 (-13.8)	2311 (-18.1)	2216 (-21.5)
		7	3251	2887 (-11.2)	2441 (-24.9)	2599 (-20.1)
	Slab	2	1491	1448 (-2.9)	1349 (-9.5)	1263 (-15.3)
		4	2262	2014 (-11.0)	1844 (-18.5)	2159 (-4.6)
		7	2545	2550 (0.2)	2240 (-12.0)	2485 (-2.4)
35% FA-C	**Block**	2	3422	2685 (-21.5)	3325 (-2.8)	1732 (-49.4)
		4	4405	3496 (-20.6)	3858 (-12.4)	2998 (-31.9)
		7	4953	4035 (-18.5)	4123 (-16.8)	3695 (-25.4)

* values in the brackets are strength percent difference between match cure and that column

Table E.3 Average percent differences between match-cured and various other in-place strength prediction techniques

Mixture	Concrete Element	Maturity Method, %	Pullout, %	Field Cure
Control	**Block**	16.0	12.6	43.1
	Slab	42.1	19.1	34.2
35% FA-A	**Block**	37.3	35.1	45.7
50% FA-A	**Block**	14.3	14.4	29.3
	Slab	4.6	13.3	7.4
35% FA-C	**Block**	20.2	10.7	35.6
Average		**22.4**	**17.5**	**32.6**

Table E.4 Maturity calculations control mixture-block

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
0.0	12.8	-	-		0	0.00
0.3	12.8	12.8	0.55	0.18	0.18	620
0.7	12.8	12.8	0.55	0.18	0.36	626
1.0	12.8	12.8	0.55	0.18	0.54	632
1.3	12.8	12.8	0.55	0.18	0.72	638
1.7	14.0	13.4	0.59	0.19	0.92	644
2.0	14.5	14.3	0.61	0.20	1.12	650
2.3	14.5	14.5	0.61	0.20	1.32	656
2.7	15.0	14.8	0.63	0.21	1.53	663
3.0	15.0	15.0	0.63	0.21	1.73	669
3.3	15.5	15.3	0.65	0.21	1.95	676
3.7	15.5	15.5	0.65	0.21	2.16	683
4.0	16.0	15.8	0.67	0.22	2.38	689
4.3	16.5	16.3	0.69	0.23	2.60	696
4.7	17.0	16.8	0.71	0.23	2.84	703
5.0	17.0	17.0	0.71	0.23	3.07	711
5.3	17.5	17.3	0.73	0.24	3.31	718
5.7	18.0	17.8	0.75	0.25	3.56	725
6.0	18.5	18.3	0.77	0.25	3.81	733
6.3	19.0	18.8	0.79	0.26	4.07	741
6.7	19.5	19.3	0.82	0.27	4.34	749
7.0	20.5	20.0	0.87	0.29	4.63	758
7.3	21.0	20.8	0.89	0.29	4.92	767

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
7.7	21.5	21.3	0.92	0.30	5.23	776
8.0	22.0	21.8	0.94	0.31	5.54	785
8.3	22.5	22.3	0.97	0.32	5.86	794
8.7	23.5	23.0	1.03	0.34	6.20	804
9.0	24.0	23.8	1.06	0.35	6.55	814
9.3	25.0	24.5	1.12	0.37	6.92	825
9.7	25.5	25.3	1.15	0.38	7.30	836
10.0	26.5	26.0	1.22	0.40	7.70	848
10.3	27.5	27.0	1.29	0.42	8.12	860
10.7	28.5	28.0	1.36	0.45	8.57	873
11.0	29.5	29.0	1.44	0.47	9.05	886
11.3	30.5	30.0	1.52	0.50	9.55	900
11.7	31.0	30.8	1.56	0.51	10.06	914
12.0	31.5	31.3	1.60	0.53	10.59	929
12.3	32.0	31.8	1.64	0.54	11.13	944
12.7	32.5	32.3	1.69	0.56	11.69	959
13.0	33.0	32.8	1.73	0.57	12.26	975
13.3	33.0	33.0	1.73	0.57	12.83	990
13.7	33.5	33.3	1.78	0.59	13.42	1006
14.0	34.0	33.8	1.83	0.60	14.02	1022
14.3	34.0	34.0	1.83	0.60	14.62	1038
14.7	34.5	34.3	1.88	0.62	15.24	1054
15.0	34.5	34.5	1.88	0.62	15.86	1070
15.3	35.0	34.8	1.93	0.64	16.50	1086
15.7	35.0	35.0	1.93	0.64	17.13	1102
16.0	35.5	35.3	1.98	0.65	17.79	1119

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
16.3	35.5	35.5	1.98	0.65	18.44	1135
16.7	35.5	35.5	1.98	0.65	19.09	1151
17.0	36.0	35.8	2.03	0.67	19.76	1168
17.3	36.0	36.0	2.03	0.67	20.43	1184
17.7	36.0	36.0	2.03	0.67	21.10	1200
18.0	36.5	36.3	2.08	0.69	21.79	1217
18.3	36.5	36.5	2.08	0.69	22.47	1233
18.7	36.5	36.5	2.08	0.69	23.16	1249
19.0	37.0	36.8	2.14	0.71	23.87	1266
19.3	37.0	37.0	2.14	0.71	24.57	1282
19.7	37.0	37.0	2.14	0.71	25.28	1299
20.0	37.0	37.0	2.14	0.71	25.98	1315
20.3	37.0	37.0	2.14	0.71	26.69	1331
20.7	37.5	37.3	2.19	0.72	27.41	1347
21.0	37.5	37.5	2.19	0.72	28.14	1363
21.3	37.5	37.5	2.19	0.72	28.86	1379
21.7	37.5	37.5	2.19	0.72	29.58	1395
22.0	37.5	37.5	2.19	0.72	30.31	1411
22.3	37.5	37.5	2.19	0.72	31.03	1426
22.7	37.5	37.5	2.19	0.72	31.76	1442
23.0	37.5	37.5	2.19	0.72	32.48	1457
23.3	37.5	37.5	2.19	0.72	33.20	1472
23.7	37.5	37.5	2.19	0.72	33.93	1487
24.0	37.5	37.5	2.19	0.72	34.65	1502
24.3	37.5	37.5	2.19	0.72	35.38	1517
24.7	37.5	37.5	2.19	0.72	36.10	1531

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
25.0	37.5	37.5	2.19	0.72	36.82	1546
25.3	38.0	37.8	2.25	0.74	37.57	1561
25.7	38.0	38.0	2.25	0.74	38.31	1576
26.0	38.0	38.0	2.25	0.74	39.05	1590
26.3	38.5	38.3	2.31	0.76	39.81	1605
26.7	38.5	38.5	2.31	0.76	40.58	1620
27.0	38.5	38.5	2.31	0.76	41.34	1634
27.3	38.5	38.5	2.31	0.76	42.10	1649
27.7	39.0	38.8	2.37	0.78	42.88	1663
28.0	39.0	39.0	2.37	0.78	43.66	1678
28.3	39.0	39.0	2.37	0.78	44.45	1692
28.7	39.0	39.0	2.37	0.78	45.23	1707
29.0	39.0	39.0	2.37	0.78	46.01	1721
29.3	39.0	39.0	2.37	0.78	46.79	1735
29.7	39.0	39.0	2.37	0.78	47.57	1749
30.0	39.0	39.0	2.37	0.78	48.36	1763
30.3	39.5	39.3	2.43	0.80	49.16	1777
30.7	39.5	39.5	2.43	0.80	49.96	1791
31.0	39.5	39.5	2.43	0.80	50.76	1805
31.3	39.0	39.3	2.37	0.78	51.54	1818
31.7	39.0	39.0	2.37	0.78	52.33	1832
32.0	39.0	39.0	2.37	0.78	53.11	1845
32.3	39.0	39.0	2.37	0.78	53.89	1858
32.7	39.0	39.0	2.37	0.78	54.67	1871
33.0	39.0	39.0	2.37	0.78	55.45	1884
33.3	39.0	39.0	2.37	0.78	56.24	1897

Age (hours)	Temperature (^{o}C)	Average Temperature (^{o}C)	Age Factor	Eq. Age @ 23^{o}C Increment (hours)	Eq. Age @ 23^{o}C Cumulative (hours)	Predicted Compressive Strength (psi)
33.7	39.0	39.0	2.37	0.78	57.02	1909
34.0	38.5	38.8	2.31	0.76	57.78	1922
34.3	38.5	38.5	2.31	0.76	58.54	1934
34.7	38.5	38.5	2.31	0.76	59.30	1946
35.0	38.5	38.5	2.31	0.76	60.07	1958
35.3	38.0	38.3	2.25	0.74	60.81	1969
35.7	38.0	38.0	2.25	0.74	61.55	1981
36.0	38.0	38.0	2.25	0.74	62.29	1992
36.3	38.0	38.0	2.25	0.74	63.04	2004
36.7	38.0	38.0	2.25	0.74	63.78	2015
37.0	37.5	37.8	2.19	0.72	64.50	2026
37.3	37.5	37.5	2.19	0.72	65.23	2037
37.7	37.5	37.5	2.19	0.72	65.95	2047
38.0	37.5	37.5	2.19	0.72	66.68	2058
38.3	37.5	37.5	2.19	0.72	67.40	2069
38.7	37.0	37.3	2.14	0.71	68.11	2079
39.0	37.0	37.0	2.14	0.71	68.81	2089
39.3	37.0	37.0	2.14	0.71	69.52	2099
39.7	37.0	37.0	2.14	0.71	70.22	2109
40.0	36.5	36.8	2.08	0.69	70.91	2119
40.3	36.5	36.5	2.08	0.69	71.60	2128
40.7	36.5	36.5	2.08	0.69	72.28	2138
41.0	36.5	36.5	2.08	0.69	72.97	2148
41.3	36.0	36.3	2.03	0.67	73.64	2157
41.7	36.0	36.0	2.03	0.67	74.31	2166
42.0	36.0	36.0	2.03	0.67	74.98	2175

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
42.3	36.0	36.0	2.03	0.67	75.65	2184
42.7	35.5	35.8	1.98	0.65	76.30	2193
43.0	35.5	35.5	1.98	0.65	76.95	2202
43.3	35.5	35.5	1.98	0.65	77.61	2210
43.7	35.5	35.5	1.98	0.65	78.26	2219
44.0	35.5	35.5	1.98	0.65	78.91	2227
44.3	35.0	35.3	1.93	0.64	79.55	2236
44.7	35.0	35.0	1.93	0.64	80.18	2244
45.0	35.0	35.0	1.93	0.64	80.82	2252
45.3	35.0	35.0	1.93	0.64	81.45	2260
45.7	34.5	34.8	1.88	0.62	82.07	2268
46.0	34.5	34.5	1.88	0.62	82.69	2276
46.3	34.5	34.5	1.88	0.62	83.31	2284
46.7	34.5	34.5	1.88	0.62	83.93	2292
47.0	34.5	34.5	1.88	0.62	84.55	2299
47.3	34.0	34.3	1.83	0.60	85.15	2307
47.7	34.0	34.0	1.83	0.60	85.76	2314
48.0	34.0	34.0	1.83	0.60	86.36	2322
48.3	34.0	34.0	1.83	0.60	86.96	2329
48.7	33.5	33.8	1.78	0.59	87.55	2336
49.0	33.5	33.5	1.78	0.59	88.14	2343
49.3	33.5	33.5	1.78	0.59	88.72	2350
49.7	33.5	33.5	1.78	0.59	89.31	2357
50.0	33.5	33.5	1.78	0.59	89.90	2364
50.3	33.5	33.5	1.78	0.59	90.48	2371
50.7	33.5	33.5	1.78	0.59	91.07	2378

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
51.0	33.5	33.5	1.78	0.59	91.66	2385
51.3	33.5	33.5	1.78	0.59	92.25	2392
51.7	33.5	33.5	1.78	0.59	92.83	2399
52.0	33.5	33.5	1.78	0.59	93.42	2405
52.3	33.5	33.5	1.78	0.59	94.01	2412
52.7	33.5	33.5	1.78	0.59	94.59	2419
53.0	33.5	33.5	1.78	0.59	95.18	2426
53.3	33.5	33.5	1.78	0.59	95.77	2432
53.7	33.5	33.5	1.78	0.59	96.36	2439
54.0	33.5	33.5	1.78	0.59	96.94	2445
54.3	33.0	33.3	1.73	0.57	97.52	2452
54.7	33.0	33.0	1.73	0.57	98.09	2458
55.0	33.0	33.0	1.73	0.57	98.66	2464
55.3	32.5	32.8	1.69	0.56	99.22	2471
55.7	32.5	32.5	1.69	0.56	99.77	2477
56.0	32.5	32.5	1.69	0.56	100.33	2483
56.3	32.5	32.5	1.69	0.56	100.89	2489
56.7	32.5	32.5	1.69	0.56	101.44	2495
57.0	32.0	32.3	1.64	0.54	101.99	2501
57.3	32.0	32.0	1.64	0.54	102.53	2506
57.7	32.0	32.0	1.64	0.54	103.07	2512
58.0	32.0	32.0	1.64	0.54	103.61	2518
58.3	31.5	31.8	1.60	0.53	104.14	2523
58.7	31.5	31.5	1.60	0.53	104.67	2529
59.0	31.5	31.5	1.60	0.53	105.19	2534
59.3	31.5	31.5	1.60	0.53	105.72	2540

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
59.7	31.0	31.3	1.56	0.51	106.24	2545
60.0	31.0	31.0	1.56	0.51	106.75	2551
60.3	31.0	31.0	1.56	0.51	107.26	2556
60.7	31.0	31.0	1.56	0.51	107.78	2561
61.0	30.5	30.8	1.52	0.50	108.28	2566
61.3	30.5	30.5	1.52	0.50	108.78	2571
61.7	30.5	30.5	1.52	0.50	109.28	2576
62.0	30.5	30.5	1.52	0.50	109.78	2581
62.3	30.5	30.5	1.52	0.50	110.28	2586
62.7	30.0	30.3	1.47	0.49	110.76	2591
63.0	30.0	30.0	1.47	0.49	111.25	2596
63.3	30.0	30.0	1.47	0.49	111.74	2601
63.7	30.0	30.0	1.47	0.49	112.23	2606
64.0	29.5	29.8	1.44	0.47	112.70	2610
64.3	29.5	29.5	1.44	0.47	113.17	2615
64.7	29.5	29.5	1.44	0.47	113.65	2620
65.0	29.5	29.5	1.44	0.47	114.12	2624
65.3	29.5	29.5	1.44	0.47	114.59	2629
65.7	29.0	29.3	1.40	0.46	115.05	2633
66.0	29.0	29.0	1.40	0.46	115.52	2638
66.3	29.0	29.0	1.40	0.46	115.98	2642
66.7	29.0	29.0	1.40	0.46	116.44	2647
67.0	29.0	29.0	1.40	0.46	116.90	2651
67.3	28.5	28.8	1.36	0.45	117.35	2655
67.7	28.5	28.5	1.36	0.45	117.80	2659
68.0	28.5	28.5	1.36	0.45	118.24	2664

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
68.3	28.5	28.5	1.36	0.45	118.69	2668
68.7	28.5	28.5	1.36	0.45	119.14	2672
69.0	28.0	28.3	1.32	0.44	119.58	2676
69.3	28.0	28.0	1.32	0.44	120.01	2680
69.7	28.0	28.0	1.32	0.44	120.45	2684
70.0	28.0	28.0	1.32	0.44	120.89	2688
70.3	28.0	28.0	1.32	0.44	121.32	2692
70.7	27.5	27.8	1.29	0.42	121.75	2696
71.0	27.5	27.5	1.29	0.42	122.17	2700
71.3	27.5	27.5	1.29	0.42	122.60	2704
71.7	27.5	27.5	1.29	0.42	123.02	2708
72.0	27.5	27.5	1.29	0.42	123.45	2712
72.3	27.0	27.3	1.25	0.41	123.86	2715
72.7	27.0	27.0	1.25	0.41	124.27	2719
73.0	27.0	27.0	1.25	0.41	124.68	2723
73.3	27.0	27.0	1.25	0.41	125.10	2726
73.7	27.0	27.0	1.25	0.41	125.51	2730
74.0	27.0	27.0	1.25	0.41	125.92	2734
74.3	27.0	27.0	1.25	0.41	126.34	2737
74.7	27.0	27.0	1.25	0.41	126.75	2741
75.0	27.0	27.0	1.25	0.41	127.16	2745
75.3	27.0	27.0	1.25	0.41	127.58	2748
75.7	27.0	27.0	1.25	0.41	127.99	2752
76.0	27.0	27.0	1.25	0.41	128.40	2756
76.3	27.0	27.0	1.25	0.41	128.81	2759
76.7	26.5	26.8	1.22	0.40	129.22	2763

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
77.0	26.5	26.5	1.22	0.40	129.62	2766
77.3	26.5	26.5	1.22	0.40	130.02	2770
77.7	26.5	26.5	1.22	0.40	130.42	2773
78.0	26.0	26.3	1.18	0.39	130.81	2776
78.3	26.0	26.0	1.18	0.39	131.20	2780
78.7	26.0	26.0	1.18	0.39	131.59	2783
79.0	26.0	26.0	1.18	0.39	131.98	2786
79.3	26.0	26.0	1.18	0.39	132.37	2790
79.7	26.0	26.0	1.18	0.39	132.77	2793
80.0	26.0	26.0	1.18	0.39	133.16	2796
80.3	25.5	25.8	1.15	0.38	133.54	2799
80.7	25.5	25.5	1.15	0.38	133.92	2803
81.0	25.5	25.5	1.15	0.38	134.30	2806
81.3	25.5	25.5	1.15	0.38	134.68	2809
81.7	25.0	25.3	1.12	0.37	135.04	2812
82.0	25.0	25.0	1.12	0.37	135.41	2815
82.3	25.0	25.0	1.12	0.37	135.78	2818
82.7	25.0	25.0	1.12	0.37	136.15	2821
83.0	24.5	24.8	1.09	0.36	136.51	2824
83.3	24.5	24.5	1.09	0.36	136.87	2827
83.7	24.5	24.5	1.09	0.36	137.23	2830
84.0	24.5	24.5	1.09	0.36	137.59	2833
84.3	24.0	24.3	1.06	0.35	137.94	2836
84.7	24.0	24.0	1.06	0.35	138.29	2839
85.0	24.0	24.0	1.06	0.35	138.64	2841
85.3	24.0	24.0	1.06	0.35	138.99	2844

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
85.7	23.5	23.8	1.03	0.34	139.33	2847
86.0	23.5	23.5	1.03	0.34	139.67	2850
86.3	23.5	23.5	1.03	0.34	140.01	2852
86.7	23.5	23.5	1.03	0.34	140.35	2855
87.0	23.0	23.3	1.00	0.33	140.68	2858
87.3	23.0	23.0	1.00	0.33	141.01	2860
87.7	23.0	23.0	1.00	0.33	141.34	2863
88.0	23.0	23.0	1.00	0.33	141.67	2866
88.3	23.0	23.0	1.00	0.33	142.00	2868
88.7	22.5	22.8	0.97	0.32	142.32	2871
89.0	22.5	22.5	0.97	0.32	142.64	2873
89.3	22.5	22.5	0.97	0.32	142.96	2876
89.7	22.5	22.5	0.97	0.32	143.28	2878
90.0	22.5	22.5	0.97	0.32	143.60	2881
90.3	22.0	22.3	0.94	0.31	143.91	2883
90.7	22.0	22.0	0.94	0.31	144.22	2886
91.0	22.0	22.0	0.94	0.31	144.53	2888
91.3	22.0	22.0	0.94	0.31	144.85	2890
91.7	21.5	21.8	0.92	0.30	145.15	2893
92.0	21.5	21.5	0.92	0.30	145.45	2895
92.3	21.5	21.5	0.92	0.30	145.75	2898
92.7	21.5	21.5	0.92	0.30	146.06	2900
93.0	21.5	21.5	0.92	0.30	146.36	2902
93.3	21.5	21.5	0.92	0.30	146.66	2904
93.7	21.0	21.3	0.89	0.29	146.96	2907
94.0	21.0	21.0	0.89	0.29	147.25	2909

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
94.3	21.0	21.0	0.89	0.29	147.55	2911
94.7	21.0	21.0	0.89	0.29	147.84	2913
95.0	21.0	21.0	0.89	0.29	148.13	2916
95.3	20.5	20.8	0.87	0.29	148.42	2918
95.7	20.5	20.5	0.87	0.29	148.71	2920
96.0	20.5	20.5	0.87	0.29	148.99	2922
96.3	20.5	20.5	0.87	0.29	149.28	2924
96.7	20.5	20.5	0.87	0.29	149.56	2926
97.0	20.5	20.5	0.87	0.29	149.85	2929
97.3	20.5	20.5	0.87	0.29	150.14	2931
97.7	20.5	20.5	0.87	0.29	150.42	2933
98.0	20.5	20.5	0.87	0.29	150.71	2935
98.3	20.5	20.5	0.87	0.29	150.99	2937
98.7	20.5	20.5	0.87	0.29	151.28	2939
99.0	20.5	20.5	0.87	0.29	151.57	2941
99.3	20.5	20.5	0.87	0.29	151.85	2943
99.7	20.5	20.5	0.87	0.29	152.14	2945
100.0	21.0	20.8	0.89	0.29	152.43	2948
100.3	21.0	21.0	0.89	0.29	152.73	2950
100.7	20.5	20.8	0.87	0.29	153.01	2952
101.0	20.5	20.5	0.87	0.29	153.30	2954
101.3	20.5	20.5	0.87	0.29	153.58	2956
101.7	20.5	20.5	0.87	0.29	153.87	2958
102.0	20.0	20.3	0.84	0.28	154.15	2960
102.3	20.0	20.0	0.84	0.28	154.43	2962
102.7	20.5	20.3	0.87	0.29	154.71	2964

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
103.0	20.0	20.3	0.84	0.28	154.99	2966
103.3	20.0	20.0	0.84	0.28	155.27	2968
103.7	20.0	20.0	0.84	0.28	155.55	2970
104.0	20.0	20.0	0.84	0.28	155.82	2972
104.3	20.0	20.0	0.84	0.28	156.10	2974
104.7	20.0	20.0	0.84	0.28	156.38	2976
105.0	20.0	20.0	0.84	0.28	156.66	2978
105.3	20.0	20.0	0.84	0.28	156.93	2980
105.7	20.0	20.0	0.84	0.28	157.21	2982
106.0	20.0	20.0	0.84	0.28	157.49	2984
106.3	20.0	20.0	0.84	0.28	157.77	2986
106.7	19.5	19.8	0.82	0.27	158.04	2988
107.0	19.5	19.5	0.82	0.27	158.31	2990
107.3	19.5	19.5	0.82	0.27	158.58	2992
107.7	19.5	19.5	0.82	0.27	158.85	2994
108.0	19.5	19.5	0.82	0.27	159.12	2996
108.3	19.5	19.5	0.82	0.27	159.39	2997
108.7	19.5	19.5	0.82	0.27	159.66	2999
109.0	19.5	19.5	0.82	0.27	159.93	3001
109.3	19.5	19.5	0.82	0.27	160.20	3003
109.7	19.5	19.5	0.82	0.27	160.47	3005
110.0	19.5	19.5	0.82	0.27	160.74	3007
110.3	19.0	19.3	0.79	0.26	161.00	3009
110.7	19.0	19.0	0.79	0.26	161.26	3010
111.0	19.0	19.0	0.79	0.26	161.52	3012
111.3	19.0	19.0	0.79	0.26	161.78	3014

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
111.7	19.0	19.0	0.79	0.26	162.05	3016
112.0	19.0	19.0	0.79	0.26	162.31	3018
112.3	19.0	19.0	0.79	0.26	162.57	3020
112.7	19.0	19.0	0.79	0.26	162.83	3021
113.0	19.0	19.0	0.79	0.26	163.09	3023
113.3	19.0	19.0	0.79	0.26	163.36	3025
113.7	19.0	19.0	0.79	0.26	163.62	3027
114.0	19.0	19.0	0.79	0.26	163.88	3028
114.3	19.0	19.0	0.79	0.26	164.14	3030
114.7	19.0	19.0	0.79	0.26	164.40	3032
115.0	19.0	19.0	0.79	0.26	164.67	3034
115.3	18.5	18.8	0.77	0.25	164.92	3035
115.7	18.5	18.5	0.77	0.25	165.18	3037
116.0	18.5	18.5	0.77	0.25	165.43	3039
116.3	18.5	18.5	0.77	0.25	165.68	3041
116.7	18.5	18.5	0.77	0.25	165.94	3042
117.0	18.5	18.5	0.77	0.25	166.19	3044
117.3	18.5	18.5	0.77	0.25	166.45	3046
117.7	18.5	18.5	0.77	0.25	166.70	3047
118.0	18.5	18.5	0.77	0.25	166.96	3049
118.3	18.5	18.5	0.77	0.25	167.21	3051
118.7	18.5	18.5	0.77	0.25	167.47	3053
119.0	18.5	18.5	0.77	0.25	167.72	3054
119.3	18.5	18.5	0.77	0.25	167.98	3056
119.7	18.5	18.5	0.77	0.25	168.23	3058
120.0	18.5	18.5	0.77	0.25	168.48	3059

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
120.3	18.5	18.5	0.77	0.25	168.74	3061
120.7	18.5	18.5	0.77	0.25	168.99	3063
121.0	18.0	18.3	0.75	0.25	169.24	3064
121.3	18.0	18.0	0.75	0.25	169.49	3066
121.7	18.0	18.0	0.75	0.25	169.74	3067
122.0	18.0	18.0	0.75	0.25	169.98	3069
122.3	18.0	18.0	0.75	0.25	170.23	3071
122.7	18.0	18.0	0.75	0.25	170.48	3072
123.0	18.0	18.0	0.75	0.25	170.72	3074
123.3	18.0	18.0	0.75	0.25	170.97	3076
123.7	18.5	18.3	0.77	0.25	171.23	3077
124.0	18.5	18.5	0.77	0.25	171.48	3079
124.3	18.5	18.5	0.77	0.25	171.73	3080
124.7	18.5	18.5	0.77	0.25	171.99	3082
125.0	18.5	18.5	0.77	0.25	172.24	3084
125.3	18.5	18.5	0.77	0.25	172.50	3085
125.7	18.5	18.5	0.77	0.25	172.75	3087
126.0	18.5	18.5	0.77	0.25	173.01	3089
126.3	18.5	18.5	0.77	0.25	173.26	3090
126.7	18.5	18.5	0.77	0.25	173.52	3092
127.0	18.5	18.5	0.77	0.25	173.77	3094
127.3	18.5	18.5	0.77	0.25	174.03	3095
127.7	18.5	18.5	0.77	0.25	174.28	3097
128.0	18.5	18.5	0.77	0.25	174.53	3098
128.3	18.5	18.5	0.77	0.25	174.79	3100
128.7	18.5	18.5	0.77	0.25	175.04	3102

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
129.0	18.5	18.5	0.77	0.25	175.30	3103
129.3	18.5	18.5	0.77	0.25	175.55	3105
129.7	18.0	18.3	0.75	0.25	175.80	3106
130.0	18.0	18.0	0.75	0.25	176.05	3108
130.3	18.0	18.0	0.75	0.25	176.29	3109
130.7	18.0	18.0	0.75	0.25	176.54	3111
131.0	18.0	18.0	0.75	0.25	176.79	3113
131.3	18.0	18.0	0.75	0.25	177.04	3114
131.7	18.0	18.0	0.75	0.25	177.28	3116
132.0	18.0	18.0	0.75	0.25	177.53	3117
132.3	18.0	18.0	0.75	0.25	177.78	3119
132.7	18.0	18.0	0.75	0.25	178.02	3120
133.0	18.0	18.0	0.75	0.25	178.27	3122
133.3	18.0	18.0	0.75	0.25	178.52	3123
133.7	18.0	18.0	0.75	0.25	178.77	3125
134.0	18.0	18.0	0.75	0.25	179.01	3126
134.3	18.0	18.0	0.75	0.25	179.26	3128
134.7	18.0	18.0	0.75	0.25	179.51	3129
135.0	18.0	18.0	0.75	0.25	179.75	3131
135.3	18.0	18.0	0.75	0.25	180.00	3132
135.7	18.0	18.0	0.75	0.25	180.25	3134
136.0	18.0	18.0	0.75	0.25	180.50	3135
136.3	18.0	18.0	0.75	0.25	180.74	3137
136.7	17.5	17.8	0.73	0.24	180.98	3138
137.0	17.5	17.5	0.73	0.24	181.22	3140
137.3	17.5	17.5	0.73	0.24	181.46	3141

Age (hours)	Temperature (^{o}C)	Average Temperature (^{o}C)	Age Factor	Eq. Age @ 23^{o}C Increment (hours)	Eq. Age @ 23^{o}C Cumulative (hours)	Predicted Compressive Strength (psi)
137.7	17.5	17.5	0.73	0.24	181.70	3143
138.0	17.5	17.5	0.73	0.24	181.94	3144
138.3	17.5	17.5	0.73	0.24	182.18	3146
138.7	17.5	17.5	0.73	0.24	182.42	3147
139.0	17.5	17.5	0.73	0.24	182.66	3149
139.3	17.5	17.5	0.73	0.24	182.90	3150
139.7	17.5	17.5	0.73	0.24	183.14	3152
140.0	17.5	17.5	0.73	0.24	183.38	3153
140.3	17.5	17.5	0.73	0.24	183.62	3154
140.7	17.5	17.5	0.73	0.24	183.86	3156
141.0	17.5	17.5	0.73	0.24	184.10	3157
141.3	17.5	17.5	0.73	0.24	184.34	3159
141.7	17.5	17.5	0.73	0.24	184.58	3160
142.0	17.5	17.5	0.73	0.24	184.82	3162
142.3	17.0	17.3	0.71	0.23	185.06	3163
142.7	17.0	17.0	0.71	0.23	185.29	3164
143.0	17.0	17.0	0.71	0.23	185.52	3166
143.3	17.0	17.0	0.71	0.23	185.75	3167
143.7	17.0	17.0	0.71	0.23	185.99	3168
144.0	17.0	17.0	0.71	0.23	186.22	3170
144.3	17.0	17.0	0.71	0.23	186.45	3171
144.7	17.0	17.0	0.71	0.23	186.69	3173
145.0	17.0	17.0	0.71	0.23	186.92	3174
145.3	17.5	17.3	0.73	0.24	187.16	3175
145.7	17.5	17.5	0.73	0.24	187.40	3177
146.0	17.5	17.5	0.73	0.24	187.64	3178

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
146.3	17.5	17.5	0.73	0.24	187.88	3180
146.7	17.5	17.5	0.73	0.24	188.12	3181
147.0	18.0	17.8	0.75	0.25	188.37	3182
147.3	18.0	18.0	0.75	0.25	188.61	3184
147.7	18.0	18.0	0.75	0.25	188.86	3185
148.0	18.0	18.0	0.75	0.25	189.11	3187
148.3	18.5	18.3	0.77	0.25	189.36	3188
148.7	18.5	18.5	0.77	0.25	189.62	3190
149.0	18.5	18.5	0.77	0.25	189.87	3191
149.3	18.5	18.5	0.77	0.25	190.13	3193
149.7	19.0	18.8	0.79	0.26	190.39	3194
150.0	19.0	19.0	0.79	0.26	190.65	3196
150.3	19.0	19.0	0.79	0.26	190.91	3197
150.7	19.0	19.0	0.79	0.26	191.17	3199
151.0	19.0	19.0	0.79	0.26	191.44	3200
151.3	19.0	19.0	0.79	0.26	191.70	3202
151.7	19.0	19.0	0.79	0.26	191.96	3203
152.0	19.0	19.0	0.79	0.26	192.22	3205
152.3	19.0	19.0	0.79	0.26	192.49	3206
152.7	19.0	19.0	0.79	0.26	192.75	3208
153.0	19.0	19.0	0.79	0.26	193.01	3209
153.3	19.0	19.0	0.79	0.26	193.27	3211
153.7	19.0	19.0	0.79	0.26	193.53	3212
154.0	19.0	19.0	0.79	0.26	193.80	3213
154.3	19.0	19.0	0.79	0.26	194.06	3215
154.7	19.0	19.0	0.79	0.26	194.32	3216

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
155.0	19.0	19.0	0.79	0.26	194.58	3218
155.3	19.0	19.0	0.79	0.26	194.84	3219
155.7	18.5	18.8	0.77	0.25	195.10	3221
156.0	18.5	18.5	0.77	0.25	195.35	3222
156.3	18.5	18.5	0.77	0.25	195.61	3224
156.7	18.5	18.5	0.77	0.25	195.86	3225
157.0	18.5	18.5	0.77	0.25	196.12	3226
157.3	18.5	18.5	0.77	0.25	196.37	3228
157.7	18.5	18.5	0.77	0.25	196.63	3229
158.0	18.5	18.5	0.77	0.25	196.88	3231
158.3	18.5	18.5	0.77	0.25	197.13	3232
158.7	18.5	18.5	0.77	0.25	197.39	3234
159.0	18.5	18.5	0.77	0.25	197.64	3235
159.3	18.5	18.5	0.77	0.25	197.90	3236
159.7	18.5	18.5	0.77	0.25	198.15	3238
160.0	18.5	18.5	0.77	0.25	198.41	3239
160.3	18.5	18.5	0.77	0.25	198.66	3240
160.7	18.0	18.3	0.75	0.25	198.91	3242
161.0	18.0	18.0	0.75	0.25	199.16	3243
161.3	18.0	18.0	0.75	0.25	199.40	3245
161.7	18.0	18.0	0.75	0.25	199.65	3246
162.0	18.0	18.0	0.75	0.25	199.90	3247
162.3	18.0	18.0	0.75	0.25	200.14	3249
162.7	18.0	18.0	0.75	0.25	200.39	3250
163.0	18.0	18.0	0.75	0.25	200.64	3251
163.3	18.0	18.0	0.75	0.25	200.89	3253

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
163.7	18.0	18.0	0.75	0.25	201.13	3254
164.0	18.0	18.0	0.75	0.25	201.38	3255
164.3	18.0	18.0	0.75	0.25	201.63	3257
164.7	18.0	18.0	0.75	0.25	201.88	3258
165.0	17.5	17.8	0.73	0.24	202.12	3259
165.3	17.5	17.5	0.73	0.24	202.36	3260
165.7	17.5	17.5	0.73	0.24	202.60	3262
166.0	17.5	17.5	0.73	0.24	202.84	3263
166.3	17.5	17.5	0.73	0.24	203.08	3264
166.7	17.5	17.5	0.73	0.24	203.32	3266
167.0	17.5	17.5	0.73	0.24	203.56	3267
167.3	17.5	17.5	0.73	0.24	203.80	3268
167.7	17.5	17.5	0.73	0.24	204.04	3269
168.0	17.5	17.5	0.73	0.24	204.28	3271

Table E.5 Maturity calculations 35% FA-A-block

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
0.0	12.8	-	-		0	0.00
0.3	14.5	13.6	0.83	0.27	0.27	502
0.7	14.5	14.5	0.83	0.27	0.55	505
1.0	15.0	14.8	0.84	0.28	0.82	508
1.3	15.0	15.0	0.84	0.28	1.10	511
1.7	15.0	15.0	0.84	0.28	1.38	514
2.0	15.5	15.3	0.85	0.28	1.66	518
2.3	15.5	15.5	0.85	0.28	1.94	521
2.7	16.0	15.8	0.86	0.28	2.22	524
3.0	16.0	16.0	0.86	0.28	2.50	527
3.3	16.5	16.3	0.87	0.29	2.79	531
3.7	16.5	16.5	0.87	0.29	3.08	534
4.0	17.0	16.8	0.88	0.29	3.37	537
4.3	17.0	17.0	0.88	0.29	3.65	541
4.7	17.5	17.3	0.89	0.29	3.95	544
5.0	17.5	17.5	0.89	0.29	4.24	547
5.3	18.0	17.8	0.90	0.30	4.54	551
5.7	18.5	18.3	0.91	0.30	4.84	554
6.0	18.5	18.5	0.91	0.30	5.13	558
6.3	19.0	18.8	0.92	0.30	5.44	561
6.7	19.5	19.3	0.93	0.31	5.74	564
7.0	19.5	19.5	0.93	0.31	6.05	568

Age (hours)	**Temperature (^{o}C)**	**Average Temperature (^{o}C)**	**Age Factor**	**Eq. Age @ 23^{o}C Increment (hours)**	**Eq. Age @ 23^{o}C Cumulative (hours)**	**Predicted Compressive Strength (psi)**
7.3	20.0	19.8	0.94	0.31	6.36	571
7.7	20.5	20.3	0.95	0.31	6.67	575
8.0	21.0	20.8	0.96	0.32	6.99	579
8.3	21.5	21.3	0.97	0.32	7.31	582
8.7	22.0	21.8	0.98	0.32	7.63	586
9.0	22.5	22.3	0.99	0.33	7.96	589
9.3	23.0	22.8	1.00	0.33	8.29	593
9.7	23.5	23.3	1.01	0.33	8.62	597
10.0	24.5	24.0	1.03	0.34	8.96	601
10.3	25.0	24.8	1.04	0.34	9.30	605
10.7	26.0	25.5	1.07	0.35	9.66	608
11.0	26.5	26.3	1.08	0.36	10.01	612
11.3	27.0	26.8	1.09	0.36	10.37	616
11.7	27.5	27.3	1.10	0.36	10.73	620
12.0	27.5	27.5	1.10	0.36	11.10	625
12.3	28.0	27.8	1.11	0.37	11.46	629
12.7	28.5	28.3	1.12	0.37	11.83	633
13.0	28.5	28.5	1.12	0.37	12.20	637
13.3	29.0	28.8	1.13	0.37	12.58	641
13.7	29.0	29.0	1.13	0.37	12.95	645
14.0	29.5	29.3	1.15	0.38	13.33	649
14.3	29.5	29.5	1.15	0.38	13.71	653
14.7	30.0	29.8	1.16	0.38	14.09	657
15.0	30.0	30.0	1.16	0.38	14.47	662
15.3	30.0	30.0	1.16	0.38	14.85	666
15.7	30.5	30.3	1.17	0.39	15.24	670

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
16.0	30.5	30.5	1.17	0.39	15.63	674
16.3	30.5	30.5	1.17	0.39	16.01	678
16.7	31.0	30.8	1.18	0.39	16.40	683
17.0	31.0	31.0	1.18	0.39	16.79	687
17.3	31.0	31.0	1.18	0.39	17.18	691
17.7	31.5	31.3	1.19	0.39	17.58	695
18.0	31.5	31.5	1.19	0.39	17.97	700
18.3	31.5	31.5	1.19	0.39	18.36	704
18.7	31.5	31.5	1.19	0.39	18.76	708
19.0	32.0	31.8	1.21	0.40	19.16	712
19.3	32.0	32.0	1.21	0.40	19.55	716
19.7	32.0	32.0	1.21	0.40	19.95	721
20.0	32.0	32.0	1.21	0.40	20.35	725
20.3	32.0	32.0	1.21	0.40	20.75	729
20.7	32.0	32.0	1.21	0.40	21.14	733
21.0	32.5	32.3	1.22	0.40	21.55	738
21.3	32.5	32.5	1.22	0.40	21.95	742
21.7	32.5	32.5	1.22	0.40	22.35	746
22.0	32.5	32.5	1.22	0.40	22.75	750
22.3	32.5	32.5	1.22	0.40	23.15	755
22.7	32.5	32.5	1.22	0.40	23.56	759
23.0	32.5	32.5	1.22	0.40	23.96	763
23.3	32.5	32.5	1.22	0.40	24.36	767
23.7	33.0	32.8	1.23	0.41	24.77	771
24.0	33.0	33.0	1.23	0.41	25.17	776
24.3	33.0	33.0	1.23	0.41	25.58	780

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
24.7	33.0	33.0	1.23	0.41	25.98	784
25.0	33.0	33.0	1.23	0.41	26.39	788
25.3	33.0	33.0	1.23	0.41	26.80	793
25.7	33.0	33.0	1.23	0.41	27.20	797
26.0	33.0	33.0	1.23	0.41	27.61	801
26.3	33.0	33.0	1.23	0.41	28.01	805
26.7	33.0	33.0	1.23	0.41	28.42	809
27.0	33.0	33.0	1.23	0.41	28.83	813
27.3	33.0	33.0	1.23	0.41	29.23	818
27.7	33.0	33.0	1.23	0.41	29.64	822
28.0	33.0	33.0	1.23	0.41	30.04	826
28.3	33.0	33.0	1.23	0.41	30.45	830
28.7	33.0	33.0	1.23	0.41	30.86	834
29.0	33.0	33.0	1.23	0.41	31.26	838
29.3	33.0	33.0	1.23	0.41	31.67	842
29.7	33.0	33.0	1.23	0.41	32.07	846
30.0	33.0	33.0	1.23	0.41	32.48	851
30.3	33.0	33.0	1.23	0.41	32.89	855
30.7	33.0	33.0	1.23	0.41	33.29	859
31.0	33.0	33.0	1.23	0.41	33.70	863
31.3	33.0	33.0	1.23	0.41	34.10	867
31.7	33.0	33.0	1.23	0.41	34.51	871
32.0	33.0	33.0	1.23	0.41	34.91	875
32.3	33.0	33.0	1.23	0.41	35.32	879
32.7	33.0	33.0	1.23	0.41	35.73	883
33.0	33.0	33.0	1.23	0.41	36.13	887

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
33.3	33.0	33.0	1.23	0.41	36.54	891
33.7	33.0	33.0	1.23	0.41	36.94	895
34.0	33.0	33.0	1.23	0.41	37.35	899
34.3	33.0	33.0	1.23	0.41	37.76	903
34.7	32.5	32.8	1.22	0.40	38.16	907
35.0	32.5	32.5	1.22	0.40	38.56	911
35.3	32.5	32.5	1.22	0.40	38.96	915
35.7	32.5	32.5	1.22	0.40	39.36	919
36.0	32.5	32.5	1.22	0.40	39.77	923
36.3	32.5	32.5	1.22	0.40	40.17	927
36.7	32.5	32.5	1.22	0.40	40.57	931
37.0	32.5	32.5	1.22	0.40	40.97	935
37.3	32.5	32.5	1.22	0.40	41.37	939
37.7	32.5	32.5	1.22	0.40	41.78	943
38.0	32.0	32.3	1.21	0.40	42.17	946
38.3	32.0	32.0	1.21	0.40	42.57	950
38.7	32.0	32.0	1.21	0.40	42.97	954
39.0	32.0	32.0	1.21	0.40	43.37	958
39.3	32.0	32.0	1.21	0.40	43.77	962
39.7	32.0	32.0	1.21	0.40	44.16	966
40.0	32.0	32.0	1.21	0.40	44.56	969
40.3	32.0	32.0	1.21	0.40	44.96	973
40.7	32.0	32.0	1.21	0.40	45.36	977
41.0	32.0	32.0	1.21	0.40	45.75	981
41.3	31.5	31.8	1.19	0.39	46.15	984
41.7	31.5	31.5	1.19	0.39	46.54	988

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
42.0	31.5	31.5	1.19	0.39	46.94	992
42.3	31.5	31.5	1.19	0.39	47.33	996
42.7	31.5	31.5	1.19	0.39	47.72	999
43.0	31.5	31.5	1.19	0.39	48.12	1003
43.3	31.5	31.5	1.19	0.39	48.51	1007
43.7	31.5	31.5	1.19	0.39	48.91	1011
44.0	31.5	31.5	1.19	0.39	49.30	1014
44.3	31.5	31.5	1.19	0.39	49.69	1018
44.7	31.0	31.3	1.18	0.39	50.08	1022
45.0	31.0	31.0	1.18	0.39	50.47	1025
45.3	31.0	31.0	1.18	0.39	50.86	1029
45.7	31.0	31.0	1.18	0.39	51.25	1033
46.0	31.0	31.0	1.18	0.39	51.64	1036
46.3	31.0	31.0	1.18	0.39	52.03	1040
46.7	31.0	31.0	1.18	0.39	52.42	1043
47.0	31.0	31.0	1.18	0.39	52.81	1047
47.3	31.0	31.0	1.18	0.39	53.20	1051
47.7	31.0	31.0	1.18	0.39	53.59	1054
48.0	31.0	31.0	1.18	0.39	53.98	1058
48.3	31.0	31.0	1.18	0.39	54.37	1061
48.7	31.0	31.0	1.18	0.39	54.76	1065
49.0	31.0	31.0	1.18	0.39	55.15	1069
49.3	31.0	31.0	1.18	0.39	55.54	1072
49.7	30.5	30.8	1.17	0.39	55.93	1076
50.0	30.5	30.5	1.17	0.39	56.31	1079
50.3	30.5	30.5	1.17	0.39	56.70	1083

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
50.7	30.5	30.5	1.17	0.39	57.09	1086
51.0	30.5	30.5	1.17	0.39	57.47	1090
51.3	30.5	30.5	1.17	0.39	57.86	1093
51.7	30.5	30.5	1.17	0.39	58.24	1097
52.0	30.5	30.5	1.17	0.39	58.63	1100
52.3	30.5	30.5	1.17	0.39	59.02	1104
52.7	30.5	30.5	1.17	0.39	59.40	1107
53.0	30.5	30.5	1.17	0.39	59.79	1111
53.3	30.5	30.5	1.17	0.39	60.17	1114
53.7	30.0	30.3	1.16	0.38	60.56	1118
54.0	30.0	30.0	1.16	0.38	60.94	1121
54.3	30.0	30.0	1.16	0.38	61.32	1124
54.7	30.0	30.0	1.16	0.38	61.70	1128
55.0	30.0	30.0	1.16	0.38	62.08	1131
55.3	30.0	30.0	1.16	0.38	62.47	1135
55.7	29.5	29.8	1.15	0.38	62.84	1138
56.0	29.5	29.5	1.15	0.38	63.22	1141
56.3	29.5	29.5	1.15	0.38	63.60	1145
56.7	29.5	29.5	1.15	0.38	63.98	1148
57.0	29.5	29.5	1.15	0.38	64.36	1151
57.3	29.0	29.3	1.13	0.37	64.73	1155
57.7	29.0	29.0	1.13	0.37	65.10	1158
58.0	29.0	29.0	1.13	0.37	65.48	1161
58.3	29.0	29.0	1.13	0.37	65.85	1165
58.7	29.0	29.0	1.13	0.37	66.23	1168
59.0	28.5	28.8	1.12	0.37	66.60	1171

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
59.3	28.5	28.5	1.12	0.37	66.97	1174
59.7	28.5	28.5	1.12	0.37	67.34	1178
60.0	28.5	28.5	1.12	0.37	67.71	1181
60.3	28.5	28.5	1.12	0.37	68.08	1184
60.7	28.5	28.5	1.12	0.37	68.45	1187
61.0	28.0	28.3	1.11	0.37	68.82	1190
61.3	28.0	28.0	1.11	0.37	69.18	1194
61.7	28.0	28.0	1.11	0.37	69.55	1197
62.0	28.0	28.0	1.11	0.37	69.92	1200
62.3	28.0	28.0	1.11	0.37	70.28	1203
62.7	27.5	27.8	1.10	0.36	70.65	1206
63.0	27.5	27.5	1.10	0.36	71.01	1209
63.3	27.5	27.5	1.10	0.36	71.37	1213
63.7	27.5	27.5	1.10	0.36	71.74	1216
64.0	27.5	27.5	1.10	0.36	72.10	1219
64.3	27.0	27.3	1.09	0.36	72.46	1222
64.7	27.0	27.0	1.09	0.36	72.82	1225
65.0	27.0	27.0	1.09	0.36	73.18	1228
65.3	27.0	27.0	1.09	0.36	73.53	1231
65.7	27.0	27.0	1.09	0.36	73.89	1234
66.0	27.0	27.0	1.09	0.36	74.25	1237
66.3	26.5	26.8	1.08	0.36	74.61	1240
66.7	26.5	26.5	1.08	0.36	74.96	1243
67.0	26.5	26.5	1.08	0.36	75.32	1246
67.3	26.5	26.5	1.08	0.36	75.67	1249
67.7	26.5	26.5	1.08	0.36	76.03	1252

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
68.0	26.0	26.3	1.07	0.35	76.38	1255
68.3	26.0	26.0	1.07	0.35	76.73	1258
68.7	26.0	26.0	1.07	0.35	77.08	1261
69.0	26.0	26.0	1.07	0.35	77.44	1264
69.3	26.0	26.0	1.07	0.35	77.79	1267
69.7	26.0	26.0	1.07	0.35	78.14	1270
70.0	25.5	25.8	1.05	0.35	78.49	1273
70.3	25.5	25.5	1.05	0.35	78.84	1276
70.7	25.5	25.5	1.05	0.35	79.18	1279
71.0	25.5	25.5	1.05	0.35	79.53	1281
71.3	25.5	25.5	1.05	0.35	79.88	1284
71.7	25.5	25.5	1.05	0.35	80.23	1287
72.0	25.5	25.5	1.05	0.35	80.58	1290
72.3	25.5	25.5	1.05	0.35	80.92	1293
72.7	25.5	25.5	1.05	0.35	81.27	1296
73.0	25.5	25.5	1.05	0.35	81.62	1299
73.3	25.5	25.5	1.05	0.35	81.97	1302
73.7	25.5	25.5	1.05	0.35	82.32	1304
74.0	25.0	25.3	1.04	0.34	82.66	1307
74.3	25.0	25.0	1.04	0.34	83.00	1310
74.7	25.0	25.0	1.04	0.34	83.35	1313
75.0	25.0	25.0	1.04	0.34	83.69	1316
75.3	25.0	25.0	1.04	0.34	84.04	1319
75.7	25.0	25.0	1.04	0.34	84.38	1321
76.0	25.0	25.0	1.04	0.34	84.73	1324
76.3	25.0	25.0	1.04	0.34	85.07	1327

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
76.7	25.0	25.0	1.04	0.34	85.41	1330
77.0	25.0	25.0	1.04	0.34	85.76	1333
77.3	25.0	25.0	1.04	0.34	86.10	1335
77.7	24.5	24.8	1.03	0.34	86.44	1338
78.0	24.5	24.5	1.03	0.34	86.78	1341
78.3	24.5	24.5	1.03	0.34	87.13	1344
78.7	24.5	24.5	1.03	0.34	87.47	1346
79.0	24.0	24.3	1.02	0.34	87.80	1349
79.3	24.0	24.0	1.02	0.34	88.14	1352
79.7	24.0	24.0	1.02	0.34	88.48	1355
80.0	24.0	24.0	1.02	0.34	88.81	1357
80.3	24.0	24.0	1.02	0.34	89.15	1360
80.7	23.5	23.8	1.01	0.33	89.49	1363
81.0	23.5	23.5	1.01	0.33	89.82	1365
81.3	23.5	23.5	1.01	0.33	90.15	1368
81.7	23.5	23.5	1.01	0.33	90.49	1371
82.0	23.5	23.5	1.01	0.33	90.82	1373
82.3	23.0	23.3	1.00	0.33	91.15	1376
82.7	23.0	23.0	1.00	0.33	91.48	1379
83.0	23.0	23.0	1.00	0.33	91.81	1381
83.3	23.0	23.0	1.00	0.33	92.14	1384
83.7	23.0	23.0	1.00	0.33	92.47	1386
84.0	22.5	22.8	0.99	0.33	92.80	1389
84.3	22.5	22.5	0.99	0.33	93.12	1392
84.7	22.5	22.5	0.99	0.33	93.45	1394
85.0	22.5	22.5	0.99	0.33	93.78	1397

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
85.3	22.5	22.5	0.99	0.33	94.10	1399
85.7	22.0	22.3	0.98	0.32	94.42	1402
86.0	22.0	22.0	0.98	0.32	94.75	1404
86.3	22.0	22.0	0.98	0.32	95.07	1407
86.7	22.0	22.0	0.98	0.32	95.39	1409
87.0	22.0	22.0	0.98	0.32	95.72	1412
87.3	21.5	21.8	0.97	0.32	96.04	1414
87.7	21.5	21.5	0.97	0.32	96.36	1417
88.0	21.5	21.5	0.97	0.32	96.68	1419
88.3	21.5	21.5	0.97	0.32	96.99	1422
88.7	21.5	21.5	0.97	0.32	97.31	1424
89.0	21.0	21.3	0.96	0.32	97.63	1427
89.3	21.0	21.0	0.96	0.32	97.95	1429
89.7	21.0	21.0	0.96	0.32	98.26	1432
90.0	21.0	21.0	0.96	0.32	98.58	1434
90.3	21.0	21.0	0.96	0.32	98.89	1437
90.7	21.0	21.0	0.96	0.32	99.21	1439
91.0	20.5	20.8	0.95	0.31	99.52	1441
91.3	20.5	20.5	0.95	0.31	99.84	1444
91.7	20.5	20.5	0.95	0.31	100.15	1446
92.0	20.5	20.5	0.95	0.31	100.46	1449
92.3	20.5	20.5	0.95	0.31	100.77	1451
92.7	20.0	20.3	0.94	0.31	101.08	1453
93.0	20.0	20.0	0.94	0.31	101.39	1456
93.3	20.0	20.0	0.94	0.31	101.70	1458
93.7	20.0	20.0	0.94	0.31	102.01	1460

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
94.0	20.0	20.0	0.94	0.31	102.32	1463
94.3	20.0	20.0	0.94	0.31	102.63	1465
94.7	20.0	20.0	0.94	0.31	102.94	1468
95.0	20.0	20.0	0.94	0.31	103.25	1470
95.3	20.5	20.3	0.95	0.31	103.56	1472
95.7	20.5	20.5	0.95	0.31	103.87	1475
96.0	20.5	20.5	0.95	0.31	104.19	1477
96.3	20.5	20.5	0.95	0.31	104.50	1479
96.7	20.5	20.5	0.95	0.31	104.81	1482
97.0	21.0	20.8	0.96	0.32	105.13	1484
97.3	21.0	21.0	0.96	0.32	105.44	1486
97.7	21.0	21.0	0.96	0.32	105.76	1489
98.0	21.0	21.0	0.96	0.32	106.08	1491
98.3	21.0	21.0	0.96	0.32	106.39	1494
98.7	20.5	20.8	0.95	0.31	106.70	1496
99.0	21.0	20.8	0.96	0.32	107.02	1498
99.3	21.0	21.0	0.96	0.32	107.34	1501
99.7	21.5	21.3	0.97	0.32	107.66	1503
100.0	21.5	21.5	0.97	0.32	107.98	1505
100.3	21.5	21.5	0.97	0.32	108.30	1508
100.7	21.5	21.5	0.97	0.32	108.61	1510
101.0	21.5	21.5	0.97	0.32	108.93	1513
101.3	21.5	21.5	0.97	0.32	109.25	1515
101.7	21.5	21.5	0.97	0.32	109.57	1517
102.0	21.5	21.5	0.97	0.32	109.89	1520
102.3	21.5	21.5	0.97	0.32	110.21	1522

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
102.7	21.5	21.5	0.97	0.32	110.53	1524
103.0	21.5	21.5	0.97	0.32	110.85	1527
103.3	21.5	21.5	0.97	0.32	111.17	1529
103.7	21.0	21.3	0.96	0.32	111.49	1531
104.0	21.0	21.0	0.96	0.32	111.80	1534
104.3	21.0	21.0	0.96	0.32	112.12	1536
104.7	21.0	21.0	0.96	0.32	112.43	1538
105.0	21.0	21.0	0.96	0.32	112.75	1541
105.3	21.0	21.0	0.96	0.32	113.07	1543
105.7	21.0	21.0	0.96	0.32	113.38	1545
106.0	21.0	21.0	0.96	0.32	113.70	1548
106.3	21.0	21.0	0.96	0.32	114.02	1550
106.7	21.0	21.0	0.96	0.32	114.33	1552
107.0	21.0	21.0	0.96	0.32	114.65	1555
107.3	20.5	20.8	0.95	0.31	114.96	1557
107.7	20.5	20.5	0.95	0.31	115.27	1559
108.0	20.5	20.5	0.95	0.31	115.59	1561
108.3	20.5	20.5	0.95	0.31	115.90	1564
108.7	20.5	20.5	0.95	0.31	116.21	1566
109.0	20.5	20.5	0.95	0.31	116.52	1568
109.3	20.5	20.5	0.95	0.31	116.84	1571
109.7	20.5	20.5	0.95	0.31	117.15	1573
110.0	20.5	20.5	0.95	0.31	117.46	1575
110.3	20.5	20.5	0.95	0.31	117.77	1577
110.7	20.0	20.3	0.94	0.31	118.08	1579
111.0	20.0	20.0	0.94	0.31	118.39	1582

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
111.3	20.0	20.0	0.94	0.31	118.70	1584
111.7	20.0	20.0	0.94	0.31	119.01	1586
112.0	20.0	20.0	0.94	0.31	119.32	1588
112.3	20.0	20.0	0.94	0.31	119.63	1591
112.7	20.0	20.0	0.94	0.31	119.94	1593
113.0	20.0	20.0	0.94	0.31	120.25	1595
113.3	20.0	20.0	0.94	0.31	120.56	1597
113.7	19.5	19.8	0.93	0.31	120.86	1599
114.0	19.5	19.5	0.93	0.31	121.17	1602
114.3	19.5	19.5	0.93	0.31	121.48	1604
114.7	19.5	19.5	0.93	0.31	121.78	1606
115.0	19.5	19.5	0.93	0.31	122.09	1608
115.3	19.5	19.5	0.93	0.31	122.39	1610
115.7	19.5	19.5	0.93	0.31	122.70	1612
116.0	19.5	19.5	0.93	0.31	123.00	1615
116.3	19.0	19.3	0.92	0.30	123.31	1617
116.7	19.0	19.0	0.92	0.30	123.61	1619
117.0	19.0	19.0	0.92	0.30	123.91	1621
117.3	19.0	19.0	0.92	0.30	124.21	1623
117.7	19.0	19.0	0.92	0.30	124.52	1625
118.0	19.0	19.0	0.92	0.30	124.82	1627
118.3	19.0	19.0	0.92	0.30	125.12	1629
118.7	19.0	19.0	0.92	0.30	125.42	1632
119.0	19.0	19.0	0.92	0.30	125.73	1634
119.3	19.0	19.0	0.92	0.30	126.03	1636
119.7	19.0	19.0	0.92	0.30	126.33	1638

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
120.0	19.5	19.3	0.93	0.31	126.64	1640
120.3	19.5	19.5	0.93	0.31	126.94	1642
120.7	19.5	19.5	0.93	0.31	127.25	1644
121.0	19.5	19.5	0.93	0.31	127.56	1646
121.3	19.5	19.5	0.93	0.31	127.86	1649
121.7	19.5	19.5	0.93	0.31	128.17	1651
122.0	19.5	19.5	0.93	0.31	128.47	1653
122.3	19.5	19.5	0.93	0.31	128.78	1655
122.7	20.0	19.8	0.94	0.31	129.09	1657
123.0	20.0	20.0	0.94	0.31	129.40	1659
123.3	20.0	20.0	0.94	0.31	129.71	1661
123.7	20.0	20.0	0.94	0.31	130.02	1663
124.0	20.0	20.0	0.94	0.31	130.33	1666
124.3	20.0	20.0	0.94	0.31	130.64	1668
124.7	20.5	20.3	0.95	0.31	130.95	1670
125.0	20.0	20.3	0.94	0.31	131.26	1672
125.3	20.0	20.0	0.94	0.31	131.57	1674
125.7	20.0	20.0	0.94	0.31	131.88	1676
126.0	20.0	20.0	0.94	0.31	132.19	1678
126.3	20.0	20.0	0.94	0.31	132.49	1680
126.7	20.0	20.0	0.94	0.31	132.80	1683
127.0	20.0	20.0	0.94	0.31	133.11	1685
127.3	20.0	20.0	0.94	0.31	133.42	1687
127.7	20.0	20.0	0.94	0.31	133.73	1689
128.0	20.0	20.0	0.94	0.31	134.04	1691
128.3	20.0	20.0	0.94	0.31	134.35	1693

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
128.7	20.0	20.0	0.94	0.31	134.66	1695
129.0	20.0	20.0	0.94	0.31	134.97	1697
129.3	20.0	20.0	0.94	0.31	135.28	1699
129.7	20.0	20.0	0.94	0.31	135.59	1701
130.0	19.5	19.8	0.93	0.31	135.89	1704
130.3	19.5	19.5	0.93	0.31	136.20	1706
130.7	19.5	19.5	0.93	0.31	136.50	1708
131.0	19.5	19.5	0.93	0.31	136.81	1710
131.3	19.5	19.5	0.93	0.31	137.12	1712
131.7	19.5	19.5	0.93	0.31	137.42	1714
132.0	19.5	19.5	0.93	0.31	137.73	1716
132.3	19.5	19.5	0.93	0.31	138.03	1718
132.7	19.5	19.5	0.93	0.31	138.34	1720
133.0	19.5	19.5	0.93	0.31	138.65	1722
133.3	19.5	19.5	0.93	0.31	138.95	1724
133.7	19.5	19.5	0.93	0.31	139.26	1726
134.0	19.5	19.5	0.93	0.31	139.56	1728
134.3	19.5	19.5	0.93	0.31	139.87	1730
134.7	19.5	19.5	0.93	0.31	140.18	1732
135.0	19.5	19.5	0.93	0.31	140.48	1734
135.3	19.5	19.5	0.93	0.31	140.79	1736
135.7	19.5	19.5	0.93	0.31	141.09	1738
136.0	19.5	19.5	0.93	0.31	141.40	1740
136.3	19.0	19.3	0.92	0.30	141.70	1742
136.7	19.0	19.0	0.92	0.30	142.00	1744
137.0	19.0	19.0	0.92	0.30	142.31	1746

Age (hours)	Temperature (^{o}C)	Average Temperature (^{o}C)	Age Factor	Eq. Age @ 23^{o}C Increment (hours)	Eq. Age @ 23^{o}C Cumulative (hours)	Predicted Compressive Strength (psi)
137.3	19.0	19.0	0.92	0.30	142.61	1748
137.7	19.0	19.0	0.92	0.30	142.91	1750
138.0	19.0	19.0	0.92	0.30	143.21	1752
138.3	19.0	19.0	0.92	0.30	143.52	1754
138.7	19.0	19.0	0.92	0.30	143.82	1756
139.0	19.0	19.0	0.92	0.30	144.12	1758
139.3	19.0	19.0	0.92	0.30	144.42	1760
139.7	19.0	19.0	0.92	0.30	144.73	1762
140.0	19.0	19.0	0.92	0.30	145.03	1764
140.3	19.0	19.0	0.92	0.30	145.33	1766
140.7	19.0	19.0	0.92	0.30	145.63	1768
141.0	19.0	19.0	0.92	0.30	145.94	1770
141.3	19.0	19.0	0.92	0.30	146.24	1772
141.7	19.0	19.0	0.92	0.30	146.54	1774
142.0	19.0	19.0	0.92	0.30	146.84	1776
142.3	19.0	19.0	0.92	0.30	147.15	1778
142.7	19.0	19.0	0.92	0.30	147.45	1780
143.0	19.0	19.0	0.92	0.30	147.75	1782
143.3	19.0	19.0	0.92	0.30	148.06	1784
143.7	19.0	19.0	0.92	0.30	148.36	1786
144.0	19.0	19.0	0.92	0.30	148.66	1788
144.3	19.0	19.0	0.92	0.30	148.96	1790
144.7	19.5	19.3	0.93	0.31	149.27	1792
145.0	19.5	19.5	0.93	0.31	149.57	1794
145.3	19.5	19.5	0.93	0.31	149.88	1796
145.7	19.5	19.5	0.93	0.31	150.19	1798

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
146.0	20.0	19.8	0.94	0.31	150.50	1800
146.3	20.0	20.0	0.94	0.31	150.80	1802
146.7	20.0	20.0	0.94	0.31	151.11	1803
147.0	20.0	20.0	0.94	0.31	151.42	1805
147.3	20.0	20.0	0.94	0.31	151.73	1807
147.7	20.0	20.0	0.94	0.31	152.04	1809
148.0	20.0	20.0	0.94	0.31	152.35	1811
148.3	20.0	20.0	0.94	0.31	152.66	1813
148.7	20.0	20.0	0.94	0.31	152.97	1815
149.0	20.0	20.0	0.94	0.31	153.28	1817
149.3	20.0	20.0	0.94	0.31	153.59	1819
149.7	20.0	20.0	0.94	0.31	153.90	1821
150.0	20.0	20.0	0.94	0.31	154.21	1823
150.3	20.0	20.0	0.94	0.31	154.52	1825
150.7	20.0	20.0	0.94	0.31	154.83	1827
151.0	20.0	20.0	0.94	0.31	155.13	1829
151.3	20.0	20.0	0.94	0.31	155.44	1831
151.7	20.0	20.0	0.94	0.31	155.75	1833
152.0	20.0	20.0	0.94	0.31	156.06	1835
152.3	20.0	20.0	0.94	0.31	156.37	1837
152.7	20.0	20.0	0.94	0.31	156.68	1839
153.0	20.0	20.0	0.94	0.31	156.99	1841
153.3	20.0	20.0	0.94	0.31	157.30	1843
153.7	20.0	20.0	0.94	0.31	157.61	1845
154.0	20.0	20.0	0.94	0.31	157.92	1847
154.3	20.0	20.0	0.94	0.31	158.23	1848

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
154.7	20.0	20.0	0.94	0.31	158.54	1850
155.0	20.0	20.0	0.94	0.31	158.85	1852
155.3	20.0	20.0	0.94	0.31	159.16	1854
155.7	20.0	20.0	0.94	0.31	159.46	1856
156.0	19.5	19.8	0.93	0.31	159.77	1858
156.3	19.5	19.5	0.93	0.31	160.08	1860
156.7	19.5	19.5	0.93	0.31	160.38	1862
157.0	19.5	19.5	0.93	0.31	160.69	1864
157.3	19.5	19.5	0.93	0.31	160.99	1866
157.7	19.5	19.5	0.93	0.31	161.30	1868
158.0	19.5	19.5	0.93	0.31	161.61	1869
158.3	19.5	19.5	0.93	0.31	161.91	1871
158.7	19.5	19.5	0.93	0.31	162.22	1873
159.0	19.5	19.5	0.93	0.31	162.52	1875
159.3	19.5	19.5	0.93	0.31	162.83	1877
159.7	19.5	19.5	0.93	0.31	163.14	1879
160.0	19.5	19.5	0.93	0.31	163.44	1881
160.3	19.5	19.5	0.93	0.31	163.75	1883
160.7	19.5	19.5	0.93	0.31	164.05	1884
161.0	19.5	19.5	0.93	0.31	164.36	1886
161.3	19.5	19.5	0.93	0.31	164.66	1888
161.7	19.5	19.5	0.93	0.31	164.97	1890
162.0	19.5	19.5	0.93	0.31	165.28	1892
162.3	19.5	19.5	0.93	0.31	165.58	1894
162.7	19.0	19.3	0.92	0.30	165.88	1896
163.0	19.0	19.0	0.92	0.30	166.19	1897

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
163.3	19.0	19.0	0.92	0.30	166.49	1899
163.7	19.0	19.0	0.92	0.30	166.79	1901
164.0	19.0	19.0	0.92	0.30	167.09	1903
164.3	19.0	19.0	0.92	0.30	167.40	1905
164.7	19.0	19.0	0.92	0.30	167.70	1907
165.0	19.0	19.0	0.92	0.30	168.00	1908
165.3	19.0	19.0	0.92	0.30	168.31	1910
165.7	19.0	19.0	0.92	0.30	168.61	1912
166.0	19.0	19.0	0.92	0.30	168.91	1914
166.3	19.0	19.0	0.92	0.30	169.21	1916
166.7	19.0	19.0	0.92	0.30	169.52	1918
167.0	19.0	19.0	0.92	0.30	169.82	1919
167.3	19.0	19.0	0.92	0.30	170.12	1921
167.7	19.0	19.0	0.92	0.30	170.42	1923
168.0	19.0	19.0	0.92	0.30	170.73	1925

Table E.6 Maturity calculations 50% FA-A-block

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
0.0	13.9	-	-		0	0.00
0.3	16.0	14.9	0.72	0.24	0.24	683
0.7	16.0	16.0	0.72	0.24	0.48	688
1.0	16.0	16.0	0.72	0.24	0.71	694
1.3	16.5	16.3	0.74	0.24	0.96	699
1.7	16.5	16.5	0.74	0.24	1.20	705
2.0	17.0	16.8	0.76	0.25	1.45	710
2.3	17.0	17.0	0.76	0.25	1.70	716
2.7	17.0	17.0	0.76	0.25	1.95	722
3.0	17.5	17.3	0.77	0.26	2.20	727
3.3	17.5	17.5	0.77	0.26	2.46	733
3.7	18.0	17.8	0.79	0.26	2.72	739
4.0	18.0	18.0	0.79	0.26	2.98	745
4.3	18.5	18.3	0.81	0.27	3.25	751
4.7	18.5	18.5	0.81	0.27	3.52	757
5.0	19.0	18.8	0.83	0.27	3.79	763
5.3	19.5	19.3	0.85	0.28	4.07	769
5.7	19.5	19.5	0.85	0.28	4.35	775
6.0	20.0	19.8	0.87	0.29	4.64	781
6.3	20.5	20.3	0.89	0.29	4.93	788
6.7	21.0	20.8	0.91	0.30	5.23	794
7.0	21.0	21.0	0.91	0.30	5.53	801
7.3	21.5	21.3	0.93	0.31	5.84	808

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
7.7	22.5	22.0	0.98	0.32	6.16	815
8.0	23.0	22.8	1.00	0.33	6.49	822
8.3	23.5	23.3	1.02	0.34	6.83	829
8.7	24.0	23.8	1.05	0.35	7.18	837
9.0	24.5	24.3	1.07	0.35	7.53	844
9.3	25.0	24.8	1.10	0.36	7.89	852
9.7	25.5	25.3	1.12	0.37	8.26	860
10.0	25.5	25.5	1.12	0.37	8.63	868
10.3	26.0	25.8	1.15	0.38	9.01	876
10.7	26.0	26.0	1.15	0.38	9.39	884
11.0	26.0	26.0	1.15	0.38	9.77	892
11.3	26.5	26.3	1.17	0.39	10.15	900
11.7	26.5	26.5	1.17	0.39	10.54	908
12.0	27.0	26.8	1.20	0.40	10.93	917
12.3	27.0	27.0	1.20	0.40	11.33	925
12.7	27.0	27.0	1.20	0.40	11.73	933
13.0	27.5	27.3	1.23	0.40	12.13	941
13.3	27.5	27.5	1.23	0.40	12.53	950
13.7	27.5	27.5	1.23	0.40	12.94	958
14.0	28.0	27.8	1.25	0.41	13.35	967
14.3	28.0	28.0	1.25	0.41	13.77	975
14.7	28.0	28.0	1.25	0.41	14.18	984
15.0	28.0	28.0	1.25	0.41	14.59	992
15.3	28.5	28.3	1.28	0.42	15.02	1001
15.7	28.5	28.5	1.28	0.42	15.44	1009
16.0	28.5	28.5	1.28	0.42	15.86	1018

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
16.3	28.5	28.5	1.28	0.42	16.28	1026
16.7	29.0	28.8	1.31	0.43	16.72	1035
17.0	29.0	29.0	1.31	0.43	17.15	1044
17.3	29.0	29.0	1.31	0.43	17.58	1052
17.7	29.0	29.0	1.31	0.43	18.01	1061
18.0	29.0	29.0	1.31	0.43	18.44	1069
18.3	29.5	29.3	1.34	0.44	18.89	1078
18.7	29.5	29.5	1.34	0.44	19.33	1087
19.0	29.5	29.5	1.34	0.44	19.77	1095
19.3	29.5	29.5	1.34	0.44	20.21	1104
19.7	29.5	29.5	1.34	0.44	20.65	1113
20.0	29.5	29.5	1.34	0.44	21.09	1121
20.3	30.0	29.8	1.37	0.45	21.55	1130
20.7	30.0	30.0	1.37	0.45	22.00	1139
21.0	30.0	30.0	1.37	0.45	22.45	1147
21.3	30.0	30.0	1.37	0.45	22.90	1156
21.7	30.0	30.0	1.37	0.45	23.35	1165
22.0	30.0	30.0	1.37	0.45	23.80	1173
22.3	30.0	30.0	1.37	0.45	24.25	1182
22.7	30.0	30.0	1.37	0.45	24.71	1190
23.0	30.0	30.0	1.37	0.45	25.16	1199
23.3	30.5	30.3	1.40	0.46	25.62	1208
23.7	30.5	30.5	1.40	0.46	26.08	1216
24.0	30.5	30.5	1.40	0.46	26.54	1225
24.3	30.5	30.5	1.40	0.46	27.00	1233
24.7	30.5	30.5	1.40	0.46	27.47	1242

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
25.0	30.5	30.5	1.40	0.46	27.93	1251
25.3	30.5	30.5	1.40	0.46	28.39	1259
25.7	31.0	30.8	1.43	0.47	28.86	1268
26.0	31.0	31.0	1.43	0.47	29.33	1276
26.3	31.0	31.0	1.43	0.47	29.80	1285
26.7	31.0	31.0	1.43	0.47	30.27	1294
27.0	31.0	31.0	1.43	0.47	30.75	1302
27.3	31.0	31.0	1.43	0.47	31.22	1311
27.7	31.0	31.0	1.43	0.47	31.69	1319
28.0	31.0	31.0	1.43	0.47	32.16	1328
28.3	31.0	31.0	1.43	0.47	32.63	1336
28.7	31.0	31.0	1.43	0.47	33.10	1344
29.0	31.0	31.0	1.43	0.47	33.58	1353
29.3	31.0	31.0	1.43	0.47	34.05	1361
29.7	31.0	31.0	1.43	0.47	34.52	1369
30.0	31.0	31.0	1.43	0.47	34.99	1378
30.3	31.0	31.0	1.43	0.47	35.46	1386
30.7	31.0	31.0	1.43	0.47	35.93	1394
31.0	31.0	31.0	1.43	0.47	36.41	1403
31.3	31.0	31.0	1.43	0.47	36.88	1411
31.7	31.0	31.0	1.43	0.47	37.35	1419
32.0	30.5	30.8	1.40	0.46	37.81	1427
32.3	30.5	30.5	1.40	0.46	38.27	1435
32.7	30.5	30.5	1.40	0.46	38.73	1443
33.0	30.5	30.5	1.40	0.46	39.20	1451
33.3	30.5	30.5	1.40	0.46	39.66	1458

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
33.7	30.5	30.5	1.40	0.46	40.12	1466
34.0	30.5	30.5	1.40	0.46	40.58	1474
34.3	30.5	30.5	1.40	0.46	41.04	1482
34.7	30.5	30.5	1.40	0.46	41.50	1490
35.0	30.5	30.5	1.40	0.46	41.96	1497
35.3	30.5	30.5	1.40	0.46	42.43	1505
35.7	30.5	30.5	1.40	0.46	42.89	1513
36.0	30.5	30.5	1.40	0.46	43.35	1520
36.3	30.5	30.5	1.40	0.46	43.81	1528
36.7	30.0	30.3	1.37	0.45	44.26	1535
37.0	30.0	30.0	1.37	0.45	44.71	1543
37.3	30.0	30.0	1.37	0.45	45.17	1550
37.7	30.0	30.0	1.37	0.45	45.62	1558
38.0	30.0	30.0	1.37	0.45	46.07	1565
38.3	30.0	30.0	1.37	0.45	46.52	1572
38.7	30.0	30.0	1.37	0.45	46.97	1580
39.0	30.0	30.0	1.37	0.45	47.42	1587
39.3	30.0	30.0	1.37	0.45	47.87	1594
39.7	30.0	30.0	1.37	0.45	48.33	1601
40.0	29.5	29.8	1.34	0.44	48.77	1609
40.3	29.5	29.5	1.34	0.44	49.21	1616
40.7	29.5	29.5	1.34	0.44	49.65	1623
41.0	29.5	29.5	1.34	0.44	50.09	1630
41.3	29.5	29.5	1.34	0.44	50.53	1637
41.7	29.5	29.5	1.34	0.44	50.98	1644
42.0	29.5	29.5	1.34	0.44	51.42	1651

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
42.3	29.5	29.5	1.34	0.44	51.86	1657
42.7	29.5	29.5	1.34	0.44	52.30	1664
43.0	29.5	29.5	1.34	0.44	52.74	1671
43.3	29.0	29.3	1.31	0.43	53.18	1678
43.7	29.0	29.0	1.31	0.43	53.61	1685
44.0	29.0	29.0	1.31	0.43	54.04	1691
44.3	29.0	29.0	1.31	0.43	54.47	1698
44.7	29.0	29.0	1.31	0.43	54.90	1705
45.0	29.0	29.0	1.31	0.43	55.34	1711
45.3	29.0	29.0	1.31	0.43	55.77	1718
45.7	29.0	29.0	1.31	0.43	56.20	1724
46.0	29.0	29.0	1.31	0.43	56.63	1731
46.3	29.0	29.0	1.31	0.43	57.06	1738
46.7	28.5	28.8	1.28	0.42	57.49	1744
47.0	28.5	28.5	1.28	0.42	57.91	1750
47.3	28.5	28.5	1.28	0.42	58.33	1757
47.7	28.5	28.5	1.28	0.42	58.76	1763
48.0	28.5	28.5	1.28	0.42	59.18	1769
48.3	28.5	28.5	1.28	0.42	59.60	1776
48.7	28.5	28.5	1.28	0.42	60.02	1782
49.0	28.5	28.5	1.28	0.42	60.45	1788
49.3	28.5	28.5	1.28	0.42	60.87	1794
49.7	28.5	28.5	1.28	0.42	61.29	1801
50.0	28.5	28.5	1.28	0.42	61.71	1807
50.3	28.5	28.5	1.28	0.42	62.14	1813
50.7	28.5	28.5	1.28	0.42	62.56	1819

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^{o}C Increment (hours)	Eq. Age @ 23^{o}C Cumulative (hours)	Predicted Compressive Strength (psi)
51.0	28.5	28.5	1.28	0.42	62.98	1825
51.3	28.5	28.5	1.28	0.42	63.40	1832
51.7	28.5	28.5	1.28	0.42	63.83	1838
52.0	28.5	28.5	1.28	0.42	64.25	1844
52.3	28.5	28.5	1.28	0.42	64.67	1850
52.7	28.0	28.3	1.25	0.41	65.09	1856
53.0	28.0	28.0	1.25	0.41	65.50	1862
53.3	28.0	28.0	1.25	0.41	65.91	1868
53.7	28.0	28.0	1.25	0.41	66.33	1874
54.0	28.0	28.0	1.25	0.41	66.74	1880
54.3	28.0	28.0	1.25	0.41	67.15	1885
54.7	28.0	28.0	1.25	0.41	67.57	1891
55.0	28.0	28.0	1.25	0.41	67.98	1897
55.3	28.0	28.0	1.25	0.41	68.39	1903
55.7	28.0	28.0	1.25	0.41	68.81	1909
56.0	28.0	28.0	1.25	0.41	69.22	1915
56.3	28.0	28.0	1.25	0.41	69.63	1920
56.7	27.5	27.8	1.23	0.40	70.04	1926
57.0	27.5	27.5	1.23	0.40	70.44	1932
57.3	27.5	27.5	1.23	0.40	70.85	1937
57.7	27.5	27.5	1.23	0.40	71.25	1943
58.0	27.5	27.5	1.23	0.40	71.66	1948
58.3	27.5	27.5	1.23	0.40	72.06	1954
58.7	27.5	27.5	1.23	0.40	72.46	1960
59.0	27.5	27.5	1.23	0.40	72.87	1965
59.3	27.5	27.5	1.23	0.40	73.27	1971

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
59.7	27.0	27.3	1.20	0.40	73.67	1976
60.0	27.0	27.0	1.20	0.40	74.06	1981
60.3	27.0	27.0	1.20	0.40	74.46	1987
60.7	27.0	27.0	1.20	0.40	74.86	1992
61.0	27.0	27.0	1.20	0.40	75.25	1997
61.3	27.0	27.0	1.20	0.40	75.65	2003
61.7	27.0	27.0	1.20	0.40	76.04	2008
62.0	27.0	27.0	1.20	0.40	76.44	2013
62.3	27.0	27.0	1.20	0.40	76.83	2019
62.7	27.0	27.0	1.20	0.40	77.23	2024
63.0	27.0	27.0	1.20	0.40	77.62	2029
63.3	26.5	26.8	1.17	0.39	78.01	2034
63.7	26.5	26.5	1.17	0.39	78.40	2039
64.0	26.5	26.5	1.17	0.39	78.78	2045
64.3	26.5	26.5	1.17	0.39	79.17	2050
64.7	26.5	26.5	1.17	0.39	79.56	2055
65.0	26.5	26.5	1.17	0.39	79.94	2060
65.3	26.5	26.5	1.17	0.39	80.33	2065
65.7	26.5	26.5	1.17	0.39	80.72	2070
66.0	26.5	26.5	1.17	0.39	81.10	2075
66.3	26.5	26.5	1.17	0.39	81.49	2080
66.7	26.5	26.5	1.17	0.39	81.88	2085
67.0	26.0	26.3	1.15	0.38	82.26	2090
67.3	26.0	26.0	1.15	0.38	82.63	2095
67.7	26.0	26.0	1.15	0.38	83.01	2100
68.0	26.0	26.0	1.15	0.38	83.39	2105

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
68.3	26.0	26.0	1.15	0.38	83.77	2109
68.7	26.0	26.0	1.15	0.38	84.15	2114
69.0	26.0	26.0	1.15	0.38	84.52	2119
69.3	26.0	26.0	1.15	0.38	84.90	2124
69.7	26.0	26.0	1.15	0.38	85.28	2129
70.0	26.0	26.0	1.15	0.38	85.66	2133
70.3	26.0	26.0	1.15	0.38	86.04	2138
70.7	26.0	26.0	1.15	0.38	86.42	2143
71.0	26.0	26.0	1.15	0.38	86.79	2148
71.3	26.0	26.0	1.15	0.38	87.17	2153
71.7	26.0	26.0	1.15	0.38	87.55	2157
72.0	25.5	25.8	1.12	0.37	87.92	2162
72.3	25.5	25.5	1.12	0.37	88.29	2167
72.7	25.5	25.5	1.12	0.37	88.66	2171
73.0	25.0	25.3	1.10	0.36	89.02	2176
73.3	25.0	25.0	1.10	0.36	89.38	2180
73.7	25.5	25.3	1.12	0.37	89.75	2185
74.0	25.0	25.3	1.10	0.36	90.11	2189
74.3	25.0	25.0	1.10	0.36	90.47	2194
74.7	25.0	25.0	1.10	0.36	90.84	2198
75.0	25.0	25.0	1.10	0.36	91.20	2203
75.3	25.0	25.0	1.10	0.36	91.56	2207
75.7	25.0	25.0	1.10	0.36	91.92	2211
76.0	25.0	25.0	1.10	0.36	92.28	2216
76.3	24.5	24.8	1.07	0.35	92.64	2220
76.7	24.5	24.5	1.07	0.35	92.99	2224

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
77.0	24.5	24.5	1.07	0.35	93.34	2229
77.3	24.5	24.5	1.07	0.35	93.70	2233
77.7	24.5	24.5	1.07	0.35	94.05	2237
78.0	24.5	24.5	1.07	0.35	94.40	2241
78.3	24.5	24.5	1.07	0.35	94.76	2246
78.7	24.5	24.5	1.07	0.35	95.11	2250
79.0	24.0	24.3	1.05	0.35	95.45	2254
79.3	24.0	24.0	1.05	0.35	95.80	2258
79.7	24.0	24.0	1.05	0.35	96.15	2262
80.0	24.0	24.0	1.05	0.35	96.49	2266
80.3	24.0	24.0	1.05	0.35	96.84	2271
80.7	24.0	24.0	1.05	0.35	97.18	2275
81.0	23.5	23.8	1.02	0.34	97.52	2279
81.3	23.5	23.5	1.02	0.34	97.86	2283
81.7	23.5	23.5	1.02	0.34	98.19	2287
82.0	23.0	23.3	1.00	0.33	98.52	2290
82.3	23.0	23.0	1.00	0.33	98.85	2294
82.7	23.0	23.0	1.00	0.33	99.18	2298
83.0	23.0	23.0	1.00	0.33	99.51	2302
83.3	22.5	22.8	0.98	0.32	99.84	2306
83.7	22.5	22.5	0.98	0.32	100.16	2310
84.0	22.5	22.5	0.98	0.32	100.48	2313
84.3	22.5	22.5	0.98	0.32	100.80	2317
84.7	22.0	22.3	0.96	0.32	101.12	2321
85.0	22.0	22.0	0.96	0.32	101.43	2324
85.3	22.0	22.0	0.96	0.32	101.75	2328

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
85.7	22.0	22.0	0.96	0.32	102.06	2332
86.0	22.0	22.0	0.96	0.32	102.38	2335
86.3	21.5	21.8	0.93	0.31	102.69	2339
86.7	21.5	21.5	0.93	0.31	103.00	2342
87.0	21.5	21.5	0.93	0.31	103.30	2346
87.3	21.5	21.5	0.93	0.31	103.61	2349
87.7	21.5	21.5	0.93	0.31	103.92	2353
88.0	21.0	21.3	0.91	0.30	104.22	2356
88.3	21.0	21.0	0.91	0.30	104.52	2360
88.7	21.0	21.0	0.91	0.30	104.82	2363
89.0	21.0	21.0	0.91	0.30	105.12	2367
89.3	21.0	21.0	0.91	0.30	105.42	2370
89.7	21.0	21.0	0.91	0.30	105.73	2373
90.0	21.0	21.0	0.91	0.30	106.03	2377
90.3	20.5	20.8	0.89	0.29	106.32	2380
90.7	20.5	20.5	0.89	0.29	106.61	2383
91.0	20.5	20.5	0.89	0.29	106.91	2387
91.3	20.5	20.5	0.89	0.29	107.20	2390
91.7	20.0	20.3	0.87	0.29	107.49	2393
92.0	20.0	20.0	0.87	0.29	107.78	2396
92.3	20.0	20.0	0.87	0.29	108.06	2400
92.7	20.0	20.0	0.87	0.29	108.35	2403
93.0	20.0	20.0	0.87	0.29	108.64	2406
93.3	20.0	20.0	0.87	0.29	108.93	2409
93.7	20.0	20.0	0.87	0.29	109.21	2412
94.0	20.0	20.0	0.87	0.29	109.50	2416

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
94.3	20.0	20.0	0.87	0.29	109.79	2419
94.7	20.0	20.0	0.87	0.29	110.07	2422
95.0	19.5	19.8	0.85	0.28	110.35	2425
95.3	19.5	19.5	0.85	0.28	110.63	2428
95.7	19.5	19.5	0.85	0.28	110.92	2431
96.0	19.5	19.5	0.85	0.28	111.20	2434
96.3	18.5	19.0	0.81	0.27	111.46	2437
96.7	19.0	18.8	0.83	0.27	111.74	2440
97.0	19.0	19.0	0.83	0.27	112.01	2443
97.3	19.0	19.0	0.83	0.27	112.29	2446
97.7	19.0	19.0	0.83	0.27	112.56	2449
98.0	19.0	19.0	0.83	0.27	112.83	2452
98.3	19.0	19.0	0.83	0.27	113.11	2455
98.7	19.0	19.0	0.83	0.27	113.38	2458
99.0	19.0	19.0	0.83	0.27	113.66	2461
99.3	19.0	19.0	0.83	0.27	113.93	2464
99.7	19.0	19.0	0.83	0.27	114.20	2467
100.0	19.0	19.0	0.83	0.27	114.48	2470
100.3	19.0	19.0	0.83	0.27	114.75	2473
100.7	18.5	18.8	0.81	0.27	115.02	2476
101.0	18.5	18.5	0.81	0.27	115.29	2478
101.3	18.5	18.5	0.81	0.27	115.55	2481
101.7	18.5	18.5	0.81	0.27	115.82	2484
102.0	18.5	18.5	0.81	0.27	116.09	2487
102.3	18.5	18.5	0.81	0.27	116.36	2490
102.7	18.5	18.5	0.81	0.27	116.63	2493

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
103.0	18.5	18.5	0.81	0.27	116.89	2496
103.3	18.0	18.3	0.79	0.26	117.15	2498
103.7	18.0	18.0	0.79	0.26	117.42	2501
104.0	18.0	18.0	0.79	0.26	117.68	2504
104.3	18.0	18.0	0.79	0.26	117.94	2507
104.7	18.0	18.0	0.79	0.26	118.20	2509
105.0	18.0	18.0	0.79	0.26	118.46	2512
105.3	18.0	18.0	0.79	0.26	118.72	2515
105.7	18.0	18.0	0.79	0.26	118.98	2518
106.0	18.0	18.0	0.79	0.26	119.25	2520
106.3	17.5	17.8	0.77	0.26	119.50	2523
106.7	17.5	17.5	0.77	0.26	119.76	2526
107.0	17.5	17.5	0.77	0.26	120.01	2528
107.3	17.5	17.5	0.77	0.26	120.27	2531
107.7	17.5	17.5	0.77	0.26	120.52	2534
108.0	17.5	17.5	0.77	0.26	120.78	2536
108.3	17.5	17.5	0.77	0.26	121.03	2539
108.7	17.5	17.5	0.77	0.26	121.29	2542
109.0	17.0	17.3	0.76	0.25	121.54	2544
109.3	17.0	17.0	0.76	0.25	121.79	2547
109.7	17.0	17.0	0.76	0.25	122.03	2549
110.0	17.0	17.0	0.76	0.25	122.28	2552
110.3	17.0	17.0	0.76	0.25	122.53	2554
110.7	17.0	17.0	0.76	0.25	122.78	2557
111.0	16.5	16.8	0.74	0.24	123.03	2560
111.3	16.5	16.5	0.74	0.24	123.27	2562

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
111.7	16.5	16.5	0.74	0.24	123.51	2564
112.0	16.5	16.5	0.74	0.24	123.76	2567
112.3	16.5	16.5	0.74	0.24	124.00	2569
112.7	16.5	16.5	0.74	0.24	124.24	2572
113.0	16.0	16.3	0.72	0.24	124.48	2574
113.3	16.0	16.0	0.72	0.24	124.72	2577
113.7	16.0	16.0	0.72	0.24	124.95	2579
114.0	16.0	16.0	0.72	0.24	125.19	2582
114.3	16.0	16.0	0.72	0.24	125.43	2584
114.7	16.0	16.0	0.72	0.24	125.67	2586
115.0	15.5	15.8	0.70	0.23	125.90	2589
115.3	15.5	15.5	0.70	0.23	126.13	2591
115.7	15.5	15.5	0.70	0.23	126.36	2593
116.0	15.5	15.5	0.70	0.23	126.60	2596
116.3	15.5	15.5	0.70	0.23	126.83	2598
116.7	15.5	15.5	0.70	0.23	127.06	2600
117.0	15.5	15.5	0.70	0.23	127.29	2603
117.3	15.0	15.3	0.69	0.23	127.52	2605
117.7	15.5	15.3	0.70	0.23	127.75	2607
118.0	15.5	15.5	0.70	0.23	127.98	2610
118.3	15.5	15.5	0.70	0.23	128.21	2612
118.7	15.5	15.5	0.70	0.23	128.44	2614
119.0	15.5	15.5	0.70	0.23	128.68	2617
119.3	15.5	15.5	0.70	0.23	128.91	2619
119.7	15.5	15.5	0.70	0.23	129.14	2621
120.0	15.5	15.5	0.70	0.23	129.37	2624

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
120.3	15.0	15.3	0.69	0.23	129.60	2626
120.7	15.5	15.3	0.70	0.23	129.83	2628
121.0	15.5	15.5	0.70	0.23	130.06	2630
121.3	15.5	15.5	0.70	0.23	130.29	2633
121.7	15.5	15.5	0.70	0.23	130.53	2635
122.0	15.5	15.5	0.70	0.23	130.76	2637
122.3	15.5	15.5	0.70	0.23	130.99	2640
122.7	15.5	15.5	0.70	0.23	131.22	2642
123.0	15.0	15.3	0.69	0.23	131.45	2644
123.3	15.0	15.0	0.69	0.23	131.67	2646
123.7	15.0	15.0	0.69	0.23	131.90	2648
124.0	15.0	15.0	0.69	0.23	132.13	2651
124.3	15.0	15.0	0.69	0.23	132.35	2653
124.7	15.0	15.0	0.69	0.23	132.58	2655
125.0	15.0	15.0	0.69	0.23	132.81	2657
125.3	15.0	15.0	0.69	0.23	133.03	2660
125.7	15.0	15.0	0.69	0.23	133.26	2662
126.0	15.0	15.0	0.69	0.23	133.49	2664
126.3	15.0	15.0	0.69	0.23	133.71	2666
126.7	14.5	14.8	0.67	0.22	133.93	2668
127.0	14.5	14.5	0.67	0.22	134.15	2670
127.3	14.5	14.5	0.67	0.22	134.37	2673
127.7	14.5	14.5	0.67	0.22	134.60	2675
128.0	14.5	14.5	0.67	0.22	134.82	2677
128.3	14.5	14.5	0.67	0.22	135.04	2679
128.7	14.5	14.5	0.67	0.22	135.26	2681

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
129.0	14.5	14.5	0.67	0.22	135.48	2683
129.3	14.5	14.5	0.67	0.22	135.70	2685
129.7	14.0	14.3	0.65	0.22	135.92	2687
130.0	14.0	14.0	0.65	0.22	136.13	2689
130.3	14.0	14.0	0.65	0.22	136.35	2692
130.7	14.0	14.0	0.65	0.22	136.56	2694
131.0	14.0	14.0	0.65	0.22	136.78	2696
131.3	14.0	14.0	0.65	0.22	136.99	2698
131.7	14.0	14.0	0.65	0.22	137.21	2700
132.0	14.0	14.0	0.65	0.22	137.43	2702
132.3	14.0	14.0	0.65	0.22	137.64	2704
132.7	14.0	14.0	0.65	0.22	137.86	2706
133.0	14.0	14.0	0.65	0.22	138.07	2708
133.3	14.0	14.0	0.65	0.22	138.29	2710
133.7	13.5	13.8	0.64	0.21	138.50	2712
134.0	13.5	13.5	0.64	0.21	138.71	2714
134.3	13.5	13.5	0.64	0.21	138.92	2716
134.7	13.5	13.5	0.64	0.21	139.13	2718
135.0	13.5	13.5	0.64	0.21	139.34	2720
135.3	13.5	13.5	0.64	0.21	139.55	2722
135.7	13.5	13.5	0.64	0.21	139.76	2724
136.0	13.5	13.5	0.64	0.21	139.97	2726
136.3	13.5	13.5	0.64	0.21	140.18	2728
136.7	13.0	13.3	0.62	0.21	140.39	2730
137.0	13.0	13.0	0.62	0.21	140.59	2732
137.3	13.0	13.0	0.62	0.21	140.80	2734

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
137.7	13.0	13.0	0.62	0.21	141.00	2736
138.0	13.0	13.0	0.62	0.21	141.21	2737
138.3	13.0	13.0	0.62	0.21	141.41	2739
138.7	13.0	13.0	0.62	0.21	141.62	2741
139.0	12.5	12.8	0.61	0.20	141.82	2743
139.3	12.5	12.5	0.61	0.20	142.02	2745
139.7	12.5	12.5	0.61	0.20	142.22	2747
140.0	12.5	12.5	0.61	0.20	142.42	2749
140.3	12.5	12.5	0.61	0.20	142.62	2751
140.7	12.5	12.5	0.61	0.20	142.82	2752
141.0	12.5	12.5	0.61	0.20	143.02	2754
141.3	12.5	12.5	0.61	0.20	143.22	2756
141.7	12.0	12.3	0.59	0.20	143.42	2758
142.0	12.0	12.0	0.59	0.20	143.61	2760
142.3	12.0	12.0	0.59	0.20	143.81	2762
142.7	12.0	12.0	0.59	0.20	144.00	2763
143.0	12.0	12.0	0.59	0.20	144.20	2765
143.3	12.0	12.0	0.59	0.20	144.39	2767
143.7	12.0	12.0	0.59	0.20	144.59	2769
144.0	12.0	12.0	0.59	0.20	144.78	2771
144.3	12.0	12.0	0.59	0.20	144.98	2772
144.7	12.0	12.0	0.59	0.20	145.18	2774
145.0	12.0	12.0	0.59	0.20	145.37	2776
145.3	12.0	12.0	0.59	0.20	145.57	2778
145.7	12.0	12.0	0.59	0.20	145.76	2779
146.0	12.0	12.0	0.59	0.20	145.96	2781

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
146.3	12.0	12.0	0.59	0.20	146.15	2783
146.7	12.0	12.0	0.59	0.20	146.35	2785
147.0	12.0	12.0	0.59	0.20	146.54	2787
147.3	12.0	12.0	0.59	0.20	146.74	2788
147.7	12.0	12.0	0.59	0.20	146.93	2790
148.0	12.0	12.0	0.59	0.20	147.13	2792
148.3	12.0	12.0	0.59	0.20	147.33	2794
148.7	11.5	11.8	0.58	0.19	147.52	2795
149.0	11.5	11.5	0.58	0.19	147.71	2797
149.3	11.5	11.5	0.58	0.19	147.90	2799
149.7	11.5	11.5	0.58	0.19	148.09	2801
150.0	11.5	11.5	0.58	0.19	148.28	2802
150.3	11.5	11.5	0.58	0.19	148.47	2804
150.7	11.5	11.5	0.58	0.19	148.66	2806
151.0	11.5	11.5	0.58	0.19	148.85	2807
151.3	11.5	11.5	0.58	0.19	149.04	2809
151.7	11.0	11.3	0.56	0.19	149.23	2811
152.0	11.0	11.0	0.56	0.19	149.41	2812
152.3	11.0	11.0	0.56	0.19	149.60	2814
152.7	11.0	11.0	0.56	0.19	149.79	2816
153.0	11.0	11.0	0.56	0.19	149.97	2817
153.3	11.0	11.0	0.56	0.19	150.16	2819
153.7	11.0	11.0	0.56	0.19	150.34	2821
154.0	11.0	11.0	0.56	0.19	150.53	2822
154.3	11.0	11.0	0.56	0.19	150.72	2824
154.7	11.0	11.0	0.56	0.19	150.90	2826

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
155.0	11.0	11.0	0.56	0.19	151.09	2827
155.3	10.5	10.8	0.55	0.18	151.27	2829
155.7	10.5	10.5	0.55	0.18	151.45	2831
156.0	10.5	10.5	0.55	0.18	151.63	2832
156.3	10.5	10.5	0.55	0.18	151.81	2834
156.7	10.5	10.5	0.55	0.18	151.99	2835
157.0	10.5	10.5	0.55	0.18	152.18	2837
157.3	10.5	10.5	0.55	0.18	152.36	2839
157.7	10.5	10.5	0.55	0.18	152.54	2840
158.0	10.5	10.5	0.55	0.18	152.72	2842
158.3	10.5	10.5	0.55	0.18	152.90	2843
158.7	10.5	10.5	0.55	0.18	153.08	2845
159.0	10.5	10.5	0.55	0.18	153.26	2847
159.3	10.0	10.3	0.54	0.18	153.44	2848
159.7	10.0	10.0	0.54	0.18	153.62	2850
160.0	10.0	10.0	0.54	0.18	153.79	2851
160.3	10.0	10.0	0.54	0.18	153.97	2853
160.7	10.0	10.0	0.54	0.18	154.15	2854
161.0	10.0	10.0	0.54	0.18	154.33	2856
161.3	10.0	10.0	0.54	0.18	154.50	2857
161.7	10.0	10.0	0.54	0.18	154.68	2859
162.0	9.5	9.8	0.52	0.17	154.85	2860
162.3	9.5	9.5	0.52	0.17	155.02	2862
162.7	9.5	9.5	0.52	0.17	155.20	2863
163.0	9.5	9.5	0.52	0.17	155.37	2865
163.3	9.5	9.5	0.52	0.17	155.54	2866

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
163.7	9.5	9.5	0.52	0.17	155.71	2868
164.0	9.5	9.5	0.52	0.17	155.89	2869
164.3	9.5	9.5	0.52	0.17	156.06	2871
164.7	9.5	9.5	0.52	0.17	156.23	2872
165.0	9.5	9.5	0.52	0.17	156.40	2874
165.3	9.5	9.5	0.52	0.17	156.58	2875
165.7	9.5	9.5	0.52	0.17	156.75	2877
166.0	9.5	9.5	0.52	0.17	156.92	2878
166.3	9.5	9.5	0.52	0.17	157.09	2880
166.7	9.5	9.5	0.52	0.17	157.27	2881
167.0	9.5	9.5	0.52	0.17	157.44	2883
167.3	9.5	9.5	0.52	0.17	157.61	2884
167.7	9.5	9.5	0.52	0.17	157.78	2886
168.0	9.5	9.5	0.52	0.17	157.96	2887

Table E.7 Maturity calculations 35% FA-C-block

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
0.0	22.2	-	-		0	0.00
0.3	26.0	24.1	1.12	0.37	0.37	21
0.7	26.0	26.0	1.12	0.37	0.74	42
1.0	26.5	26.3	1.14	0.38	1.12	63
1.3	26.5	26.5	1.14	0.38	1.50	84
1.7	26.5	26.5	1.14	0.38	1.87	105
2.0	27.0	26.8	1.17	0.38	2.26	126
2.3	27.0	27.0	1.17	0.38	2.64	146
2.7	27.5	27.3	1.19	0.39	3.03	168
3.0	28.0	27.8	1.21	0.40	3.43	189
3.3	28.5	28.3	1.23	0.41	3.84	210
3.7	29.0	28.8	1.26	0.41	4.26	232
4.0	29.5	29.3	1.28	0.42	4.68	254
4.3	30.5	30.0	1.33	0.44	5.12	277
4.7	31.0	30.8	1.35	0.45	5.56	300
5.0	31.5	31.3	1.38	0.45	6.02	323
5.3	32.0	31.8	1.40	0.46	6.48	347
5.7	32.5	32.3	1.43	0.47	6.95	370
6.0	32.5	32.5	1.43	0.47	7.43	394
6.3	33.0	32.8	1.46	0.48	7.91	417
6.7	33.5	33.3	1.48	0.49	8.40	441
7.0	33.5	33.5	1.48	0.49	8.88	465
7.3	34.0	33.8	1.51	0.50	9.38	489

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
7.7	34.0	34.0	1.51	0.50	9.88	512
8.0	34.5	34.3	1.54	0.51	10.39	536
8.3	35.0	34.8	1.57	0.52	10.90	560
8.7	35.0	35.0	1.57	0.52	11.42	584
9.0	35.5	35.3	1.59	0.53	11.95	608
9.3	36.0	35.8	1.62	0.54	12.48	633
9.7	36.0	36.0	1.62	0.54	13.02	657
10.0	36.5	36.3	1.65	0.54	13.56	681
10.3	37.0	36.8	1.68	0.55	14.12	706
10.7	37.5	37.3	1.71	0.56	14.68	730
11.0	37.5	37.5	1.71	0.56	15.25	755
11.3	38.0	37.8	1.74	0.57	15.82	779
11.7	38.5	38.3	1.77	0.58	16.41	804
12.0	38.5	38.5	1.77	0.58	16.99	829
12.3	39.0	38.8	1.80	0.60	17.59	854
12.7	39.5	39.3	1.84	0.61	18.19	879
13.0	39.5	39.5	1.84	0.61	18.80	903
13.3	40.0	39.8	1.87	0.62	19.41	928
13.7	40.0	40.0	1.87	0.62	20.03	953
14.0	40.5	40.3	1.90	0.63	20.66	978
14.3	40.5	40.5	1.90	0.63	21.28	1002
14.7	41.0	40.8	1.93	0.64	21.92	1027
15.0	41.0	41.0	1.93	0.64	22.56	1051
15.3	41.5	41.3	1.97	0.65	23.21	1076
15.7	41.5	41.5	1.97	0.65	23.86	1101
16.0	41.5	41.5	1.97	0.65	24.51	1125

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
16.3	42.0	41.8	2.00	0.66	25.17	1149
16.7	42.0	42.0	2.00	0.66	25.83	1173
17.0	42.0	42.0	2.00	0.66	26.49	1197
17.3	42.5	42.3	2.04	0.67	27.16	1221
17.7	42.5	42.5	2.04	0.67	27.83	1245
18.0	42.5	42.5	2.04	0.67	28.50	1268
18.3	42.5	42.5	2.04	0.67	29.17	1292
18.7	43.0	42.8	2.07	0.68	29.86	1315
19.0	43.0	43.0	2.07	0.68	30.54	1338
19.3	43.0	43.0	2.07	0.68	31.22	1361
19.7	43.0	43.0	2.07	0.68	31.91	1384
20.0	43.0	43.0	2.07	0.68	32.59	1406
20.3	43.0	43.0	2.07	0.68	33.27	1429
20.7	43.5	43.3	2.11	0.69	33.97	1451
21.0	43.5	43.5	2.11	0.69	34.66	1473
21.3	43.5	43.5	2.11	0.69	35.36	1495
21.7	43.5	43.5	2.11	0.69	36.05	1517
22.0	43.5	43.5	2.11	0.69	36.75	1538
22.3	43.5	43.5	2.11	0.69	37.44	1560
22.7	43.5	43.5	2.11	0.69	38.14	1581
23.0	43.5	43.5	2.11	0.69	38.83	1602
23.3	43.5	43.5	2.11	0.69	39.53	1622
23.7	43.5	43.5	2.11	0.69	40.22	1643
24.0	43.5	43.5	2.11	0.69	40.92	1663
24.3	43.5	43.5	2.11	0.69	41.61	1683
24.7	43.5	43.5	2.11	0.69	42.31	1703

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
25.0	43.5	43.5	2.11	0.69	43.00	1723
25.3	43.5	43.5	2.11	0.69	43.70	1743
25.7	43.5	43.5	2.11	0.69	44.39	1762
26.0	43.5	43.5	2.11	0.69	45.09	1781
26.3	43.5	43.5	2.11	0.69	45.78	1800
26.7	43.5	43.5	2.11	0.69	46.48	1819
27.0	43.5	43.5	2.11	0.69	47.17	1837
27.3	43.5	43.5	2.11	0.69	47.87	1856
27.7	43.5	43.5	2.11	0.69	48.56	1874
28.0	43.5	43.5	2.11	0.69	49.26	1892
28.3	43.5	43.5	2.11	0.69	49.95	1910
28.7	43.5	43.5	2.11	0.69	50.65	1928
29.0	43.5	43.5	2.11	0.69	51.34	1946
29.3	43.5	43.5	2.11	0.69	52.04	1963
29.7	43.5	43.5	2.11	0.69	52.73	1981
30.0	43.5	43.5	2.11	0.69	53.43	1998
30.3	43.0	43.3	2.07	0.68	54.11	2014
30.7	43.0	43.0	2.07	0.68	54.80	2031
31.0	43.0	43.0	2.07	0.68	55.48	2047
31.3	43.0	43.0	2.07	0.68	56.16	2064
31.7	43.0	43.0	2.07	0.68	56.85	2080
32.0	43.0	43.0	2.07	0.68	57.53	2096
32.3	43.0	43.0	2.07	0.68	58.21	2112
32.7	42.5	42.8	2.04	0.67	58.88	2127
33.0	42.5	42.5	2.04	0.67	59.56	2143
33.3	42.5	42.5	2.04	0.67	60.23	2158

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
33.7	42.5	42.5	2.04	0.67	60.90	2173
34.0	42.5	42.5	2.04	0.67	61.57	2188
34.3	42.5	42.5	2.04	0.67	62.24	2203
34.7	42.0	42.3	2.00	0.66	62.90	2217
35.0	42.0	42.0	2.00	0.66	63.56	2232
35.3	42.0	42.0	2.00	0.66	64.22	2246
35.7	42.0	42.0	2.00	0.66	64.88	2260
36.0	42.0	42.0	2.00	0.66	65.54	2274
36.3	41.5	41.8	1.97	0.65	66.19	2288
36.7	41.5	41.5	1.97	0.65	66.84	2301
37.0	41.5	41.5	1.97	0.65	67.49	2315
37.3	41.5	41.5	1.97	0.65	68.14	2328
37.7	41.5	41.5	1.97	0.65	68.79	2342
38.0	41.0	41.3	1.93	0.64	69.43	2355
38.3	41.0	41.0	1.93	0.64	70.06	2367
38.7	41.0	41.0	1.93	0.64	70.70	2380
39.0	41.0	41.0	1.93	0.64	71.34	2393
39.3	40.5	40.8	1.90	0.63	71.97	2405
39.7	40.5	40.5	1.90	0.63	72.59	2417
40.0	40.5	40.5	1.90	0.63	73.22	2430
40.3	40.5	40.5	1.90	0.63	73.85	2442
40.7	40.0	40.3	1.87	0.62	74.46	2454
41.0	40.0	40.0	1.87	0.62	75.08	2465
41.3	40.0	40.0	1.87	0.62	75.70	2477
41.7	40.0	40.0	1.87	0.62	76.31	2489
42.0	39.5	39.8	1.84	0.61	76.92	2500

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
42.3	39.5	39.5	1.84	0.61	77.52	2511
42.7	39.5	39.5	1.84	0.61	78.13	2522
43.0	39.5	39.5	1.84	0.61	78.74	2533
43.3	39.5	39.5	1.84	0.61	79.34	2544
43.7	39.0	39.3	1.80	0.60	79.94	2555
44.0	39.0	39.0	1.80	0.60	80.53	2566
44.3	39.0	39.0	1.80	0.60	81.13	2576
44.7	39.0	39.0	1.80	0.60	81.72	2587
45.0	38.5	38.8	1.77	0.58	82.31	2597
45.3	38.5	38.5	1.77	0.58	82.89	2607
45.7	38.5	38.5	1.77	0.58	83.48	2617
46.0	38.5	38.5	1.77	0.58	84.06	2627
46.3	38.0	38.3	1.74	0.57	84.64	2637
46.7	38.0	38.0	1.74	0.57	85.21	2647
47.0	38.0	38.0	1.74	0.57	85.79	2657
47.3	38.0	38.0	1.74	0.57	86.36	2666
47.7	37.5	37.8	1.71	0.56	86.92	2676
48.0	37.5	37.5	1.71	0.56	87.49	2685
48.3	37.5	37.5	1.71	0.56	88.05	2695
48.7	37.5	37.5	1.71	0.56	88.62	2704
49.0	37.5	37.5	1.71	0.56	89.18	2713
49.3	37.5	37.5	1.71	0.56	89.75	2722
49.7	37.0	37.3	1.68	0.55	90.30	2731
50.0	37.0	37.0	1.68	0.55	90.86	2740
50.3	37.0	37.0	1.68	0.55	91.41	2749
50.7	37.0	37.0	1.68	0.55	91.97	2758

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
51.0	37.0	37.0	1.68	0.55	92.52	2766
51.3	36.5	36.8	1.65	0.54	93.07	2775
51.7	36.5	36.5	1.65	0.54	93.61	2784
52.0	36.0	36.3	1.62	0.54	94.15	2792
52.3	36.0	36.0	1.62	0.54	94.68	2800
52.7	36.0	36.0	1.62	0.54	95.22	2808
53.0	36.0	36.0	1.62	0.54	95.75	2816
53.3	36.0	36.0	1.62	0.54	96.29	2825
53.7	36.0	36.0	1.62	0.54	96.82	2833
54.0	35.5	35.8	1.59	0.53	97.35	2841
54.3	35.5	35.5	1.59	0.53	97.87	2848
54.7	35.5	35.5	1.59	0.53	98.40	2856
55.0	35.5	35.5	1.59	0.53	98.93	2864
55.3	35.5	35.5	1.59	0.53	99.45	2872
55.7	35.5	35.5	1.59	0.53	99.98	2879
56.0	35.0	35.3	1.57	0.52	100.49	2887
56.3	35.0	35.0	1.57	0.52	101.01	2894
56.7	35.0	35.0	1.57	0.52	101.53	2902
57.0	35.0	35.0	1.57	0.52	102.04	2909
57.3	35.0	35.0	1.57	0.52	102.56	2917
57.7	34.5	34.8	1.54	0.51	103.07	2924
58.0	34.5	34.5	1.54	0.51	103.57	2931
58.3	34.5	34.5	1.54	0.51	104.08	2938
58.7	34.5	34.5	1.54	0.51	104.59	2945
59.0	34.5	34.5	1.54	0.51	105.10	2952
59.3	34.0	34.3	1.51	0.50	105.60	2959

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
59.7	34.0	34.0	1.51	0.50	106.09	2966
60.0	34.0	34.0	1.51	0.50	106.59	2973
60.3	34.0	34.0	1.51	0.50	107.09	2980
60.7	34.0	34.0	1.51	0.50	107.59	2986
61.0	33.5	33.8	1.48	0.49	108.08	2993
61.3	33.5	33.5	1.48	0.49	108.57	3000
61.7	33.5	33.5	1.48	0.49	109.06	3006
62.0	33.5	33.5	1.48	0.49	109.55	3013
62.3	33.5	33.5	1.48	0.49	110.03	3019
62.7	33.0	33.3	1.46	0.48	110.52	3026
63.0	33.0	33.0	1.46	0.48	111.00	3032
63.3	33.0	33.0	1.46	0.48	111.48	3038
63.7	33.0	33.0	1.46	0.48	111.96	3044
64.0	33.0	33.0	1.46	0.48	112.44	3051
64.3	33.0	33.0	1.46	0.48	112.92	3057
64.7	32.5	32.8	1.43	0.47	113.39	3063
65.0	32.5	32.5	1.43	0.47	113.86	3069
65.3	32.5	32.5	1.43	0.47	114.33	3075
65.7	32.5	32.5	1.43	0.47	114.81	3081
66.0	32.5	32.5	1.43	0.47	115.28	3087
66.3	32.0	32.3	1.40	0.46	115.74	3093
66.7	32.0	32.0	1.40	0.46	116.20	3099
67.0	32.0	32.0	1.40	0.46	116.67	3104
67.3	32.0	32.0	1.40	0.46	117.13	3110
67.7	32.0	32.0	1.40	0.46	117.59	3116
68.0	31.5	31.8	1.38	0.45	118.05	3122

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
68.3	31.5	31.5	1.38	0.45	118.50	3127
68.7	31.5	31.5	1.38	0.45	118.96	3133
69.0	31.5	31.5	1.38	0.45	119.41	3138
69.3	31.5	31.5	1.38	0.45	119.87	3144
69.7	31.0	31.3	1.35	0.45	120.31	3149
70.0	31.0	31.0	1.35	0.45	120.76	3154
70.3	31.0	31.0	1.35	0.45	121.21	3160
70.7	31.0	31.0	1.35	0.45	121.65	3165
71.0	31.0	31.0	1.35	0.45	122.10	3170
71.3	31.0	31.0	1.35	0.45	122.55	3176
71.7	31.0	31.0	1.35	0.45	122.99	3181
72.0	31.0	31.0	1.35	0.45	123.44	3186
72.3	31.0	31.0	1.35	0.45	123.89	3191
72.7	31.0	31.0	1.35	0.45	124.33	3197
73.0	31.0	31.0	1.35	0.45	124.78	3202
73.3	31.0	31.0	1.35	0.45	125.23	3207
73.7	31.0	31.0	1.35	0.45	125.67	3212
74.0	31.0	31.0	1.35	0.45	126.12	3217
74.3	31.5	31.3	1.38	0.45	126.58	3222
74.7	31.5	31.5	1.38	0.45	127.03	3228
75.0	31.5	31.5	1.38	0.45	127.49	3233
75.3	31.5	31.5	1.38	0.45	127.94	3238
75.7	31.5	31.5	1.38	0.45	128.40	3243
76.0	31.5	31.5	1.38	0.45	128.85	3248
76.3	31.0	31.3	1.35	0.45	129.30	3253
76.7	30.5	30.8	1.33	0.44	129.74	3258

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
77.0	30.5	30.5	1.33	0.44	130.17	3263
77.3	30.5	30.5	1.33	0.44	130.61	3268
77.7	30.5	30.5	1.33	0.44	131.05	3273
78.0	30.5	30.5	1.33	0.44	131.49	3277
78.3	30.5	30.5	1.33	0.44	131.93	3282
78.7	30.5	30.5	1.33	0.44	132.37	3287
79.0	30.5	30.5	1.33	0.44	132.80	3292
79.3	30.5	30.5	1.33	0.44	133.24	3296
79.7	30.5	30.5	1.33	0.44	133.68	3301
80.0	30.0	30.3	1.30	0.43	134.11	3306
80.3	30.0	30.0	1.30	0.43	134.54	3310
80.7	30.0	30.0	1.30	0.43	134.97	3315
81.0	30.0	30.0	1.30	0.43	135.40	3319
81.3	30.0	30.0	1.30	0.43	135.83	3324
81.7	30.0	30.0	1.30	0.43	136.26	3328
82.0	29.5	29.8	1.28	0.42	136.69	3333
82.3	29.5	29.5	1.28	0.42	137.11	3337
82.7	29.5	29.5	1.28	0.42	137.53	3342
83.0	29.5	29.5	1.28	0.42	137.95	3346
83.3	29.5	29.5	1.28	0.42	138.38	3350
83.7	29.5	29.5	1.28	0.42	138.80	3355
84.0	29.0	29.3	1.26	0.41	139.21	3359
84.3	29.0	29.0	1.26	0.41	139.63	3363
84.7	29.0	29.0	1.26	0.41	140.04	3368
85.0	29.0	29.0	1.26	0.41	140.46	3372
85.3	29.0	29.0	1.26	0.41	140.87	3376

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
85.7	28.5	28.8	1.23	0.41	141.28	3380
86.0	28.5	28.5	1.23	0.41	141.69	3384
86.3	28.5	28.5	1.23	0.41	142.09	3388
86.7	28.5	28.5	1.23	0.41	142.50	3392
87.0	28.5	28.5	1.23	0.41	142.91	3396
87.3	28.0	28.3	1.21	0.40	143.31	3400
87.7	28.0	28.0	1.21	0.40	143.71	3404
88.0	28.0	28.0	1.21	0.40	144.11	3408
88.3	28.0	28.0	1.21	0.40	144.51	3412
88.7	28.0	28.0	1.21	0.40	144.90	3416
89.0	28.0	28.0	1.21	0.40	145.30	3420
89.3	27.5	27.8	1.19	0.39	145.70	3424
89.7	27.5	27.5	1.19	0.39	146.09	3428
90.0	27.5	27.5	1.19	0.39	146.48	3431
90.3	27.5	27.5	1.19	0.39	146.87	3435
90.7	27.0	27.3	1.17	0.38	147.26	3439
91.0	27.0	27.0	1.17	0.38	147.64	3442
91.3	27.0	27.0	1.17	0.38	148.03	3446
91.7	27.0	27.0	1.17	0.38	148.41	3450
92.0	27.0	27.0	1.17	0.38	148.80	3453
92.3	26.5	26.8	1.14	0.38	149.17	3457
92.7	26.5	26.5	1.14	0.38	149.55	3461
93.0	26.5	26.5	1.14	0.38	149.93	3464
93.3	26.5	26.5	1.14	0.38	150.31	3468
93.7	26.5	26.5	1.14	0.38	150.68	3471
94.0	26.5	26.5	1.14	0.38	151.06	3475

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
94.3	26.5	26.5	1.14	0.38	151.44	3478
94.7	26.5	26.5	1.14	0.38	151.82	3482
95.0	26.5	26.5	1.14	0.38	152.19	3485
95.3	26.5	26.5	1.14	0.38	152.57	3489
95.7	26.5	26.5	1.14	0.38	152.95	3492
96.0	26.5	26.5	1.14	0.38	153.33	3496
96.3	26.5	26.5	1.14	0.38	153.70	3499
96.7	26.5	26.5	1.14	0.38	154.08	3502
97.0	26.5	26.5	1.14	0.38	154.46	3506
97.3	26.5	26.5	1.14	0.38	154.84	3509
97.7	26.5	26.5	1.14	0.38	155.21	3513
98.0	26.5	26.5	1.14	0.38	155.59	3516
98.3	26.5	26.5	1.14	0.38	155.97	3520
98.7	26.5	26.5	1.14	0.38	156.35	3523
99.0	26.5	26.5	1.14	0.38	156.72	3526
99.3	27.0	26.8	1.17	0.38	157.11	3530
99.7	27.0	27.0	1.17	0.38	157.49	3533
100.0	27.0	27.0	1.17	0.38	157.88	3536
100.3	27.0	27.0	1.17	0.38	158.26	3540
100.7	27.0	27.0	1.17	0.38	158.65	3543
101.0	27.0	27.0	1.17	0.38	159.03	3547
101.3	27.0	27.0	1.17	0.38	159.42	3550
101.7	27.0	27.0	1.17	0.38	159.80	3553
102.0	27.0	27.0	1.17	0.38	160.18	3557
102.3	27.0	27.0	1.17	0.38	160.57	3560
102.7	27.0	27.0	1.17	0.38	160.95	3563

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
103.0	27.0	27.0	1.17	0.38	161.34	3567
103.3	27.0	27.0	1.17	0.38	161.72	3570
103.7	27.0	27.0	1.17	0.38	162.11	3573
104.0	27.0	27.0	1.17	0.38	162.49	3577
104.3	27.0	27.0	1.17	0.38	162.88	3580
104.7	27.0	27.0	1.17	0.38	163.26	3583
105.0	27.0	27.0	1.17	0.38	163.65	3586
105.3	27.0	27.0	1.17	0.38	164.03	3590
105.7	27.0	27.0	1.17	0.38	164.42	3593
106.0	27.0	27.0	1.17	0.38	164.80	3596
106.3	27.0	27.0	1.17	0.38	165.19	3599
106.7	26.5	26.8	1.14	0.38	165.56	3602
107.0	26.5	26.5	1.14	0.38	165.94	3606
107.3	26.5	26.5	1.14	0.38	166.32	3609
107.7	26.5	26.5	1.14	0.38	166.70	3612
108.0	26.5	26.5	1.14	0.38	167.07	3615
108.3	26.5	26.5	1.14	0.38	167.45	3618
108.7	26.5	26.5	1.14	0.38	167.83	3621
109.0	26.5	26.5	1.14	0.38	168.21	3624
109.3	26.5	26.5	1.14	0.38	168.58	3627
109.7	26.5	26.5	1.14	0.38	168.96	3630
110.0	26.0	26.3	1.12	0.37	169.33	3633
110.3	26.0	26.0	1.12	0.37	169.70	3636
110.7	26.0	26.0	1.12	0.37	170.07	3639
111.0	26.0	26.0	1.12	0.37	170.44	3642
111.3	26.0	26.0	1.12	0.37	170.81	3645

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
111.7	26.0	26.0	1.12	0.37	171.18	3648
112.0	26.0	26.0	1.12	0.37	171.55	3651
112.3	26.0	26.0	1.12	0.37	171.92	3654
112.7	26.0	26.0	1.12	0.37	172.29	3657
113.0	25.5	25.8	1.10	0.36	172.66	3660
113.3	25.5	25.5	1.10	0.36	173.02	3663
113.7	25.5	25.5	1.10	0.36	173.38	3666
114.0	25.5	25.5	1.10	0.36	173.75	3669
114.3	25.5	25.5	1.10	0.36	174.11	3671
114.7	25.5	25.5	1.10	0.36	174.47	3674
115.0	25.5	25.5	1.10	0.36	174.84	3677
115.3	25.0	25.3	1.08	0.36	175.19	3680
115.7	25.0	25.0	1.08	0.36	175.55	3683
116.0	25.0	25.0	1.08	0.36	175.91	3685
116.3	25.0	25.0	1.08	0.36	176.26	3688
116.7	25.0	25.0	1.08	0.36	176.62	3691
117.0	25.0	25.0	1.08	0.36	176.98	3694
117.3	25.0	25.0	1.08	0.36	177.33	3696
117.7	25.0	25.0	1.08	0.36	177.69	3699
118.0	25.0	25.0	1.08	0.36	178.05	3702
118.3	25.0	25.0	1.08	0.36	178.40	3704
118.7	25.0	25.0	1.08	0.36	178.76	3707
119.0	25.0	25.0	1.08	0.36	179.11	3710
119.3	25.0	25.0	1.08	0.36	179.47	3712
119.7	25.0	25.0	1.08	0.36	179.83	3715
120.0	25.0	25.0	1.08	0.36	180.18	3718

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
120.3	25.0	25.0	1.08	0.36	180.54	3721
120.7	25.0	25.0	1.08	0.36	180.90	3723
121.0	25.0	25.0	1.08	0.36	181.25	3726
121.3	25.0	25.0	1.08	0.36	181.61	3728
121.7	25.0	25.0	1.08	0.36	181.97	3731
122.0	25.0	25.0	1.08	0.36	182.32	3734
122.3	25.5	25.3	1.10	0.36	182.69	3736
122.7	25.5	25.5	1.10	0.36	183.05	3739
123.0	25.5	25.5	1.10	0.36	183.41	3742
123.3	25.5	25.5	1.10	0.36	183.78	3744
123.7	25.5	25.5	1.10	0.36	184.14	3747
124.0	25.5	25.5	1.10	0.36	184.50	3750
124.3	25.5	25.5	1.10	0.36	184.87	3752
124.7	25.5	25.5	1.10	0.36	185.23	3755
125.0	26.0	25.8	1.12	0.37	185.60	3758
125.3	26.0	26.0	1.12	0.37	185.97	3760
125.7	26.0	26.0	1.12	0.37	186.34	3763
126.0	26.0	26.0	1.12	0.37	186.71	3766
126.3	26.0	26.0	1.12	0.37	187.08	3768
126.7	26.0	26.0	1.12	0.37	187.45	3771
127.0	26.0	26.0	1.12	0.37	187.82	3774
127.3	26.0	26.0	1.12	0.37	188.19	3776
127.7	26.0	26.0	1.12	0.37	188.56	3779
128.0	26.0	26.0	1.12	0.37	188.93	3781
128.3	26.0	26.0	1.12	0.37	189.30	3784
128.7	26.0	26.0	1.12	0.37	189.67	3787

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
129.0	26.0	26.0	1.12	0.37	190.04	3789
129.3	25.5	25.8	1.10	0.36	190.41	3792
129.7	25.5	25.5	1.10	0.36	190.77	3794
130.0	25.5	25.5	1.10	0.36	191.13	3797
130.3	25.5	25.5	1.10	0.36	191.50	3799
130.7	25.5	25.5	1.10	0.36	191.86	3802
131.0	25.5	25.5	1.10	0.36	192.22	3804
131.3	25.5	25.5	1.10	0.36	192.59	3807
131.7	25.5	25.5	1.10	0.36	192.95	3809
132.0	25.5	25.5	1.10	0.36	193.31	3812
132.3	25.5	25.5	1.10	0.36	193.68	3814
132.7	25.5	25.5	1.10	0.36	194.04	3817
133.0	25.5	25.5	1.10	0.36	194.40	3819
133.3	25.5	25.5	1.10	0.36	194.77	3822
133.7	25.5	25.5	1.10	0.36	195.13	3824
134.0	25.0	25.3	1.08	0.36	195.49	3827
134.3	25.0	25.0	1.08	0.36	195.84	3829
134.7	25.0	25.0	1.08	0.36	196.20	3831
135.0	25.0	25.0	1.08	0.36	196.56	3834
135.3	25.0	25.0	1.08	0.36	196.91	3836
135.7	25.0	25.0	1.08	0.36	197.27	3839
136.0	25.0	25.0	1.08	0.36	197.63	3841
136.3	25.0	25.0	1.08	0.36	197.98	3843
136.7	25.0	25.0	1.08	0.36	198.34	3846
137.0	25.0	25.0	1.08	0.36	198.70	3848
137.3	25.0	25.0	1.08	0.36	199.05	3850

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
137.7	24.5	24.8	1.06	0.35	199.40	3853
138.0	24.5	24.5	1.06	0.35	199.75	3855
138.3	24.5	24.5	1.06	0.35	200.10	3857
138.7	24.5	24.5	1.06	0.35	200.45	3859
139.0	24.5	24.5	1.06	0.35	200.80	3862
139.3	24.5	24.5	1.06	0.35	201.15	3864
139.7	24.5	24.5	1.06	0.35	201.50	3866
140.0	24.5	24.5	1.06	0.35	201.85	3869
140.3	24.5	24.5	1.06	0.35	202.20	3871
140.7	24.0	24.3	1.04	0.34	202.54	3873
141.0	24.0	24.0	1.04	0.34	202.89	3875
141.3	24.0	24.0	1.04	0.34	203.23	3877
141.7	24.0	24.0	1.04	0.34	203.57	3880
142.0	24.0	24.0	1.04	0.34	203.92	3882
142.3	24.0	24.0	1.04	0.34	204.26	3884
142.7	24.0	24.0	1.04	0.34	204.60	3886
143.0	24.0	24.0	1.04	0.34	204.94	3888
143.3	24.0	24.0	1.04	0.34	205.29	3891
143.7	24.0	24.0	1.04	0.34	205.63	3893
144.0	24.0	24.0	1.04	0.34	205.97	3895
144.3	24.0	24.0	1.04	0.34	206.32	3897
144.7	24.0	24.0	1.04	0.34	206.66	3899
145.0	24.0	24.0	1.04	0.34	207.00	3901
145.3	24.0	24.0	1.04	0.34	207.35	3903
145.7	24.0	24.0	1.04	0.34	207.69	3906
146.0	24.0	24.0	1.04	0.34	208.03	3908

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
146.3	24.0	24.0	1.04	0.34	208.37	3910
146.7	24.0	24.0	1.04	0.34	208.72	3912
147.0	24.0	24.0	1.04	0.34	209.06	3914
147.3	24.0	24.0	1.04	0.34	209.40	3916
147.7	24.0	24.0	1.04	0.34	209.75	3918
148.0	24.0	24.0	1.04	0.34	210.09	3920
148.3	24.0	24.0	1.04	0.34	210.43	3922
148.7	24.0	24.0	1.04	0.34	210.78	3925
149.0	24.0	24.0	1.04	0.34	211.12	3927
149.3	24.0	24.0	1.04	0.34	211.46	3929
149.7	24.0	24.0	1.04	0.34	211.80	3931
150.0	24.0	24.0	1.04	0.34	212.15	3933
150.3	24.0	24.0	1.04	0.34	212.49	3935
150.7	24.0	24.0	1.04	0.34	212.83	3937
151.0	24.0	24.0	1.04	0.34	213.18	3939
151.3	24.0	24.0	1.04	0.34	213.52	3941
151.7	24.0	24.0	1.04	0.34	213.86	3943
152.0	24.0	24.0	1.04	0.34	214.21	3945
152.3	23.5	23.8	1.02	0.34	214.54	3947
152.7	23.5	23.5	1.02	0.34	214.88	3949
153.0	23.5	23.5	1.02	0.34	215.22	3951
153.3	23.5	23.5	1.02	0.34	215.55	3953
153.7	23.5	23.5	1.02	0.34	215.89	3955
154.0	23.5	23.5	1.02	0.34	216.22	3957
154.3	23.5	23.5	1.02	0.34	216.56	3959
154.7	23.5	23.5	1.02	0.34	216.90	3961

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
155.0	23.5	23.5	1.02	0.34	217.23	3963
155.3	23.5	23.5	1.02	0.34	217.57	3965
155.7	23.5	23.5	1.02	0.34	217.91	3967
156.0	23.5	23.5	1.02	0.34	218.24	3969
156.3	23.5	23.5	1.02	0.34	218.58	3971
156.7	23.5	23.5	1.02	0.34	218.92	3973
157.0	23.5	23.5	1.02	0.34	219.25	3975
157.3	23.5	23.5	1.02	0.34	219.59	3977
157.7	23.5	23.5	1.02	0.34	219.93	3979
158.0	23.0	23.3	1.00	0.33	220.26	3981
158.3	23.0	23.0	1.00	0.33	220.59	3983
158.7	23.0	23.0	1.00	0.33	220.92	3984
159.0	23.0	23.0	1.00	0.33	221.25	3986
159.3	23.0	23.0	1.00	0.33	221.58	3988
159.7	23.0	23.0	1.00	0.33	221.91	3990
160.0	23.0	23.0	1.00	0.33	222.24	3992
160.3	23.0	23.0	1.00	0.33	222.57	3994
160.7	23.0	23.0	1.00	0.33	222.90	3996
161.0	23.0	23.0	1.00	0.33	223.23	3998
161.3	23.0	23.0	1.00	0.33	223.56	3999
161.7	23.0	23.0	1.00	0.33	223.89	4001
162.0	23.0	23.0	1.00	0.33	224.22	4003
162.3	23.0	23.0	1.00	0.33	224.55	4005
162.7	23.0	23.0	1.00	0.33	224.88	4007
163.0	22.5	22.8	0.98	0.32	225.20	4009
163.3	22.5	22.5	0.98	0.32	225.52	4010

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
163.7	22.5	22.5	0.98	0.32	225.85	4012
164.0	22.5	22.5	0.98	0.32	226.17	4014
164.3	22.5	22.5	0.98	0.32	226.49	4016
164.7	22.5	22.5	0.98	0.32	226.82	4018
165.0	22.5	22.5	0.98	0.32	227.14	4019
165.3	22.5	22.5	0.98	0.32	227.46	4021
165.7	22.5	22.5	0.98	0.32	227.79	4023
166.0	22.5	22.5	0.98	0.32	228.11	4025
166.3	22.5	22.5	0.98	0.32	228.44	4027
166.7	22.5	22.5	0.98	0.32	228.76	4028
167.0	22.5	22.5	0.98	0.32	229.08	4030
167.3	22.5	22.5	0.98	0.32	229.41	4032
167.7	22.5	22.5	0.98	0.32	229.73	4034
168.0	22.5	22.5	0.98	0.32	230.05	4035

Table E.8 Maturity calculations control mixture-slab

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
0.0	15.0	-	-		0	0.00
0.3	15.5	15.3	0.65	0.21	0.21	621
0.7	15.0	15.3	0.63	0.21	0.42	628
1.0	15.0	15.0	0.63	0.21	0.63	635
1.3	15.0	15.0	0.63	0.21	0.83	641
1.7	15.0	15.0	0.63	0.21	1.04	648
2.0	15.0	15.0	0.63	0.21	1.25	654
2.3	15.0	15.0	0.63	0.21	1.45	661
2.7	15.5	15.3	0.65	0.21	1.67	667
3.0	15.5	15.5	0.65	0.21	1.88	674
3.3	15.5	15.5	0.65	0.21	2.09	680
3.7	15.5	15.5	0.65	0.21	2.31	687
4.0	16.0	15.8	0.67	0.22	2.53	694
4.3	16.0	16.0	0.67	0.22	2.75	701
4.7	16.5	16.3	0.69	0.23	2.97	708
5.0	16.5	16.5	0.69	0.23	3.20	714
5.3	17.0	16.8	0.71	0.23	3.43	722
5.7	17.0	17.0	0.71	0.23	3.66	729
6.0	17.5	17.3	0.73	0.24	3.90	736
6.3	17.5	17.5	0.73	0.24	4.14	743
6.7	18.0	17.8	0.75	0.25	4.39	751
7.0	18.0	18.0	0.75	0.25	4.64	758
7.3	18.5	18.3	0.77	0.25	4.89	766

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
7.7	18.5	18.5	0.77	0.25	5.15	773
8.0	19.0	18.8	0.79	0.26	5.41	781
8.3	19.5	19.3	0.82	0.27	5.68	789
8.7	20.0	19.8	0.84	0.28	5.96	797
9.0	20.0	20.0	0.84	0.28	6.23	805
9.3	20.5	20.3	0.87	0.29	6.52	814
9.7	21.0	20.8	0.89	0.29	6.82	822
10.0	21.5	21.3	0.92	0.30	7.12	831
10.3	22.0	21.8	0.94	0.31	7.43	840
10.7	22.0	22.0	0.94	0.31	7.74	849
11.0	22.5	22.3	0.97	0.32	8.06	858
11.3	22.5	22.5	0.97	0.32	8.38	867
11.7	22.5	22.5	0.97	0.32	8.70	876
12.0	22.5	22.5	0.97	0.32	9.02	885
12.3	22.5	22.5	0.97	0.32	9.35	894
12.7	22.5	22.5	0.97	0.32	9.67	903
13.0	22.5	22.5	0.97	0.32	9.99	912
13.3	22.5	22.5	0.97	0.32	10.31	921
13.7	22.5	22.5	0.97	0.32	10.63	930
14.0	22.5	22.5	0.97	0.32	10.95	939
14.3	22.5	22.5	0.97	0.32	11.27	948
14.7	22.0	22.3	0.94	0.31	11.58	956
15.0	22.0	22.0	0.94	0.31	11.89	965
15.3	22.0	22.0	0.94	0.31	12.20	973
15.7	22.0	22.0	0.94	0.31	12.52	982
16.0	22.0	22.0	0.94	0.31	12.83	990

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^{o}C Increment (hours)	Eq. Age @ 23^{o}C Cumulative (hours)	Predicted Compressive Strength (psi)
16.3	22.0	22.0	0.94	0.31	13.14	998
16.7	22.0	22.0	0.94	0.31	13.45	1007
17.0	21.5	21.8	0.92	0.30	13.75	1015
17.3	21.5	21.5	0.92	0.30	14.06	1023
17.7	21.5	21.5	0.92	0.30	14.36	1031
18.0	21.5	21.5	0.92	0.30	14.66	1039
18.3	21.5	21.5	0.92	0.30	14.97	1046
18.7	21.0	21.3	0.89	0.29	15.26	1054
19.0	21.0	21.0	0.89	0.29	15.55	1062
19.3	21.0	21.0	0.89	0.29	15.85	1069
19.7	21.0	21.0	0.89	0.29	16.14	1077
20.0	20.5	20.8	0.87	0.29	16.43	1084
20.3	20.5	20.5	0.87	0.29	16.72	1092
20.7	20.5	20.5	0.87	0.29	17.00	1099
21.0	20.5	20.5	0.87	0.29	17.29	1106
21.3	20.5	20.5	0.87	0.29	17.57	1113
21.7	20.5	20.5	0.87	0.29	17.86	1121
22.0	20.0	20.3	0.84	0.28	18.14	1127
22.3	20.0	20.0	0.84	0.28	18.41	1134
22.7	20.0	20.0	0.84	0.28	18.69	1141
23.0	20.0	20.0	0.84	0.28	18.97	1148
23.3	20.0	20.0	0.84	0.28	19.25	1155
23.7	20.5	20.3	0.87	0.29	19.53	1162
24.0	20.5	20.5	0.87	0.29	19.82	1169
24.3	20.5	20.5	0.87	0.29	20.11	1176
24.7	20.5	20.5	0.87	0.29	20.39	1183

Age (hours)	Temperature (^{o}C)	Average Temperature (^{o}C)	Age Factor	Eq. Age @ 23^{o}C Increment (hours)	Eq. Age @ 23^{o}C Cumulative (hours)	Predicted Compressive Strength (psi)
25.0	21.0	20.8	0.89	0.29	20.69	1190
25.3	21.0	21.0	0.89	0.29	20.98	1197
25.7	21.0	21.0	0.89	0.29	21.27	1205
26.0	21.5	21.3	0.92	0.30	21.58	1212
26.3	21.5	21.5	0.92	0.30	21.88	1219
26.7	21.5	21.5	0.92	0.30	22.18	1226
27.0	22.0	21.8	0.94	0.31	22.49	1234
27.3	22.0	22.0	0.94	0.31	22.81	1241
27.7	22.0	22.0	0.94	0.31	23.12	1248
28.0	22.0	22.0	0.94	0.31	23.43	1256
28.3	22.0	22.0	0.94	0.31	23.74	1263
28.7	22.0	22.0	0.94	0.31	24.05	1270
29.0	22.0	22.0	0.94	0.31	24.37	1278
29.3	22.0	22.0	0.94	0.31	24.68	1285
29.7	22.0	22.0	0.94	0.31	24.99	1292
30.0	22.0	22.0	0.94	0.31	25.30	1299
30.3	21.5	21.8	0.92	0.30	25.60	1306
30.7	21.5	21.5	0.92	0.30	25.91	1313
31.0	21.5	21.5	0.92	0.30	26.21	1320
31.3	21.5	21.5	0.92	0.30	26.51	1327
31.7	21.0	21.3	0.89	0.29	26.81	1333
32.0	21.0	21.0	0.89	0.29	27.10	1340
32.3	21.0	21.0	0.89	0.29	27.39	1347
32.7	21.0	21.0	0.89	0.29	27.69	1353
33.0	21.0	21.0	0.89	0.29	27.98	1360
33.3	20.5	20.8	0.87	0.29	28.27	1366

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
33.7	20.5	20.5	0.87	0.29	28.56	1372
34.0	20.5	20.5	0.87	0.29	28.84	1379
34.3	20.5	20.5	0.87	0.29	29.13	1385
34.7	20.0	20.3	0.84	0.28	29.41	1391
35.0	20.0	20.0	0.84	0.28	29.68	1397
35.3	20.0	20.0	0.84	0.28	29.96	1403
35.7	20.0	20.0	0.84	0.28	30.24	1409
36.0	20.0	20.0	0.84	0.28	30.52	1415
36.3	20.0	20.0	0.84	0.28	30.79	1421
36.7	19.5	19.8	0.82	0.27	31.06	1427
37.0	19.5	19.5	0.82	0.27	31.33	1433
37.3	19.5	19.5	0.82	0.27	31.60	1438
37.7	19.5	19.5	0.82	0.27	31.87	1444
38.0	19.5	19.5	0.82	0.27	32.14	1450
38.3	19.5	19.5	0.82	0.27	32.41	1455
38.7	19.5	19.5	0.82	0.27	32.68	1461
39.0	19.5	19.5	0.82	0.27	32.95	1467
39.3	19.0	19.3	0.79	0.26	33.21	1472
39.7	19.0	19.0	0.79	0.26	33.48	1478
40.0	19.0	19.0	0.79	0.26	33.74	1483
40.3	19.0	19.0	0.79	0.26	34.00	1489
40.7	19.0	19.0	0.79	0.26	34.26	1494
41.0	19.0	19.0	0.79	0.26	34.53	1499
41.3	19.0	19.0	0.79	0.26	34.79	1505
41.7	19.0	19.0	0.79	0.26	35.05	1510
42.0	19.0	19.0	0.79	0.26	35.31	1516

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
42.3	18.5	18.8	0.77	0.25	35.57	1521
42.7	18.5	18.5	0.77	0.25	35.82	1526
43.0	18.5	18.5	0.77	0.25	36.08	1531
43.3	18.5	18.5	0.77	0.25	36.33	1536
43.7	18.5	18.5	0.77	0.25	36.58	1541
44.0	18.5	18.5	0.77	0.25	36.84	1546
44.3	18.5	18.5	0.77	0.25	37.09	1551
44.7	18.5	18.5	0.77	0.25	37.35	1557
45.0	18.5	18.5	0.77	0.25	37.60	1562
45.3	18.5	18.5	0.77	0.25	37.86	1567
45.7	18.0	18.3	0.75	0.25	38.10	1572
46.0	18.0	18.0	0.75	0.25	38.35	1576
46.3	18.0	18.0	0.75	0.25	38.60	1581
46.7	18.0	18.0	0.75	0.25	38.85	1586
47.0	18.0	18.0	0.75	0.25	39.09	1591
47.3	18.0	18.0	0.75	0.25	39.34	1596
47.7	18.0	18.0	0.75	0.25	39.59	1601
48.0	18.0	18.0	0.75	0.25	39.83	1605
48.3	18.0	18.0	0.75	0.25	40.08	1610
48.7	18.0	18.0	0.75	0.25	40.33	1615
49.0	18.0	18.0	0.75	0.25	40.58	1620
49.3	18.0	18.0	0.75	0.25	40.82	1624
49.7	18.0	18.0	0.75	0.25	41.07	1629
50.0	18.0	18.0	0.75	0.25	41.32	1634
50.3	16.5	17.3	0.69	0.23	41.54	1638
50.7	16.0	16.3	0.67	0.22	41.76	1642

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Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
51.0	15.5	15.8	0.65	0.21	41.98	1646
51.3	16.0	15.8	0.67	0.22	42.20	1651
51.7	16.0	16.0	0.67	0.22	42.42	1655
52.0	16.0	16.0	0.67	0.22	42.63	1659
52.3	16.0	16.0	0.67	0.22	42.85	1663
52.7	16.0	16.0	0.67	0.22	43.07	1667
53.0	16.0	16.0	0.67	0.22	43.29	1671
53.3	16.0	16.0	0.67	0.22	43.51	1675
53.7	16.0	16.0	0.67	0.22	43.73	1679
54.0	16.0	16.0	0.67	0.22	43.95	1683
54.3	16.0	16.0	0.67	0.22	44.17	1687
54.7	16.0	16.0	0.67	0.22	44.39	1691
55.0	16.0	16.0	0.67	0.22	44.61	1696
55.3	16.0	16.0	0.67	0.22	44.83	1700
55.7	16.0	16.0	0.67	0.22	45.05	1704
56.0	16.0	16.0	0.67	0.22	45.27	1708
56.3	16.0	16.0	0.67	0.22	45.49	1712
56.7	16.0	16.0	0.67	0.22	45.71	1716
57.0	16.0	16.0	0.67	0.22	45.93	1720
57.3	16.0	16.0	0.67	0.22	46.15	1724
57.7	15.5	15.8	0.65	0.21	46.36	1727
58.0	15.5	15.5	0.65	0.21	46.57	1731
58.3	15.5	15.5	0.65	0.21	46.79	1735
58.7	15.5	15.5	0.65	0.21	47.00	1739
59.0	15.0	15.3	0.63	0.21	47.21	1743
59.3	15.0	15.0	0.63	0.21	47.41	1746

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
59.7	14.5	14.8	0.61	0.20	47.61	1750
60.0	14.5	14.5	0.61	0.20	47.82	1753
60.3	14.0	14.3	0.59	0.19	48.01	1757
60.7	14.0	14.0	0.59	0.19	48.20	1760
61.0	14.0	14.0	0.59	0.19	48.40	1764
61.3	13.5	13.8	0.57	0.19	48.59	1767
61.7	13.5	13.5	0.57	0.19	48.78	1770
62.0	13.5	13.5	0.57	0.19	48.97	1774
62.3	13.5	13.5	0.57	0.19	49.15	1777
62.7	13.5	13.5	0.57	0.19	49.34	1780
63.0	13.0	13.3	0.56	0.18	49.53	1784
63.3	13.0	13.0	0.56	0.18	49.71	1787
63.7	13.0	13.0	0.56	0.18	49.89	1790
64.0	13.0	13.0	0.56	0.18	50.08	1793
64.3	13.0	13.0	0.56	0.18	50.26	1796
64.7	13.0	13.0	0.56	0.18	50.44	1799
65.0	13.0	13.0	0.56	0.18	50.63	1803
65.3	13.0	13.0	0.56	0.18	50.81	1806
65.7	13.0	13.0	0.56	0.18	50.99	1809
66.0	13.0	13.0	0.56	0.18	51.18	1812
66.3	13.0	13.0	0.56	0.18	51.36	1815
66.7	13.0	13.0	0.56	0.18	51.54	1818
67.0	13.0	13.0	0.56	0.18	51.73	1821
67.3	13.0	13.0	0.56	0.18	51.91	1825
67.7	13.0	13.0	0.56	0.18	52.09	1828
68.0	13.0	13.0	0.56	0.18	52.28	1831

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
68.3	13.0	13.0	0.56	0.18	52.46	1834
68.7	13.0	13.0	0.56	0.18	52.64	1837
69.0	12.5	12.8	0.54	0.18	52.82	1840
69.3	12.5	12.5	0.54	0.18	53.00	1843
69.7	13.0	12.8	0.56	0.18	53.18	1846
70.0	12.5	12.8	0.54	0.18	53.36	1849
70.3	12.5	12.5	0.54	0.18	53.54	1852
70.7	12.5	12.5	0.54	0.18	53.71	1855
71.0	12.5	12.5	0.54	0.18	53.89	1858
71.3	13.0	12.8	0.56	0.18	54.08	1861
71.7	13.0	13.0	0.56	0.18	54.26	1864
72.0	13.0	13.0	0.56	0.18	54.44	1867
72.3	13.0	13.0	0.56	0.18	54.63	1870
72.7	13.0	13.0	0.56	0.18	54.81	1873
73.0	13.0	13.0	0.56	0.18	54.99	1876
73.3	13.0	13.0	0.56	0.18	55.18	1879
73.7	13.0	13.0	0.56	0.18	55.36	1882
74.0	13.0	13.0	0.56	0.18	55.54	1885
74.3	13.0	13.0	0.56	0.18	55.72	1888
74.7	13.0	13.0	0.56	0.18	55.91	1891
75.0	13.0	13.0	0.56	0.18	56.09	1894
75.3	13.0	13.0	0.56	0.18	56.27	1897
75.7	13.0	13.0	0.56	0.18	56.46	1900
76.0	13.0	13.0	0.56	0.18	56.64	1903
76.3	13.0	13.0	0.56	0.18	56.82	1906
76.7	13.0	13.0	0.56	0.18	57.01	1909

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
77.0	13.0	13.0	0.56	0.18	57.19	1912
77.3	13.0	13.0	0.56	0.18	57.37	1915
77.7	13.0	13.0	0.56	0.18	57.56	1918
78.0	13.0	13.0	0.56	0.18	57.74	1921
78.3	13.0	13.0	0.56	0.18	57.92	1924
78.7	13.0	13.0	0.56	0.18	58.11	1927
79.0	13.0	13.0	0.56	0.18	58.29	1930
79.3	13.0	13.0	0.56	0.18	58.47	1933
79.7	13.0	13.0	0.56	0.18	58.66	1936
80.0	13.0	13.0	0.56	0.18	58.84	1938
80.3	13.0	13.0	0.56	0.18	59.02	1941
80.7	13.0	13.0	0.56	0.18	59.21	1944
81.0	13.0	13.0	0.56	0.18	59.39	1947
81.3	13.0	13.0	0.56	0.18	59.57	1950
81.7	13.0	13.0	0.56	0.18	59.76	1953
82.0	13.0	13.0	0.56	0.18	59.94	1956
82.3	13.0	13.0	0.56	0.18	60.12	1959
82.7	13.0	13.0	0.56	0.18	60.31	1961
83.0	13.0	13.0	0.56	0.18	60.49	1964
83.3	13.0	13.0	0.56	0.18	60.67	1967
83.7	13.0	13.0	0.56	0.18	60.86	1970
84.0	13.0	13.0	0.56	0.18	61.04	1973
84.3	13.0	13.0	0.56	0.18	61.22	1976
84.7	13.0	13.0	0.56	0.18	61.41	1979
85.0	13.0	13.0	0.56	0.18	61.59	1981
85.3	13.0	13.0	0.56	0.18	61.77	1984

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
85.7	13.0	13.0	0.56	0.18	61.96	1987
86.0	13.0	13.0	0.56	0.18	62.14	1990
86.3	13.0	13.0	0.56	0.18	62.32	1993
86.7	13.0	13.0	0.56	0.18	62.51	1995
87.0	13.0	13.0	0.56	0.18	62.69	1998
87.3	13.0	13.0	0.56	0.18	62.87	2001
87.7	13.0	13.0	0.56	0.18	63.06	2004
88.0	12.5	12.8	0.54	0.18	63.23	2007
88.3	12.5	12.5	0.54	0.18	63.41	2009
88.7	12.5	12.5	0.54	0.18	63.59	2012
89.0	12.5	12.5	0.54	0.18	63.77	2015
89.3	12.5	12.5	0.54	0.18	63.94	2017
89.7	12.5	12.5	0.54	0.18	64.12	2020
90.0	12.5	12.5	0.54	0.18	64.30	2023
90.3	12.5	12.5	0.54	0.18	64.48	2025
90.7	12.5	12.5	0.54	0.18	64.66	2028
91.0	12.5	12.5	0.54	0.18	64.83	2031
91.3	12.5	12.5	0.54	0.18	65.01	2033
91.7	12.0	12.3	0.52	0.17	65.18	2036
92.0	12.0	12.0	0.52	0.17	65.36	2038
92.3	12.0	12.0	0.52	0.17	65.53	2041
92.7	12.0	12.0	0.52	0.17	65.70	2044
93.0	12.0	12.0	0.52	0.17	65.87	2046
93.3	12.0	12.0	0.52	0.17	66.05	2049
93.7	12.0	12.0	0.52	0.17	66.22	2051
94.0	12.0	12.0	0.52	0.17	66.39	2054

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
94.3	12.0	12.0	0.52	0.17	66.56	2056
94.7	12.0	12.0	0.52	0.17	66.73	2059
95.0	12.0	12.0	0.52	0.17	66.91	2061
95.3	12.0	12.0	0.52	0.17	67.08	2064
95.7	12.0	12.0	0.52	0.17	67.25	2066
96.0	12.0	12.0	0.52	0.17	67.42	2069
96.3	12.5	12.3	0.54	0.18	67.60	2071
96.7	12.5	12.5	0.54	0.18	67.78	2074
97.0	12.5	12.5	0.54	0.18	67.96	2077
97.3	13.0	12.8	0.56	0.18	68.14	2079
97.7	13.0	13.0	0.56	0.18	68.32	2082
98.0	13.5	13.3	0.57	0.19	68.51	2085
98.3	14.0	13.8	0.59	0.19	68.71	2087
98.7	14.5	14.3	0.61	0.20	68.91	2090
99.0	14.5	14.5	0.61	0.20	69.11	2093
99.3	14.5	14.5	0.61	0.20	69.31	2096
99.7	15.0	14.8	0.63	0.21	69.52	2099
100.0	15.0	15.0	0.63	0.21	69.72	2102
100.3	15.0	15.0	0.63	0.21	69.93	2105
100.7	15.0	15.0	0.63	0.21	70.14	2108
101.0	15.0	15.0	0.63	0.21	70.34	2111
101.3	15.5	15.3	0.65	0.21	70.56	2114
101.7	15.5	15.5	0.65	0.21	70.77	2117
102.0	15.0	15.3	0.63	0.21	70.98	2120
102.3	15.0	15.0	0.63	0.21	71.18	2123
102.7	15.0	15.0	0.63	0.21	71.39	2126

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
103.0	15.0	15.0	0.63	0.21	71.60	2128
103.3	14.5	14.8	0.61	0.20	71.80	2131
103.7	14.5	14.5	0.61	0.20	72.00	2134
104.0	14.5	14.5	0.61	0.20	72.20	2137
104.3	14.5	14.5	0.61	0.20	72.40	2140
104.7	14.0	14.3	0.59	0.19	72.59	2142
105.0	14.0	14.0	0.59	0.19	72.79	2145
105.3	14.0	14.0	0.59	0.19	72.98	2148
105.7	14.0	14.0	0.59	0.19	73.18	2150
106.0	14.0	14.0	0.59	0.19	73.37	2153
106.3	14.0	14.0	0.59	0.19	73.57	2156
106.7	13.5	13.8	0.57	0.19	73.76	2158
107.0	13.5	13.5	0.57	0.19	73.95	2161
107.3	13.5	13.5	0.57	0.19	74.14	2164
107.7	13.5	13.5	0.57	0.19	74.32	2166
108.0	13.5	13.5	0.57	0.19	74.51	2169
108.3	13.5	13.5	0.57	0.19	74.70	2171
108.7	13.5	13.5	0.57	0.19	74.89	2174
109.0	13.0	13.3	0.56	0.18	75.07	2176
109.3	13.0	13.0	0.56	0.18	75.26	2179
109.7	13.0	13.0	0.56	0.18	75.44	2181
110.0	13.0	13.0	0.56	0.18	75.62	2184
110.3	13.0	13.0	0.56	0.18	75.81	2186
110.7	13.0	13.0	0.56	0.18	75.99	2189
111.0	13.0	13.0	0.56	0.18	76.17	2191
111.3	13.0	13.0	0.56	0.18	76.36	2194

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
111.7	13.0	13.0	0.56	0.18	76.54	2196
112.0	12.5	12.8	0.54	0.18	76.72	2198
112.3	12.5	12.5	0.54	0.18	76.90	2201
112.7	12.5	12.5	0.54	0.18	77.07	2203
113.0	12.5	12.5	0.54	0.18	77.25	2206
113.3	12.5	12.5	0.54	0.18	77.43	2208
113.7	12.5	12.5	0.54	0.18	77.61	2210
114.0	12.5	12.5	0.54	0.18	77.78	2213
114.3	12.5	12.5	0.54	0.18	77.96	2215
114.7	12.5	12.5	0.54	0.18	78.14	2217
115.0	12.5	12.5	0.54	0.18	78.32	2220
115.3	12.0	12.3	0.52	0.17	78.49	2222
115.7	12.0	12.0	0.52	0.17	78.66	2224
116.0	12.0	12.0	0.52	0.17	78.83	2226
116.3	12.0	12.0	0.52	0.17	79.01	2229
116.7	12.0	12.0	0.52	0.17	79.18	2231
117.0	12.0	12.0	0.52	0.17	79.35	2233
117.3	12.0	12.0	0.52	0.17	79.52	2235
117.7	12.0	12.0	0.52	0.17	79.70	2238
118.0	12.0	12.0	0.52	0.17	79.87	2240
118.3	12.0	12.0	0.52	0.17	80.04	2242
118.7	12.0	12.0	0.52	0.17	80.21	2244
119.0	12.0	12.0	0.52	0.17	80.39	2247
119.3	12.0	12.0	0.52	0.17	80.56	2249
119.7	12.0	12.0	0.52	0.17	80.73	2251
120.0	12.5	12.3	0.54	0.18	80.91	2253

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
120.3	12.5	12.5	0.54	0.18	81.09	2256
120.7	13.0	12.8	0.56	0.18	81.27	2258
121.0	13.0	13.0	0.56	0.18	81.45	2260
121.3	13.5	13.3	0.57	0.19	81.64	2263
121.7	13.5	13.5	0.57	0.19	81.83	2265
122.0	13.5	13.5	0.57	0.19	82.02	2268
122.3	14.0	13.8	0.59	0.19	82.21	2270
122.7	14.0	14.0	0.59	0.19	82.41	2272
123.0	14.5	14.3	0.61	0.20	82.61	2275
123.3	14.5	14.5	0.61	0.20	82.81	2278
123.7	14.5	14.5	0.61	0.20	83.01	2280
124.0	15.0	14.8	0.63	0.21	83.22	2283
124.3	15.0	15.0	0.63	0.21	83.43	2285
124.7	15.0	15.0	0.63	0.21	83.63	2288
125.0	15.0	15.0	0.63	0.21	83.84	2290
125.3	15.0	15.0	0.63	0.21	84.05	2293
125.7	15.0	15.0	0.63	0.21	84.25	2296
126.0	15.0	15.0	0.63	0.21	84.46	2298
126.3	15.0	15.0	0.63	0.21	84.67	2301
126.7	14.5	14.8	0.61	0.20	84.87	2303
127.0	14.5	14.5	0.61	0.20	85.07	2306
127.3	14.5	14.5	0.61	0.20	85.27	2308
127.7	14.5	14.5	0.61	0.20	85.47	2311
128.0	14.5	14.5	0.61	0.20	85.67	2313
128.3	14.0	14.3	0.59	0.19	85.86	2316
128.7	14.0	14.0	0.59	0.19	86.06	2318

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
129.0	14.0	14.0	0.59	0.19	86.25	2320
129.3	14.0	14.0	0.59	0.19	86.45	2323
129.7	14.0	14.0	0.59	0.19	86.64	2325
130.0	14.0	14.0	0.59	0.19	86.84	2328
130.3	13.5	13.8	0.57	0.19	87.03	2330
130.7	13.5	13.5	0.57	0.19	87.22	2332
131.0	13.5	13.5	0.57	0.19	87.40	2334
131.3	13.5	13.5	0.57	0.19	87.59	2337
131.7	13.5	13.5	0.57	0.19	87.78	2339
132.0	13.5	13.5	0.57	0.19	87.97	2341
132.3	13.0	13.3	0.56	0.18	88.15	2343
132.7	13.0	13.0	0.56	0.18	88.34	2346
133.0	13.0	13.0	0.56	0.18	88.52	2348
133.3	13.0	13.0	0.56	0.18	88.70	2350
133.7	13.0	13.0	0.56	0.18	88.89	2352
134.0	13.0	13.0	0.56	0.18	89.07	2354
134.3	13.0	13.0	0.56	0.18	89.25	2357
134.7	13.0	13.0	0.56	0.18	89.44	2359
135.0	13.0	13.0	0.56	0.18	89.62	2361
135.3	12.5	12.8	0.54	0.18	89.80	2363
135.7	12.5	12.5	0.54	0.18	89.98	2365
136.0	12.5	12.5	0.54	0.18	90.15	2367
136.3	12.5	12.5	0.54	0.18	90.33	2369
136.7	12.5	12.5	0.54	0.18	90.51	2372
137.0	12.5	12.5	0.54	0.18	90.69	2374
137.3	12.5	12.5	0.54	0.18	90.86	2376

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
137.7	12.5	12.5	0.54	0.18	91.04	2378
138.0	12.5	12.5	0.54	0.18	91.22	2380
138.3	12.5	12.5	0.54	0.18	91.40	2382
138.7	12.5	12.5	0.54	0.18	91.58	2384
139.0	12.5	12.5	0.54	0.18	91.75	2386
139.3	12.0	12.3	0.52	0.17	91.93	2388
139.7	12.0	12.0	0.52	0.17	92.10	2390
140.0	12.0	12.0	0.52	0.17	92.27	2392
140.3	12.0	12.0	0.52	0.17	92.44	2394
140.7	12.0	12.0	0.52	0.17	92.62	2396
141.0	12.0	12.0	0.52	0.17	92.79	2398
141.3	12.0	12.0	0.52	0.17	92.96	2400
141.7	12.0	12.0	0.52	0.17	93.13	2402
142.0	12.0	12.0	0.52	0.17	93.31	2404
142.3	12.0	12.0	0.52	0.17	93.48	2406
142.7	12.0	12.0	0.52	0.17	93.65	2408
143.0	12.0	12.0	0.52	0.17	93.82	2410
143.3	12.0	12.0	0.52	0.17	93.99	2412
143.7	12.5	12.3	0.54	0.18	94.17	2414
144.0	12.5	12.5	0.54	0.18	94.35	2416
144.3	12.5	12.5	0.54	0.18	94.53	2418
144.7	13.0	12.8	0.56	0.18	94.71	2420
145.0	13.0	13.0	0.56	0.18	94.89	2422
145.3	13.0	13.0	0.56	0.18	95.08	2424
145.7	13.5	13.3	0.57	0.19	95.27	2427
146.0	13.5	13.5	0.57	0.19	95.46	2429

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
146.3	14.0	13.8	0.59	0.19	95.65	2431
146.7	14.0	14.0	0.59	0.19	95.85	2433
147.0	14.5	14.3	0.61	0.20	96.05	2435
147.3	14.5	14.5	0.61	0.20	96.25	2438
147.7	14.5	14.5	0.61	0.20	96.45	2440
148.0	14.5	14.5	0.61	0.20	96.65	2442
148.3	15.0	14.8	0.63	0.21	96.85	2444
148.7	15.0	15.0	0.63	0.21	97.06	2447
149.0	15.0	15.0	0.63	0.21	97.27	2449
149.3	15.0	15.0	0.63	0.21	97.48	2451
149.7	15.0	15.0	0.63	0.21	97.68	2454
150.0	15.0	15.0	0.63	0.21	97.89	2456
150.3	14.5	14.8	0.61	0.20	98.09	2458
150.7	14.5	14.5	0.61	0.20	98.29	2460
151.0	14.5	14.5	0.61	0.20	98.49	2463
151.3	14.5	14.5	0.61	0.20	98.69	2465
151.7	14.5	14.5	0.61	0.20	98.89	2467
152.0	14.5	14.5	0.61	0.20	99.09	2469
152.3	14.0	14.3	0.59	0.19	99.29	2471
152.7	14.0	14.0	0.59	0.19	99.48	2473
153.0	14.0	14.0	0.59	0.19	99.68	2476
153.3	14.0	14.0	0.59	0.19	99.87	2478
153.7	14.0	14.0	0.59	0.19	100.07	2480
154.0	13.5	13.8	0.57	0.19	100.26	2482
154.3	13.5	13.5	0.57	0.19	100.44	2484
154.7	13.5	13.5	0.57	0.19	100.63	2486

Age (hours)	Temperature (^{o}C)	Average Temperature (^{o}C)	Age Factor	Eq. Age @ 23^{o}C Increment (hours)	Eq. Age @ 23^{o}C Cumulative (hours)	Predicted Compressive Strength (psi)
155.0	13.5	13.5	0.57	0.19	100.82	2488
155.3	13.5	13.5	0.57	0.19	101.01	2490
155.7	13.5	13.5	0.57	0.19	101.20	2492
156.0	13.5	13.5	0.57	0.19	101.39	2494
156.3	13.5	13.5	0.57	0.19	101.58	2496
156.7	13.0	13.3	0.56	0.18	101.76	2498
157.0	13.0	13.0	0.56	0.18	101.94	2500
157.3	13.0	13.0	0.56	0.18	102.13	2502
157.7	13.0	13.0	0.56	0.18	102.31	2504
158.0	13.0	13.0	0.56	0.18	102.49	2506
158.3	13.0	13.0	0.56	0.18	102.68	2508
158.7	13.0	13.0	0.56	0.18	102.86	2510
159.0	13.0	13.0	0.56	0.18	103.04	2512
159.3	13.0	13.0	0.56	0.18	103.23	2514
159.7	12.5	12.8	0.54	0.18	103.41	2516
160.0	12.5	12.5	0.54	0.18	103.58	2518
160.3	12.5	12.5	0.54	0.18	103.76	2519
160.7	12.5	12.5	0.54	0.18	103.94	2521
161.0	12.5	12.5	0.54	0.18	104.12	2523
161.3	12.5	12.5	0.54	0.18	104.29	2525
161.7	12.5	12.5	0.54	0.18	104.47	2527
162.0	12.5	12.5	0.54	0.18	104.65	2529
162.3	12.5	12.5	0.54	0.18	104.83	2531
162.7	12.5	12.5	0.54	0.18	105.00	2532
163.0	12.0	12.3	0.52	0.17	105.18	2534
163.3	12.0	12.0	0.52	0.17	105.35	2536

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
163.7	12.0	12.0	0.52	0.17	105.52	2538
164.0	12.0	12.0	0.52	0.17	105.69	2540
164.3	12.0	12.0	0.52	0.17	105.87	2541
164.7	12.0	12.0	0.52	0.17	106.04	2543
165.0	12.0	12.0	0.52	0.17	106.21	2545
165.3	12.0	12.0	0.52	0.17	106.38	2547
165.7	12.0	12.0	0.52	0.17	106.56	2549
166.0	12.0	12.0	0.52	0.17	106.73	2550
166.3	12.0	12.0	0.52	0.17	106.90	2552
166.7	12.0	12.0	0.52	0.17	107.07	2554
167.0	12.0	12.0	0.52	0.17	107.25	2556
167.3	12.0	12.0	0.52	0.17	107.42	2557
167.7	12.5	12.3	0.54	0.18	107.60	2559
168.0	12.5	12.5	0.54	0.18	107.77	2561

Table E.9 Maturity calculations 50% FA-A mixture-slab

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
0.0	17.0	-	-		0	0.00
0.3	16.5	16.8	0.74	0.24	0.24	683
0.7	16.5	16.5	0.74	0.24	0.49	689
1.0	16.5	16.5	0.74	0.24	0.73	694
1.3	16.5	16.5	0.74	0.24	0.97	700
1.7	16.5	16.5	0.74	0.24	1.22	705
2.0	16.5	16.5	0.74	0.24	1.46	711
2.3	16.5	16.5	0.74	0.24	1.70	716
2.7	16.5	16.5	0.74	0.24	1.95	722
3.0	16.5	16.5	0.74	0.24	2.19	727
3.3	17.0	16.8	0.76	0.25	2.44	733
3.7	17.0	17.0	0.76	0.25	2.69	738
4.0	17.0	17.0	0.76	0.25	2.94	744
4.3	17.0	17.0	0.76	0.25	3.19	749
4.7	17.5	17.3	0.77	0.26	3.44	755
5.0	17.5	17.5	0.77	0.26	3.70	761
5.3	17.5	17.5	0.77	0.26	3.95	766
5.7	17.5	17.5	0.77	0.26	4.21	772
6.0	17.5	17.5	0.77	0.26	4.46	778
6.3	18.0	17.8	0.79	0.26	4.72	783
6.7	18.0	18.0	0.79	0.26	4.99	789
7.0	18.0	18.0	0.79	0.26	5.25	795
7.3	18.0	18.0	0.79	0.26	5.51	801
7.7	18.5	18.3	0.81	0.27	5.78	806

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
8.0	18.5	18.5	0.81	0.27	6.04	812
8.3	19.0	18.8	0.83	0.27	6.32	818
8.7	19.0	19.0	0.83	0.27	6.59	824
9.0	19.0	19.0	0.83	0.27	6.87	830
9.3	19.5	19.3	0.85	0.28	7.15	836
9.7	19.5	19.5	0.85	0.28	7.43	842
10.0	20.0	19.8	0.87	0.29	7.71	848
10.3	20.0	20.0	0.87	0.29	8.00	854
10.7	20.0	20.0	0.87	0.29	8.29	861
11.0	20.0	20.0	0.87	0.29	8.58	867
11.3	20.0	20.0	0.87	0.29	8.86	873
11.7	20.0	20.0	0.87	0.29	9.15	879
12.0	20.0	20.0	0.87	0.29	9.44	885
12.3	20.0	20.0	0.87	0.29	9.72	891
12.7	20.0	20.0	0.87	0.29	10.01	897
13.0	20.0	20.0	0.87	0.29	10.30	903
13.3	20.0	20.0	0.87	0.29	10.59	909
13.7	20.0	20.0	0.87	0.29	10.87	915
14.0	20.0	20.0	0.87	0.29	11.16	921
14.3	20.0	20.0	0.87	0.29	11.45	927
14.7	20.0	20.0	0.87	0.29	11.73	933
15.0	20.0	20.0	0.87	0.29	12.02	939
15.3	20.0	20.0	0.87	0.29	12.31	945
15.7	19.5	19.8	0.85	0.28	12.59	951
16.0	19.5	19.5	0.85	0.28	12.87	957
16.3	19.5	19.5	0.85	0.28	13.15	963

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
16.7	19.5	19.5	0.85	0.28	13.43	968
17.0	19.5	19.5	0.85	0.28	13.71	974
17.3	19.5	19.5	0.85	0.28	13.99	980
17.7	19.5	19.5	0.85	0.28	14.27	986
18.0	19.5	19.5	0.85	0.28	14.55	991
18.3	19.5	19.5	0.85	0.28	14.83	997
18.7	19.5	19.5	0.85	0.28	15.11	1003
19.0	19.5	19.5	0.85	0.28	15.39	1008
19.3	19.5	19.5	0.85	0.28	15.68	1014
19.7	19.5	19.5	0.85	0.28	15.96	1020
20.0	19.0	19.3	0.83	0.27	16.23	1025
20.3	19.0	19.0	0.83	0.27	16.50	1031
20.7	19.0	19.0	0.83	0.27	16.78	1036
21.0	19.0	19.0	0.83	0.27	17.05	1042
21.3	19.0	19.0	0.83	0.27	17.33	1047
21.7	19.0	19.0	0.83	0.27	17.60	1053
22.0	19.0	19.0	0.83	0.27	17.87	1058
22.3	19.0	19.0	0.83	0.27	18.15	1064
22.7	19.0	19.0	0.83	0.27	18.42	1069
23.0	19.0	19.0	0.83	0.27	18.70	1074
23.3	19.0	19.0	0.83	0.27	18.97	1080
23.7	19.0	19.0	0.83	0.27	19.24	1085
24.0	19.0	19.0	0.83	0.27	19.52	1091
24.3	19.5	19.3	0.85	0.28	19.80	1096
24.7	19.5	19.5	0.85	0.28	20.08	1102
25.0	19.5	19.5	0.85	0.28	20.36	1107

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^{o}C Increment (hours)	Eq. Age @ 23^{o}C Cumulative (hours)	Predicted Compressive Strength (psi)
25.3	19.5	19.5	0.85	0.28	20.64	1112
25.7	19.5	19.5	0.85	0.28	20.92	1118
26.0	19.5	19.5	0.85	0.28	21.20	1123
26.3	19.5	19.5	0.85	0.28	21.48	1129
26.7	19.5	19.5	0.85	0.28	21.76	1134
27.0	20.0	19.8	0.87	0.29	22.05	1140
27.3	20.0	20.0	0.87	0.29	22.34	1145
27.7	20.0	20.0	0.87	0.29	22.62	1151
28.0	20.0	20.0	0.87	0.29	22.91	1156
28.3	20.0	20.0	0.87	0.29	23.20	1162
28.7	20.0	20.0	0.87	0.29	23.49	1167
29.0	20.0	20.0	0.87	0.29	23.77	1173
29.3	20.0	20.0	0.87	0.29	24.06	1178
29.7	19.5	19.8	0.85	0.28	24.34	1184
30.0	19.5	19.5	0.85	0.28	24.62	1189
30.3	19.5	19.5	0.85	0.28	24.90	1194
30.7	19.5	19.5	0.85	0.28	25.18	1199
31.0	19.5	19.5	0.85	0.28	25.46	1205
31.3	19.5	19.5	0.85	0.28	25.74	1210
31.7	19.5	19.5	0.85	0.28	26.02	1215
32.0	19.5	19.5	0.85	0.28	26.30	1220
32.3	19.0	19.3	0.83	0.27	26.58	1226
32.7	19.0	19.0	0.83	0.27	26.85	1231
33.0	19.0	19.0	0.83	0.27	27.13	1236
33.3	19.0	19.0	0.83	0.27	27.40	1241
33.7	19.0	19.0	0.83	0.27	27.67	1246

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^{o}C Increment (hours)	Eq. Age @ 23^{o}C Cumulative (hours)	Predicted Compressive Strength (psi)
34.0	19.0	19.0	0.83	0.27	27.95	1251
34.3	19.0	19.0	0.83	0.27	28.22	1256
34.7	19.0	19.0	0.83	0.27	28.50	1261
35.0	19.0	19.0	0.83	0.27	28.77	1266
35.3	19.0	19.0	0.83	0.27	29.04	1271
35.7	19.0	19.0	0.83	0.27	29.32	1276
36.0	18.5	18.8	0.81	0.27	29.59	1281
36.3	18.5	18.5	0.81	0.27	29.85	1286
36.7	18.5	18.5	0.81	0.27	30.12	1291
37.0	18.5	18.5	0.81	0.27	30.39	1296
37.3	18.5	18.5	0.81	0.27	30.66	1301
37.7	18.5	18.5	0.81	0.27	30.92	1305
38.0	18.5	18.5	0.81	0.27	31.19	1310
38.3	18.5	18.5	0.81	0.27	31.46	1315
38.7	18.5	18.5	0.81	0.27	31.73	1320
39.0	18.5	18.5	0.81	0.27	31.99	1325
39.3	18.5	18.5	0.81	0.27	32.26	1329
39.7	18.0	18.3	0.79	0.26	32.52	1334
40.0	18.0	18.0	0.79	0.26	32.79	1339
40.3	18.0	18.0	0.79	0.26	33.05	1343
40.7	18.0	18.0	0.79	0.26	33.31	1348
41.0	18.0	18.0	0.79	0.26	33.57	1353
41.3	18.0	18.0	0.79	0.26	33.83	1357
41.7	18.0	18.0	0.79	0.26	34.09	1362
42.0	18.0	18.0	0.79	0.26	34.35	1367
42.3	18.0	18.0	0.79	0.26	34.61	1371

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
42.7	18.0	18.0	0.79	0.26	34.88	1376
43.0	18.0	18.0	0.79	0.26	35.14	1380
43.3	18.0	18.0	0.79	0.26	35.40	1385
43.7	18.0	18.0	0.79	0.26	35.66	1390
44.0	18.0	18.0	0.79	0.26	35.92	1394
44.3	18.0	18.0	0.79	0.26	36.18	1399
44.7	18.0	18.0	0.79	0.26	36.44	1403
45.0	18.0	18.0	0.79	0.26	36.71	1408
45.3	18.0	18.0	0.79	0.26	36.97	1412
45.7	18.0	18.0	0.79	0.26	37.23	1417
46.0	18.0	18.0	0.79	0.26	37.49	1421
46.3	18.0	18.0	0.79	0.26	37.75	1426
46.7	18.0	18.0	0.79	0.26	38.01	1430
47.0	18.0	18.0	0.79	0.26	38.27	1435
47.3	18.0	18.0	0.79	0.26	38.54	1439
47.7	18.5	18.3	0.81	0.27	38.80	1444
48.0	18.5	18.5	0.81	0.27	39.07	1448
48.3	19.0	18.8	0.83	0.27	39.34	1453
48.7	19.0	19.0	0.83	0.27	39.62	1458
49.0	19.0	19.0	0.83	0.27	39.89	1462
49.3	19.0	19.0	0.83	0.27	40.17	1467
49.7	19.0	19.0	0.83	0.27	40.44	1472
50.0	19.0	19.0	0.83	0.27	40.71	1476
50.3	19.0	19.0	0.83	0.27	40.99	1481
50.7	19.0	19.0	0.83	0.27	41.26	1486
51.0	19.5	19.3	0.85	0.28	41.54	1490

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
51.3	19.5	19.5	0.85	0.28	41.82	1495
51.7	19.5	19.5	0.85	0.28	42.10	1500
52.0	19.5	19.5	0.85	0.28	42.38	1504
52.3	19.5	19.5	0.85	0.28	42.67	1509
52.7	19.5	19.5	0.85	0.28	42.95	1514
53.0	19.0	19.3	0.83	0.27	43.22	1518
53.3	19.0	19.0	0.83	0.27	43.49	1523
53.7	19.0	19.0	0.83	0.27	43.77	1527
54.0	19.0	19.0	0.83	0.27	44.04	1532
54.3	19.0	19.0	0.83	0.27	44.32	1536
54.7	19.0	19.0	0.83	0.27	44.59	1541
55.0	19.0	19.0	0.83	0.27	44.86	1545
55.3	19.0	19.0	0.83	0.27	45.14	1550
55.7	19.0	19.0	0.83	0.27	45.41	1554
56.0	19.0	19.0	0.83	0.27	45.69	1559
56.3	19.0	19.0	0.83	0.27	45.96	1563
56.7	19.0	19.0	0.83	0.27	46.23	1568
57.0	19.0	19.0	0.83	0.27	46.51	1572
57.3	19.0	19.0	0.83	0.27	46.78	1577
57.7	18.5	18.8	0.81	0.27	47.05	1581
58.0	18.5	18.5	0.81	0.27	47.32	1585
58.3	18.5	18.5	0.81	0.27	47.59	1590
58.7	18.5	18.5	0.81	0.27	47.85	1594
59.0	18.5	18.5	0.81	0.27	48.12	1598
59.3	18.5	18.5	0.81	0.27	48.39	1602
59.7	18.5	18.5	0.81	0.27	48.66	1607

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
60.0	18.5	18.5	0.81	0.27	48.92	1611
60.3	18.5	18.5	0.81	0.27	49.19	1615
60.7	18.5	18.5	0.81	0.27	49.46	1620
61.0	18.5	18.5	0.81	0.27	49.73	1624
61.3	18.5	18.5	0.81	0.27	49.99	1628
61.7	18.5	18.5	0.81	0.27	50.26	1632
62.0	18.5	18.5	0.81	0.27	50.53	1637
62.3	18.5	18.5	0.81	0.27	50.80	1641
62.7	18.5	18.5	0.81	0.27	51.06	1645
63.0	18.5	18.5	0.81	0.27	51.33	1649
63.3	18.5	18.5	0.81	0.27	51.60	1653
63.7	18.5	18.5	0.81	0.27	51.87	1658
64.0	18.5	18.5	0.81	0.27	52.13	1662
64.3	18.0	18.3	0.79	0.26	52.40	1666
64.7	18.0	18.0	0.79	0.26	52.66	1670
65.0	18.0	18.0	0.79	0.26	52.92	1674
65.3	18.0	18.0	0.79	0.26	53.18	1678
65.7	18.0	18.0	0.79	0.26	53.44	1682
66.0	18.0	18.0	0.79	0.26	53.70	1686
66.3	18.0	18.0	0.79	0.26	53.96	1690
66.7	18.0	18.0	0.79	0.26	54.23	1694
67.0	18.0	18.0	0.79	0.26	54.49	1698
67.3	18.0	18.0	0.79	0.26	54.75	1702
67.7	18.0	18.0	0.79	0.26	55.01	1706
68.0	18.0	18.0	0.79	0.26	55.27	1710
68.3	18.0	18.0	0.79	0.26	55.53	1714

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
68.7	18.0	18.0	0.79	0.26	55.79	1718
69.0	18.0	18.0	0.79	0.26	56.06	1722
69.3	18.0	18.0	0.79	0.26	56.32	1726
69.7	18.0	18.0	0.79	0.26	56.58	1730
70.0	18.0	18.0	0.79	0.26	56.84	1734
70.3	18.0	18.0	0.79	0.26	57.10	1738
70.7	18.0	18.0	0.79	0.26	57.36	1742
71.0	18.0	18.0	0.79	0.26	57.62	1746
71.3	18.0	18.0	0.79	0.26	57.88	1750
71.7	18.0	18.0	0.79	0.26	58.15	1754
72.0	18.0	18.0	0.79	0.26	58.41	1758
72.3	18.0	18.0	0.79	0.26	58.67	1762
72.7	18.0	18.0	0.79	0.26	58.93	1766
73.0	18.0	18.0	0.79	0.26	59.19	1770
73.3	18.0	18.0	0.79	0.26	59.45	1773
73.7	18.0	18.0	0.79	0.26	59.71	1777
74.0	18.0	18.0	0.79	0.26	59.98	1781
74.3	18.0	18.0	0.79	0.26	60.24	1785
74.7	18.5	18.3	0.81	0.27	60.50	1789
75.0	18.5	18.5	0.81	0.27	60.77	1793
75.3	18.5	18.5	0.81	0.27	61.04	1797
75.7	18.5	18.5	0.81	0.27	61.31	1801
76.0	18.5	18.5	0.81	0.27	61.58	1805
76.3	18.5	18.5	0.81	0.27	61.84	1809
76.7	18.5	18.5	0.81	0.27	62.11	1813
77.0	18.5	18.5	0.81	0.27	62.38	1817

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
77.3	18.5	18.5	0.81	0.27	62.65	1821
77.7	18.5	18.5	0.81	0.27	62.91	1824
78.0	18.5	18.5	0.81	0.27	63.18	1828
78.3	18.5	18.5	0.81	0.27	63.45	1832
78.7	18.5	18.5	0.81	0.27	63.72	1836
79.0	18.5	18.5	0.81	0.27	63.98	1840
79.3	18.0	18.3	0.79	0.26	64.25	1844
79.7	18.0	18.0	0.79	0.26	64.51	1848
80.0	18.0	18.0	0.79	0.26	64.77	1851
80.3	18.0	18.0	0.79	0.26	65.03	1855
80.7	18.0	18.0	0.79	0.26	65.29	1859
81.0	18.0	18.0	0.79	0.26	65.55	1863
81.3	18.0	18.0	0.79	0.26	65.81	1866
81.7	18.0	18.0	0.79	0.26	66.07	1870
82.0	18.0	18.0	0.79	0.26	66.34	1874
82.3	18.0	18.0	0.79	0.26	66.60	1878
82.7	17.5	17.8	0.77	0.26	66.85	1881
83.0	17.5	17.5	0.77	0.26	67.11	1885
83.3	17.5	17.5	0.77	0.26	67.36	1888
83.7	17.5	17.5	0.77	0.26	67.62	1892
84.0	17.5	17.5	0.77	0.26	67.87	1896
84.3	17.5	17.5	0.77	0.26	68.13	1899
84.7	17.0	17.3	0.76	0.25	68.38	1903
85.0	17.0	17.0	0.76	0.25	68.63	1906
85.3	17.0	17.0	0.76	0.25	68.88	1910
85.7	17.0	17.0	0.76	0.25	69.13	1913

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
86.0	17.0	17.0	0.76	0.25	69.37	1917
86.3	17.0	17.0	0.76	0.25	69.62	1920
86.7	17.0	17.0	0.76	0.25	69.87	1924
87.0	16.5	16.8	0.74	0.24	70.12	1927
87.3	16.5	16.5	0.74	0.24	70.36	1930
87.7	16.5	16.5	0.74	0.24	70.60	1934
88.0	16.5	16.5	0.74	0.24	70.85	1937
88.3	16.5	16.5	0.74	0.24	71.09	1941
88.7	16.5	16.5	0.74	0.24	71.33	1944
89.0	16.0	16.3	0.72	0.24	71.57	1947
89.3	16.0	16.0	0.72	0.24	71.81	1950
89.7	16.0	16.0	0.72	0.24	72.05	1954
90.0	16.0	16.0	0.72	0.24	72.28	1957
90.3	16.0	16.0	0.72	0.24	72.52	1960
90.7	16.0	16.0	0.72	0.24	72.76	1964
91.0	16.0	16.0	0.72	0.24	73.00	1967
91.3	15.5	15.8	0.70	0.23	73.23	1970
91.7	15.5	15.5	0.70	0.23	73.46	1973
92.0	15.5	15.5	0.70	0.23	73.69	1976
92.3	15.5	15.5	0.70	0.23	73.92	1979
92.7	15.5	15.5	0.70	0.23	74.16	1983
93.0	15.5	15.5	0.70	0.23	74.39	1986
93.3	15.5	15.5	0.70	0.23	74.62	1989
93.7	15.5	15.5	0.70	0.23	74.85	1992
94.0	15.5	15.5	0.70	0.23	75.08	1995
94.3	15.5	15.5	0.70	0.23	75.32	1998

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
94.7	15.5	15.5	0.70	0.23	75.55	2001
95.0	15.5	15.5	0.70	0.23	75.78	2005
95.3	15.5	15.5	0.70	0.23	76.01	2008
95.7	15.5	15.5	0.70	0.23	76.24	2011
96.0	16.0	15.8	0.72	0.24	76.48	2014
96.3	16.0	16.0	0.72	0.24	76.72	2017
96.7	16.0	16.0	0.72	0.24	76.96	2020
97.0	16.0	16.0	0.72	0.24	77.19	2023
97.3	16.0	16.0	0.72	0.24	77.43	2027
97.7	16.5	16.3	0.74	0.24	77.67	2030
98.0	16.5	16.5	0.74	0.24	77.92	2033
98.3	16.5	16.5	0.74	0.24	78.16	2036
98.7	16.5	16.5	0.74	0.24	78.40	2040
99.0	16.5	16.5	0.74	0.24	78.65	2043
99.3	16.5	16.5	0.74	0.24	78.89	2046
99.7	16.5	16.5	0.74	0.24	79.13	2049
100.0	16.5	16.5	0.74	0.24	79.38	2052
100.3	16.5	16.5	0.74	0.24	79.62	2056
100.7	16.5	16.5	0.74	0.24	79.86	2059
101.0	16.5	16.5	0.74	0.24	80.11	2062
101.3	16.5	16.5	0.74	0.24	80.35	2065
101.7	16.5	16.5	0.74	0.24	80.59	2068
102.0	16.0	16.3	0.72	0.24	80.83	2071
102.3	16.0	16.0	0.72	0.24	81.07	2075
102.7	16.0	16.0	0.72	0.24	81.31	2078
103.0	16.0	16.0	0.72	0.24	81.54	2081

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
103.3	16.0	16.0	0.72	0.24	81.78	2084
103.7	16.0	16.0	0.72	0.24	82.02	2087
104.0	16.0	16.0	0.72	0.24	82.26	2090
104.3	15.5	15.8	0.70	0.23	82.49	2093
104.7	15.5	15.5	0.70	0.23	82.72	2096
105.0	15.5	15.5	0.70	0.23	82.95	2099
105.3	15.5	15.5	0.70	0.23	83.18	2102
105.7	15.5	15.5	0.70	0.23	83.42	2105
106.0	15.5	15.5	0.70	0.23	83.65	2108
106.3	15.5	15.5	0.70	0.23	83.88	2111
106.7	15.5	15.5	0.70	0.23	84.11	2114
107.0	15.0	15.3	0.69	0.23	84.34	2117
107.3	15.0	15.0	0.69	0.23	84.56	2120
107.7	15.0	15.0	0.69	0.23	84.79	2122
108.0	15.0	15.0	0.69	0.23	85.02	2125
108.3	15.0	15.0	0.69	0.23	85.24	2128
108.7	15.0	15.0	0.69	0.23	85.47	2131
109.0	15.0	15.0	0.69	0.23	85.70	2134
109.3	15.0	15.0	0.69	0.23	85.92	2137
109.7	15.0	15.0	0.69	0.23	86.15	2140
110.0	14.5	14.8	0.67	0.22	86.37	2142
110.3	14.5	14.5	0.67	0.22	86.59	2145
110.7	14.5	14.5	0.67	0.22	86.81	2148
111.0	14.5	14.5	0.67	0.22	87.03	2151
111.3	14.5	14.5	0.67	0.22	87.25	2154
111.7	14.5	14.5	0.67	0.22	87.47	2156

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
112.0	14.5	14.5	0.67	0.22	87.70	2159
112.3	14.5	14.5	0.67	0.22	87.92	2162
112.7	14.0	14.3	0.65	0.22	88.13	2165
113.0	14.0	14.0	0.65	0.22	88.35	2167
113.3	14.0	14.0	0.65	0.22	88.56	2170
113.7	14.0	14.0	0.65	0.22	88.78	2173
114.0	14.0	14.0	0.65	0.22	88.99	2175
114.3	14.0	14.0	0.65	0.22	89.21	2178
114.7	14.0	14.0	0.65	0.22	89.43	2181
115.0	14.0	14.0	0.65	0.22	89.64	2183
115.3	14.0	14.0	0.65	0.22	89.86	2186
115.7	13.5	13.8	0.64	0.21	90.07	2189
116.0	13.5	13.5	0.64	0.21	90.28	2191
116.3	13.5	13.5	0.64	0.21	90.49	2194
116.7	13.5	13.5	0.64	0.21	90.70	2196
117.0	13.5	13.5	0.64	0.21	90.91	2199
117.3	13.5	13.5	0.64	0.21	91.12	2202
117.7	13.5	13.5	0.64	0.21	91.33	2204
118.0	13.5	13.5	0.64	0.21	91.54	2207
118.3	13.5	13.5	0.64	0.21	91.75	2209
118.7	13.5	13.5	0.64	0.21	91.96	2212
119.0	13.5	13.5	0.64	0.21	92.17	2214
119.3	13.5	13.5	0.64	0.21	92.38	2217
119.7	13.5	13.5	0.64	0.21	92.59	2220
120.0	13.5	13.5	0.64	0.21	92.80	2222
120.3	13.5	13.5	0.64	0.21	93.01	2225

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
120.7	14.0	13.8	0.65	0.22	93.23	2227
121.0	14.0	14.0	0.65	0.22	93.44	2230
121.3	14.0	14.0	0.65	0.22	93.66	2232
121.7	14.0	14.0	0.65	0.22	93.88	2235
122.0	14.0	14.0	0.65	0.22	94.09	2238
122.3	14.0	14.0	0.65	0.22	94.31	2240
122.7	14.0	14.0	0.65	0.22	94.52	2243
123.0	14.5	14.3	0.67	0.22	94.74	2246
123.3	14.5	14.5	0.67	0.22	94.96	2248
123.7	14.5	14.5	0.67	0.22	95.19	2251
124.0	14.5	14.5	0.67	0.22	95.41	2253
124.3	14.5	14.5	0.67	0.22	95.63	2256
124.7	14.5	14.5	0.67	0.22	95.85	2259
125.0	14.5	14.5	0.67	0.22	96.07	2261
125.3	14.0	14.3	0.65	0.22	96.29	2264
125.7	14.0	14.0	0.65	0.22	96.50	2267
126.0	14.0	14.0	0.65	0.22	96.72	2269
126.3	14.0	14.0	0.65	0.22	96.93	2272
126.7	14.0	14.0	0.65	0.22	97.15	2274
127.0	14.0	14.0	0.65	0.22	97.36	2277
127.3	14.0	14.0	0.65	0.22	97.58	2279
127.7	14.0	14.0	0.65	0.22	97.79	2282
128.0	14.0	14.0	0.65	0.22	98.01	2284
128.3	14.0	14.0	0.65	0.22	98.23	2287
128.7	14.0	14.0	0.65	0.22	98.44	2289
129.0	14.0	14.0	0.65	0.22	98.66	2292

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
129.3	13.5	13.8	0.64	0.21	98.87	2294
129.7	13.5	13.5	0.64	0.21	99.08	2297
130.0	13.5	13.5	0.64	0.21	99.29	2299
130.3	13.5	13.5	0.64	0.21	99.50	2302
130.7	13.5	13.5	0.64	0.21	99.71	2304
131.0	13.5	13.5	0.64	0.21	99.92	2307
131.3	13.5	13.5	0.64	0.21	100.13	2309
131.7	13.5	13.5	0.64	0.21	100.34	2312
132.0	13.5	13.5	0.64	0.21	100.55	2314
132.3	13.5	13.5	0.64	0.21	100.76	2317
132.7	13.5	13.5	0.64	0.21	100.97	2319
133.0	13.5	13.5	0.64	0.21	101.18	2321
133.3	13.5	13.5	0.64	0.21	101.39	2324
133.7	13.5	13.5	0.64	0.21	101.60	2326
134.0	13.5	13.5	0.64	0.21	101.81	2329
134.3	13.5	13.5	0.64	0.21	102.02	2331
134.7	13.5	13.5	0.64	0.21	102.23	2334
135.0	13.5	13.5	0.64	0.21	102.44	2336
135.3	13.0	13.3	0.62	0.21	102.65	2338
135.7	13.0	13.0	0.62	0.21	102.86	2341
136.0	13.0	13.0	0.62	0.21	103.06	2343
136.3	13.0	13.0	0.62	0.21	103.27	2345
136.7	13.0	13.0	0.62	0.21	103.47	2348
137.0	13.0	13.0	0.62	0.21	103.68	2350
137.3	13.0	13.0	0.62	0.21	103.88	2352
137.7	13.0	13.0	0.62	0.21	104.09	2355

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
138.0	13.0	13.0	0.62	0.21	104.29	2357
138.3	13.0	13.0	0.62	0.21	104.50	2359
138.7	13.0	13.0	0.62	0.21	104.70	2362
139.0	13.0	13.0	0.62	0.21	104.91	2364
139.3	13.0	13.0	0.62	0.21	105.11	2366
139.7	12.5	12.8	0.61	0.20	105.31	2369
140.0	12.5	12.5	0.61	0.20	105.51	2371
140.3	12.5	12.5	0.61	0.20	105.71	2373
140.7	12.5	12.5	0.61	0.20	105.92	2376
141.0	12.5	12.5	0.61	0.20	106.12	2378
141.3	12.5	12.5	0.61	0.20	106.32	2380
141.7	12.5	12.5	0.61	0.20	106.52	2382
142.0	12.5	12.5	0.61	0.20	106.72	2385
142.3	12.5	12.5	0.61	0.20	106.92	2387
142.7	12.5	12.5	0.61	0.20	107.12	2389
143.0	12.5	12.5	0.61	0.20	107.32	2391
143.3	12.5	12.5	0.61	0.20	107.52	2393
143.7	12.5	12.5	0.61	0.20	107.72	2396
144.0	12.5	12.5	0.61	0.20	107.92	2398
144.3	13.0	12.8	0.62	0.21	108.12	2400
144.7	13.0	13.0	0.62	0.21	108.33	2403
145.0	13.0	13.0	0.62	0.21	108.53	2405
145.3	13.0	13.0	0.62	0.21	108.74	2407
145.7	13.5	13.3	0.64	0.21	108.95	2409
146.0	13.5	13.5	0.64	0.21	109.16	2412
146.3	13.5	13.5	0.64	0.21	109.37	2414

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
146.7	13.5	13.5	0.64	0.21	109.58	2416
147.0	13.5	13.5	0.64	0.21	109.79	2419
147.3	13.5	13.5	0.64	0.21	110.00	2421
147.7	14.0	13.8	0.65	0.22	110.22	2423
148.0	14.0	14.0	0.65	0.22	110.43	2426
148.3	14.0	14.0	0.65	0.22	110.65	2428
148.7	14.0	14.0	0.65	0.22	110.86	2431
149.0	13.5	13.8	0.64	0.21	111.08	2433
149.3	13.5	13.5	0.64	0.21	111.29	2435
149.7	13.5	13.5	0.64	0.21	111.50	2437
150.0	13.5	13.5	0.64	0.21	111.71	2440
150.3	13.5	13.5	0.64	0.21	111.92	2442
150.7	13.0	13.3	0.62	0.21	112.12	2444
151.0	13.0	13.0	0.62	0.21	112.33	2446
151.3	13.0	13.0	0.62	0.21	112.53	2449
151.7	13.0	13.0	0.62	0.21	112.74	2451
152.0	13.0	13.0	0.62	0.21	112.94	2453
152.3	13.0	13.0	0.62	0.21	113.15	2455
152.7	12.5	12.8	0.61	0.20	113.35	2458
153.0	12.5	12.5	0.61	0.20	113.55	2460
153.3	12.5	12.5	0.61	0.20	113.75	2462
153.7	12.5	12.5	0.61	0.20	113.95	2464
154.0	12.5	12.5	0.61	0.20	114.15	2466
154.3	12.5	12.5	0.61	0.20	114.35	2468
154.7	12.5	12.5	0.61	0.20	114.55	2471
155.0	12.0	12.3	0.59	0.20	114.75	2473

Age (hours)	Temperature (^oC)	Average Temperature (^oC)	Age Factor	Eq. Age @ 23^oC Increment (hours)	Eq. Age @ 23^oC Cumulative (hours)	Predicted Compressive Strength (psi)
155.3	12.0	12.0	0.59	0.20	114.94	2475
155.7	12.0	12.0	0.59	0.20	115.14	2477
156.0	12.0	12.0	0.59	0.20	115.33	2479
156.3	12.0	12.0	0.59	0.20	115.53	2481
156.7	12.0	12.0	0.59	0.20	115.72	2483
157.0	12.0	12.0	0.59	0.20	115.92	2485
157.3	12.0	12.0	0.59	0.20	116.11	2487
157.7	12.0	12.0	0.59	0.20	116.31	2489
158.0	12.0	12.0	0.59	0.20	116.51	2491
158.3	12.0	12.0	0.59	0.20	116.70	2493
158.7	11.5	11.8	0.58	0.19	116.89	2496
159.0	11.5	11.5	0.58	0.19	117.08	2498
159.3	11.5	11.5	0.58	0.19	117.27	2500
159.7	11.5	11.5	0.58	0.19	117.46	2502
160.0	11.5	11.5	0.58	0.19	117.65	2504
160.3	11.5	11.5	0.58	0.19	117.85	2506
160.7	11.5	11.5	0.58	0.19	118.04	2508
161.0	11.5	11.5	0.58	0.19	118.23	2510
161.3	11.0	11.3	0.56	0.19	118.41	2512
161.7	11.0	11.0	0.56	0.19	118.60	2514
162.0	11.0	11.0	0.56	0.19	118.78	2515
162.3	11.0	11.0	0.56	0.19	118.97	2517
162.7	11.0	11.0	0.56	0.19	119.16	2519
163.0	11.0	11.0	0.56	0.19	119.34	2521
163.3	11.0	11.0	0.56	0.19	119.53	2523
163.7	11.0	11.0	0.56	0.19	119.71	2525

Age (hours)	Temperature (°C)	Average Temperature (°C)	Age Factor	Eq. Age @ 23°C Increment (hours)	Eq. Age @ 23°C Cumulative (hours)	Predicted Compressive Strength (psi)
164.0	11.0	11.0	0.56	0.19	119.90	2527
164.3	11.0	11.0	0.56	0.19	120.09	2529
164.7	10.5	10.8	0.55	0.18	120.27	2531
165.0	10.5	10.5	0.55	0.18	120.45	2533
165.3	10.5	10.5	0.55	0.18	120.63	2535
165.7	10.5	10.5	0.55	0.18	120.81	2537
166.0	10.5	10.5	0.55	0.18	120.99	2539
166.3	10.5	10.5	0.55	0.18	121.17	2540
166.7	10.5	10.5	0.55	0.18	121.36	2542
167.0	11.0	10.8	0.56	0.19	121.54	2544
167.3	11.0	11.0	0.56	0.19	121.73	2546
167.7	11.0	11.0	0.56	0.19	121.91	2548
168.0	11.0	11.0	0.56	0.19	122.10	2550