RESEARCH

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COLD IN-PLACE RECYCLE PHASE III: MIX DESIGN

Prepared For:

Utah Department of Transportation
Research Division

Submitted By:

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(CMETG)

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16. Abstract

This project's purpose is to revise the UDOT accepted design methods for Cold In-Place Recycling so that they better reflect field behavior and target the desirable attributes of the material. The previous design process failed to adequately predict behavior related to temperature as well as did a poor job of characterizing return to traffic performance. This project calls upon both laboratory observation and field experience to obtain optimization between rutting, stripping and intermediate temperature cracking. It also ties down the constructability and return to traffic parameters required by maintenance of traffic constraints. The new design process continues the use of Marshall Stability and Tensile Strength Ratio to set rutting and stripping resistance. It further uses Semicircular bending to set an intermediate temperature cracking parameter. New compaction/temperature and compaction/gradation relationships are developed to help determine final density and emulsion targets. A new test for emulsion set time is developed to prequalify emulsion construction performance. Modified BBR and Elastic Recovery testing is used to establish cold temperature properties of recovered binder.

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UNIT CONVERSION FACTORS

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. (Adapted from FHWA report template, Revised March 2003)

LIST OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
CIR	Cold In-Place Recycled asphalt
DCT	Disk-Shaped Compact Tensile Test
ESCRE	Engineered Solventless Cold Recycle Emulsion: Asphalt emulsion engineered to meet the requirements of CIR using less than 1% solvent.
FHWA	Federal Highway Administration
HMA	Hot Mix Asphalt
RAP	Recycled Asphalt Pavement
SCB	Semi-Circular Bending Test
SGC	Superpave Gyratory Compactor
UDOT	Utah Department of Transportation

EXECUTIVE SUMMARY

CIR has proven to be an efficient, economical tool in the pavement preservation tool box. CIR may be used under a chip seal on low volume roads, or as a base isolation interlayer in heavier traffic applications. Interspersed with great performance are those projects which underperform. This happens often enough to cause UDOT to want a more full understanding of the design and application of the product. Current mix design practices appear to have limitations as they relate to both material qualification and construction. Applicators regularly reduce the emulsion rate between 0.5 and 1.0 percent from the mix design target to prevent rutting and shoving. This behavior indicates a disconnect between laboratory design intentions and field compaction efforts. Further, no method exists to separate emulsions that are suitable for use in CIR and those which will not meet Department expectations, most specifically related to quick return of the pavement to traffic.

The expectations of a CIR project have always been that CIR is like Hot Mix Asphalt. One of the lessons from this research is that it is a very different material from HMA. It has markedly different strength, cracking potential and construction characteristics. Curing time must be controllable for aggressive maintenance of traffic to be managed. One of the goals of this research is to measure these properties and to determine appropriate applications for it. Another goal is to develop methods to obtain consistent results so that when pavement design is done, the as-constructed product will both carry the design loads, and perform adequately in an environmental durability category.

A method to determine temperature and gradation sensitivity is developed by using the superpave gyratory compactor to measure compaction variability. This technique is used to set target densities and emulsion contents at varying temperatures for varying gradation types. Field measurements of these two factors can then be used to manage optimum construction practices.

The use of the Semi-Circular Bending test is investigated in developing standards for cracking behavior. It is unknown at present whether high fracture toughness and fracture energy are desired in a base isolation interlayer.

A method to qualify emulsions for CIR use is also developed allowing the Department to determine, in advance, the demulsification rates of various asphalt emulsions. This is critical to

the support of CIR by UDOT as the department has set a premium on limiting traffic impacts. It is also critical to the evaluation of emulsions for constructability as the potential for aggressive emulsions to flash-set in the CIR train will increase. A set of proposed specification standards are proposed.

1.0 INTRODUCTION

1.1 Problem Statement

As asphalt roadways become more expensive and less lane miles can be maintained, UDOT is exploring methods to effectively rehabilitate pavements at lower cost. Cold In-Place recycle has been shown to provide a strong base layer allowing construction of a thinner load distribution layer. CIR has also been shown to do a good job of strengthening a stripped pavement layer in preparation for a thinner wearing layer placed over top.

Experience has shown that although CIR has many beneficial applications, it tends to be somewhat unpredictable when using current design and construction methods. The goal of this research is to improve the project success rate by improving the design process. Current design methodology ignores the time and temperature dependency of real world construction practices and does a poor job of predicting emulsion field performance needs. Current material specifications ignore the issue of timely return to traffic, as well as density and field stability.

1.2 Objectives

Issues addressed in mix design must relate to field performance both in construction and long term durability. Observation of construction practices has revealed a number of troubling departures from mix design. Areas of lack of control include:

- Gradation and its effects on achieving density and optimum emulsion content.
- Density and its effects on emulsion content, stability, cracking potential and permeability.
- Evaluation of proper emulsion addition rates, typically far less than predicted.
- Objective determination of proper time to return to traffic.

The goal of this research is to understand the drivers behind these departures from current mix design practices and to improve the predictive abilities of the mix design process. Several areas will be investigated including:

1. Does the treatment of a laboratory sample (and thereby the field produced pavement) effect stability?

2. How does RAP compactability respond to temperature?
3. How does RAP compactability respond to gradation?
4. How does increased density affect allowable moisture (all forms)?
5. How do changes in gradation affect allowable moisture (all forms)?
6. What are the drivers of emulsion break and how can they be managed?
7. Can emulsions be differentiated on the basis of constructability and release to traffic parameters?

1.3 Scope

Question 1: Does the treatment of a laboratory sample (and thereby the field produced pavement) effect stability? This question was broken into two parts.

- Does the sample production temperature affect stability? One RAP source, two emulsions and four temperatures were used for comparison. All were mixed with 6% total moisture, 2.0% emulsion and 1.5% lime. They were then cured for 2 hours prior to compaction. All were compacted to 50 gyrations and held for 8 hours prior to conducting the Marshall stability test. These protocols were developed from the handling of field produced mixes documented in earlier research for UDOT.

- Does post compaction curing time affect stability? One RAP source, two emulsions and one temperature were used for comparison. All were mixed with 6% total moisture, 2.0% emulsion and 1.5% lime. They were then cured for 2 hours prior to compaction. All were compacted to 50 gyrations. The samples were then held for 2, 4, 6. 8 and 10 hours.

Questions 2 and 3 were addressed in the same data set: How does RAP compactability respond to temperature? Also, how does RAP compactablity respond to gradation?

These two questions were addressed using the following experimental design.
RAP millings were selected from two of the major climate areas in the State of Utah. Specifically: SR-32 Jordanelle, US 40 Strawberry and Sothern Parkway Saint George. The range of climates is Dry/No Freeze and Wet/Freeze. This selection produces RAP qualities from very hard to semi-soft. Each RAP was screened and medium and coarse mix gradations were produced. Each mix gradation heated to the test temperature and combined with 2% water by weight. No emulsion was added. Compaction was done in the Superpave Gyratory Compactor (SCG) at test temperature ± 1°F to 50 gyrations. Three replicates were performed of each of the

four mixes. Test temperatures were as follows: 60, 80, 100, 120, 140°F. Compaction curves were recorded. Compaction densities were calculated and plotted. Average densities were determined and plotted for each temperature, gradation and RAP source. Trends were observed.

Questions 4 and 5 were handled from a single data set. How does increased density affect allowable moisture (all forms)? And, how do changes in gradation affect allowable moisture (all forms)?

The experimental design used the Southern Parkway RAP source. A medium and coarse mix was blended from screened material. Three replicates of each mix were tested. Water was added incrementally to each mix using a Modified Proctor procedure to determine optimum moisture.

Questions 6 and 7 involve all we have learned from questions 1 thru 5. What are the drivers of emulsion break? How can they be managed? Can emulsions be differentiated on the basis of constructability and release to traffic parameters? A number of factors were considered to develop a test which will answer this question. The specifics of these factors will be discussed later but the final experimental design requires mixing minus #30 screen material with water, lime and emulsion, consolidating the mix sample by vibration, holding the samples at the test temperature for periods of 10, 20, 30, 45 minutes and 1, 2, 3, 4, 6 and 24 hours. At each time increment, a custom designed cone penetration test is performed and the peak penetration force is recorded. Maximum % strength increase limits are placed on the sample during the first 30 minutes and Minimum % strength increase limits are set after 3 hours.

1.4 Outline of Report

- Introduction
- Research Methods
- Data Collection
- Data Evaluation (or Analysis)
- Conclusions
- Recommendations and Implementation

2.0 RESEARCH METHODS

2.1 Overview

Traditionally, the design of a CIR mix is done by sampling, crushing and grading the RAP into two gradations. Compacted samples are then prepared at a single temperature in the Superpave Gyratory Compactor (SGC) using varying emulsion contents. These samples are then tested for Marshall Stability and Flow (rutting), Tensile Strength Ratio (moisture susceptibility), Indirect Tensile (cold temperature cracking) and Raveling (loss of material through abrasion). An additional test was added around 2007 in the form of a Disk Shaped Tension Test (DCT) to measure intermediate temperature cracking potential. This system of tests should result in a balanced mix design with four of the five major distress mechanisms optimized. The difficulty is that the mix, as designed, is impossible to build. For several reasons which became apparent in prior UDOT research, emulsion quantity was regularly reduced in the field. The cause of these reductions will be shown in this research to be related to temperature sensitivity of the RAP source causing variations in gradation and compaction. These sensitivities in turn affect available void space and available specific surface.

Traditional CIR mix design has also concerned itself with ultimate mix performance while giving no thought to short term strength development. This research will provide some insight to the short and intermediate term demulsification properties of the emulsion. A new test procedure is developed to discriminate between emulsions exhibiting behavior conducive to CIR and those failing to produce acceptable characteristics.

Five tools were used to develop results in this investigation. They are as follows:

- Modified Proctor Compaction AASHTO T 180 method C.
- Modified Marshall Stability AASHTO T 245.
- Superpave Gyratory Compactor (SGC) AASHTO T 312
- Semi-Circular Bending – Modified Method
- Forced Cone Penetration – New Method

2.2 Background for Modified Proctor Compaction AASHTO T 180

Two issues were investigated with this procedure. Both were pursued on compacted, dried samples. This procedure is used to determine the optimum moisture content required to produce maximum density in a coarse granular material. A 56 blows with a 10 pound hammer dropped 1.5 feet, is imposed on a material sample contained in a 6 inch diameter mold with a volume of 0.075 ft^3 (Figure 1). The sample is built up in 5 equal lifts. When compaction is complete, the top is leveled and a mass recorded. This process is repeated across a sweep of moisture content (2, 4, 6, 8, and 10%) and the mass is plotted against moisture. The peak mass vs moisture is where the moisture lubricates the compaction without pushing the particles and is termed the Proctor Density. In an unbound material, the particles are discreet and temperature plays no part. Since RAP is thermosetting, all tests were done at 100°F.

Figure 1. Proctor Hammer

A single RAP source was used for this experiment. The SR-32 project RAP was screened and two gradations (Medium and Coarse) were tested. Table 1 tabulates the gradations.

Screen	Medium Gradation	Coarse Gradation
Size	Percent Passing	Percent Passing
½”	86	73
3/8”	77	62
#4	52	38
#8	33	20
#16	16	8
#30	7	3
Minus #30	0	0

Table 1: RAP Gradations for Proctor Testing

2.3 Background for Marshall Stability AASHTO T 245

AASHTO T 245 is a method of determining the rut susceptibility in a Hot Mix Asphalt. Both saturated and unsaturated flow (distance to maximum load) and stability (maximum load) are determined. The test was originally set up to use the 4” Marshall pill but has been modified to accept the 6” SGC puck. Marshall Stability is determined by:

$$St = \frac{2 * P}{3.14 * D * t} \tag{2.3.1}$$

Where:

S_t = tensile strength (psi)

P = maximum load (lb)

D = specimen diameter (in)

T = specimen thickness (in)

A Marshall Stability machine is shown in Figure 2

Figure 2: Marshall Stability Machine

Two issues were investigated with stability. The first was how does stability vary with temperature? The second, how does stability vary with time? As to the first question, the experimental plan was as shown in Table 2

Conditions of Test		Temperatures (deg F)			
		60	80	100	120
Aggregate and lime Weight (g)	3500	X	X	X	X
Water Weight (g)	140.8	X	X	X	X
Emulsion Weight (g)	58.5	X	X	X	X
Gradation	Medium	X	X	X	X
Gyrations in SGC	50	X	X	X	X
Solventless Engineered Emulsion		3 *	3	3	3
CSS-1 Emulsion		3	3	3	3

* number of replicates

Table 2: Stability vs Temperature Experimental Plan

The RAP was from I-84 at Henefer. RAP samples were conditioned dry for at least 4 hours to bring the materials to the mixing temperature. Lime, water and emulsion, in that order, were added and the resulting mix was sealed in a plastic bag where experimental test temperature was maintained for 2 hours prior to compaction. The SGC compactor molds and plates were brought to test temperature and the samples were densified. The samples were placed back in the environmental chamber where temperatures were maintained for 8 hours. The stability test was then performed on the cured, unsaturated sample.

Table 3 is the experimental plan to answer the second question.

Experimental Conditions		Time (hours)				
		2	4	6	8	10
Aggregate and lime Weight (g)	3250	X	X	X	X	X
Water Weight (g)	140.8	X	X	X	X	X
Emulsion Weight (g)	58.5	X	X	X	X	X
Gradation	medium	X	X	X	X	X
Gyrations in SGC	50	X	X	X	X	X
Temperature (Degrees F)	80	X	X	X	X	X
Solventless Engineered Emulsion		3*	3	3	3	3
CSS1 Emulsion		3	3	3	3	3

* number of replicates

Table 3: Stability vs Time, Experimental Plan

The RAP was from I-84 at Henefer. RAP samples were conditioned dry for at least 4 hours to bring the materials to the mixing temperature. Lime, water and emulsion, in that order, were added and the resulting mix was bagged and 80°F was maintained for the 2 hours prior to compaction. The SGC compactor molds and plates were brought to test temperature and the samples were densified. The samples were placed back in the environmental chamber where 80°F was maintained for the experimental duration. The stability test was then performed on the cured, unsaturated sample.

2.4 Background of Superpave Gyratory Compactor AASHTO T 312

The SGC is the central player in Superpave volumetric design. With this device, accurate and repeatable compaction energy can be imparted to a sample. Temperature can be controlled reasonably well over a few minutes due to the mass of the molds and sample. Two to four degrees temperature drop can be expected if sample materials are properly heated and compacted with reasonable dispatch. The high compactive forces render the test relatively insensitive to this magnitude of temperature variation. The device both applies pressure and kneading to simulate the compaction roller in the field. The height of the sample is recorded at each gyration creating a record of the compaction curve. The volume of the sample can therefore be determined at any point in the procedure.

Compaction densities can be then calculated using the following scheme:

$$\pi * r^2 \text{ h } = \text{V} \quad (2.4.1)$$

Where r and h are in cm

$$G_{mm} * V_{cs} = W_{mm} \quad (2.4.2)$$

Where G_{mm} is the maximum specific gravity of the mix (Rice)

V_{cs} is the Volume of the compacted sample

W_{mm} is the maximum weight of the sample if no air voids are present

$$(1 - W_{sdry} / W_{mm}) * 100 = \%\text{Air} \quad (2.4.3)$$

Where W_{sdry} is the weight of the dry aggregate

$$100 - \%\text{Air} = \text{Density of the sample} \quad (2.4.4)$$

A photo of a typical SGC is shown in Figure 3

Figure 3: Superpave Gyratory Compactor

The questions to be answered with this device are whether the compaction of a RAP is sensitive to temperature and if so, is the temperature sensitivity unique to the RAP source. To answer these questions, the following experimental procedure was executed:

RAP millings were selected from two of the major climate areas in the State of Utah. Specifically: SR-32 Jordanelle, US 40 Strawberry and Sothern Parkway Saint George. The range of climates is Dry/No Freeze and Wet/Freeze. This selection produces RAP qualities from very hard to semi-soft.

A medium and fine gradation, as described in section 2.2 Table 1, were prepared for each RAP source.

Each mix gradation heated to the test temperature and combined with 2% water by weight. No emulsion was added. Compaction was accomplished in the SGC at test temperature ± 1°F to 50 gyrations. Three replicates were performed of each of the four mixes. Test temperatures were as follows: 60, 80, 100, 120, 140°F

2.5 Background of Semi-Circular Bending

Great interest has been given to fracture mechanics in asphalt pavements in recent years. Many tests have been developed in an attempt to understand low and intermediate temperature cracking. One test showing great promise due to its simplicity is the Semi-Circular Bending test. The configuration used in this study is shown in Figure 4.

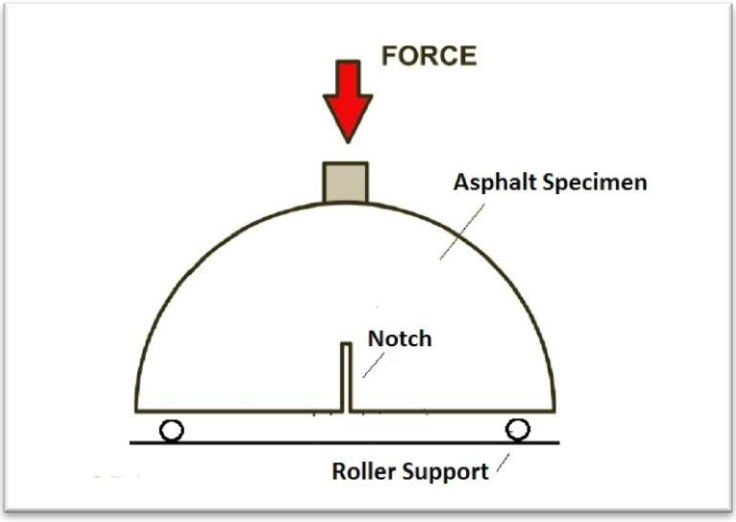


Figure 4: Semi-Circular Bending Configuration

The center crack is loaded in three point bending where load and displacement are plotted. The tests were run at 2 inches per minute and 80°F. The sample was 153mm in diameter with a 9mm tall notch. Two properties are of interest in this test. The first is Fracture

Toughness. The Second is Fracture Energy. (Biligiri et.al, 2012) Fracture toughness is a function of the maximum stress and the cross section of the beam. The formulation is as follows:

$$\sigma \text{ max} = \frac{4.263\ x\ fmax}{D\ x\ t} \text{ N/mm}^2 \qquad (2.5.1)$$

Where:

D = Diameter of sample (mm)

T = Thickness of Sample (mm)

Fmax = Maximum Force in Newtons

For notched SCB specimens with s/r = 0.8, fracture toughness is as follows

$$KIC = \sigma \max \sqrt{\pi x a}\ x\ f\left(\frac{a}{w}\right)\ N/mm^{\frac{3}{2}} \qquad (2.5.2)$$

Where:

W = Height (mm)

a = Notch depth (mm)

σ_{max} = Stress at failure calculated in equation 2.5.1

$f\left(\frac{a}{w}\right)$ = Geometric Factor

$= 4.782 - [1.219(a/r)] + [0.603e^{[7.045(a/r)]}]$

Where:

s = half of the spacing between rollers = 60mm

r = radius of the specimen = 75mm

The fracture energy of the material is the work done on the material to increase fractured surface within the area of the ligament.

Work is the area under the load/deformation curve obtained by summing up the height of the curve incrementally from zero to the maximum force.

Area of the ligament is the radius of the sample minus the notch height times the sample thickness.

Given the previous discussion, and removing the constants, four parameters rise to the surface for investigation. Maximum force, displacement at fracture, slope of the force/displacement curve and the area under the force/strain curve tell the basic story of fracture toughness and fracture energy. Two of these are measured and two calculated. The two measurements will be taken in the following experiment.

Experimental design:

- Field mix gradation

- One RAP source, Geneva Rock Products, Gradation: Field
- Five emulsions: PassR, RS.EE, E.EE, CQS 1, CSS 1
- Replicates = 2 Pucks, 4 tests
- Cure Time: 24, 48, 72 hours.
- Temperature = 80°F.
- Sample preparation:
    - Bring all materials to temperature for 4 hours
    - Mix 2950g of RAP with 1% lime, 3% water and 2.5% emulsion
    - Condition sample at test temperature for 2 hours.
    - Compact sample to constant height/density ~ 15% void in heated compactor molds
    - Cure sample for 12 hours
    - Cut sample in half and notch
    - Condition sample for 2 hours to equalize temperature
    - Break the sample and record the data.
- Test Speed = 2 inches/minute
- Test Apparatus: Humbolt HM-3000 with a with a 4 k newton load cell. Recording rate: 500/sec

Figure 5: Humbolt HM-3000 w 4kn load cell

2.6. Background for Forced Cone Penetration

Engineered emulsion performance tests are typically used to evaluate final mix properties after demulsification is complete. These tests are valuable but fail to characterize construction properties which are left to the field for adjustment. A method to understand the cure rate of an emulsion is needed to identify both construction and long term behavior. Emulsions break in a number of ways including evaporation, water loss by absorption into adjacent surfaces, chemical neutralization, exposure to vibratory energy and as many others a clever engineers can imagine. In developing a test which adequately investigates construction properties, a number of issues were considered.

Size of sample: It was observed that to look at gains in shear resistance (increasing viscosity) over time, a number of samples would have to be created at time zero and tested over time increments of interest. This would involve creating as many as ten uniform samples. Creating a single batch and dividing it into small samples seemed a logical way to proceed. Looking at the disposable Dynamic Cone Penetrometer head as a potential test apparatus and the minus #30 screen RAP as the mortar producing portion of the sample, a 2 oz. vinyl cup produced by Silo was determined to be of adequate diameter and depth to contain an 80g test sample. A uniform sample could be produced rapidly from a larger batch without producing aggregate or moisture segregation. If the fine particles were supersaturated with fluids, the cup would be sufficiently larger than the test head so that viscosity could be measured without interference from friction at the zero-slip surfaces.

Size of aggregate: The goal of this test procedure is to measure the relative viscosity gain in an emulsion/mortar system in a specific temperature range. The mortar fraction is generally considered to consist of the aggregates passing the break screen. (in this case #8) Using particles up to this size greatly increases the required sample size with no apparent change in test outcome. Reducing the particle size to those passing the #30 screen allows much better control over water content and allows the sample container to be 2.5 inches in diameter and 1.25 inches deep.

Moisture: Experiments were run to determine how sensitive the emulsion cure time was to moisture content. Minus #8 screen RAP together with lime was mixed with emulsion only (no added water). Lime and emulsion were proportioned for the full mix at 1% and 2.5% respectively. Break was immediate and no cohesion was observed. Conclusion: Absorption against dry aggregates and other surfaces causes rapid demulsification. A moisture sweep was then conducted to determine the requirement to prevent immediate emulsion break. This sweep

consisted of adding moisture as a percent of lime. A 1:1, 2:1 and 3:1 water to lime ratio was used. Rapid break was observed in all cases but aggregate coating improved along with adhesion. Conclusion: Since the lime was applied to the small aggregates at the rate prescribed for the full mix and the water was applied as a ratio to the lime, all of the water from the lime slurry was taken up by the minus #8 portion of the mix. In the case of the medium mix, this portion is only 30% of the total aggregate. Further addition of water up to liquefaction was required to prevent flash demulsification. Moisture in excess of supersaturation was shown to reduce initial viscosity and to slow the increase of viscosity in both the near and long term.

Moisture content as a % of fines/total mix: Two mix design gradations were provided in the standard Road Science mix design. They are as presented in Table 4.

Screen	**Medium Gradation**		**Coarse Gradation**	
Size	% Passing	% Retained	% Passing	% Retained
½"	86	14	73	27
3/8"	77	9	62	11
#4	52	25	38	24
#8	33	19	20	18
#16	16	17	8	12
#30	7	9	3	5
Minus #30	0	7	0	3

Table 4: RAP Gradations

The initial questions on moisture come from work done in the Proctor test using the full mix. What is the water content at maximum Proctor Density? How much of this water is contained in the minus #8 material? How much of this water is contained on the minus #30 material? These questions are relevant to the requirement that the minus #30 material must be supersaturated to prevent flash emulsion break.

Proctor results on the medium gradation mix show that density increases until free water is observed. Adding additional water has no effect on density, it simply runs out of the mix. This value was 8% moisture for the medium and 6% for the coarse gradation. The top of the curve was very flat in both cases making it difficult to be more precise than 1%. The water at optimum for the mix has been calculated as a percent of the minus #8 and minus #30 fines. This is to determine if the fines are super-saturated at optimum moisture. Results are shown in Table 5.

Gradation	% Passing		Lime	Total Fines (g) 100g sample		Water (g) Full Mix Proctor	Proctor Water % of Fines	
	#8	#30	1.5%	#8	#30	100 g sample	#8	#30
Medium	33	7	1.5	34.5	8.5	8	23.2	94.1
Coarse	20	3	1.5	21.5	4.5	6	27.9	133.3

Table 5: Optimum Moisture (Proctor Test)

Moisture sweeps were run on the full gradation, the minus #8 and the minus #30 fines to determine supersaturation condition. This condition is defined as the point where sufficient moisture is present in the aggregate to produce liquefaction under a vibratory input. The vibration in this experiment was produced by a concrete consolidation vibrator. Supersaturation is required to prevent flash demulsification when emulsion is added. For the medium gradation, supersaturation was reached at 5% water while the coarse reached this point at 2.6%. Results for the minus #8 and minus #30 are in Table 6. These results demonstrate that 95 to 100 percent of the moisture required to prevent flash demulsification is contained on the minus #8 screen and that when using this technique to determine optimum water content, the percent passing both #8 and #30 screens must be measured.

Water to liquifaction of fines (g) 100 g sample		% minus # 30 in the #8 fines	Water in the #8 on the minus #30	Water in the #8 on the minus #30	% water in the mix based on the liquifaction of the minus #8 fines	% water in the mix based on the liquifaction of the minus #30 fines
#8	#30		grams	Percent		
15.0	36	21	7.6	50.9	5.0	2.5
15.0	36	15	5.4	36.0	3.0	1.1

Table 6: Water to Reach Supersaturation.

Upper line = Med, Lower line = Coarse gradation

Load Cell: All test results fall in the one to ten pound range. This is less than 5% of a 200 pound load cell. It would be much better if a 50 pound load cell was available. These cells are available from "Interface" and "Celtron" at a reasonable price.

Head Configuration: Several head configurations were tried. 3/16 flat, 5/16 flat and 3/4 inch-90 degree cone were investigated. Only the cone produced measured forces sufficiently high to demonstrate variation in viscosity. The challenge with this configuration is that the force increases with the increasing diameter of the cone and the increasing contact area. Care must be taken to place the tip of the cone on the surface of the slurry and penetrate the sample to the same depth each time.

Vibration/Consolidation: One of the inputs to the CIR mat in the field is the vibration from the knock down roller. This input has been discussed as a possible energy input in the demulsification process. In the field, the vibration intensity and amplitude is variable based on the compactive needs of the mat. It is necessary to standardize this input in the lab. A concrete consolidation vibrator was chosen to provide the necessary input and a duration of 15 seconds was similarly chosen. The effect of this operation at the fluid levels developed above is to liquefy the mortar and fully disperse the particles in fluid. All consolidation from this point is either settlement or demulsification.

Temperature: While working with full pucks, it was demonstrated that temperature dominates demulsifacation. In the field, the most common processing temperature was between 80 and 100°F. 100°F is therefore the critical temperature for constructability. The emulsion must not break in the windrow at this temperature. For this reason, 100°F was chosen as the test temperature for emulsion performance qualification.

Speed: A sweep of head speed was conducted from 0.1 inches per minute to one inch per minute. The best resolution at the most reasonable test duration was 0.5 inches per minute.

Time: Time is a critical factor in both constructability and release to traffic. The emulsion break must delay for enough time to pass through the paver but must develop viscosity in time to release to traffic. Twenty minutes is sufficient time to pass the paver and three hours is sufficient to release to traffic. The emulsion must therefore show minimal viscosity gain over the first twenty minutes but must show significant gain in the next three hours.

Test Procedure: With deference to the considerations presented above, a Cone Penetration Test is proposed for Qualifying a Engineered Solventless Cold In Place Recycling Emulsions (ESCIRE). The test consists of driving a cone into a sample of emulsion/RAP mortar and measuring the resistance at time increments between 10 minutes and 24 hours. See appendex 1 for the complete test procedure.

Experimental Plan:

- One RAP source, Southern Parkway, minus #30 sieved fraction.
- Three Emulsions, RS-EE from SR-32, Erg-EE and Erg-CSS1h provided to the project for research purposes.
- Temperature 100°F.
- Penetration rate 0.5 inches per minute.

The cone apparatus and the sample are shown in Figure 6. The test equipment is shown in Figure 7

Figure 6: Cone Apparatus and Sample of RAP mortar.

Figure 7: Cone Penetration Test Equipment

3.0 DATA COLLECTION

3.1 Overview

Pavement performance is a balancing act between competing mix properties. An optimization must be developed between rutting resistance and cracking resistance. CIR has additional challenges including, a need for short term stability, a lack of gradation control, temperature sensitive amorphous particles, a need for space to store fluids during construction and a need for long term fracture energy control. The following tests are proposed to give insight into these issues:

- Modified Proctor Compaction AASHTO T 180 method C. (Fluid capacity)
- Modified Marshall Stability AASHTO T 245. (Short and long term stability)
- Superpave Gyratory Compactor (SGC) AASHTO T 312 (Compactability)
- Semi-circular Bending (Long term fracture energy)
- Forced Cone Penetration (Short term stability behavior)

Data from these tests are presented below.

3.2 Modified Proctor Compaction AASHTO T 180 method C.

To determine the optimum compaction moisture at 100°F (a common mat temperature in the field), SR-32 RAP was screened. Coarse and Medium gradations were prepared and compacted at the target temperature. The weight of a unit volume of compacted material was recorded at each of five moisture contents.

The peak of the graph is the optimum moisture content.

Figure 8 illustrates the recorded data for the medium gradation and Figure 9 for the coarse gradation.

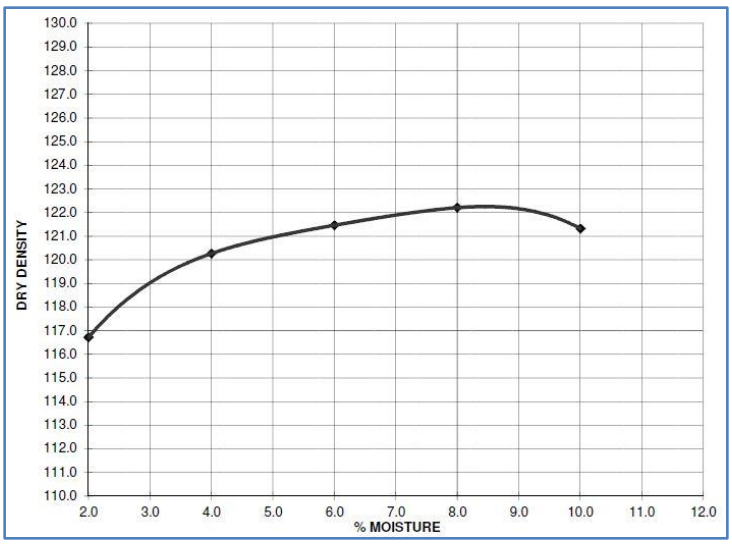


Figure 8: Proctor Graph: Optimum Moisture Medium Gradation

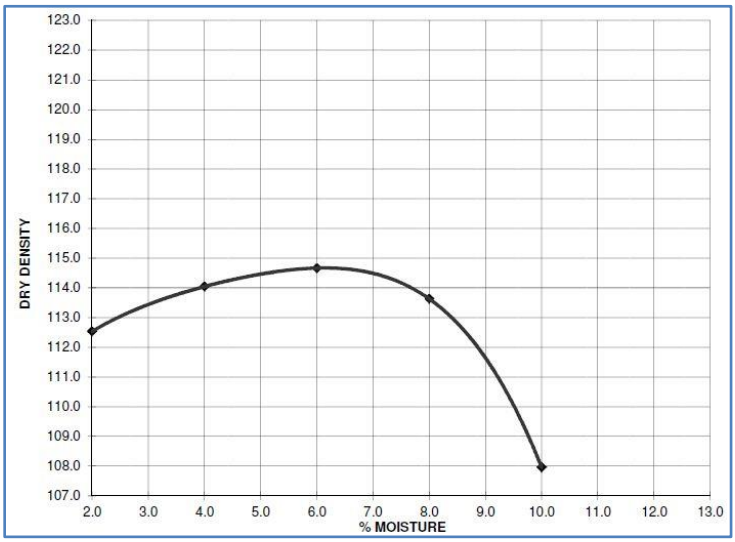


Figure 9: Proctor Graph: Optimum moisture Coarse Gradation

At 6% moisture in the coarse and 8% in the medium gradations, free water began to appear in the samples. Beyond this point, water was draining from the sample during compaction. This is not an unusual result when testing non plastic, open- graded, unbound materials.

3.3 Modified Marshall Stability AASHTO T 245.

The Marshall Stability procedure is a basic test for stiffness characterization of asphalt mixes. Early stages of the research were focused on two mix characteristics using this procedure. They include;

- How does the sample stability change with change in temperature?
- How does the stability of the sample change with changes in curing time?

The goal of the investigation of the time and temperature variations in stability was to determine if certain temperature ranges or curing times could be used to differentiate between different emulsions and their rate of early strength gain during construction.

3.4 Test Procedures

The test procedures for both of these phases are very similar, with changes primarily being made to either the curing time used or the curing and testing temperature used. Specific parameters include:

Objective 1: Curing Temperature sensitivity of CIR Emulsion

Road Science Emulsion & CSS-1

Mix and cure @ 60, 80, 100, 120° F

Test 8 hour stability using Marshall Stability

Objective 2: Curing Time sensitivity of CIR Emulsion

Road Science Emulsion & CSS-1

Mix and cure @ 80° F

Test 4, 6 and 10 hour stability using Marshall Stability

3.4.1 Curing Temperature Sensitivity

RAP collected from the I- 84 project was used in the making of CIR pucks to compare the performance of different emulsions mixed, compacted and cured at different temperatures. Characteristics of the samples included:

1. Lime was already on RAP

2. 3250 grams of RAP were used in each sample.
3. 140.8 grams of water were used in each sample.
4. 58.5 grams of emulsion were used in each sample.
5. Pucks were compacted to 50 gyrations.
6. 3 -Road Science Reflex emulsion samples and 3-CSS-1 emulsion samples were made at 60, 80, 100 and 120° F each.
7. 3 –PMCIR, CQS and PASS-R samples were made at 60° F and 80° F each.

The RAP was quartered and split down to the 3250 gram samples from the buckets taken at the I-84 Henefer to Echo project. It was calculated that the 3250 grams of RAP with water and emulsion added would result in approximately 90 mm pucks. The bags of RAP were conditioned to the temperature used at mixing, compaction and curing of the pucks for at least 4 hours.

The RAP was combined with water and emulsion and mixed until there was uniform coating of the RAP. The quantities of RAP, water and emulsion were measured and recorded.

Note: The Road Science emulsion would combine with the RAP and leave very little residue in the mixing bowl. The CSS-1 emulsion left considerably more residue in the mixing bowl especially at lower temperatures.

The mixed samples were bagged in Ziploc bags and kept at the test temperature for 2 hours before compaction. The samples were compacted at 50 gyrations.

Note: The height of the samples at 50 gyrations changed with the change in temperatures from 84.1 mm average ht. at 120° F *to 95.5 mm average at 60°* F. *The amount of water forced from the mix at compaction changed accordingly with little to no water in gyro at 60 degrees. The Road Science pucks had less moisture between the puck and the plates of the gyratory compactor so the plates were considerably more difficult to remove.*

The pucks were weighed after compaction and kept at the test temperature for 8 hours. They were weighed again prior to stability tests. Stability tests were performed and the results recorded.

Note: The pucks done at 120° F *had lower stability numbers, however the pucks showed little cracking or crumbling as a result of the test. The cooler temperatures increased the amount of crumbling and cracking especially on the CSS-1. The Stability test results were highest on the*

80° F pucks however the CSS-1 pucks at 80° F and both sets of pucks at 60° F were cracking and breaking apart while removing the puck from the test mold.

Figure 10: Reflex puck after stability test at 120 degrees

Figure 11: Reflex Puck after Stability at 80 degrees

Figure 12: CSS-1 Puck after Stability at 80 Degrees

Figure 13: Reflex Puck after Stability at 60 degrees.

3.4.1.1 Curing Time Sensitivity

RAP collected from the I- 84 project was used in the making of CIR pucks to compare the performance of different emulsions at different amounts of time to test after compaction. As with the temperature sensitivity investigation, the characteristics of the samples included:

1. Lime was already on RAP
2. 3250 grams of RAP were used in each sample.

3. 140.8 grams of water were used in each sample.
4. 58.5 grams of emulsion were used in each sample.
5. Pucks were compacted to 50 gyrations for the 4 and 6 hour samples and 90 mm height for the 2 and 10 hour samples.
6. 3 -Road Science Reflex emulsion samples and 3-CSS-1 emulsion samples were made at 80 degrees and tested at 2, 4, 6, 8, 10 hours after compaction.

RAP, water and emulsion were measured out, recorded and mixed similar to Task 1 at 80° F. The samples were placed in Ziploc bags and stored at 80° F for 2 hours prior to compaction.

Note: The Reflex emulsion still left little residue in bowl after mixing while the CSS-1 emulsion left residue in the mixing bowl.

Figure 14: Road Science Reflex after mixing

Figure 15: CSS-1 after mixing

The samples were compacted 2 hours after mixing. The 4, 6, and 8 hour to stability test samples were done first. They were compacted to 50 gyrations and placed in an 80° F oven until Stability tests were performed. After these were complete it was decided that the going forward the pucks would be made to a set height of 90 mm instead of at 50 gyrations to keep the voids similar rather than the compaction effort. The 2 and 10 hour to stability test pucks were made to 90 mm height which required 63-85 gyrations.

Note: There was some water forced out of the mix at compaction and the CSS-1 had more moisture under the plates making the plates easier to remove.

The weight of the pucks was recorded after compaction and prior to stability testing. Stability tests were performed at the set times after compaction. The 4 and 6 hour results were very similar to the 8 hour results from the pucks made with Task 1.

Note: The 2 hour pucks had higher stability test numbers than pucks tested at other times after compaction. I thought this may be due to the extra compaction effort used to bring them to 90 mm however the 10 hour pucks, which were made similar to the 2 hour pucks had test results very similar to the 4, 6 and 8 hour pucks made previously at 50 gyrations.

3.5 Superpave Gyratory Compactor (SGC) AASHTO T 312

The SGC was used to see whether RAP compaction is temperature sensitive and if so, is this sensitivity unique to each RAP source. Constant mass samples were compacted with 2% water at various temperatures to 50 gyrations. The results were graphed.

3.5.1 US-40 Medium and Coarse gradations

These graphs demonstrate the temperature sensitivity of the US 40 RAP. Each colored curve represents the compaction of the material at a specific temperature. This RAP comes from a high altitude, cold temperature area.

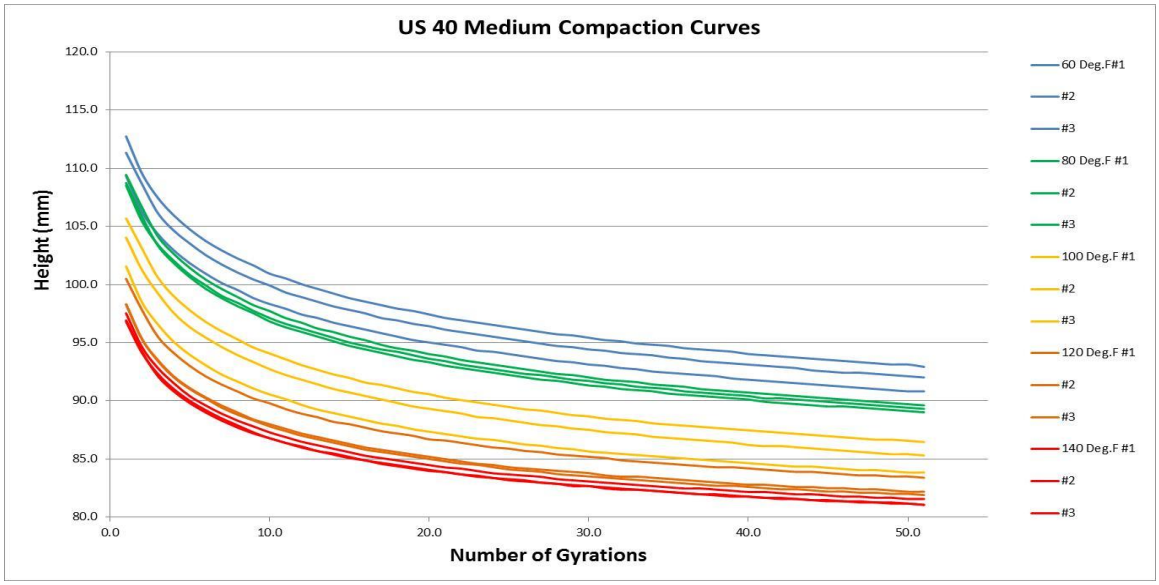


Figure 16: US-40 Medium Gradation Compaction Curves

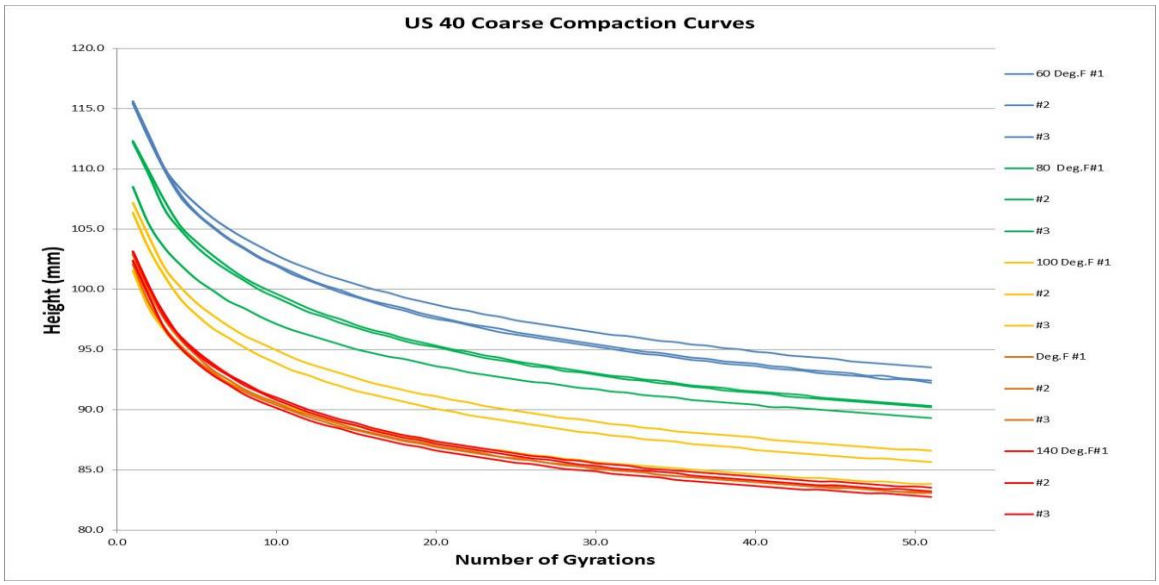


Figure 17: US-40 Coarse Gradation Compaction Curves

3.5.2 SR-32 MEDIUM AND COARSE GRADATIONS

These graphs demonstrate the temperature sensitivity of the SR-32 RAP. Each colored curve represents the compaction of the material at a specific temperature. This RAP comes from a high altitude, cold temperature area.

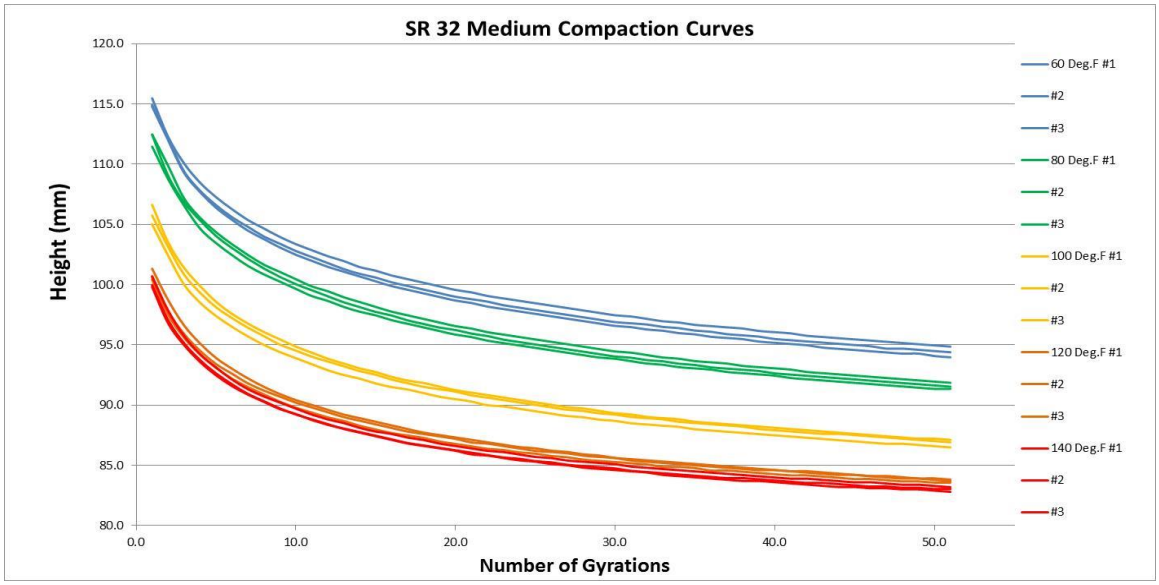


Figure 18: SR-32 Medium Gradation Compaction Curves

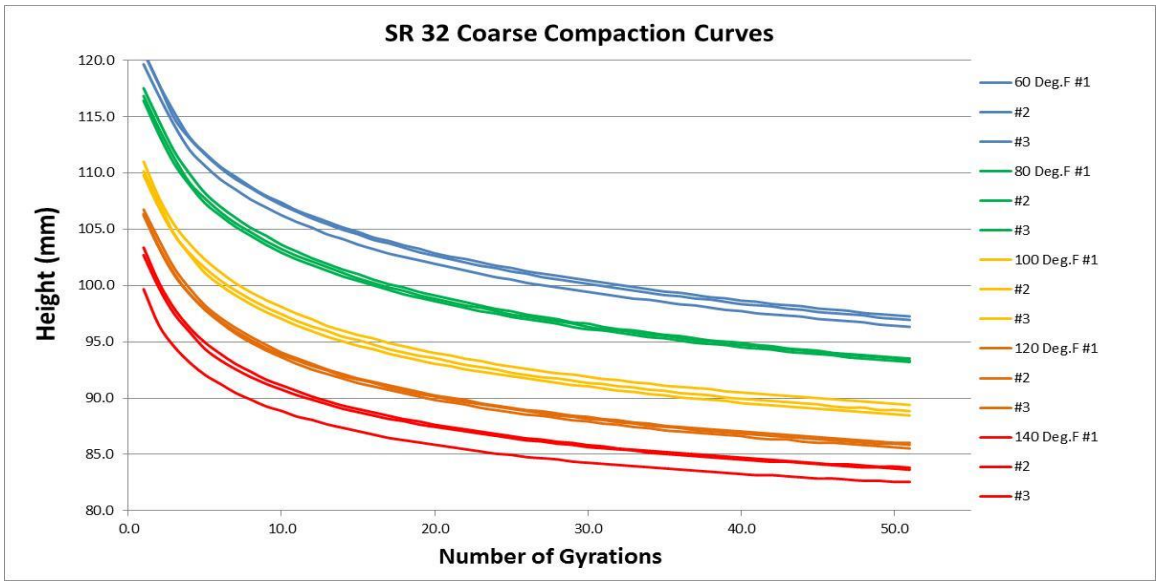


Figure 19: SR-32 Coarse Gradation Compaction Curves

3.5.3 SOUTHERN PARKWAY MEDIUM AND COARSE GRADATIONS

These graphs demonstrate the temperature sensitivity of the Southern Parkway RAP. Each colored curve represents the compaction of the material at a specific temperature. This RAP comes from low altitude, hot temperature area.

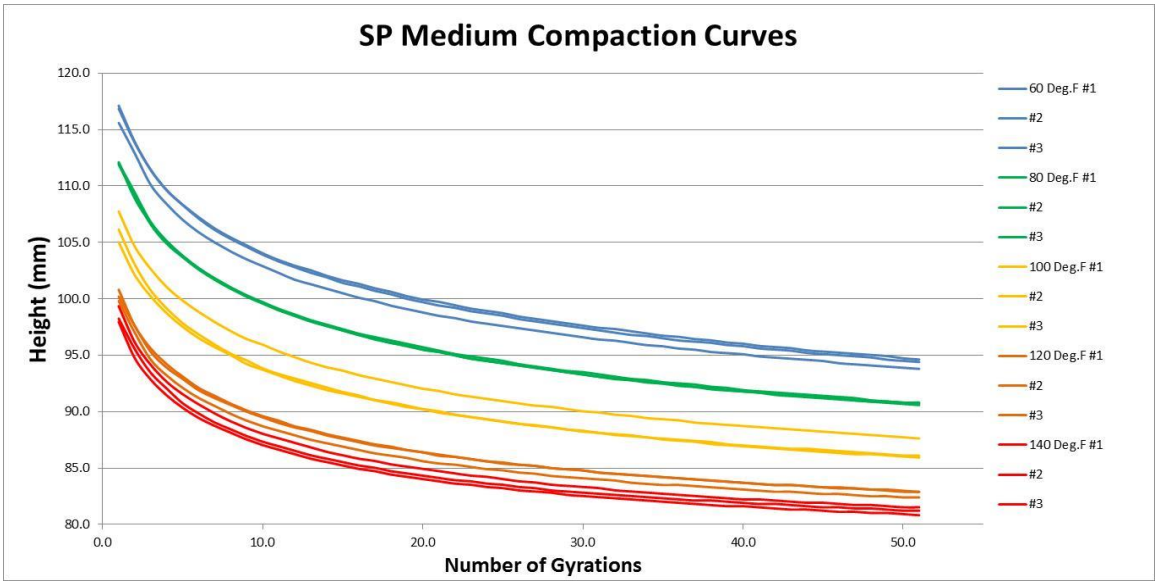


Figure 20: Southern Parkway Medium Gradation Compaction Curves

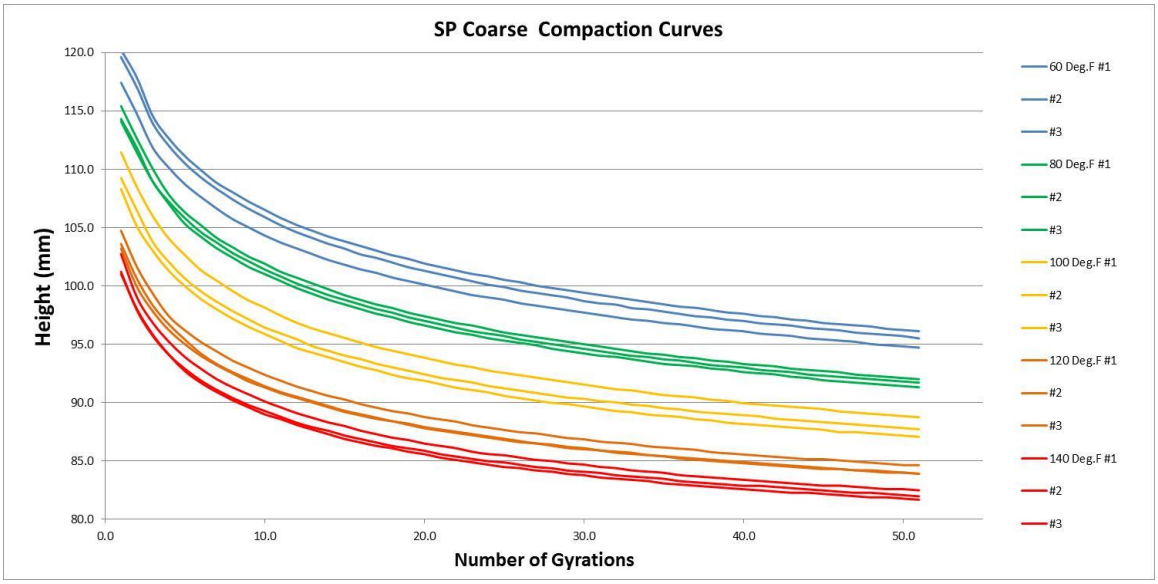


Figure 21: Southern Parkway Coarse Gradation Compaction Curves

3.6 Semi-Circular Bending

The 5 test results from the five emulsions are illustrated in Figure 22 through Figure 24.

3.6.1 TYPICAL RAW DATA

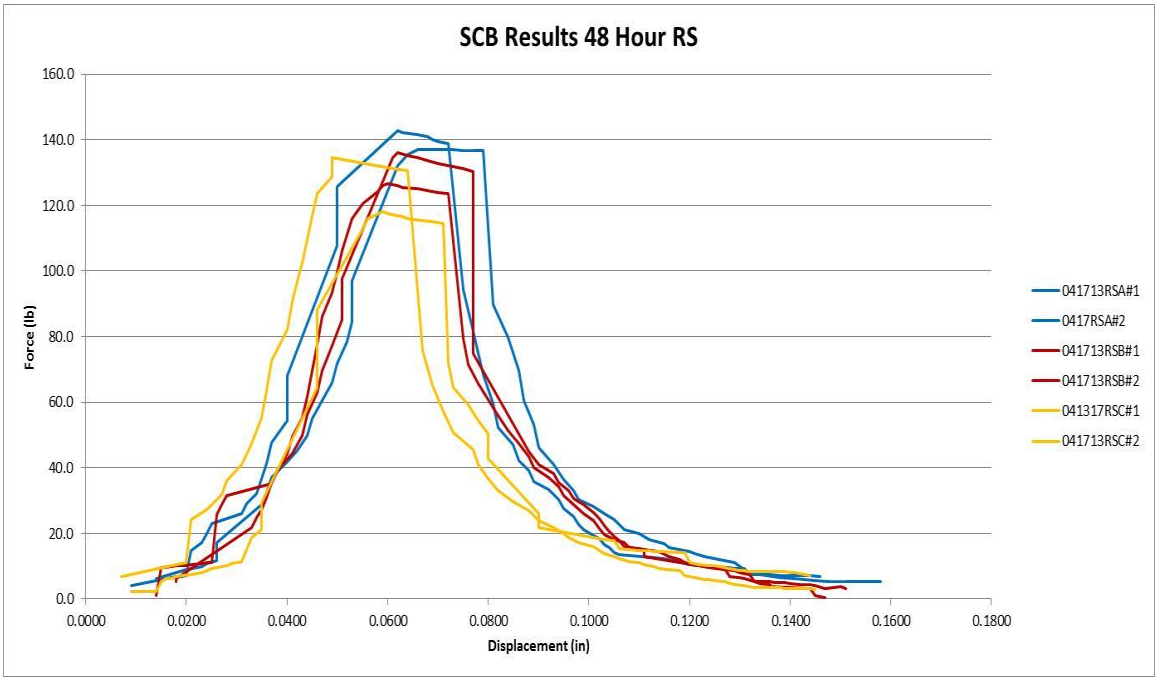


Figure 22: Typical SCB Results 3 pucks, 6 tests, 48 hour cure

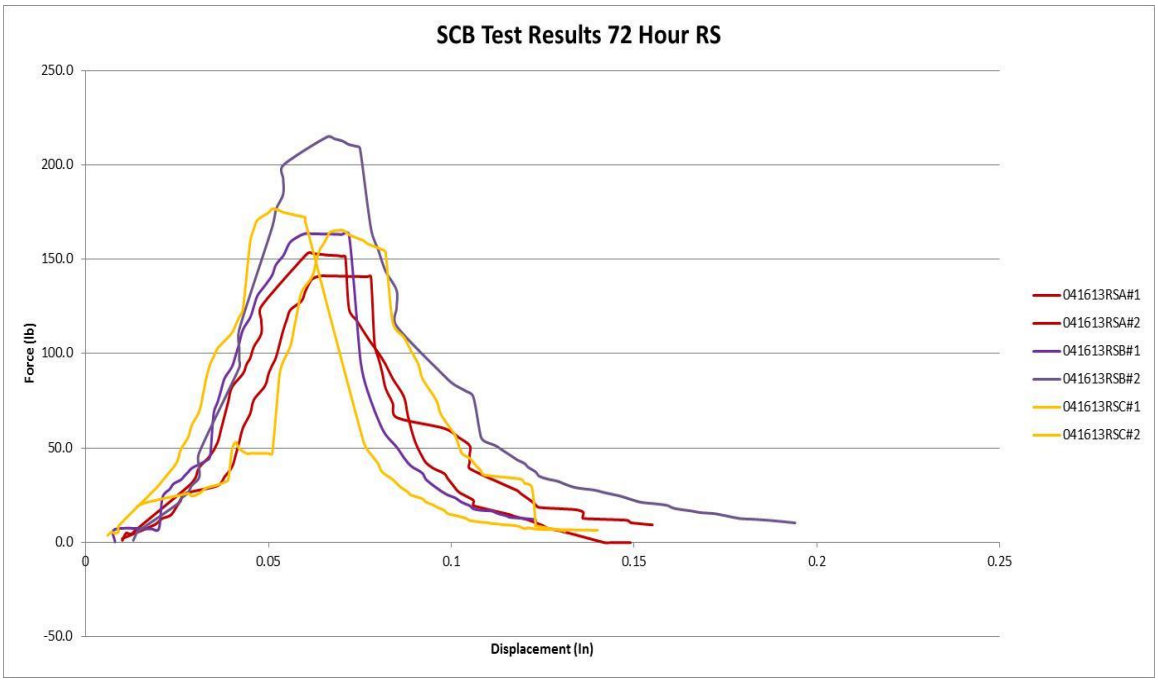


Figure 23: Typical SCB Results 3 pucks, 6 tests, 72 hour cure

3.6.2 PROCESSED DATA

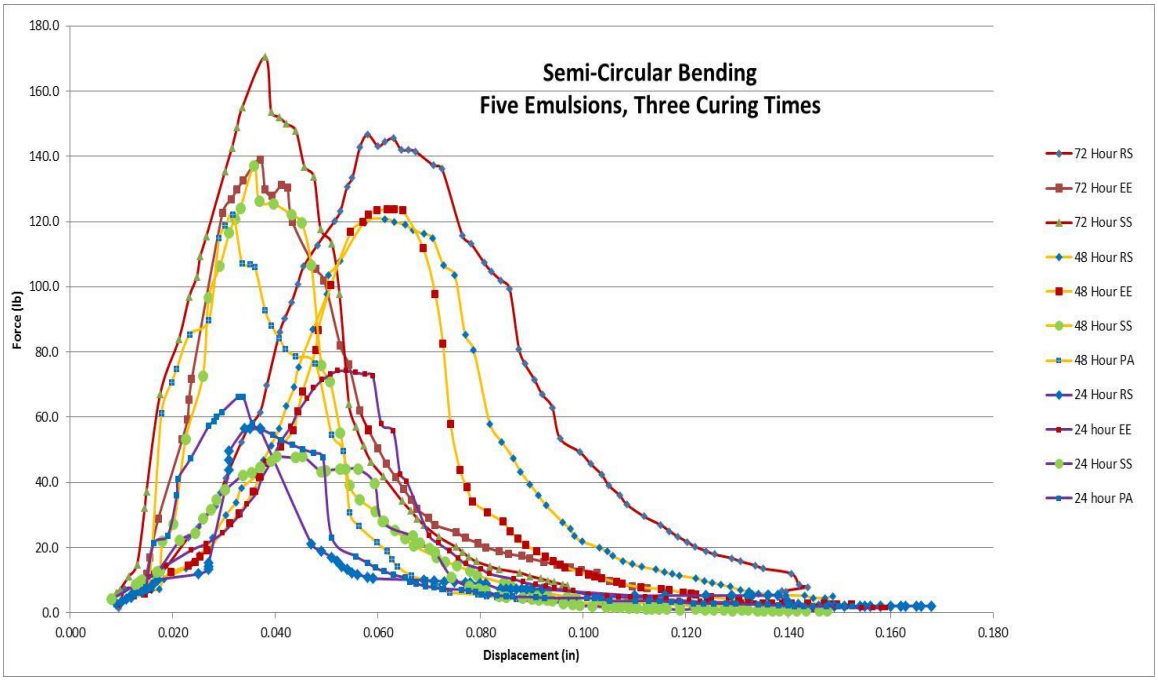


Figure 24: SCB results averaged from 6 tests for 5 emulsions and 3 curing times

The individual results have a fair amount of scatter leading to a need for better test controls. The foreleg of each curve is fairly well defined and a peak force value along with a displacement at that value can be determined directly from the data. The foreleg looks as if it will lend itself to regression fitting but a triangular model is a good start. The research will proceed on this basis with the recognition that improvements should be made.

3.7 Forced Cone Penetration

Test UT-01-14 was run on three emulsions. Two are ESCIRE and one is a slow set. Graphs of both maximum force vs time and % force vs time are presented in graphs 1 and 2

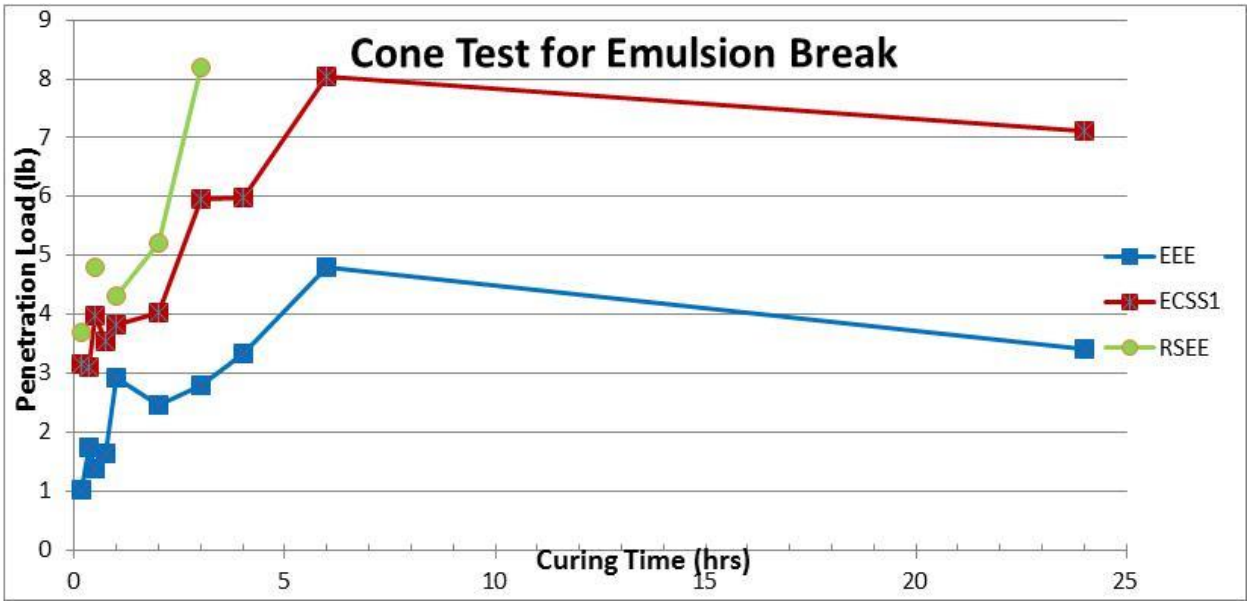


Figure 25: Penetration Load vs Time

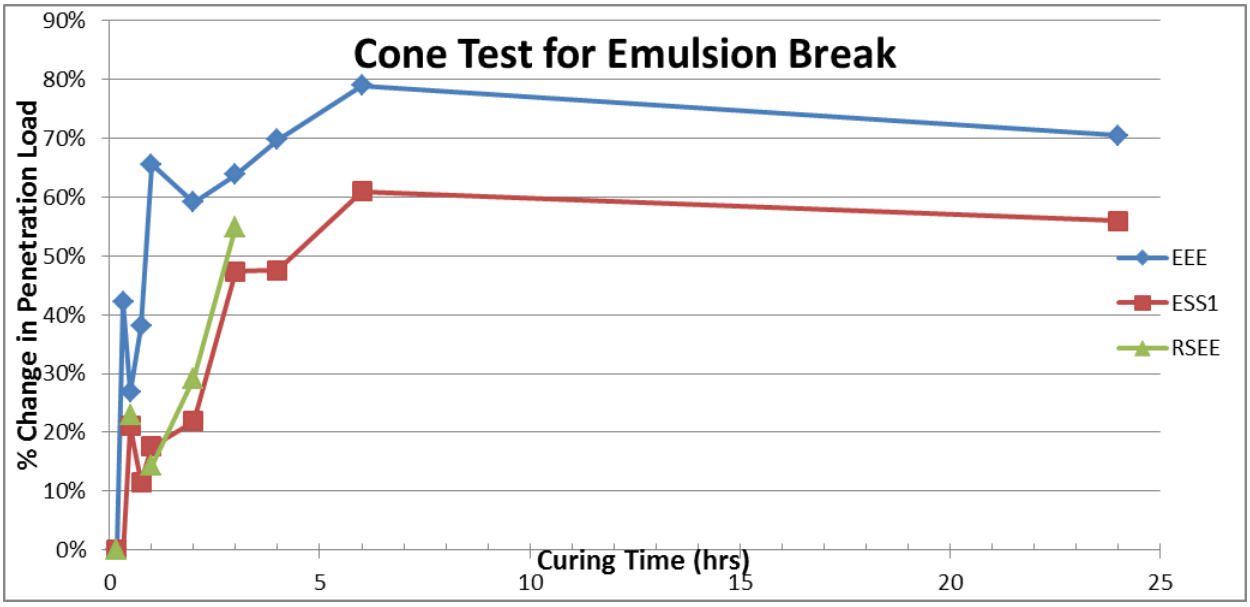


Figure 26: % Change in Penetration Load vs Time

Note that the percent change in the engineered emulsions is much greater than the slow set emulsion in the first four hours. This trend continues long after this initial set time. The initial stiffness as well as the near term stiffness shows no trend from one emulsion to another.

3.8 Summary

These experiments show that RAP particles are not discreet above 80° F but become more discreet above 120° F. Between these temperatures, RAP compaction behavior follows a predictable pattern. This pattern is offset vertically based on gradation in a predictable manner. They also demonstrate the temperature sensitivity in the development of stability These observations are valuable when setting long term design values.

Fracture in CIR is a little understood property. It is unknown whether strong and resilient or weak and brittle is the correct attribute. Measuring this property is a first step in understanding what is desired in a base isolation interlayer.

Emulsion demulsification rate in the first three hours is imperative to control mixing, paving, compaction and return to traffic. The proposed test shows merit in understanding these properties.

4.0 DATA EVALUATION

4.1 Overview

Introduce the chapter contents. The Data Evaluation chapter includes information on how and why the data was evaluated. Statistical methods employed should be listed and their use justified. Extrapolated and evaluated data should be included on tables or charts or graphs that simplify and help understand trends or other information gathered.

4.2 Data Evaluation Modified Proctor Compaction. AASHTO T 180 method C.

Density in unbound materials is a function of compactive effort, moisture content and the surface area of the material. The more fines in a gradation, the more moisture it can hold before the voids are filled and the particles are pushed apart resulting in lower density. When a gradation has a high percentage of large particles, it can hold very little moisture before density is reduced and free moisture begins to drain from the sample. The data indicates that when the percent passing the #8 screen falls by 40%, the optimum moisture falls by 50%. This leads to a table of optimum moisture based on the percent of the sample passing the #8 screen.

	% passing #8	Optimum Moisture (%)
Fine Gradation	50	13.5
Medium Gradation	33	8
Coarse Gradation	20	6
Extra Coarse Gradation	13	3.6

Figure 27: Optimum Moisture Based on % Passing #8 Screen

4.3 Data Evaluation Modified Marshall Stability AASHTO T 245

4.3.1 SAMPLE STABILITY WITH TEMPERATURE

Observation of the results of the stability versus test temperature testing exhibited the typical decrease in the stability values with increases in temperature seen in other portions of the research. Pucks for the Road Science and CSS-1 emulsions were compacted at 50 gyrations,

where the remaining emulsions were compacted to a target height of 90 mm. Comparison of the results should be done in two categories. When compacting to a target density (height), the stability results show the typical downward trend of stability values with increased temperature (Figure 28). For the emulsions compacted with consistent compactive effort, the downward trend is present from 80° F and above, however the 60° F pucks show lower stability values. This is likely due to the significant increase in voids present. When above 80° F, the binder in the RAP material appears to be mobilizing, aiding in compaction and also reducing stability due to a reduction in viscosity. This is also consistent with other phases of the research.

Potential for differentiation of the emulsions was looked at. Deviations of the results were most notable below 80 degrees, however it would need to be done with consistent compactive effort. Compactive efforts that are modified to meet a target void content or height will compensate for any variations in the emulsion characteristics.

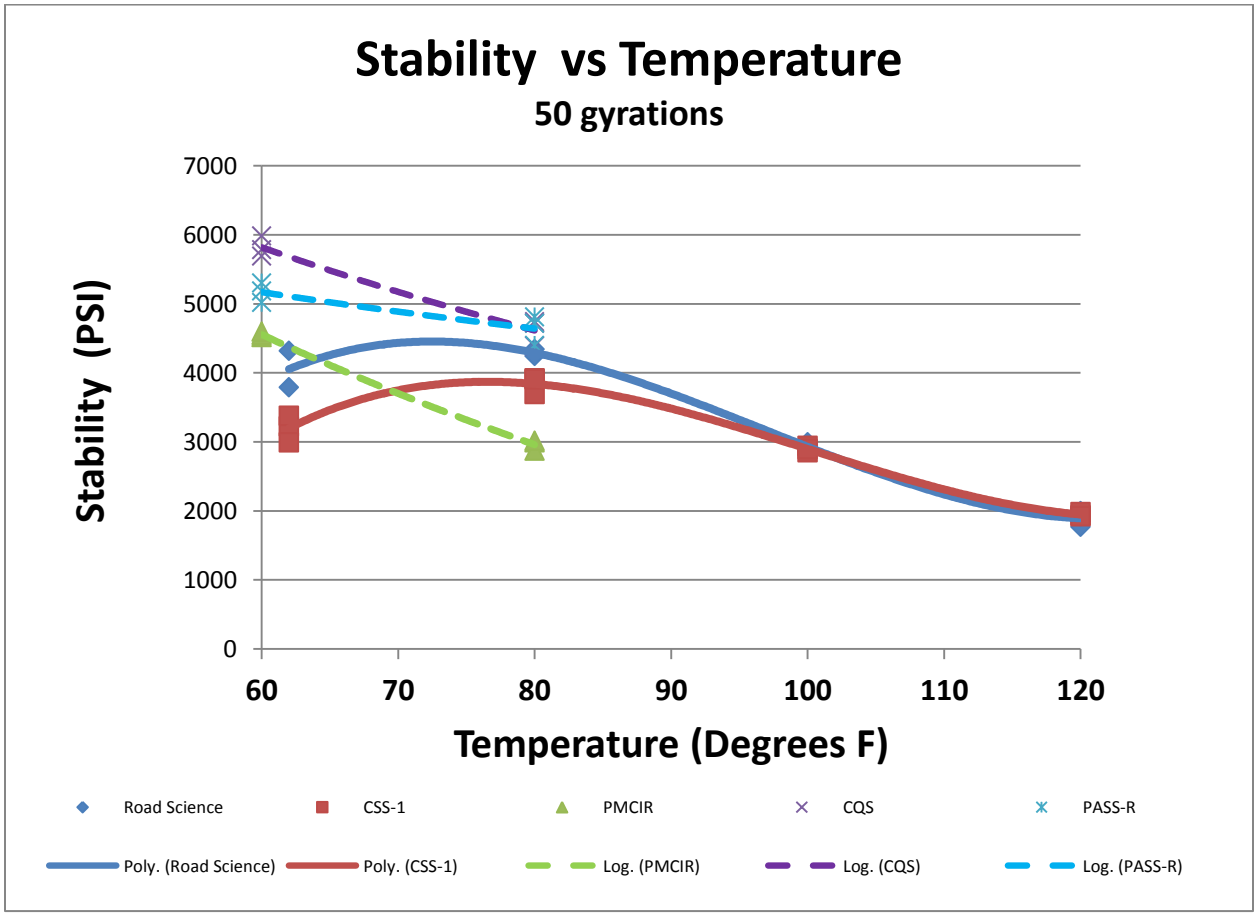


Figure 28: Stability of Samples vs Test Temperature

4.3.2 Sample Stability with Time

Observation of the results of the curing time versus stability testing showed that the stabilities were very consistent after about four hours, regardless of the actual length of curing time (Figure 29). The two hour times were significantly higher in stability. Several things are thought to contribute to the increased stability at two hours. This includes the increased compactive effort used to create pucks of the same height as the remaining pucks, the possibility that two hours in the oven is insufficient to reach the 80° F test temperature, and the increased stiffness of the emulsion residue that has been observed in other test evaluations. Subsequent phases of the investigation have used modified procedures where all ingredients are brought to temperature prior to mixing, so as to eliminate any potential thermal gradients.

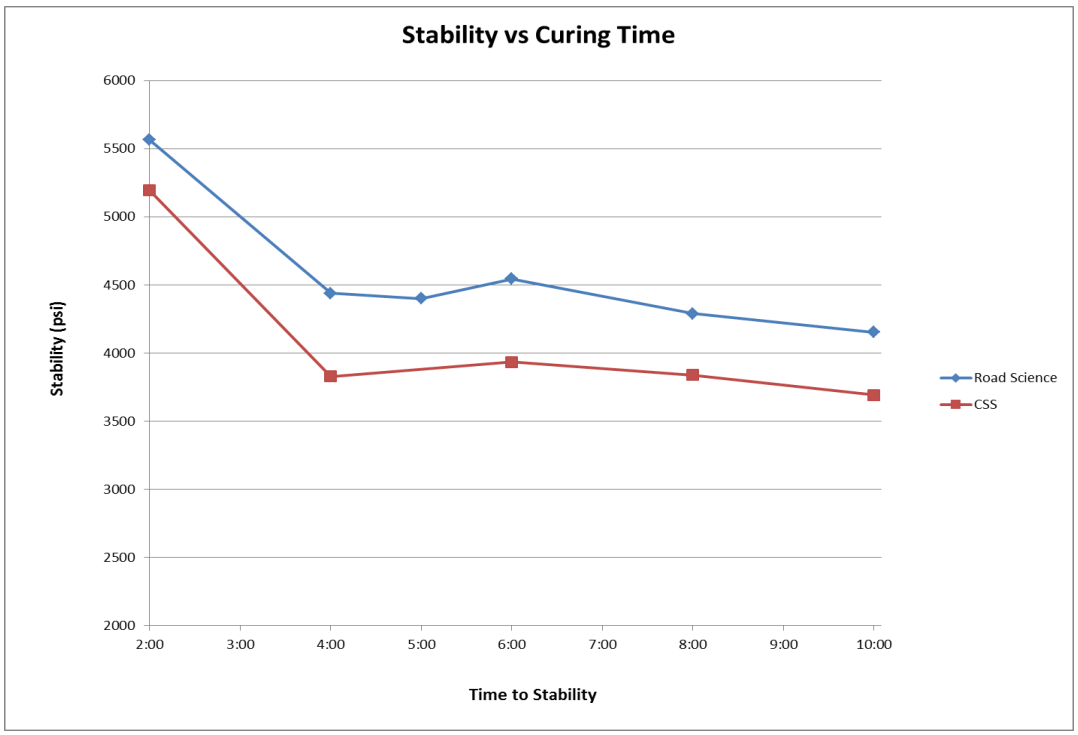


Figure 29: Stability of Samples vs Test Temperature

Results of the testing did not differentiate between emulsions as related to the curing time, however a continual variation in the ultimate stability was present throughout the results, with the CSS-1 exhibiting more than 10% less strength than the Road Science emulsion.

4.4 Data Evaluation Superpave Gyratory Compactor (SGC) AASHTO T 312

4.4.1 Relationship between density and temperature

The calculated densities were compared to field densities and the 30 gyration compaction endpoint was selected for plotting against sample height.

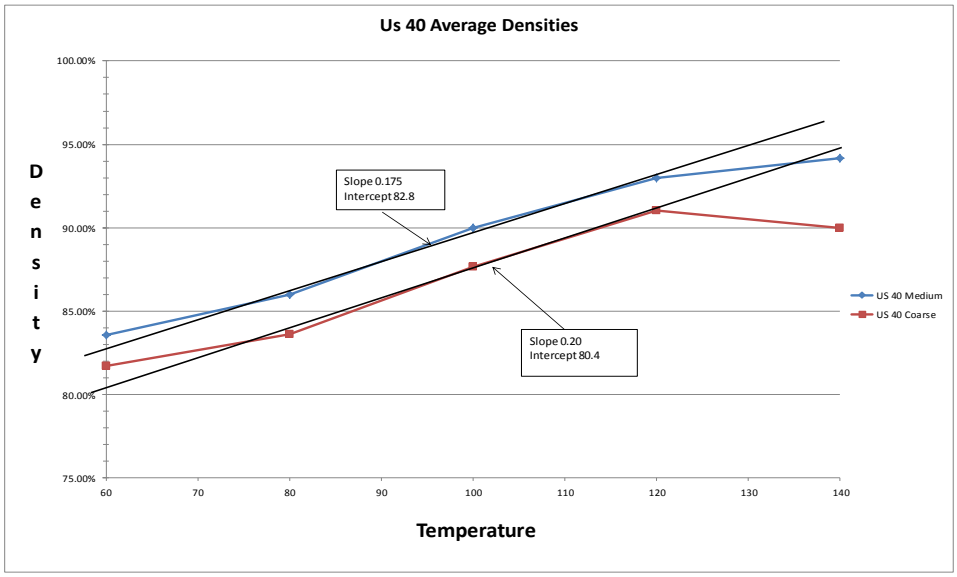


Figure 30: Average Density at 30 Gyrations vs Temperature US-40

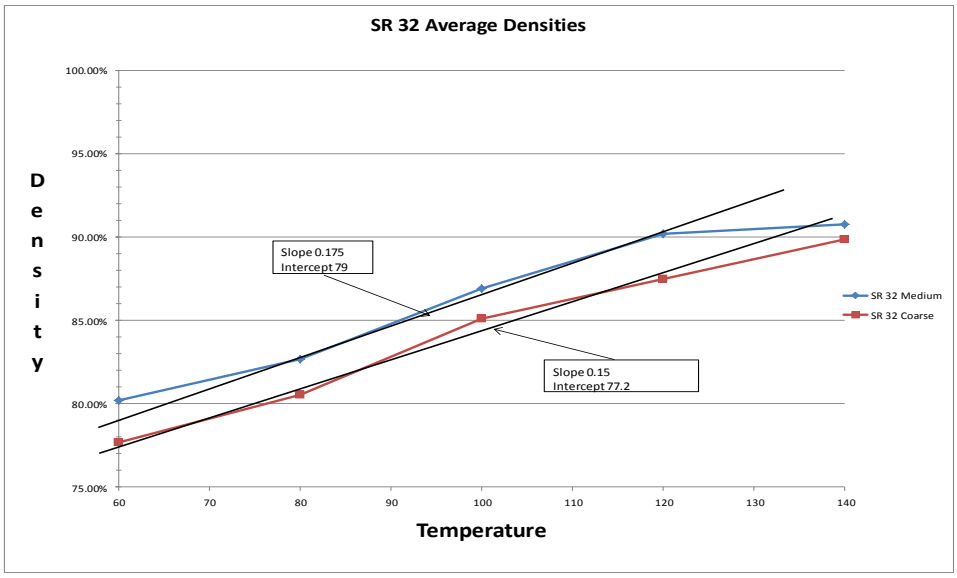


Figure 31: Average Density at 30 Gyrations vs Temperature SR-32

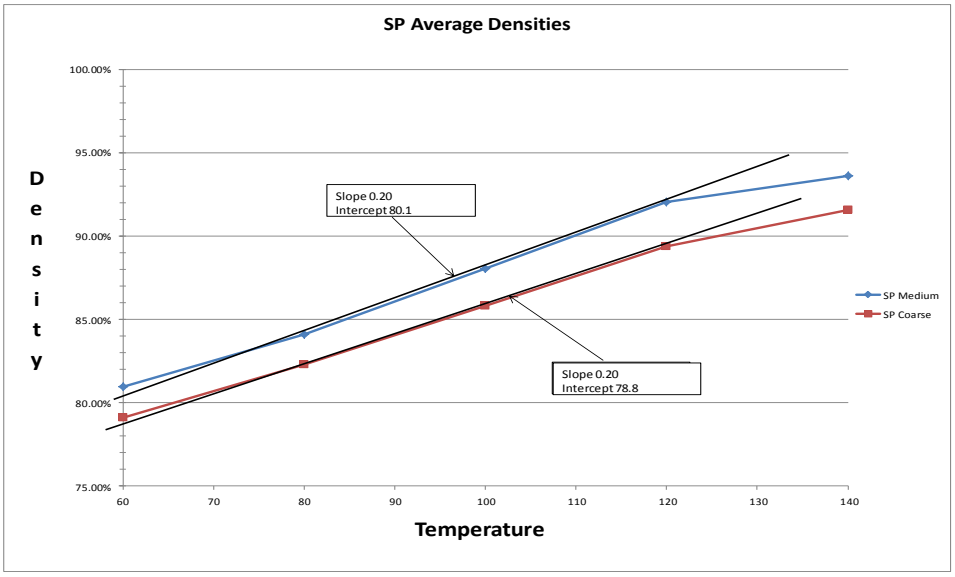


Figure 32: Average Density at 30 Gyrations v Temperatures, Southern Parkway

Although each Rap source compacts differently, each of them achieve higher density as temperature rises. That is the endpoint density curve rises as temperature increases. The endpoint density curve is linear between 80°F and 120°F. The slope of these curves falls between 0.15 and 0.20 and could be reasonably estimated at 0.18. Intersection with the density axis is RAP source and gradation dependent however the two sources from wet/freeze climate were more difficult to compact than the dry/no freeze climate.

4.4.2 DENSITY VS GRADATION

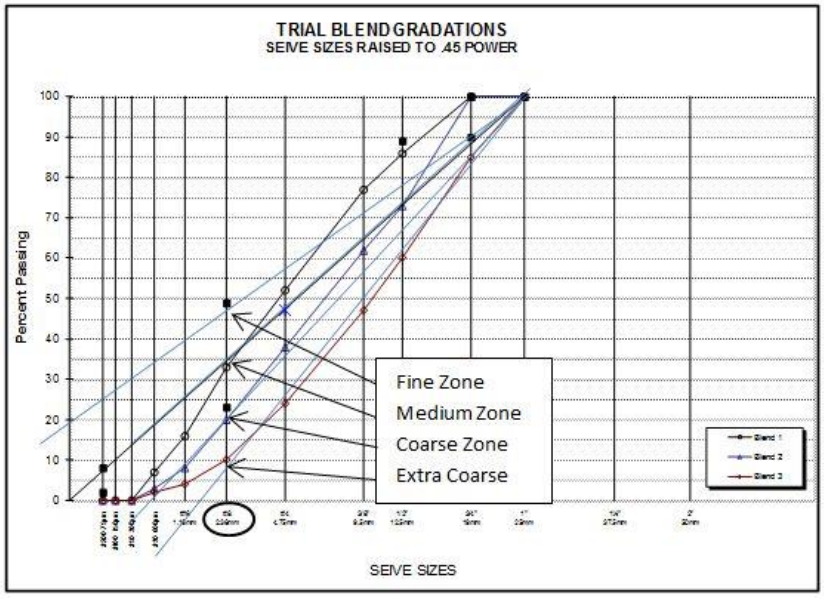


Figure 33: Power 45 Chart with: Blend 1, Medium Gradation
Blend 2, Coarse Gradation
Blend 3, SR-32 Gradation

The density change between medium and coarse gradations is approximately 2% consistently across the measured RAP Sources. Studies have shown that Voids are controlled most significantly by the materials passing the break screen.(usually #8 or #10) The difference between a medium gradation and a coarse gradation in this study is 13% on the #8 screen. Hypothesis: For each 13%-passing change on the #8 screen, there is a 2% change in compacted void at any temperature between 80 and 120°F. This needs to be tested in the field.

4.5 Data Evaluation Semi-circular Bending

The data lends itself to a triangular model where the peak force, the displacement at peak force and the area within the triangle defined by one half the peak force times the displacement at the peak force. These three values are the basis for fracture toughness and fracture energy. They will be shown graphically in Figure 34 to Figure 36.

4.5.1 PEAK FORCE

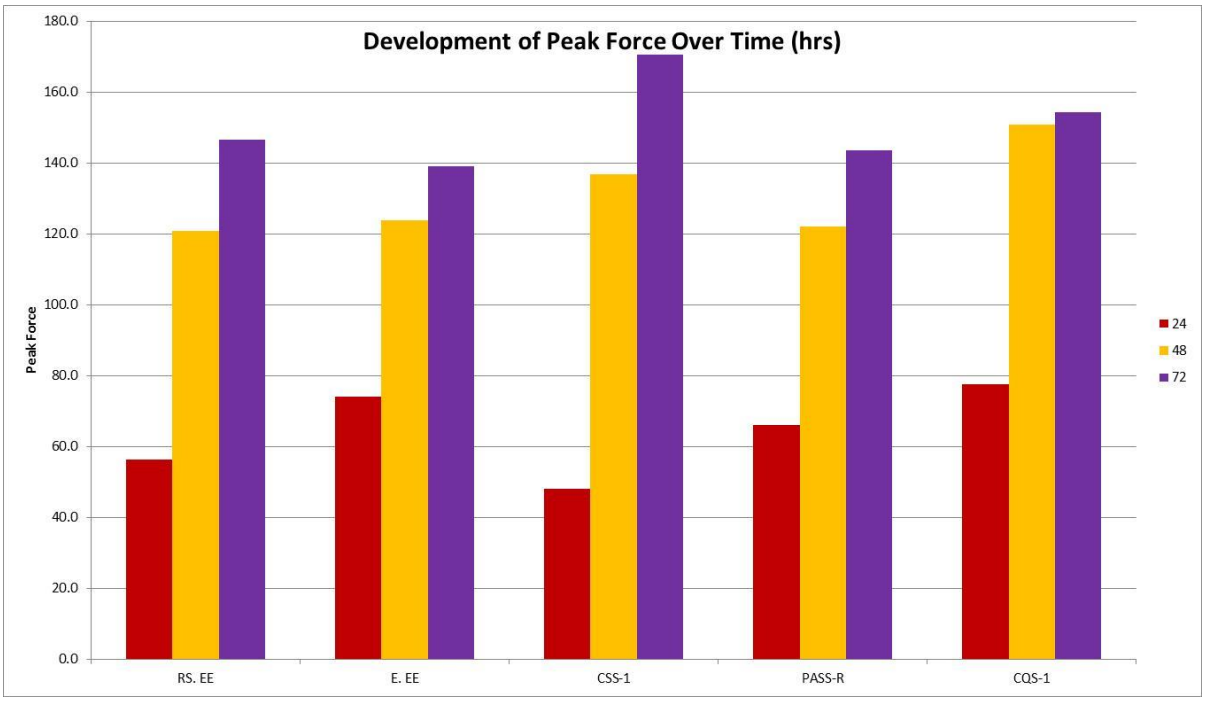


Figure 34: SCB Development of Peak Force over Time

All of the emulsions gain strength over time. The engineered emulsions start high indicating rapid strength gain in the first 24 hours. The CQS1 and Pass are similar. The CSS1 is much slower. Good strength is gain is obtained from all emulsions in 48 hours with the CSS1 and the CQS1 producing higher values at this point. The 72 hour result is very near to the base asphalt performance with the CSS1 showing a harder base while all of the others are similar.

4.5.2 DISPLACEMENT AT PEAK FORCE

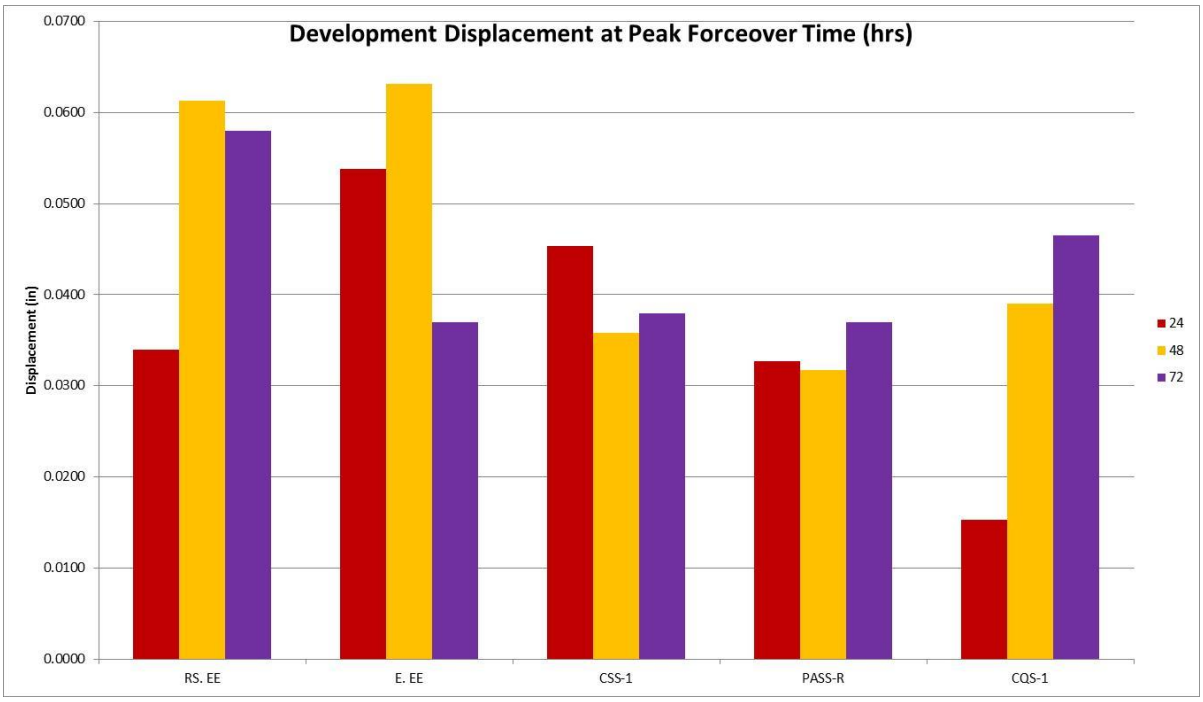


Figure 35: SCB Development of Displacement at Peak Force over Time

Low displacement at peak force is an indication of brittleness or if coupled with low strength, an indication of crack susceptibility. The two engineered emulsions show similar development of ductile strength but the base binders are dissimilar. The CSS1, PassR and CQS all show limited ductility with passing time as compared to the engineered emulsion.

4.5.3 Area within the Peak Force vs Displacement at Peak Force Triangle

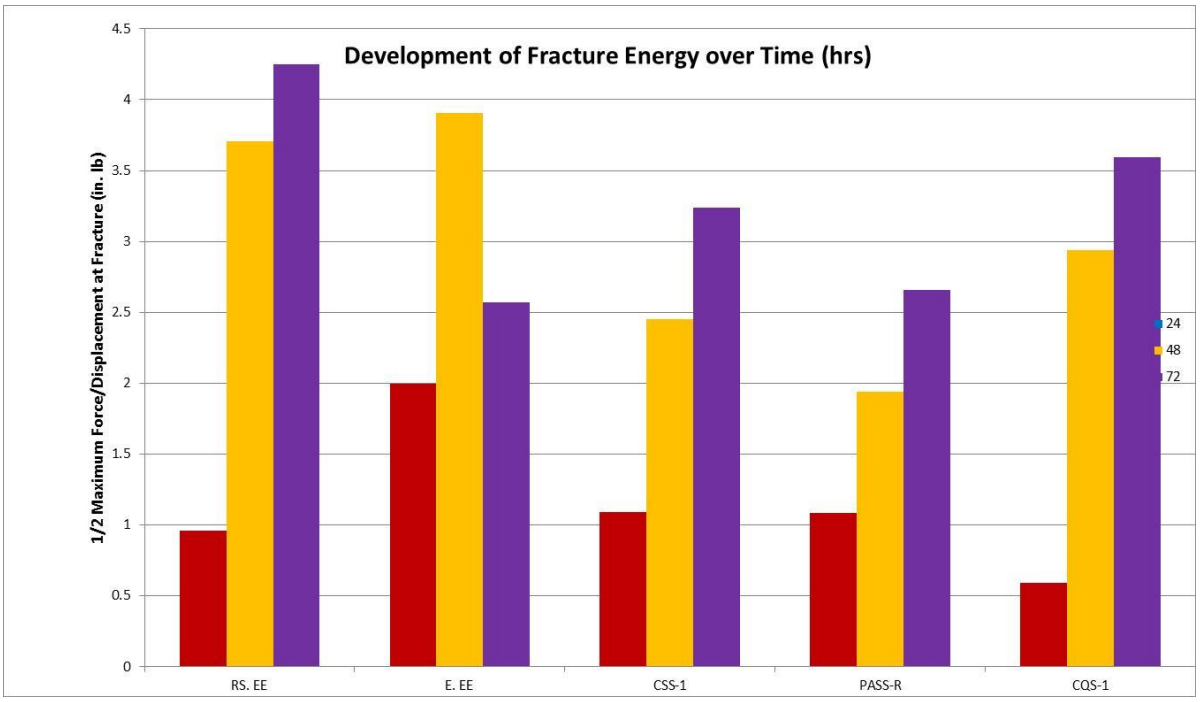


Figure 36: SCB: Development of Area-within-the-Peak-Force vs Displacement-at-Peak-Force Triangle over Time

All of the emulsions exhibit similar but low areas under the force/displacement curve. This indicates low fracture energy early in the mixes' life. Most emulsions exhibit a growing fracture energy over time.

4.5.4 Observations:

All emulsions grow in strength over time. Each is formulated to increase viscosity at a predictable rate. The SCB test has shown an ability to rank emulsion based mixes for intermediate and long term fracture toughness (maximum force) and fracture energy (area under the force/displacement curve). The meaning of the results has yet to be determined.

4.6 Data Forced Cone Penetration

Note that all three emulsions exhibit demulsification onset after 20 minutes. As water is released, viscosity rises and then declines. This decline lasts until 30 to 45 minutes have passed

and then all three emulsions exhibit a sharp increase in viscosity. The EEE and the RSEE indicate a greater percent rise than the ESS1 at the end of 3 hours. This higher viscosity change persists thereafter. It is clear that these are not absolute values. Beginning viscosity is very different in each emulsion. This will be the case when the beginning moisture is different. It has been observed that if evaporation is allowed, break time is reduced and the rate of viscosity gain is increased.

It appears that thresholds can be set for separating CMS, ESCIRE and CSS emulsions. Initial demulsification should result in no more than 30% increase in viscosity at the 30 minute mark and should exhibit an increase greater than 50% at the 3 hour mark.

4.7 Summary

A clear demonstration to RAP densification sensitivity to temperature and gradation has been accomplished. This will lead to the ability to tabulate density targets in mix design. A new test has been developed to measure the rate of demulsification for various emulsion types. This will lead to timing compaction as well as to qualifying asphalt emulsions for use in CIR.

5.0 CONCLUSIONS

5.1 Summary

CIR has proven to be a useful, economical tool in the pavement preservation toolbox. The number of successful projects has been tainted by a few unsuccessful applications. Several issues have come to light during field observation highlighting deficiencies in the current mix design process. Questions regarding density targets, emulsion content gradation control and proper compaction timing are the objects of this research.

5.2 Findings

New understandings of temperature sensitivity and gradation effects on compaction have been gained through the use of Proctor, Marshall and SGC testing. A new test has been developed for evaluating the demulsification of ESCRE as well as other proposed CIR emulsions.

5.2.1 Findings Modified Proctor

The materials in use are relatively gap-graded, non-plastic materials. Most of the moisture is held on the particles passing the #8 screen. When these particles reach optimum moisture, compaction ceases. Shortly thereafter, moisture pours into the larger voids and drains from the aggregate structure. A moisture source with higher viscosity (asphalt emulsion) may be made to hang in the larger voids but under modified Proctor compaction energies at room temperatures, density falls off after the fines reach near saturation. These are the compaction conditions used in the existing mix design procedure and are now known to be variable with temperature.

5.2.2 Findings Modified Marshall Stability

While there does appear to be the potential to perform binder differentiation, the potential would have to be evaluated for variability and sensitivity of results affected by both the timing and temperature and the window for differentiation appears small. Differences in the emulsion

were present at lower temperatures, temperatures that are at the low end of the typical operating spectrum of CIR placement.

Temperatures above 80° F appear to be significantly influenced by the temperature sensitivity of the RAP. The rate of curing of the emulsion is an important factor in the development of strength in the mix however, in addition to temperature and time, other phases of this research have shown that the influence of fines and moisture content, and thereby film-thickness has a very large impact on the curing rate of the mix. This characteristic is discussed later. As part of that discussion, it is noted that the overall compactability of the CIR mix is best performed above 80° F.

5.2.3 Findings Superpave Gyratory Compactor

Compactability of RAP is not confined to gradation at room temperature. It is a much more complex issue that changes with base RAP binder and temperature. Since gradation is affected by mill speed which is also affected by temperature, understanding compaction sensitivity to these factors is essential.

The RAP sources used in Utah are made from similar base binder. They all react to temperature in the same way given an offset for aging and original binder stiffness. The various RAPs compact along a line with an 18% slope as temperatures rise between 80° F and 120° F. Below 80° F they behave like an unbound material with discrete particles. Above 120° F the original aggregate structure begins to shape the outcome. The density at 60° F is different for each RAP source and is dependent on the gradation and binder stiffness at this temperature.

A table can now be developed to relate temperature and gradation to target density at the time of compaction. With the aid of a temperature dependent rate-of-demulsification test, target densities can now be determined.

5.2.4 Findings Semi-Circular Bending Test

Although there is a great deal of discussion regarding the SCB test, CIR seems to be weak and brittle enough in cracking to produce a reasonably linear crack response. Differences between emulsion types, curing time and curing temperature can be observed. It is unknown at

this time whether high fracture toughness and fracture energy is desirable or whether these properties should be limited to a maximum value in a base isolation interlayer. These issues will be resolved with further study.

5.2.5 FINDINGS FORCED CONE PENETRATION TEST

Moisture is held in the RAP gradations according to the fines available. Moisture, including emulsion drains out of the system when the fines become supersaturated. 95% or more of the moisture required for mix supersaturation is contained on the minus #8 screen material while 50% of the moisture is held by the minus #30 fines. The fines must be supersaturated to prevent flash demulsification and a moisture sweep needs to be run above the point of supersaturation to determine whether excess moisture can be used to slow the break. The forced cone penetration test in the configuration proposed can, if sufficiently controlled, differentiate between CSS and ESCIRE emulsions. Experimental thresholds have been set. It is not yet known how the temperature sensitive void space and the supersaturation requirement work together to produce a successful mix.

6.0 RECOMMENDATIONS AND IMPLEMENTATION

6.1 Recommendations

Three outcomes from this research are valuable to the specifier.

1. A tabulation can be developed in mix design which will target emulsion content at any temperature and gradation.

2. A tabulation can be developed so that a density target can be set for any temperature, gradation and RAP source.

3. Emulsions can be evaluated for suitability for use in CIR construction.

6.2 Implementation Plan

Specifications need to be modified to provide for the use of these tools.

REFERENCES

Biligiri, K.P., Said, S., Hakim, H, 2012 “Mixtures’ Crack Propagation Assessment using Semi-Circular Bending Tests” International Journal of Pavement Research Technology

APPENDIX A: Utah Test UT-01-14 Qualifying Engineered Solventless Cold-In-Place Recycling Emulsions (ESCIRE)

Purpose: This test is to determine the rate of demulsibility of an ESCIRE in the presence of water, RAP fines, Hydrated Lime, Constant temperature and vibration. The test will determine viscosity change in the mortar fraction of a RAP mixture over time.

Apparatus: The test requires a vertical press with an adjustable speed control allowing for 0.5 ± 0.05 inches per minute and a load cell with a span of no greater than 200 pounds. A reporting accuracy of 0.1 pound must be provided. The press must have position control with accuracy within 0.01 inch. The data recording device must be capable of recording at a minimum of 50 points per second and must report these points in a form which may be graphed. Use a test head which is 3/4 inches in diameter and 7/8 inches tall with a 90 degree cone coming to an acute tip. The surface of the cone will be finished with a 1000 grit sandpaper with all finish marks being concentric to the axis. Control temperature with an incubator with temperature control to within 1°F. of the target in the range of 60 to 150°F. Vibrate the sample on a vibratory table producing 60 hz. at an amplitude of 0.125 inches.

Figure 37: Test Head

A cup to contain the sample must be correctly sized to reduce interaction between the test head and the sidewalls. A cup at least 2 inches in diameter and 1.75 inches deep is required. A tight fitting lid is required to reduce moisture loss.

Figure 38: Sample Cup

Sample Preparation: Select a test temperature. Samples may be qualified at 80, 100, 120 or 140°F depending on the temperature that processing is expected. Bring all parts of the test sample to test temperature in the incubator. Include mixing tools and sample containers. For the sample cup shown, obtain 900 grams of minus #30 RAP from the proposed project. Obtain 13.5g lime and at least 400g potable water. 258g of emulsion will be added after wetting the aggregate.

Thoroughly mix the RAP and lime with 300g of water. Vibrate the mix for 15 seconds and watch for liquefaction. Increase water content in 10g increments. Mix and vibrate at each increment. Stop when the mortar liquefies. Add 258g emulsion and mix until evenly distributed in the mortar. Consistency should be like a milkshake and should self-level. Spoon the mortar into the sample cups so that each cup contains 80 ± 0.5g. Cap each sample and vibrate for 15 ± 1 seconds on the vibratory table. Return the samples to the incubator. Increase these weights proportional to the chosen sample container.

Test Procedure: Tests will be run at 10, 20, 30, 45 minutes, 1, 2, 3, 4, 6 and 24 hours. Uncover the sample and place in the test apparatus within one minute of the target time up to one hour and within 5 minutes of the target time after one hour. Gently remove any water from the surface of the sample with a towel. Do not disturb the surface of the mortar. Bring the tip of the test head into contact with the surface of the mortar without penetration. This is the beginning displacement. Press the cone into the mortar at the rate of 0.5 in/min to a depth of 1 inch. Remove the test head from the sample. Clean the head with acetone.

Reporting:

Emulsion Mfgr.

Emulsion Label

Test Technician and Lab

Manufacturer of press and controls system

Date of sample preparation

Time at beginning of each test

Test Temperature

Maximum force required to penetrate 1 inch into the sample at each test time

Graph of maximum force vs time

Graph of % change in force vs time

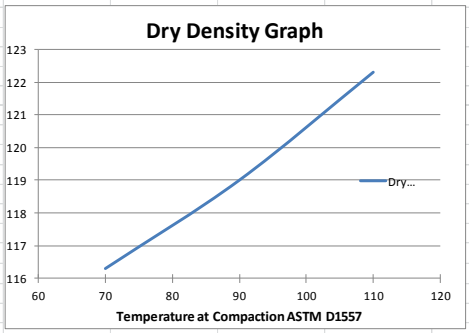
APPENDIX B: MODIFIED PROCTOR

The Data obtained from the experimental plan using the Modified Proctor is presented here.

RAP Proctor Densities

Project	Bluffdale QA	Date	7/2/2014
Project #	126	Sample location	2700 West on West side of Road at approximately 14000 South- Stockpile
Test	ASTM D 1557		

Date	Samples	Wt. RAP Total	Wt. Water	Water %	Temp	Temp after test	Wet density	Dry Density
7/1/2014	A	6499.3	261	4.0	70	68	120.9	116.3
7/1/2014	B	6499.3	259.8	4.0	90	86	123.8	119
7/1/2014	C	6499.7	261.7	4.0	110	106.3	127.2	122.3



ASTM D1557 US 40 Coarse RAP

Sample	2%	4%	6%	8%	10%
Mold + Soil (g)	10301.0	10448.1	10529.1	10588.9	10433.0
Mold (g)	6393.9	6411.7	6393.9	6411.7	6393.9
Wet RAP (g)	3907.1	4036.4	4135.2	4177.2	4039.1
Wet RAP (lbs)	8.61	8.90	9.12	9.21	8.90
Mold Vol (ft^3)	0.075	0.075	0.075	0.075	0.075
Wet Den(lbs/ft^3)	114.8	118.6	121.6	122.8	118.7
Dry Den(lbs/ft^3)	112.6	114.1	114.7	113.7	107.9

ASTM D1557 US 40 Medium RAP

Sample	2%	4%	6%	8%	10%
Mold + Soil (g)	10433.4	10664.9	10735.3	10903.0	10933.8
Mold (g)	6393.9	6411.7	6393.9	6411.7	6393.9
Wet RAP (g)	4039.5	4253.2	4341.4	4491.3	4539.9
Wet RAP (lbs)	8.91	9.38	9.57	9.90	10.01
Mold Vol (ft^3)	0.075	0.075	0.075	0.075	0.075
Wet Den(lbs/ft^3)	118.7	125.0	127.6	132.0	133.4
Dry Den(lbs/ft^3)	116.4	120.2	120.4	122.2	121.3

Temperature and Max dry Density

65-75	75-85	85-95	95-105	105-115	
116.3	117.6	119	120.6	122.3	Max Dens.

APPENDIX C: DATA FOR MARSHALL STABILITY

The Data obtained from the experimental plan using the Modified Marshall Stability is presented here.

CIR Phase 3 Vary Temperature Worksheet

RAP is from I-84 CIR train with lime already on the RAP	**Target amounts**	**Target Percentages**	**Emulsions**
	3250 Grams of RAP	90-95 mm	Road Science Reflex (RS)
50 Gyrations to compact	58.5 grams emulsion	1.80%	Ergon CSS-1 (CS)
	140.8 grams water	5.50%	Western Emulsons PASS-R (PS)

Sample#	Temperature	Wt. RAP w/ Lime	Wt. Emulsion	Wt. Water	Time of Mix	Wt. before comp.	Gyrations	Wt. after comp.	Ht.-Puck	Time of Comp	Time of Stability	Elapsed time	Stability	Stab. (lbs)	Wt. at Stab.	Emuls
121812RSA	120	3246.2	58.4	141.2	6:26	3424.2	50	3341.7	84.1	8:24	16:32	8:08	170	1994	3302.9	RS
121812RSB	120	3245.6	59.2	140.1	6:38	3424.6	50	3344	85.2	8:38	16:40	8:02	151	1771	3310.7	RS
121812RSC	120	3245.5	59	140.9	6:57	3423.4	50	3345	84.1	8:56	16:57	8:01	163	1912	3306.7	RS
121812CSA	120	3245	58.3	140.9	7:11	3423.3	50	3344	83.7	9:10	17:10	8:00	165	1935	3306.6	RS
121812CSB	120	3246.1	58.9	141.1	7:26	3427.7	50	3342.3	83.5	9:24	17:27	8:03	169	1982	3310.9	RS
121812CSC	120	3245.2	59.2	141.2	7:38	3425.3	50	3347.2	83.8	9:36	17:37	8:01	164	1924	3308.5	RS
121912RSA	100	3247	58.5	140.9	6:15	3426	50	3367.8	87.7	8:18	16:16	7:58	255	2991	3310.1	RS
121912RSB	100	3247.1	59.1	140.7	6:28	3431.2	50	3369.2	87.4	8:29	16:27	7:58	249	2921	3310.2	RS
121912RSC	100	3245.8	59.1	140.9	6:40	3431.4	50	3369.4	87.7	8:41	16:41	8:00	245	2874	3308.6	RS
121912CSA	100	3247.5	58.1	141	6:55	3433	50	3369.8	86.3	8:54	16:55	8:01	251	2944	3315	RS
121912CSB	100	3246.4	58.9	140.2	7:08	3432.9	50	3371.4	87	9:01	17:09	8:08	243	2850	3314.3	RS
121912CSC	100	3246.5	58.9	140.7	7:19	3433.6	50	3368.6	83.3	9:20	17:18	7:58	247	2897	3313.6	CS
122012RSA	80	3247.1	58.6	141.2	620	3431.2	50	3388.4	90.3	8:20	16:20	8:00	365	4281	3312.6	CS
122012RSB	80	3247.7	58.5	140.6	6:32	3434.1	50	3393.5	89.8	8:32	16:33	8:01	370	4340	3313	CS
122012RSC	80	3246.7	58.8	140.9	6:44	3437.2	50	3392.6	90.3	8:45	16:44	7:59	362	4246	3308.7	CS
122012CSA	80	3247.2	58.5	140.7	6:57	3433.3	50	3401.8	89.8	8:56	16:55	7:59	334	3918	3322.8	CS
122012CSB	80	3247.1	59.1	140.6	7:10	3437.1	50	3400.9	89.9	9:09	17:09	8:00	315	3695	3322.7	CS
122012CSC	80	3247.3	58.7	140.8	7:21	3435.7	50	3399.5	90.1	9:20	17:21	8:01	333	3906	3320.3	CS
122712RSA	62	3249.1	58.3	141.2	6:33	3438.4	50	3416.2	96.9	8:33	16:33	8:00	323	3789	3406.4	CS
122712RSB	62	3243.3	57.9	141.4	6:51	3430	50	3415.8	94.9	8:52	16:51	7:59	368	4317	3405.8	CS
122712CSA	62	3248.9	58.7	140.8	7:03	3440	50	3433.6	95.2	9:04	17:03	7:59	275	3226	3423.6	CS
122712CSB	62	3249.6	58.3	141	7:15	3441.2	50	3433.3	95.4	9:16	17:17	8:01	255	2991	3422.8	CS
122712CSC	62	3249.8	60.1	141.2	7:27	3444.5	50	3437.5	95.1	9:27	17:26	7:59	288	3378	3425.8	CS
012213RSA	120	3245.6	57.7	141.3	7:39	3414.2	18	3361.6	90.2	10:53	18:55	8:02	870	10205	3332.1	PM
012213RSB	120	3245.6	58.3	140.8	7:48	3422.4	14	3363.5	90.3	10:59	19:10	8:11	870	10205	3333.8	PM
012213RSC	120	3245.3	58.9	141.2	7:58	3426.5	14	3367.3	90.2	11:05	19:25	8:20	870	10205	3336.7	PM
012413PMA	80	3248.9	56.6	141	10:38	3429.8	59	3372.5	90	12:45	16:45	4:00	255	2991.15	3317	PM
012413PMB	80	3249.6	58.7	141.5	10:46	3440.2	50	3379.1	90.1	12:53	16:56	4:03	245	2873.85	3325.1	PM
012413PMC	80	3249	58.3	141.6	10:56	3434.1	52	3373.6	90.1	13:01	17:01	4:00	257	3014.61	3323.5	PM
012413CQA	80	3249.1	57.5	141.4	11:05	3438.2	72	3386.8	90.1	13:07	17:08	4:01	404	4738.92	3319.5	CQ
012413CQB	80	3248.4	58.6	140.8	11:13	3441.1	75	3387.8	90.1	13:14	17:15	4:01	402	4715.46	3319.4	CQ
012413CQC	80	3248.7	58.4	140.5	11:21	3438.6	67	3376	90.1	13:20	17:21	4:01	374	4387.02	3307.7	CQ
012413PAA	80	3245.8	57.5	141.5	11:30	3432.6	67	3395.3	90.1	13:27	17:27	4:00	375	4398.75	3320.1	CQ
012413PAB	80	3249.2	58.8	140.6	11:38	3439	68	3406.6	90.1	13:34	17:34	4:00	410	4809.3	3330.3	CQ
012413PAC	80	3249	59.3	140.8	11:52	3439.8	61	3407.4	90	13:45	17:46	4:01	402	4715.46	3343	CQ
013013PMA	60	3246.7	57.4	140.4	9:18	3436.1	191	3374.5	90	11:18	15:40	4:22	385	4516.05	3363.1	PA
013013PMB	60	3249.9	58.2	140.7	9:26	3450	141	3376.6	90	11:30	15:46	4:16	388	4551.24	3369.2	PA
013013PMC	60	3246.8	58.4	140.5	9:34	3438.4	170	3377.5	90	11:39	15:49	4:10	392	4598.16	3363.6	PA
013013CQA	60	3246.7	47.5	140.9	9:48	3432.3	188	3389.8	90	11:50	15:55	4:05	510	5982.3	3383.2	PA
013013CQB	60	3249.7	58	141.2	9:56	3445	176	3402.8	90	11:59	16:00	4:01	485	5689.05	3401.9	PA
013013CQC	60	3249.6	58.9	141.1	10:04	3445.6	168	3405.2	90	12:09	16:09	4:00	493	5782.89	3404.6	PA
013013PAA	60	3250.3	57.6	140.3	10:14	3440.4	134	3400.1	90	12:18	16:19	4:01	452	5301.96	3397.6	PA
013013PAB	60	3249.8	58.5	140.3	10:22	3443.3	147	3395.5	90	12:26	16:25	3:59	442	5184.66	3391.4	PA
013013PAC	60	3249.4	58.5	140.6	10:30	3443.7	142	3403.1	90	12:35	16:32	3:57	428	5020.44	3400.1	RS
040913SSA	100	3247.5	58.8	140.5	10:15	3430.1	41	3385.4	90	12:28	16:25	3:57	304	3565.92		
040913SSB	100	3247.8	58.9	140.9	10:23	3436.2	42	3391.6	90	12:36	16:30	3:54	338	3964.74		
040913SSC	80	3247.4	58.7	141.1	10:31	3436.6	84	3393.5	90	12:42	16:35	3:53	501	5876.73		
040913SSD	80	3248	58.6	140.8	10:38	3442.8	85	3396.9	90	12:49	16:39	3:50	490	5747.7		

Table 7: Stability with Varying Temperature

Sample#	Temperature	Wt. RAP w/ Lime	Wt. Emulsion	Wt. Water	Time of Mix	Wt. before comp.	Gyrations	Wt. after comp.	Ht.-Puck	Time of Comp	Time of Stability	Elapsed time	Stability	Stab. (lbs)	Weight at stab.	Emulsion
122012RSA	80	3247.1	58.6	141.2	620	3431.2	50	3388.4	90.3	8:20	16:20	8:00	365	4281	3312.6	RS
122012RSB	80	3247.7	58.5	140.6	6:32	3434.1	50	3393.5	89.8	8:32	16:33	8:01	370	4340	3313	RS
122012RSC	80	3246.7	58.8	140.9	6:44	3437.2	50	3392.6	90.3	8:45	16:44	7:59	362	4246	3308.7	RS
122012CSA	80	3247.2	58.5	140.7	6:57	3433.3	50	3401.8	89.8	8:56	16:55	7:59	334	3918	3322.8	RS
122012CSB	80	3247.1	59.1	140.6	7:10	3437.1	50	3400.9	89.9	9:09	17:09	8:00	315	3695	3322.7	RS
122012CSC	80	3247.3	58.7	140.8	7:21	3435.7	50	3399.5	90.1	9:20	17:21	8:01	333	3906	3320.3	RS
012213RSA	120	3245.6	57.7	141.3	7:39	3414.2	18	3361.6	90.2	10:53	18:55	8:02	870	10205	3332.1	RS
012213RSB	120	3245.6	58.3	140.8	7:48	3422.4	14	3363.5	90.3	10:59	19:10	8:11	870	10205	3333.8	RS
012213RSC	120	3245.3	58.9	141.2	7:58	3426.5	14	3367.3	90.2	11:05	19:25	8:20	870	10205	3336.7	RS
012413PMA	80	3248.9	56.6	141	10:38	3429.8	59	3372.5	90	12:45	16:45	4:00	255	2991.15	3317	CS
012413PMB	80	3249.6	58.7	141.5	10:46	3440.2	50	3379.1	90.1	12:53	16:56	4:03	245	2873.85	3325.1	CS
012413PMC	80	3249	58.3	141.6	10:56	3434.1	52	3373.6	90.1	13:01	17:01	4:00	257	3014.61	3323.5	CS
012413CQA	80	3249.1	57.5	141.4	11:05	3438.2	72	3386.8	90.1	13:07	17:08	4:01	404	4738.92	3319.5	CS
012413CQB	80	3248.4	58.6	140.8	11:13	3441.1	75	3387.8	90.1	13:14	17:15	4:01	402	4715.46	3319.4	CS
012413CQC	80	3248.7	58.4	140.5	11:21	3438.6	67	3376	90.1	13:20	17:21	4:01	374	4387.02	3307.7	CS
012413PAA	80	3245.8	57.5	141.5	11:30	3432.6	67	3395.3	90.1	13:27	17:27	4:00	375	4398.75	3320.1	CS
012413PAB	80	3249.2	58.8	140.6	11:38	3439	68	3406.6	90.1	13:34	17:34	4:00	410	4809.3	3330.3	CS
012413PAC	80	3249	59.3	140.8	11:52	3439.8	61	3407.4	90	13:45	17:46	4:01	402	4715.46	3343	CS
010313CSD	80	3247.7	58.2	140.6	9:53	3435.9	50	3402.4	90.5	11:53	15:53	4:00	331	3883	3329.5	PM
010313CSE	80	3247.4	58.2	141.2	10:03	3436.1	50	3397.1	89.8	12:02	16:02	4:00	333	3906	3323.9	PM
010313CSF	80	3248.7	58.4	141.0	10:13	3440.8	50	3404.3	89.9	12:15	16:15	4:00	315	3695	3327.3	PM
010913RSA	80	3248	60.3	140.8	7:20	3435.5	85	3385.2	90.0	9:18	19:18	10:00	361	4235	3312.8	PM
010913RSB	80	3247.4	59.4	140.2	7:30	3438.8	75	3387.4	90.0	9:30	19:32	10:02	349	4094	3313.1	PM
010913RSC	80	3248.1	58.9	141	7:38	3438.9	75	3388.9	90.0	9:39	19:40	10:01	352	4129	3314.5	PM
010913CSA	80	3247.4	58.8	140.6	7:47	3432.1	63	3392.7	90.0	9:45	19:47	10:02	300	3519	3306.9	CQ
010913CSB	80	3247.3	58.9	140.6	7:55	3438.4	63	3395.8	90.0	9:55	19:55	10:00	321	3765	3315.2	CQ
010913CSC	80	3247.2	58.6	140.4	8:03	3436.8	65	3395.0	90.0	10:04	20:03	9:59	323	3789	3314.5	CQ
010913RSD	80	3250.1	59.1	141.8	2:22	3434.4	64	3387.0	90.0	16:25	18:24	1:59	456	5349	3337.4	CQ
010913RSE	80	3249.4	59.7	140.7	2:33	3440.0	57	3392.0	90.0	16:34	18:34	2:00	471	5525	3335.1	CQ
010913RSF	80	3249.6	58.9	141.7	2:38	3441.7	65	3394.3	90.0	16:42	18:42	2:00	496	5818	3349.1	CQ
010913CSD	80	3248.5	58.2	140.9	2:45	3438.1	64	3393.9	90.0	16:49	18:48	1:59	435	5103	3354.0	PA
010913CSE	80	3249.4	58.5	140.8	2:53	3442.6	63	3400.6	90.0	16:55	18:57	2:02	438	5138	3361.0	PA
010913CSF	80	3250.2	58.8	140.9	3:00	3442.0	66	3398.2	90.0	17:02	19:03	2:01	455	5337	3357.7	PA

Table 8: Stability with Varying Time

APPENDIX D: SUPERPAVE GYRATORY COMPACTOR

The Data obtained from the experimental plan using the SGC is presented here.

Combined 60°F																		
US 40						SR-32						Southern Parkway						
Med			Coarse			Med			Coarse			Med			Coarse			
1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
109.3	111.3	112.7	115.6	115.4	114.8	114.7	115.4	114.8	119.6	120.7	120.7	117.1	116.8	115.6	117.4	119.6	120.2	
106.2	108.6	109.5	112.8	112.2	112.0	111.9	112.2	112.0	116.8	117.8	117.8	113.9	113.8	112.9	114.7	117.0	117.8	
104.3	106.1	107.4	110.0	110.0	109.3	109.2	110.0	109.3	114.2	115.3	114.8	111.4	111.4	110.1	111.8	113.9	114.5	
102.9	104.6	105.9	108.3	108.4	107.7	107.6	108.4	107.7	112.0	113.1	113.0	109.6	109.6	108.4	110.1	112.0	112.6	
101.8	103.5	104.7	107.0	107.2	106.5	106.3	107.2	106.5	110.6	111.7	111.6	108.3	108.3	107.0	108.7	110.5	111.1	
100.9	102.5	103.7	105.9	106.2	105.5	105.3	106.2	105.5	109.4	110.5	110.4	107.1	107.2	105.9	107.6	109.3	109.9	
100.1	101.7	102.9	105.0	105.3	104.7	104.4	105.3	104.7	108.5	109.6	109.4	106.1	106.2	105.0	106.6	108.3	108.8	
99.5	101.0	102.2	104.2	104.6	103.9	103.7	104.6	103.9	107.6	108.7	108.6	105.3	105.4	104.2	105.7	107.4	108.0	
98.8	100.4	101.6	103.5	103.9	103.3	103.0	103.9	103.3	106.9	107.9	107.8	104.6	104.7	103.5	105.0	106.6	107.2	
98.3	99.9	100.9	102.8	103.3	102.7	102.4	103.3	102.7	106.2	107.3	107.1	103.9	104.0	102.9	104.3	105.9	106.5	
97.9	99.3	100.5	102.2	102.8	102.2	101.9	102.8	102.2	105.6	106.6	106.5	103.3	103.4	102.3	103.7	105.2	105.8	
97.4	98.9	100.0	101.7	102.3	101.7	101.4	102.3	101.7	105.1	106.1	105.9	102.8	102.9	101.7	103.2	104.6	105.2	
97.1	98.5	99.6	101.2	101.9	101.2	101.0	101.9	101.2	104.5	105.6	105.4	102.3	102.5	101.3	102.7	104.1	104.7	
96.7	98.1	99.2	100.8	101.4	100.8	100.6	101.4	100.8	104.1	105.1	104.9	101.9	102.0	100.9	102.2	103.6	104.2	
96.4	97.8	98.8	100.4	101.1	100.5	100.2	101.1	100.5	103.6	104.7	104.5	101.4	101.6	100.5	101.8	103.2	103.8	
96.1	97.5	98.5	100.0	100.7	100.1	99.8	100.7	100.1	103.2	104.2	104.0	101.1	101.3	100.1	101.4	102.7	103.4	
95.8	97.1	98.2	99.7	100.4	99.8	99.5	100.4	99.8	102.8	103.9	103.7	100.7	100.9	99.8	101.1	102.4	103.0	
95.5	96.9	97.9	99.3	100.1	99.5	99.2	100.1	99.5	102.5	103.5	103.3	100.4	100.6	99.4	100.7	102.0	102.6	
95.2	96.6	97.7	99.0	99.8	99.2	98.9	99.8	99.2	102.2	103.2	102.9	100.0	100.2	99.1	100.4	101.6	102.3	
95.0	96.4	97.4	98.7	99.5	98.9	98.6	99.5	98.9	101.9	102.8	102.6	99.7	99.9	98.8	100.1	101.3	101.9	
94.8	96.1	97.1	98.4	99.3	98.7	98.4	99.3	98.7	101.6	102.5	102.3	99.4	99.7	98.5	99.8	101.0	101.6	
94.6	95.9	96.9	98.2	99.0	98.5	98.1	99.0	98.5	101.3	102.3	102.0	99.2	99.4	98.3	99.5	100.7	101.3	
94.3	95.7	96.7	97.9	98.8	98.2	97.9	98.8	98.2	101.0	102.0	101.7	98.9	99.1	98.0	99.2	100.4	101.0	
94.2	95.5	96.5	97.7	98.6	98.0	97.7	98.6	98.0	100.7	101.7	101.5	98.7	98.9	97.8	99.0	100.1	100.8	
94.0	95.3	96.3	97.4	98.4	97.8	97.5	98.4	97.8	100.5	101.5	101.2	98.5	98.7	97.6	98.8	99.9	100.5	
93.8	95.1	96.1	97.2	98.2	97.6	97.3	98.2	97.6	100.2	101.2	101.0	98.2	98.4	97.4	98.5	99.6	100.3	
93.6	94.9	95.9	97.0	98.0	97.4	97.1	98.0	97.4	100.0	101.0	100.7	98.0	98.2	97.2	98.3	99.4	100.0	
93.4	94.7	95.7	96.8	97.8	97.2	96.9	97.8	97.2	99.8	100.8	100.5	97.8	98.0	97.0	98.1	99.2	99.8	
93.3	94.6	95.6	96.6	97.6	97.0	96.7	97.6	97.0	99.6	100.6	100.3	97.6	97.8	96.8	97.9	99.0	99.6	
93.1	94.4	95.4	96.4	97.4	96.8	96.5	97.4	96.8	99.4	100.4	100.1	97.4	97.6	96.6	97.7	98.7	99.4	
93.0	94.3	95.2	96.2	97.3	96.7	96.4	97.3	96.7	99.2	100.2	99.9	97.2	97.4	96.4	97.5	98.5	99.2	
92.8	94.1	95.1	96.1	97.1	96.6	96.2	97.1	96.6	99.0	100.0	99.7	97.0	97.3	96.3	97.3	98.4	99.0	
92.7	94.0	94.9	95.9	96.9	96.4	96.1	96.9	96.4	98.8	99.8	99.5	96.8	97.1	96.1	97.1	98.1	98.8	
92.5	93.9	94.8	95.7	96.8	96.3	95.9	96.8	96.3	98.7	99.6	99.3	96.7	96.9	95.9	97.0	98.0	98.6	
92.4	93.7	94.7	95.6	96.6	96.1	95.8	96.6	96.1	98.5	99.4	99.1	96.5	96.7	95.8	96.8	97.8	98.4	
92.3	93.6	94.5	95.4	96.5	96.0	95.6	96.5	96.0	98.3	99.3	99.0	96.3	96.6	95.6	96.7	97.6	98.2	
92.2	93.4	94.4	95.3	96.4	95.8	95.5	96.4	95.8	98.2	99.1	98.8	96.2	96.4	95.5	96.5	97.4	98.1	
92.1	93.3	94.3	95.1	96.3	95.7	95.4	96.3	95.7	98.0	98.9	98.7	96.1	96.3	95.3	96.3	97.3	97.9	
91.9	93.2	94.2	95.0	96.1	95.6	95.2	96.1	95.6	97.8	98.8	98.5	95.9	96.1	95.2	96.2	97.1	97.7	
91.8	93.1	94.0	94.8	96.0	95.4	95.1	96.0	95.4	97.7	98.6	98.3	95.8	96.0	95.1	96.1	97.0	97.6	
91.7	93.0	93.9	94.7	95.9	95.3	95.0	95.9	95.3	97.5	98.5	98.2	95.6	95.8	94.9	95.9	96.8	97.4	
91.6	92.9	93.8	94.5	95.7	95.2	94.9	95.7	95.2	97.4	98.3	98.1	95.5	95.7	94.8	95.8	96.7	97.3	
91.5	92.8	93.7	94.4	95.6	95.1	94.7	95.6	95.1	97.3	98.2	97.9	95.4	95.6	94.7	95.7	96.6	97.1	
91.4	92.6	93.6	94.3	95.5	95.0	94.6	95.5	95.0	97.2	98.1	97.8	95.2	95.4	94.6	95.5	96.4	97.0	
91.3	92.5	93.5	94.2	95.4	94.9	94.5	95.4	94.9	97.0	97.9	97.6	95.1	95.3	94.5	95.4	96.3	96.8	
91.2	92.4	93.4	94.0	95.3	94.8	94.4	95.3	94.8	96.9	97.8	97.5	95.0	95.2	94.3	95.3	96.2	96.7	
91.1	92.4	93.3	93.9	95.2	94.6	94.3	95.2	94.6	96.8	97.7	97.4	94.9	95.1	94.2	95.2	96.0	96.6	
91.0	92.3	93.2	93.8	95.1	94.6	94.2	95.1	94.6	96.7	97.5	97.3	94.8	95.0	94.1	95.0	95.9	96.5	
90.9	92.2	93.1	93.7	95.0	94.5	94.2	95.0	94.5	96.5	97.4	97.1	94.6	94.9	94.0	94.9	95.8	96.3	
90.8	92.1	93.1	93.6	94.9	94.4	94.0	94.9	94.4	96.4	97.3	97.0	94.5	94.7	93.9	94.8	95.7	96.2	
90.8	92.0	92.9	93.5	94.8	94.3	93.9	94.8	94.3	96.3	97.2	96.9	94.4	94.6	93.8	94.7	95.5	96.1	

Table 9: Compaction at 60°F, Medium and Coarse Gradations

Combined 80°F																		
US 40						SR-32						Southern Parkway						
Med			Coarse			Med			Coarse			Med			Coarse			
1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
108.7	109.4	108.5	112.2	112.3	113.6	112.4	112.4	111.4	117.5	116.8	116.4	112.1	111.9	112.0	114.3	115.4	114.1	
105.8	106.6	105.4	109.5	109.8	110.4	109.8	109.0	108.7	114.6	113.9	113.4	108.9	109.2	109.4	111.8	112.6	111.4	
103.3	104.1	103.4	106.6	107.3	108.0	107.1	106.8	106.5	111.9	111.3	110.8	106.7	106.6	106.8	108.9	110.0	108.9	
101.8	102.6	102.0	104.9	105.2	106.3	105.5	105.3	104.6	109.9	109.1	108.9	105.1	104.9	105.1	107.2	107.8	107.0	
100.6	101.4	100.8	103.5	103.9	105.0	104.3	104.0	103.4	108.2	107.7	107.3	103.8	103.7	103.8	105.8	106.3	105.3	
99.6	100.4	99.9	102.4	102.8	103.8	103.3	103.0	102.4	107.0	106.5	106.2	102.7	102.6	102.7	104.6	105.2	104.2	
98.8	99.6	99.0	101.5	101.8	102.9	102.4	102.1	101.5	106.0	105.5	105.2	101.8	101.7	101.8	103.7	104.1	103.2	
98.1	98.9	98.4	100.7	100.9	102.1	101.6	101.3	100.8	105.1	104.7	104.4	101.0	100.9	101.0	102.8	103.3	102.4	
97.5	98.2	97.7	99.9	100.2	101.3	101.0	100.6	100.2	104.4	103.9	103.6	100.2	100.2	100.3	102.1	102.5	101.6	
96.8	97.7	97.1	99.3	99.6	100.7	100.4	100.0	99.6	103.6	103.2	102.9	99.6	99.6	99.7	101.4	101.9	101.0	
96.3	97.1	96.6	98.7	99.0	100.1	99.8	99.5	99.0	103.0	102.6	102.3	99.0	99.0	99.1	100.8	101.2	100.4	
95.9	96.7	96.2	98.1	98.4	99.5	99.4	99.0	98.6	102.4	102.1	101.8	98.5	98.5	98.6	100.2	100.7	99.8	
95.5	96.2	95.8	97.7	97.9	99.0	98.9	98.5	98.1	101.9	101.6	101.3	98.0	98.0	98.1	99.7	100.2	99.3	
95.1	95.9	95.4	97.2	97.5	98.6	98.5	98.1	97.7	101.4	101.1	100.8	97.6	97.6	97.7	99.2	99.7	98.8	
94.7	95.5	95.0	96.8	97.0	98.1	98.1	97.7	97.4	101.0	100.6	100.4	97.2	97.2	97.3	98.8	99.2	98.4	
94.4	95.2	94.7	96.4	96.6	97.8	97.7	97.4	97.0	100.5	100.2	100.0	96.8	96.8	96.9	98.4	98.8	98.0	
94.1	94.8	94.4	96.1	96.3	97.4	97.4	97.0	96.7	100.1	99.8	99.6	96.4	96.5	96.6	98.0	98.4	97.6	
93.8	94.5	94.2	95.7	95.9	97.0	97.1	96.7	96.4	99.8	99.5	99.2	96.1	96.1	96.3	97.7	98.1	97.3	
93.5	94.3	93.9	95.4	95.6	96.7	96.8	96.4	96.1	99.4	99.1	98.9	95.8	95.9	96.0	97.3	97.7	96.9	
93.3	94.0	93.6	95.2	95.3	96.4	96.5	96.2	95.8	99.1	98.8	98.6	95.5	95.5	95.7	97.0	97.4	96.6	
93.0	93.8	93.4	94.9	95.0	96.1	96.3	95.9	95.6	98.8	98.5	98.3	95.3	95.3	95.4	96.7	97.1	96.3	
92.8	93.5	93.1	94.6	94.8	95.9	96.0	95.7	95.3	98.5	98.2	98.0	95.0	95.0	95.1	96.4	96.8	96.0	
92.6	93.3	92.9	94.3	94.5	95.6	95.8	95.4	95.1	98.2	98.0	97.7	94.7	94.7	94.9	96.1	96.6	95.8	
92.4	93.1	92.7	94.1	94.3	95.3	95.6	95.2	94.9	97.9	97.7	97.5	94.5	94.5	94.7	95.9	96.3	95.5	
92.2	92.9	92.5	93.9	94.0	95.1	95.4	95.0	94.7	97.7	97.4	97.2	94.3	94.3	94.5	95.7	96.0	95.3	
92.0	92.7	92.3	93.6	93.8	94.9	95.2	94.8	94.5	97.4	97.2	97.0	94.1	94.1	94.2	95.4	95.8	95.1	
91.8	92.5	92.2	93.5	93.6	94.7	95.0	94.6	94.3	97.2	97.0	96.8	93.9	93.9	94.0	95.2	95.6	94.9	
91.7	92.3	92.0	93.2	93.4	94.5	94.8	94.4	94.1	97.0	96.8	96.6	93.7	93.7	93.8	95.0	95.4	94.6	
91.5	92.2	91.8	93.1	93.2	94.2	94.6	94.2	93.9	96.7	96.6	96.3	93.5	93.5	93.6	94.8	95.2	94.4	
91.3	92.0	91.7	92.9	93.0	94.0	94.4	94.0	93.8	96.6	96.3	96.1	93.3	93.3	93.5	94.6	95.0	94.2	
91.2	91.8	91.5	92.7	92.8	93.9	94.3	93.9	93.6	96.3	96.1	96.0	93.1	93.1	93.3	94.4	94.8	94.0	
91.0	91.7	91.4	92.5	92.7	93.7	94.1	93.7	93.4	96.1	96.0	95.8	93.0	92.9	93.1	94.2	94.6	93.9	
90.9	91.6	91.2	92.4	92.5	93.5	93.9	93.6	93.3	96.0	95.8	95.6	92.8	92.8	92.9	94.0	94.4	93.7	
90.8	91.4	91.1	92.2	92.4	93.3	93.8	93.4	93.1	95.8	95.6	95.4	92.7	92.6	92.8	93.9	94.2	93.5	
90.6	91.3	91.0	92.1	92.2	93.2	93.6	93.3	93.0	95.6	95.5	95.3	92.5	92.5	92.6	93.7	94.1	93.3	
90.5	91.2	90.8	91.9	92.0	93.0	93.5	93.1	92.9	95.5	95.3	95.1	92.4	92.3	92.5	93.6	93.9	93.2	
90.4	91.0	90.7	91.8	91.9	92.9	93.4	93.0	92.7	95.3	95.1	94.9	92.2	92.2	92.4	93.4	93.8	93.1	
90.3	90.9	90.6	91.6	91.8	92.7	93.2	92.9	92.6	95.1	95.0	94.8	92.1	92.0	92.2	93.2	93.6	92.9	
90.2	90.8	90.5	91.5	91.6	92.6	93.1	92.8	92.5	95.0	94.8	94.7	91.9	91.9	92.1	93.1	93.5	92.8	
90.1	90.7	90.4	91.4	91.5	92.4	93.0	92.6	92.4	94.9	94.7	94.5	91.8	91.8	91.9	93.0	93.3	92.6	
89.9	90.6	90.2	91.3	91.4	92.3	92.9	92.5	92.2	94.7	94.6	94.4	91.7	91.7	91.8	92.8	93.2	92.5	
89.8	90.5	90.2	91.1	91.3	92.2	92.7	92.4	92.1	94.6	94.4	94.3	91.6	91.5	91.7	92.7	93.1	92.4	
89.7	90.4	90.1	91.0	91.2	92.1	92.6	92.3	92.0	94.4	94.3	94.1	91.5	91.4	91.6	92.6	92.9	92.2	
89.6	90.3	90.0	90.9	91.0	91.9	92.5	92.2	91.9	94.3	94.2	94.0	91.4	91.3	91.5	92.4	92.8	92.1	
89.5	90.2	89.9	90.8	90.9	91.8	92.4	92.1	91.8	94.2	94.0	93.9	91.3	91.2	91.4	92.3	92.7	91.9	
89.5	90.1	89.8	90.7	90.8	91.7	92.3	92.0	91.7	94.0	93.9	93.8	91.2	91.1	91.3	92.2	92.6	91.8	
89.4	90.0	89.7	90.6	90.7	91.6	92.2	91.9	91.6	93.9	93.8	93.6	91.0	91.0	91.2	92.1	92.4	91.7	
89.3	89.9	89.6	90.5	90.6	91.5	92.1	91.8	91.5	93.8	93.7	93.5	90.9	90.9	91.0	92.0	92.3	91.6	
89.2	89.8	89.5	90.4	90.5	91.4	92.0	91.7	91.4	93.7	93.6	93.4	90.9	90.8	90.9	91.9	92.2	91.5	
89.1	89.7	89.4	90.3	90.4	91.3	91.9	91.6	91.3	93.6	93.5	93.3	90.8	90.7	90.8	91.8	92.1	91.4	
89.0	89.6	89.3	90.2	90.3	91.2	91.8	91.5	91.3	93.5	93.3	93.2	90.7	90.6	90.8	91.7	92.0	91.3	

Table 10: Compaction at 80°F, Medium and Coarse Gradations

Combined 100°F																		
US 40						SR-32						Southern Parkway						
Med			Coarse			Med			Coarse			Med			Coarse			
1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
105.6	103.9	101.5	106.3	106.7	107.1	106.0	105.6	104.9	110.1	110.1	111.0	105.0	106.1	107.7	111.4	109.1	108.2	
103.0	101.1	98.4	103.3	103.9	103.7	102.9	103.0	102.3	107.2	107.3	107.8	102.1	103.0	104.6	108.4	106.3	105.0	
100.5	99.1	96.5	101.0	101.3	101.4	100.8	100.7	99.9	104.8	104.5	105.4	100.2	100.7	102.6	105.9	103.6	102.9	
98.9	97.4	95.0	99.1	99.7	99.8	99.3	99.2	98.4	103.0	102.8	103.7	98.7	99.1	101.0	104.0	101.9	101.2	
97.7	96.2	93.9	97.8	98.4	98.5	98.0	98.0	97.3	101.4	101.5	102.3	97.5	97.8	99.8	102.6	100.5	99.9	
96.7	95.3	93.0	96.7	97.4	97.4	97.0	97.1	96.4	100.3	100.4	101.2	96.5	96.8	98.8	101.3	99.4	98.8	
95.9	94.5	92.2	95.9	96.5	96.5	96.2	96.3	95.6	99.4	99.5	100.2	95.7	95.9	97.9	100.4	98.5	97.9	
95.2	93.8	91.6	95.1	95.7	95.7	95.5	95.6	94.9	98.6	98.7	99.4	95.0	95.1	97.1	99.5	97.7	97.1	
94.5	93.2	91.0	94.4	95.1	95.0	94.9	94.9	94.3	97.9	98.0	98.7	94.2	94.5	96.4	98.7	97.0	96.4	
94.0	92.6	90.5	93.8	94.5	94.5	94.3	94.4	93.8	97.3	97.4	98.1	93.7	93.8	95.9	98.1	96.3	95.8	
93.5	92.1	90.1	93.2	93.9	93.9	93.8	93.9	93.3	96.7	96.8	97.5	93.2	93.3	95.3	97.4	95.8	95.2	
93.0	91.7	89.6	92.8	93.4	93.4	93.3	93.5	92.8	96.2	96.3	97.0	92.7	92.9	94.8	96.8	95.3	94.6	
92.6	91.3	89.2	92.3	93.0	93.0	92.9	93.1	92.4	95.7	95.9	96.4	92.3	92.5	94.3	96.3	94.7	94.2	
92.2	90.9	88.9	91.9	92.6	92.5	92.5	92.7	92.1	95.3	95.4	96.0	91.9	92.1	93.9	95.9	94.3	93.8	
91.9	90.6	88.6	91.5	92.2	92.2	92.2	92.4	91.7	94.9	95.1	95.6	91.6	91.7	93.6	95.5	93.9	93.4	
91.5	90.3	88.3	91.2	91.8	91.8	91.8	92.0	91.4	94.6	94.7	95.3	91.3	91.4	93.2	95.1	93.6	93.0	
91.3	90.0	88.0	90.9	91.5	91.5	91.5	91.7	91.2	94.2	94.3	94.9	91.0	91.0	92.9	94.7	93.2	92.7	
91.0	89.7	87.8	90.6	91.2	91.2	91.3	91.4	90.9	93.9	94.0	94.6	90.7	90.8	92.6	94.4	92.9	92.3	
90.7	89.4	87.5	90.3	90.9	90.9	91.0	91.2	90.6	93.6	93.7	94.3	90.4	90.5	92.3	94.1	92.6	92.0	
90.5	89.2	87.3	90.0	90.7	90.6	90.7	91.0	90.4	93.3	93.5	94.0	90.2	90.2	92.0	93.8	92.3	91.8	
90.2	89.0	87.1	89.8	90.4	90.4	90.5	90.7	90.2	93.1	93.2	93.8	89.9	90.0	91.8	93.5	92.0	91.5	
90.0	88.8	86.9	89.5	90.2	90.1	90.3	90.5	89.9	92.8	92.9	93.5	89.7	89.7	91.5	93.2	91.8	91.2	
89.8	88.5	86.7	89.3	89.9	89.9	90.1	90.3	89.8	92.6	92.7	93.3	89.5	89.5	91.3	93.0	91.6	91.0	
89.6	88.4	86.6	89.1	89.7	89.7	89.9	90.1	89.6	92.4	92.5	93.0	89.3	89.3	91.1	92.7	91.3	90.8	
89.4	88.2	86.4	88.9	89.5	89.5	89.7	89.9	89.4	92.2	92.2	92.8	89.1	89.1	90.9	92.5	91.1	90.5	
89.2	88.0	86.2	88.7	89.3	89.3	89.5	89.7	89.2	92.0	92.0	92.6	88.9	88.9	90.7	92.3	90.9	90.3	
89.1	87.8	86.1	88.5	89.1	89.1	89.3	89.5	89.0	91.8	91.8	92.4	88.8	88.7	90.5	92.1	90.7	90.1	
88.9	87.7	85.9	88.3	88.9	88.9	89.2	89.4	88.9	91.6	91.7	92.2	88.6	88.6	90.4	91.9	90.5	89.9	
88.7	87.5	85.8	88.1	88.8	88.8	89.0	89.2	88.7	91.4	91.5	92.1	88.4	88.4	90.2	91.7	90.3	89.8	
88.6	87.4	85.6	88.0	88.6	88.6	88.8	89.1	88.6	91.3	91.3	91.9	88.3	88.2	90.0	91.5	90.2	89.6	
88.4	87.2	85.5	87.8	88.4	88.4	88.7	88.9	88.4	91.1	91.2	91.7	88.1	88.1	89.9	91.3	90.0	89.4	
88.3	87.1	85.4	87.7	88.3	88.3	88.5	88.8	88.3	90.9	91.0	91.6	88.0	87.9	89.7	91.1	89.9	89.2	
88.2	87.0	85.3	87.5	88.1	88.1	88.4	88.7	88.2	90.8	90.9	91.4	87.9	87.8	89.6	91.0	89.7	89.1	
88.0	86.8	85.2	87.4	88.0	88.0	88.3	88.5	88.1	90.6	90.7	91.3	87.7	87.7	89.4	90.8	89.6	88.9	
87.9	86.7	85.1	87.3	87.8	87.8	88.1	88.4	87.9	90.5	90.6	91.1	87.6	87.5	89.3	90.6	89.4	88.8	
87.8	86.6	85.0	87.1	87.7	87.7	88.0	88.3	87.8	90.3	90.4	91.0	87.5	87.4	89.2	90.5	89.3	88.7	
87.7	86.5	84.9	87.0	87.6	87.6	87.9	88.2	87.7	90.2	90.3	90.9	87.4	87.3	89.0	90.4	89.1	88.5	
87.6	86.4	84.8	86.9	87.5	87.4	87.8	88.1	87.6	90.1	90.2	90.8	87.3	87.1	88.9	90.2	89.0	88.4	
87.5	86.3	84.7	86.8	87.4	87.3	87.7	87.9	87.5	90.0	90.0	90.6	87.1	87.0	88.8	90.1	88.9	88.2	
87.4	86.1	84.6	86.6	87.3	87.2	87.6	87.8	87.4	89.8	89.9	90.5	87.0	86.9	88.7	89.9	88.8	88.1	
87.3	86.0	84.5	86.5	87.1	87.1	87.5	87.7	87.3	89.7	89.8	90.4	86.9	86.8	88.6	89.8	88.7	88.0	
87.2	86.0	84.4	86.4	87.0	87.0	87.4	87.6	87.2	89.6	89.7	90.3	86.8	86.7	88.5	89.7	88.5	87.9	
87.1	85.9	84.3	86.3	86.9	86.9	87.3	87.5	87.1	89.5	89.6	90.2	86.7	86.6	88.4	89.6	88.4	87.8	
87.0	85.8	84.3	86.2	86.8	86.8	87.2	87.5	87.0	89.4	89.5	90.1	86.7	86.5	88.3	89.5	88.3	87.7	
86.9	85.7	84.2	86.1	86.7	86.7	87.1	87.4	86.9	89.3	89.4	90.0	86.6	86.4	88.2	89.4	88.2	87.6	
86.8	85.6	84.1	86.0	86.6	86.6	87.0	87.3	86.8	89.2	89.2	89.9	86.5	86.3	88.1	89.2	88.1	87.4	
86.7	85.5	84.0	85.9	86.5	86.5	86.9	87.2	86.7	89.1	89.1	89.8	86.4	86.2	88.0	89.1	88.0	87.4	
86.6	85.4	84.0	85.9	86.4	86.4	86.8	87.1	86.7	89.0	89.1	89.7	86.3	86.2	87.9	89.0	87.9	87.3	
86.6	85.3	83.9	85.8	86.3	86.3	86.7	87.0	86.6	88.9	88.9	89.6	86.2	86.1	87.8	88.9	87.8	87.2	
86.5	85.3	83.8	85.7	86.3	86.2	86.7	86.9	86.5	88.8	88.9	89.5	86.1	86.0	87.7	88.8	87.7	87.1	
86.4	85.2	83.8	85.6	86.2	86.1	86.6	86.8	86.4	88.7	88.8	89.4	86.1	85.9	87.6	88.7	87.6	87.0	

Table 11: Compaction at 100°F, Medium and Coarse Gradations

Combined 120°F																		
US 40						SR-32						Southern Parkway						
Med			Coarse			Med			Coarse			Med			Coarse			
1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
100.5	98.3	98.3	102.9	106.7	0.0	100.1	101.3	100.6	106.7	106.3	106.2	100.2	99.8	100.8	104.3	103.2	103.6	
97.8	95.3	95.3	99.9	103.9	0.0	97.2	98.7	97.7	104.0	103.4	103.3	97.6	97.0	97.6	101.2	99.9	100.6	
95.5	93.5	93.4	97.5	101.3	0.0	95.3	96.6	95.8	101.5	101.0	100.9	95.3	94.6	95.6	98.9	97.8	98.3	
94.1	92.1	92.0	95.8	99.7	0.0	93.9	95.1	94.4	99.7	99.2	99.2	93.9	93.2	94.2	97.0	96.2	96.7	
93.0	91.1	91.0	94.5	98.4	0.0	92.8	93.9	93.3	98.2	97.9	97.8	92.9	92.1	93.1	95.8	95.0	95.4	
92.1	90.3	90.2	93.3	97.4	0.0	91.9	93.0	92.5	97.1	96.8	96.7	91.9	91.2	92.1	94.8	94.0	94.2	
91.4	89.6	89.4	92.5	96.5	0.0	91.2	92.2	91.7	96.2	95.9	95.7	91.2	90.5	91.4	94.0	93.2	93.3	
90.8	89.0	88.8	91.7	95.7	0.0	90.6	91.5	91.1	95.4	95.1	94.9	90.6	89.8	90.7	93.2	92.5	92.6	
90.2	88.4	88.3	91.1	95.1	0.0	90.0	90.9	90.6	94.7	94.4	94.2	90.0	89.2	90.1	92.6	91.8	92.0	
89.8	88.0	87.8	90.6	94.5	0.0	89.5	90.4	90.1	94.0	93.8	93.6	89.5	88.7	89.6	92.0	91.3	91.4	
89.3	87.6	87.4	90.0	93.9	0.0	89.1	90.0	89.7	93.5	93.3	93.0	89.0	88.3	89.2	91.5	90.8	90.9	
88.9	87.2	87.0	89.6	93.4	0.0	88.7	89.6	89.3	93.0	92.8	92.5	88.6	87.9	88.7	91.0	90.4	90.5	
88.6	86.9	86.7	89.2	93.0	0.0	88.4	89.2	88.9	92.5	92.4	92.1	88.3	87.5	88.4	90.6	90.0	90.1	
88.2	86.6	86.4	88.8	92.6	0.0	88.0	88.9	88.6	92.1	91.9	91.7	87.9	87.2	88.0	90.2	89.6	89.7	
88.0	86.3	86.1	88.4	92.2	0.0	87.7	88.6	88.3	91.7	91.6	91.3	87.6	86.9	87.7	89.9	89.2	89.3	
87.7	86.0	85.8	88.1	91.8	0.0	87.4	88.3	88.0	91.4	91.3	91.0	87.3	86.6	87.4	89.5	88.9	89.0	
87.4	85.8	85.6	87.8	91.5	0.0	87.2	88.0	87.7	91.1	90.9	90.7	87.0	86.3	87.1	89.2	88.6	88.7	
87.2	85.6	85.4	87.5	91.2	0.0	87.0	87.7	87.5	90.8	90.6	90.4	86.8	86.1	86.9	88.9	88.4	88.4	
87.0	85.4	85.2	87.3	90.9	0.0	86.7	87.5	87.3	90.5	90.3	90.1	86.6	85.9	86.6	88.7	88.1	88.2	
86.7	85.2	85.0	87.0	90.7	0.0	86.5	87.3	87.1	90.2	90.1	89.8	86.4	85.6	86.4	88.4	87.8	87.9	
86.6	85.0	84.8	86.8	90.4	0.0	86.3	87.1	86.8	90.0	89.8	89.6	86.1	85.4	86.2	88.2	87.6	87.7	
86.4	84.8	84.6	86.6	90.2	0.0	86.1	86.9	86.7	89.8	89.6	89.4	86.0	85.3	86.0	88.0	87.4	87.5	
86.2	84.6	84.5	86.4	89.9	0.0	86.0	86.7	86.5	89.5	89.4	89.1	85.8	85.1	85.8	87.7	87.2	87.3	
86.0	84.5	84.3	86.1	89.7	0.0	85.8	86.5	86.3	89.3	89.2	88.9	85.6	84.9	85.6	87.5	87.0	87.1	
85.9	84.3	84.1	86.0	89.5	0.0	85.7	86.4	86.1	89.1	89.0	88.7	85.4	84.8	85.5	87.3	86.8	86.9	
85.7	84.2	84.0	85.8	89.3	0.0	85.5	86.2	86.0	88.9	88.8	88.5	85.3	84.6	85.3	87.1	86.6	86.7	
85.6	84.1	83.9	85.6	89.1	0.0	85.4	86.1	85.9	88.8	88.6	88.4	85.2	84.5	85.2	87.0	86.5	86.5	
85.4	84.0	83.7	85.5	88.9	0.0	85.2	85.9	85.7	88.6	88.4	88.2	85.0	84.3	85.0	86.8	86.3	86.4	
85.3	83.9	83.6	85.3	88.8	0.0	85.1	85.8	85.6	88.4	88.3	88.0	84.9	84.2	84.9	86.6	86.1	86.2	
85.2	83.8	83.5	85.2	88.6	0.0	85.0	85.6	85.5	88.3	88.1	87.9	84.8	84.1	84.8	86.5	86.0	86.1	
85.1	83.6	83.4	85.0	88.4	0.0	84.9	85.5	85.3	88.1	88.0	87.7	84.6	84.0	84.6	86.3	85.9	85.9	
84.9	83.5	83.3	84.9	88.3	0.0	84.8	85.4	85.2	88.0	87.8	87.6	84.5	83.9	84.5	86.2	85.7	85.8	
84.8	83.5	83.2	84.8	88.1	0.0	84.6	85.3	85.1	87.8	87.7	87.4	84.4	83.7	84.4	86.1	85.6	85.7	
84.7	83.4	83.1	84.6	88.0	0.0	84.6	85.2	85.0	87.7	87.5	87.3	84.3	83.6	84.3	85.9	85.5	85.5	
84.6	83.3	83.0	84.5	87.8	0.0	84.5	85.1	84.9	87.5	87.4	87.1	84.2	83.5	84.2	85.8	85.4	85.4	
84.5	83.2	82.9	84.4	87.7	0.0	84.3	85.0	84.8	87.4	87.3	87.0	84.1	83.5	84.1	85.7	85.2	85.3	
84.4	83.1	82.8	84.3	87.6	0.0	84.3	84.9	84.7	87.3	87.1	86.9	84.0	83.4	84.0	85.6	85.1	85.2	
84.3	83.0	82.7	84.2	87.5	0.0	84.2	84.8	84.6	87.2	87.0	86.8	83.9	83.3	83.9	85.4	85.0	85.1	
84.3	82.9	82.7	84.1	87.4	0.0	84.1	84.7	84.5	87.1	86.9	86.7	83.8	83.2	83.8	85.3	84.9	85.0	
84.2	82.8	82.6	84.0	87.3	0.0	84.0	84.6	84.5	87.0	86.8	86.6	83.7	83.1	83.7	85.2	84.8	84.9	
84.1	82.8	82.5	83.9	87.1	0.0	83.9	84.5	84.4	86.9	86.7	86.4	83.6	83.0	83.6	85.1	84.7	84.8	
84.0	82.7	82.4	83.8	87.0	0.0	83.9	84.5	84.3	86.8	86.6	86.3	83.5	82.9	83.5	85.0	84.6	84.7	
83.9	82.6	82.4	83.7	86.9	0.0	83.8	84.4	84.2	86.7	86.5	86.3	83.5	82.9	83.5	84.9	84.5	84.6	
83.9	82.6	82.3	83.6	86.8	0.0	83.7	84.3	84.1	86.6	86.4	86.1	83.4	82.8	83.4	84.8	84.4	84.5	
83.8	82.5	82.2	83.5	86.7	0.0	83.6	84.2	84.1	86.5	86.3	86.0	83.3	82.7	83.3	84.8	84.3	84.4	
83.7	82.5	82.2	83.5	86.6	0.0	83.6	84.1	84.0	86.4	86.2	86.0	83.3	82.7	83.2	84.7	84.3	84.3	
83.6	82.4	82.1	83.4	86.5	0.0	83.5	84.1	83.9	86.3	86.1	85.9	83.2	82.6	83.2	84.6	84.2	84.2	
83.6	82.4	82.1	83.3	86.4	0.0	83.4	84.0	83.8	86.2	86.0	85.8	83.1	82.5	83.1	84.5	84.1	84.2	
83.5	82.3	82.0	83.2	86.3	0.0	83.4	83.9	83.8	86.1	85.9	85.7	83.1	82.5	83.0	84.4	84.0	84.1	
83.5	82.2	82.0	83.1	86.3	0.0	83.3	83.9	83.7	86.0	85.9	85.6	83.0	82.4	82.9	84.3	84.0	84.0	
83.4	82.2	81.9	83.1	86.2	0.0	83.3	83.8	83.6	86.0	85.8	85.5	82.9	82.4	82.9	84.3	83.9	83.9	

Table 12: Compaction at 120°F, Medium and Coarse Gradations

Combined 140°F																	
US 40						SR-32						Southern Parkway					
Med			Coarse			Med			Coarse			Med			Coarse		
1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
96.5	97.2	96.6	102.0	101.2	102.1	99.6	100.3	99.4	102.4	103.1	99.6	97.8	98.1	99.2	102.5	100.8	101.0
93.8	94.3	93.9	99.1	98.3	99.3	96.7	97.5	96.4	99.5	100.0	96.4	94.6	95.4	96.0	98.8	97.8	97.7
92.0	92.5	91.8	96.8	95.6	96.7	94.8	95.4	94.6	97.2	97.7	94.5	92.7	93.3	94.0	96.6	95.6	95.5
90.7	91.2	90.5	94.9	94.0	95.1	93.4	93.9	93.2	95.6	96.0	93.1	91.3	91.9	92.5	95.0	93.9	93.9
89.7	90.1	89.5	93.6	92.8	93.9	92.3	92.8	92.1	94.1	94.7	92.0	90.2	90.6	91.4	93.7	92.5	92.7
88.9	89.3	88.7	92.6	91.8	92.9	91.4	91.8	91.2	93.1	93.7	91.2	89.3	89.7	90.5	92.7	91.5	91.7
88.2	88.6	88.0	91.8	91.0	92.0	90.6	91.0	90.5	92.3	92.8	90.4	88.6	88.9	89.7	91.8	90.7	90.9
87.6	88.0	87.4	91.0	90.2	91.3	90.0	90.4	89.9	91.6	92.1	89.8	88.0	88.3	89.0	91.1	90.0	90.2
87.0	87.5	86.9	90.4	89.6	90.6	89.4	89.9	89.3	91.0	91.4	89.2	87.4	87.7	88.4	90.5	89.4	89.6
86.5	87.0	86.5	89.8	89.1	90.1	88.9	89.4	88.9	90.5	90.9	88.8	86.9	87.2	87.9	89.9	88.8	89.1
86.1	86.6	86.1	89.3	88.6	89.6	88.5	88.9	88.4	90.0	90.4	88.3	86.5	86.8	87.5	89.4	88.4	88.6
85.8	86.2	85.7	88.8	88.1	89.1	88.1	88.5	88.0	89.6	89.9	88.0	86.1	86.4	87.1	88.9	87.9	88.1
85.4	85.9	85.4	88.4	87.7	88.7	87.7	88.2	87.7	89.2	89.5	87.6	85.7	86.0	86.7	88.5	87.5	87.7
85.2	85.6	85.1	88.0	87.4	88.3	87.4	87.8	87.4	88.8	89.1	87.3	85.4	85.7	86.3	88.1	87.1	87.4
84.9	85.3	84.8	87.7	87.0	88.0	87.1	87.5	87.1	88.5	88.8	87.0	85.1	85.4	86.0	87.8	86.7	87.0
84.6	85.0	84.6	87.3	86.7	87.6	86.8	87.3	86.8	88.2	88.5	86.7	84.8	85.1	85.7	87.4	86.4	86.7
84.4	84.8	84.3	87.0	86.4	87.3	86.5	87.0	86.5	87.9	88.2	86.4	84.6	84.9	85.5	87.1	86.1	86.4
84.2	84.6	84.1	86.7	86.1	87.0	86.3	86.8	86.3	87.7	87.9	86.2	84.3	84.6	85.2	86.8	85.9	86.1
84.0	84.4	83.9	86.5	85.9	86.8	86.1	86.5	86.1	87.4	87.7	86.0	84.1	84.4	85.0	86.6	85.6	85.9
83.8	84.2	83.7	86.2	85.6	86.5	85.9	86.3	85.9	87.2	87.4	85.8	83.9	84.2	84.8	86.3	85.4	85.7
83.6	84.0	83.6	86.0	85.4	86.3	85.6	86.1	85.7	87.0	87.2	85.6	83.7	84.0	84.6	86.1	85.1	85.4
83.4	83.9	83.4	85.8	85.2	86.1	85.5	85.9	85.5	86.8	87.0	85.4	83.5	83.8	84.4	85.9	84.9	85.2
83.3	83.7	83.2	85.6	85.0	85.9	85.3	85.8	85.3	86.6	86.8	85.2	83.4	83.7	84.2	85.6	84.7	85.0
83.1	83.5	83.1	85.4	84.8	85.7	85.1	85.6	85.2	86.4	86.6	85.0	83.2	83.5	84.1	85.4	84.5	84.8
83.0	83.4	82.9	85.2	84.6	85.5	85.0	85.4	85.0	86.2	86.4	84.9	83.1	83.4	83.9	85.3	84.3	84.7
82.9	83.3	82.8	85.0	84.5	85.3	84.8	85.3	84.9	86.0	86.2	84.7	82.9	83.2	83.7	85.1	84.2	84.5
82.7	83.2	82.7	84.9	84.3	85.2	84.7	85.1	84.7	85.9	86.1	84.6	82.8	83.1	83.6	84.9	84.0	84.3
82.6	83.0	82.6	84.7	84.1	85.0	84.5	85.0	84.6	85.7	85.9	84.5	82.7	82.9	83.4	84.8	83.9	84.2
82.5	82.9	82.4	84.5	84.0	84.9	84.4	84.9	84.5	85.6	85.8	84.3	82.5	82.8	83.3	84.6	83.7	84.0
82.4	82.8	82.4	84.4	83.9	84.7	84.3	84.8	84.4	85.4	85.6	84.2	82.4	82.7	83.2	84.5	83.6	83.9
82.3	82.7	82.2	84.2	83.7	84.6	84.2	84.6	84.2	85.3	85.5	84.1	82.3	82.6	83.1	84.3	83.4	83.8
82.2	82.6	82.1	84.1	83.6	84.5	84.1	84.5	84.1	85.2	85.3	84.0	82.2	82.5	82.9	84.2	83.3	83.6
82.1	82.5	82.1	84.0	83.5	84.3	83.9	84.4	84.0	85.1	85.2	83.9	82.1	82.4	82.8	84.0	83.2	83.5
82.0	82.4	82.0	83.9	83.4	84.2	83.8	84.3	83.9	84.9	85.1	83.8	82.0	82.3	82.7	83.9	83.1	83.4
81.9	82.3	81.9	83.8	83.2	84.1	83.7	84.2	83.8	84.8	85.0	83.7	81.9	82.2	82.6	83.8	82.9	83.3
81.8	82.2	81.8	83.6	83.1	84.0	83.6	84.1	83.7	84.7	84.9	83.6	81.8	82.1	82.5	83.6	82.8	83.1
81.7	82.2	81.7	83.5	83.0	83.9	83.5	84.0	83.6	84.6	84.8	83.5	81.7	82.0	82.4	83.5	82.7	83.0
81.7	82.1	81.6	83.4	82.9	83.8	83.4	83.9	83.6	84.5	84.7	83.4	81.6	82.0	82.3	83.4	82.6	82.9
81.6	82.0	81.5	83.3	82.8	83.7	83.4	83.8	83.5	84.4	84.6	83.3	81.5	81.9	82.2	83.3	82.5	82.8
81.5	81.9	81.5	83.2	82.7	83.6	83.3	83.7	83.4	84.3	84.5	83.2	81.5	81.8	82.1	83.2	82.4	82.7
81.4	81.9	81.4	83.1	82.6	83.5	83.2	83.6	83.3	84.2	84.4	83.1	81.4	81.7	82.1	83.1	82.3	82.7
81.4	81.8	81.3	83.0	82.5	83.4	83.1	83.6	83.2	84.1	84.3	83.1	81.3	81.7	82.0	83.0	82.2	82.6
81.3	81.7	81.3	82.9	82.4	83.3	83.0	83.5	83.2	84.1	84.2	83.0	81.2	81.6	81.9	82.9	82.1	82.5
81.2	81.7	81.2	82.8	82.4	83.2	82.9	83.4	83.1	84.0	84.1	82.9	81.2	81.5	81.8	82.8	82.1	82.4
81.2	81.6	81.1	82.8	82.3	83.2	82.9	83.3	83.0	83.9	84.0	82.8	81.1	81.4	81.8	82.7	82.0	82.3
81.1	81.5	81.1	82.7	82.2	83.1	82.8	83.3	82.9	83.8	83.9	82.8	81.0	81.4	81.7	82.7	81.9	82.2
81.1	81.5	81.0	82.6	82.1	83.0	82.8	83.2	82.9	83.7	83.9	82.7	81.0	81.3	81.6	82.6	81.8	82.1
81.0	81.4	81.0	82.5	82.1	82.9	82.7	83.1	82.8	83.6	83.8	82.6	80.9	81.3	81.6	82.5	81.7	82.1
81.0	81.4	80.9	82.5	82.0	82.8	82.7	83.1	82.8	83.6	83.7	82.6	80.9	81.2	81.5	82.4	81.7	82.0
80.9	81.3	80.9	82.4	81.9	82.8	82.6	83.0	82.7	83.5	83.7	82.5	80.8	81.1	81.4	82.4	81.6	81.9
80.8	81.3	80.8	82.3	81.8	82.7	82.5	82.9	82.7	83.4	83.6	82.5	80.7	81.1	81.4	82.3	81.5	81.8

Table 13: Compaction at 140°F, Medium and Coarse Gradations

APPENDIX E: SEMI-CIRCULAR BENDING

The Data obtained from the experimental plan using the SCB is presented here.

SCB Test Results on CBR Equipment 04-30-14 72 Hour Curing

043013PAA#1		043013PAA#2		043013PAB#1		043013PAB#2		043013PAC#1		043013PAC#2		043013CQA#1		043013CQA#2		043013CQB#1		043013CQB#2		043013CQC#1		043013CQC#2	
16.9	1.08	17.9	1.147	6.5	1.113	12.7	1.159	5.7	1.150	11.9	1.114	5.4	0.015	5.7	1.123	6.6	1.111	7.2	1.156	5.9	1.116	5.4	1.154
20.1	1.087	39.2	1.156	26.5	1.115	18.0	1.165	5.7	1.154	12.4	1.114	17.2	0.023	5.7	1.125	6.6	1.111	8.6	1.158	5.9	1.119	6.8	1.162
24.1	1.089	40.9	1.157	30.4	1.116	20.6	1.166	5.7	1.154	12.7	1.114	19.2	0.024	5.7	1.127	6.6	1.111	10.0	1.160	5.9	1.119	22.5	1.163
28.9	1.089	42.7	1.158	39.7	1.116	24.0	1.167	20.3	1.154	20.3	1.119	19.5	0.026	15.8	1.129	25.4	1.114	11.9	1.163	19.4	1.123	26.1	1.165
34.2	1.089	44.4	1.159	88.5	1.123	28.2	1.168	161.1	1.162	22.6	1.12	19.8	0.026	18.2	1.131	26.3	1.114	13.3	1.164	22.5	1.124	30.1	1.167
76.7	1.099	46.1	1.16	99.6	1.124	32.9	1.169	171.5	1.163	25.1	1.121	20.2	0.026	21.5	1.133	27.9	1.114	15.5	1.166	25.5	1.127	34.7	1.168
87.1	1.101	47.8	1.162	111.3	1.125	37.9	1.171	180.7	1.164	27.9	1.122	50.6	0.035	25.0	1.134	54.4	1.122	19.1	1.167	29.2	1.128	40.4	1.169
97.9	1.103	79.5	1.163	123.2	1.127	43.4	1.172	188.2	1.165	30.7	1.124	56.1	0.036	28.7	1.137	58.9	1.122	22.9	1.169	33.8	1.129	47.3	1.172
108.9	1.104	88.1	1.164	135.1	1.128	48.8	1.173	193.8	1.166	33.6	1.125	63.1	0.038	33.0	1.138	63.3	1.122	26.4	1.171	38.7	1.129	55.5	1.173
119.8	1.105	98.3	1.165	146.6	1.129	52.4	1.175	196.0	1.168	37.3	1.127	70.5	0.038	38.5	1.14	68.3	1.122	30.1	1.173	44.9	1.129	64.3	1.174
131.8	1.106	109.5	1.166	157.3	1.130	54.9	1.176	192.6	1.169	41.4	1.128	77.8	0.038	43.2	1.142	97	1.131	34.9	1.174	93.2	1.139	73.6	1.175
143.8	1.108	120.5	1.168	167.0	1.131	57.5	1.179	189.2	1.172	45.9	1.13	119.7	0.049	47.1	1.144	104.1	1.132	39.5	1.176	104.2	1.140	83.5	1.177
155.3	1.11	131.9	1.168	175.2	1.133	60.0	1.18	185.9	1.173	50.4	1.131	126.0	0.050	52.6	1.146	111.2	1.133	44.4	1.179	115.4	1.141	93.6	1.179
165.9	1.112	143.9	1.168	181.2	1.134	62.6	1.181	182.5	1.175	54.8	1.133	132.7	0.050	59.1	1.147	119.1	1.134	50.6	1.181	127.7	1.142	103.4	1.18
175.2	1.112	185.4	1.179	184.5	1.137	65.1	1.182	179.1	1.177	59.7	1.134	139.8	0.050	65.6	1.148	127.1	1.136	58.1	1.182	140.1	1.144	113.4	1.182
182.4	1.112	184.6	1.18	184.2	1.138	67.7	1.184	175.7	1.181	65.2	1.136	158.4	0.060	72.1	1.15	134.3	1.137	67.1	1.184	152.8	1.145	124.2	1.183
179.5	1.123	183.9	1.182	184.0	1.140	70.2	1.184	172.4	1.182	71.7	1.137	158.1	0.062	78.4	1.153	142.3	1.138	76.3	1.185	164.0	1.146	135.9	1.184
177.1	1.124	183.1	1.184	183.7	1.141	107.5	1.184	87.5	1.183	78.6	1.139	157.8	0.063	85.1	1.154	150.1	1.139	86.1	1.186	173.9	1.147	148.6	1.185
174.7	1.127	182.4	1.186	183.5	1.144	153.8	1.19	78.3	1.185	86.1	1.14	157.5	0.064	93.2	1.155	153	1.141	96.3	1.189	181.7	1.148	161.5	1.186
172.4	1.128	181.7	1.189	183.2	1.145	156.5	1.191	70.9	1.188	93.8	1.142	157.1	0.066	102.3	1.157	153.6	1.141	107.0	1.190	186.8	1.150	173.3	1.188
95.6	1.13	180.9	1.191	183.0	1.146	155.2	1.192	65.1	1.189	101.9	1.144	156.8	0.067	111.3	1.158	154.2	1.141	117.0	1.191	186.8	1.153	183.8	1.189
87.7	1.131	74.4	1.193	182.7	1.147	153.9	1.193	59.7	1.190	109.5	1.145	120.2	0.068	120.8	1.159	174.8	1.151	127.5	1.192	186.8	1.154	192.6	1.19
80.5	1.132	64.0	1.194	78.6	1.148	152.6	1.194	54.8	1.191	117.0	1.146	112.2	0.069	130.2	1.16	161.4	1.153	137.3	1.193	186.7	1.156	199.1	1.191
73.3	1.133	54.2	1.195	62.7	1.149	151.3	1.195	50.6	1.193	124.0	1.148	104.4	0.070	139.6	1.163	146.8	1.155	146.0	1.194	186.6	1.158	202.0	1.192
65.5	1.134	47.0	1.197	49.8	1.150	150.0	1.198	46.4	1.194	131.2	1.149	97.1	0.077	148.3	1.164	132.3	1.156	155.1	1.197	186.5	1.160	200.9	1.194
58.1	1.136	41.8	1.199	40.4	1.151	148.6	1.199	42.8	1.195	138.3	1.151	90.3	0.079	156.5	1.166	117.3	1.157	163.9	1.197	186.4	1.162	199.9	1.195
51.9	1.137	37.2	1.2	34.0	1.158	147.3	1.2	39.8	1.197	144.2	1.153	84.1	0.081	164.5	1.167	102.9	1.159	170.9	1.197	186.4	1.164	198.8	1.198
45.0	1.139	33.4	1.201	29.9	1.159	63.7	1.201	37.0	1.198	148.7	1.155	78.1	0.082	171.2	1.169	88.9	1.162	181.7	1.209	72.9	1.165	197.7	1.2
36.6	1.141	29.7	1.202	26.6	1.162	55.1	1.203	34.3	1.199	152.0	1.156	72.3	0.084	176.9	1.171	75.4	1.163	181.0	1.211	63.5	1.167	196.6	1.202
33.0	1.144	26.7	1.203	23.9	1.163	48.4	1.205	31.5	1.201	154.0	1.158	66.9	0.085	180.6	1.172	64.1	1.164	180.3	1.214	55.4	1.168	195.6	1.205
30.0	1.146	24.8	1.206	21.7	1.165	42.6	1.206	29.2	1.202	154.1	1.159	61.8	0.087	182.5	1.174	54.8	1.166	179.7	1.215	49.0	1.171	194.5	1.207
27.3	1.148	23.2	1.207	20.0	1.166	37.6	1.207	26.9	1.205	154.0	1.162	57.5	0.089	182.2	1.176	47.5	1.167	179.0	1.217	43.5	1.172	109.4	1.209
26.6	1.15	21.3	1.209	18.4	1.168	33.2	1.208	25.2	1.206	153.9	1.164	53.5	0.090	182.0	1.177	42.1	1.168	84.5	1.219	38.6	1.174	92.0	1.211
26.3	1.153	19.5	1.21	17.0	1.171	29.4	1.209	23.7	1.207	153.8	1.166	50.1	0.092	181.7	1.18	38.1	1.171	70.9	1.221	34.6	1.175	77.7	1.212
25.9	1.155	18.4	1.211	15.8	1.173	26.7	1.21	22.3	1.208	153.7	1.169	46.6	0.094	181.5	1.181	35.2	1.171	61.4	1.223	31.2	1.176	65.8	1.214
25.6	1.156	17.4	1.212	14.5	1.173	24.5	1.211	20.9	1.210	153.7	1.172	43.2	0.095	181.2	1.182	33	1.171	54.7	1.224	28.2	1.177	55.5	1.215
25.3	1.158	16.1	1.215	13.3	1.173	22.6	1.221	19.3	1.211	153.6	1.174	40.5	0.097	181.0	1.183	24.5	1.183	48.9	1.225	25.8	1.180	47.5	1.216
25.0	1.16	15.3	1.216	9.3	1.185	21.2	1.224	17.9	1.212	70.3	1.177	38.0	0.098	180.8	1.184	24	1.184	44.6	1.226	23.7	1.181	41.3	1.217
24.6	1.162	14.4	1.216	8.8	1.186	19.8	1.226	16.5	1.215	59.2	1.18	35.7	0.101	118.0	1.185	23.3	1.186	40.6	1.227	21.7	1.182	36.6	1.218
24.3	1.163	13.9	1.216	8.2	1.188	18.6	1.228	15.1	1.216	50.1	1.182	33.8	0.102	104.6	1.186	22.6	1.189	37.3	1.228	19.7	1.183	33.2	1.219
17.5	1.165	10.5	1.226	7.7	1.189	17.6	1.231	13.8	1.218	43.2	1.185	31.6	0.104	92.1	1.188	22.2	1.190	34.7	1.229	18.1	1.185	30.6	1.227
15.9	1.167	10.1	1.228	7.3	1.190	16.9	1.232	12.8	1.219	37.7	1.188	29.2	0.105	81.4	1.194	21.7	1.191	32.7	1.236	16.6	1.186	28.7	1.228
14.0	1.168	9.7	1.229	6.8	1.191	15.7	1.234	12.0	1.220	33.4	1.19	27.2	0.107	72.1	1.195	21.2	1.193	30.7	1.237	15.0	1.189	26.8	1.231
12.4	1.169	9.3	1.232	6.4	1.192	14.6	1.234	11.3	1.221	30.0	1.192	25.4	0.108	64.1	1.198	20.7	1.195	29.2	1.240	13.7	1.190	25.1	1.232
11.2	1.172	9.1	1.233	6.2	1.193	13.6	1.234	10.8	1.224	26.9	1.194	23.7	0.110	57.6	1.2	19.8	1.198	27.6	1.241	12.4	1.192	23.8	1.233
10.0	1.173	9.1	1.235	6.2	1.202	9.6	1.241	10.2	1.225	24.1	1.197	22.2	0.111	52.0	1.201	18.9	1.199	26.2	1.243	11.4	1.193	22.5	1.235
9.1	1.175	9.1	1.236	6.2	1.203	9.2	1.242	9.5	1.225	21.4	1.199	21.1	0.113	47.2	1.203	18.2	1.200	25.2	1.244	10.6	1.195	21.2	1.236
8.2	1.176	9	1.238	6.2	1.205	8.7	1.244	8.7	1.225	19.3	1.201	19.8	0.114	43.4	1.205	17.2	1.202	24.1	1.246	10.0	1.197	20.0	1.237
7.6	1.177	8.9	1.24	6.2	1.207	8.5	1.246	6.3	1.233	17.4	1.205	18.5	0.115	40.5	1.207	16.3	1.205	23.0	1.247	9.6	1.199	18.8	1.238
6.5	1.179	8.8	1.242	6.2	1.208	8.1	1.247	6.3	1.234	15.6	1.208	17.8	0.116	38.0	1.208	15.7	1.206	22.2	1.250	9.1	1.199	17.4	1.24

SCB Test Results on CBR Equipment 04-26 72 Hour Curing

042313EEA#1		042313EEA#2		042313EEB#1		042313EEB#2		042313EEC#1		042313EEC#2		042313SSA#1		042313SSA#2		042313SSB#1		042313SSB#2		042313SSC#1		042313SSC#2	
5.8	0.02	4.4	0.008	2.5	0.015	16.0	0.011	5.7	0.008	3.1	0.019	7.1	0.013	5.6	0.014	10.1	0.001	5.7	0.005	4.2	0.010	4.6	0.011
6.5	0.02	4.9	0.008	2.8	0.015	18.4	0.012	35.9	0.014	3.5	0.02	7.8	0.014	6.6	0.015	12.5	0.002	6.0	0.006	4.5	0.010	5.3	0.011
7.3	0.02	24.5	0.01	3.0	0.015	21.4	0.012	42.1	0.016	3.8	0.02	27.0	0.022	6.8	0.015	15.2	0.003	6.4	0.007	4.9	0.010	6.0	0.011
8.5	0.02	53.0	0.016	35.5	0.017	24.1	0.012	48.4	0.018	4.1	0.02	32.2	0.023	20.9	0.018	17.6	0.004	6.7	0.008	5.2	0.010	6.2	0.015
18.7	0.025	58.9	0.018	107.7	0.024	48.7	0.018	54.3	0.019	30.9	0.027	38.0	0.023	69.0	0.019	20.5	0.007	27.9	0.010	30.5	0.012	6.3	0.016
21.7	0.025	66.4	0.02	117.3	0.024	54.9	0.02	59.5	0.020	35.6	0.028	43.4	0.023	77.0	0.019	24.3	0.008	32.3	0.010	39.8	0.012	6.5	0.017
25.0	0.025	74.6	0.02	126.2	0.024	62.2	0.021	64.4	0.021	40.3	0.028	172.4	0.031	85.0	0.019	28	0.010	38.3	0.010	71.6	0.018	6.7	0.017
29.2	0.025	82.9	0.02	134.3	0.024	70.7	0.022	67.5	0.023	45.3	0.028	178.8	0.033	131.3	0.029	31.8	0.011	78.4	0.018	76.3	0.019	6.8	0.017
147.7	0.032	134.1	0.029	164.3	0.034	78.8	0.023	70.5	0.024	140.6	0.036	183.7	0.034	137.7	0.03	35.7	0.012	87.0	0.019	81.5	0.021	55.1	0.023
152.3	0.033	141.5	0.03	166.3	0.036	86.8	0.026	73.5	0.026	140.0	0.037	186.4	0.036	143.5	0.031	40.8	0.015	96.8	0.020	87.6	0.023	63.3	0.023
154.8	0.034	147.0	0.032	165.6	0.037	95.0	0.026	76.6	0.027	139.4	0.039	185.2	0.037	148.6	0.032	46.1	0.015	107.4	0.021	95.6	0.024	73.0	0.023
155.5	0.036	151.4	0.033	164.9	0.038	104.7	0.026	79.6	0.028	138.8	0.041	184.0	0.040	152.8	0.033	51.3	0.015	118.0	0.023	104.7	0.025	81.2	0.023
154.4	0.037	154.2	0.036	164.3	0.040	140.5	0.036	82.7	0.029	138.3	0.044	182.9	0.041	155.6	0.034	101.5	0.024	128.9	0.024	113.9	0.026	130.1	0.032
153.3	0.038	153.7	0.037	163.6	0.041	139.6	0.037	85.7	0.030	82.4	0.045	181.7	0.043	156.7	0.036	113.1	0.024	140.1	0.026	123.3	0.027	140.2	0.033
152.3	0.04	153.1	0.038	163.0	0.043	138.7	0.038	88.8	0.031	72.3	0.046	180.6	0.044	155.0	0.038	124.3	0.024	151.2	0.026	132.4	0.028	150.0	0.035
151.2	0.042	152.5	0.04	162.3	0.045	137.8	0.04	118.8	0.033	64.0	0.047	179.4	0.046	153.3	0.04	135.1	0.024	162.0	0.026	141.1	0.029	158.6	0.036
150.1	0.042	151.9	0.041	161.7	0.047	136.9	0.043	124.9	0.033	56.7	0.048	178.3	0.049	151.5	0.041	178.7	0.033	200.5	0.036	148.3	0.032	165.9	0.037
149.1	0.042	151.4	0.044	102.0	0.048	136.0	0.044	130.5	0.033	50.6	0.049	66.0	0.051	149.8	0.042	183.4	0.034	199.7	0.037	151.9	0.033	171.3	0.038
72.8	0.054	150.8	0.045	92.8	0.049	135.1	0.045	136.9	0.044	44.6	0.05	55.3	0.052	148.1	0.044	186.9	0.035	198.9	0.038	148.8	0.034	174.5	0.041
66.7	0.055	150.2	0.047	84.9	0.051	134.1	0.047	136.4	0.046	39.4	0.051	47.3	0.053	146.3	0.047	187.7	0.036	198.1	0.040	145.8	0.035	174.4	0.042
60.7	0.057	98.3	0.049	77.1	0.054	84.3	0.049	135.9	0.048	35.2	0.059	41.0	0.055	144.6	0.048	186.9	0.038	197.3	0.042	142.7	0.037	174.3	0.044
55.8	0.058	88.0	0.05	70.0	0.055	75.6	0.052	135.4	0.049	31.4	0.062	36.2	0.057	88.6	0.05	186.2	0.039	196.4	0.043	139.7	0.040	174.2	0.045
51.9	0.06	78.2	0.053	64.1	0.057	68.2	0.053	82.0	0.052	28.2	0.064	32.4	0.059	78.6	0.051	185.4	0.041	195.6	0.045	136.6	0.042	174.2	0.047
48.5	0.062	69.8	0.054	59.7	0.058	60.8	0.055	72.4	0.054	25.2	0.066	29.6	0.060	69.7	0.053	184.7	0.042	114.8	0.046	133.6	0.043	174.1	0.049
45.9	0.064	61.6	0.056	55.6	0.060	53.4	0.057	64.1	0.056	22.7	0.067	27.1	0.062	61.8	0.056	184	0.044	102.3	0.049	130.5	0.045	174.0	0.05
43.6	0.065	53.8	0.057	51.1	0.063	47.0	0.06	57.4	0.057	21.2	0.068	24.6	0.065	55.5	0.058	183.2	0.045	91.3	0.050	57.6	0.046	173.9	0.051
40.8	0.067	47.4	0.059	47.2	0.065	41.8	0.061	51.9	0.059	20.0	0.07	22.4	0.067	50.5	0.059	113.1	0.047	81.0	0.052	51.5	0.049	64.9	0.052
38.0	0.068	42.3	0.06	44.2	0.066	37.3	0.063	47.3	0.062	18.6	0.071	20.5	0.069	46.3	0.061	100.3	0.048	72.0	0.053	46.0	0.050	56.9	0.053
35.8	0.069	38.2	0.063	41.0	0.067	33.3	0.065	42.6	0.063	17.1	0.072	18.9	0.070	42.6	0.062	90	0.051	64.0	0.054	41.4	0.052	50.2	0.054
33.6	0.071	34.8	0.064	38.5	0.068	29.6	0.066	38.1	0.064	16.0	0.073	17.3	0.072	39.0	0.065	82.3	0.052	56.8	0.054	38.0	0.054	44.4	0.055
31.0	0.073	31.9	0.066	36.8	0.071	26.5	0.069	33.5	0.066	14.9	0.074	15.2	0.074	36.1	0.066	75.7	0.054	49.7	0.054	34.4	0.055	39.7	0.063
28.9	0.074	28.7	0.067	35.0	0.073	24.5	0.071	30.2	0.067	14.1	0.075	12.8	0.075	33.4	0.068	69	0.055	23.4	0.066	31.5	0.058	35.7	0.066
27.2	0.076	25.5	0.069	32.4	0.076	22.9	0.074	27.4	0.070	13.3	0.086	11.0	0.077	31.5	0.069	63.3	0.057	21.4	0.067	28.3	0.060	32.9	0.068
25.4	0.077	23.5	0.071	30.3	0.077	21.3	0.077	24.9	0.071	12.0	0.089	9.8	0.078	29.7	0.071	58.5	0.059	20.0	0.069	25.3	0.060	30.5	0.069
23.7	0.08	22.2	0.073	28.7	0.080	19.9	0.079	23.2	0.073	10.9	0.092	9.1	0.080	27.5	0.074	54.5	0.061	18.9	0.069	23.1	0.060	28.1	0.07
22.5	0.081	20.8	0.074	27.5	0.081	18.0	0.082	21.5	0.074	10.3	0.094	8.2	0.081	25.4	0.076	50.6	0.062	17.7	0.069	11.9	0.072	25.9	0.071
21.3	0.083	19.6	0.076	26.3	0.083	16.2	0.087	19.9	0.076	9.8	0.097	7.3	0.084	23.7	0.077	46.6	0.063	9.5	0.082	10.3	0.073	24.0	0.072
20.0	0.084	19.4	0.077	25.2	0.085	15.5	0.09	18.6	0.078	9.7	0.099	6.4	0.085	22.1	0.079	42.8	0.064	8.5	0.082	9.4	0.076	22.6	0.073
19.0	0.085	18.9	0.08	24.4	0.088	15.0	0.094	17.4	0.080	9.6	0.101	5.9	0.086	20.5	0.08	39.2	0.065	7.2	0.082	8.3	0.078	21.5	0.075
18.3	0.086	18.5	0.082	23.4	0.089	14.5	0.097	15.8	0.081	9.4	0.103	5.8	0.087	18.9	0.083	36.2	0.067	6.0	0.082	7.2	0.080	20.4	0.076
17.0	0.087	18.1	0.084	21.8	0.091	14.0	0.101	14.0	0.083	9.2	0.108	5.8	0.088	17.7	0.084	33.8	0.068	2.7	0.088	6.3	0.081	19.2	0.082
15.7	0.089	17.7	0.088	19.7	0.093	13.5	0.105	12.5	0.085	9.1	0.11	5.8	0.088	16.1	0.086	32	0.069	2.6	0.090	5.8	0.084	18.0	0.085
14.6	0.09	17.3	0.09	18.1	0.095	13.0	0.108	11.2	0.088	8.9	0.114	4.6	0.096	14.4	0.087	30.6	0.077	2.4	0.092	4.9	0.087	16.7	0.087
13.3	0.091	16.9	0.093	16.8	0.097	12.5	0.112	10.3	0.089	8.7	0.116	4.3	0.098	13.1	0.09	29.2	0.078	2.3	0.094	3.5	0.090	15.2	0.088
11.9	0.098	16.5	0.095	14.8	0.098	12.0	0.115	9.7	0.091	8.6	0.119	4.3	0.100	11.9	0.091	27.8	0.080	2.1	0.096	3.0	0.093	13.8	0.09
10.9	0.1	11.4	0.099	13.3	0.099	8.4	0.12	8.7	0.092	5.8	0.121	4.3	0.102	11.1	0.093	26.4	0.081	1.9	0.097	2.7	0.094	12.8	0.092
10.0	0.103	10.5	0.101	12.4	0.100	7.2	0.124	7.8	0.093	5.2	0.125	4.3	0.103	10.6	0.094	24.6	0.082	1.8	0.098	2.6	0.095	12.2	0.094
9.0	0.106	10	0.103	11.1	0.101	6.6	0.127	6.6	0.094	5.1	0.127	4.3	0.105	10.0	0.096	23.4	0.083	0.6	0.101	2.6	0.096	11.4	0.095
8.1	0.108	9.8	0.107	9.8	0.102	6.3	0.131	6.0	0.096	5.2	0.131	4.3	0.106	9.3	0.096	22.9	0.085	0.2	0.102	2.5	0.097	10.5	0.096

SCB Test Results on CBR Equipment 04-26 72 Hour Curing

042313EEA#1		042313EEA#2		042313EEB#1		042313EEB#2		042313EEC#1		042313EEC#2		042313SSA#1		042313SSA#2		042313SSB#1		042313SSB#2		042313SSC#1		042313SSC#2	
5.8	0.02	4.4	0.008	2.5	0.015	16.0	0.011	5.7	0.008	3.1	0.019	7.1	0.013	5.6	0.014	10.1	0.001	5.7	0.005	4.2	0.010	4.6	0.011
6.5	0.02	4.9	0.008	2.8	0.015	18.4	0.012	35.9	0.014	3.5	0.02	7.8	0.014	6.6	0.015	12.5	0.002	6.0	0.006	4.5	0.010	5.3	0.011
7.3	0.02	24.5	0.01	3.0	0.015	21.4	0.012	42.1	0.016	3.8	0.02	27.0	0.022	6.8	0.015	15.2	0.003	6.4	0.007	4.9	0.010	6.0	0.011
8.5	0.02	53.0	0.016	35.5	0.017	24.1	0.012	48.4	0.018	4.1	0.02	32.2	0.023	20.9	0.018	17.6	0.004	6.7	0.008	5.2	0.010	6.2	0.015
18.7	0.025	58.9	0.018	107.7	0.024	48.7	0.018	54.3	0.019	30.9	0.027	38.0	0.023	69.0	0.019	20.5	0.007	27.9	0.010	30.5	0.012	6.3	0.016
21.7	0.025	66.4	0.02	117.3	0.024	54.9	0.02	59.5	0.020	35.6	0.028	43.4	0.023	77.0	0.019	24.3	0.008	32.3	0.010	39.8	0.012	6.5	0.017
25.0	0.025	74.6	0.02	126.2	0.024	62.2	0.021	64.4	0.021	40.3	0.028	172.4	0.031	85.0	0.019	28	0.010	38.3	0.010	71.6	0.018	6.7	0.017
29.2	0.025	82.9	0.02	134.3	0.024	70.7	0.022	67.5	0.023	45.3	0.028	178.8	0.033	131.3	0.029	31.8	0.011	78.4	0.018	76.3	0.019	6.8	0.017
147.7	0.032	134.1	0.029	164.3	0.034	78.8	0.023	70.5	0.024	140.6	0.036	183.7	0.034	137.7	0.03	35.7	0.012	87.0	0.019	81.5	0.021	55.1	0.023
152.3	0.033	141.5	0.03	166.3	0.036	86.8	0.026	73.5	0.026	140.0	0.037	186.4	0.036	143.5	0.031	40.8	0.015	96.8	0.020	87.6	0.023	63.3	0.023
154.8	0.034	147.0	0.032	165.6	0.037	95.0	0.026	76.6	0.027	139.4	0.039	185.2	0.037	148.6	0.032	46.1	0.015	107.4	0.021	95.6	0.024	73.0	0.023
155.5	0.036	151.4	0.033	164.9	0.038	104.7	0.026	79.6	0.028	138.8	0.041	184.0	0.040	152.8	0.033	51.3	0.015	118.0	0.023	104.7	0.025	81.2	0.023
154.4	0.037	154.2	0.036	164.3	0.040	140.5	0.036	82.7	0.029	138.3	0.044	182.9	0.041	155.6	0.034	101.5	0.024	128.9	0.024	113.9	0.026	130.1	0.032
153.3	0.038	153.7	0.037	163.6	0.041	139.6	0.037	85.7	0.030	82.4	0.045	181.7	0.043	156.7	0.036	113.1	0.024	140.1	0.026	123.3	0.027	140.2	0.033
152.3	0.04	153.1	0.038	163.0	0.043	138.7	0.038	88.8	0.031	72.3	0.046	180.6	0.044	155.0	0.038	124.3	0.024	151.2	0.026	132.4	0.028	150.0	0.035
151.2	0.042	152.5	0.04	162.3	0.045	137.8	0.04	118.8	0.033	64.0	0.047	179.4	0.046	153.3	0.04	135.1	0.024	162.0	0.026	141.1	0.029	158.6	0.036
150.1	0.042	151.9	0.041	161.7	0.047	136.9	0.043	124.9	0.033	56.7	0.048	178.3	0.049	151.5	0.041	178.7	0.033	200.5	0.036	148.3	0.032	165.9	0.037
149.1	0.042	151.4	0.044	102.0	0.048	136.0	0.044	130.5	0.033	50.6	0.049	66.0	0.051	149.8	0.042	183.4	0.034	199.7	0.037	151.9	0.033	171.3	0.038
72.8	0.054	150.8	0.045	92.8	0.049	135.1	0.045	136.9	0.044	44.6	0.05	55.3	0.052	148.1	0.044	186.9	0.035	198.9	0.038	148.8	0.034	174.5	0.041
66.7	0.055	150.2	0.047	84.9	0.051	134.1	0.047	136.4	0.046	39.4	0.051	47.3	0.053	146.3	0.047	187.7	0.036	198.1	0.040	145.8	0.035	174.4	0.042
60.7	0.057	98.3	0.049	77.1	0.054	84.3	0.049	135.9	0.048	35.2	0.059	41.0	0.055	144.6	0.048	186.9	0.038	197.3	0.042	142.7	0.037	174.3	0.044
55.8	0.058	88.0	0.05	70.0	0.055	75.6	0.052	135.4	0.049	31.4	0.062	36.2	0.057	88.6	0.05	186.2	0.039	196.4	0.043	139.7	0.040	174.2	0.045
51.9	0.06	78.2	0.053	64.1	0.057	68.2	0.053	82.0	0.052	28.2	0.064	32.4	0.059	78.6	0.051	185.4	0.041	195.6	0.045	136.6	0.042	174.2	0.047
48.5	0.062	69.8	0.054	59.7	0.058	60.8	0.055	72.4	0.054	25.2	0.066	29.6	0.060	69.7	0.053	184.7	0.042	114.8	0.046	133.6	0.043	174.1	0.049
45.9	0.064	61.6	0.056	55.6	0.060	53.4	0.057	64.1	0.056	22.7	0.067	27.1	0.062	61.8	0.056	184	0.044	102.3	0.049	130.5	0.045	174.0	0.05
43.6	0.065	53.8	0.057	51.1	0.063	47.0	0.06	57.4	0.057	21.2	0.068	24.6	0.065	55.5	0.058	183.2	0.045	91.3	0.050	57.6	0.046	173.9	0.051
40.8	0.067	47.4	0.059	47.2	0.065	41.8	0.061	51.9	0.059	20.0	0.07	22.4	0.067	50.5	0.059	113.1	0.047	81.0	0.052	51.5	0.049	64.9	0.052
38.0	0.068	42.3	0.06	44.2	0.066	37.3	0.063	47.3	0.062	18.6	0.071	20.5	0.069	46.3	0.061	100.3	0.048	72.0	0.053	46.0	0.050	56.9	0.053
35.8	0.069	38.2	0.063	41.0	0.067	33.3	0.065	42.6	0.063	17.1	0.072	18.9	0.070	42.6	0.062	90	0.051	64.0	0.054	41.4	0.052	50.2	0.054
33.6	0.071	34.8	0.064	38.5	0.068	29.6	0.066	38.1	0.064	16.0	0.073	17.3	0.072	39.0	0.065	82.3	0.052	56.8	0.054	38.0	0.054	44.4	0.055
31.0	0.073	31.9	0.066	36.8	0.071	26.5	0.069	33.5	0.066	14.9	0.074	15.2	0.074	36.1	0.066	75.7	0.054	49.7	0.054	34.4	0.055	39.7	0.063
28.9	0.074	28.7	0.067	35.0	0.073	24.5	0.071	30.2	0.067	14.1	0.075	12.8	0.075	33.4	0.068	69	0.055	23.4	0.066	31.5	0.058	35.7	0.066
27.2	0.076	25.5	0.069	32.4	0.076	22.9	0.074	27.4	0.070	13.3	0.086	11.0	0.077	31.5	0.069	63.3	0.057	21.4	0.067	28.3	0.060	32.9	0.068
25.4	0.077	23.5	0.071	30.3	0.077	21.3	0.077	24.9	0.071	12.0	0.089	9.8	0.078	29.7	0.071	58.5	0.059	20.0	0.069	25.3	0.060	30.5	0.069
23.7	0.08	22.2	0.073	28.7	0.080	19.9	0.079	23.2	0.073	10.9	0.092	9.1	0.080	27.5	0.074	54.5	0.061	18.9	0.069	23.1	0.060	28.1	0.07
22.5	0.081	20.8	0.074	27.5	0.081	18.0	0.082	21.5	0.074	10.3	0.094	8.2	0.081	25.4	0.076	50.6	0.062	17.7	0.069	11.9	0.072	25.9	0.071
21.3	0.083	19.6	0.076	26.3	0.083	16.2	0.087	19.9	0.076	9.8	0.097	7.3	0.084	23.7	0.077	46.6	0.063	9.5	0.082	10.3	0.073	24.0	0.072
20.0	0.084	19.4	0.077	25.2	0.085	15.5	0.09	18.6	0.078	9.7	0.099	6.4	0.085	22.1	0.079	42.8	0.064	8.5	0.082	9.4	0.076	22.6	0.073
19.0	0.085	18.9	0.08	24.4	0.088	15.0	0.094	17.4	0.080	9.6	0.101	5.9	0.086	20.5	0.08	39.2	0.065	7.2	0.082	8.3	0.078	21.5	0.075
18.3	0.086	18.5	0.082	23.4	0.089	14.5	0.097	15.8	0.081	9.4	0.103	5.8	0.087	18.9	0.083	36.2	0.067	6.0	0.082	7.2	0.080	20.4	0.076
17.0	0.087	18.1	0.084	21.8	0.091	14.0	0.101	14.0	0.083	9.2	0.108	5.8	0.088	17.7	0.084	33.8	0.068	2.7	0.088	6.3	0.081	19.2	0.082
15.7	0.089	17.7	0.088	19.7	0.093	13.5	0.105	12.5	0.085	9.1	0.11	5.8	0.088	16.1	0.086	32	0.069	2.6	0.090	5.8	0.084	18.0	0.085
14.6	0.09	17.3	0.09	18.1	0.095	13.0	0.108	11.2	0.088	8.9	0.114	4.6	0.096	14.4	0.087	30.6	0.077	2.4	0.092	4.9	0.087	16.7	0.087
13.3	0.091	16.9	0.093	16.8	0.097	12.5	0.112	10.3	0.089	8.7	0.116	4.3	0.098	13.1	0.09	29.2	0.078	2.3	0.094	3.5	0.090	15.2	0.088
11.9	0.098	16.5	0.095	14.8	0.098	12.0	0.115	9.7	0.091	8.6	0.119	4.3	0.100	11.9	0.091	27.8	0.080	2.1	0.096	3.0	0.093	13.8	0.09
10.9	0.1	11.4	0.099	13.3	0.099	8.4	0.12	8.7	0.092	5.8	0.121	4.3	0.102	11.1	0.093	26.4	0.081	1.9	0.097	2.7	0.094	12.8	0.092
10.0	0.103	10.5	0.101	12.4	0.100	7.2	0.124	7.8	0.093	5.2	0.125	4.3	0.103	10.6	0.094	24.6	0.082	1.8	0.098	2.6	0.095	12.2	0.094
9.0	0.106	10	0.103	11.1	0.101	6.6	0.127	6.6	0.094	5.1	0.127	4.3	0.105	10.0	0.096	23.4	0.083	0.6	0.101	2.6	0.096	11.4	0.095
8.1	0.108	9.8	0.107	9.8	0.102	6.3	0.131	6.0	0.096	5.2	0.131	4.3	0.106	9.3	0.096	22.9	0.085	0.2	0.102	2.5	0.097	10.5	0.096

SCB Test Results on CBR Equipment 04-19-14 48 Hour Curing

Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ
041713RSA#1		041713RSA#2		041713RSB#1		041713RSB#2		041713RSC#1		041713RSC#2		041713EEA#1		041713EEA#2		041713EEB#1		041713EEB#2		041713EEC#1		041713EEC#2	
3.9	0.0090	6.2	0.014	5.2	0.0180	1.1	0.0140	6.8	0.0070	2.1	0.009	1.5	0.013	3.5	0.011	2.1	0.001	2.1	0.012	2.6	0.006	5.3	0.012
6.3	0.0160	7.1	0.016	5.6	0.0180	9.5	0.0150	10.5	0.0180	2.1	0.012	5.6	0.013	3.7	0.012	2.2	0.002	7.2	0.021	7.1	0.014	6.1	0.012
6.5	0.0170	8.0	0.018	5.9	0.0180	9.7	0.0170	11.2	0.0200	2.1	0.014	6.6	0.022	4	0.012	2.4	0.003	7.5	0.023	7.8	0.015	7.1	0.012
6.7	0.0180	8.9	0.02	6.2	0.0180	10.0	0.0180	24.3	0.0210	5.3	0.015	6.8	0.024	8.6	0.012	2.6	0.005	7.7	0.024	8.9	0.015	8.6	0.012
6.8	0.0190	9.8	0.023	21.6	0.0330	10.2	0.0200	27.3	0.0240	6.2	0.016	14.3	0.025	16.7	0.025	6.9	0.007	8	0.025	10	0.015	18.4	0.021
7.0	0.0200	10.7	0.024	24.7	0.0340	10.5	0.0210	31.8	0.0270	6.3	0.017	16.1	0.026	18.3	0.026	6.8	0.009	8.2	0.026	16.1	0.028	20.8	0.023
14.7	0.0210	11.6	0.026	27.3	0.0350	10.7	0.0230	36.1	0.0280	6.7	0.018	17.6	0.027	21	0.028	6.8	0.01	8.5	0.027	16.2	0.029	23.3	0.025
17.1	0.0230	12.5	0.026	30.9	0.0360	11.0	0.0240	41.1	0.0310	7.0	0.019	19.8	0.028	24.6	0.029	6.8	0.011	8.7	0.028	16.4	0.031	26.8	0.025
19.8	0.0240	17.2	0.026	35.5	0.0370	11.2	0.0250	47.3	0.0330	7.3	0.021	23.1	0.03	28.2	0.031	7	0.011	9	0.031	16.6	0.032	30.6	0.025
23.1	0.0250	28.7	0.035	38.9	0.0380	25.7	0.0260	55.3	0.0350	7.9	0.023	26.4	0.031	32.3	0.032	13.8	0.023	18.9	0.032	16.7	0.033	56.7	0.036
25.9	0.0310	32.5	0.036	44.4	0.0400	28.6	0.0270	63.5	0.0360	8.5	0.024	29.8	0.032	37.7	0.033	14.7	0.026	21.7	0.034	16.9	0.035	62.7	0.038
29.0	0.0320	37.1	0.037	49.5	0.0410	31.6	0.0280	72.8	0.0370	9.1	0.025	33.6	0.041	43.7	0.034	16	0.028	25	0.035	37.2	0.036	68.1	0.04
32.0	0.0340	38.8	0.038	55.2	0.0430	35.1	0.0370	82.0	0.0400	9.6	0.026	38.3	0.042	49.3	0.035	17.5	0.03	28.7	0.036	41	0.037	74.4	0.041
36.7	0.0350	41.8	0.04	61.7	0.0440	39.4	0.0380	90.7	0.0410	10.2	0.028	44.3	0.044	55.7	0.036	19.8	0.032	32.7	0.037	42.9	0.038	81.3	0.043
41.3	0.0360	45.3	0.042	69.5	0.0450	44.2	0.0410	96.9	0.0420	10.8	0.029	50.8	0.046	63.7	0.042	22	0.035	37.5	0.04	44.8	0.039	87.3	0.044
47.6	0.0370	49.8	0.044	77.6	0.0460	49.9	0.0430	102.7	0.0430	11.4	0.031	58.5	0.049	71.4	0.043	25	0.037	42.7	0.041	46.7	0.046	92.2	0.045
54.3	0.0400	54.9	0.045	86.1	0.0470	56.2	0.0440	109.6	0.0440	18.7	0.033	67.7	0.049	78.7	0.044	29.1	0.038	49.2	0.042	48.6	0.047	96.8	0.046
60.8	0.0400	60.5	0.047	93.4	0.0490	62.8	0.0460	116.9	0.0450	21.2	0.035	76.4	0.049	86.5	0.045	33.7	0.04	56.5	0.043	50.5	0.048	104	0.047
68.2	0.0400	66.1	0.049	99.4	0.0500	69.5	0.0470	123.5	0.0460	25.0	0.035	120.8	0.058	94.3	0.046	38.1	0.041	65.1	0.045	52.4	0.048	113.1	0.049
107.7	0.0500	71.9	0.05	106.1	0.0510	77.3	0.0490	128.7	0.0490	29.3	0.035	126.7	0.059	99.3	0.047	44.4	0.041	74.2	0.045	54.3	0.048	121.5	0.05
114.1	0.0500	78.5	0.052	111.2	0.0520	85.1	0.0510	132.6	0.0490	64.5	0.046	130.2	0.061	104.3	0.049	51.1	0.041	82.2	0.045	106.3	0.058	128.7	0.051
120.2	0.0500	84.7	0.053	116.1	0.0530	92.5	0.0510	134.6	0.0490	72.4	0.046	131.4	0.062	110.8	0.05	92.5	0.052	124.4	0.053	106.6	0.059	134.6	0.052
125.8	0.0500	91.7	0.053	120.4	0.0550	97.8	0.0510	131.2	0.0610	80.8	0.046	130.9	0.065	116.1	0.055	96.2	0.053	131	0.054	106.3	0.062	138.8	0.053
142.9	0.0620	97.1	0.053	124.2	0.0580	134.6	0.0610	130.6	0.0640	88.3	0.046	130.3	0.066	119.3	0.056	101.3	0.054	135.2	0.055	106	0.064	140.7	0.054
142.2	0.0630	132.1	0.062	126	0.0590	136.1	0.0620	75.8	0.0670	112.8	0.055	129.7	0.068	120.6	0.059	109.3	0.055	135.2	0.056	105.7	0.066	139.6	0.055
141.6	0.0660	135.4	0.064	126.5	0.0600	135.3	0.0640	65.1	0.0690	116.1	0.056	129.1	0.069	118.1	0.06	115.7	0.057	135.2	0.059	105.3	0.068	138.5	0.058
140.9	0.0680	137.0	0.066	126	0.062	134.5	0.0660	57.1	0.0710	118.0	0.059	128.5	0.071	115.6	0.061	120.7	0.057	135.2	0.06	105	0.071	137.4	0.059
140.2	0.0690	137.1	0.068	125.5	0.063	133.7	0.0680	50.8	0.0730	117.5	0.06	128	0.074	113.1	0.062	122.9	0.057	135.2	0.062	104.7	0.073	136.4	0.061
139.6	0.0700	137.0	0.069	125	0.066	132.8	0.0700	45.5	0.0770	117.0	0.062	127.4	0.076	110.7	0.064	115.5	0.072	135.2	0.064	46.6	0.075	135.3	0.062
138.9	0.0720	136.9	0.071	124.5	0.068	132.0	0.0720	40.9	0.0780	116.5	0.063	54.2	0.078	108.2	0.067	114.3	0.074	135.2	0.069	40.6	0.076	134.2	0.063
94.2	0.0750	136.9	0.073	124	0.07	131.2	0.0750	36.6	0.0800	116.0	0.064	45	0.079	105.7	0.068	41	0.076	135.2	0.071	35.5	0.078	133.2	0.064
81.4	0.0770	136.8	0.075	123.5	0.072	130.4	0.0770	33.1	0.0820	115.5	0.067	37.2	0.08	103.3	0.069	34.3	0.078	55.9	0.073	31.2	0.079	86.1	0.066
68.3	0.0790	136.7	0.077	79.4	0.075	82.6	0.0770	29.8	0.0850	115.0	0.069	31.5	0.082	49.1	0.071	29.6	0.08	48.6	0.076	27.6	0.08	76.3	0.067
59.5	0.0810	136.6	0.079	71.5	0.076	74.9	0.0770	26.9	0.0880	114.5	0.071	27.3	0.083	42.2	0.072	26.5	0.082	43.4	0.078	24	0.081	67.3	0.068
52.1	0.0820	89.6	0.081	65.6	0.078	45.0	0.0880	23.9	0.0900	71.6	0.072	23	0.085	37.2	0.073	24	0.083	40	0.079	20.9	0.082	60.1	0.069
46.9	0.0850	79.7	0.084	60.7	0.08	41.1	0.0900	21.7	0.0930	64.4	0.073	20.3	0.086	33.4	0.076	22.6	0.085	37.1	0.081	18.4	0.083	53.1	0.077
42.2	0.0860	69.7	0.086	55.8	0.082	38.2	0.0930	19.9	0.0950	59.3	0.076	18.9	0.088	29.7	0.077	21.5	0.088	34.5	0.084	16.6	0.09	46.1	0.079
39.1	0.0880	60.4	0.087	51.3	0.084	35.4	0.0940	18.7	0.0960	54.4	0.078	17	0.091	26.8	0.079	19.8	0.089	31.7	0.085	15	0.091	40	0.08
35.8	0.0890	53.1	0.089	47.3	0.086	33.0	0.0960	17.1	0.0980	50.3	0.08	15.2	0.092	25	0.081	18.4	0.09	29.4	0.087	13.5	0.093	35	0.081
33.3	0.0920	46.1	0.09	43.3	0.088	30.6	0.0970	16.0	0.1010	46.3	0.08	13.6	0.094	23.4	0.082	17.1	0.092	27.6	0.089	11.8	0.094	31	0.082
30.3	0.0940	40.9	0.093	40.1	0.089	28.6	0.0990	14.6	0.1020	42.7	0.08	11.2	0.096	21.7	0.085	16.2	0.094	26	0.09	10	0.097	27.9	0.084
27.6	0.0950	36.3	0.095	37	0.092	26.2	0.1010	13.9	0.1030	26.1	0.09	9.6	0.097	20.3	0.087	15.2	0.096	24	0.093	8.6	0.098	25.4	0.085
25.0	0.0970	33.0	0.097	34.2	0.094	24.5	0.1020	12.9	0.1050	24.5	0.09	8.6	0.1	19.7	0.089	14.2	0.097	22	0.094	7.4	0.099	23.3	0.086
22.7	0.0980	30.4	0.098	31.4	0.095	22.2	0.1030	12.3	0.1060	22.6	0.09	7.3	0.101	19	0.092	13.4	0.098	20.1	0.095	6.8	0.1	21.7	0.087
21.0	0.0990	28.0	0.101	28.7	0.097	20.5	0.1040	11.4	0.1080	21.7	0.09	6.8	0.102	18.4	0.094	13.1	0.099	19	0.096	6.3	0.1	20.3	0.088
19.4	0.1010	25.9	0.103	26	0.099	18.9	0.1050	11.0	0.1100	18.6	0.101	6.2	0.103	17.7	0.095	12.8	0.101	18	0.098	1.9	0.108	19.1	0.09
18.4	0.1020	24.1	0.105	23.8	0.101	17.8	0.1060	10.5	0.1110	18.2	0.103	5.2	0.105	17	0.096	12.4	0.104	16.7	0.099	1.7	0.11	17.8	0.092
16.6	0.1030	22.6	0.106	21.5	0.102	15.8	0.107	10.1	0.1120	17.8	0.105	4.9	0.106	16.4	0.097	12.1	0.106	15.5	0.101	1.4	0.11	16.9	0.094
15.6	0.1040	21.0	0.107	19.7	0.103	14.5	0.114	9.7	0.1130	15.2	0.106	4.6	0.109	15.7	0.098	11.8	0.107	14	0.102	1	0.11	16.4	0.096
14.2	0.1050	19.8	0.11	18.1	0.105	12.9	0.116	9.3	0.1140	15.0	0.108	4.2	0.109	11.4	0.099	11.4	0.108	12.8	0.103	0.6	0.123	15.7	0.097
13.6	0.1060	18.2	0.112	17.1	0.107	11.9	0.118	8.9	0.1160	14.8	0.11	4.4	0.109	10.5	0.101	11.1	0.109	12.1	0.104	0.3	0.124	14.8	0.099
12.7	0.1130	17.0	0.115	15.6	0.108	11.0	0.119	8.5	0.1180	14.7	0.112	3	0.123	9.6	0.102	8.4	0.111	11.7	0.106	0.5	0.125	13.8	0.101
12.2	0.1150	15.6	0.116	14.9	0.111	10.5	0.121	7.0	0.1190	14.5	0.113	1.2	0.124	9.5	0.121	8.5	0.113	11.3	0.106	0.7	0.126	12.8	0.102
11.5	0.1180	15.0	0.118	13.9	0.111	10.0	0.122	6.8	0.1200	14.3	0.115	1.1	0.127	9.2	0.123	8.4	0.114	10.9	0.106	0.8	0.128	11.9	0.103
10.8	0.1190	14.3	0.12	13	0.111	9.5	0.1240	6.5	0.121	14.2	0.118	1.2	0.128	9	0.127	8.3	0.115	6.2	0.113	0.9	0.13	11.1	0.104
10.5	0.1200	13.7	0.121	9.9	0.123	9.0	0.1270	6.3	0.122	14.0	0.119	1.1	0.13	8.7	0.129	8.2	0.116	5.6	0.114	0.7	0.132	10.5	0.105
10.3	0.1220	13.0	0.123	9.5	0.125	8.5	0.1290	6.0	0.123	11.0	0.12	1	0.131	8.5	0.132	8.1	0.116	5.1	0.114	0.6	0.133	10.1	0.106
10.0	0.1230	12.4	0.125	9.1	0.127	8.0	0.1300	5.8	0.124	10.5	0.122	0.9	0.132	8.2	0.136	4.6	0.124	4.8	0.114	0.7	0.135	9.6	0.108
9.8	0.1250	11.7	0.127	6.9	0.128	7.5	0.1320	5.5	0.125	10.2	0.124	0.8	0.135	8	0.14	4.5	0.125	2.5	0.125	0.7	0.136	9	0.11
9.6	0.1280	11.0	0.129	6.5	0.13	5.4	0.1330	5.3	0.127	10.0	0.125	0.7	0.136	7.7	0.144	4.4	0.125	2.3	0.127	0.8	0.139	8.6	0.111
9.3	0.1290	7.7	0.132	6.1	0.131	5.2	0.1360	4.4	0.129	9.5	0.127	0.7	0.137	6.2	0.148	4.4	0.125	2.1	0.129	0.9	0.141	7.8	0.113
9.1	0.1310	7.3	0.134	5.2	0.133	5.0	0.1370	3.9	0.131	9.1	0.128	0.1	0.139	5.3	0.15	2.3	0.135	2	0.13	0.7	0.143	7.2	0.114
7.3	0.1320	6.5	0.138	4.7	0.134	4.9	0.1390	3.5	0.133	8.9	0.129	0.5	0.14	5.2	0.154	2.7	0.136	1.8	0.132	0.5	0.144	6.8	0.115
7.4	0.1340	6.2	0.141	4.3	0.136	4.7	0.1400	3.4	0.136	8.7	0.13	0	0.143	5.3	0.158	2.7	0.137	2	0.132	0.4	0.146	6.8	0.118
7.3	0.1360	5.5	0.145	3.8	0.136	4.5	0.1420	3.3	0.138	8.6	0.131	-0.2	0.143	5.2	0.16	2.7	0.139	2.1	0.132	0.5	0.15	6.7	0.12
7.2	0.1380	5.4	0.148	3.7	0.136	4.4	0.1440	3.2	0.139	8.4	0.132	0.1	0.143	5.1	0.164	2.7	0.14	2.1	0.144	0.6	0.151	6.6	0.121
7.2	0.1400	5.4	0.151	3.2	0.144	4.2	0.1450	3.1	0.14	8.2	0.139	-0.2	0.154	5	0.166	2.7	0.141	1.8	0.146	0.7	0.152	6.5	0.123
7.1	0.1420	5.4	0.154	0.9	0.145	3.1	0.1470	3.0	0.141	8.1	0.14	-0.2	0.155	4.9	0.168	2.7	0.142	1.4	0.147	0.5	0.153	6.4	0.124
7.0	0.1440	5.4	0.157	0.5	0.147	3.7	0.1500	3.0	0.144	7.9	0.141	-0.2	0.156	4.9	0.171	2.7	0.143	1.2	0.148	0.2	0.154	6.3	0.125
6.9	0.1460	5.4	0.158		0.148	3.0	0.1510	2.9	0.145	7.1	0.144	-0.5	0.157	4.8	0.174	2.7	0.15	1.2	0.15	0.2	0.155	6.3	0.128

SCB Test Results on CBR Equipment 04-26 48 Hour Curing

042413PAA#1		042413PAA#2		042413PAB#1		042413PAB#2		042413PAC#1		042413PAC#2		042413SSA#1		042413SSA#2		042413SSB#1		042413SSB#2		042413SSC#1		042413SSC#2	
4.9	0.004	5.4	0.027	6.5	0.02	7.6	0.006	6.6	0.024	5.5	0.017	22	0.022	17.1	0.026	6.3	0.021	5.8	0.016	11.9	0.01	5	0.005
9	0.014	5.8	0.027	6.6	0.02	8.5	0.006	6.6	0.024	6.8	0.017	23.5	0.024	21	0.026	6.5	0.021	7.2	0.016	13.4	0.011	5.5	0.007
9.6	0.015	6.1	0.027	6.7	0.02	9.2	0.006	113.8	0.028	112.3	0.022	23.6	0.025	25.3	0.026	21.2	0.021	39.5	0.018	15.1	0.011	6.5	0.007
21.2	0.015	21.3	0.035	6.8	0.02	22.5	0.011	117.9	0.029	121.2	0.024	23.8	0.027	30.2	0.026	24.1	0.021	51.1	0.019	16.8	0.011	17.8	0.017
24.1	0.015	23.4	0.035	19.8	0.025	24.8	0.012	121.1	0.032	129.5	0.024	24	0.025	68	0.027	114.3	0.029	53.4	0.019	42	0.016	17.9	0.019
56.6	0.024	26.2	0.035	22.7	0.027	26.8	0.012	121.8	0.033	136.5	0.024	24.1	0.027	155.4	0.036	123.4	0.03	67.8	0.027	47.5	0.016	18	0.019
64.1	0.026	29.8	0.035	25.3	0.025	28.9	0.012	121.6	0.034	144.4	0.036	119.2	0.029	154.1	0.039	132.2	0.031	103.3	0.028	53.4	0.016	18	0.019
72.2	0.027	30.6	0.037	28.1	0.027	122.4	0.016	121.5	0.036	143.6	0.037	126.8	0.03	152.8	0.04	139.7	0.033	111.4	0.03	59.9	0.016	47.1	0.026
80.5	0.028	27.6	0.038	46.8	0.036	129.9	0.017	121.3	0.037	142.9	0.039	133.8	0.032	151.4	0.042	145.3	0.034	118.8	0.031	98.1	0.021	51.6	0.026
88.7	0.030	24.8	0.039	40.3	0.038	136.4	0.018	121.1	0.038	142.1	0.041	139.3	0.033	150.1	0.043	147.2	0.036	125.4	0.033	106.1	0.022	56.2	0.026
96.8	0.031	22.0	0.04	35.1	0.04	141.1	0.019	121	0.041	69.6	0.043	143	0.035	148.8	0.044	144.8	0.037	131.4	0.034	114.9	0.023	61.8	0.026
103.5	0.032	17.2	0.046	31.2	0.042	144	0.02	120.8	0.043	58.9	0.045	144.5	0.036	147.5	0.047	142.4	0.038	136.5	0.036	123.4	0.023	127.4	0.035
108.7	0.033	16.4	0.054	27.9	0.044	144.4	0.021	120.6	0.044	50.3	0.046	142.3	0.037	74	0.049	140	0.04	140	0.036	131.2	0.023	129.5	0.036
111.3	0.036	15.2	0.058	24.9	0.045	144	0.024	72.5	0.045	42.8	0.047	140.1	0.038	65.3	0.05	137.6	0.041	141.5	0.036	140.8	0.036	127.6	0.037
111.2	0.037	14.1	0.062	22.2	0.047	143.6	0.026	61.2	0.046	36.2	0.048	137.9	0.04	57.6	0.051	135.2	0.043	135.1	0.048	140.5	0.039	125.7	0.038
111	0.039	12.8	0.066	19.8	0.048	143.2	0.028	51	0.047	31.2	0.049	135.6	0.041	50.6	0.053	132.8	0.045	134	0.051	140.2	0.042	123.8	0.039
110.8	0.040	11.5	0.071	17	0.05	142.8	0.029	42.6	0.049	27.6	0.05	133.4	0.042	44.1	0.054	130.4	0.047	70.1	0.052	139.8	0.046	121.9	0.041
110.7	0.043	10.2	0.075	14.2	0.051	142.4	0.032	36.2	0.05	24.8	0.051	131.2	0.044	38.3	0.056	71.2	0.048	59.5	0.054	35.1	0.049	120	0.043
110.5	0.045	9.2	0.08	11.6	0.054	142	0.035	31.1	0.051	22.6	0.06	129	0.045	33.5	0.058	64.2	0.05	51.1	0.056	29.6	0.051	118.1	0.044
110.3	0.047	8.6	0.084	9.9	0.054	60.5	0.037	26.8	0.058	21	0.062	56.2	0.046	29.9	0.059	58.5	0.051	45.1	0.059	25.6	0.056	116.2	0.045
110.2	0.049	7.7	0.087	8.7	0.054	46	0.04	23.4	0.06	19.3	0.064	47.7	0.047	26.7	0.06	53	0.054	40.3	0.061	22.6	0.059	43.9	0.046
48.1	0.050	6.9	0.091	5.9	0.061	36.6	0.043	20.4	0.06	17.5	0.065	41.1	0.048	24.1	0.062	47.9	0.055	36.2	0.063	20	0.064	38.4	0.047
41.8	0.053	6.3	0.094	5.9	0.064	30.5	0.046	17.8	0.06	16.1	0.066	36.5	0.056	22.2	0.063	42.9	0.057	33.2	0.065	18	0.066	33.8	0.05
36.6	0.054	5.9	0.099	5.9	0.066	25.7	0.05	9.6	0.068	14.5	0.067	33	0.057	20.2	0.065	38.4	0.058	30.5	0.068	16	0.068	29.6	0.051
31.8	0.056	5.7	0.101	5.9	0.068	22.1	0.053	8.5	0.069	12.9	0.069	30	0.059	18.4	0.066	34	0.06	28.3	0.07	14.2	0.072	26.1	0.053
27.3	0.057	5.4	0.106	5.9	0.071	19.1	0.055	7.7	0.07	11.7	0.069	27.7	0.061	16.6	0.068	30	0.06	26.3	0.073	12.6	0.076	23.1	0.054
23.8	0.059	5.1	0.108	5.9	0.074	16.1	0.056	7.2	0.071	10.1	0.069	25.4	0.062	15.2	0.07	26.3	0.06	24.2	0.077	11	0.078	20.8	0.055
21	0.061	4.9	0.111	2.3	0.076	13.3	0.058	6.3	0.071	4.8	0.076	23.4	0.064	13.9	0.073	13.6	0.073	22.6	0.08	9.6	0.082	19.3	0.057
18.6	0.063	4.8	0.114	2.1	0.079	11.4	0.059	5.8	0.078	4.3	0.077	21.8	0.065	12.4	0.073	12.6	0.074	21.2	0.083	8.5	0.085	17.7	0.059
16.6	0.064	4.8	0.117	2	0.082	10	0.06	5.8	0.079	3.8	0.08	20.3	0.066	11.3	0.073	11.4	0.076	20.1	0.087	7.6	0.089	16.3	0.061
14.7	0.065	4.8	0.119	1.9	0.084	8.9	0.061	5.8	0.08	3.3	0.081	18.6	0.067	6.9	0.082	10	0.076	18.5	0.091	6.9	0.091	15.1	0.061
12.8	0.067	4.8	0.122	1.7	0.088	7.7	0.062	5.8	0.08	2.4	0.082	16.9	0.068	6.3	0.082	8.9	0.076	17	0.095	6.3	0.094	13.3	0.061
11.4	0.070	4.8	0.124	2	0.09	7	0.063	4.1	0.08	2.4	0.083	15.1	0.071	5.9	0.082	5.1	0.088	15.3	0.098	6	0.097	7.3	0.071
10.2	0.071	4.8	0.125	2	0.093	6.4	0.072	3.2	0.09	2.4	0.085	13.4	0.072	5.4	0.082	4.8	0.089	13.9	0.101	5.8	0.1	6.2	0.072
9.2	0.072	4.8	0.127	2	0.097	5.8	0.073	3.1	0.093	2.4	0.087	12.1	0.074	4.3	0.093	4.4	0.09	12.7	0.105	5.4	0.102	5.2	0.073
8.5	0.074	4.8	0.128	2	0.1	5.1	0.075	3	0.095	2.4	0.089	11	0.074	4.2	0.094	4	0.092	11.4	0.109	4.8	0.104	4.4	0.074
7.6	0.075	5.1	0.13	2	0.103	4.7	0.076	3.1	0.097	2.4	0.09	9.9	0.074	4.1	0.095	3.7	0.095	10.4	0.113	4.7	0.107	3.8	0.074
7	0.078	5.4	0.132	2	0.106	4.6	0.077	3.2	0.101	2.4	0.092	4.8	0.082	4	0.095	3.5	0.097	9.5	0.117	4.5	0.11	3	0.081
6.6	0.079	5.7	0.133	2	0.107	4.5	0.079	3.3	0.103	2.4	0.094	4.5	0.082	4	0.095	3.4	0.099	8.9	0.121	4.2	0.112	2.9	0.083
6.1	0.081	5.6	0.134	2	0.109	4.4	0.081	3.3	0.106	2.4	0.097	4	0.082	2.1	0.113	3.1	0.1	8.6	0.124	3.8	0.116	2.7	0.085
5.8	0.082	5.5	0.135	1.1	0.111	4.4	0.085	3.3	0.108	2.4	0.098	3.9	0.082	2.1	0.117	2.9	0.1	8.4	0.127	3.7	0.117	-0.1	0.087
5.8	0.084	5.4	0.137	1	0.112	4.3	0.087	3.3	0.113	1.2	0.099	3.5	0.094	2	0.121	2.6	0.1	8.1	0.131	3.6	0.118	-0.1	0.089
5.7	0.084	5.2	0.14	0.9	0.115	4.2	0.087	3.3	0.116	0.9	0.101	3.5	0.096	1.9	0.124	0.6	0.123	7.6	0.133	3.5	0.119	-0.1	0.09
5.6	0.084	5.0	0.142	0.7	0.117	4.1	0.087	3.3	0.12	0.8	0.103	3.4	0.097	1.8	0.128	0.2	0.126	7.6	0.135	3.3	0.12	-0.1	0.092
3.6	0.094	4.9	0.143	0.7	0.118	0.1	0.097	3.3	0.123	0.9	0.103	1.6	0.099	1.7	0.13	0	0.129	7.6	0.139	3	0.121	-0.1	0.096
3.4	0.094	4.7	0.144	0.6	0.119	0.2	0.098	3.3	0.126	1.1	0.103	1.6	0.1	1.6	0.134	0.1	0.132	7.6	0.141	3.2	0.123	-0.1	0.099
3.5	0.094	4.5	0.145	0.5	0.12	0.4	0.099	1.6	0.131	1.1	0.116	1.6	0.101	1.6	0.137	0.1	0.134	7.6	0.144	3.2	0.124	-0.1	0.102
3.4	0.094	4.4	0.148	0.6	0.122	0.7	0.102	1.5	0.136	1.1	0.117	1.5	0.102	0	0.141	0.1	0.136	7.6	0.147	3.2	0.141	-0.1	0.105
3	0.102	3.6	0.149	0.7	0.123	0.7	0.103	1.4	0.14	1.1	0.119	1.4	0.105	-0.1	0.147	0.1	0.139	7.6	0.149	3.2	0.143	-0.5	0.106

SCB Test Results on CBR Equipment 05-11-14 48 Hour Curing											
050113CQA#1		050113CQA#2		050113CQB#1		050113CQB#2		050113CQC#1		050113CQC#2	
5.4	1.125	6.8	1.173	13.1	1.119	5.3	1.165	5.5	1.165	8.5	0.008
5.4	1.125	11.4	1.174	19.7	1.127	5.2	1.165	13.2	1.169	10.1	0.008
20	1.134	12.4	1.175	22.1	1.129	5.3	1.165	14.7	1.169	32.4	0.015
22.7	1.136	13.6	1.176	24.6	1.13	5.4	1.167	16.8	1.169	37.1	0.014
26.4	1.137	15.1	1.177	27.8	1.131	5.4	1.168	19	1.169	42.3	0.015
30.1	1.138	16.7	1.18	31.5	1.132	5.4	1.168	43	1.173	47.9	0.014
34.4	1.139	18.9	1.18	35.9	1.134	32	1.175	55.9	1.172	39.4	0.024
39.6	1.140	21.8	1.18	41	1.134	36.5	1.176	131.8	1.181	33	0.026
45.1	1.141	39.0	1.188	46.3	1.134	42.2	1.177	130.7	1.182	28.5	0.027
51.5	1.142	43.6	1.188	93.6	1.144	48.8	1.179	67.1	1.184	25.4	0.028
58.9	1.144	48.8	1.188	101.2	1.145	64.4	1.179	58.5	1.186	23.6	0.028
66.8	1.145	54.7	1.188	109.3	1.146	119.1	1.186	51.7	1.189	22.1	0.028
75	1.146	95.9	1.193	117.9	1.147	126.9	1.188	46	1.191	15.7	0.035
83.7	1.148	104.5	1.193	127.2	1.148	133.7	1.189	41.4	1.193	15	0.035
92.7	1.148	113.6	1.193	136.5	1.149	138.7	1.19	37.7	1.195	14.1	0.035
101.6	1.148	122.9	1.193	145.2	1.15	140.7	1.192	34.3	1.198	13.2	0.035
146.2	1.158	152.7	1.2	153.3	1.151	138.9	1.194	31	1.198	9.9	0.042
149.5	1.159	151.5	1.202	160.6	1.154	137.2	1.195	28.5	1.198	9.5	0.044
150.7	1.162	150.4	1.203	166.6	1.155	135.5	1.198	17.6	1.214	9.1	0.045
149	1.164	149.2	1.206	171.1	1.156	133.7	1.2	16.2	1.217	8.8	0.047
147.2	1.165	148.1	1.208	172.7	1.157	132	1.202	15.4	1.219	8.6	0.05
145.5	1.167	146.9	1.21	171	1.159	130.3	1.203	14.6	1.22	8.2	0.051
143.8	1.169	145.8	1.212	169.4	1.16	128.5	1.206	13.9	1.221	7.9	0.053
142.1	1.172	74.5	1.216	167.7	1.163	52.2	1.208	13.3	1.223	7.7	0.054
140.3	1.174	67.9	1.218	166.1	1.165	43.5	1.209	12.8	1.224	7.4	0.056
138.6	1.175	62.0	1.22	164.5	1.167	36.8	1.211	12.4	1.225	7.3	0.058
83.3	1.176	56.7	1.224	162.8	1.169	31.5	1.212	11.9	1.226	7.2	0.06
73.7	1.177	52.0	1.227	161.2	1.172	27.3	1.215	11.4	1.227	7.2	0.062
66.7	1.179	48.0	1.231	60.8	1.174	24.3	1.215	11	1.233	7.1	0.066
60.7	1.180	44.5	1.233	46.1	1.177	22.2	1.215	10.6	1.234	7	0.069
55.5	1.181	41.3	1.235	35.9	1.18	13.4	1.228	10	1.235	6.9	0.072
50.6	1.182	39.4	1.238	29.2	1.181	12.4	1.229	9.6	1.236	6.8	0.077
45.6	1.190	38.0	1.24	25	1.183	11.5	1.232	8.9	1.237	5.8	0.08
39.7	1.191	37.1	1.242	22	1.185	11	1.233	8.2	1.237	5.6	0.081
34.3	1.192	36.3	1.244	19.3	1.188	10.8	1.234	6.2	1.249	5.1	0.084
32	1.194	35.3	1.246	16.6	1.191	10.4	1.235	6	1.251	4.7	0.086
30	1.195	34.6	1.249	14.2	1.193	9.8	1.236	5.7	1.253	4.4	0.088
28.5	1.197	33.9	1.251	12.5	1.195	9.1	1.237	5.4	1.256	4	0.09
26.9	1.199	33.2	1.253	11	1.199	8.2	1.238	5.2	1.259	3.8	0.093
25.1	1.200	32.6	1.255	9.5	1.202	7	1.238	4.9	1.263	3.6	0.094
23.2	1.201	32.1	1.256	8.4	1.207	5.3	1.243	5.1	1.269	3.5	0.096
20.8	1.203	31.6	1.259	7.2	1.212	5.2	1.244	5.2	1.275	3.3	0.097
18.7	1.205	31.1	1.261	6	1.217	5.1	1.246	5.2	1.278	3.1	0.099
16.4	1.207	30.8	1.262	4.9	1.223	5	1.247	5.2	1.28	3	0.101
14.3	1.208	30.5	1.264	4	1.228	4.9	1.25	5.2	1.282	2.8	0.102
13.1	1.209	30.5	1.266	3.3	1.235	4.9	1.252	5.2	1.285	2.6	0.102
12	1.211	30.5	1.268	3	1.243	2.8	1.254	5.2	1.287	2	0.102
11.2	1.212	30.5	1.269	2.5	1.253	2.7	1.255	5.2	1.288	1.9	0.11
10.4	1.214	30.5	1.27	2	1.262	2.6	1.256	5.2	1.29	1.9	0.111
9.4	1.215	30.5	1.271	1.5	1.267	2.2	1.259	5.4	1.292	1.9	0.112

SCB Test Results on CBR Equipment 04-19-14 24 Hour Curing

Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ	Force	Δ
041813EEA#1		041813EEA#2		041813EEB#1		041813EEB#2		041813EEC#1		041813EEC#2		041813SSA#1		041813SSA#2		041813SSB#1		041813SSB#2		041813SSC#1		041813SSC#2	
7.8	0.014	2.5	0.014	6.1	0.012	5.8	0.011	5	0.01	5.3	0.015	6.1	0	0	0.008	6	0.011	8.4	0.014	2.4	0.006	1.9	0.009
8.9	0.015	24	0.024	15.2	0.013	6.3	0.012	5.6	0.012	5.1	0.015	8.5	0.001	7.2	0.016	17.8	0.021	8.7	0.016	2.6	0.006	7.2	0.017
11	0.015	26.8	0.026	16.6	0.014	7.1	0.014	5.8	0.014	5.3	0.015	10.2	0.002	7.3	0.016	20	0.021	8.9	0.017	2.7	0.006	7.5	0.019
12.9	0.015	29.6	0.027	17.4	0.016	7.2	0.014	6.1	0.014	13.8	0.026	11	0.003	7.4	0.016	22.4	0.021	9.2	0.018	2.9	0.006	7.7	0.02
27.2	0.025	31.9	0.029	17.8	0.017	17.1	0.029	6.3	0.014	15.1	0.028	12	0.004	7.5	0.016	24.8	0.021	9.4	0.02	12.6	0.017	8	0.023
29.1	0.026	35.7	0.031	18.5	0.018	19.1	0.032	7.8	0.023	16.9	0.029	13.2	0.005	27.9	0.029	39.7	0.031	28.5	0.021	15	0.018	8.2	0.024
30.4	0.028	39.2	0.032	20	0.028	21.6	0.034	16.3	0.025	19	0.031	14	0.014	31.4	0.031	42.7	0.032	33.1	0.024	17.3	0.02	8.5	0.025
31.7	0.031	43.2	0.033	21.5	0.03	23.8	0.035	19.3	0.026	22.9	0.033	15.5	0.017	35.2	0.033	45	0.033	37.6	0.025	19.8	0.021	20.2	0.026
33	0.032	47.5	0.034	23.1	0.033	26.1	0.037	21.8	0.027	26.9	0.034	17	0.018	39.1	0.035	46.3	0.035	42.4	0.026	22.5	0.023	23.2	0.028
34.3	0.033	52.7	0.035	25.4	0.035	29.3	0.04	25.4	0.029	32	0.035	17.7	0.02	43.2	0.035	45.9	0.036	47.7	0.027	25.9	0.024	27.2	0.029
35.7	0.034	57.6	0.036	28.4	0.037	32.2	0.042	30.1	0.032	37.3	0.037	17.7	0.022	47.1	0.035	45.5	0.038	53.6	0.029	29.5	0.025	32	0.032
37	0.035	63.8	0.037	31.9	0.038	36.8	0.043	35.3	0.033	42.7	0.038	17.7	0.024	63.2	0.048	45	0.039	58.8	0.032	31.5	0.026	37.2	0.033
38.3	0.037	68.3	0.038	35.3	0.039	41.9	0.045	40.4	0.034	48.6	0.04	17.7	0.026	62.7	0.051	44.6	0.041	63.5	0.033	27.7	0.027	41.3	0.034
55.5	0.04	72.5	0.04	40.3	0.042	47.1	0.047	45.3	0.036	53.7	0.041	17.7	0.028	62.3	0.053	44.2	0.042	66.9	0.035	31.4	0.028	45.7	0.036
59.5	0.041	76	0.042	44.7	0.044	51.9	0.051	51.1	0.038	59.3	0.042	17.7	0.028	61.8	0.054	43.8	0.045	69.4	0.036	36.6	0.035	50.2	0.037
63.6	0.042	78.1	0.043	49.6	0.045	56.7	0.052	56.7	0.04	63.9	0.044	17.7	0.028	61.3	0.056	43.4	0.046	69.6	0.038	42	0.036	53.3	0.038
67.3	0.044	80.5	0.045	54.6	0.047	61.4	0.054	62.7	0.042	67.9	0.045	37.6	0.039	60.8	0.059	14.6	0.046	69.6	0.041	47.6	0.038	55	0.041
69.8	0.045	81.3	0.046	59.8	0.048	64.9	0.056	67.8	0.043	69.6	0.047	40.4	0.041	60.3	0.061	11.1	0.046	69.6	0.042	52.4	0.04	54.5	0.042
73	0.046	81.2	0.047	64	0.051	68.7	0.058	72.4	0.044	69.3	0.049	43.6	0.044	30.7	0.062	2.4	0.061	69.6	0.043	58.3	0.04	54	0.044
74.9	0.047	81.1	0.05	66.7	0.052	71	0.06	76.8	0.045	68.9	0.051	47.1	0.045	26	0.063	2.2	0.062	69.6	0.044	63.2	0.04	53.5	0.045
76.1	0.049	81	0.051	67.3	0.053	72	0.062	79.8	0.046	68.6	0.052	50.9	0.047	22.9	0.064	2.1	0.062	69.6	0.045	66.3	0.052	53	0.046
76.3	0.05	80.9	0.053	66.7	0.055	71	0.064	81.9	0.047	68.3	0.054	54.4	0.047	20	0.065	2	0.062	69.6	0.046	65.7	0.053	52.5	0.049
76.1	0.051	80.9	0.055	66.1	0.056	70	0.067	80.9	0.049	67.9	0.056	57.8	0.047	17.5	0.066	2	0.072	69.6	0.047	65.1	0.054	52	0.051
75.9	0.052	80.8	0.058	65.5	0.057	69	0.069	80	0.05	67.6	0.059	64.7	0.059	15.5	0.068	2	0.073	39.1	0.049	64.6	0.056	51.6	0.051
75.8	0.053	80.7	0.06	65	0.059	68	0.071	79	0.051	67.3	0.06	63.8	0.062	13.7	0.069	2	0.074	33.7	0.05	30.6	0.059	23.8	0.051
75.6	0.054	33.7	0.062	64.4	0.061	67	0.073	78	0.052	28.6	0.062	62.9	0.064	11.8	0.08	1.6	0.076	28.9	0.056	26	0.061	9.9	0.064
75.4	0.06	28.8	0.064	63.8	0.063	66	0.075	77	0.053	23.5	0.063	62	0.065	10	0.082	1.3	0.078	24.5	0.056	21.8	0.062	9.3	0.066
75.3	0.061	24.5	0.067	31.4	0.064	28.4	0.075	76	0.056	19.2	0.063	61.1	0.067	8.6	0.086	1.3	0.079	21.1	0.056	18.3	0.064	8.6	0.068
75.1	0.062	20.8	0.07	28.6	0.066	24.8	0.075	75	0.058	16.2	0.063	60.2	0.067	7.7	0.089	1.3	0.08	18.6	0.056	16	0.066	7.8	0.069
49.4	0.063	18	0.072	26.4	0.068	11.7	0.084	30.1	0.06	6.5	0.073	24.6	0.067	7	0.092	1.3	0.082	11.6	0.067	13.9	0.068	7.3	0.07
44.8	0.064	15.2	0.076	24.3	0.07	11	0.085	26	0.061	6.3	0.075	10.2	0.079	6.3	0.095	1.3	0.083	10.7	0.068	12.3	0.07	7	0.072
39.4	0.066	13.3	0.08	22.4	0.072	10	0.087	22.3	0.063	6	0.076	8.7	0.081	6	0.098	1.3	0.085	9.3	0.068	10.9	0.071	6.8	0.075
33.8	0.067	11.1	0.084	20.5	0.073	9.3	0.089	19.8	0.064	5.8	0.077	7.5	0.083	6	0.1	1.3	0.087	8.6	0.068	9.8	0.072	6.5	0.076
28.1	0.068	10.6	0.086	18.9	0.074	8.3	0.09	18	0.066	5.5	0.079	6.4	0.083	6	0.103	1.3	0.089	2.6	0.075	8.6	0.075	6.1	0.077
23.7	0.077	9.7	0.089	17.4	0.077	7.7	0.09	16.3	0.067	5.3	0.081	5.6	0.083	6	0.105	1.3	0.091	2.1	0.076	7.7	0.076	6.2	0.079
18.9	0.079	8.9	0.093	16.5	0.078	7.1	0.09	15	0.069	5	0.082	4.6	0.094	6	0.107	1.3	0.092	1.8	0.078	7	0.077	6.1	0.081
15.7	0.081	7.8	0.096	15	0.08	5.6	0.106	13	0.071	4.8	0.085	4.4	0.096	6	0.112	1.3	0.093	1.5	0.079	6.3	0.078	6	0.082
13.3	0.084	7.9	0.098	13.7	0.082	5.4	0.107	11.4	0.073	4.5	0.086	4.3	0.097	6	0.114	1.3	0.094	1.3	0.08	5.6	0.08	5.9	0.084
11.6	0.086	7.8	0.102	12.4	0.085	5.3	0.108	9.7	0.077	4.4	0.087	4.1	0.099	6	0.114	1.3	0.097	1.1	0.082	5.2	0.081	5.8	0.085
10.5	0.088	7.7	0.105	11.6	0.086	5.1	0.11	8.5	0.08	4.5	0.088	2.6	0.1	6	0.114	1.3	0.098	1.2	0.084	4.5	0.082	5.8	0.086
9.6	0.089	7.7	0.107	10.1	0.088	4.9	0.111	7.8	0.082	4.4	0.09	2.8	0.101	2.3	0.12	1.3	0.099	1.2	0.085	4.2	0.085	5.7	0.087
9	0.092	7.6	0.111	9.1	0.089	4.8	0.112	6.9	0.086	4.4	0.09	3.1	0.104	2.3	0.12	1.3	0.101	1.2	0.087	3.6	0.088	3.4	0.088
8.4	0.093	7.5	0.114	7.9	0.091	4.6	0.113	6.8	0.088	4.3	0.09	3.1	0.105	2.3	0.12	0.4	0.104	1.2	0.088	2.9	0.09	3.1	0.089
8.2	0.094	7.4	0.116	7.4	0.092	2.3	0.114	6.6	0.093	1.9	0.097	3.1	0.107	2.3	0.12	0.2	0.107	1.2	0.09	2.7	0.093	2.9	0.094
8.1	0.095	5.7	0.119	6.6	0.095	1.9	0.124	6.4	0.097	1.9	0.098	3.1	0.108	1	0.129	-0.2	0.108	1.2	0.092	2.6	0.095	2.6	0.095
7.9	0.096	5.1	0.121	5.8	0.096	1.8	0.127	6.3	0.103	1.9	0.099	3.1	0.11	1	0.13	-0.1	0.11	1.2	0.094	2.6	0.097	2.5	0.096
7.7	0.097	5.4	0.123	5.7	0.097	1.7	0.129	6.1	0.108	1.9	0.102	3.1	0.111	1	0.131	-0.2	0.111	1.2	0.095	2.5	0.098	2.3	0.098
7.6	0.098	5.2	0.127	5.5	0.098	1.8	0.131	5.9	0.115	1.9	0.104	3.1	0.113	1	0.133	-0.2	0.114	1.2	0.096	2.4	0.099	2	0.099
7.4	0.099	5.3	0.129	5.4	0.099	1.7	0.134	5.8	0.118	1.9	0.106	3.1	0.114	1	0.134	-0.1	0.116	0.7	0.097	2.3	0.101	1.8	0.101
7.2	0.101	5.2	0.131	5.2	0.1	1.6	0.137	3.6	0.121	1.9	0.108	2.1	0.116	1	0.137	0	0.118	0.6	0.098	2.2	0.102	1.5	0.103
5.4	0.108	5.1	0.132	5.2	0.101	1.6	0.139	3.2	0.123	1.9	0.11	2.3	0.117	1	0.139	0.1	0.119	0.8	0.099	2.1	0.103	1.4	0.104
5.8	0.108	5	0.133	5.2	0.103	1.5	0.142	3.5	0.127	0.7	0.112	2.3	0.118	1	0.141	0.2	0.12	0.6	0.101	1.7	0.104	1.2	0.105
5.2	0.108	4.9	0.136	5.2	0.104	1	0.146	3	0.129	0.5	0.114	2.3	0.119	1	0.143	0.2	0.123	0.3	0.102	1.6	0.105	1.1	0.106
5.4	0.108	4.7	0.137	5.2	0.105	0.8	0.148	3.1	0.131	0.6	0.116	2.3	0.122	1	0.146	0.3	0.125	0.2	0.103	1.6	0.111	0.8	0.107
4.5	0.124	4.5	0.138	5.2	0.123	1	0.151	3	0.132	0.5	0.118	2.3	0.123	1	0.148	0.2	0.127	0.3	0.114	1.6	0.112	1	0.108
4.4	0.125	4.4	0.138	5.2	0.124	0.8	0.154	3	0.133	0.6	0.119	2.3	0.124	1	0.15	0.2	0.128	0.2	0.116	1.6	0.114	0.9	0.111
4	0.128	4.2	0.138	5.2	0.126	0.7	0.156	2.9	0.134	0.5	0.12	2.3	0.125	1	0.153	0.1	0.13	0.1	0.118	1.6	0.115	0.8	0.112
3.9	0.129	2.2	0.144	2.8	0.129	0.7	0.158	2.8	0.136	0.4	0.121	2.3	0.127	1	0.156	0	0.131	0	0.12	1.6	0.118	0.7	0.113
3.6	0.131	2.1	0.144	2.4	0.131	0.7	0.16	2.7	0.137	0.3	0.122	1.3	0.128	1	0.158	0	0.133	-0.1	0.121	1.6	0.12	0.7	0.115
3.1	0.132	2.1	0.144	2.4	0.132	0.7	0.163	2.6	0.138	0.2	0.123	1.6	0.131	1	0.159	0	0.134	-0.1	0.123	1.6	0.121	0.7	0.118
3.3	0.134	1.9	0.144	2.4	0.133	0.7	0.165	2.2	0.139	0.2	0.124	1.6	0.132	1	0.161	0	0.135	-0.1	0.124	1.6	0.122	0.7	0.119
3.1	0.136	1.3	0.148	2.4	0.134	0.7	0.167	2	0.151	0.1	0.127	1.6	0.133	1	0.162	0	0.137	0.1	0.127	1	0.124	0.7	0.121
2.9	0.137	1.4	0.15	2.4	0.135	0.7	0.169	2.4	0.154	0	0.129	1.5	0.134	1	0.164	0	0.139	0.4	0.128	0.8	0.125	0.7	0.122
3	0.139	1.4	0.153	2.4	0.137	0.7	0.172	2.1	0.156	-0.1	0.13	1.4	0.136	1	0.165	0	0.141	0.4	0.13	0.8	0.127	0.7	0.123
3	0.141	1.4	0.155	2.4	0.138	0.7	0.174	2.5	0.158	-0.2	0.131	1.3	0.137	1	0.166	0	0.142	0.4	0.131	0.8	0.129	0.7	0.125
3	0.144	1.4	0.157	2.4	0.139	0.7	0.175	2.4	0.16	-0.2	0.133	1.2	0.139	1	0.167	0	0.143	0.6	0.132	0.8	0.131	0.7	0.128
3	0.145	1.4	0.159	1.9	0.148	0.7	0.177	2.2	0.163	-0.3	0.134	1.2	0.141	1	0.168	0	0.145	0.8	0.134	0.8	0.132	0.6	0.13
3	0.147	1.4	0.162	1.9	0.15	0.7	0.179	2.3	0.165	-0.4	0.137	1	0.142	1	0.169	0	0.148	0.7	0.137	0.8	0.133	0.6	0.132
3	0.149	1.4	0.162	1.9	0.152	0.7	0.181	2.2	0.167	-0.5	0.138	1.2	0.144	0.7	0.177	0	0.149	0.6	0.138	0.8	0.136	0.6	0.133
3	0.15	1.4	0.162	1.9	0.153	0.7	0.182	2.3	0.169	-0.7	0.139	1.5	0.145	0.9	0.178	0	0.15	0.7	0.139	0.8	0.138	0.6	0.136

SCB Test Results on CBR Equipment 05-21-14 24 Hour Curing									
050213CQA#1		050213CQA#2		050213CQB#1		050213CQB#2	050213CQC#1	050213CQC#2	
13.8	1.242	20.5	1.168	10.2	1.208			6.8	1.155
23.7	1.249	39.9	1.172	11.8	1.208			6.9	1.155
26.7	1.249	46.1	1.171	27.9	1.215			7	1.155
30.1	1.249	97.3	1.179	30.7	1.216			28.7	1.156
34.6	1.249	95.1	1.181	34.8	1.216			100.1	1.162
53.4	1.255	92.9	1.182	39.4	1.216			100.1	1.164
53.9	1.256	36.6	1.184	77.1	1.22			100.1	1.165
54.5	1.256	31.5	1.185	83.7	1.221			100.1	1.166
55.1	1.256	27.4	1.188	89.8	1.223			36.3	1.168
33.1	1.26	24.1	1.189	95.4	1.224			31	1.169
29.9	1.262	21.3	1.19	104.3	1.224			27.1	1.171
27.6	1.263	18.9	1.192	102.9	1.235			24.4	1.172
26.4	1.266	16.8	1.193	102.3	1.237			19.4	1.172
25.4	1.268	14.8	1.195	101.6	1.24			12.1	1.186
24.4	1.27	12.9	1.198	29.5	1.241			11.4	1.188
23.1	1.273	11.4	1.199	25	1.243			10.5	1.189
21.7	1.278	10.2	1.2	21.4	1.245			9.8	1.19
19.8	1.281	9.1	1.201	19	1.247			9.1	1.191
17.9	1.287	8.4	1.203	17	1.25			8.2	1.192
16.4	1.29	7.5	1.205	15	1.252			7.5	1.193
14.9	1.296	6.3	1.207	13.2	1.253			6.9	1.194
13.4	1.301	5.6	1.208	11.5	1.254			6.6	1.211
11.9	1.306	4.8	1.21	10.2	1.255			6.5	1.217
10.5	1.311	3.5	1.211	9.1	1.256			6.4	1.223
9	1.315	2.7	1.214	8.1	1.258			6.3	1.231
7.7	1.32	2.2	1.216	7.4	1.259			6.3	1.238
								6.2	
								6.1	
								6	
								5.9	
								3	
								2.8	
								2.8	
								2.8	
								2.8	
								2.8	
								2.8	
								2.8	
								2.8	
								1.9	
								1.8	
								1.8	
								1.8	
								1.8	
								1.8	
								1.8	
								1.8	
								1.8	
								1.8	
								1.9	
						117	103	1.9	

APPENDIX F: FORCED CONE PENETRATION

The Data obtained from the experimental plan using the Forced Cone Penetration is presented here.

Force at 0.75" Penetration			
Minutes	EEE	CSS1	RSEE
10	1.01	3.14	3.7
20	1.75	3.11	
30	1.38	3.98	4.8
45	1.63	3.55	
60	2.93	3.81	4.32
120	2.47	4.02	5.22
180	2.79	5.96	8.2
240	3.34	5.99	
360	4.79	8.04	
1440	3.42	7.12	

Table 14: Force at 0.75" at Various Cure Times