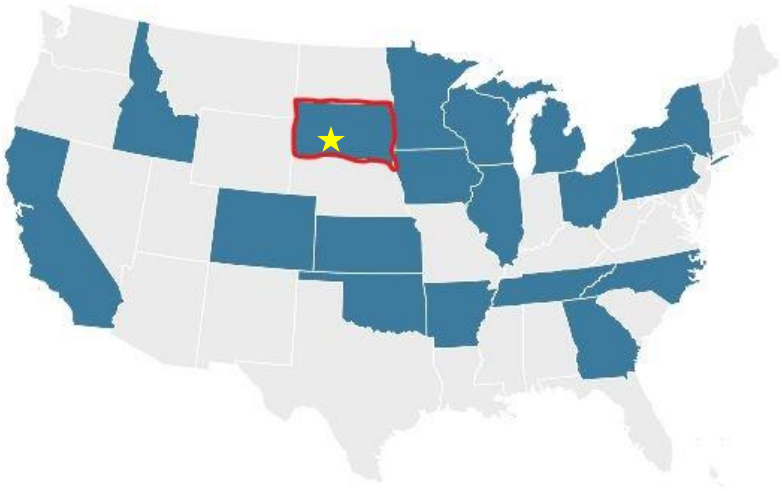
Post Construction Report for South Dakota DOT Demonstration Project Implementation of Performance Engineered Mixtures (PEM)/AASHTO PP 84

August 30, 2019



Participating state DOTs: Arkansas, California, Colorado, Georgia, Idaho, Illinois, Iowa, Kansas, Michigan, Minnesota, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Dakota, Tennessee, and Wisconsin.

Submitted to: Michael F. Praul, P.E.
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Concrete Engineer
South Dakota DOT

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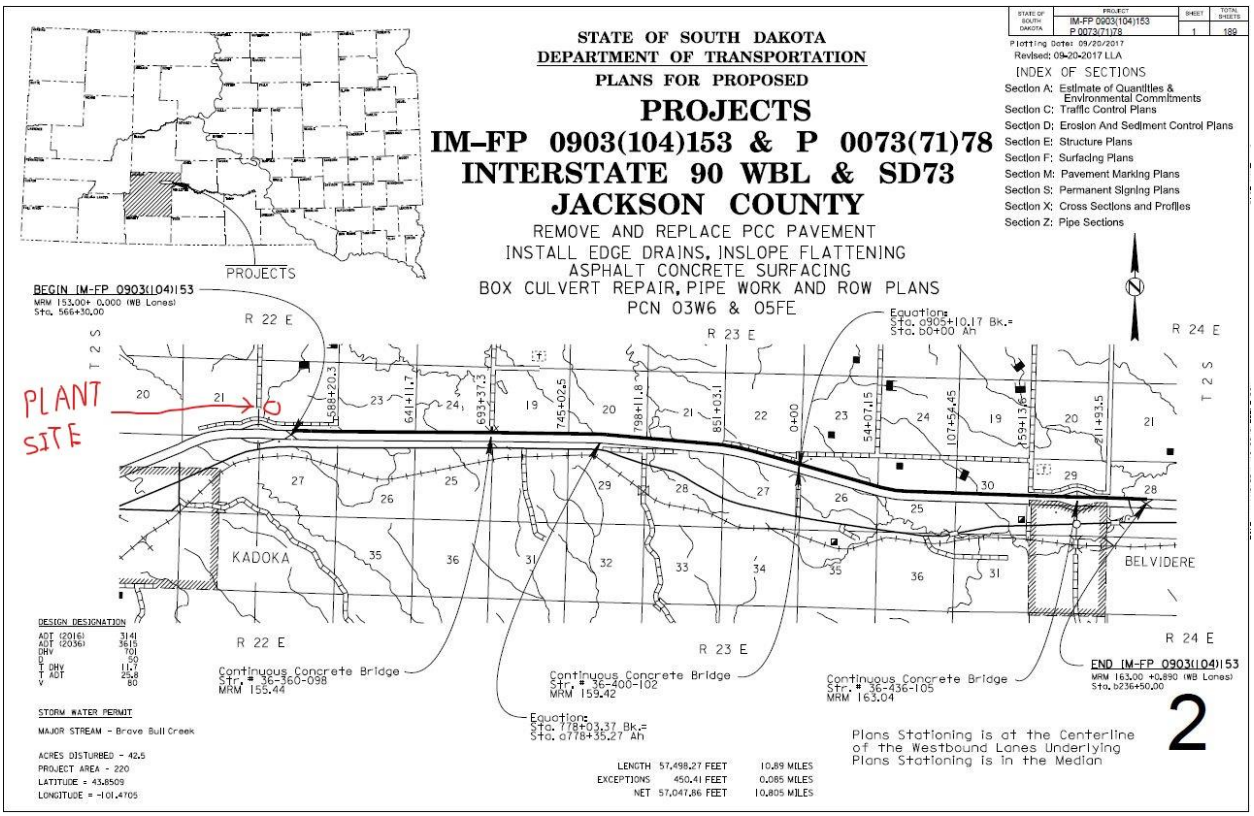
Implementation of Performance Engineered Mixtures (PEM)/AASHTO PP 84

INTRODUCTION

The South Dakota Department of Transportation applied for funds through the Performance Engineered Concrete Paving Mixtures pooled fund project (TPF-5(368)) to collect data and demonstrate the new tests. The FHWA approved the application for $60,000. The SDDOT's portion was $12,000 which is a 20% match of the total $60,000. The application can be found in Appendix A.

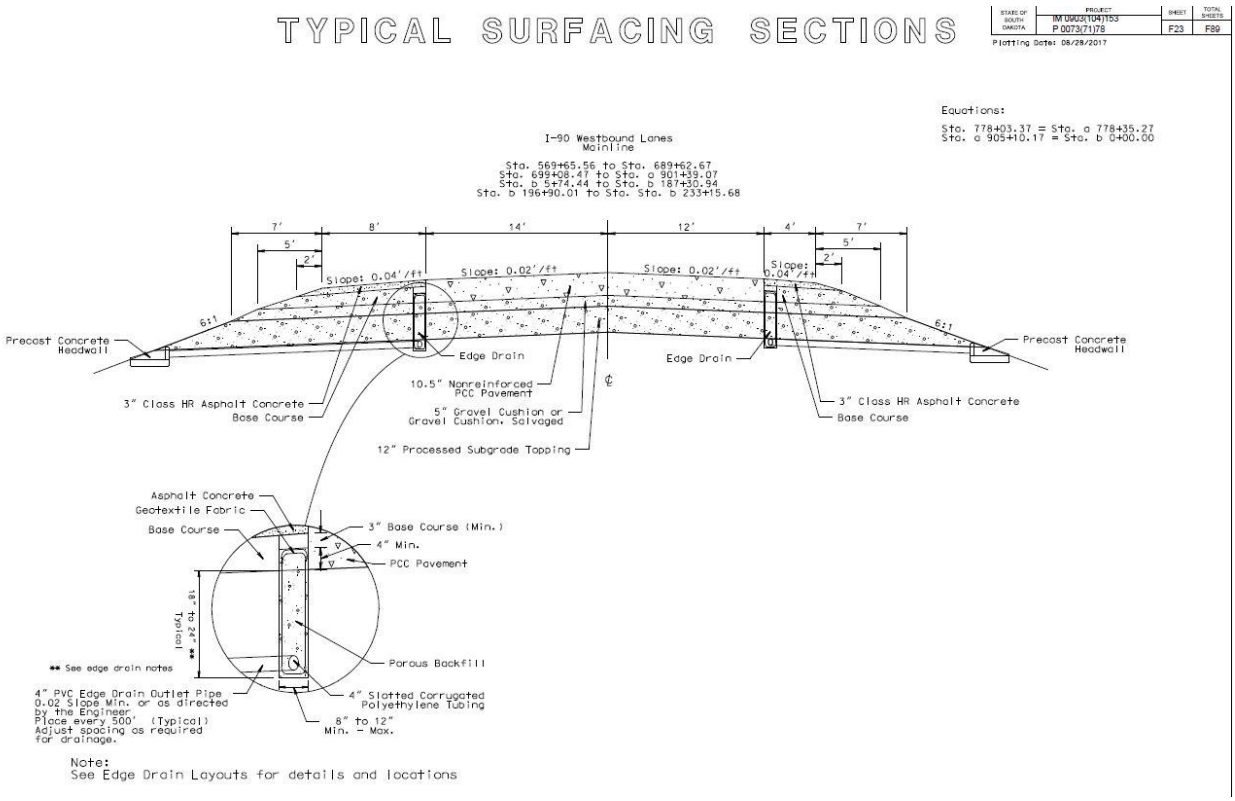
The project location was on Interstate 90 in Jackson County between Kadoka and about a mile East of Belvidere. Reede Construction was awarded the $18.7 million contract for this stretch of I90 on November 21, 2017. Reede is the paving contractor who performed all the 169,880 yd² of 10.5" PCCP and 2,133 yd² of PCC shoulder paving on the project. Grading and paving began in 2018 with almost all the concrete mainline paving done in the fall of 2018. The project was completed mid-2019. All the PEM sampling and testing was performed on the mainline concrete paving, there was also concrete paving on ramps and select shoulder locations. Figure 1 shows the project tile sheet and the plant location.

Figure 1



The Gross length of the project is 10.89 miles with a net paving length of 10.805 miles. The existing 8" Continuously Reinforced Concrete Pavement (CRCP) was originally placed in 1969. The 49-year-old CRCP section had isolated asphalt overlays placed at different times to smooth the ride due to shale heave locations. The existing CRCP still had an average overall Surface Condition Index of about 3.40 out of 5. There were large roller coaster feeling bumps from the shale heaves and numerous repairs needed in the CRCP, so full remove and replacement was selected. The typical cross section for the new 10.5" PCCP is shown below in figure 2. The notable design features are the 14' driving lane and edge drains on both sides of the new 10.5" PCCP.

Figure 2



The design life is 20 years with an expected service life of 40 years. The ADT on this section of WB I90 in 2016 was 3141 with 25.8% trucks.

The contract was let before a decision was made to use this project for the PEM implementation funds. The local area office worked with the contractor to add the requirements to the project via Construction Change Order.

PEM implementation funds were used for the following:

- Incorporate the SAM and box test into the mix design and mix design verification process.
    - The contractor hired a testing lab that performed the 4 required lab batches. These lab batches were tested for SAM and Box Test in addition to the normal requirements.
    - They had to pass the requirements of ≤ 2 for the Box Test and <0.20 for the SAM. These results are attached in Appendix B.
    - The SDDOT then performed one verification batch doing all the same testing to verify the testing labs results. These results are also in Appendix C.
- Perform shadow testing on a project. The SDDOT performed additional sampling and testing during the paving process. These samples were obtained from in front of the paver:
    - Plastic air content and SAM test side by side comparison
        - The SAM was performed at least once per 5 SDDOT fresh concrete tests. The minimum frequency for fresh concrete tests is every 2 hours during production.
    - Box Test performed on the grade.
    - Surface Resistivity testing was done on two 4x8 cylinders cast for each SAM test performed.
    - The air content, SAM number, SAM air, Box Test results, unit weight and temperature were recorded on the associated fresh concrete test sheet.
    - Cylinders were sent to the Central Laboratory for resistivity testing typically at 7, 14, and 28 days.
    - Surface Resistivity testing was also performed at later ages before the cylinders were sent to the CP Tech center for hardened air void analysis.

Additional PEM testing:

- The CP Tech Center obtained project materials and developed a mix design with lower cementitious and different aggregate proportioning for the contractor to try. The SDDOT left the decision to try the mix design with the contractor. Due to late season paving, the contractor decided not to try the CP Tech Center mix design.
- The CP Tech Center trailer was on the project shortly after paving began. The complete list of tests performed with results is available from the CP Tech Center.
- The CP Tech Center completed Hardened Air Void analysis on selected Surface Resistivity samples.

MIX DESIGN PROPERTIES

The SDDOT requires the contractor to furnish their own mix design for the PCC pavement. The SDDOT paving mixes utilize well graded aggregate to benefit the paving operation and allow lower cementitious contents. Low Water to Cement (w/c) ratios are also used to aid in long life durable concrete. Type F modified fly ash is used mainly to mitigate ASR that commonly occurs with local SD aggregate. Quarried ledge rock sources are also mandated for durability reasons. The Air Entraining Admixture (AEA) must be 100% Vinsol Resin based.

The contractor hired a consultant Aaron Swan & Associates (ASA) to perform the laboratory trial batching (included in Appendix B). The trial batches had to meet the special provision requirements. These included a well graded combined aggregate gradation (SDDOT 0.45 Power and Coarseness Workability chart), a minimum (575 lb/yd3) and maximum (800 lb/yd3) cementitious content, a fly ash % range (20% to 25%), and a maximum W/C ratio of 0.42. In addition, the trial batches had to meet the fresh and hardened concrete properties required for trial batching that include: (a) 20 minute slump between 1.25 and 2.75", (b) Box Test of no more than a #2 rating, (c) Air Content of ≥ 5.0% with a SAM # of ≤ 0.20, (d) fresh temps between 68 to 86 °F, and (e) compressive strength of 5200 psi at 28 days.

Once ASA was finished with the laboratory trial batches, the SDDOT did a verification batch of the selected mix "ASA trial #1". Results of the SDDOT verification batching are included in Appendix C.

Gradations for all aggregates were performed by both labs and production gradation averages were gathered from the aggregate sources. The results are included in Appendix D. The ASA gradations that were used to set the mix design targets were plotted on the Tarantula Curve (Figure 3) and clearly meet the requirements for a slipform mix.

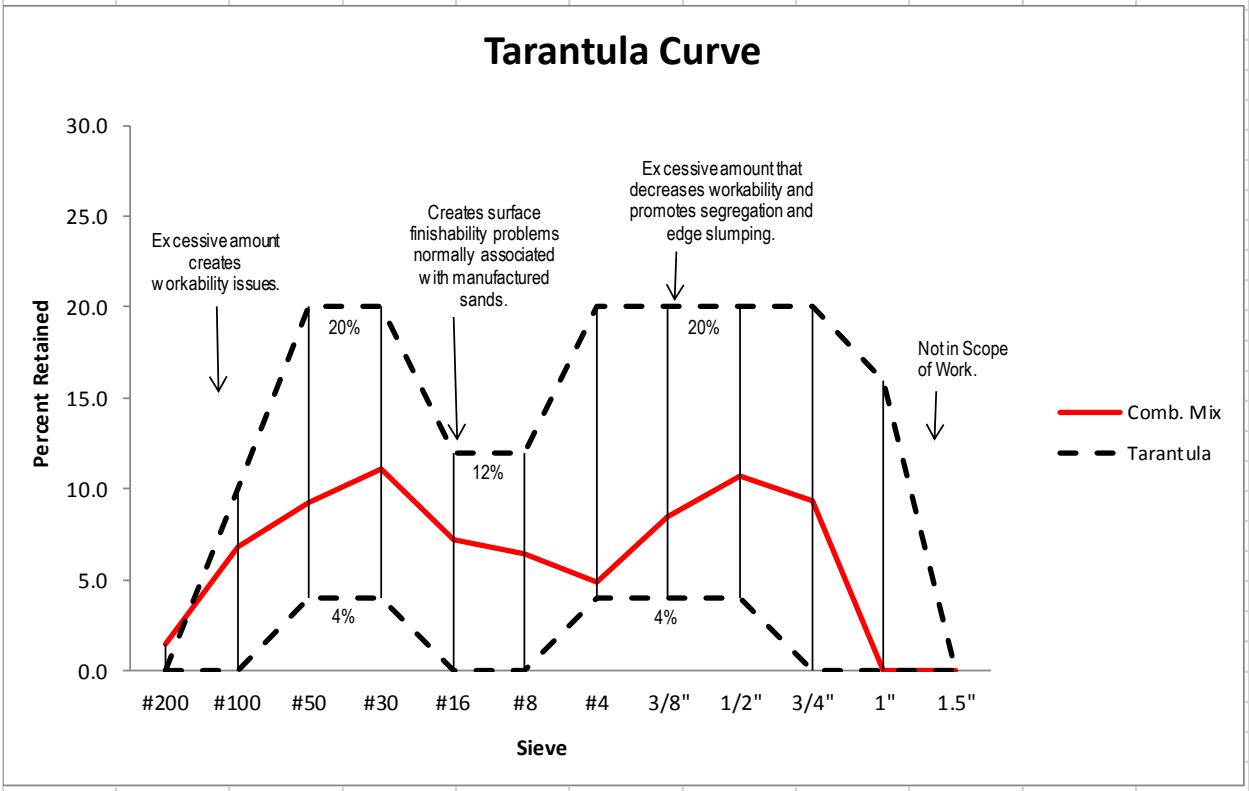
The mix design used to start the project is included as Figure 4. A few minor field adjustments were made to the mix design during construction. The only notable modification was a change in the cement source to GCC Pueblo CO type II for a portion of the project.

Before production began, the Central Office held a SAM training event on 8-30-19 for all region and area office personnel interested in the SAM meter. Kyle Watkins is the SDDOT Central Office technician "SAM Super User" who provided most of the training with help from other central office employees. The first part of the training was on calibration. Both meters to be used on the project were calibrated at this time. Operation of the SAM was then demonstrated with water before fresh concrete was batched. Each participant experienced hands-on training with the SAM. Jay Lovejoy who did the testing on the project performed multiple side by side fresh concrete tests until proficiency was obtained.

Figure 3

Jackson 03W6

Aaron Swan & Assoc: PLS Limestone 1", 3/8" Chips; PLS Wasta Sand 5-19-18



	% Retain, Combined Gradation		
Sieve	Comb. Mix	Tarantula	Tarantula
#200	1.5	0.0	0.0
#100	6.9	10.0	0.0
#50	9.2	20.0	4.0
#30	11.1	20.0	4.0
#16	7.2	12.0	0.0
#8	6.4	12.0	0.0
#4	4.9	20.0	4.0
3/8"	8.4	20.0	4.0
1/2"	10.7	20.0	4.0
3/4"	9.3	20.0	0.0
1"	0.0	16.0	0.0
1.5"	0	0.0	0.0

28.6 **= 24% to 34%**

24.7 **> 20%**

Figure 4

Contractor Concrete Mix Design

DOT-24 (1-15)

Project: IM-FP 0903(104)153 County: Jackson PCN: 03W6

Concrete Supplier: Reede Construction Class of Concrete: PCCP

Supplier Signature: [signature] Mix # (DOT use): PCCP, Optim.

Prepared by/ Title: Steve McCarty/Lab Manager/AS&A Approved by (DOT): [signature]

Date Prepared: 8/16/2018 [signature] Approval Date (DOT): 8-30-2018

MATERIALS:

		Sp. Gr.	Absorption	F.M.
Fine Aggregate (source, type):	Pete Lien - Concrete Sand	* 2.633	1.07	2.67
(pit name, county):	Wasta Pit, Pennington			
(Section-Township-Range):	Sec 17-T1N-R14E			
Coarse #1 (source, type, size):	Pete Lien - 1" Rock Limestone	2.698	0.49	
(pit name, county):	Rapid City Quarry, Pennington			
(Section-Township-Range):	Sec 16,20,21 - T2N - R7E			
Coarse #2 (source, type, size):	Pete Lien - #8 chips Limestone	2.687	0.46	
(pit name, county):	Pete Lien - Pennington			
(Section-Township-Range):	Sec 16,20,21 - T2N - R7E			
Cement (brand, type, source):	GCC Dacotah Type I/II - Rapid Clt, SD	3.17		
Fly Ash (brand, type, source):	Coal Creek Headwaters - Class F modified	2.52		
Water (source, location):	City of Kadoka, Hydrant by Plant	1.00		
			oz/yd³, oz/cwt, lb/yd³	
Admixture(s), etc (brand, type):	GRT - Polychem Paver Plus		17.3 oz/yd3	
	GRT - Polychem VR		4.0 oz/yd3	

* Saturated Surface Dry Basis

DESIGN MIX PROPORTIONS:

W/C Ratio: 0.42 (field max.)

			lb/yd³	Abs. Vol. (ft³) -
Cement			460	2.33
Fly Ash	20.0	(% cementitious)	115	0.73
Fine Aggr. %	40.0	Gradation	1239	7.54
Coarse #1 %	45.0	Size No.	1395	8.29
Coarse #2 %	15.0	15	465	2.77
Water			240	3.85
Air Content (structural, paving- 6.5%)			6.5%	1.76
TOTAL			3914	27.27 (27.0-27.4 ft³)

%- Percent of Total Aggregate

Absolute Vol.= (lb. of product)÷[(Sp.Gr.)×(62.4)]

TRIAL MIX TEST DATA: Attach Supporting Lab Test Documents - Aggregate: {sieve analysis, coarse % particles passing 200, absorption, fineness modulus, specific gravity, % particles less than 1.95 sp. gr., soundness, LA abrasion, flat and elongated, colormetric} Trial Batch: {batch weights, slump, air content, unit weight, actual aggregate moisture, actual w/c ratio, cylinder compressive strengths, strength gain curve}

Concrete Purpose: PCCP - Slipform Paving

Comments:

Distribution: Conc. Engr. - Area Engr. - Reg. Matl's Engr.

PRODUCTION AND CONSTRUCTION

The plant location was on the far West end of the project in a field with good access to the project and easy access off I90 for materials transport. Reede Construction set up their own portable high production batch plant for the mainline paving (Figure 5). Paving began at the East end of the project. With the plant location on the West end, the longest haul was at the beginning of the project being approximately 15 to 20 minutes. Paving proceeded toward the plant on the west end, so haul times were shortened as progress was made.

Figure 5

Weather became a factor during the paving operations. October and November in South Dakota that year were wet and cold at times. Equipment and plant break downs also delayed paving operations. Reede was able to place from 2,000 ft to 3,500 ft per day of the 26' wide 10.5" PCCP on full production days. On these days, the plant would produce from 1800 to 3200 yd^3 per day.

The PCC paving operation is shown in figure 6. The paving train involved an unloader, spreader, paver, carpet drag, and a tining/curing machine. The paving operation was an “Iowa Special” style where dump trucks used the grade to haul the fresh concrete and dump into an unloading machine. This machine allows the dowel baskets and tie bars to be staked in place under the conveyor carrying the concrete (Figure 7).

Figure 6

Figure 7

The base was reworked on the project and gravel pre-trimmed, but left a little high. The “Iowa Special” unloading machine also performs the final trim of the base course cushion material leaving a fresh uniform cross section and base for the new concrete surfacing.

The final stages of the paving operation are to apply texture, cure, then saw and seal the joints. The texture applied was a carpet drag and longitudinally tined surface. Shortly after a water based curing compound (W.R. Meadows 1600 White) was applied. Transverse joints were initially cut to T/4 (Figure 8), then widened and sealed with silicone joint sealant. The longitudinal joint was cut to T/3, then widened and filled with hot pour joint sealant.

Figure 8

PRODUCTION MIX PROPERTIES AND TEST RESULTS

All samples taken during production were from the concrete immediately ahead of the paver. The SDDOT Winner Area office performed the SAM testing and made cylinder samples for surface resistivity. Standard SDDOT testing requirements were also fulfilled. Side by side comparisons were done for each SAM test with a standard air test.

Thirty-four SAM test results were reported, with the data is shown in Figure 9. The traditional air test results are also included. Tyler Ley was contacted after the 5th and 6th SAM tests when a 0.51 and a 0.42 SAM# were reported. Tyler was working on some analysis of each pressure step to determine if errors in testing could be flagged. To help gather data for that work, Jay Lovejoy recorded pressure steps for most of the subsequent SAM tests he performed. The SAM pressure step data was provided to Tyler Lay and the CP Tech center.

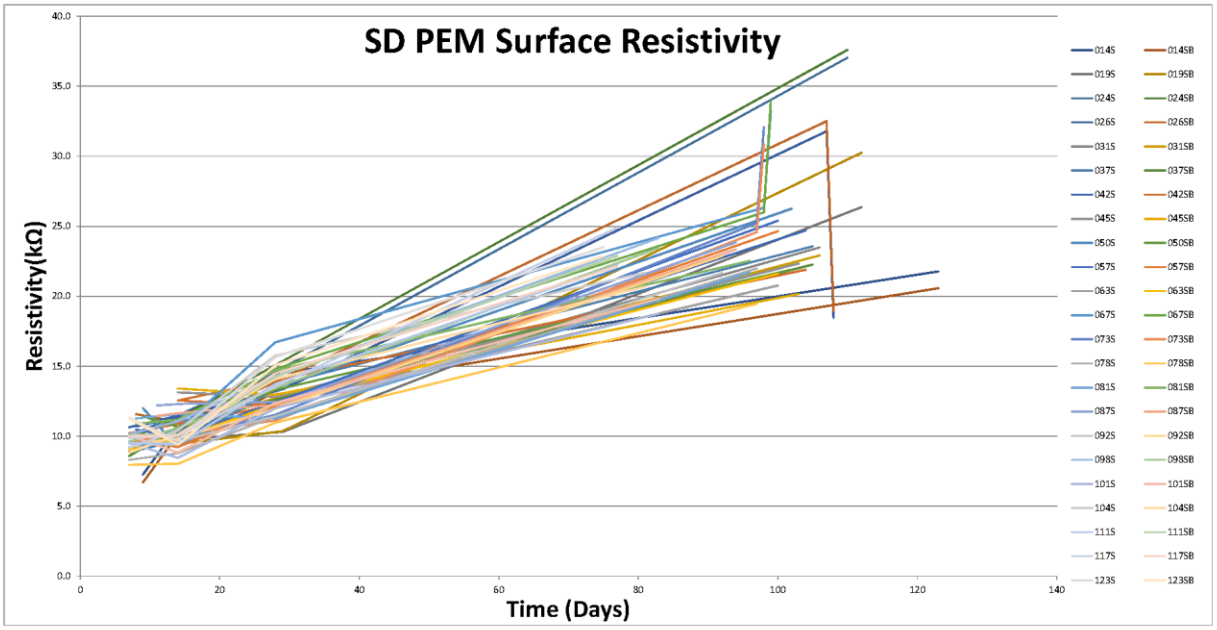
Figure 9

				ASTM	SAM Meter	
	#	ID	Date	Air (%)	SAM #	Air (%)
	1		09/29/2018	5.9	0.19	6.1
	2	2282353	10/01/2018	6.6	0.09	6.5
SDDOT	3	2282629	10/03/2018	5.5	0.18	5.8
ISU	4	at ISU			0.17	5.1
10:00 AM	5	2282922	10/06/2018	5.7	0.51	5.7
11:00 AM	6		10/06/2018		0.42	6.2
	7		10/16/2018	7.4	0.23	7.4
	8		10/18/2018	5.8	0.23	5.6
	9		10/21/2018	6.4	0.34	6.1
	10		10/21/2018	6.6	0.1	7
	11		10/22/2018	6.4	0.19	6.2
	12		10/23/2018	7	0.25	7.1
	13		10/24/2018	7	0.32	7.3
	14	2284435	10/26/2018	7.4	0.32	7.6
	15	2284485	10/27/2018	6.1	0.1	6.2
	16		10/28/2018	7	0.23	6.9
	17	2284620	10/29/2018	7.1	0.39	7.2
	18				0.33	6.7
	19				0.12	6.8
	20				0.33	6.3
	21		10/30/2018	5.7	0.19	5.6
	22		10/31/2018	6.5	0.35	6.7
	23	2284978	11/01/2018	7.1	0.25	7.3
	24	2285097	11/02/2018	6.1	0.23	6
	25				0.47	5.7
	26				0.24	5.3
	27	2285113	11/04/2018	7	0.08	7.2
	28		11/05/2018	6	0.26	6
	29		11/14/2018	7.5	0.17	8.3
	30	2285629	11/15/2018	6.6	0.31	6.5
	31		11/16/2018	6.6	0.22	6.9
	32		11/20/2018	7.2	0.24	7.9
	33	2285909	11/21/2018	7.8	0.15	8.2
	34	2285954	11/23/2018	7.2	0.3	8.2

The SDDOT central office performed the Box Test on the grade during production. The results on 10-29-18 and 11-2-18 were both a visual #2 indicating acceptable workability for slipform paving. The slipform paving and workability of the mix on the days tested was generally good.

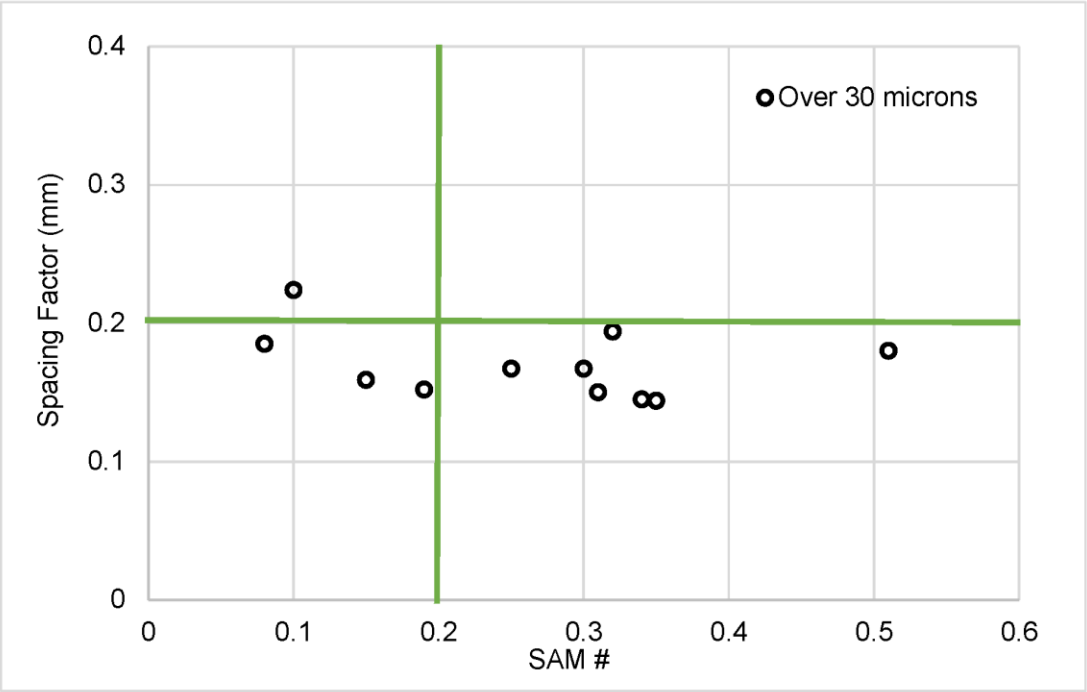
Although not originally part of the testing plan, the CP Tech center worked with the SDDOT on adding surface resistivity testing. An added benefit was that these specimens could later be used for Hardened Air Void Analysis by the CPTech Center. The 4x8 inch cylinders were made in the field and sealed immediately after finishing. The next day upon demolding, the specimens were cured via the "Bucket Method". All data points for the 23 sets of cylinders can be seen in the plot of Surface Resistivity in Figure 10. Each cylinder's set of surface resistivity results is included in Appendix E. The temperature of the specimens was not taken at the time of surface resistivity testing, as this was not in the procedure provided to the SDDOT. There is good temperature control in the lab where the buckets were stored and testing was performed. All samples were likely in the range of 67 to 71 Deg F during storage and testing. Later age surface resistivity data was obtained from specimens prior to shipping for the hardened air testing. There was some confusion on which specimens were to be tested. As a result, some samples were taken out of the buckets a few days early and dried out. The dried samples were re-soaked for 24 hours prior to final testing and are identified in the "Comments" column. This might explain why there are some plot line differences that exist past 28 days.

Figure 10



Twelve samples were selected by the CP Tech center for Hardened Air Testing via the “Rapid Air” method. Eleven Rapid Air test results were reported by the tech center. The entire data set of Rapid Air results are in Appendix F. The plot of the SAM # obtained during production Vs. the Rapid Air results using the cords over 30 microns is Figure 11.

Figure 11



SUMMARY

This was a great opportunity for the SDDOT, CP Tech Center, and the Contractor to gain experience with the PEM testing utilized on the project. There was a lot of cooperation between everyone involved to plan, perform testing, collect and analyze data.

The contractor was very accommodating to work with for the PEM testing. The Department was not able to get a response from Reede Construction on their opinions pertaining to the PEM testing performed on the project.

The mix design process went well; it is believed to be the first time a Box Test and SAM test were a mix design requirement on a project. The SDDOT will likely be adding these parameters in the future to the "Special Provision for Contractor Furnished Mix Design for PCC Pavement".

There is some concern with the variation in the SAM field sample results. 65% of the SAM #'s were above 0.2 and 32% were above 0.3. All but one of the 34 SAM test locations had an ASTM % air within the SDDOT specification of 5.0% to 7.5%. The one air test (7.8%) was only over the limit by 0.3%. The SAM testing data indicates we likely will have issues related to freeze thaw. Based on historical performance of comparable mix design with similar ASTM % air results, the SDDOT has minimal direct freeze thaw related issues. There was good correlation between the ASTM Air % and the SAM meter Air %.

The Rapid Air results from the hardened concrete samples indicate that almost all the concrete will likely exhibit acceptable freeze thaw field performance. There was poor correlation between the SAM and the Rapid Air testing for SAM #'s greater than 0.2.

The production and mix design Box Test results all produced the same #2 visual result. There was generally good workability of the mix on the project. The Box Test does seem to be an improved indicator over the slump test for a mix's performance during the slipform paving process.

The surface resistivity testing results were generally similar through the first 28 days. Temperatures were not taken during testing, but the lab climate control helped produce consistent results.

This was a good learning experience and the data collected will provided a wealth of information to further the PEM initiative.

APPENDIX A:

Demonstration Project for
Implementation of Performance Engineered Mixtures/AASHTO PP 84
Project Application Form

Date : 2-14-18

1. State Agency: __South Dakota DOT

State Agency Contact(s): Darin Hodges, Concrete Engineer, 605-773-7193, darin.hodges@state.sd.us)

FHWA Division Office Contact(s): Brett Hestdalen, Operations Engineer, 605-776-1007, Brett.Hestdalen@dot.gov

2. Project Location/Description: (route designation, project length, pavement thickness, include anticipated date of construction, etc.)

One of the following project to be constructed this summer (2018) would be selected. All of these projects have already been let so a CCO would be required to add any requirements:

a) I90 WBL Jackson Co. 10.9 Miles of 10.5" PCC PCN 03W6 from Kadoka to Belvidere__

b) I29 SBL Roberts Co. 15.3 Miles of mostly 8" overlay, PCN 021V is Exit 224 to Exit 242__

c) Hwy 37 N&SBL Davison Co. (8) Miles of 7" overlay, PCN 023F Mitchell N. 4 Miles___

3. Requested Funding:

Indicate which category(ies) of funding you are seeking support for:

YES - Category A: $40,000 for incorporating two or more AASHTO PP 84-17 tests in the mix design/approval process. Shadow testing is acceptable.

YES - Category B: $20,000 for incorporating one or more AASHTO PP 84-17 test in the acceptance process. Shadow testing is acceptable.

No - Category C: $20,000 for requiring a comprehensive QC Plan from the contractor that will be approved and monitored by the state.

No - Category D: $20,000 for requiring the use of control charts, as called for in AASHTO PP 84-17.

4. **Description of What will be accomplished in each category:**

For each Category, from above, you are seeking funding support for, please discuss the requested information.

Category A: Identify which tests you will be evaluating, your mix design/approval process, and how the use of the tests differs from your current process.

- The fresh concrete Air Content via SAM and the Box Test would be specified as mix design properties the contractor would have to obtain and the SDDOT would verify during the process. If funded, SDDOT would use a selected project to have an updated Contractor Mix Design Special Provision that included specifications for the SAM and Box Test CCO'd onto the project. As part of the mix design process, the contractor would be required to do lab batching that included typical fresh and hardened testing; in addition the new tests (SAM and Box) would be required. Once the contractor has obtained a mix design that meets the requirements, the SDDOT would do a verification batch to also check the properties. The difference between how we currently do business would be the addition of the box test requirement and using the SAM for acceptance of mix design air content.

Category B: Identify which test(s) you will be evaluating, how your acceptance process will use the test(s) results, and how the use of the tests differs from your current process.

- The fresh Air Content via SAM would be evaluated on the project utilizing shadow testing by area office personnel. Currently in SD, the SAM has only been used by Central Lab personnel. This will be a good trial run of the procedure during construction to see how it would work for field acceptance. There will be a specification, procedure, and testing frequency that the area office will need to follow.

Category C: Identify what you will require in the QC Plan and how you will monitor compliance with the Plan. Note if you currently require QC Plans; if currently required, note

how your process will differ on this project. Category D: Identify what control charts you will require the contractor/supplier to use and how the charts will be monitored during construction.
5. Other Information: The SDDOT is excited about helping move the selected SAM and Box test procedures forward. We are also interested in the other procedures listed in PP84-17 that were not selected for initial evaluation and hope to work with them more as well.

Submit to:
Michael F. Praul, P.E.
Senior Concrete Engineer
Office of Preconstruction, Construction, and Pavements (HICP-40)
michael.praul@dot.gov

APPENDIX B:

AARON SWAN & ASSOCIATES
CONSULTING ENGINEERS , SURVEYING & MATERIAL TESTING
29310 GARY STREET , PIERRE, SD 57501
PHONE # (605) 945-1315 FAX # (605) 945-0310

CONCRETE MIX DESIGN

REPORT DATE: 06/13/18
LAB FILE #: 18-158

PROJECT: IM-FP 0903(104)153 PCN 03W6
Interstate 90 Jackson County

FURNISHED BY: Pete Lien & Sons

REPORTED TO: Reede Construction

COPIES TO: SDDOT

SPECIFIC GRAVITIES OF MATERIALS

COARSE AGGREGATE	2.698	CEMENT	3.15	FINENESS MODULUS	2.67
FINE AGGREGATE	2.633	FLY ASH	2.52	CHIPS	2.687

Mix #1 MIX DESIGN

Batch size 27.30 CU. FT.

wtr/cem ratio **0.42**
% Flyash **20%**
Calculated air content **6.5%**

Fine Agg. Wasta Pit	**1239**	lbs
Coarse Agg. Rapid City Pit	**1395**	lbs
CHIPS Rapid City Pit	**465**	lbs
Total Agg.	3099	lbs
GCC Dacotah I/II cement	**460**	lbs
Coal Creek Fly Ash	**115**	lbs
water	**240**	lbs
Polychem Paver Plus	**17.3**	ozs
Polychem VR	**4.0**	ozs

COMPRESSIVE STRENGTH

				3 Day	AVERAGE
					psi
				7 DAY	AVERAGE
4000	4024	4035	**4020**	psi	
		14 DAY			
4590	4677	4607	**4625**	psi	
		28 DAY			
5420	5322	5368	**5370**	psi	

WRA
AEA

BATCH NUMBERS

Batch size ____ CU. FT.

wtr/cem ratio **0.42**
% Flyash **20%**
Calculated air content **6.5%**

Fine Agg. Wasta Pit	**145.5**	lbs
Coarse Agg. Rapid City Plt	**161.3**	lbs
CHIPS Rapid City Pit	**54.3**	lbs
Total Agg.	361.1	lbs
GCC Dacotah I/II cement	**52.9**	lbs
Coal Creek Fly Ash	**13.2**	lbs
water	**23.0**	lbs
Polychem Paver Plus	**58.8**	ml
Polychem VR	**13.6**	ml

FREE MOISTURE

ROCK = 0.6% CHIPS = 1.4% SAND = 2.1%

FRESH CONCRETE TESTS

		20 min. wait
AIR	6.80%	
SLUMP	3 1/2"	2 1/4"
UNIT WT	143.2	
TEMP	68	
SAM	0.15	6.5% air reading
Box Test	2	

REMARKS: *All weights are Saturated Surface Dry.
MIX #1 = ROCK 45% CHIPS 15% AND SAND 40%.

SIGNED: John M. Lien

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29310 GARY STREET , PIERRE, SD 57501
PHONE # (605) 945-1315 FAX # (605) 945-0310

CONCRETE MIX DESIGN

REPORT DATE: 06/13/18
LAB FILE #: 18-158

PROJECT: IM-FP 0903(104)153 PCN 03W6
Interstate 90 Jackson County

FURNISHED BY: Pete Lien & Sons

REPORTED TO: Reede Construction

COPIES TO: SDDOT

SPECIFIC GRAVITIES OF MATERIALS

COARSE AGGREGATE	2.698	CEMENT	3.15	FINENESS MODULUS	2.67
FINE AGGREGATE	2.633	FLY ASH	2.52	CHIPS	2.687

Mix #2 MIX DESIGN

Batch size 27.30 CU. FT.

wtr/cem ratio **0.40**
% Flyash **20%**
Calculated air content **6.5%**

Fine Agg. Wasta Pit	**1254** lbs						
Coarse Agg. Rapid City Pit	**1408** lbs						
CHIPS Rapid City Pit	**469** lbs						
Total Agg.	3131 lbs						
					3 Day	**AVERAGE**	
							psi
					7 DAY	**AVERAGE**	
GCC Dacotah I/II cement	**460** lbs		4375	4349	4151	**4292**	psi
Coal Creek Fly Ash	**115** lbs				**14 DAY**		
water	**228** lbs		4886	4904	5033	**4941**	psi
Polychem Paver Plus	**23.0** ozs	WRA			**28 DAY**		
Polychem VR	**5.8** ozs	AEA	5710	5634	5688	**5677**	psi

COMPRESSIVE STRENGTH

BATCH NUMBERS

Batch size _____ CU. FT.

wtr/cem ratio **0.40**
% Flyash **20%**
Calculated air content **6. 5%**

Fine Agg. Wasta Pit	**147.2** lbs		
Coarse Agg. Rapid City Pit	**162.8** lbs		
CHIPS Rapid City Pit	**54.7** lbs		
Total Agg.	364.78 lbs		
GCC Dacotah I/II cement	**52.9** lbs		
Coal Creek Fly Ash	**13.2** lbs		
water	**21.7** lbs		
Polychem Paver Plus	**78.2** ml	WRA	
Polychem VR	**19.7** ml	AEA	

FREE MOISTURE

ROCK = 0.6% CHIPS = 1.4% SAND = 2.1%

FRESH CONCRETE TESTS

		20 min. wait
AIR	7.00%	
SLUMP	3"	2"
UNIT WT	142.6	
TEMP	70	
SAM	0.14	7.1% air reading
Box Test	2	

REMARKS: *All weights are Saturated Surface Dry.
MIX #2 = ROCK 45% CHIPS 15% AND SAND 40%.

SIGNED: _____

AARON SWAN & ASSOCIATES
CONSULTING ENGINEERS , SURVEYING & MATERIAL TESTING
29310 GARY STREET , PIERRE, SD 57501
PHONE # (605) 945-1315 FAX # (605) 945-0310

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SPECIFIC GRAVITIES OF MATERIALS

COARSE AGGREGATE	2.698	CEMENT	3.15	FINENESS MODULUS	2.67
FINE AGGREGATE	2.633	FLY ASH	2.52	CHIPS	2.687

Mix #3 MIX DESIGN

Batch size 27.30 CU. FT.

wtr/cem ratio **0.42**
% Flyash **20%**
Calculated air content **6.5%**

Fine Agg. Wasta Pit	**1239**	lbs						
Coarse Agg. Rapid City Pit	**1457**	lbs						
CHIPS Rapid City Pit	**404**	lbs						
Total Agg.	3100	lbs						
GCC Dacotah I/II cement	**460**	lbs						
Coal Creek Fly Ash	**115**	lbs						
water	**240**	lbs						
Polychem Paver Plus	**17.3**	ozs	WRA					
Polychem VR	**4.0**	ozs	AEA					

COMPRESSIVE STRENGTH

			AVERAGE	
3 Day				psi
7 DAY			AVERAGE	
4062	4040	4053	**4052**	psi
14 DAY				
4546	4675	4542	**4588**	psi
28 DAY				
5352	5422	5368	**5381**	psi

BATCH NUMBERS

Batch size _____ CU. FT.

wtr/cem ratio **0.42**
% Flyash **20%**
Calculated air content **6.5%**

Fine Agg. Wasta Pit	**145.6**	lbs	
Coarse Agg. Rapid City Pit	**168.6**	lbs	
CHIPS Rapid City Pit	**47.0**	lbs	ROCK = 0.6% CHIPS = 1.4% SAND = 2.1%
Total Agg.	361.215	lbs	
GCC Dacotah I/II cement	**52.9**	lbs	
Coal Creek Fly Ash	**13.2**	lbs	
water	**23.1**	lbs	
Polychem Paver Plus	**58.8**	ml	WRA
Polychem VR	**13.6**	ml	AEA

FREE MOISTURE

FRESH CONCRETE TESTS

		20 min. wait
AIR	6.50%	
SLUMP	3"	2"
UNIT WT	143.9	
TEMP	70	
SAM	0.2	6.8% air reading
Box Test	2	

REMARKS: *All weights are Saturated Surface Dry.
MIX #3 = ROCK 47% CHIPS 13% AND SAND 40%

SIGNED: John McGraft

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CONCRETE MIX DESIGN

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SPECIFIC GRAVITIES OF MATERIALS

COARSE AGGREGATE	2.698	CEMENT	3.15	FINENESS MODULUS	2.67
FINE AGGREGATE	2.633	FLY ASH	2.52	CHIPS	2.687

Mix #4 MIX DESIGN

Batch size 27.30 CU. FT.

wtr/cem ratio **0.40**
% Flyash **20%**
Calculated air content **6.5%**

Fine Agg. Wasta Pit	**1254**	lbs						
Coarse Agg. Rapid City Pit	**1470**	lbs						
CHIPS Rapid City Pit	**407**	lbs						
Total Agg.	3131	lbs						
GCC Dacotah I/II cement	**460**	lbs						
Coal Creek Fly Ash	**115**	lbs						
water	**228**	lbs						
Polychem Paver Plus	**23.0**	ozs	WRA					
Polychem VR	**5.8**	ozs	AEA					

COMPRESSIVE STRENGTH

			AVERAGE	
3 Day				psi
7 DAY			AVERAGE	
7 DAY	4305	4312	4181	**4266** psi
14 DAY	4790	4798	4994	**4861** psi
28 DAY	5831	5872	5902	**5868** psi

BATCH NUMBERS

Batch size ____ CU. FT.

wtr/cem ratio **0.40**
% Flyash **20%**
Calculated air content **6.5%**

Fine Agg. Wasta Pit	**147.3**	lbs	
Coarse Agg. Rapid City Pit	**170.0**	lbs	
CHIPS Rapid City Pit	**47.5**	lbs	ROCK = 0.6% CHIPS = 1.4% SAND 2.1%
Total Agg.	364.78	lbs	
GCC Dacotah I/II cement	**52.9**	lbs	
Coal Creek Fly Ash	**13.2**	lbs	
water	**21.8**	lbs	
Polychem Paver Plus	**78.2**	ml	WRA
Polychem VR	**19.7**	ml	AEA

FREE MOISTURE

FRESH CONCRETE TESTS

		20 min. wait	
AIR	7.00%		
SLUMP	2 3/4"	1 3/4"	
UNIT WT	142.4		
TEMP	68		
SAM	0.09	7.3% air reading	
Box Test	2		

REMARKS: *All weights are Saturated Surface Dry.
MIX #4 = ROCK 47% CHIPS 13% AND SAND 40%.

SIGNED: John McCraft

APPENDIX C:

CONCRETE MIX DESIGN DATE: 6-20-2018 **TRIAL 1**

CLASS: 1.0" Optimized Paving CONTRACTOR: Reede Const.
SAND: Pete Lien & Sons, Wasta LAB/SUPPLIER: Aaron Swan & Assoc
ROCK: PLS, Rapid City: Limestone, 1" Rock & Chips
CEMENT: GCC Dacotah I/II, Rapid C PROJECT: IM-FP 0903(104)153
FLY ASH: Boral Res, Coal Creek Typ COUNTY: Jackson
AIR ENTRAIN: GRT Polychem \ PCN: 03W6
WATER RED.: GRT Polychem Paver Plus
Jackson 03W6- MDes Verif.xlsx

SAND:	2.63	ABSORPTION %	1.07	UNIT WT #/CF	0.00
Chips	2.69	ABSORPTION %	0.46	UNIT WT #/CF	0.00
1"	2.70	ABSORPTION %	0.49	UNIT WT #/CF	0.00
	1.00	ABSORPTION %	0.00	UNIT WT #/CF	0.00
	1.00	ABSORPTION %	0.00	UNIT WT #/CF	0.00
CEMENT:	3.15				
FLY ASH:	2.52				

	Batch Size	
	3.20	3.20
DESIGN MIX (BATCH):		**Adjusted for Moistures**
# OF CEMENT:	53.9	53.9
# OF FLYASH:	13.5	13.5
W/C&FA RATIO	0.420	0.420
# OF WATER:	28.3	28.1
% Air:	6.5	6.5
# OF SAND	145.3	145.6
# OF Chips	54.5	54.7
# OF 1"	163.5	163.4
# OF	0.0	0.0
# OF	0.0	0.0
ML. W.R.A.:		52.0
ML. W.R.A.(2):		0.0
ML. A.E.A.:		12.0

Targets	143.2 pcf
Air (6.5 - 8.0%) -	6.8
Init/20-min Slump ( ) -	3.5/2.25
Sam # / %	0.15/ 6.5
Box Test #	~ 2

<-(Calculated)

Initial Moistures	% Total W/O Moisture	Average Moistures	2nd Moisture
1.22	40.0	1.12	1.02
0.74	15.0	0.71	0.67
0.42	45.0	0.42	0.41
0.00	0.0	0.00	0.00
0.00	0.0	0.00	0.00
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0

BATCHED UNIT WT. #: (without air)	153.4	153.4	153.4	153.4	153.4
W/C-FA Ratio with 2nd moisture :		0.417	0.417	0.417	0.417

	Batch 1	2	3	4
Add water (cc):	0			
Initial Slump :	3.50			
Slump @ 20 mins :	2.50			
Unit weight (pcf):	143.3			
Unit Weight Air Content:	6.6	100.0	100.0	100.0
Pressure - Air Content:	7.2			
Mix Time:	3-3-2			
Concrete Temp:	73.5			
Lab Temp:	70.7			
Water Temp:	67.9			
Sand Temp:	70.8			
Chips Temp:				
Coarse 1 Temp:	70.0			
Coarse 2 Temp:				
Coarse 3 Temp:				
Cement Temp:	71.3			
Fly Ash Temp:	71.5			
Microwave W/C:				
weight on#4/expected				
SAM Unit Wt (pcf)	142.4			
SAM Air %	7.2			
SAM #	0.13			
Box Test #	2			
Edge Slump	1/8"			

CYLINDERS: 1-9
LAB. NO.: BZ4468-76

CYL. BREAKS: **7-DAY**	3830			
	3980			
	3850			
AVE.	3887	#DIV/0!	#DIV/0!	#DIV/0!
Cylinder	145.7			
Unit	145.7			
Weights	146.2			

CYL. BREAKS: **14-DAY**	4060			
	4070			
	4070			
AVE.	4067	#DIV/0!	#DIV/0!	#DIV/0!
Cylinder	146.7			
Unit	146.7			
Weights	147.2			

CYL. BREAKS: **28-DAY**	5000			
	4760			
	4760			
AVE.	4840	#DIV/0!	#DIV/0!	#DIV/0!
Cylinder	146.7			
Unit	146.7			
Weights	145.7			

CYL. BREAKS: **90-DAY**				
AVE.	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Cylinder				
Unit				
Weights				

APPENDIX D:

Jackson 03W6

Sand	Max	Min	Average	1 (Pete Lien & Sons: Limestone 1", 3/8" Chips (May-Sep2017, Rec'd 5-20-18); Wasta Sand)	2 (DOT Verif Matls: PLS Limestone 1" (2nd submittal, Rec'd 5-24-18), 3/8" Chips; PLS Wasta Sand- 5-15-18)	3 (Aaron Swan & Assoc: PLS Limestone 1", 3/8" Chips; PLS Wasta Sand 5-19-18)	4	5	6
3/8"									
1/4"									
#4									
#8			90.8		91.5	90.1			
#16			72.5		72.8	72.2			
#30			44.9		45.2	44.6			
#50			21.7		21.7	21.6			
#100			4.6		4.7	4.5			
#200			0.9		0.9	0.9			

Jackson 03W6 Pete Lien & S DOT Verif Ma Aaron Swan &

Chips	Max	Min	Average	1	2	3	4	5	6
1.5"									
1.25"									
1"									
.75"									
.625"									
.5"									
.375"			99.3	98.7		99.9			
.25"			50.2		54.9	45.4			
#4			17.2	14.6	20.3	16.6			
#8			1.8	1.3	2.9	1.3			
#16			1.5	0.8	2.5	1.2			
#30			1.3	0.7	2.0	1.1			
#50			1.0	0.6	1.5	1.0			
#100			0.8	0.6	1.0	0.9			
#200			0.6	0.5	0.5	0.8			

Jackson 03W6 Pete Lien & S DOT Verif Ma Aaron Swan &

1"	Max	Min	Average	1	2	3	4	5	6
1.5"									
1.25"									
1"									
.75"			79.3	75.7	82.9	79.3			
.625"			60.3	60.0	58.9	62.0			
.5"			36.7	35.2	36.8	38.2			
.375"			16.0	15.0	13.6	19.5			
.25"			2.1	2.5	1.7	2.0			
#4			1.1	1.5	1.1	0.8			
#8			0.7	0.8	1.0	0.4			
#16			0.6	0.6	0.8	0.4			
#30			0.6	0.5	0.8	0.4			
#50			0.5	0.5	0.6	0.4			
#100			0.5	0.5	0.6	0.4			
#200			0.4	0.4	0.4	0.4			

APPENDIX E:

Date Tested	Tested By:	Curing Period	Date Made	Mix Design	PCN	County	Sample Number	(1) 0°	(1) 90°	(1) 180°	(1) 270°	(2) 0°	(2) 90°	(2) 180°	(2) 270°	Ave S.R.	Comments
10/15/18	PL	9	10/06/2018		03W6	Jackson	014S	7.4	7.3	7.3	7.2	7.2	7.3	7.2	7.2	**7.3**	
10/15/18	PL	9	10/06/2018		03W6	Jackson	014SB	6.8	6.6	6.6	6.5	6.8	7.2	6.6	6.5	**6.7**	
10/19/18	PL	13	10/06/2018		03W6	Jackson	014S	10.5	10.5	9.8	9.4	9.8	9.9	10.2	10.1	**10.0**	
10/19/18	PL	13	10/06/2018		03W6	Jackson	014SB	9.8	10.0	9.2	9.1	9.0	9.9	9.0	9.6	**9.5**	
11/2/18	PL	27	10/06/2018		03W6	Jackson	014S	16.9	14.7	14.7	14.0	14.1	14.1	12.7	13.5	**14.3**	
11/2/18	PL	27	10/06/2018		03W6	Jackson	014SB	12.7	13.1	13.0	12.9	13.0	12.7	13.0	12.9	**12.9**	
2/6/19	PL	123	10/06/2018		03W6	Jackson	014S	22.0	21.0	21.6	21.9	20.1	23.3	20.9	23.4	**21.8**	Original Cylinder After 24 Hr Soak
2/6/19	PL	123	10/06/2018		03W6	Jackson	014SB	22.5	19.0	20.0	20.7	20.6	20.1	20.3	21.4	**20.6**	Original Cylinder After 24 Hr Soak
10/24/18	PL	8	10/16/2018		03W6	Jackson	019S	10.4	10.3	9.9	10.5	10.3	9.9	9.5	10.5	**10.2**	
10/24/18	PL	8	10/16/2018		03W6	Jackson	019SB	10.0	10.4	10.7	10.6	9.9	10.2	10.4	10.4	**10.3**	
10/30/18	PL	14	10/16/2018		03W6	Jackson	019S	9.8	9.2	9.9	10.3	10.3	9.1	9.5	10.1	**9.8**	
10/30/18	PL	14	10/16/2018		03W6	Jackson	019SB	9.6	9.1	9.4	9.5	9.8	9.3	9.8	9.2	**9.5**	
11/14/18	PL	29	10/16/2018		03W6	Jackson	019S	10.5	10.2	10.4	10.1	10.4	10.4	10.5	10.0	**10.3**	
11/14/18	PL	29	10/16/2018		03W6	Jackson	019SB	10.3	10.3	10.6	10.5	10.5	10.1	10.3	10.3	**10.4**	
2/5/19	PL	112	10/16/2018		03W6	Jackson	019S	26.2	26.1	26.4	25.9	27.0	27.3	26.4	25.7	**26.4**	CYL. NOT SELECTED
2/5/19	PL	112	10/16/2018		03W6	Jackson	019SB	27.0	29.6	33.5	30.3	28.5	29.7	32.6	30.9	**30.3**	CYL. NOT SELECTED
10/25/18	PL	7	10/18/2018		03W6	Jackson	024S	10.9	9.7	9.9	9.5	10.7	10.0	10.1	9.5	**10.0**	
10/25/18	PL	7	10/18/2018		03W6	Jackson	024SB	9.6	9.2	9.9	10.7	9.9	9.1	10.0	10.7	**9.9**	
11/1/18	PL	14	10/18/2018		03W6	Jackson	024S	12.1	11.5	12.7	11.1	11.3	11.0	11.8	10.5	**11.5**	
11/1/18	PL	14	10/18/2018		03W6	Jackson	024SB	10.6	11.3	11.9	11.4	11.0	11.6	11.4	10.9	**11.3**	
11/15/18	PL	28	10/18/2018		03W6	Jackson	024S	14.5	14.4	15.5	14.2	14.7	14.0	15.1	14.4	**14.6**	
11/15/18	PL	28	10/18/2018		03W6	Jackson	024SB	15.8	14.5	15.0	15.7	15.2	14.2	14.8	15.5	**15.1**	
2/5/19	PL	110	10/18/2018		03W6	Jackson	024S	33.9	36.3	36.6	39.7	35.7	37.1	34.9	42.2	**37.1**	CYL. NOT SELECTED
2/5/19	PL	110	10/18/2018		03W6	Jackson	024SB	34.2	36.7	40.2	39.9	35.1	37.8	36.9	40.1	**37.6**	CYL. NOT SELECTED
10/29/18	PL	8	10/21/2018		03W6	Jackson	026S	10.9	10.2	11.2	11.1	10.7	10.6	10.9	10.0	**10.7**	
10/29/18	PL	8	10/21/2018		03W6	Jackson	026SB	11.9	11.6	11.7	11.9	11.5	10.9	11.8	11.4	**11.6**	
11/5/18	PL	15	10/21/2018		03W6	Jackson	026S	12.2	11.9	11.6	11.7	11.6	11.2	10.8	11.1	**11.5**	
11/5/18	PL	15	10/21/2018		03W6	Jackson	026SB	10.9	11.3	10.8	11.4	10.5	11.0	10.5	11.2	**11.0**	
11/19/18	PL	29	10/21/2018		03W6	Jackson	026S	13.2	13.4	13.9	13.2	13.0	13.4	13.7	13.1	**13.4**	
11/19/18	PL	29	10/21/2018		03W6	Jackson	026SB	14.1	14.5	13.9	14.3	13.8	14.3	13.7	14.3	**14.1**	
2/5/19	PL	107	10/21/2018		03W6	Jackson	026S	32.0	30.5	32.4	31.9	33.0	30.3	31.9	32.3	**31.8**	EXTRA CYL. SELECTED
2/5/19	PL	107	10/21/2018		03W6	Jackson	026SB	31.9	33.3	32.6	34.1	31.3	33.0	31.7	32.2	**32.5**	EXTRA CYL. SELECTED
2/6/19	PL	108	10/21/2018		03W6	Jackson	026S	19.1	20.1	18.4	17.3	17.8	19.0	19.1	16.9	**18.5**	Original Cylinder After 24 Hr Soak
2/6/19	PL	108	10/21/2018		03W6	Jackson	026SB	17.9	20.6	17.6	19.0	18.0	21.3	18.1	19.1	**19.0**	Original Cylinder After 24 Hr Soak
10/30/18	PL	8	10/22/2018		03W6	Jackson	031S	10.9	9.6	10.7	10.7	10.4	9.5	9.8	10.2	**10.2**	
10/30/18	PL	8	10/22/2018		03W6	Jackson	031SB	10.1	10.6	9.4	9.0	9.4	9.4	8.9	8.8	**9.5**	
11/5/18	PL	14	10/22/2018		03W6	Jackson	031S	11.3	11.2	10.7	11.4	11.2	11.0	10.1	11.5	**11.1**	
11/5/18	PL	14	10/22/2018		03W6	Jackson	031SB	10.8	10.8	10.6	10.9	10.3	10.5	10.5	10.7	**10.6**	
11/19/18	PL	28	10/22/2018		03W6	Jackson	031S	12.4	13.2	11.9	13.2	12.6	12.9	11.4	12.3	**12.5**	
11/19/18	PL	28	10/22/2018		03W6	Jackson	031SB	12.9	12.6	12.8	12.8	12.9	12.5	12.9	12.5	**12.7**	
2/5/19	PL	106	10/22/2018		03W6	Jackson	031S	23.5	23.9	24.3	22.5	24.4	23.5	23.1	22.8	**23.5**	CYL. NOT SELECTED
2/5/19	PL	106	10/22/2018		03W6	Jackson	031SB	23.9	22.6	22.4	23.0	22.2	23.1	23.5	22.7	**22.9**	CYL. NOT SELECTED
10/30/18	PL	7	10/23/2018		03W6	Jackson	037S	9.1	8.7	9.7	8.7	8.6	8.5	9.2	8.5	**8.9**	
10/30/18	PL	7	10/23/2018		03W6	Jackson	037SB	9.1	8.7	8.3	8.8	8.9	8.1	8.2	8.6	**8.6**	
11/6/18	PL	14	10/23/2018		03W6	Jackson	037S	10.7	9.7	9.8	9.4	10.0	9.5	9.4	9.0	**9.7**	
11/6/18	PL	14	10/23/2018		03W6	Jackson	037SB	10.6	10.4	10.4	10.5	11.6	11.0	10.6	10.4	**10.7**	
11/20/18	PL	28	10/23/2018		03W6	Jackson	037S	13.9	13.5	14.7	13.8	13.5	13.1	13.8	12.7	**13.6**	
11/20/18	PL	28	10/23/2018		03W6	Jackson	037SB	12.2	12.1	13.3	13.0	12.1	12.2	13.0	13.1	**12.6**	
2/5/19	PL	105	10/23/2018		03W6	Jackson	037S	25.5	25.3	22.7	23.2	22.5	23.9	22.9	22.6	**23.6**	CYL. NOT SELECTED
2/5/19	PL	105	10/23/2018		03W6	Jackson	037SB	24.0	23.8	20.8	21.4	23.3	22.9	21.0	21.0	**22.3**	CYL. NOT SELECTED
10/31/18	PL	7	10/24/2018		03W6	Jackson	042S	11.7	10.9	10.9	10.4	11.2	10.3	10.2	9.6	**10.7**	
10/31/18	PL	7	10/24/2018		03W6	Jackson	042SB	11.1	10.1	9.8	9.9	11.0	10.0	9.9	10.0	**10.2**	
11/7/18	PL	14	10/24/2018		03W6	Jackson	042S	11.0	10.2	11.3	11.1	11.9	12.2	12.6	11.5	**11.5**	
11/7/18	PL	14	10/24/2018		03W6	Jackson	042SB	11.6	12.1	12.8	13.3	12.2	12.6	12.9	13.0	**12.6**	
11/21/18	PL	28	10/24/2018		03W6	Jackson	042S	13.7	13.0	12.6	12.7	11.3	11.9	11.5	12.3	**12.4**	
11/21/18	PL	28	10/24/2018		03W6	Jackson	042SB	13.1	12.8	12.2	12.1	12.4	12.1	11.6	11.4	**12.2**	
2/5/19	PL	104	10/24/2018		03W6	Jackson	042S	25.6	27.8	24.4	24.5	23.4	25.7	22.6	23.7	**24.7**	CYL. NOT SELECTED
2/5/19	PL	104	10/24/2018		03W6	Jackson	042SB	24.6	22.1	21.6	20.1	23.3	20.9	21.6	21.0	**21.9**	CYL. NOT SELECTED
11/9/18	PL	14	10/26/2018		03W6	Jackson	045S	14.1	13.2	12.6	13.5	13.3	13.0	12.7	12.7	**13.1**	
11/9/18	PL	14	10/26/2018		03W6	Jackson	045SB	15.0	13.5	14.3	13.5	13.9	12.2	12.9	12.0	**13.4**	
11/23/18	PL	28	10/26/2018		03W6	Jackson	045S	13.2	13.2	13.0	13.0	13.0	12.5	12.3	12.5	**12.8**	
11/23/18	PL	28	10/26/2018		03W6	Jackson	045SB	12.8	12.7	13.3	13.1	13.9	12.4	12.8	12.8	**13.0**	
2/6/19	PL	103	10/26/2018		03W6	Jackson	045S	24.0	21.4	21.3	21.9	22.1	22.1	23.3	22.7	**22.4**	Original Cylinder After 24 Hr Soak
2/6/19	PL	103	10/26/2018		03W6	Jackson	045SB	19.5	20.0	19.1	21.9	19.2	20.0	19.3	22.3	**20.2**	Original Cylinder After 24 Hr Soak
11/5/18	PL	9	10/27/2018		03W6	Jackson	050S	11.4	12.3	12.9	12.0	11.6	12.3	12.3	11.4	**12.0**	
11/5/18	PL	9	10/27/2018		03W6	Jackson	050SB	11.9	11.3	12.0	11.6	11.4	10.1	11.8	11.3	**11.4**	
11/10/18	PL	14	10/27/2018		03W6	Jackson	050S	10.6	9.2	9.6	8.8	9.1	9.4	8.6	8.4	**9.2**	
11/10/18	PL	14	10/27/2018		03W6	Jackson	050SB	10.2	10.6	11.4	11.0	10.0	10.3	11.3	10.7	**10.7**	
11/24/18	PL	28	10/27/2018		03W6	Jackson	050S	12.7	14.0	13.6	13.5	13.4	13.5	13.3	13.5	**13.4**	
11/24/18	PL	28	10/27/2018		03W6	Jackson	050SB	13.0	14.0	13.5	12.5	13.1	13.5	13.3	13.5	**13.3**	
2/6/19	PL	102	10/27/2018		03W6	Jackson	050S	27.9	26.2	26.4	25.6	26.8	24.9	26.2	26.1	**26.3**	Original Cylinder After 24 Hr Soak
2/6/19	PL	102	10/27/2018		03W6	Jackson	050SB	21.3	24.9	20.2	21.6	21.0	23.7	20.7	22.0	**21.9**	Original Cylinder After 24 Hr Soak
11/5/18	PL	8	10/28/2018		03W6	Jackson	057S	11.3	10.8	10.4	10.6	10.7	9.7	10.2	10.2	**10.5**	
11/5/18	PL	8	10/28/2018		03W6	Jackson	057SB	10.2	10.4	9.8	9.6	9.8	9.8	9.4	9.8	**9.9**	
11/11/18	PL	14	10/28/2018		03W6	Jackson	057S	10.0	9.9	10.3	9.7	9.8	9.3	10.4	9.6	**9.9**	
11/11/18	PL	14	10/28/2018		03W6	Jackson	057SB	9.3	9.4	9.0	9.3	9.4	9.3	9.0	9.1	**9.2**	
11/25/18	PL	28	10/28/2018		03W6	Jackson	057S	12.2	13.3	12.6	12.2	12.0	12.7	12.3	12.2	**12.4**	
11/25/18	PL	28	10/28/2018		03W6	Jackson	057SB	12.4	12.7	12.5	11.9	12.1	12.1	11.8	11.4	**12.1**	
2/5/19	PL	100	10/28/2018		03W6	Jackson	057S	26.3	24.7	25.1	25.8	26.4	25.3	24.6	25.0	**25.4**	CYL. NOT SELECTED
2/5/19	PL	100	10/28/2018		03W6	Jackson	057SB	26.1	27.4	24.9	24.4	24.2	24.1	22.6	23.5	**24.7**	CYL. NOT SELECTED
11/5/18	PL	7	10/29/2018		03W6	Jackson	063S	9.8	10.2	9.5	9.6	9.7	9.6	9.4	9.4	**9.7**	
11/5/18	PL	7	10/29/2018		03W6	Jackson	063SB	9.1	9.0	9.2	9.0	9.0	9.0	9.3	8.9	**9.1**	

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11/12/18	PL	14	10/29/2018		03W6	Jackson	063S	10.0	9.3	9.4	9.4	9.6	9.2	9.3	9.4	**9.5**	
11/12/18	PL	14	10/29/2018		03W6	Jackson	063SB	10.5	9.8	10.2	9.6	9.9	9.6	9.4	9.4	**9.8**	
11/26/18	PL	28	10/29/2018		03W6	Jackson	063S	12.4	13.0	12.2	12.7	11.9	12.4	11.5	12.3	**12.3**	
11/26/18	PL	28	10/29/2018		03W6	Jackson	063SB	12.4	12.6	12.3	12.9	12.4	11.4	11.9	12.4	**12.3**	
2/6/19	PL	100	10/29/2018		03W6	Jackson	063S	20.7	21.0	20.9	20.8	19.8	21.2	21.0	20.8	**20.8**	Original Cylinder After 24 Hr Soak
2/6/19	PL	100	10/29/2018		03W6	Jackson	063SB	22.1	23.5	20.6	21.6	20.2	21.0	21.3	22.7	**21.6**	Original Cylinder After 24 Hr Soak
11/7/18	PL	8	10/30/2018		03W6	Jackson	067S	10.0	11.0	10.0	9.6	9.9	10.4	9.7	9.2	**10.0**	
11/7/18	PL	8	10/30/2018		03W6	Jackson	067SB	10.4	10.0	9.4	9.8	10.0	9.9	9.1	9.9	**9.8**	
11/13/18	PL	14	10/30/2018		03W6	Jackson	067S	10.7	10.1	10.9	10.3	10.4	10.0	10.8	10.5	**10.5**	
11/13/18	PL	14	10/30/2018		03W6	Jackson	067SB	10.4	9.9	10.0	10.0	10.5	10.2	9.9	10.3	**10.2**	
11/27/18	PL	28	10/30/2018		03W6	Jackson	067S	16.5	18.6	18.2	16.4	15.7	16.4	16.3	15.7	**16.7**	
11/27/18	PL	28	10/30/2018		03W6	Jackson	067SB	14.9	15.3	16.3	14.9	14.8	14.2	14.6	13.5	**14.8**	
2/5/19	PL	98	10/30/2018		03W6	Jackson	067S	27.1	28.4	27.5	24.0	26.1	26.5	26.1	24.9	**26.3**	EXTRA CYL. SELECTED
2/5/19	PL	98	10/30/2018		03W6	Jackson	067SB	30.1	26.1	24.8	25.7	26.7	24.5	25.2	24.9	**26.0**	EXTRA CYL. SELECTED
2/6/19	PL	99	10/30/2018		03W6	Jackson	067S	34.1	33.9	32.1	32.8	34.3	34.4	31.5	32.6	**33.2**	Original Cylinder After 24 Hr Soak
2/6/19	PL	99	10/30/2018		03W6	Jackson	067SB	30.9	34.3	35.7	34.8	31.5	34.3	35.7	34.9	**34.0**	Original Cylinder After 24 Hr Soak
11/7/18	PL	7	10/31/2018		03W6	Jackson	073S	8.8	9.5	9.5	9.6	8.2	9.0	9.6	9.4	**9.2**	
11/7/18	PL	7	10/31/2018		03W6	Jackson	073SB	9.7	9.7	9.9	9.0	9.6	9.1	10.0	9.8	**9.6**	
11/14/18	PL	14	10/31/2018		03W6	Jackson	073S	10.2	9.9	9.6	10.1	10.1	9.9	9.7	10.0	**9.9**	
11/14/18	PL	14	10/31/2018		03W6	Jackson	073SB	10.4	10.2	9.9	9.8	10.2	10.1	9.9	10.5	**10.1**	
11/28/18	PL	28	10/31/2018		03W6	Jackson	073S	11.7	11.9	12.3	11.2	11.1	12.0	11.4	10.7	**11.5**	
11/28/18	PL	28	10/31/2018		03W6	Jackson	073SB	11.2	11.9	11.1	11.7	11.0	11.5	10.5	10.2	**11.1**	
2/5/19	PL	97	10/31/2018		03W6	Jackson	073S	29.4	24.5	24.6	26.2	25.4	23.7	23.3	24.8	**25.2**	EXTRA CYL. SELECTED
2/5/19	PL	97	10/31/2018		03W6	Jackson	073SB	27.3	25.2	24.0	25.8	25.3	23.4	22.9	22.8	**24.6**	EXTRA CYL. SELECTED
2/6/19	PL	98	10/31/2018		03W6	Jackson	073S	31.9	30.9	32.8	33.8	31.5	31.5	31.9	32.4	**32.1**	Original Cylinder After 24 Hr Soak
2/6/19	PL	98	10/31/2018		03W6	Jackson	073SB	29.7	28.5	32.6	30.3	29.7	31.3	33.4	31.5	**30.9**	Original Cylinder After 24 Hr Soak
11/8/18	PL	7	11/01/2018		03W6	Jackson	078S	8.6	8.7	8.7	7.9	8.2	8.1	8.4	7.9	**8.3**	
11/8/18	PL	7	11/01/2018		03W6	Jackson	078SB	8.9	8.2	7.4	7.7	8.7	7.9	7.1	7.8	**8.0**	
11/15/18	PL	14	11/01/2018		03W6	Jackson	078S	9.0	9.1	8.9	8.5	8.8	8.9	8.7	8.5	**8.8**	
11/15/18	PL	14	11/01/2018		03W6	Jackson	078SB	9.0	8.1	7.6	7.8	9.0	7.9	7.4	7.5	**8.0**	
11/29/18	PL	28	11/01/2018		03W6	Jackson	078S	11.8	12.2	11.1	11.4	11.4	11.6	10.6	11.3	**11.4**	
11/29/18	PL	28	11/01/2018		03W6	Jackson	078SB	10.5	12.6	11.3	10.4	10.3	11.8	10.6	10.3	**11.0**	
2/6/19	PL	97	11/01/2018		03W6	Jackson	078S	23.9	23.4	20.0	22.0	20.0	24.0	21.7	21.0	**22.0**	Original Cylinder After 24 Hr Soak
2/6/19	PL	97	11/01/2018		03W6	Jackson	078SB	20.0	17.3	19.7	21.3	19.3	17.8	19.5	20.8	**19.5**	Original Cylinder After 24 Hr Soak
11/10/18	PL	8	11/02/2018		03W6	Jackson	081S	11.5	12.0	11.8	11.5	10.0	11.2	11.3	10.9	**11.3**	
11/10/18	PL	8	11/02/2018		03W6	Jackson	081SB	10.2	10.8	11.4	12.5	9.7	10.2	10.7	11.7	**10.9**	
11/16/18	PL	14	11/02/2018		03W6	Jackson	081S	11.8	12.6	11.4	11.9	10.9	11.3	11.7	11.3	**11.6**	
11/16/18	PL	14	11/02/2018		03W6	Jackson	081SB	10.6	11.2	12.1	12.4	10.4	10.1	11.0	11.8	**11.2**	
11/30/18	PL	28	11/02/2018		03W6	Jackson	081S	12.3	11.4	11.5	11.6	11.9	11.1	10.2	10.2	**11.3**	
11/30/18	PL	28	11/02/2018		03W6	Jackson	081SB	14.5	14.3	15.2	15.4	15.9	13.7	14.0	14.6	**14.7**	
2/6/19	PL	96	11/02/2018		03W6	Jackson	081S	23.3	22.6	20.1	22.2	21.9	21.8	20.5	21.3	**21.7**	Original Cylinder After 24 Hr Soak
2/6/19	PL	96	11/02/2018		03W6	Jackson	081SB	22.5	20.9	23.8	23.6	23.4	21.6	22.3	22.2	**22.5**	Original Cylinder After 24 Hr Soak
11/15/18	PL	11	11/04/2018		03W6	Jackson	087S	11.6	12.6	12.4	11.7	11.7	12.6	12.7	12.4	**12.2**	
11/15/18	PL	11	11/04/2018		03W6	Jackson	087SB	12.4	12.3	11.8	11.7	12.1	10.8	10.5	10.1	**11.5**	
11/19/18	PL	15	11/04/2018		03W6	Jackson	087S	11.5	12.7	12.2	12.0	11.8	12.8	13.0	12.6	**12.3**	
11/19/18	PL	15	11/04/2018		03W6	Jackson	087SB	12.3	12.4	11.9	12.2	12.3	10.9	10.8	10.8	**11.7**	
12/3/18	PL	29	11/04/2018		03W6	Jackson	087S	12.8	12.6	12.7	12.7	13.0	12.1	11.2	12.7	**12.5**	
12/3/18	PL	29	11/04/2018		03W6	Jackson	087SB	12.3	11.8	13.5	12.1	12.0	11.6	13.1	11.9	**12.3**	
2/6/19	PL	94	11/04/2018		03W6	Jackson	087S	25.6	23.6	26.1	24.1	22.6	22.1	22.4	24.4	**23.9**	Original Cylinder After 24 Hr Soak
2/6/19	PL	94	11/04/2018		03W6	Jackson	087SB	27.9	24.1	22.5	22.1	24.9	21.0	20.7	23.7	**23.4**	Original Cylinder After 24 Hr Soak
11/15/18	PL	10	11/05/2018		03W6	Jackson	092S	10.2	9.9	9.4	9.4	9.3	9.2	9.0	8.9	**9.4**	
11/15/18	PL	10	11/05/2018		03W6	Jackson	092SB	9.9	9.4	10.1	9.6	9.7	9.3	9.6	9.4	**9.6**	
11/19/18	PL	14	11/05/2018		03W6	Jackson	092S	10.3	10.1	9.4	9.6	9.6	9.4	9.1	9.5	**9.6**	
11/19/18	PL	14	11/05/2018		03W6	Jackson	092SB	10.2	9.4	10.3	9.9	9.8	10.0	9.5	9.7	**9.9**	
12/3/18	PL	28	11/05/2018		03W6	Jackson	092S	11.6	11.9	11.5	11.6	11.4	11.2	11.1	11.2	**11.4**	
12/3/18	PL	28	11/05/2018		03W6	Jackson	092SB	12.0	12.8	12.1	12.2	11.8	11.8	11.5	11.7	**12.0**	
2/5/19	PL	92	11/05/2018		03W6	Jackson	092S	22.1	22.5	21.6	23.1	20.7	20.9	20.4	22.0	**21.7**	CYL. NOT SELECTED
2/5/19	PL	92	11/05/2018		03W6	Jackson	092SB	24.6	22.0	23.2	22.2	24.1	21.8	23.6	21.6	**22.9**	CYL. NOT SELECTED
11/21/18	PL	7	11/14/2018		03W6	Jackson	098S	11.0	10.0	10.6	10.2	10.0	9.6	10.0	9.8	**10.2**	
11/21/18	PL	7	11/14/2018		03W6	Jackson	098SB	11.2	9.1	9.9	9.5	10.4	8.4	9.5	9.1	**9.6**	
11/28/18	PL	14	11/14/2018		03W6	Jackson	098S	11.6	11.7	10.6	11.3	11.2	10.8	10.3	11.1	**11.1**	
11/28/18	PL	14	11/14/2018		03W6	Jackson	098SB	11.2	10.7	11.4	9.9	11.0	10.2	10.9	9.5	**10.6**	
12/12/18	PL	28	11/14/2018		03W6	Jackson	098S	14.9	14.9	14.6	13.2	14.9	14.9	14.2	12.7	**14.3**	
12/12/18	PL	28	11/14/2018		03W6	Jackson	098SB	12.5	14.2	13.6	14.5	12.6	13.5	12.9	13.9	**13.5**	
2/5/19	PL	83	11/14/2018		03W6	Jackson	098S	25.8	26.4	23.4	22.0	23.1	24.2	24.1	24.5	**24.2**	CYL. NOT SELECTED
2/5/19	PL	83	11/14/2018		03W6	Jackson	098SB	25.1	25.3	22.9	24.2	21.9	23.8	22.4	22.1	**23.5**	CYL. NOT SELECTED
11/22/18	PL	7	11/15/2018		03W6	Jackson	101S	9.9	9.2	10.1	9.8	9.3	8.8	9.4	9.7	**9.5**	
11/22/18	PL	7	11/15/2018		03W6	Jackson	101SB	10.6	10.7	10.4	9.6	10.0	9.8	9.7	9.7	**10.1**	
11/29/18	PL	14	11/15/2018		03W6	Jackson	101S	8.7	8.9	8.4	8.1	8.8	8.6	8.2	8.0	**8.5**	
11/29/18	PL	14	11/15/2018		03W6	Jackson	101SB	8.8	8.8	9.4	9.4	8.4	8.5	8.8	8.6	**8.8**	
12/13/18	PL	28	11/15/2018		03W6	Jackson	101S	11.9	11.2	12.2	13.1	11.8	11.4	11.9	12.5	**12.0**	
12/13/18	PL	28	11/15/2018		03W6	Jackson	101SB	13.0	12.3	12.7	12.6	13.0	12.0	11.5	12.0	**12.4**	
2/6/19	PL	83	11/15/2018		03W6	Jackson	101S	18.0	20.3	20.7	17.1	17.5	19.3	20.1	17.2	**18.8**	Original Cylinder After 24 Hr Soak
2/6/19	PL	83	11/15/2018		03W6	Jackson	101SB	20.9	21.3	19.9	18.1	18.9	20.2	20.6	18.9	**19.9**	Original Cylinder After 24 Hr Soak
11/23/18	PL	7	11/16/2018		03W6	Jackson	104S	9.7	9.8	9.1	9.1	9.3	9.1	8.8	8.5	**9.2**	
11/23/18	PL	7	11/16/2018		03W6	Jackson	104SB	10.4	8.4	8.6	8.8	9.7	7.9	8.3	8.5	**8.8**	
11/30/18	PL	14	11/16/2018		03W6	Jackson	104S	10.7	10.6	10.7	10.4	10.0	10.5	10.4	10.0	**10.4**	
11/30/18	PL	14	11/16/2018		03W6	Jackson	104SB	11.0	10.1	10.0	9.9	10.7	9.6	10.0	9.6	**10.1**	
12/14/18	PL	28	11/16/2018		03W6	Jackson	104S	16.8	15.8	15.9	16.3	15.2	15.5	15.1	15.6	**15.8**	
12/14/18	PL	28	11/16/2018		03W6	Jackson	104SB	15.3	15.1	15.5	13.2	13.5	12.7	14.0	13.5	**14.1**	
2/5/19	PL	81	11/16/2018		03W6	Jackson	104S	20.5	26.2	22.2	20.9	21.1	21.0	20.9	20.8	**21.7**	CYL. NOT SELECTED
2/5/19	PL	81	11/16/2018		03W6	Jackson	104SB	19.7	20.2	20.0	21.5	21.2	18.8	20.3	23.8	**20.7**	CYL. NOT SELECTED
11/27/18	PL	7	11/20/2018		03W6	Jackson	111S	9.9	10.0	9.8	9.4	8.9	9.5	9.7	9.1	**9.5**	
11/27/18	PL	7	11/20/2018		03W6	Jackson	111SB	10.3	10.4	10.6	9.9	9.7	9.6	10.6	9.6	**10.1**	

12/4/18	PL	14	11/20/2018		03W6	Jackson	111S	9.2	10.0	9.6	9.7	9.3	8.9	9.5	9.0	**9.4**	
12/4/18	PL	14	11/20/2018		03W6	Jackson	111SB	11.2	10.3	9.5	10.1	10.1	10.0	9.7	10.3	**10.2**	
12/18/18	PL	28	11/20/2018		03W6	Jackson	111S	13.9	14.4	13.9	14.2	13.4	13.5	13.4	13.3	**13.8**	
12/18/18	PL	28	11/20/2018		03W6	Jackson	111SB	13.8	14.3	15.3	14.3	13.7	14.1	14.6	14.0	**14.3**	
2/5/19	PL	77	11/20/2018		03W6	Jackson	111S	21.7	21.8	22.6	24.2	23.4	21.9	21.3	20.9	**22.2**	CYL. NOT SELECTED
2/5/19	PL	77	11/20/2018		03W6	Jackson	111SB	25.6	22.5	21.4	23.0	24.5	21.6	21.9	22.6	**22.9**	CYL. NOT SELECTED
11/28/18	PL	7	11/21/2018		03W6	Jackson	117S	10.2	9.9	10.6	9.8	9.7	9.7	9.9	9.2	**9.9**	
11/28/18	PL	7	11/21/2018		03W6	Jackson	117SB	10.8	9.9	10.0	10.7	10.2	9.6	9.2	9.5	**10.0**	
12/5/18	PL	14	11/21/2018		03W6	Jackson	117S	10.1	10.4	10.0	9.9	9.3	10.4	10.9	9.4	**10.1**	
12/5/18	PL	14	11/21/2018		03W6	Jackson	117SB	11.1	10.1	9.7	10.3	10.3	9.7	9.4	9.9	**10.1**	
12/19/18	PL	28	11/21/2018		03W6	Jackson	117S	13.4	13.6	14.3	13.8	13.5	13.4	12.9	13.6	**13.6**	
12/19/18	PL	28	11/21/2018		03W6	Jackson	117SB	15.8	14.8	14.2	14.4	14.8	14.9	13.7	13.4	**14.5**	
2/6/19	PL	77	11/21/2018		03W6	Jackson	117S	25.5	26.0	24.1	24.3	24.7	25.4	24.0	23.2	**24.9**	Original Cylinder After 24 Hr Soak
2/6/19	PL	77	11/21/2018		03W6	Jackson	117SB	23.2	23.3	21.5	22.4	21.9	23.3	19.6	22.0	**22.2**	Original Cylinder After 24 Hr Soak
11/30/18	PL	7	11/23/2018		03W6	Jackson	123S	10.7	11.7	11.5	11.4	10.7	12.0	11.4	11.1	**11.3**	
11/30/18	PL	7	11/23/2018		03W6	Jackson	123SB	11.4	10.9	11.5	11.6	11.4	11.2	11.1	11.2	**11.3**	
12/7/18	PL	14	11/23/2018		03W6	Jackson	123S	9.6	9.6	10.0	9.6	9.4	9.8	10.1	9.3	**9.7**	
12/7/18	PL	14	11/23/2018		03W6	Jackson	123SB	9.4	10.4	9.2	9.2	8.9	10.2	9.0	8.9	**9.4**	
12/21/18	PL	28	11/23/2018		03W6	Jackson	123S	15.8	15.4	15.9	15.7	15.6	15.5	16.0	15.4	**15.7**	
12/21/18	PL	28	11/23/2018		03W6	Jackson	123SB	14.8	16.4	15.2	14.1	14.7	15.5	15.4	14.5	**15.1**	
2/6/19	PL	75	11/23/2018		03W6	Jackson	123S	24.0	24.3	24.3	23.6	22.7	22.8	23.4	23.0	**23.5**	Original Cylinder After 24 Hr Soak
2/6/19	PL	75	11/23/2018		03W6	Jackson	123SB	24.7	21.9	21.2	25.3	23.7	21.2	20.8	24.1	**22.9**	Original Cylinder After 24 Hr Soak

APPENDIX F:

Date	ID	Field No.	ASTM	SAM Meter		All Chords			Over 30 microns		
			Air (%)	SAM #	Air (%)	Air (%)	Spacing Factor (mm)	Specific Surface Area (mm^{-1})	Air (%)	Spacing Factor (mm)	Specific Surface Area (mm^{-1})
10/06/2018	2282922	014S	5.7	0.51	5.7	5.99	0.1	47.92	5.46	0.18	27.65
10/21/2018		026S	6.4	0.34	6.1	7.87	0.08	51.16	7.15	0.145	30.44
10/26/2018	2284435	045S	7.4	0.32	7.6	7.04	0.137	32.38	6.74	0.194	23.38
10/27/2018	2284485	050S	6.1	0.1	6.2	5.97	0.119	40.19	5.51	0.224	22.15
10/30/2018		067S	5.7	0.19	5.6	7.85	0.08	50.71	7.08	0.152	29.15
10/31/2018		073S	6.5	0.35	6.7	8.52	0.078	48.35	7.76	0.144	28.6
11/01/2018	2284978	078S	7.1	0.25	7.3	7.28	0.12	36.34	6.93	0.167	26.71
11/04/2018	2285113	087S	7	0.08	7.2	6.47	0.131	35.09	6.18	0.185	25.42
11/15/2018	2285629	101S	6.6	0.31	6.5	8.09	0.08	49.77	7.33	0.15	29.05
11/21/2018	2285909	117S	7.8	0.15	8.2	7.06	0.088	50.59	6.4	0.159	29.07
11/23/2018	2285954	123S	7.2	0.3	8.2	7.03	0.101	43.85	6.51	0.167	27.59