ERDC/GSL TR-18-32

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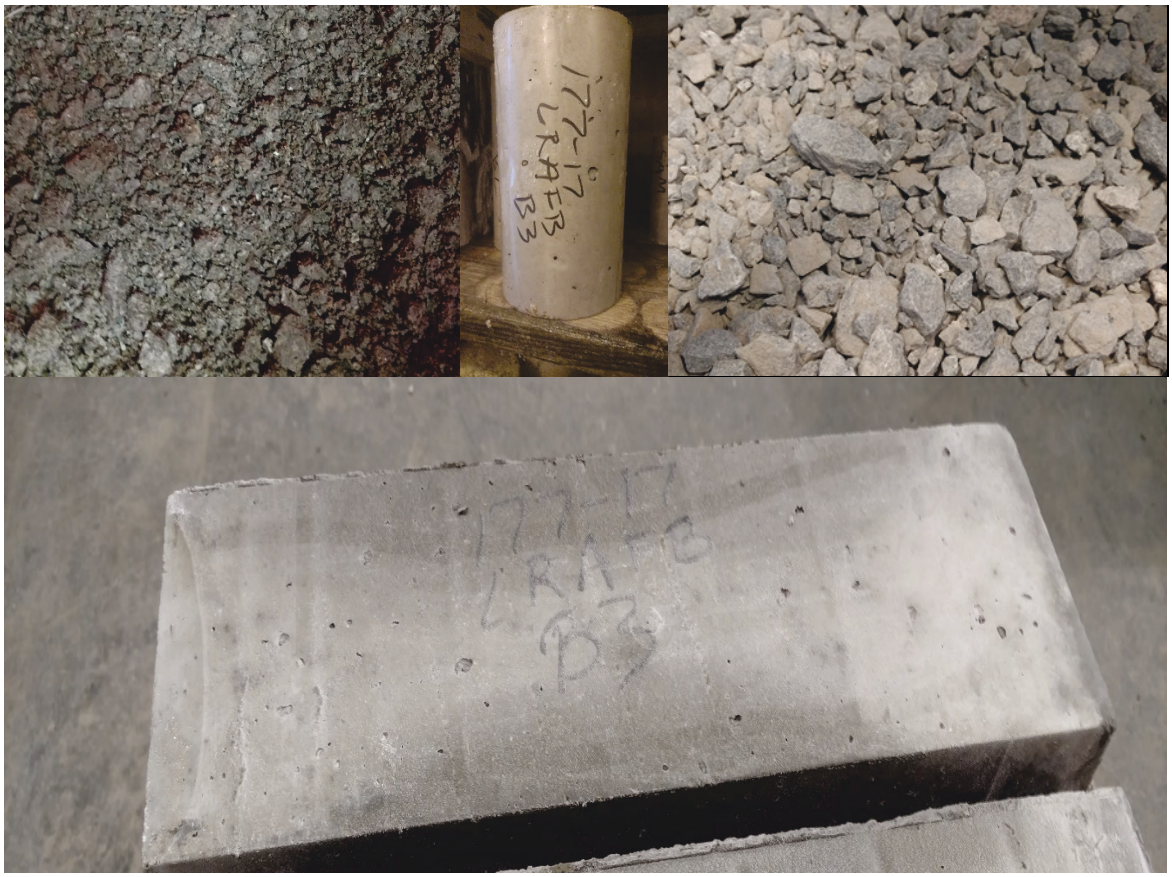
Little Rock Air Force Base Aggregate and Concrete Testing

Jameson D. Shannon

November 2018



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Final report

Prepared for USACE Little Rock District
700 W. Capitol Avenue, Federal Building 7th Floor,
Little Rock, AR 72203

Under LCC 2EF9E5

Abstract

The Little Rock Air Force Base (LRAFB) tasked the ERDC to test and evaluate a concrete mixture design and the aggregates used therein. Experimentation consisted of basic aggregate test methods such as gradation, specific gravity, absorption, and organic materials. Concrete testing consisted of manufacturing a laboratory concrete mixture design provided by LRAFB and conducting compressive and flexural strength testing of cast specimens.

In most cases the selected aggregate and concrete mixture design testing met specifications. However, there were some areas, such as aggregate gradations, in which the materials did not align with specified values or standards. Final hardened concrete properties of compressive and flexural strength met the mixture design requirements.

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Preface

This study was conducted for the U.S. Army Corps of Engineers Little Rock District. The technical monitor was Dr. Jameson D. Shannon.

The work was performed by the Concrete and Materials Branch (GMC) of the Engineering Systems and Materials Division (GM), U.S. Army Engineer Research and Development Center, Geotechnical and Structures Laboratory (ERDC-GSL). At the time of publication, Mr. Christopher M. Moore was Chief, CEERD-GMC; Dr. G. William McMahon was Chief, CEERD-GM; and Ms. Pamela Kinnebrew, CEERD-GTZ, was the Technical Director for Military Engineering. The Deputy Director of ERDC-GSL was Dr. William P. Grogan, and the Director was Mr. Bartley P. Durst.

COL Ivan P. Beckman was the Commander of ERDC, and Dr. David W. Pitman was the Director.

Unit Conversion Factors

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
feet	0.3048	meters
gallons (US liquid)	3.785412 E-03	cubic meters
inches	0.0254	meters
square feet	0.09290304	square meters
square inches	6.4516 E-04	square meters
yards	0.9144	meters

1 Introduction and Background

The construction and repair of concrete runways is an integral part of the operations of the U.S. Army Corps of Engineers for both military and civilian installations. Recently, issues involving the deterioration of runways by spalling, sometimes referred to as sliver spalling, have been designated as potentially problematic on a large scale. A possible cause of this issue was thought to be aggregate gradations used in the concrete mixture and, accordingly, studies to evaluate mixture gradation's relationship to concrete performance were desired.

This research effort seeks to investigate a concrete runway mixture design, focusing on aggregate gradations, in an attempt to determine the suitability of the mixture design for use. Aggregate gradations restrictions were based on the power 45 curve and workability versus coarseness factor. The mixture was evaluated by compressive and flexural strength, as well as fresh-mixed concrete properties and visual observations.

2 Experimental Program

2.1 Materials tested

Testing was conducted on a concrete mixture design with a focus on aggregate materials. The mixture design was originally developed for Little Rock Air Force Base (LRAFB) to be used in concrete paving operations. In total six material samples were obtained, one each of cement, fly ash, 1.5-in. crushed limestone aggregate, #57 aggregate, intermediate aggregate, and sand. The intermediate aggregate was identified only as "Product 1." Materials and proportions for the concrete mixture are listed in Table 1.

Table 1. Concrete mixture materials.

Material	Supplier	Weight (lb) per yd^3 of Concrete	Volume (ft^3) per yd^3 of Concrete
Cement	Ash Grove	428	2.18
Fly Ash	Martin Lake	183	1.17
1.5-in. Agg.	Granite Mtn.	740	4.53
#57 Agg.	Granite Mtn.	1040	6.34
Product 1	Granite Mtn.	396	2.42
Sand	Jeffrey	870	5.28
Water	---	208	3.33
Air	---	---	1.76

Water used in concrete mixing was onsite potable water from Vicksburg, MS. Euclid Admixtures AEA 92 (air entrainment) and Eucon NW (superplasticizer – water reducer) were used at dosage rates of 0.5-2.0 oz/cwt and 4-6 oz/cwt, respectively.

Sampling was conducted by ERDC personnel at the temporary stockpile locations at Little Rock AFB on 4 April 2017. Stockpiles were first "rolled" to remove the top layer of materials and to facilitate more accurate sampling. Samples of materials were then hand shoveled into 5-gal buckets and transferred to a larger container for transport. Cement, fly ash, and Product 1 were transported in 55-gal drums while 1.5-in., #57, and sand materials were transported in supersacks. Due to concerns about the age of admixtures at the Little Rock location, fresh admixtures were also collected by the ERDC to be used in the mixture designs.

2.2 Aggregate testing procedures

All aggregate testing was conducted by technicians with appropriate certifications and with equipment that is regularly calibrated and certified by an external laboratory. Aggregates were stored in their transportation containers, either supersacks or 55-gal drums, until tested. Aggregates were placed into a 3-ft^3 concrete mixing drum and rotated before testing to alleviate any segregation that may have occurred during transportation. Gradations for all four aggregates were determined using ASTM C136 standards. Sieve sizes used for the 1.5-in. and #57 materials were 4 in. (100 mm), 3.5 in. (90 mm), 3 in. (75 mm), 2.5 in. (63 mm), 2 in. (50 mm), 1.5 in. (37.5 mm), 1 in. (25 mm), 0.75 in. (19 mm), 0.5 in. (12.5 mm), 0.375 in. (9.5 mm), No. 4 (4.75 mm), and No. 8 (2.36 mm).

For the "Product 1" aggregate, all larger sieve sizes were used, and No. 16 (1.18 mm) and No. 30 (600 µm) were added. For the sand aggregate all larger sizes were used; and No. 40 (425 µm), No. 50 (300 µm), No. 100 (150 µm), and No. 200 (75 µm) were added. ASTM C117 standards were also conducted on all aggregates to determine materials finer than 75 µm. All ASTM C136 and C117 testing was conducted with two different material samples, and results were based on the average.

Relative densities and absorptions of the 1.5-in., #57, and Product 1 materials were determined by ASTM C127 standards. Relative densities and absorption of sand were conducted according to ASTM C128 standards. All ASTM C127 and ASTM C128 testing was conducted on two different material samples, and results were based on the average. Organic impurity testing on the sand was conducted according to ASTM C40 standards. A test matrix for aggregate testing with the number of samples shown is in Table 2.

Table 2. Aggregate testing matrix.

	ASTM Test Method and Number of Samples				
	C136	C117	C127	C128	C40
1.5 in.	2	2	2	---	---
#57	2	2	2	---	---
Product 1	2	2	2	---	---
Sand	2	2	---	2	1

2.3 Concrete mixture design testing procedures

All concrete mixing and testing were conducted by technicians with appropriate certifications and with equipment that is regularly calibrated and certified by an external laboratory. Concrete mixtures were batched according to ASTM C192 standards. A single mixture design was batched in triplicate, and each batch had a volume of 3 ft^3. The three batches were each mixed, tested for fresh properties, and placed into molds on the same day during a 6-hr period. Immediately after mixing, the batches were tested for fresh mixed properties of slump, air content, and unit weight according to ASTM C143, ASTM C231, and ATM C138 standards, respectively.

After fresh property testing was completed, four 6-in. x 12-in. cylinders and four 6-in. x 6-in. x 21-in. beams were manufactured from each concrete mixture using appropriate plastic molds. Cylinders and beams were extruded from their molds approximately 24 hr after batching and were stored in either a 100% humidity concrete curing room (cylinders) or a lime-water bath (beams) of appropriate temperature according to ASTM specifications. A single cylinder and single beam from each batch were tested at 3, 7, 14, and 28 days according to ASTM C39 and ASTM C78 standards.

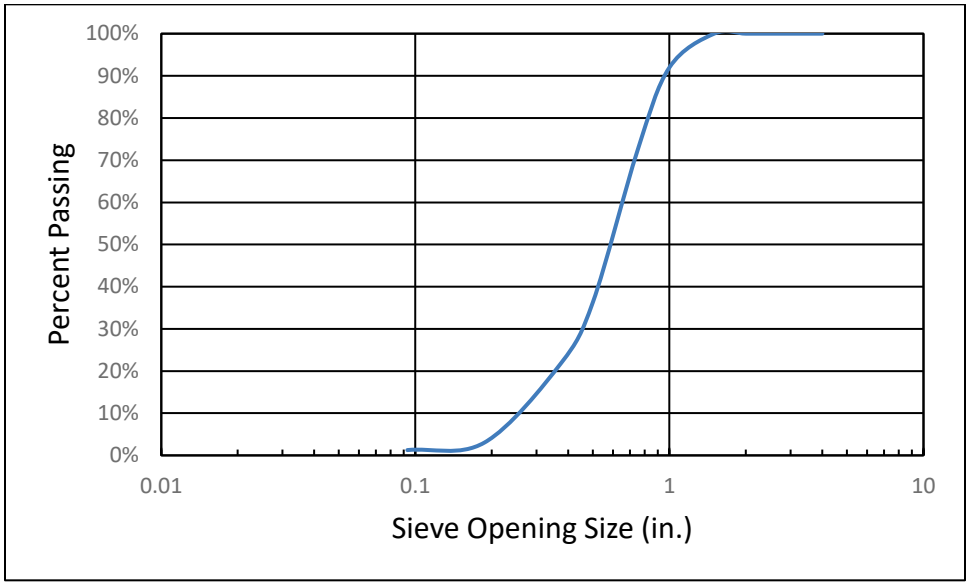
3 Results

3.1 Aggregate testing results

Final and processed data for aggregate testing are shown and discussed in this chapter. Raw data test results are included in Appendix A. Results from ASTM C136 for each aggregate are shown in Figures 1 through 4. Two samples were tested for each aggregate. Of the materials tested, the #57 and sand aggregates met their respective specified gradation requirements. The 1.5-in. aggregate did not meet one of the five size fraction requirements, and the Product 1 aggregate was dissimilar to any standard concrete aggregate size.

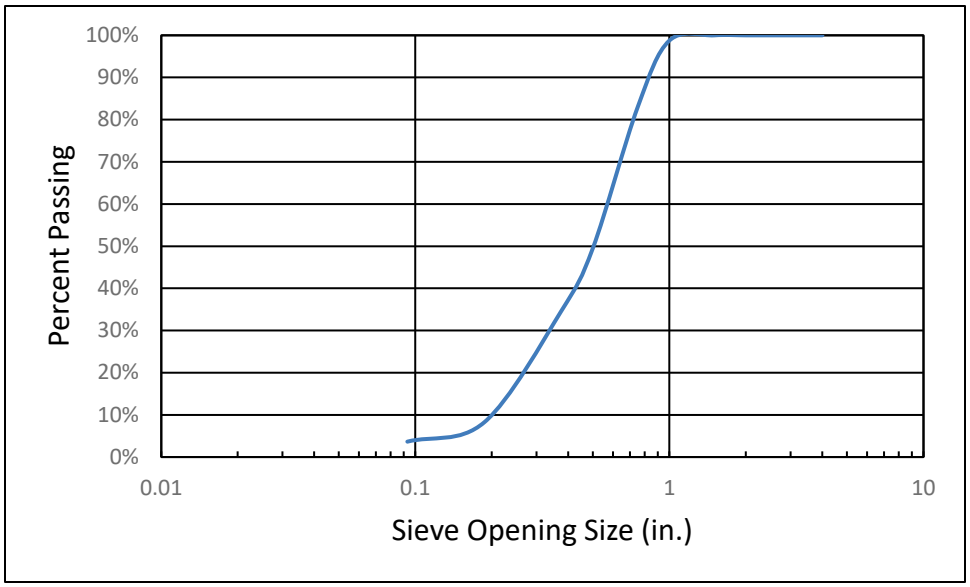
According to ASTM C33 (*Standard Specification for Concrete Aggregates*), the 1.5-in. material was most similar to a #467 aggregate. This aggregate size is constrained by 100% passing 2 in., 95-100% passing 1.5 in., 35-70% passing 0.75 in., 10-30% passing 0.375 in., and 0-5% passing No. 4. Results for the 1.5-in material are given in Figure 1. This material met all gradation requirements for a #467 aggregate except for 35-70% passing 0.75 in. For both samples, this aggregate was out of tolerance on this sieve size by an average of 2.43%, on the high side. The material was 100% passing on the 1.5-in. sieve and 92% passing on the 1-in. sieve. This would indicate that the nominal maximum size is 1 in.

Figure 1. ASTM C136 results for 1.5-in. aggregate.



A #57 material is required by ASTM C33 to meet the size requirements of 100% passing 1.5 in., 95-100% passing the 1 in., 25-60% passing 0.5 in., 0-10% passing No. 4, and 0-5% passing No. 8. Results for the #57 material are given in Figure 2. The tested material met all requirements on both samples.

Figure 2. ASTM C136 results for #57 aggregate.



The aggregate "Product 1" was unknown but appeared to be an intermediate size aggregate. Results for the "Product 1" material are given in Figure 3. ASTM C136 results showed that this material did not meet the requirements of any concrete aggregate listed in ASTM C33. The most similar standard size material appeared to be a size #89, in which the material met three of the six gradation requirements for that size. Results for the sand aggregate material are given in Figure 4. The sand tested met all ASTM C33 requirements for a standard concrete fine aggregate.

Figure 3. ASTM C136 results for Product 1 aggregate.

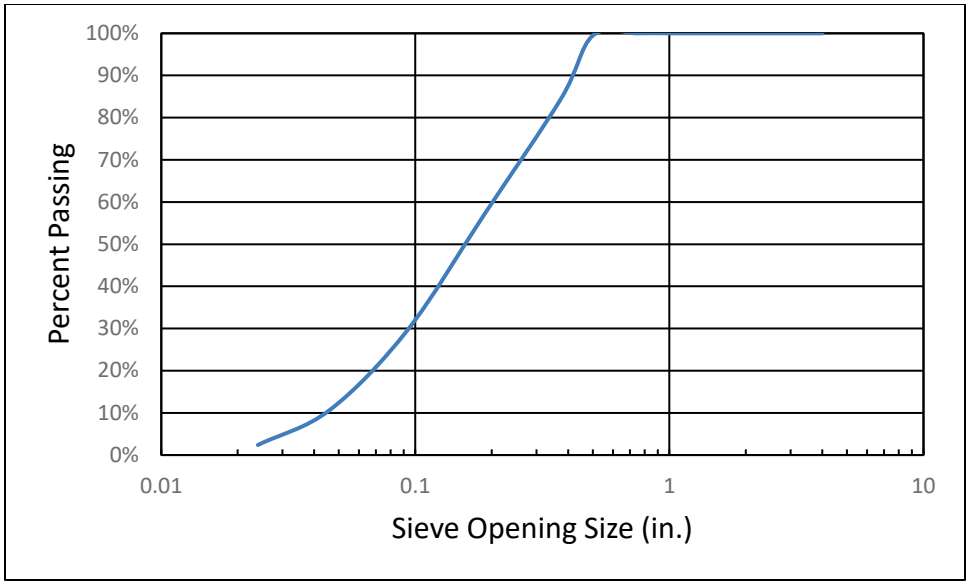
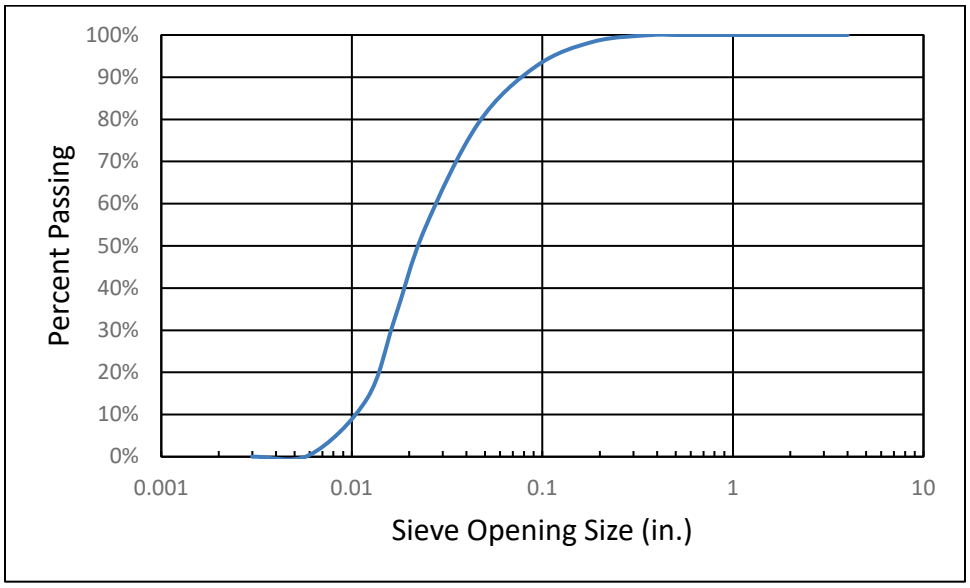


Figure 4. ASTM C136 results for sand aggregate.



Results from ASTM C117 are shown in Table 3. The average value represents the percentage of material finer than the No. 200 sieve (75 µm). The results indicate a normal to slightly low percent finer than No. 200 for the sand, and a normal to slightly high percent finer than No. 200 for the coarse and intermediate aggregates. Results from ASTM C127 and ASTM C128 are shown in Table 4. No outliers or abnormal percentage of fines was recorded for any of the materials tested.

Table 3. ASTM C117 results.

Material	Sample 1	Sample 2	Average
1.5 in.	0.87%	0.90%	0.9%
#57	1.36%	1.51%	1.4%
Product 1	0.91%	0.90%	0.9%
Sand	0.19%	0.13%	0.2%

Table 4. ASTM C127 and ASTM C128 test results.

	1.5 in.	#57	Product 1	Sand
Relative Density - OD	2.59	2.63	2.61	2.61
Relative Density - SSD	2.60	2.63	2.62	2.62
Relative Density - Apparent	2.61	2.65	2.64	2.64
Absorption	0.4%	0.3%	0.4%	0.4%

3.2 Combined aggregate testing results

A combined aggregate gradation was determined based on the specific mix design parameters listed in Table 1. Table 5 gives the results of the combined aggregate gradation. A combined percent retained chart was created and is shown in Figure 5. Each point on the percent retained curve designates a sieve size. Combined aggregate gradations were used in determining the power 45 curve (Figure 6) and coarseness and workability factors.

The combined percent retained showed an area of gradation between the No. 4 and No. 30 sieves in which there were two low points between two peaks. As per the specifications, it was indicated that there should be no more than one low point between two peaks.

The combined gradation curve (Figure 6) appears to stay within the upper and lower boundary with the exception of material smaller than the No. 30 sieve. This is generally normal for concrete mixtures to allow space for the paste portion. The gradation curve does approach the upper boundary from sizes No. 16 to No. 8 and again from 0.75 in. to 1 in.

Table 5. Combined Aggregate Gradation.

Sieve Size	Individual % Ret	Cumulative % Ret	Cumulative % Passing
4 in.	0.00%	0.00%	100.00%
3.5 in.	0.00%	0.00%	100.00%
3 in.	0.00%	0.00%	100.00%
2.5 in.	0.00%	0.00%	100.00%
2 in.	0.00%	0.00%	100.00%
1.5 in.	0.00%	0.00%	100.00%
1 in.	2.34%	2.34%	97.66%
0.75 in.	10.06%	12.40%	87.60%
0.5 in.	20.07%	32.48%	67.52%
0.375 in.	10.50%	42.98%	57.02%
No. 4	17.50%	60.48%	39.52%
No. 8	7.26%	67.74%	32.26%
No. 16	7.96%	75.70%	24.30%
No. 30	8.39%	84.09%	15.91%
No. 40	6.50%	90.60%	9.40%
No. 50	5.42%	96.02%	3.98%
No. 100	3.86%	99.88%	0.12%
No. 200	0.12%	100.00%	0.00%

Figure 5. Combined percent retained by sieve size.

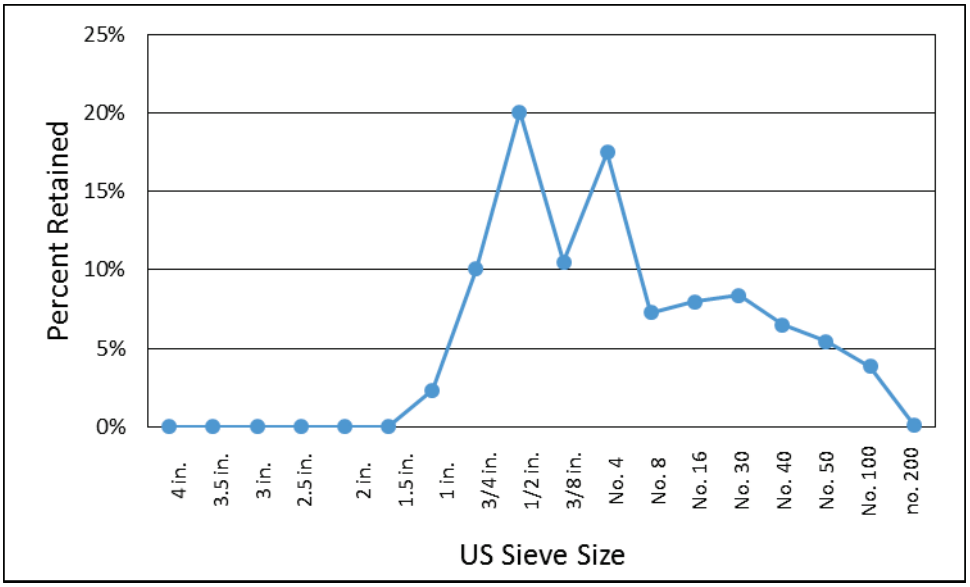
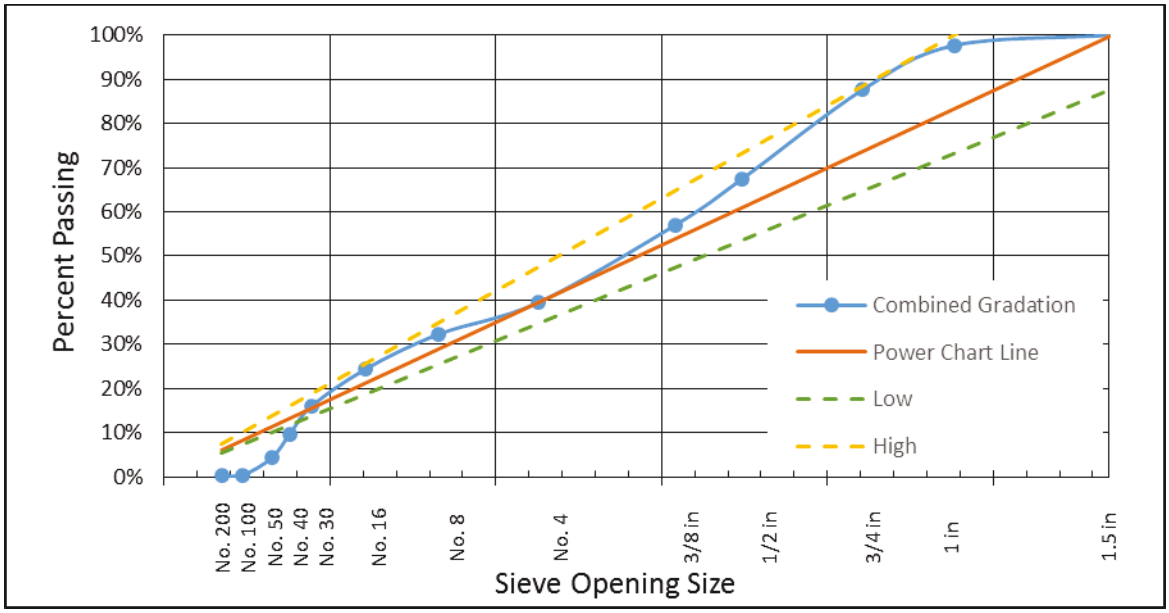


Figure 6. Power 45 chart.

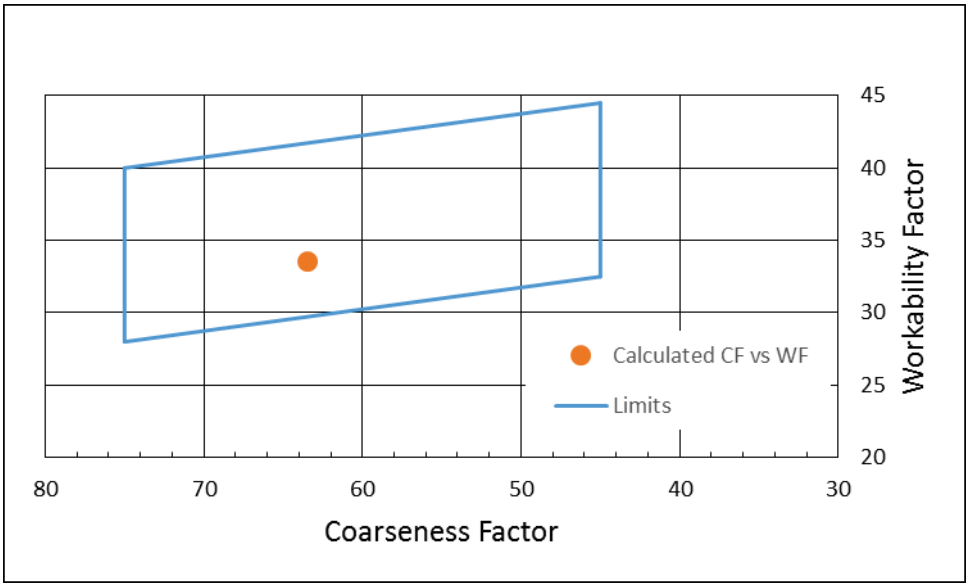


The coarseness factor (CF) and workability factor (WF) for the combined aggregate gradation were determined using equations 1 and 2. Calculated values were 63.45 for CF and 33.51 for WF. Figure 7 illustrates the calculated CF versus WF factor and the target limits described in the specifications. As seen in the figure, the calculated values fell within the prescribed limits.

$$CF = \frac{cumulative\ \%\ retained\ on\ \frac{3}{8}{-}in\ sieve}{cumulative\ \%\ retained\ on\ No.8\ sieve} * 100 \quad (1)$$

$$WF = (cumulative\ \%\ passing\ No.8\ sieve) + 2.5 * \frac{cementitious\ content - 564}{94} \quad (2)$$

Figure 7. Calculated CF versus WF with limits shown.



3.3 Concrete mixture design results

Final and reduced data for concrete testing is shown and discussed in this section. Raw data test results are included in Appendix B. Moisture contents of the materials at the time of batching were 0.22%, 0.37%, 3.40% and 2.94% for 1.5-in., #57, "Product 1," and sand materials, respectively. Batch quantities were adjusted for moisture contents to ensure consistency with field mixtures. Fresh concrete properties are shown in Table 6 for each mixture. Target fresh properties were slump of 0-2 in., unit weight of 143.1 lb/ft^3, and air content of 6% ± 1.5%. Values were rounded to either the nearest quarter inch (slump) or the nearest tenth (unit weight, air content, temperature).

Table 6. Fresh mixed concrete properties.

	Slump (in.)	Unit Weight (lb/ft^3)	Air Content (%)	Temperature (°F)
Batch 1	1.00	146.0	5.8	70.6
Batch 2	0.25	148.4	4.8	70.2
Batch 3	0.25	147.2	5.1	70.3
Average	0.50	147.2	5.2	70.4

Slump met the specified requirements, but was on the lower half of the targeted values. Unit weight values were 2.9% higher than the theoretical calculated values for the mixture. Air contents were within specified tolerances, but were 1.3% lower, on average, than the target air content.

Temperature met the requirements outlined in standard ASTM specifications for laboratory mixed concrete.

Based on visual inspection immediately after mixing, the concrete appeared to be stiff or "boney." This was expected as recent studies by the Federal Highways Administration have noted that mixtures adhering closely to the maximum density line of the power 45 chart can be dense and difficult to work (FHWA-HIF-15-019, 2015). Cylinders and beams were vibrated to consolidate the mixture, and it was noted that the vibratory process took longer than for most concrete mixtures, and even with a longer vibration period there were still a large number of unclosed spaces and voids in the finished specimens. Figure 8 illustrates the unclosed holes in final specimens.

Figure 8. Specimen photos illustrating unclosed holes.

Table 7 and Table 8 show results for the flexural strength and compressive strength testing, respectively. A single specimen from each batch was tested at each test day so that the average results represent the average of one specimen each from three batches. Coefficients of variation (CoVs) are also included in the tables for statistical validation. The specification prescribed a flexural strength of 650 psi at 28 days. Based on the results from these tables, the mixture achieved sufficient flexural strength by seven days. Averages and CoV values show a good level of agreement between batches.

Table 7. Flexural strength results.

	3 Day	7 Day	14 Day	28 Day
Batch 1 (psi)	619	645	745	845
Batch 2 (psi)	615	675	720	970
Batch 3 (psi)	610	715	790	930
Average (psi)	615	678	752	915
CoV (%)	0.6	4.2	3.9	5.7

Table 8. Compressive strength results (psi).

	3 Day	7 Day	14 Day	28 Day
Mixture 1	---*	4350	4980	5510
Mixture 2	4490	4610	5460	6010
Mixture 3	4010	4400	5220	5900
Average	4250	4453	5220	5807
CoV	5.7	2.5	3.8	3.7

*Cylinder break was non-traditional and was excluded from average.

4 Summary and Conclusions

4.1 Summary

Of the coarse aggregate materials, the #57 material met all requirements of ASTM C33 for a #57 aggregate. The 1.5-in. aggregate was similar to a #467 material, meeting all but one of the five gradation requirements. As the "Product 1" aggregate was most similar to a #89 material but met only three of the six gradation requirements for a size #89, the "Product 1" material did not fit into any size category described in ASTM C33.

Specifications stated a coarse aggregate nominal maximum aggregate size of 1.5 in. However, based on testing contained in this report, the nominal maximum aggregate size was 1 in. The combined aggregate gradation met the requirements of the 45 power chart but was frequently at the maximum upper end of the limit. The gradation was within the limits of the coarseness versus workability factors.

The concrete mixture met the slump and air content tolerances as specified, but the air content was 1.3% lower, on average, than the target. Measured unit weight was 2.9% higher than theoretical. Visually, the mixture appeared stiff, or "boney," and was difficult to finish. The mixture was difficult to work into molds and had to be vibrated longer than usual to consolidate.

On average, hardened concrete properties of compressive and flexural strength met 28 day specification guidelines at 7 days.

4.2 Conclusions

In general, there were some discrepancies in the coarse aggregate materials, such as not fitting into ASTM C33 gradation categories and the actual nominal maximum aggregate size being lower than specified. However, the combined gradation was able to achieve the prescribed power 45 and workability versus coarseness requirements. Fresh mixed concrete properties of slump and air content and hardened properties of compressive and flexural strength also met the requirements outlined.

Despite meeting the tested concrete performance properties, the mixture was difficult to finish and consolidate. Definitive conclusions on mixture

design performance are not obtainable from this study as only a portion of the specified requirements were evaluated. However, the mixture design did meet all of the combined gradation, fresh mixed concrete properties, and hardened concrete properties that were selected for testing.

5 Contact Information

Permission to publish was granted by the Director, Geotechnical and Structures Laboratory. For questions related to this investigation, contact

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Federal Highway Administration (FHWA). 2015. *Blended aggregates for concrete mixture optimization – best practices for jointed concrete pavements*. FHWA-HIF-15-019. Washington, DC: FHWA.

Appendix A: Raw Data Sheets for Aggregate Testing

Table A1. ASTM C127 for 1.5-in. aggregate.

ASTM C 136 & ASTM C 117 WORKSHEET

CMB Log In No.:	170076	Date:	15-May-17
District:		Tested By:	CEERD-GM-C
Material Supplier:	Little Rock - AFB	Date Received:	
Sampled By:	S.M.	Material Type:	1 1/2in. Stone

ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates

			Date Tested:	15-May-17			Date Tested:	15-May-17				ASTM C33 SPECIFICATIONS		
			Run 1				Run 2					FOR: No. 467		
Sieve Size			Individual		Cumulative		Individual		Cumulative		Average	Percent Passing		
std.	mm	FM	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Percent Passing	Min.	Max.	Results
4.0	100		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
3.5	90		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
3.0	75	x	0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
2.5	63		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
2.0	50		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%	100%	100%	Pass
1.5	37.5	x	0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%	95%	100%	Pass
1.0	25		1,272.20	8.46%	8.46%	91.54%	1,338.80	7.56%	7.56%	92.44%	92%			
3/4	19	x	2,986.50	19.86%	28.32%	71.68%	3,409.90	19.26%	26.82%	73.18%	72%	35%	70%	Out
1/2	12.5		5,391.10	35.85%	64.17%	35.83%	6,421.70	36.28%	63.10%	36.90%	36%			
3/8	9.5	x	2,167.00	14.41%	78.58%	21.42%	2,563.70	14.48%	77.58%	22.42%	22%	10%	30%	Pass
No. 4	4.75	x	2,768.50	18.41%	96.99%	3.01%	3,425.20	19.35%	96.93%	3.07%	3%	0%	5%	Pass
No. 8	2.36	x	260.20	1.73%	98.72%	1.28%	324.40	1.83%	98.76%	1.24%	1%			
Pan			192.30	1.28%	100.00%	0.00%	219.00	1.24%	100.00%	0.00%	0%			
Total			15,037.80	100.00%			17,702.70	100.00%						
Fineness Modulus:					7.026				7.001		7.01			

x = Sieves used to calculate fineness modulus

			Run 1		Run 2	
				Acceptance Range		Acceptance Range
Yes	No	*Results for ASTM C 136 No. 200 include ASTM C 117 Results.*	Original Dry Mass, g	15,083.0	Original Dry Mass, g	17,755.9
	X		15,037.9	14,992.8	17,702.8	17,649.7

If the same ASTM C 117 sample is used for the above ASTM C 136 test then add the mass loss (g) from ASTM C 117 to the pan mass retained (g) from ASTM C 136.

ASTM C 117 Minus 75 µm (No. 200)

Procedure A	X	Washed with Plain Water	Date Tested:	12-May-17
Procedure B		Washed with Wetting Agent		

	Original Dry Mass, g	Dry Mass After Wash, g	Mass Loss, g	Percent Loss	Average
Run 1	15,169.5	15,037.9	131.6	0.87%	0.9%
Run 2	17,864.2	17,702.8	161.4	0.90%	

Table A2. ASTM C127 for 1.5-in. aggregate.

ASTM C 127 Worksheet										
CMB Log In No.:	170076				Date:	16-May-17				
District:					Tested By:	CEERD-GM-C				
Material Supplier:	Little Rock - AFB				Date Received:					
Sampled By:	S.M.				Material Type:	1 1/2in. Stone				
ASTM C 127 Relative Density and Absorption of Coarse Aggregate										
	Oven-Dry Mass in Air, g	S.S.D. Mass in Air, g	S.S.D. Mass in Water, g	Relative Density Oven-Dry	Relative Density S.S.D.	Apparent Relative Density	Percent Absorption	Water Temp., C	Soak Time, hrs.	Pan No.
RUN 1	14,540.5	14,596.0	8,983.1	2.591	2.600	2.616	0.38%	22.6	21.0	R-4
RUN 2	17,154.2	17,210.9	10,592.0	2.592	2.600	2.614	0.33%	23.0	23.0	X-1
	AVERAGE			2.59	2.60	2.62	0.4%	22.8	22.00	

ASTM C 127 Relative Density and Absorption of Coarse Aggregate Precision								
Test Results						ASTM C 127-15 Table 1 Precision Values		Test Results
	Run 1	Run 2	Average	Standard Deviation (1s)	Standard Deviation (d2s)1.96√2	Standard Deviation (1s)	Standard Deviation (d2s)1.96√2	Standard Deviation (d2s)1.96√2
Relative Density Oven-Dry	2.591	2.592	2.59	0.001	0.002	0.009	0.025	Pass
Relative Density S.S.D.	2.600	2.600	2.60	0.000	0.000	0.007	0.020	Pass
Apparent Relative Density	2.616	2.614	2.62	0.002	0.005	0.007	0.020	Pass

Table A3. ASTM C136 and ASTM C117 precision for 1.5-in. aggregate.

ASTM C 136 & C 117 PRECISION WORKSHEET

CMB Log In No.:	170076	Date:	15-May-17
District:		Tested By:	CEERD-GM-C
Material Supplier:	Little Rock - AFB	Date Received:	
Sampled By:	S.M.	Material Type:	1 1/2in. Stone

ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates

Sieve Size			Cumulative Test Results					ASTM C 136-14 Table 2 Precision Values			Test Results
std.	mm	FM	Run 1 Total Percent Passing	Run 2 Total Percent Passing	Average Percent Passing	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Total Percent Passing	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Standard Deviation (d2s)1.96√2, %
4.0	100		100.00%	100.00%	100.00%	0.00%	0.00%				
3.5	90		100.00%	100.00%	100.00%	0.00%	0.00%				
3.0	75	x	100.00%	100.00%	100.00%	0.00%	0.00%				
2.5	63		100.00%	100.00%	100.00%	0.00%	0.00%				
2.0	50		100.00%	100.00%	100.00%	0.00%	0.00%				
1.5	37.5	x	100.00%	100.00%	100.00%	0.00%	0.00%				
1.0	25		91.54%	92.44%	91.99%	0.63%	1.76%	95-85	0.81%	2.30%	Pass
3/4	19	x	71.68%	73.18%	72.43%	1.06%	2.93%	80-60	2.25%	6.40%	Pass
1/2	12.5		35.83%	36.90%	36.37%	0.76%	2.10%	60-20	1.32%	3.40%	Pass
3/8	9.5	x	21.42%	22.42%	21.92%	0.71%	1.96%	60-20	1.32%	3.40%	Pass
No. 4	4.75	x	3.01%	3.07%	3.04%	0.04%	0.12%	5-2	0.53%	1.50%	Pass
No. 8	2.36	x	1.28%	1.24%	1.26%	0.03%	0.08%	2-0	0.27%	0.80%	Pass

Coarse Aggregate Values

ASTM C 136-14 Table 2 Precision Coarse Aggregate Values

Total Percent Passing		Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
Less	Greater or Equal		
100%	95%	0.32%	0.90%
95%	85%	0.81%	2.30%
85%	80%	1.34%	3.80%
80%	60%	2.25%	6.40%
60%	20%	1.32%	3.40%
20%	15%	0.96%	2.70%
15%	10%	1.00%	2.80%
10%	5%	0.75%	2.10%
5%	2%	0.53%	1.50%
2%	0%	0.27%	0.80%

ASTM C 136-14 Table 2 Precision Fine Aggregate Values

Total Percent Passing		Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
Less	Greater or Equal		
100%	95%	0.26%	0.70%
95%	60%	0.55%	1.60%
60%	20%	0.83%	2.40%
20%	15%	0.54%	1.50%
15%	10%	0.36%	1.00%
10%	2%	0.37%	0.40%
2%	0%	0.14%	0.60%

ASTM C 117 Minus 75 µm (No. 200)

Test Results						ASTM C 117-13 Table 1 Precision Values		Test Results
	Run 1	Run 2	Average	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Standard Deviation (d2s)1.96√2, %
Percent Loss	0.87%	0.90%	0.9%	0.03%	0.07%	0.10%	0.28%	Pass

ASTM C 117-13 Table 1 Precision Coarse Aggregate Values

Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
0.10%	0.28%

ASTM C 117-13 Table 1 Precision Fine Aggregate Values

Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
0.15%	0.43%

Table A4. ASTM C136 and ASTM C117 for #57 aggregate.

ASTM C 136 & ASTM C 117 WORKSHEET

CMB Log In No.:	170077	Date:	15-May-17
District:		Tested By:	CEERD-GM-C
Material Supplier:	Little Rock - AFB	Date Received:	
Sampled By:	S.M.	Material Type:	No. 57 Stone

ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates

Sieve Size			Date Tested:	15-May-17			Date Tested:	15-May-17				ASTM C33 SPECIFICATIONS FOR: No. 57		
			Run 1				Run 2					Percent Passing		
			Individual		Cumulative		Individual		Cumulative		Average			
std.	mm	FM	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Percent Passing	Min.	Max.	Results
4.0	100		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
3.5	90		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
3.0	75	x	0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
2.5	63		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
2.0	50		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
1.5	37.5	x	0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%	100%	100%	Pass
1.0	25		128.40	1.15%	1.15%	98.85%	144.60	1.31%	1.31%	98.69%	99%	95%	100%	Pass
3/4	19	x	1,728.00	15.46%	16.61%	83.39%	1,780.90	16.13%	17.44%	82.56%	83%			
1/2	12.5		3,721.60	33.29%	49.90%	50.10%	3,696.50	33.48%	50.92%	49.08%	50%	25%	60%	Pass
3/8	9.5	x	1,673.30	14.97%	64.87%	35.13%	1,658.30	15.02%	65.94%	34.06%	35%			
No. 4	4.75	x	2,998.30	26.82%	91.69%	8.31%	2,850.70	25.82%	91.76%	8.24%	8%	0%	10%	Pass
No. 8	2.36	x	518.50	4.64%	96.33%	3.67%	507.90	4.60%	96.36%	3.64%	4%	0%	5%	Pass
Pan			410.20	3.67%	100.00%		401.70	3.64%	100.00%	0.00%				
Total			11,178.30	100.00%			11,040.60	100.00%						
Fineness Modulus:					6.695				6.715		6.70			

x = Sieves used to calculate fineness modulus

			Run 1		Run 2	
				Acceptance Range		Acceptance Range
Yes	No	Results for ASTM C 136 No. 200 include ASTM C 117 Results.	Original Dry Mass, g	11,212.0	Original Dry Mass, g	11,073.9
	X		11,178.5	11,145.0	11,040.8	11,007.7

If the same ASTM C 117 sample is used for the above ASTM C 136 test then add the mass loss (g) from ASTM C 117 to the pan mass retained (g) from ASTM C 136.

ASTM C 117 Minus 75 µm (No. 200)

Procedure A	X	Washed with Plain Water	Date Tested:	12-May-17
Procedure B		Washed with Wetting Agent		

	Original Dry Mass, g	Dry Mass After Wash, g	Mass Loss, g	Percent Loss	Average
Run 1	11,332.7	11,178.5	154.2	1.36%	1.4%
Run 2	11,210.1	11,040.8	169.3	1.51%	

Table A5. ASTM C127 for #57 aggregate.

ASTM C 127 Worksheet			
CMB Log In No.:	170077	Date:	16-May-17
District:		Tested By:	CEERD-GM-C
Material Supplier:	Little Rock - AFB	Date Received:	
Sampled By:	S.M.	Material Type:	No. 57 Stone

ASTM C 127 Relative Density and Absorption of Coarse Aggregate

	Oven-Dry Mass in Air, g	S.S.D. Mass in Air, g	S.S.D. Mass in Water, g	Relative Density Oven-Dry	Relative Density S.S.D.	Apparent Relative Density	Percent Absorption	Water Temp., C	Soak Time, hrs.	Pan No.
RUN 1	10,241.3	10,273.1	6,377.7	2.629	2.637	2.651	0.31%	22.6	22.0	101
RUN 2	10,133.1	10,167.4	6,304.8	2.623	2.632	2.647	0.34%	22.4	23.5	1
	AVERAGE			2.63	2.63	2.65	0.3%	22.5	22.75	

ASTM C 127 Relative Density and Absorption of Coarse Aggregate Precision

	Test Results					ASTM C 127-15 Table 1 Precision Values		Test Results
	Run 1	Run 2	Average	Standard Deviation (1s)	Standard Deviation (d2s)1.96√2	Standard Deviation (1s)	Standard Deviation (d2s)1.96√2	Standard Deviation (d2s)1.96√2
Relative Density Oven-Dry	2.629	2.623	2.63	0.004	0.011	0.009	0.025	Pass
Relative Density S.S.D.	2.637	2.632	2.63	0.004	0.010	0.007	0.020	Pass
Apparent Relative Density	2.651	2.647	2.65	0.003	0.007	0.007	0.020	Pass

Table A6. ASTM C136 and C137 precision for #57 aggregate.

ASTM C 136 & C 117 PRECISION WORKSHEET			
CMB Log In No.:	170077	Date:	15-May-17
District:		Tested By:	CEERD-GM-C
Material Supplier:	Little Rock - AFB	Date Received:	
Sampled By:	S.M.	Material Type:	No. 57 Stone

ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates

Sieve Size			Cumulative Test Results					ASTM C 136-14 Table 2 Precision Values			Test Results	
std.	mm	F.M	Run 1 Total Percent Passing	Run 2 Total Percent Passing	Average Percent Passing	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Total Percent Passing	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Standard Deviation (d2s)1.96√2, %	
4.0	100		100.00%	100.00%	100.00%	0.00%	0.00%					Coarse Aggregate Values
3.5	90		100.00%	100.00%	100.00%	0.00%	0.00%					
3.0	75	x	100.00%	100.00%	100.00%	0.00%	0.00%					
2.5	63		100.00%	100.00%	100.00%	0.00%	0.00%					
2.0	50		100.00%	100.00%	100.00%	0.00%	0.00%					
1.5	37.5	x	100.00%	100.00%	100.00%	0.00%	0.00%					
1.0	25		98.85%	98.69%	98.77%	0.11%	0.32%	100-95	0.32%	0.90%	Pass	
3/4	19	x	83.39%	82.56%	82.98%	0.59%	1.63%	85-80	1.34%	3.80%	Pass	
1/2	12.5		50.10%	49.08%	49.59%	0.72%	2.00%	60-20	1.32%	3.40%	Pass	
3/8	9.5	x	35.13%	34.06%	34.60%	0.76%	2.10%	60-20	1.32%	3.40%	Pass	
No. 4	4.75	x	8.31%	8.24%	8.28%	0.05%	0.14%	10-5	0.75%	2.10%	Pass	
No. 8	2.36	x	3.67%	3.64%	3.66%	0.02%	0.06%	5-2	0.53%	1.50%	Pass	

ASTM C 136-14 Table 2 Precision Coarse Aggregate Values

Total Percent Passing		Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
Less	Greater or Equal		
100%	95%	0.32%	0.90%
95%	85%	0.81%	2.30%
85%	80%	1.34%	3.80%
80%	60%	2.25%	6.40%
60%	20%	1.32%	3.40%
20%	15%	0.96%	2.70%
15%	10%	1.00%	2.80%
10%	5%	0.75%	2.10%
5%	2%	0.53%	1.50%
2%	0%	0.27%	0.80%

ASTM C 136-14 Table 2 Precision Fine Aggregate Values

Total Percent Passing		Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
Less	Greater or Equal		
100%	95%	0.26%	0.70%
95%	60%	0.55%	1.60%
60%	20%	0.83%	2.40%
20%	15%	0.54%	1.50%
15%	10%	0.36%	1.00%
10%	2%	0.37%	0.40%
2%	0%	0.14%	0.60%

ASTM C 117 Minus 75 µm (No. 200)

Test Results						ASTM C 117-13 Table 1 Precision Coarse Aggregate Values		Test Results
	Run 1	Run 2	Average	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Standard Deviation (d2s)1.96√2, %
Percent Loss	1.36%	1.51%	1.4%	0.11%	0.29%	0.10%	0.28%	Pass

ASTM C 117-13 Table 1 Precision Coarse Aggregate Values

Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
0.10%	0.28%

ASTM C 117-13 Table 1 Precision Fine Aggregate Values

Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
0.15%	0.43%

Table A7. ASTM C137 and C137 for Product 1 aggregate.

ASTM C 136 & ASTM C 117 WORKSHEET

CMB Log In No.:	170078	Date:	11-May-17
District:		Tested By:	CEERD-GM-C
Material Supplier:	Little Rock - AFB	Date Received:	
Sampled By:	S.M.	Material Type:	Product No. 1

ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates

Sieve Size			Run 1 Date Tested: 11-May-17				Run 2 Date Tested: 11-May-17				Average	ASTM C33 SPECIFICATIONS FOR:		
			Individual		Cumulative		Individual		Cumulative			Percent Passing		
std.	mm	FM	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Percent Passing	Min.	Max.	Results
4.0	100		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
3.5	90		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
3.0	75	x	0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
2.5	63		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
2.0	50		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
1.5	37.5	x	0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
1.0	25		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
3/4	19	x	0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%			
1/2	12.5		27.30	0.40%	0.40%	99.60%	41.10	0.61%	0.61%	99.39%	100%			
3/8	9.5	x	1,018.90	14.95%	15.35%	84.65%	1,003.60	14.90%	15.51%	84.49%	85%			
No. 4	4.75	x	1,887.10	27.68%	43.03%	56.97%	1,835.50	27.25%	42.76%	57.24%	57%			
No. 8	2.36	x	1,872.80	27.47%	70.50%	29.50%	1,857.70	27.58%	70.34%	29.66%	30%			
No. 16	1.18	x	1,282.60	18.81%	89.32%	10.68%	1,279.80	19.00%	89.34%	10.66%	11%			
No. 30	600 µm	x	562.20	8.25%	97.56%	2.44%	559.70	8.31%	97.65%	2.35%	2%			
Pan			166.10	2.44%	100.00%	0.00%	158.30	2.35%	100.00%	0.00%				
Total			6,817.00	100.00%			6,735.70	100.00%						
Fineness Modulus:					5.158				5.156		5.16			

x = Sieves used to calculate fineness modulus

			Run 1		Run 2	
				Acceptance Range		Acceptance Range
Yes	No	Results for ASTM C 136 No. 200 include ASTM C 117 Results.	Original Dry Mass, g	6,837.5	Original Dry Mass, g	6,755.9
	X		6,817.0	6,796.5	6,735.7	6,715.5

If the same ASTM C 117 sample is used for the above ASTM C 136 test then add the mass loss (g) from ASTM C 117 to the pan mass retained (g) from ASTM C 136.

ASTM C 117 Minus 75 µm (No. 200)

Procedure A	X	Washed with Plain Water	Date Tested: 10-May-17
Procedure B		Washed with Wetting Agent	

	Original Dry Mass, g	Dry Mass After Wash, g	Mass Loss, g	Percent Loss	Average
Run 1	6,879.4	6,817.0	62.4	0.91%	0.9%
Run 2	6,796.6	6,735.7	60.9	0.90%	

Table A8. ASTM C127 and ASTM C128 for Product 1 aggregate.

Worksheet For Weighted Values of Realative Density and Absorption Tested in Separte Sizes By Methods ASTM C 127 & C 128											
CMB Log In No.:		170078				Date:		26-May-17			
District:						Tested By:		CEERD-GM-C			
Material Supplier:		Little Rock - AFB				Date Received:					
Sampled By:		S.M.				Material Type:		Product No. 1			
Size Fraction											
std.	mm	Avg. Percent Retained	Sample Mass Used in Test	Avg. Relative Density Oven-Dry	Weighted Value of Relative Density Oven-Dry	Avg. Relative Density S.S.D.	Weighted Value of Relative Density S.S.D.	Avg. Apparent Relative Density	Weighted Value of Apparent Relative Density	Avg. Percent Absorption	Weighted Value of Percent Absorption
1/2 to No. 4	37.5 to 4.75	42.90%	9,468.0	2.611	0.164	2.624	0.164	2.643	0.162	0.461%	0.198%
No. 8 to No. 30	2.36 to 600 µm	57.11%	2,012.2	2.615	0.218	2.625	0.218	2.642	0.216	0.380%	0.217%
Total	Results	100%	11,480.2		2.61		2.62		2.64		0.4%

ASTM C 128 Relative Density and Absorption of Fine Aggregate											
Test Size: 500 ± 10g											
Run	Flask No.	S.S.D. Mass in Air, g	Mass of Pycnometer with Water, g	Mass of Pycnometer with Water & Sample, g	Oven-Dry Mass in Air, g	Relative Density Oven-Dry	Relative Density S.S.D.	Apparent Relative Density	Percent Absorption	Water Temp., C	Soak Time, hrs.
1	A	502.00	1440.50	1751.40	500.10	2.617	2.627	2.643	0.38%	22.8	24.50
2	B	501.30	1429.10	1740.30	499.30	2.627	2.637	2.654	0.40%	22.9	24.40
1	C	505.90	1448.70	1761.80	503.90	2.614	2.624	2.641	0.40%	22.8	25.00
2	D	503.00	1455.20	1766.50	501.10	2.614	2.624	2.640	0.38%	22.8	25.00
		AVERAGE				2.62	2.63	2.64	0.4%	22.8	24.75

Table A9. ASTM C128 for Product 1 aggregate.

ASTM C 128 Worksheet

CMB Log In No.:	170078	Date:	24-May-17
District:		Tested By:	CEERD-GM-C
Material Supplier:	Little Rock - AFB	Date Received:	
Sampled By:	S.M.	Material Type:	Product No. 1 (No. 8 to No. 30 - Sample 2)

ASTM C 128 Relative Density and Absorption of Fine Aggregate

Test Size: 500 ± 10g		S.S.D. Mass in Air, g	Mass of Pycnometer with Water, g	Mass of Pycnometer with Water & Sample, g	Oven-Dry Mass in Air, g	Relative Density Oven-Dry	Relative Density S.S.D.	Apparent Relative Density	Percent Absorption	Water Temp., C	Soak Time, hrs.
Run	Flask No.										
1	C	505.90	1448.70	1761.80	503.90	2.614	2.624	2.641	0.40%	22.8	25.00
2	D	503.00	1455.20	1766.50	501.10	2.614	2.624	2.640	0.38%	22.8	25.00
		AVERAGE				2.61	2.62	2.64	0.4%	22.8	25.00

ASTM C 128 Relative Density and Absorption of Coarse Aggregate Precision

	Test Results					ASTM C 128-15 Table 1 Precision Values		Test Results
	Run 1	Run 2	Average	Standard Deviation (1s)	Standard Deviation (d2s)1.96√2	Standard Deviation (1s)	Standard Deviation (d2s)1.96√2	Standard Deviation (d2s)1.96√2
Relative Density Oven-Dry	2.614	2.614	2.61	0.000	0.001	0.011	0.032	Pass
Relative Density S.S.D.	2.624	2.624	2.62	0.000	0.000	0.0095	0.027	Pass
Apparent Relative Density	2.641	2.640	2.64	0.001	0.002	0.0095	0.027	Pass
Percent Absorption	0.40%	0.38%	0.4%	0.000	0.000	0.11%	0.31%	Pass

Table A10. ASTM C136 and C117 precision.

ASTM C 136 & C 117 PRECISION WORKSHEET			
CMB Log In No.:	170078	Date:	11-May-17
District:		Tested By:	CEERD-GM-C
Material Supplier:	Little Rock - AFB	Date Received:	
Sampled By:	S.M.	Material Type:	Product No. 1

ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates

Sieve Size			Cumulative Test Results					ASTM C 136-14 Table 2 Precision Values			Test Results	
std.	mm	FM	Run 1 Total Percent Passing	Run 2 Total Percent Passing	Average Percent Passing	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Total Percent Passing	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Standard Deviation (d2s)1.96√2, %	
4.0	100		100.00%	100.00%	100.00%	0.00%	0.00%					Coarse Aggregate Values
3.5	90		100.00%	100.00%	100.00%	0.00%	0.00%					
3.0	75	x	100.00%	100.00%	100.00%	0.00%	0.00%					
2.5	63		100.00%	100.00%	100.00%	0.00%	0.00%					
2.0	50		100.00%	100.00%	100.00%	0.00%	0.00%					
1.5	37.5	x	100.00%	100.00%	100.00%	0.00%	0.00%					
1.0	25		100.00%	100.00%	100.00%	0.00%	0.00%					
3/4	19	x	100.00%	100.00%	100.00%	0.00%	0.00%					
1/2	12.5		99.60%	99.39%	99.49%	0.15%	0.41%	100-95	0.32%	0.90%	Pass	
3/8	9.5	x	84.65%	84.49%	84.57%	0.12%	0.32%	95-85	0.81%	2.30%	Pass	
No. 4	4.75	x	56.97%	57.24%	57.11%	0.19%	0.53%	60-20	0.83%	2.40%	Pass	Fine Aggregate Values
No. 8	2.36	x	29.50%	29.66%	29.58%	0.11%	0.32%	60-20	0.83%	2.40%	Pass	
No. 16	1.18	x	10.68%	10.66%	10.67%	0.02%	0.05%	15-10	0.36%	1.00%	Pass	
No. 30	600 µm	x	2.44%	2.35%	2.39%	0.06%	0.17%	10-2	0.37%	0.40%	Pass	

ASTM C 136-14 Table 2 Precision Coarse Aggregate Values

Total Percent Passing		Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
Less	Greater or Equal		
100%	95%	0.32%	0.90%
95%	85%	0.81%	2.30%
85%	80%	1.34%	3.80%
80%	60%	2.25%	6.40%
60%	20%	1.32%	3.40%
20%	15%	0.96%	2.70%
15%	10%	1.00%	2.80%
10%	5%	0.75%	2.10%
5%	2%	0.53%	1.50%
2%	0%	0.27%	0.80%

ASTM C 136-14 Table 2 Precision Fine Aggregate Values

Total Percent Passing		Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
Less	Greater or Equal		
100%	95%	0.26%	0.70%
95%	60%	0.55%	1.60%
60%	20%	0.83%	2.40%
20%	15%	0.54%	1.50%
15%	10%	0.36%	1.00%
10%	2%	0.37%	0.40%
2%	0%	0.14%	0.60%

ASTM C 117 Minus 75 µm (No. 200)

Test Results						ASTM C 117-13 Table 1 Precision Fine Aggregate Values		Test Results
	Run 1	Run 2	Average	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Standard Deviation (d2s)1.96√2, %
Percent Loss	0.91%	0.90%	0.9%	0.01%	0.02%	0.15%	0.43%	Pass

ASTM C 117-13 Table 1 Precision Coarse Aggregate Values

Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
0.10%	0.28%

ASTM C 117-13 Table 1 Precision Fine Aggregate Values

Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
0.15%	0.43%

Table A11. ASTM C136, ASTM C117, and ASTM C40.

ASTM C 136, ASTM C 117, & ASTM C 40 WORKSHEET															
CMB Log In No.:	170079					Date:	10-May-17								
District:						Tested By:	CEERD-GM-C								
Material Supplier:	Little Rock - AFB					Date Received:									
Sampled By:	S.M.					Material Type:	Sand								
ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates															
			Date Tested:	10-May-17			Date Tested:	10-May-17				ASTM C33 SPECIFICATIONS			
			Run 1				Run 2					FOR: Fine Aggregate			
Sieve Size			Individual		Cumulative		Individual		Cumulative		Average	Percent Passing			
std.	mm	F M	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Percent Passing	Min.	Max.	Results	
4.0	100		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%				
3.5	90		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%				
3.0	75	x	0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%				
2.5	63		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%				
2.0	50		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%				
1.5	37.5	x	0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%				
1.0	25		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%				
3/4	19	x	0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%				
1/2	12.5		0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%				
3/8	9.5	x	0.00	0.00%	0.00%	100.00%	0.00	0.00%	0.00%	100.00%	100%	100%	100%	Pass	
No. 4	4.75	x	7.80	1.48%	1.48%	98.52%	7.30	1.59%	1.59%	98.41%	99%	95%	100%	Pass	
No. 8	2.36	x	30.50	5.79%	7.27%	92.73%	26.80	5.83%	7.42%	92.58%	93%	80%	100%	Pass	
No. 16	1.18	x	71.30	13.53%	20.79%	79.21%	62.90	13.69%	21.11%	78.89%	79%	50%	85%	Pass	
No. 30	600 µm	x	133.50	25.33%	46.12%	53.88%	115.10	25.04%	46.15%	53.85%	54%	25%	60%	Pass	
No. 40	425 µm		112.90	21.42%	67.54%	32.46%	97.50	21.21%	67.36%	32.64%	33%				
No. 50	300 µm	x	98.00	18.59%	86.13%	13.87%	86.00	18.71%	86.07%	13.93%	14%	5%	30%	Pass	
No. 100	150 µm	x	69.90	13.26%	99.39%	0.61%	61.10	13.29%	99.37%	0.63%	1%	0%	10%	Pass	
No. 200	75 µm		2.20	0.42%	99.81%	0.19%	1.93	0.42%	99.79%	0.21%	0%	0%	3%	Pass	
Pan			0.06	0.01%	99.82%	0.00	0.01	0.00%	99.79%	0.00					
Total			526.16	99.82%			458.64	99.79%							
Fineness Modulus:					2.612				2.617		2.61				
x = Sieves used to calculate fineness modulus							Run 1		Run 2						
								Acceptance Range		Acceptance Range					
Yes	No	Results for ASTM C 136 No. 200 include ASTM C 117 Results.					Original Dry Mass, g	528.7	Original Dry Mass, g	461.0					
X							527.1	525.5	459.6	458.2					
If the same ASTM C 117 sample is used for the above ASTM C 136 test then add the mass loss (g) from ASTM C 117 to the pan mass retained (g) from ASTM C 136.															
ASTM C 117 Minus 75 µm (No. 200)															
Procedure A	X	Washed with Plain Water					Date Tested:	9-May-17							
Procedure B		Washed with Wetting Agent													
		Original Dry Mass, g		Dry Mass After Wash, g			Mass Loss, g		Percent Loss		Average				
Run 1		527.1		526.1			1.0		0.19%		0.2%				
Run 2		459.6		459.0			0.6		0.13%						
ASTM C 40 Organic Impurities in Fine Aggregate in Concrete															
Date Started:		8-May-17		Date Ended:			9-May-17		Organic Plate No.:		Clear				

Table A12. ASTM C128.

ASTM C 128 Worksheet											
CMB Log In No.:		170079				Date:		10-May-17			
District:						Tested By:		CEERD-GM-C			
Material Supplier:		Little Rock - AFB				Date Received:					
Sampled By:		S.M.				Material Type:		Sand			
ASTM C 128 Relative Density and Absorption of Fine Aggregate											
Test Size: 500 ± 10g											
Run	Flask No.	S.S.D. Mass in Air, g	Mass of Pycnometer with Water, g	Mass of Pycnometer with Water & Sample, g	Oven-Dry Mass in Air, g	Relative Density Oven-Dry	Relative Density S.S.D.	Apparent Relative Density	Percent Absorption	Water Temp., C	Soak Time, hrs.
1	A	500.20	1440.50	1749.40	497.90	2.603	2.615	2.634	0.46%	22.8	24.00
2	B	504.60	1428.60	1741.20	502.70	2.618	2.628	2.644	0.38%	22.8	24.00
		AVERAGE				2.61	2.62	2.64	0.4%	22.8	24.00

ASTM C 128 Relative Density and Absorption of Fine Aggregate Precision								
Test Results						ASTM C 128-15 Table 1 Precision Values		Test Results
	Run 1	Run 2	Average	Standard Deviation (1s)	Standard Deviation (d2s)1.96√2	Standard Deviation (1s)	Standard Deviation (d2s)1.96√2	Standard Deviation (d2s)1.96√2
Relative Density Oven-Dry	2.603	2.618	2.61	0.011	0.030	0.011	0.032	Pass
Relative Density S.S.D.	2.615	2.628	2.62	0.009	0.026	0.0095	0.027	Pass
Apparent Relative Density	2.634	2.644	2.64	0.007	0.020	0.0095	0.027	Pass
Percent Absorption	0.46%	0.38%	0.4%	0.001	0.002	0.11%	0.31%	Pass

Table A13. ASTM C136 and C117 precision.

ASTM C 136 & C 117 PRECISION WORKSHEET			
CMB Log In No.:	170079	Date:	10-May-17
District:		Tested By:	CEERD-GM-C
Material Supplier:	Little Rock - AFB	Date Received:	
Sampled By:	S.M.	Material Type:	Sand

ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates

Sieve Size			Cumulative Test Results					ASTM C 136-14 Table 2 Precision Values			Test Results	
std.	mm	FM	Run 1 Total Percent Passing	Run 2 Total Percent Passing	Average Percent Passing	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Total Percent Passing	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Standard Deviation (d2s)1.96√2, %	
4.0	100		100.00%	100.00%	100%	0.00%	0.00%					Coarse Aggregate Values
3.5	90		100.00%	100.00%	100%	0.00%	0.00%					
3.0	75	x	100.00%	100.00%	100%	0.00%	0.00%					
2.5	63		100.00%	100.00%	100%	0.00%	0.00%					
2.0	50		100.00%	100.00%	100%	0.00%	0.00%					
1.5	37.5	x	100.00%	100.00%	100%	0.00%	0.00%					
1.0	25		100.00%	100.00%	100%	0.00%	0.00%					
3/4	19	x	100.00%	100.00%	100%	0.00%	0.00%					
1/2	12.5		100.00%	100.00%	100%	0.00%	0.00%					
3/8	9.5	x	100.00%	100.00%	100%	0.00%	0.00%					
No. 4	4.75	x	98.52%	98.41%	98%	0.08%	0.21%	100-95	0.26%	0.70%	Pass	Fine Aggregate Values
No. 8	2.36	x	92.73%	92.58%	93%	0.11%	0.30%	95-60	0.55%	1.60%	Pass	
No. 16	1.18	x	79.21%	78.89%	79%	0.22%	0.61%	95-60	0.55%	1.60%	Pass	
No. 30	600 µm	x	53.88%	53.85%	54%	0.02%	0.06%	60-20	0.83%	2.40%	Pass	
No. 40	425 µm		32.46%	32.64%	33%	0.12%	0.35%	60-20	0.83%	2.40%	Pass	
No. 50	300 µm	x	13.87%	13.93%	14%	0.04%	0.11%	15-10	0.36%	1.00%	Pass	
No. 100	150 µm	x	0.61%	0.63%	1%	0.02%	0.05%	2-0	0.00%	0.60%	Pass	
No. 200	75 µm		0.19%	0.21%	0%	0.02%	0.04%	2-0	0.00%	0.60%	Pass	

ASTM C 136-14 Table 2 Precision Coarse Aggregate Values

Total Percent Passing		Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
Less	Greater or Equal		
100%	95%	0.32%	0.90%
95%	85%	0.81%	2.30%
85%	80%	1.34%	3.80%
80%	60%	2.25%	6.40%
60%	20%	1.32%	3.40%
20%	15%	0.96%	2.70%
15%	10%	1.00%	2.80%
10%	5%	0.75%	2.10%
5%	2%	0.53%	1.50%
2%	0%	0.27%	0.80%

ASTM C 136-14 Table 2 Precision Fine Aggregate Values

Total Percent Passing		Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
Less	Greater or Equal		
100%	95%	0.26%	0.70%
95%	60%	0.55%	1.60%
60%	20%	0.83%	2.40%
20%	15%	0.54%	1.50%
15%	10%	0.36%	1.00%
10%	2%	0.37%	0.40%
2%	0%	0.14%	0.60%

ASTM C 117 Minus 75 µm (No. 200)

Test Results						ASTM C 117-13 Table 1 Precision Fine Aggregate Values		Test Results
	Run 1	Run 2	Average	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %	Standard Deviation (d2s)1.96√2, %
Percent Loss	0.19%	0.13%	0.2%	0.04%	0.12%	0.15%	0.43%	Pass

ASTM C 117-13 Table 1 Precision Coarse Aggregate Values

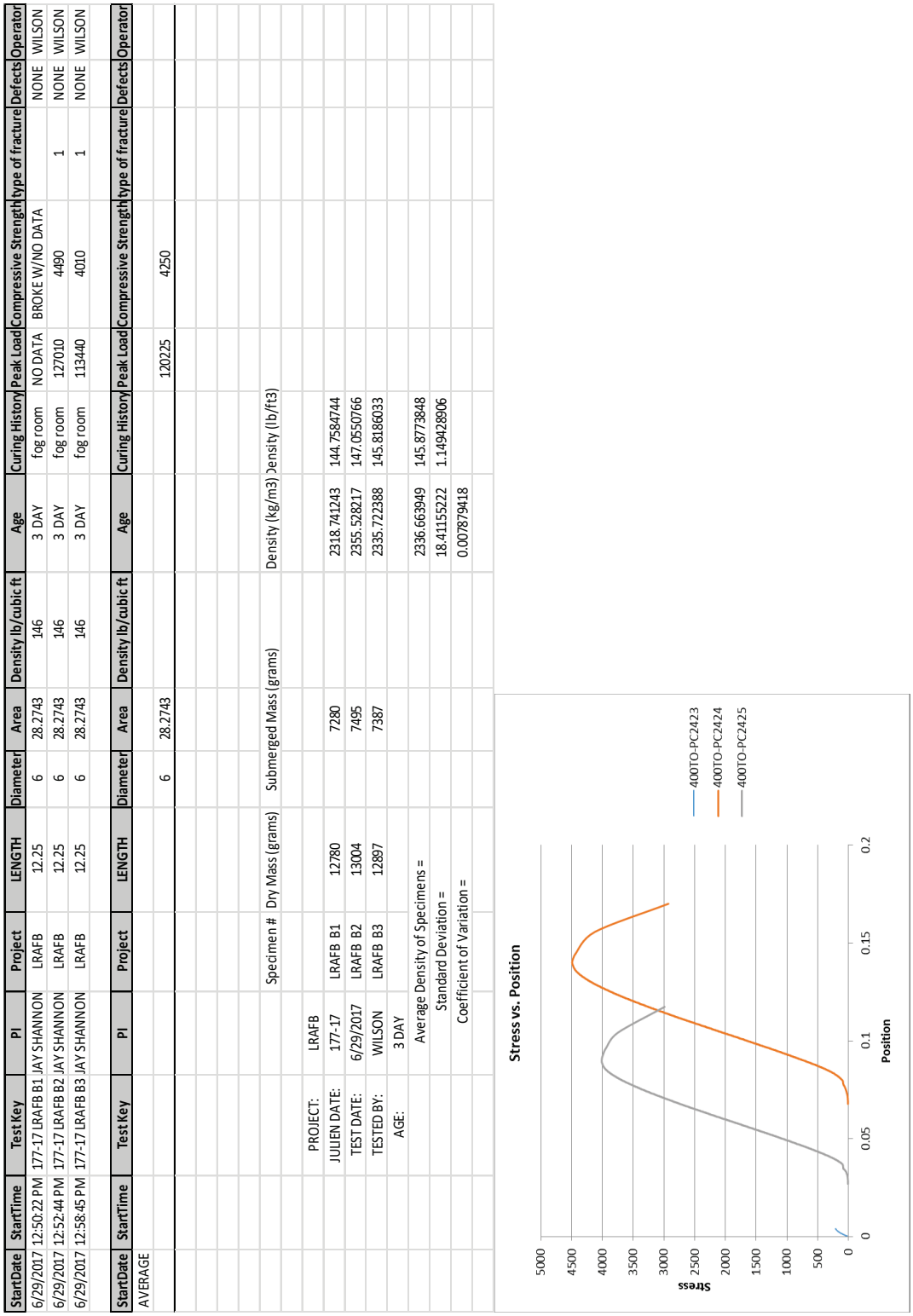
Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
0.10%	0.28%

ASTM C 117-13 Table 1 Precision Fine Aggregate Values

Standard Deviation (1s), %	Standard Deviation (d2s)1.96√2, %
0.15%	0.43%

Appendix B: Raw Data Sheets for Concrete Testing

Figure B1. Three-day compressive strength 6x12 cylinder.



StartDate	StartTime	Test Key	PI	Project	LENGTH	Diameter	Area	Density lb/cubic ft	Age	Curing History	Peak Load	Compressive Strength	type of fracture	Defects	Operator
6/29/2017	12:50:22 PM	177-17 LRAFB B1	JAY SHANNON	LRAFB	12.25	6	28.2743	146	3 DAY	fog room	NO DATA	BROKE W/NO DATA		NONE	WILSON
6/29/2017	12:52:44 PM	177-17 LRAFB B2	JAY SHANNON	LRAFB	12.25	6	28.2743	146	3 DAY	fog room	127010	4490	1	NONE	WILSON
6/29/2017	12:58:45 PM	177-17 LRAFB B3	JAY SHANNON	LRAFB	12.25	6	28.2743	146	3 DAY	fog room	113440	4010	1	NONE	WILSON

StartDate	StartTime	Test Key	PI	Project	LENGTH	Diameter	Area	Density lb/cubic ft	Age	Curing History	Peak Load	Compressive Strength	type of fracture	Defects	Operator
AVERAGE						6	28.2743				120225	4250			

		Specimen #	Dry Mass (grams)	Submerged Mass (grams)	Density (kg/m3)	Density (lb/ft3)
PROJECT:	LRAFB					
JULIEN DATE:	177-17	LRAFB B1	12780	7280	2318.741243	144.7584744
TEST DATE:	6/29/2017	LRAFB B2	13004	7495	2355.528217	147.0550766
TESTED BY:	WILSON	LRAFB B3	12897	7387	2335.722388	145.8186033
AGE:	3 DAY					
	Average Density of Specimens =				2336.663949	145.8773848
	Standard Deviation =				18.41155222	1.149428906
	Coefficient of Variation =				0.007879418	

7/3/2017	10:43:32 AM	177-17 LRAFB B1	SHANNON	LRAFB	12.25	6	28.2743	148	7 DAY	FOGROOM	123020	4350	1	NONE	WILSON
7/3/2017	10:46:55 AM	177-17 LRAFB B2	SHANNON	LRAFB	12.25	6	28.2743	147	7 DAY	FOGROOM	130340	4610	1	NONE	WILSON
7/3/2017	10:50:49 AM	177-17 LRAFB B3	SHANNON	LRAFB	12.25	6	28.2743	145	7 DAY	FOGROOM	124390	4400	2	NONE	WILSON
StartDate	StartTime	Test Key	PI	Project	LENGTH	Diameter	Area	Density lb/cubic ft	Age	Curing History	Peak Load	Compressive Strength	type of fracture	Defects	Operator
AVERAGE															
						6	28.2743				125916.6667	4453.333333			

		Specimen #	Dry Mass (grams)	Submerged Mass (grams)	Density (lb/ft3)
PROJECT:	LRAFB				
JULIEN DATE:	177-17	LRAFB B1	12790	7285	144.7
TEST DATE:	7/3/2017	LRAFB B2	13000	7498	147.2
TESTED BY:		LRAFB B3	12897	7370	145.4
AGE:	7 DAY				
	Average Density of Specimens =				145.8
	Standard Deviation =				1.276
	Coefficient of Variation =				

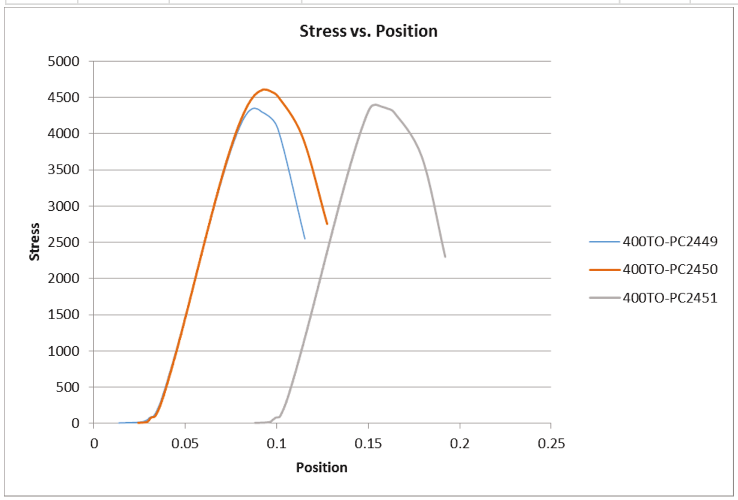


Figure B2. Seven-day compressive strength 6x12 cylinder.

Figure B3. Fourteen-day compressive strength 6x12 cylinder.

StartDate	StartTime	Test Key	PI	Project	LENGTH	Diameter	Area	Density lb/cubic ft	Age	Curing History	Peak Load	Compressive Strength	type of fracture	Defects	Operator
7/10/2017	2:00:59 PM	177-17 LRAFB B3	SHANNON	LRAFB	12.25	5.99	28.1802	145	14 DAY	FOG ROOM	146990	5220	1	NONE	WILSON
7/10/2017	2:05:23 PM	177-17 LRAFB B2	SHANNON	LRAFB	12.25	5.99	28.1802	148	14 DAY	FOG ROOM	153780	5460	2	NONE	WILSON
7/10/2017	2:10:09 PM	177-17 LRAFB B1	SHANNON	LRAFB	12.25	5.99	28.1802	146	14 DAY	FOG ROOM	140280	4980	1	NONE	WILSON

StartDate	StartTime	Test Key	PI	Project	LENGTH	Diameter	Area	Density lb/cubic ft	Age	Curing History	Peak Load	Compressive Strength	type of fracture	Defects	Operator
AVERAGE						5.99	28.1802				147016.6667	5220			

							Specimen #	Mass (grams)	Submerged Mass (grams)	Density (lb/ft3)					
		PROJECT:	LRAFB												
		JULIEN DATE:	177-17	LRAFB B1	12906		7392			145.81					
		TEST DATE:	7/10/2017	B2	13043		7544			147.76					
		TESTED BY:	Wilson	B3	12733		7246			144.57					
		AGE:	14 day												
			Average Density of Specimens =							146.05					
			Standard Deviation =							1.6111					
			Coefficient of Variation =												

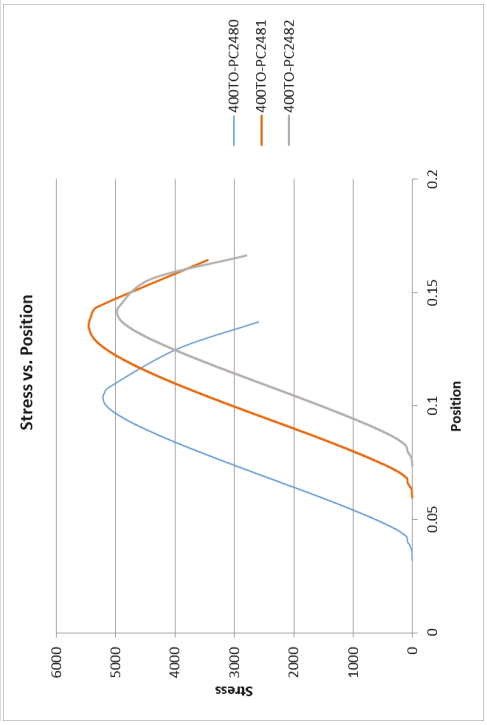


Figure B4. Twenty-eight-day compressive strength 6x12 cylinder.

StartDate	StartTime	Test Key	PI	Project	LENGTH	Diameter	Area	Density lb/cubic ft	Age	Curing History	Peak Load	Compressive Strength	type of fracture	Defects	Operator
7/24/2017	2:14:58 PM	177-17 LRAFB B1	SHANNON	LRAFB	12.24	5.93	27.6184	146	28 DAYS	FOG ROOM	152190	5510	3	NONE	NEWELL
7/24/2017	2:19:37 PM	177-17 LRAFB B2	SHANNON	LRAFB	12.22	5.94	27.7117	146	28 DAYS	FOG ROOM	166550	6010	2	NONE	NEWELL
7/24/2017	2:24:28 PM	177-17 LRAFB B3	SHANNON	LRAFB	12.31	5.94	27.7117	146	28 DAYS	FOG ROOM	163430	5900	3	NONE	NEWELL

StartDate	StartTime	Test Key	PI	Project	LENGTH	Diameter	Area	Density lb/cubic ft	Age	Curing History	Peak Load	Compressive Strength	type of fracture	Defects	Operator
AVERAGE						5.936666667	27.6806				160723.3333	5806.666667			

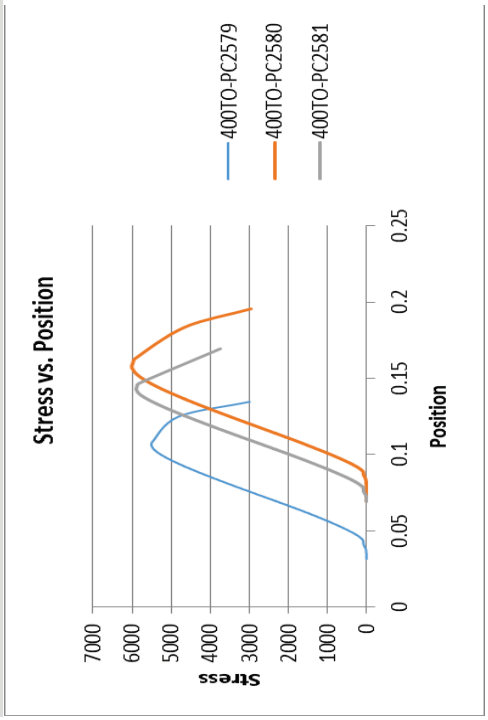


Figure B5. Three-day flexural strength 6x6x21 beam.

StartDate	PI	Test Key	AGE DAYS	Width	Depth	Support Span	Peak Load	Flexural Strength	Curing History	apperant moisture condition	Operator
6/29/2017	SHANNON	177-17 LRAFB B3		5.98	6.03	18	7380	610	LIME WATER	MOIST	Wilson
6/29/2017	SHANNON	177-17 LRAFB B2		6.03	6.02	18	7485	615	LIME WATER	MOIST	Wilson
6/29/2017	SHANNON	177-17 LRAFB B1		6.19	6.03	18	7735	619	LIME WATER	MOIST	Wilson

StartDate	PI	Test Key	AGE DAYS	Width	Depth	Support Span	Peak Load	Flexural Strength	Curing History	apperant moisture condition	Operator
AVERAGE											
				6.066666667	6.026666667	18	7533.333333	614.6666667			
AVEDEV											
				0.082222222	0.004444444	0	134.4444444	3.111111111			

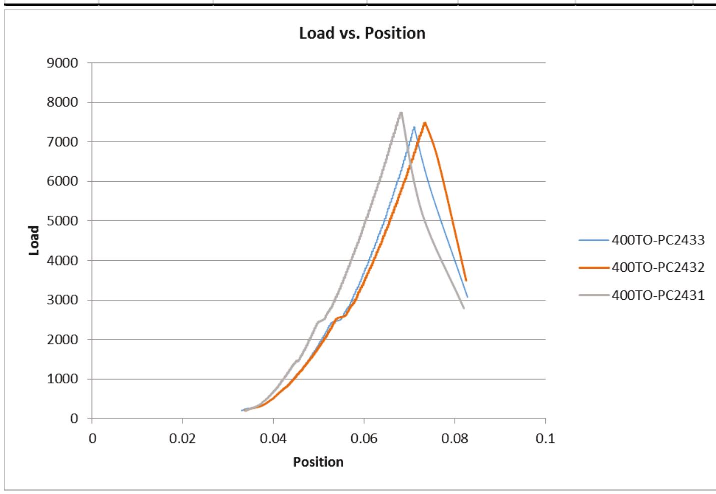


Figure B6. Seven-day flexural strength 6x6x21 beam.

StartDate	PI	Test Key	AGE DAYS	Width	Depth	Support Span	Peak Load	Flexural Strength	Curing History	Apperant moisture condition	Operator
7/3/2017	SHANNON	177-17 LRAFB B3		5.99	5.99	18	8515	715	LIME WATER	MOIST	Wilson
7/3/2017	SHANNON	177-17 LRAFB B2		6.07	6.05	18	8315	675	LIME WATER	MOIST	Wilson
7/3/2017	SHANNON	177-17 LRAFB B1		6.01	6.06	18	7880	645	LIME WATER	MOIST	Wilson

StartDate	PI	Test Key	AGE DAYS	Width	Depth	Support Span	Peak Load	Flexural Strength	Curing History	Apperant moisture condition	Operator
AVERAGE				6.023333333	6.033333333	18	8236.666667	678.3333333			
AVEDEV				0.031111111	0.028888889	0	237.7777778	24.44444444			

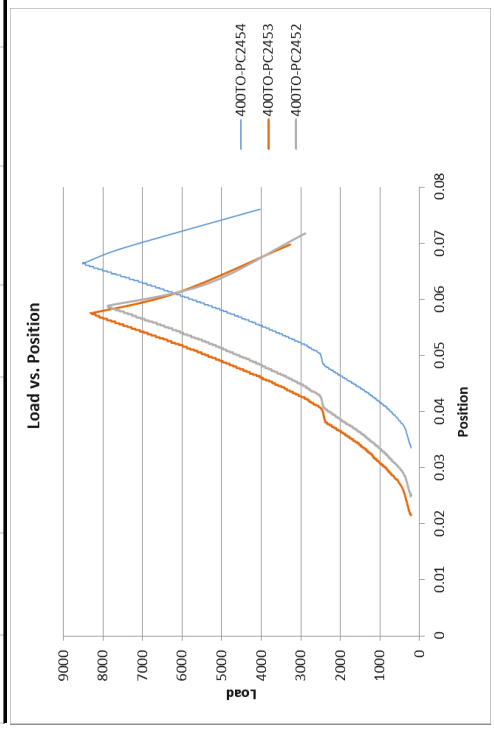


Figure B7. Fourteen-day flexural strength 6x6x21 beam.

StartDate	PI	Test Key	AGE DAYS	Width	Depth	Support Span	Peak Load	Flexural Strength	Curing History	apperant moisture condition	Operator
7/10/2017	SHANNON	BEAM 177-17 LRAFB-T1		6.04	6.04	18	9105	745	LIME WATER	DRY	WILSON
7/10/2017	SHANNON	BEAM 177-17 LRAFB-B2		6.02	6.04	18	8810	720	LIME WATER	DRY	WILSON
7/10/2017	SHANNON	BEAM 177-17 LRAFB-B3		6.05	6.04	18	9655	790	LIME WATER	DRY	WILSON

StartDate	PI	Test Key	AGE DAYS	Width	Depth	Support Span	Peak Load	Flexural Strength	Curing History	apperant moisture condition	Operator
AVERAGE											
				6.036666667	6.04	18	9190	751.6666667			
AVEDEV											
				0.011111111	0	0	310	25.55555556			

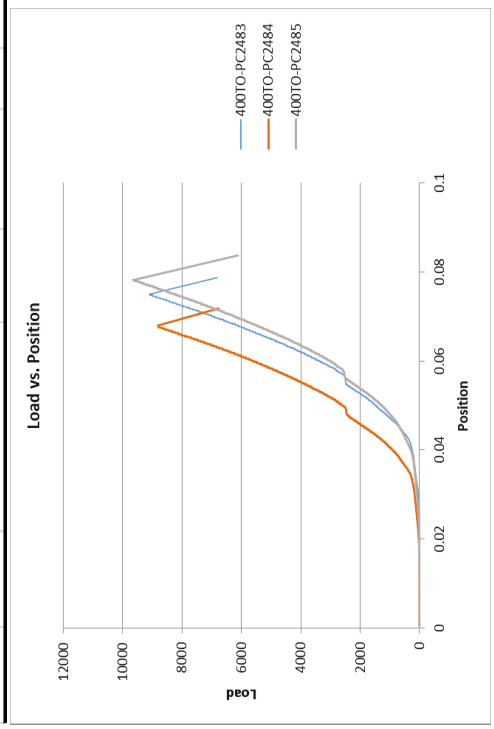
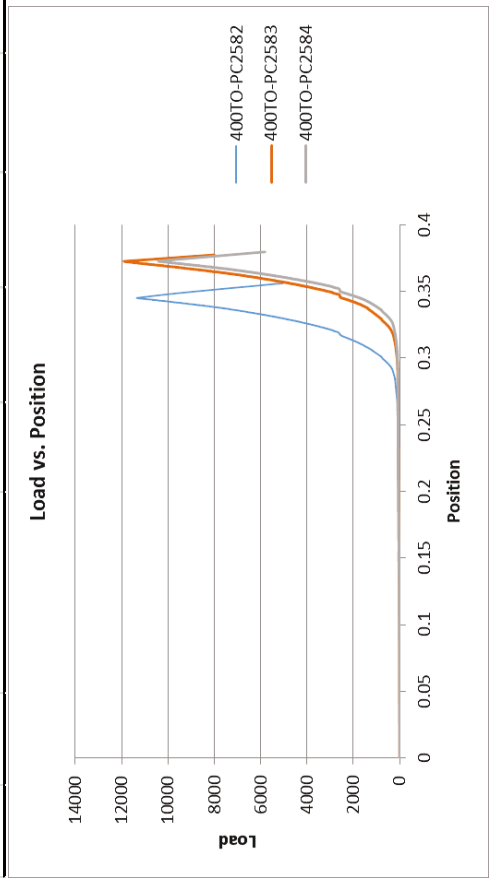


Figure B8. Twenty-eight-day flexural strength 6x6x21 beam.

StartDate	PI	Test Key	AGE DAYS	Width	Depth	Support Span	Peak Load	Flexural Strength	Curing History	apperant moisture condition	Operator
7/24/2017	SHANNON	BEAM 177-17 LRAFB-B3	28	6.03	6.03	18	11355	930	LIME WATER	DRY	WILSON
7/24/2017	SHANNON	BEAM 177-17 LRAFB-B2	28	6.011	6.06	18	11905	970	LIME WATER	DRY	WILSON
7/24/2017	SHANNON	BEAM 177-17 LRAFB-B1	28	6.08	6.04	18	10420	845	LIME WATER	DRY	WILSON

StartDate	PI	Test Key	AGE DAYS	Width	Depth	Support Span	Peak Load	Flexural Strength	Curing History	apperant moisture condition	Operator
AVERAGE											
				6.040333333	6.043333333	18	11226.66667	915			
AVEDEV											
				0.026444444	0.011111111	0	537.7777778	46.66666667			



REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
November 2018	Final	

4. TITLE AND SUBTITLE

Little Rock Air Force Base Aggregate and Concrete Testing

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Jameson D. Shannon

5d. PROJECT NUMBER
LCC 2EF9E5

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER

ERDC/GSL TR-18-32

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

USACE Little Rock District
700 W. Capitol Ave.
Federal Building 7th Floor
Little Rock, AR 72203

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The Little Rock Air Force Base (LRAFB) tasked the ERDC to test and evaluate a concrete mixture design and the aggregates used therein. Experimentation consisted of basic aggregate test methods such as gradation, specific gravity, absorption, and organic materials. Concrete testing consisted of manufacturing a laboratory concrete mixture design provided by LRAFB and conducting compressive and flexural strength testing of cast specimens.

In most cases the selected aggregate and concrete mixture design testing met specifications. However, there were some areas, such as aggregate gradations, in which the materials did not align with specified values or standards. Final hardened concrete properties of compressive and flexural strength met the mixture design requirements.

15. SUBJECT TERMS

Concrete Runway
Power 45 Curve
Workability vs Coarseness Factor
Gradation
Little Rock Air Force Base (Ark.)
Runways
Concrete – additives
Concrete - mixing

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(include area code)*
Unclassified	Unclassified	Unclassified		49	