ERDC/GSL TR-20-33

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Investigation of Testing Materials for the Chickamauga Lock and Dam Reconstruction Project

Monica A. Ramsey, Tyler R. Johnson, and Erin Rae Reed

September 2020

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Under Project Chickamauga Lock and Dam Materials Testing, MIPR W38XDD62530725

Abstract

In support of the U.S. Army Corps of Engineers (USACE) Nashville District, a preliminary investigation of concrete materials was conducted pursuant to re-construction at the Chickamauga Lock and Dam located near Chattanooga, TN. Local materials provided to the U.S. Army Engineer Research Development Center (ERDC) for testing included three different coarse aggregate gradations, two fine aggregate sources, two type I/II cements, a fly ash sources, a slag cement, a silica fume, and a limestone powder. Aggregate tests consisted of sieve analysis, specific gravity, absorption, materials finer than No. 200, organic impurities, soundness, LA abrasion, clay lumps and friable particles, flat and elongated particles, lightweight particles, petrography, and freezing and thawing. All cementitious and admixture materials were tested for chemical and physical properties based on appropriate specifications. This report presents the material characteristic results determined by laboratory testing in accordance with American Society for Testing Materials (ASTM) procedures or regulating specification criteria.

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Preface

The investigation described in this paper was conducted in support of the U.S. Army Engineer District, Nashville, (MIPR W38XDD62530725) as part of a preliminary investigation of cementitious materials and concrete design pursuant to construction at the Chickamauga Lock and Dam located seven miles NE of Chattanooga, TN. The technical monitor was Ms. Melanie Leslie, Research Geologist.

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, GMC; Mr. Justin S. Strickler was Chief, GM; and Mr. R. Nicholas Boone, GZT, was the Technical Director for Force Projection and Maneuver Support. The Deputy Director of the ERDC GSL was Mr. Charles W. Ertle, III, and the Director was Mr. Bartley P. Durst.

COL Teresa A. Schlosser was the Commander of ERDC, and Dr. David W. Pittman was the Director.

1 Introduction

1.1 Background

The Chickamauga Lock and Dam, located seven miles northeast of Chattanooga, TN, was completed in 1940 by the Tennessee Valley Authority (TVA). The U.S. Army Corps of Engineers (USACE) designed the Chickamauga Lock and Dam while the TVA designed and constructed the project. Both agencies share jurisdiction for various activities including navigation, periodic inspections, and operation and maintenance.

1.2 Problem statement

The Chickamauga Lock and Dam is suffering from "concrete growth" due to a chemical reaction known as Alkali Aggregate Reaction (AAR) caused from reactions in the aggregates and materials used in the original construction of the structure. This reaction forms a gel that absorbs moisture and swells, causing concrete expansion. If the concrete is free to expand (e.g., in the lock approach walls), the volume of the concrete increases. When the concrete is restrained (e.g., at the bottom of a lock wall monolith), the growth results in an increase of internal stresses in the concrete. This irreversible expansion is causing internal stresses throughout the lock that cause cracking and movement of concrete monoliths, affecting not only the lock's stability but also its operation to navigate the Upper Tennessee River. An aggressive rehabilitation program is underway to extend the life of the lock and dam.

1.3 Objective and scope of work

The objective of this study was to evaluate the materials provided by the USACE Nashville District to appropriate specifications to ensure quality assurance of potential construction materials. The U.S. Army Engineer Research and Development Center (ERDC) determined the properties of the aggregate and cementitious materials proposed for use in the rehabilitation of the Chickamauga Lock and Dam in accordance to the standard test designations listed in Table 1.

Table 1. Standard test methods used for materials tests.

ASTM Designation	Description	Material
C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates	3 Coarse Aggregates 2 Fine Aggregates
C127	Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate	3 Coarse Aggregates
C128	Standard Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate	2 Fine Aggregates
C117	Standard Test Method for Materials Finer than (No. 200) Sieve	3 Coarse Aggregates 2 Fine Aggregates
C40	Standard Test Method for Organic Impurities in Fine Aggregates for Concrete	2 Fine Aggregates
C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate	3 Coarse Aggregates
C131	Standard Test Method for Resistance to Degradation of Aggregates by Abrasion and Impact in the Los Angeles Machine	3 Coarse Aggregates 2 Fine Aggregates
C142	Standard Test Method for Clay Lumps and Friable Particles in Aggregates	3 Coarse Aggregates 2 Fine Aggregates
D4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate	3 Coarse Aggregates
C123	Standard Test Method for Lightweight Particles in Aggregate	3 Coarse Aggregates 2 Fine Aggregates
C666	Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing	1 Coarse Aggregate
C1271	Standard Test Method for X-ray Spectrometric Analysis of Lime and Limestone	1 Limestone Powder Source
D546	Standard Test Method for Sieve Analysis of Mineral Filler for Asphalt Paving Mixtures	
C295	Standard Practices for Petrographic Examination of Aggregates for Concrete	3 Coarse Aggregates 2 Fine Aggregates
C150	Standard Specification for portland Cement	2 Cement Source
C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete	1 Fly Ash Sources
C989	Standard Specification for Slag Cement	1 Slag Cement Source
C1240	Standard Specification for Silica Fume	1 Silica Fume Source

2 Materials

Candidate project materials including cements, pozzolans, and aggregates were chosen by the USACE Nashville District. The source materials were marketed in the vicinity of the proposed project location. Table 2 identifies the materials included in this study.

Table 2. Summary of materials used for Chickamagua Lock and Dam testing.

Material	Type	Source Location	CMB Number
Fine Aggregate	Natural Sand	Monteagle Ooltewah, TN	170014
1-½ in. Coarse Aggregate	No. 4 (1-½ to ¾-in.)	Tiftonia Quarry Ooltewah, TN	170015
¾-in. Coarse Aggregate	No. 67 (¾-in. to No. 4)	Tiftonia Quarry Ooltewah, TN	170016
3 in. Coarse Aggregate	No. 1 (3 to 1 ½-in.)	Tiftonia Quarry Ooltewah, TN	170017
Fine Aggregate	Natural Sand	Sequatchie South Pittsburg, TN	170018
Portland Cement	Type I/II	Buzzi Unicem Signal Mountain Chattanooga, TN	170019
Fly Ash	Class F	SEFA Group Cumberland City, TN	170020
Slag Cement	Grade 100	Lafarge South Chicago Plant Chicago, IL	170021
Silica Fume	Microsilica Grade 965U	Elkem Materials Inc. Pittsburgh, PA	170022
Portland Cement	Type II (MH)	Lafarge Joppa Plant, IL	170023
Limestone	Limestone Powder	Lhoist North America Crab Orchard, TN	170024

3 Aggregate Testing

Two sources of natural sand and three gradations of limestone coarse aggregates were tested in accordance with ASTM procedures presented in this section. Unless otherwise stated, the aggregate requirements for grading and quality were based on criteria defined in ASTM C33 (ASTM 2016a). Further aggregate report details can be found in Appendix A.

3.1 Sieve analysis

The gradation results for aggregates tested in accordance to ASTM C136 (ASTM 2016c) are presented in Table 3.

Table 3. Sieve analysis results of fine and coarse aggregates.

Nominal Size (Sieves with Square Openings)	Gradation of aggregates by cumulative % passing									
	Tiftonia Quarry No. 1 (3-in. to 1 ½-in.)		Tiftonia Quarry No. 4 (1½ in. to ¾-in.)		Tiftonia Quarry No. 67 (¾-in. to No. 4)		Monteagle Natural Sand		Sequatchie Natural Sand	
	Test Results	Spec. Limits	Test Results	Spec. Limits	Test Results	Spec. Limits	Test Results	Spec. Limits	Test Results	Spec. Limits
4 in.	100	100	-	-	-	-	-	-	-	-
3 ½ in.	97	90-100	-	-	-	-	-	-	-	-
3 in.	84	-	-	-	-	-	-	-	-	-
2 ½ in.	58	25-60	-	-	-	-	-	-	-	-
2 in.	16	-	100	100	-	-	-	-	-	-
1 ½ in.	4	0-15	98	90-100	-	-	-	-	-	-
1 in.	2	-	31	20-55	100	100	-	-	-	-
3/4 in.	2	0-5	5	0-15	97	90-100	-	-	-	-
1/2 in.	1	-	2	-	56	-	-	-	-	-
3/8 in.	-	-	2	0-5	31	20-55	100	100	100	100
No. 4	-	-	-	-	3	0-10	98	95-100	95	95-100
No. 8	-	-	-	-	1	0-5	89	80-100	81	80-100
No. 16	-	-	-	-	-	-	81	50-85	73	50-85
No. 30	-	-	-	-	-	-	66	25-60	65	25-60
No. 40	-	-	-	-	-	-	44	-	52	-
No. 50	-	-	-	-	-	-	25	5-30	32	5-30
No. 100	-	-	-	-	-	-	6	0-10	5	0-10
No. 200	-	-	-	-	-	-	1.7	0-3	1.3	0-3

Note: All test results are based on an average of two runs.

All aggregates from the Tiftonia quarry meet the grading requirements for coarse aggregates. The Monteagle fine aggregate met all grading requirements with the exception of the No. 30 sieve that exceeded the limit by 6 percent. The Sequatchie fine aggregate met all grading requirements with the exceptions of the No. 30 sieve that exceeded the limit by 5 percent and the No. 50 sieve that exceeded the limit by 2 percent.

3.2 Specific gravity and absorption

The bulk specific gravity at the saturated, surface-dry condition and absorption for the coarse and fine aggregates were tested in accordance with ASTM C127 (ASTM 2015a) and C128 (ASTM 2015b), respectively. Specific gravity and absorption results are provided in Table 4. All aggregates met typical ranges of specific gravity (1.6-3.2 percent) and absorption (0.2 to 4 percent for coarse aggregates and 0.2 to 2 percent for fine aggregates) as reported by ACI Committee 221 in the guide for use of normal weight aggregates in concrete (American Concrete Institute 2001).

Table 4. Bulk specific gravity and absorption results of fine and coarse aggregates.

Property	Tiftonia 3-in.	Tiftonia 1½-in.	Tiftonia ¾-in.	Monteagle Sand	Sequatchie Sand
Bulk specific gravity (SSD)	2.68	2.67	2.67	2.64	2.60
Absorption, %	0.7	0.7	0.7	0.6	1.1

*Results based on an average of two runs.

3.3 Materials finer than No. 200 sieve

The amount of material finer than a No. 200 sieve by washing was determined in accordance to ASTM C117 (ASTM 2017a). Procedure A (water only) was used to disperse clay and other particles from the aggregates during the test. The material that passed the No. 200 sieve results are provided in Table 5. All aggregates fell below the 1 percent maximum allowance for materials finer than No. 200 sieve as defined in ASTM C33 (ASTM 2016a) with the exceptions of the ¾-in. Tiftonia aggregate result of 1.1 percent and the Monteagle sand result of 1.4 percent. However, this percentage is permitted to be increased if conditions specified in Table 4 of the standard are met.

Table 5. Materials finer than No. 200 sieve results by percent.

Aggregate	Percent finer than No. 200 sieve
Tiftonia ¾-in. Aggregate	1.1
Tiftonia 1½-in. Aggregate	0.7
Tiftonia 3-in. Aggregate	0.4
Monteagle Sand	1.4
Sequatchie Sand	1.0

*Results based on an average of two runs.

3.4 Organic impurities

Fine aggregates were tested in accordance with ASTM C40 (ASTM 2016b) to quantify if injurious amounts of organic impurities were present in the aggregate sample. This test procedure exposes material to a sodium hydroxide solution (NaOH) that releases color, which is then compared to five glass color standards. The five color standards correlate to an organic plate No. 1-5 with 3 being the standard. If a sample is darker than the standard color, i.e., No. 3, the fine aggregate is considered to possibly contain injurious organic impurities. The organic plate No. results shown in Table 6 indicate that both sands do not contain organic impurities at a concentration great enough to warrant further testing at this time.

Table 6. Organic impurity results of fine aggregates.

Aggregate	Organic Plate No.
Monteagle Sand	1
Sequatchie Sand	1

3.5 Soundness of aggregates

The preliminary estimate of the soundness of aggregates proposed for project usage were tested in accordance to ASTM C88 (ASTM 2018a). Aggregates were immersed in a magnesium sulfate solution to simulate severe weathering conditions. The maximum allowable limit suggested for soundness is 18 percent for all weathering conditions. Cumulative percent loss results given in Table 7 reveal all aggregates fall below this criteria.

Table 7. Soundness of fine and coarse aggregates by cumulative percent loss.

Aggregate	Cumulative Percent Loss
Tiftonia ¾-in. Aggregate	9
Tiftonia 1½-in. Aggregate	3
Tiftonia 3-In. Aggregate	2
Monteagle Sand	8
Sequatchie Sand	17

3.6 LA abrasion

The resistance to degradation of small-size coarse aggregates by abrasion was tested in accordance to ASTM C131 (ASTM 2014). This method used a Los Angeles (LA) machine to expose aggregates to a combination of actions including abrasion, impact, and grinding in a rotating steel drum that contains a specified number of steel spheres. The drum rotates at a constant rate while the shelf inside the drum picks up the sample and steel spheres and drops them. Five hundred revolutions of the testing machine were used. Loss by abrasion and impact is reported by percent of the sample mass in Table 8. All aggregates meet the ASTM C33 (ASTM 2016a) abrasion requirement of less than 50 percent loss.

Table 8. LA abrasion and impact results by percent loss.

Aggregate	Loss (%)
Tiftonia ¾-in. Aggregate	21
Tiftonia 1½-in. Aggregate	26
Tiftonia 3-in. Aggregate	25

3.7 Clay lumps and friable particles

The approximate determination of clay lumps and friable particles in potential project aggregates was tested in accordance to ASTM C142 (ASTM 2017c). The percent clay lumps and friable particles reported in Table 9 are less than the 2.0 to 10.0 range of maximum allowable percentages given in ASTM C33 (ASTM 2016c).

Table 9. Clay lumps and friable particles in aggregate results.

Aggregate	Clay Lumps and Friable Particles (%)
Tiftonia ¾-in. Aggregate	0.1
Tiftonia 1½-in. Aggregate	0
Tiftonia 3-in. Aggregate	0
Monteagle Sand	0.1
Sequatchie Sand	0.1

3.8 Flat and elongated particles

The percentage of flat particles, elongates particles, or flat and elongated particles in coarse aggregates was tested in accordance to ASTM D4791 (ASTM 2010). The original procedure presented in the standard Method A was used for non-Superpave applications. Individual particles of aggregates of specific sieve sizes were measured with a caliper device set at a 3:1 ratio to determine the ratios of width to thickness, length to width, or length to thickness. The flat and elongated particle results by zero percent loss are provided in Table 10.

Table 10. Flat and elongated particle results by percent of sample.

Aggregate	Percent of Sample
Tiftonia ¾-in. Aggregate	0
Tiftonia 1½-in. Aggregate	0
Tiftonia 3-in. Aggregate	0

3.9 Lightweight particles

The amount of lightweight material in fine and coarse aggregates was tested in accordance with ASTM C123 (ASTM 2017b). This was determined by using the heavy liquid zinc bromide (specific gravity of 2.0) to separate particles that may be classified as coal or lignite. The maximum allowable percentage of coal and lignite particles range from 0.5 to 1.0, depending on the type or location of concrete construction defined in ASTM C33 (ASTM 2016a). The percentage of lightweight particles for aggregates summarized in Table 11 all meet this requirement.

Table 11. Lightweight particles in fine and coarse aggregates results.

Aggregate	Percent of Lightweight Particles (Tested with Zinc Chloride)
Tiftonia ¾-in. Aggregate	0
Tiftonia 1½-in. Aggregate	0
Tiftonia 3-in. Aggregate	0
Monteagle Sand	0.1
Sequatchie Sand	0.2

3.10 Freezing and thawing durability

The freezing and thawing durability of the Tiftonia coarse aggregate was determined in accordance to Procedure A of ASTM C666 (2015c). In this method, specimens were frozen in water and cycled between 4 and -18°C in 2-hr intervals until the specimens reached 300 cycles of freezing and thawing. Triplicate specimens were prepared from the mixture proportion of materials detailed in Table 12.

Table 12. Summary of concrete mixture proportions for freezing and thawing specimens.

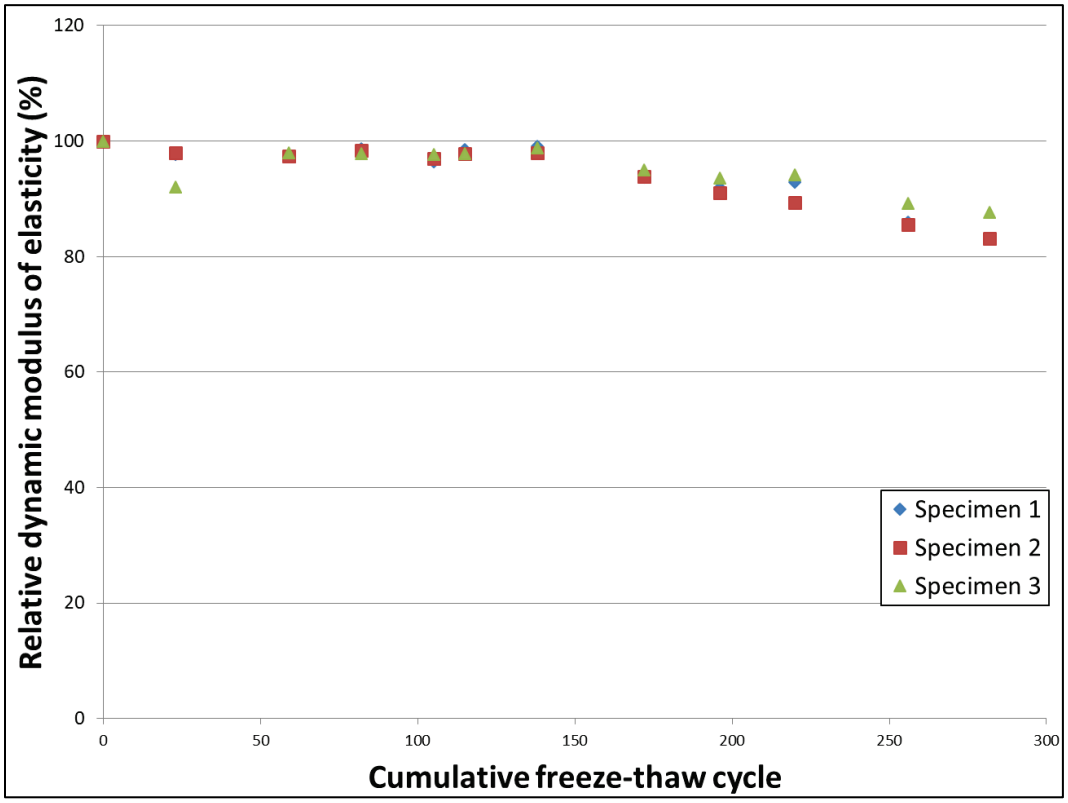
Mixture Constituent	Source	CMB ID	Weight, lb/yd³
Type I/II Cement	Buzzi Unicem	170019	563
Coarse Aggregate (Test Aggregate)	Tiftonia Quarry	170016	1,874
Sand (Control Aggregate)	Arkadelphia, AR	160142	1,158
Air Entraining Admixture (AEA)	Eucon AEA-92	170025	1.6 (fl oz)
Potable Tap Water	Vicksburg, MS Municipal	170019	276

The average weight change, relative dynamic modulus, and durability factor at the final freezing and thawing cycle duration are summarized in Table 13 and illustrated in Figure 1. Some surface spalling was observed on specimens at the end of testing, but this did not affect their durability factor. Overall, the relative dynamic modulus of elasticity stayed above 60 percent requirement for all test specimens throughout the 300 cycles of freezing and thawing.

Table 13. Freezing and thawing final results.

# Cycles	Weight Change (%)	Relative Dynamic Modulus	Durability Factor
300	0.01	83	84

Figure 1. Relative dynamic elastic modulus versus number of freeze-thaw cycles.



4 Petrographic Testing

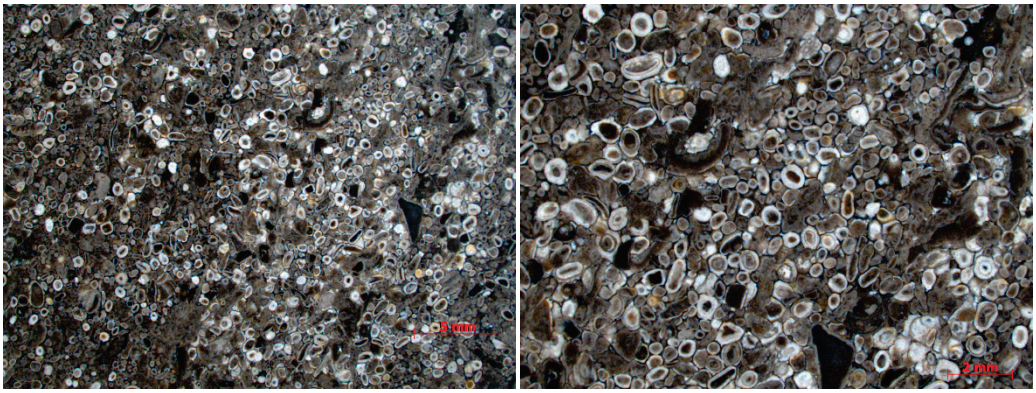
Petrographic examination of three aggregates was performed according to the method described in ASTM C295 (ASTM 2017d) "Standard Practices for Petrographic Examination of Aggregates for Concrete." Along with the petrographic examination, X-ray diffraction (XRD) was performed on the samples to identify the mineralogical composition of the received aggregate. The three samples were the Tiftonia Quarry 1½-in. coarse aggregate (CMB #170015), the Monteagle fine aggregate (CMB #170014), and the Sequatchie fine aggregate (CMB #170018). Whole pattern fit results associated with these aggregates are presented Appendix B.

Each sieve size was examined with a petrographic microscope and photographed under a stereo-microscope. The ASTM requires 150 counts per sieve size; 300 particles were counted in this study to account for mineralogical variation. Samples were grouped into categories based on mineralogy and extent of weathering. The mineralogy of the sample was determined using XRD analysis. In preparation for XRD analysis, a portion of the sample was ground in a Pulverisette (Fritsch Co., Idar-Oberstein, Germany) and passed through a 45-µm (No. 325) sieve. Random orientation powder mounts of bulk samples were analyzed using XRD to determine the mineral constituents present in each sample. XRD patterns were gathered from an X-Pert Pro Multipurpose Powder Diffractometer system that used standard techniques for phase identification (Malvern Panalytical Inc.). The run conditions included Co-Kα radiation and scanning from 2 to 70 °2θ at a step size of 0.02 °2θ and an accelerating voltage of 45 kV and 40 mA with collection of the diffraction patterns accomplished using the PC-based Windows version of X-Pert Pro Data Collector, and analysis of the patterns using the Jade2010 program (Materials Data Inc.).

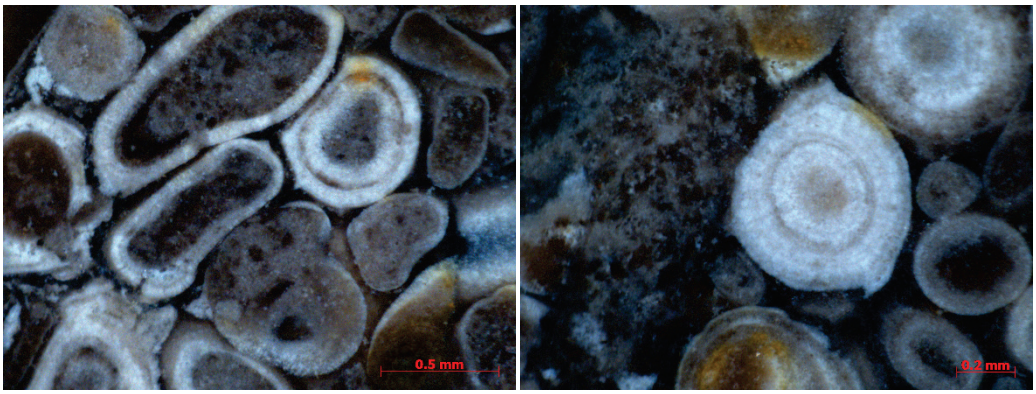
4.1 Tiftonia aggregate

The Tiftonia aggregate coarse aggregate seen in Figure 2 was acquired from the lookout quarry located near Chattanooga and is classified as ooilitic dolomitic limestone. The color of the particles varied from white (N9), light brownish gray (5YR 6/1) to dark gray (N3) to grayish black with the vugs spotted with light brown (5YR 5/6).

Figure 2. Photomicrographs of a 2.5 in. Tiftonia aggregate, cut and polished for petrographic examination.



(a) Low-magnification photomicrograph. (b) Low-magnification photomicrograph.



(c) High-magnification photomicrograph. (d) High-magnification photomicrograph.

The material is a crushed stone; thus, the particles were angular. The size fractions evaluated for ASTM C-295 were from 50-mm (2.5-in.), 50-mm (2.0-in), 37.5-mm (1.5-in.), 25-mm (1.0-in.), 19-mm (3/4-in.), 12.5-mm (1/2-in.), 9.5-mm (3/8-in.), 4.75-mm (No. 4), 2.36-mm (No. 8), 1.18-mm (No. 16), 600-µm (No. 30), 300-µm (No. 50), and 150-µm (No. 100). Results provided in Table 14 indicate that the sample is a dense material (average of 96.7 dense particles) with a small fraction being vuggy or fractured.

Table 14. Tiftonia aggregate results in accordance to ASTM C295.

Gradation Size (in)	Dense	Vuggy	Fractured
2-½	100	0.0	0.0
2	88.0	12.0	0.0
1-½	95.7	2.2	2.2
1	95.3	4.7	0.0
¾	94.0	4.5	2.0
½	96.0	2.7	1.3
3/8	98.3	1.0	0.7
#4	94.4	1.0	4.6
#8	99.0	0.7	0.3
#16	98.7	1.0	0.3
#30	99.3	0.7	0.0
#50	99.0	1.0	0.0
#100	99.7	0.3	0.0

This index of refraction for quartz within the sample was equal to 1.544 indicating no chalcedony, or opal was observed in the sample. There was no undulatory extinction or opal coating seen in this sample. Calcite evaluated was mostly massive anhedral with secondary crystals of medium to fine rhombohedrons. The dolomite crystals were very fine euhedral crystallites. Analysis of the XRD patterns (Figure 3) indicated that the predominant phase in the material was calcite. Table 15 contains the weight percent data obtained by whole pattern fitting using Jade 2010 software. Whole pattern fit analysis for the 4 size fractions evaluated contained an average weight percentage of 61.7 wt. percent calcite ($CaCO_3$), 25.7 wt. percent dolomite ($CaMg(CO_3)_2$), 11.5 wt. percent quartz (SiO_2), and 2.0 wt. percent cristobalite (SiO_2).

In summary, the predominant phase of the Tiftonia coarse aggregate was calcite ($CaCO_3$), with dolomite ($CaMg(CO_3)_2$), quartz (SiO_2), and trace amounts of cristobalite (SiO_2). This index of refraction for quartz within the sample was equal to 1.544 indicating no chalcedony or opal were observed in the sample. There was no undulatory extinction or opal coating seen in this sample. The distribution of dense particles remained consistent across aggregate size (ASTM C295). The aggregate

does contain trace amounts of cristobalite, and the dolomite crystal habit has a very fine euhedral crystallites.

Figure 3. XRD patterns of No. 16, No. 30, No. 50, and No.100 sieve fractions of the Tiftonia aggregate.

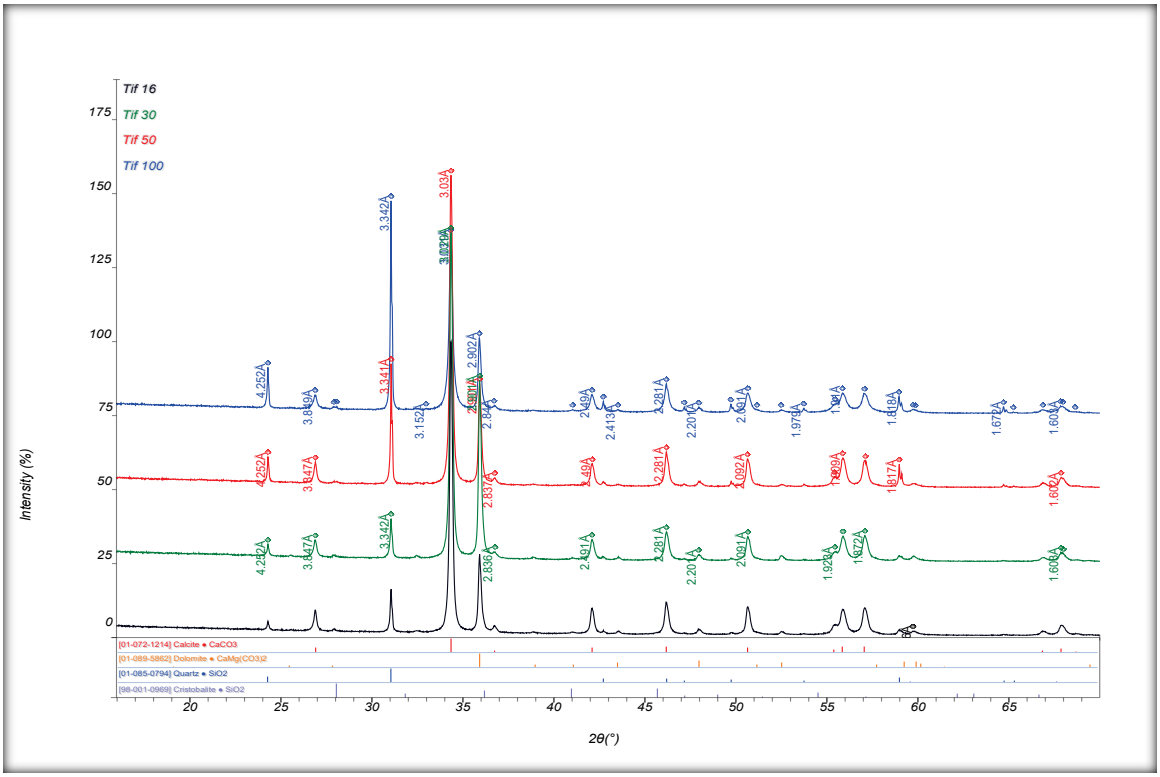


Table 15. Calculated weight percent of minerals from whole pattern fitting analysis for Tiftonia coarse aggregate.

Phase ID (mineral)	Chemical Formula	Weight Percent No. 16	Weight Percent No. 30	Weight Percent No. 50	Weight Percent No. 100	Weight Percent Average
Quartz	SiO_2	6.6	4.9	12.8	21.8	11.5
Calcite	$CaCO_3$	71.2	59.1	63.6	52.9	61.7
Dolomite	$CaMg(CO_3)_2$	22.2	36.0	23.5	21.3	24.7
Cristobolite	SiO_2	trace	trace	0.1	3.9	2.0

4.2 Monteagle aggregate

The Monteagle fine aggregate seen in Figure 4 was acquired from the Lookout Quarry near Chattanooga and is classified as quartz sandstone. The color of the particles varied from moderate reddish brown (10R 4/6), grayish brown (5YR3/2), light brown (5YR 6/4), pale brown (5YR 5/2), dark

yellowish orange (10YR 6/6), Pale Yellowish Orange (10YR 8/6), very pale orange (10YR 8/2), grayish orange (10YR 7/4), very pale orange (10YR 8/2), very light gray (N8), light gray (N7), medium light gray (N6), to white (N9).

Figure 4. Image of Monteagle No. 4 aggregate.

The material is a crushed stone thus the particles were angular. The size fractions evaluated for ASTM C-295 were from (3/8-in.), 4.75-mm (No. 4), 2.36-mm (No. 8), 1.18-mm (No. 16), 600-µm (No. 30), 300-µm (No. 50), 150-µm (No. 100), and 75-µm (No. 200). Results provided in Table 16 indicate the sample is a dense to porous material (average of 65.6 percent dense particles and 16.7 percent porous particles) with a small fraction being vuggy or fractured.

Table 16. Monteagle aggregate results in accordance to ASTM C295.

Size	#4	#8	#16	#30	#50	#100	Average
Dense	61.3	42.7	47.7	69.1	83.4	89.6	65.6
Porous	15.7	29.0	35.0	15.0	3.9	1.6	16.7
Vuggy	5.3	11.3	5.7	4.0	5.2	2.6	5.7
Fractured	18.7	17.0	11.7	12.0	7.5	5.8	12.1

This index of refraction for quartz within the sample was equal to 1.544 and approximately 3 percent of the grains observed exhibited undulatory extinction. There were no opal coatings seen in this sample. Analysis of the XRD patterns (Figure 5) indicated that the predominant phase in the material was quartz. Table 17 contains the weight percent data obtained by whole pattern fitting using Jade 2010 software. Whole pattern fit analysis for the 3 size fractions evaluated contained an average weight percentage of 9.9 wt percent quartz (SiO_2), 0.1 wt percent muscovite ($KAl_2(AlSi_3O_{10})(F,OH)_2$).

Figure 5. XRD patterns of No. 30, No. 50, and No.100 sieve fractions of the Monteagle aggregate.

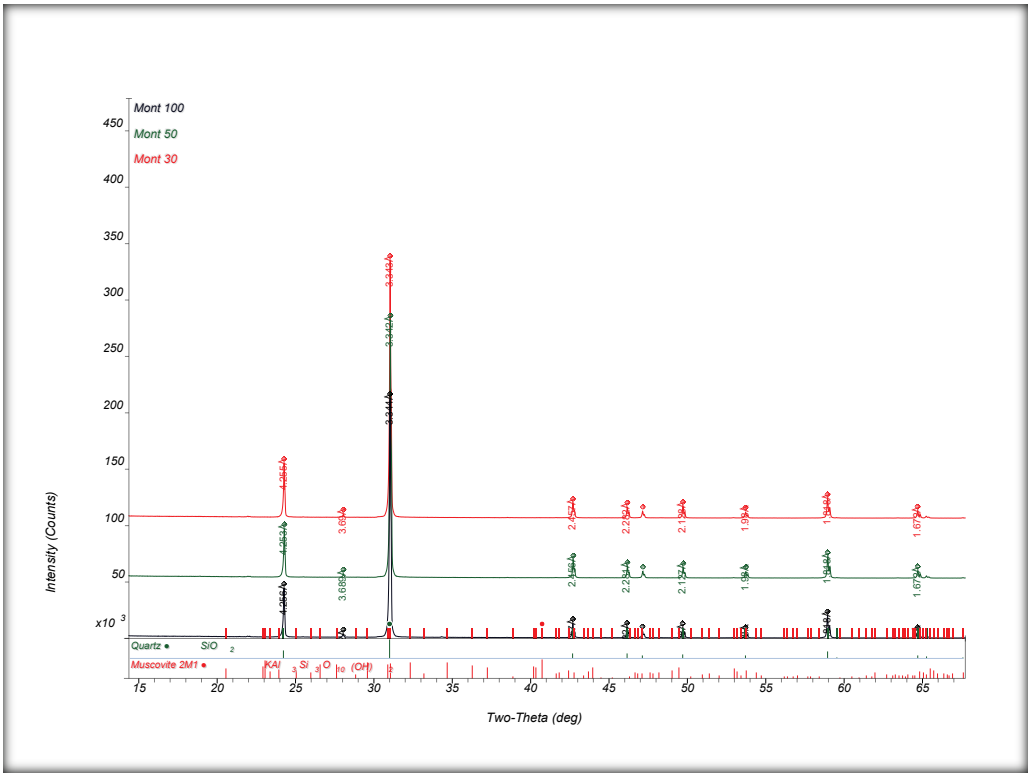


Table 17. Calculated weight percent of minerals from whole pattern fitting analysis for Monteagle aggregate.

Phase ID (mineral)	Chemical Formula	Weight Percent No. 30	Weight Percent No. 50	Weight Percent No. 100	Weight Percent Average
Quartz	SiO_2	100	99.8	99.9	99.9
Muscovite	$KAl_2(AlSi_3O_{10})(F,OH)_2$	0	0.2	0.1	0.1

In summary, the predominant phase in the material was quartz (SiO_2), with trace amounts of muscovite. This index of refraction for quartz within

the sample was equal to 1.544 and approximately 3 percent of the grains observed exhibited undulatory extinction. There were no opal coatings found in this sample. The distribution of dense and porous particles remained consistent across aggregate size. The Monteagle fine aggregate does contain quartz with undulatory extinction.

4.3 Sequatchie aggregate

The Sequatchie aggregate seen in Figure 6 was acquired from a quarry located near South Pittsburg, TN, and is classified as quartz sandstone. The color of the particles varied from dark reddish brown (10R 3/4), grayish orange pink (5YR 7/2), pale brown (5YR 5/2), moderate orange pink (5YR 8/4), very pale orange (10YR 8/2), pale yellowish orange (10YR 8/6), very light gray (N8), light gray (N7), medium light gray (N6), to white (N9).

Figure 6. Image of Sequatchie No. 4 aggregate.

The material is a crushed stone; thus, the particles were angular. The size fractions evaluated were from (3/8-in), 4.75-mm (No. 4), 2.36-mm (No. 8), 1.18-mm (No. 16), 600-µm (No. 30), 300-µm (No. 50), 150-µm (No. 100),

and 75-µm (No. 200). Results provided in Table 18 indicate that the sample is a dense to porous material (average of 52.3 percent dense particles and 37.0 percent porous particles) with a small fraction being vuggy or fractured.

Table 18. Sequatchie aggregate results in accordance to ASTM C295.

Size	#4	#8	#16	#30	#50	#100	Average
Dense	49.3	35.3	20.6	47.7	72.9	88.2	52.3
Porous	46.0	55.3	70.6	38.0	9.4	2.5	37.0
Vuggy	1.3	5.0	2.9	7.7	11.3	3.8	5.3
Fractured	3.0	5.0	5.9	6.7	6.5	5.4	5.4

This index of refraction for quartz within the sample was equal to 1.544 and no undulatory extinction was observed in the sample. There were small isotropic grains observed in the 1.4800 index oil, believed to be cristobalite (1-3 percent). There were no opal coatings seen in this sample. Analysis of the XRD patterns (Figure 7) indicated that the predominant phase in the material was quartz. Table 19 contains the weight percent data obtained by whole pattern fitting using Jade 2010 software. Whole pattern fit analysis for the 3 size fractions evaluated contained an average weight percentage of 98.03 wt percent quartz (SiO_2), 1.17 wt percent muscovite ($KAl_2(AlSi_3O_{10})(F,OH)_2$), 0.17 wt percent kaolinite ($Al_4(OH)_8(Si_4O_{10})$), 0.3 wt percent rutile (TiO_2), and 2.0 wt percent coesite (SiO_2).

In summary, the predominant phase of the Sequatchie fine aggregate was quartz (SiO_2), with small amounts of muscovite, kaolinite, and rutile. There were trace amounts of coesite (SiO_2) identified in the xrd analysis and trace amounts of cristobalite (SiO_2) identified with refractive index oils. (Figure 2 and Table 3). This index of refraction for quartz within the sample was equal to 1.544 indicating no chalcedony; no opal was observed in the sample. There was no undulatory extinction or opal coating seen in this sample. The distribution of dense and porous particles remained consistent across aggregate size. The aggregate does contain trace amounts of SiO_2 in the form of cristobalite and coesite.

Figure 7. XRD patterns of No. 30, No. 50, and No.100 sieve fractions of the Sequatchie aggregate.

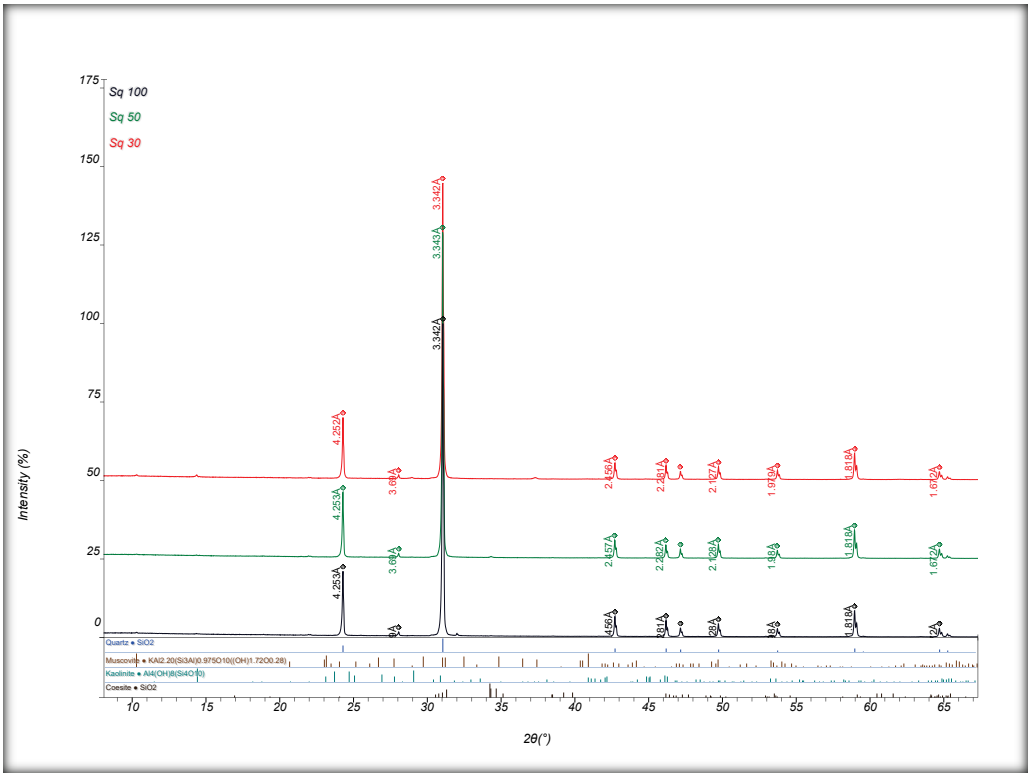


Table 19. Calculated weight percent of minerals from whole pattern fitting analysis for Sequatchie aggregate.

Phase ID (mineral)	Chemical Formula	Weight Percent No. 30	Weight Percent No. 50	Weight Percent No. 100	Weight Percent Average
Quartz	SiO_2	96.2	99.3	98.6	98.03
Coesite	SiO_2	0.2	0.7	0	0.3
Muscovite	$KAl_2(AlSi_3O_{10})(F,OH)_2$	3.0	0	0.5	1.17
Kaolinite	$Al_4(OH)_8(Si_4O_{10})$	0.5	0	0	0.17
Rutile	TiO_2	0	0	0.9	0.3

5 Cementitious Material Testing

Potential cementitious project materials were provided to the ERDC for standard compliance testing in accordance to the Chickamauga L&D specifications. Two cements, one fly ash, one slag cement, one silica fume, and one limestone powder were evaluated. This section provides result summaries of each cementitious material tested. Additional test reports can be found in Appendix C.

5.1 Portland cement

Cements from two sources were tested in accordance to ASTM C150 (ASTM 2018b) "Standard Specification for Portland Cement." Both the portland type I/II low alkali cement produced by Buzzi Unicem at the Signal Mountain Plant located in Chattanooga and the portland type I/II (MH) cement produced by Lafarge at the Joppa, IL, plant satisfied the ASTM C150 specification requirements. A summary of the chemical and physical properties of the cements are detailed in Table 20.

Table 20. Physical and chemical cement results tested in accordance to ASTM C150.

Chemical Analysis				
Compound (%)		Buzzi Unicem Cement	Lafarge Cement	Spec. Limits
SiO_2		19.77	21.24	-
Al_2O_3		4.43	2.64	6.0% max
Fe_2O_3		3.57	4.3	6.0% max
CaO		62.91	64.97	-
MgO		3.12	2.4	6.0% max
SO_3		2.61	2.79	3.0% max
Na_2O		0.11	0.06	-
K_2O		0.63	0.17	-
Total Na_2O Equivalent Alkalis		0.52	0.17	0.60% max
TiO_2		0.28	0.18	-
P_2O_5		0.06	0.11	-
Loss On Ignition		2.04	0.91	3.0% max
Physical Analysis				
Property		Buzzi Unicem Cement	Lafarge Cement	Spec. Limits
Heat of Hydration (J/g)	7 Days	220	180	290 J/g max
	28 Days	250	220	-
Surface Area (m^2/kg)		344	299	260 m^2/kg min
Autoclave Expansion (%)		0.03	-0.02	0.80% max
Initial Set by Vicat (minutes)		125	255	45 min
Final Set by Vicat (minutes)		265	310	375 max
Air Content (%)		7	4.4	12% max
False Set (%)		67	79	50% min
Compressive Strength (psi)	3 Days	3,430	2,070	1,740 min
	7 Days	4,380	2,390	2,760 min
	28 Days	6,070	4,360	4,060 min

5.2 Fly ash

A Class F fly ash produced by the SEFA (TVA) Group located in Cumberland City, TN, was tested in accordance to ASTM C618 (ASTM 2017f) . Chemical and physical results provided in Table 21 indicate compliance with all ASTM C618 pozzolan specifications.

Table 21. Fly ash results tested in accordance to ASTM C618.

Chemical Analysis (%)	Test Results	Spec. Limits
SiO_2	45.92	-
Al_2O_3	18.78	-
Fe_2O_3	18.45	-
Sum	83.15	70.0% min
Na_2O	0.62	-
K_2O	2.32	-
CaO	6.25	-
MgO	1.91	-
SO_3	3.1	5.0% max
Loss on Ignition	1.23	6.0% max
Moisture Content	0.11	3.0% max
Physical Analysis	**Test Results**	**Spec. Limits**
Strength Activity %, 7 days	87	75% min
Strength Activity %, 28 days	87	75% min
Water Requirement, % Control	95	105% max
Specific Gravity	2.67	5% max
Soundness, %	0.02	0.8% max
Fineness, % Retained on #325	22.2	34% max
Increase of drying shrinkage at 28 days	0.06	-
Uniformity Requirement, amount of Vinsol	0.15 g	-
Effectiveness in Controlling ASR at 14 days	67%	-

5.3 Slag cement

A grade 100 slag cement produced by Lafarge North America located in Chicago, IL, was tested in accordance to ASTM C989 (ASTM 2018c). A summary of the chemical and physical properties given in Table 22 validates compliance to all requirements of the specification limits.

Table 22. Slag cement results tested in accordance to ASTM C989.

Chemical Analysis (%)	Test Results	Spec. Limits
Sulfide Sulfur, (as S)	0.9	2.5% max
Sulfate Sulfur, (as SO_3)	1.28	4% max
Aluminum Oxide, (as $Al2O_3$)	10.15	-
Chloride Content of Slag	0.05	-
Na_2O	0.27	-
K_2O	0.49	-
Equivalent Alkalis-total as Na_2O	0.59	
Physical Analysis	**Test Results**	**Spec. Limits**
Compressive Strength, (psi) 7 day, Control	4,380	-
Compressive Strength, (psi) 28 day, Control	6,070	-
Compressive Strength, (psi) 7 day, Slag/Cement	3,350	-
Compressive Strength, (psi) 28 day, Slag/Cement	6,050	-
Strength Activity Index, (%) 7 day	82	70% min.
Strength Activity Index, (%) 28 day	99	90% min.
Surface Area, m^2/kg	480	260 min.
Specific Gravity	3.19	-
Fineness, % Retained on #325	0.5	20% max
Air Content, %	5.7	12% max

5.4 Silica fume

A grade 965U silica fume produced by Elkem Materials Inc. located in Euclid, OH, was tested in accordance to ASTM C1240 (ASTM 2015d). The material conforms to the chemical and physical requirements of the specification based on results summarized in Table 23.

Table 23. Silica fume results tested in accordance to ASTM C1240.

Chemical Analysis (%)	Test Results	Spec. Limits
SiO_2	96.9	85%, min.
Al_2O_3	0.06	-
Fe_2O_3	0.05	-
Sum	97.01	-
Na_2O	0.02	-
K_2O	0.86	-
MgO	0.36	-
SO_3	0.15	-
Loss on Ignition	1.2	6%, max
Moisture	0.5	3%, max
Physical Analysis	**Test Results**	**Spec. Limits**
Control Mixture: Compressive Strength, 7 day (psi)	4490	-
Test Mixture: Compressive Strength, 7 day (psi)	7280	-
Strength Activity Index, (%) 7 day	162	105%, min.
Water Requirement	100	100-115%
Specific Gravity	2.32	-
Uniformity Requirement, Amount of Vinsol	0.04 g	-
Effectiveness in Controlling ASR at 14 days	95%	80%, min.

5.5 Limestone powder

Graymont limestone powder produced by Lhoist North America located in Crab Orchard, TN, was tested in accordance to ASTM C1271 (ASTM 2012) "Standard Test Method for X-ray Spectrometric Analysis of Lime and Limestone" and ASTM D546 (ASTM 2017e) "Standard Test Method for Sieve Analysis of Mineral Filler for Asphalt Paving Mixtures." The plastic index (PI) of the material was attempted with ASTM D4318 (ASTM 2017g) but the material was non-plastic and classified as a Silt (ML). No liquid

limit or plastic limit could be run; therefore, a PI was unobtainable. The limestone chemical and sieve analysis results are detailed in Table 24.

Table 24. Limestone powder analysis summary results.

ASTM C1271 X-ray Spectrometric Analysis of Limestone		
Chemical Analysis (%)	Test Results	
SiO_2	1.3	
Al_2O_3	0.09	
Fe_2O_3	0.1	
Loss on ignition (950 °C)	44.80	
Ca as $CaCO_3$	96.49	
Mg as $MgCO_3$	1.54	
Calculated Carbonates as CO_2	43.29	
ASTM D546 Sieve Analysis of Mineral Filler for Bituminous Paving Mixtures		
Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
No. 10	0.00	100
No. 16	0.00	100
No. 30	0.00	100
No. 50	0.00	100
No. 200	0.07	99.9

Remarks: Limestone powder material was considered non-plastic silt (ML), gray when tested by ASTM D4318.

6 Summary and Conclusions

The purpose of this investigation was to test potential construction materials provided by the USACE Nashville District for the Chickamauga Lock and Dam Reconstruction Project. Materials included three coarse aggregate gradation, two fine aggregate sources, two type I/II cements, a fly ash source, a slag, a silica fume, and a limestone powder. Relevant conclusions from laboratory testing are summarized below. However, final material acceptance will be at the District's discretion.

6.1 Aggregate testing

A total of ten ASTM procedures were conducted for the three proposed project aggregate sources (Tiftonia, Monteagle, and Sequatchie). Unless otherwise stated, all requirements for the grading and quality of the fine and coarse aggregates are defined in ASTM C33. Test specific results indicate the following:

- Sieve Analysis (ASTM C136)
  All coarse aggregates from the Tiftonia quarry met the grading requirements. The Monteagle fine aggregate met all requirements with the exception of 66 percent passing the No. 30 sieve (25 to 60 percent criteria). The Sequatchie fine aggregate met all requirements with the exception of 65 percent passing the No. 30 sieve and 32 percent passing the No. 50 sieve (5 to 30 percent criteria).
- Specific Gravity and Absorption (ASTM C127/128)
  All aggregates met typical ranges of specific gravity (1.6 to 3.2 percent) and absorption (0.2 to 4 percent for coarse aggregates and 0.2 to 2 percent for fine aggregates).
- Materials Less than No. 200 Sieve (ASTM C117)
  All aggregates fell below the 1 percent maximum allowance for materials finer than No. 200 sieve with the exceptions of the ¾-in. Tiftonia aggregate result of 1.1 percent and the Monteagle sand result of 1.4 percent.
- Organic Impurities (ASTM C40)
  The organic plate results indicated both sands do not contain organic impurities at a concentration great enough to warrant further testing at this time.

- Soundness of Aggregates (ASTM C88)
  All aggregates met the magnesium sulfate soundness requirement of less than 18 percent cumulative mass loss at 5 cycles.
- LA Abrasion (ASTM C131)
  All aggregates met the abrasion requirement of less than 50 percent loss.
- Clay Lumps and Friable Particles (ASTM C142)
  The percent clay lumps and friable particles were less maximum range (2.0 to 10.0) of allowable percentages for all aggregates.
- Flat and Elongated Particles (ASTM D4791)
  No flat or elongated particles were detected in all aggregates evaluated.
- Lightweight Particles (ASTM C123)
  All aggregates fell below the 0.5 to 1.0 maximum allowable percentage of coal and lignite particles.
- Freezing and Thawing Resistance (ASTM C666, Procedure A)
  The relative dynamic modulus for the Tiftonia coarse aggregate was 84 percent at 300 cycles, which is above the 60 percent requirement throughout 300 freezing and thawing cycles.

6.2 Petrographic testing

Petrographic examination of three aggregates (Tiftonia, Monteagle, and Sequatchie) was performed according to ASTM C295. Summary findings of each aggregate include the following:

- Tiftonia
  The coarse aggregate was classified as an ooilitic dolomitic limestone. The predominant phase in the material was calcite ($CaCO_3$), with dolomite ($CaMg(CO_3)_2$), quartz (SiO_2), and trace amounts of cristobalite (SiO_2). This index of refraction for quartz within the sample was equal to 1.544 indicating no chalcedony or opal were observed in the sample. There was no undulatory extinction or opal coating seen in this sample.
- Monteagle
  The fine aggregate was classified as quartz sandstone. The predominant phase in the material was quartz (SiO_2), with trace amounts of muscovite. This index of refraction for quartz within the sample was equal to 1.544 and approximately 3 percent of the grains observed exhibited undulatory extinction. There were no opal coatings seen in this sample.

- Sequatchie
  The fine aggregate was classified as quartz sandstone. The predominant phase in the material was quartz (SiO_2), with small amounts of muscovite, kaolinite, and rutile. There were trace amounts of coesite (SiO_2) identified in the XRD analysis and trace amounts of cristobalite (SiO_2) identified with refractive index oils. This index of refraction for quartz within the sample was equal to 1.544 indicating no chalcedony; no opal was observed in the sample. There was no undulatory extinction or opal coating seen in this sample.

6.3 Cementitious material testing

- Both the portland type I/II low alkali cement produced by Buzzi Unicem at the Signal Mountain Plant located in Chattanooga and the portland type I/II (MH) cement produced by Lafarge at the Joppa plant satisfied the ASTM C150 specification requirements.
- The SEFA (TVA) group class F fly sourced from the Cumberland City complies with all ASTM C618 pozzolan specifications.
- The slag cement from the Lafarge South Chicago source location met all ASTM C989 specifications for a grade 100 slag cement.
- The Microsilica grade 965U silica fume produced by Elkem Materials conforms to all ASTM C1240 requirements.
- Almost 100 percent (99.9 percent) of the Lhoist North America limestone powder passed the #200 sieve opening size when tested in accordance to ASTM D546. The material was considered non-plastic and classified as a silt (ML) when tested in accordance to ASTM D4318.

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_____. 2018c. *Standard specification for slag cement for use in concrete and mortars*. Designation: C 989-18. West Conshohocken, PA: ASTM International.

Appendix A: Aggregate Test Reports

A.1 Tiftonia 3-in. aggregate

ASTM C 136 & ASTM C 117

CMB Log In No.:	17TJ004	Date:	4-Oct-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia - Lookout Quarry	Date Received:	
Sampled By:	RH	Material Type:	3in. Coarse Agg.

ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates

			Date Tested:	4-Oct-16			Date Tested:	4-Oct-16			
			Run 1				Run 2				
Sieve Size			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
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		2,239.60	2.63%	2.63%	97.37%	2,080.40	2.65%	2.65%	97.35%	97%
2.0	50		11,772.20	13.83%	16.46%	83.54%	10,802.40	13.76%	16.41%	83.59%	84%
1.5	37.5	x	21,796.50	25.61%	42.07%	57.93%	20,215.30	25.75%	42.16%	57.84%	58%
1.0	25		35,314.30	41.49%	83.55%	16.45%	32,548.60	41.46%	83.62%	16.38%	16%
3/4	19	x	10,971.50	12.89%	96.44%	3.56%	10,105.80	12.87%	96.49%	3.51%	4%
1/2	12.5		1,398.80	1.64%	98.09%	1.91%	1,373.90	1.75%	98.24%	1.76%	2%
3/8	9.5	x	101.60	0.12%	98.21%	1.79%	102.10	0.13%	98.37%	1.63%	2%
No. 4	4.75	x	211.60	0.25%	98.46%	1.54%	180.70	0.23%	98.60%	1.40%	1%
No. 8	2.36	x	465.80	0.55%	99.00%	1.00%	409.50	0.52%	99.12%	0.88%	1%
Pan			846.20	0.99%	100.00%	0.00	690.90	0.88%	100.00%	0.00	
Total			85,118.10	100.00%			78,509.60	100.00%			
Fineness Modulus:					8.342				8.348		8.34

x = Sieves used to calculate fineness modulus

			Run 1		Run 2	
			Original Dry Mass, g	Acceptance Range	Original Dry Mass, g	Acceptance Range
Yes	No	*Results for ASTM C 136 No. 200 include ASTM C 117 Results.*		87,674.7		80,861.2
	X		85,121.1	82,567.5	78,506.0	76,150.8

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:	30-Sep-16		
Procedure B		Washed with Wetting Agent				

	Original Dry Mass, g	Dry Mass After Wash, g	Mass Loss, g	Percent Loss	Average
Run 1	85,443.9	85,121.1	322.8	0.38%	0.4%
Run 2	78,896.5	78,506.0	390.5	0.49%	

ASTM C 131 & C 535 Los Angeles Machine Worksheet			
CMB Log In No.:	17TJ004	Date:	12-Oct-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia Quarry	Date Received:	
Sampled By:	RH	Material Type:	3" Coarse Agg.

ASTM C 131 Resistance to Degradation of Small-Size Coarse Agg. by Abrasion and Impact in the L.A. Machine

Sieve Size (Square Openings)		Target Grading				Test Samples for Grading:		
Passing	Retained on	A	B	C	D	Oven Dry Mass, g	Retained Mass, g	
37.5 mm (1 1/2 in.)	25.0 mm (1 in.)	1,250 ± 25						
25.0 mm (1 in.)	19.0 mm (3/4 in.)	1,250 ± 25						
19.0 mm (3/4 in.)	12.5 mm (1/2 in.)	1,250 ± 10	2,500 ± 10					
12.5 mm (1/2 in.)	9.5 mm (3/8 in.)	1,250 ± 10	2,500 ± 10					
9.5 mm (3/8 in.)	6.3 mm (1/4 in.)			2,500 ± 10				
6.3 mm (1/4 in.)	4.75 mm (No. 4)			2,500 ± 10				Total Loss by Abrasion & Impact, %
4.75 mm (No. 4)	2.36 mm (No. 8)				5,000 ± 10			
Total		5,000 ± 10	5,000 ± 10	5,000 ± 10	5,000 ± 10			
No. of 46mm-48mm Spheres (390-445g)		12	11	8	6			Revolutions
Mass of Charge, g		5,000 ± 25	4,580 ± 25	3,330 ± 20	2,500 ± 15			500

ASTM C 535 Resistance to Degradation of Large-Size Coarse Agg. by Abrasion and Impact in the L.A. Machine

Sieve Size (Square Openings)		Target Grading				Test Samples for Grading:	1	
Passing	Retained on	1	2	3		Oven Dry Mass, g	Retained Mass, g	
75.0 mm (3 in.)	63.0 mm (2 1/2 in.)	2,500 ± 50				2,514.0		
63.0 mm (2 1/2 in.)	50.0 mm (2 in.)	2,500 ± 50				2,486.6		
50.0 mm (2 in.)	37.5 mm (1 1/2 in.)	5,000 ± 50	5,000 ± 50			4,990.2		
37.5 mm (1 1/2 in.)	25.0 mm (1 in.)		5,000 ± 25	5,000 ± 25				
25.0 mm (1 in.)	19.0 mm (3/4 in.)			5,000 ± 25				
								Total Loss by Abrasion & Impact, %
Total		10,000 ± 100	10,000 ± 75	10,000 ± 50		9,990.8	7,444.3	25%
No. of 46mm-48mm Spheres (390-445g)		12	12	12		12		Revolutions
Mass of Charge, g		5,000 ± 25	5,000 ± 25	5,000 ± 25		5,016.4		1,000

ASTM C 142 & D 4791 Worksheet

CMB Log In No.:	17TJ004	Date:	5-Oct-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia - Lookout Quarry	Date Received:	
Sampled By:	RH	Material Type:	3in. Coarse Agg.

ASTM C 142 Clay Lumps and Friable Particles in Aggregates (Coarse Aggregate)

Sieve Size (Square Openings)			Min. Mass of Test Sample, g	Grading of Original Sample, %	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percent Passing Designated Sieve After Test	Weighted Percentage Loss	Percent of Clay Lumps & Friable Particles
Passing	Retained on	Finial Washing								
Over 37.5 mm (1 1/2 in.)	37.5 mm (1 1/2in.)	4.75 mm (No.4)	5,000	42%	34,361.7	34,357.1	4.60	0.01%	0.01%	
37.5 mm (1 1/2in.)	19.0 mm (3/4 in.)	4.75 mm (No.4)	3,000	54%	44,179.3	44,172.0	7.30	0.02%	0.01%	
19.0 mm (3/4 in.)	9.5 mm (3/8 in.)	4.75 mm (No.4)	2,000	2%	1,636.3	1,632.4	3.90	0.24%	0.00%	
9.5 mm (3/8 in.)	4.75 mm (No. 4)	2.36 mm (No.8)	1,000	0%						
Fine Aggregate	1.18 mm (No. 16)	850 µm (No.20)	25							
Total					80,177.3	80,161.5			0.02%	0.0%

Aggregate containing less than 5% of the above sizes shall be considered to contain the same % of clay lumps % friable particles as the next larger or smaller size, whichever is present.

Original Grading After ASTM C 117

Sieve Size		Run 1	Run 2	Average	D 4791
std.	mm	Percent Retained	Percent Retained	Percent Retained	Min.Total Mass of Test Sample, g
4.0	100	0.00%	0.00%		150,000
3.5	90	0.00%	0.00%		100,000
3.0	75	0.00%	0.00%		60,000
2.5	63	2.63%	2.65%	2.64%	35,000
2.0	50	13.83%	13.76%	13.79%	20,000
1.5	37.5	25.61%	25.75%	25.68%	15,000
1.0	25	41.49%	41.46%	41.47%	10,000
3/4	19	12.89%	12.87%	12.88%	5,000
1/2	12.5	1.64%	1.75%	1.70%	2,000
3/8	9.5	0.12%	0.13%	0.12%	1,000
No. 4	4.75	0.25%	0.23%	0.24%	
No. 8	2.36	0.55%	0.52%	0.53%	
No. 16					

ASTM D 4791 Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

Method A Using Proportional Caliper Device Set at 1:3

Sieve Size		Grading of Original Sample, %	Weight of Particles in Each Size Fraction Greater than 10%, grams							Percent Flat, Elongated, or Flat & Elongated Particles
std.	mm		Total Weight	Flat	Elongated	Flat and Elongated	Neither Flat nor Elongated	Total Percentage	Weighted Percentage	
4.0	100									
3.5	90									
3.0	75									
2.5	63	2.64%								
2.0	50	13.79%	11,279.1	0.0	519.4	2,495.2	8,264.5	0.27%	0.04%	
1.5	37.5	25.68%	21,018.8	441.6	0.0	3,805.9	16,771.3	0.20%	0.05%	
1.0	25	41.47%	33,952.6	1,700.5	42.6	296.5	31,913.0	0.06%	0.02%	
3/4	19	12.88%	10,554.0	442.9	62.4	1,890.8	8,157.9	0.23%	0.03%	
1/2	12.5	1.70%								
3/8	9.5	0.12%								
No. 4	4.75	0.24%								
Total			76,804.5						0.14%	0%

ASTM C 123 Lightweight Particles in Aggregate

CMB Log In No.:	17TJ004	Date:	2-Nov-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia - Lookout Quarry	Date Received:	
Sampled By:	R.H.	Material Type:	3in. Coarse Agg.

Date Tested: 1-Nov-16

ASTM C 123 USING ZINC BROMIDE FOR A SPECIFIC GRAVITY OF 2.40

Nominal Maximum Size of Aggregate									Percentage of Lightweight Particles
Sieve Size (Square Openings)	Test Material Retained on	Min. Mass of Test Sample, g	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percentage Loss			
50.0 mm (2 in.) or Larger	4.75 mm (No.4)	10,000	10678.30	10677.67	0.63	0.01%			
25.0 to 37.5 mm (1 to 1 1/2 in.)	4.75 mm (No.4)	5,000							
12.5 to 19.0 mm (1/2 to 3/4 in.)	4.75 mm (No.4)	3,000							
9.5 mm (3/8 in.)	4.75 mm (No.4)	1,500							
4.75 mm (No. 4) or Smaller	300 µm (No. 50)	200							
Total			10678.30	10677.67	0.63	0.01%			0.0%

Date Tested: 31-Oct-16

ASTM C 123 USING ZINC CHLORIDE FOR A SPECIFIC GRAVITY OF 2.00

Nominal Maximum Size of Aggregate									Percentage of Lightweight Particles
Sieve Size (Square Openings)	Test Material Retained on	Min. Mass of Test Sample, g	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percentage Loss			
50.0 mm (2 in.) or Larger	4.75 mm (No.4)	10,000	10273.70	10273.70	0.00	0.00%			
25.0 to 37.5 mm (1 to 1 1/2 in.)	4.75 mm (No.4)	5,000							
12.5 to 19.0 mm (1/2 to 3/4 in.)	4.75 mm (No.4)	3,000							
9.5 mm (3/8 in.)	4.75 mm (No.4)	1,500							
4.75 mm (No. 4) or Smaller	300 µm (No. 50)	200							
Total			10273.70	10273.70		0.00%			0.0%

ASTM C 127 Worksheet For Samples Tested in Separate Size Fractions			
CMB Log In No.:	17TJ004	Date:	11-Oct-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia - Lookout Quarry	Date Received:	
Sampled By:	RH	Material Type:	3in. Coarse Agg.

ASTM C 127 Relative Density and Absorption of Coarse Aggregate

Original Grading After ASTM C 117				Sample Tested in Separate Size Fractions							
Sieve Size		Run 1									
std.	mm	Percent Retained	Min. Mass of Test Sample, g	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
4.0	100	0.00%	40,000								
3.5	90	0.00%	25,000								
3.0	75	0.00%	18,000								
2.5	63	2.63%	12,000	2,184.90	2,201.60	1,362.60	2.604	2.624	2.657	0.76%	21.7
2.0	50	13.83%	8,000	5,874.30	5,915.80	3,701.90	2.653	2.672	2.704	0.71%	22.6
1.5	37.5	25.61%	5,000	5,027.20	5,063.50	3,161.10	2.643	2.662	2.694	0.72%	23.1
1.0	25	41.49%	4,000	4,065.70	4,094.10	2,562.00	2.654	2.672	2.704	0.70%	23.4
3/4	19	12.89%	3,000	3,148.30	3,170.50	1,985.50	2.657	2.676	2.708	0.71%	23.3
1/2	12.5	1.64%	2,000	2,038.60	2,053.10	1,287.20	2.662	2.681	2.713	0.71%	23.1
3/8	9.5	0.12%	2,000	1,649.70	1,661.50	1,042.60	2.666	2.685	2.717	0.72%	22.8
No. 4	4.75	0.25%	2,000	1,874.80	1,888.20	1,183.90	2.662	2.681	2.714	0.71%	23.3
No. 8	2.36	0.55%	2,000								
No. 16	1.18										
No. 30	600 µm										
No. 40	425 µm										
No. 50	300 µm										
No. 100	150 µm										
No. 200	75 µm										
Total				25,863.50	26,048.30	16,286.80					

Size Fraction, in. (mm)		Run 1									
Passing	Retained	Percent in Original Sample	Soak Time, hr.	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
3 (75)	1.5 (37.5)	42.07%	21.0	13,086.4	13,180.9	8,225.6	2.641	2.660	2.692	0.72%	22.5
1.5 (37.5)	1/2 (12.5)	56.02%	23.0	9,252.6	9,317.7	5,834.7	2.657	2.675	2.707	0.70%	23.3
1/2 (12.5)	No. 4 (4.75)	0.37%	24.5	3,524.5	3,549.7	2,226.5	2.664	2.683	2.715	0.71%	23.1
					Run 1	Average	2.650	2.669	2.701	0.70%	22.9

ASTM C 127 Relative Density and Absorption of Coarse Aggregate

Original Grading After ASTM C 117				Sample Tested in Separate Size Fractions							
Sieve Size		Run 2	Min. Mass of Test Sample, g	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
std.	mm	Percent Retained									
4.0	100	0.00%	40,000								
3.5	90	0.00%	25,000								
3.0	75	0.00%	18,000								
2.5	63	2.65%	12,000	2,502.30	2,521.00	1,560.00	2.604	2.623	2.656	0.75%	22.0
2.0	50	13.76%	8,000	5,989.40	6,032.00	3,769.00	2.647	2.665	2.697	0.71%	23.4
1.5	37.5	25.75%	5,000	5,087.70	5,124.40	3,200.80	2.645	2.664	2.696	0.72%	23.4
1.0	25	41.46%	4,000	4,139.30	4,168.20	2,603.30	2.645	2.664	2.695	0.70%	23.4
3/4	19	12.87%	3,000	3,067.20	3,089.00	1,934.70	2.657	2.676	2.708	0.71%	23.3
1/2	12.5	1.75%	2,000	2,179.50	2,194.90	1,377.20	2.665	2.684	2.717	0.71%	23.1
3/8	9.5	0.13%	2,000	1,964.30	1,978.30	1,241.80	2.667	2.686	2.719	0.71%	22.8
No. 4	4.75	0.23%	2,000	1,831.30	1,844.20	1,157.10	2.665	2.684	2.716	0.70%	23.3
No. 8	2.36	0.52%	2,000								
No. 16	1.18										
No. 30	600 µm										
No. 40	425 µm										
No. 50	300 µm										
No. 100	150 µm										
No. 200	75 µm										
Total				26,761.00	26,952.00	16,843.90					

Size Fraction, in. (mm)		Run 2		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
Passing	Retained	Percent in Original Sample	Soak Time, hr.								
3 (75)	1.5 (37.5)	42.16%	21.0	13,579.4	13,677.4	8,529.8	2.638	2.657	2.689	0.72%	22.9
1.5 (37.5)	1/2 (12.5)	56.08%	22.5	9,386.0	9,452.1	5,915.2	2.654	2.672	2.704	0.70%	23.3
1/2 (12.5)	No. 4 (4.75)	0.36%	24.5	3,795.6	3,822.5	2,398.9	2.666	2.685	2.718	0.71%	23.1
					Run 2	Average	2.647	2.666	2.698	0.70%	23.1
						OVERALL AVERAGE	2.65	2.67	2.70	0.7%	23.0

ASTM C 88 Soundness of Aggregates Work Sheet									
by USE of :	X	Magnesium Sulfate		Sodium Sulfate					
CMB Log In No.:	17TJ004			Date:	5-Dec-16				
District:				Tested By:	CEERD-GM-C				
Material Supplier:	Tiftonia - Lookout Quarry			Date Received:					
Sampled By:	RH			Material Type:	3in. Coarse Agg.				

Sieve Size		Grading of Original Sample, %	Sieve Used to Determine Loss	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percent Passing Designated Sieve After Test	Weighted Percentage Loss	Sample Basket Number (s)
std.	mm								
4.0	100	0.0%	3.00 in.						
3.5	90	0.0%	3.00 in.						
3.0	75	0.0%	2.50 in.						
2.5	63	2.6%	2.00 in.	2,992.4	2,990.1	2.30	0.1%	0%	
2.0	50	13.8%	1.25 in.	2,992.4	2,990.1	2.30	0.1%	0%	No. 27
1.5	37.5	25.7%	1.25 in.	1,997.5	1,972.0	25.50	1.3%	0%	No. 29
1.0	25	41.5%	5/8 in.	1,076.8	1,062.9	13.90	1.3%	1%	No. 20
3/4	19	12.9%	5/8 in.	517.6	472.7	44.90	8.7%	1%	No. 38
1/2	12.5	1.7%	5/16 in.	517.6	472.7	44.90	8.7%	0%	
3/8	9.5	0.1%	5/16 in.	517.6	472.7	44.90	8.7%	0%	
No. 4	4.75	0.2%	No. 5	517.6	472.7	44.90	8.7%	0%	
No. 8	2.36	0.5%	No. 8	517.6	472.7	44.90	8.7%	0%	
No. 16	1.18		No. 16						
No. 30	600 µm		No. 30						
No. 50	300 µm		No. 50						
No. 100	150 µm								
Minus									
No. 100	150 µm								
Total								2%	

Note: Use the percentage loss of the next smaller size if a size contains less that 5% of the original sample as received. (See 11.1.3.4)

Qualitative Examination of Coarse Sizes Greater than 19mm (3/4 in.)

Sieve Size	Splitting		Crumbling		Cracking		Flaking		Total No. Of Particles Before Test
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
63 mm (2.5 in.) to 37.5 mm (1.5 in.)							7	25%	28
37.5 mm (1.5 in.) to 19.0 mm (3/4 in.)							5	11%	44

Date:	21-Nov-16	22-Nov-16	28-Nov-16	29-Jan-16	30-Nov-16		
Specific Gravity of Solution:	1.302	1.298	1.299	1.299	1.298	X	New Solution
Solution Temp. C / F :	69	69	70	70	70		Filtered Solution
Cycle No.:	1	2	3	4	5		

A.2 Tiftonia 1½-in. coarse aggregate

ASTM C 136 & ASTM C 117			
CMB Log In No.:	17TJ002	Date:	3-Oct-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia - Lookout Quarry	Date Received:	
Sampled By:	RH	Material Type:	No. 4 - 1.5" Coarse Agg.

ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates

			Date Tested:	3-Oct-16			Date Tested:	3-Oct-16			
			Run 1				Run 2				
Sieve Size			Individual		Cumulative		Individual		Cumulative		Average
std.	mm	F.M.	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Percent Passing
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	364.60	2.24%	2.24%	97.76%	340.00	2.00%	2.00%	98.00%	98%
1.0	25		10,961.90	67.38%	69.62%	30.38%	11,431.00	67.23%	69.23%	30.77%	31%
3/4	19	x	4,106.10	25.24%	94.86%	5.14%	4,335.60	25.50%	94.73%	5.27%	5%
1/2	12.5		434.50	2.67%	97.53%	2.47%	510.70	3.00%	97.73%	2.27%	2%
3/8	9.5	x	48.50	0.30%	97.82%	2.18%	53.50	0.31%	98.05%	1.95%	2%
No. 4	4.75	x	58.80	0.36%	98.19%	1.81%	57.80	0.34%	98.39%	1.61%	2%
No. 8	2.36	x	67.60	0.42%	98.60%	1.40%	71.50	0.42%	98.81%	1.19%	1%
Pan			227.10	1.40%	100.00%		202.30	1.19%	100.00%		
Total			16,269.10	100.00%			17,002.40	100.00%			
Fineness Modulus:					7.917				7.920		7.92

x = Sieves used to calculate fineness modulus

			Run 1		Run 2	
			Original Dry Mass, g	Acceptance Range	Original Dry Mass, g	Acceptance Range
Yes	No	*Results for ASTM C 136 No. 200 include ASTM C 117 Results.*		16,757.7		17,512.7
	X		16,269.6	15,781.5	17,002.6	16,492.5

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:	30-Sep-16			
Procedure B		Washed with Wetting Agent						
	Original Dry Mass, g		Dry Mass After Wash, g		Mass Loss, g		Percent Loss	Average
Run 1	16,399.2		16,269.6		129.6		0.79%	0.7%
Run 2	17,102.7		17,002.6		100.1		0.59%	

ASTM C 131 & C 535 Los Angeles Machine Worksheet			
CMB Log In No.:	17TJ002	Date:	12-Oct-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia Quarry	Date Received:	
Sampled By:	RH	Material Type:	No. 4 - 1.5" Coarse Agg.

ASTM C 131 Resistance to Degradation of Small-Size Coarse Agg. by Abrasion and Impact in the L.A. Machine

Sieve Size (Square Openings)		Target Grading				Test Samples for Grading:		
Passing	Retained on	A	B	C	D	Oven Dry Mass, g	Retained Mass, g	
37.5 mm (1 1/2 in.)	25.0 mm (1 in.)	1,250 ± 25						
25.0 mm (1 in.)	19.0 mm (3/4 in.)	1,250 ± 25						
19.0 mm (3/4 in.)	12.5 mm (1/2 in.)	1,250 ± 10	2,500 ± 10					
12.5 mm (1/2 in.)	9.5 mm (3/8 in.)	1,250 ± 10	2,500 ± 10					
9.5 mm (3/8 in.)	6.3 mm (1/4 in.)			2,500 ± 10				
6.3 mm (1/4 in.)	4.75 mm (No. 4)			2,500 ± 10				Total Loss by Abrasion & Impact, %
4.75 mm (No. 4)	2.36 mm (No. 8)				5,000 ± 10			
Total		5,000 ± 10	5,000 ± 10	5,000 ± 10	5,000 ± 10			
No. of 46mm-48mm Spheres (390-445g)		12	11	8	6			Revolutions
Mass of Charge, g		5,000 ± 25	4,580 ± 25	3,330 ± 20	2,500 ± 15			500

ASTM C 535 Resistance to Degradation of Large-Size Coarse Agg. by Abrasion and Impact in the L.A. Machine

Sieve Size (Square Openings)		Target Grading				Test Samples for Grading:	3	
Passing	Retained on	1	2	3		Oven Dry Mass, g	Retained Mass, g	
75.0 mm (3 in.)	63.0 mm (2 1/2 in.)	2,500 ± 50						
63.0 mm (2 1/2 in.)	50.0 mm (2 in.)	2,500 ± 50						
50.0 mm (2 in.)	37.5 mm (1 1/2 in.)	5,000 ± 50	5,000 ± 50					
37.5 mm (1 1/2 in.)	25.0 mm (1 in.)		5,000 ± 25	5,000 ± 25		5,006.6		
25.0 mm (1 in.)	19.0 mm (3/4 in.)			5,000 ± 25		5,020.2		
								Total Loss by Abrasion & Impact, %
Total		10,000 ± 100	10,000 ± 75	10,000 ± 50		10,026.8	7,419.4	26%
No. of 46mm-48mm Spheres (390-445g)		12	12	12		12		Revolutions
Mass of Charge, g		5,000 ± 25	5,000 ± 25	5,000 ± 25		5,016.4		1,000

ASTM C 142 & D 4791 Worksheet

CMB Log In No.:	17TJ002	Date:	5-Oct-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia - Lookout Quarry	Date Received:	
Sampled By:	RH	Material Type:	No. 4 - 1.5" Coarse Agg.

ASTM C 142 Clay Lumps and Friable Particles in Aggregates (Coarse Aggregate)

Sieve Size (Square Openings)			Min. Mass of Test Sample, g	Grading of Original Sample, %	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percent Passing Designated Sieve After Test	Weighted Percentage Loss	Percent of Clay Lumps & Friable Particles
Passing	Retained on	Finial Washing								
Over 37.5 mm (1 1/2 in.)	37.5 mm (1 1/2in.)	4.75 mm (No.4)	5,000	2%	332.7	332.5	0.20	0.06%	0.00%	
37.5 mm (1 1/2in.)	19.0 mm (3/4 in.)	4.75 mm (No.4)	3,000	93%	15,471.6	15,470.8	0.80	0.01%	0.00%	
19.0 mm (3/4 in.)	9.5 mm (3/8 in.)	4.75 mm (No.4)	2,000	3%	499.1	498.2	0.90	0.18%	0.01%	
9.5 mm (3/8 in.)	4.75 mm (No. 4)	2.36 mm (No.8)	1,000	0%						
Fine Aggregate	1.18 mm (No. 16)	850 µm (No.20)	25	0%						
Total					16,303.4	16,301.5			0.01%	0.0%

Aggregate containing less than 5% of the above sizes shall be considered to contain the same % of clay lumps % friable particles as the next larger or smaller size, whichever is present.

Original Grading After ASTM C 117					
Sieve Size		Run 1	Run 2	Average	D 4791
std.	mm	Percent Retained	Percent Retained	Percent Retained	Min.Total Mass of Test Sample, g
4.0	100	0.00%	0.00%		150,000
3.5	90	0.00%	0.00%		100,000
3.0	75	0.00%	0.00%		60,000
2.5	63	0.00%	0.00%		35,000
2.0	50	0.00%	0.00%		20,000
1.5	37.5	2.24%	2.00%	2.12%	15,000
1.0	25	67.38%	67.23%	67.30%	10,000
3/4	19	25.24%	25.50%	25.37%	5,000
1/2	12.5	2.67%	3.00%	2.84%	2,000
3/8	9.5	0.30%	0.31%	0.31%	1,000
No. 4	4.75	0.36%	0.34%	0.35%	
No. 8	2.36	0.42%	0.42%	0.42%	
No. 16					

ASTM D 4791 Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

Method A Using Proportional Caliper Device Set at 1:3

Sieve Size		Grading of Original Sample, %	Weight of Particles in Each Size Fraction Greater than 10%, grams							Percent Flat, Elongated, or Flat & Elongated Particles
std.	mm		Total Weight	Flat	Elongated	Flat and Elongated	Neither Flat nor Elongated	Total Percentage	Weighted Percentage	
4.0	100									
3.5	90									
3.0	75									
2.5	63									
2.0	50									
1.5	37.5	2.12%								
1.0	25	67.30%	11,191.3	515.0	13.1	906.6	9,756.6	0.13%	0.09%	
3/4	19	25.37%	4,244.3	180.1	25.1	760.0	3,279.1	0.23%	0.06%	
1/2	12.5	2.84%								
3/8	9.5	0.31%								
No. 4	4.75	0.35%								
Total			15,435.6						0.14%	0%

ASTM C 123 Lightweight Particles in Aggregate

CMB Log In No.:	17TJ002	Date:	2-Nov-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia - Lookout Quarry	Date Received:	
Sampled By:	R.H.	Material Type:	No. 4 - 1.5" Coarse Agg.

Date Tested: 1-Nov-16

ASTM C 123 USING ZINC BROMIDE FOR A SPECIFIC GRAVITY OF 2.40

Nominal Maximum Size of Aggregate / Sieve Size (Square Openings)	Test Material Retained on	Min. Mass of Test Sample, g	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percentage Loss			Percentage of Lightweight Particles
50.0 mm (2 in.) or Larger	4.75 mm (No.4)	10,000							
25.0 to 37.5 mm (1 to 1 1/2 in.)	4.75 mm (No.4)	5,000	6071.80	6071.48	0.32	0.01%			
12.5 to 19.0 mm (1/2 to 3/4 in.)	4.75 mm (No.4)	3,000							
9.5 mm (3/8 in.)	4.75 mm (No.4)	1,500							
4.75 mm (No. 4) or Smaller	300 µm (No. 50)	200							
Total			6071.80	6071.48	0.32	0.01%			0.0%

Date Tested: 31-Oct-16

ASTM C 123 USING ZINC CHLORIDE FOR A SPECIFIC GRAVITY OF 2.00

Nominal Maximum Size of Aggregate / Sieve Size (Square Openings)	Test Material Retained on	Min. Mass of Test Sample, g	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percentage Loss			Percentage of Lightweight Particles
50.0 mm (2 in.) or Larger	4.75 mm (No.4)	10,000							
25.0 to 37.5 mm (1 to 1 1/2 in.)	4.75 mm (No.4)	5,000	5588.30	5588.30	0.00	0.00%			
12.5 to 19.0 mm (1/2 to 3/4 in.)	4.75 mm (No.4)	3,000							
9.5 mm (3/8 in.)	4.75 mm (No.4)	1,500							
4.75 mm (No. 4) or Smaller	300 µm (No. 50)	200							
Total			5588.30	5588.30		0.00%			0.0%

ASTM C 127 Worksheet			
CMB Log In No.:	17TJ002	Date:	11-Oct-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia - Lookout Quarry	Date Received:	
Sampled By:	RH	Material Type:	No. 4 - 1.5" Coarse Agg.

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.
RUN 1	7,425.7	7,477.7	4,680.0	2.654	2.673	2.704	0.70%	23.0	23.50
RUN 2	7,488.9	7,541.4	4,713.0	2.648	2.666	2.698	0.70%	22.8	24.00
AVERAGE				2.65	2.67	2.70	0.7%	22.9	23.75

ASTM C 88 Soundness of Aggregates Work Sheet									
by USE of :	X	Magnesium Sulfate		Sodium Sulfate					
CMB Log In No.:	17TJ002			Date:	5-Dec-16				
District:				Tested By:	CEERD-GM-C				
Material Supplier:	Tiftonia - Lookout Quarry			Date Received:					
Sampled By:	RH			Material Type:	No. 4 - 1.5" Coarse Agg.				

Sieve Size std.	Sieve Size mm	Grading of Original Sample, %	Sieve Used to Determine Loss	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percent Passing Designated Sieve After Test	Weighted Percentage Loss	Sample Basket Number (s)
4.0	100	0.0%	3.00 in.						
3.5	90	0.0%	3.00 in.						
3.0	75	0.0%	2.50 in.						
2.5	63	0.0%	2.00 in.						
2.0	50	0.0%	1.25 in.						
1.5	37.5	2.1%	1.25 in.	1,076.8	1,062.9	13.90	1.3%	0%	
1.0	25	67.3%	5/8 in.	1,076.8	1,062.9	13.90	1.3%	1%	No. 20
3/4	19	25.4%	5/8 in.	517.6	472.7	44.90	8.7%	2%	No. 38
1/2	12.5	2.8%	5/16 in.	517.6	472.7	44.90	8.7%	0%	
3/8	9.5	0.3%	5/16 in.	517.6	472.7	44.90	8.7%	0%	
No. 4	4.75	0.4%	No. 5	517.6	472.7	44.90	8.7%	0%	
No. 8	2.36	0.4%	No. 8	517.6	472.7	44.90	8.7%	0%	
No. 16	1.18		No. 16						
No. 30	600 µm		No. 30						
No. 50	300 µm		No. 50						
No. 100	150 µm								
Minus									
No. 100	150 µm								
Total								3%	

Note: Use the percentage loss of the next smaller size if a size contains less that 5% of the original sample as received. (See 11.1.3.4)

Qualitative Examination of Coarse Sizes Greater than 19mm (3/4 in.)

Sieve Size	Splitting		Crumbling		Cracking		Flaking		Total No. Of Particles Before Test
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
63 mm (2.5 in.) to 37.5 mm (1.5 in.)									
37.5 mm (1.5 in.) to 19.0 mm (3/4 in.)							5	11%	44

Date:	1.302	1.298	1.299	1.299	1.298		
Specific Gravity of Solution:	69	69	70	70	70	X	New Solution
Solution Temp. C / F :	1	2	3	4	5		Filtered Solution
Cycle No.:	1	2	3	4	5		

A.3 Tiftonia ¾-in. coarse aggregate

ASTM C 136 & ASTM C 117

CMB Log In No.:	17TJ003	Date:	3-Oct-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia - Lookout Quarry	Date Received:	
Sampled By:	RH	Material Type:	No. 67 Coarse Agg.

ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates

Sieve Size			Run 1 Date Tested: 3-Oct-16				Run 2 Date Tested: 3-Oct-16				Average
			Individual		Cumulative		Individual		Cumulative		
std.	mm	F.M.	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Percent Passing
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	186.30	2.76%	2.76%	97.24%	208.70	2.95%	2.95%	97.05%	97%
1/2	12.5		2,771.40	41.04%	43.80%	56.20%	2,901.70	41.00%	43.95%	56.05%	56%
3/8	9.5	x	1,692.10	25.06%	68.86%	31.14%	1,776.40	25.10%	69.05%	30.95%	31%
No. 4	4.75	x	1,904.40	28.20%	97.06%	2.94%	1,981.70	28.00%	97.05%	2.95%	3%
No. 8	2.36	x	133.60	1.98%	99.04%	0.96%	141.50	2.00%	99.05%	0.95%	1%
Pan			64.00	0.95%	99.99%		67.20	0.95%	100.00%		
Total			6,751.80	99.99%			7,077.20	100.00%			
Fineness Modulus:					6.677				6.681		6.68

x = Sieves used to calculate fineness modulus

			Run 1		Run 2	
			Original Dry Mass, g	Acceptance Range	Original Dry Mass, g	Acceptance Range
Yes	No	*Results for ASTM C 136 No. 200 include ASTM C 117 Results.*		6,955.0		7,289.7
	X		6,752.4	6,549.8	7,077.4	6,865.1

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:	30-Sep-16	
Procedure B		Washed with Wetting Agent			

	Original Dry Mass, g	Dry Mass After Wash, g	Mass Loss, g	Percent Loss	Average
Run 1	6,832.2	6,752.4	79.8	1.17%	1.1%
Run 2	7,149.5	7,077.4	72.1	1.01%	

ASTM C 131 & C 535 Los Angeles Machine Worksheet			
CMB Log In No.:	17TJ003	Date:	12-Oct-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia Quarry	Date Received:	
Sampled By:	RH	Material Type:	No. 67 Coarse Agg.

ASTM C 131 Resistance to Degradation of Small-Size Coarse Agg. by Abrasion and Impact in the L.A. Machine

Sieve Size (Square Openings)		Target Grading				Test Samples for Grading:	B	
Passing	Retained on	A	B	C	D	Oven Dry Mass, g	Retained Mass, g	
37.5 mm (1 1/2 in.)	25.0 mm (1 in.)	1,250 ± 25						
25.0 mm (1 in.)	19.0 mm (3/4 in.)	1,250 ± 25						
19.0 mm (3/4 in.)	12.5 mm (1/2 in.)	1,250 ± 10	2,500 ± 10			2,509.2		
12.5 mm (1/2 in.)	9.5 mm (3/8 in.)	1,250 ± 10	2,500 ± 10			2,500.5		
9.5 mm (3/8 in.)	6.3 mm (1/4 in.)			2,500 ± 10				
6.3 mm (1/4 in.)	4.75 mm (No. 4)			2,500 ± 10				Total Loss by Abrasion & Impact, %
4.75 mm (No. 4)	2.36 mm (No. 8)				5,000 ± 10			
Total		5,000 ± 10	5,000 ± 10	5,000 ± 10	5,000 ± 10	5,009.7	3,976.3	21%
No. of 46mm-48mm Spheres (390-445g)		12	11	8	6	11		Revolutions
Mass of Charge, g		5,000 ± 25	4,580 ± 25	3,330 ± 20	2,500 ± 15	4,600.0		500

ASTM C 535 Resistance to Degradation of Large-Size Coarse Agg. by Abrasion and Impact in the L.A. Machine

Sieve Size (Square Openings)		Target Grading				Test Samples for Grading:	3	
Passing	Retained on	1	2	3		Oven Dry Mass, g	Retained Mass, g	
75.0 mm (3 in.)	63.0 mm (2 1/2 in.)	2,500 ± 50						
63.0 mm (2 1/2 in.)	50.0 mm (2 in.)	2,500 ± 50						
50.0 mm (2 in.)	37.5 mm (1 1/2 in.)	5,000 ± 50	5,000 ± 50					
37.5 mm (1 1/2 in.)	25.0 mm (1 in.)		5,000 ± 25	5,000 ± 25				
25.0 mm (1 in.)	19.0 mm (3/4 in.)			5,000 ± 25				
								Total Loss by Abrasion & Impact, %
Total		10,000 ± 100	10,000 ± 75	10,000 ± 50				
No. of 46mm-48mm Spheres (390-445g)		12	12	12				Revolutions
Mass of Charge, g		5,000 ± 25	5,000 ± 25	5,000 ± 25				1,000

ASTM C 142 & D 4791 Worksheet			
CMB Log In No.:	17TJ003	Date:	5-Oct-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia - Lookout Quarry	Date Received:	
Sampled By:	RH	Material Type:	No. 67 Coarse Agg.

ASTM C 142 Clay Lumps and Friable Particles in Aggregates (Coarse Aggregate)

Sieve Size (Square Openings)			Min. Mass of Test Sample, g	Grading of Original Sample, %	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percent Passing Designated Sieve After Test	Weighted Percentage Loss	Percent of Clay Lumps & Friable Particles
Passing	Retained on	Finial Washing								
Over 37.5 mm (1 1/2 in.)	37.5 mm (1 1/2in.)	4.75 mm (No.4)	5,000	0%						
37.5 mm (1 1/2in.)	19.0 mm (3/4 in.)	4.75 mm (No.4)	3,000	3%	215.1	214.3	0.80	0.37%	0.01%	
19.0 mm (3/4 in.)	9.5 mm (3/8 in.)	4.75 mm (No.4)	2,000	66%	4,731.5	4,731.0	0.50	0.01%	0.01%	
9.5 mm (3/8 in.)	4.75 mm (No. 4)	2.36 mm (No.8)	1,000	28%	2,007.3	2,002.5	4.80	0.24%	0.07%	
Fine Aggregate	1.18 mm (No. 16)	850 µm (No.20)	25	2%	143.4	142.7	0.70	0.49%	0.01%	
Total					7,097.3	7,090.5			0.09%	0.1%

Aggregate containing less than 5% of the above sizes shall be considered to contain the same % of clay lumps % friable particles as the next larger or smaller size, whichever is present.

Original Grading After ASTM C 117					
Sieve Size		Run 1	Run 2	Average	D 4791
std.	mm	Percent Retained	Percent Retained	Percent Retained	Min.Total Mass of Test Sample, g
4.0	100	0.00%	0.00%		150,000
3.5	90	0.00%	0.00%		100,000
3.0	75	0.00%	0.00%		60,000
2.5	63	0.00%	0.00%		35,000
2.0	50	0.00%	0.00%		20,000
1.5	37.5	0.00%	0.00%		15,000
1.0	25	0.00%	0.00%		10,000
3/4	19	2.76%	2.95%	2.85%	5,000
1/2	12.5	41.04%	41.00%	41.02%	2,000
3/8	9.5	25.06%	25.10%	25.08%	1,000
No. 4	4.75	28.20%	28.00%	28.10%	
No. 8	2.36	1.98%	2.00%	1.99%	
No. 16					

ASTM D 4791 Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

Method A Using Proportional Caliper Device Set at 1:3

Sieve Size		Grading of Original Sample, %	Weight of Particles in Each Size Fraction Greater than 10%, grams							Percent Flat, Elongated, or Flat & Elongated Particles
std.	mm		Total Weight	Flat	Elongated	Flat and Elongated	Neither Flat nor Elongated	Total Percentage	Weighted Percentage	
4.0	100									
3.5	90									
3.0	75									
2.5	63									
2.0	50									
1.5	37.5									
1.0	25									
3/4	19	2.85%								
1/2	12.5	41.02%	2,836.5	28.7	0.0	229.7	2,578.1	0.09%	0.04%	
3/8	9.5	25.08%	1,734.3	2.3	0.0	42.3	1,689.8	0.03%	0.01%	
No. 4	4.75	28.10%	1,942.5	1.9	0.0	47.0	1,893.6	0.03%	0.01%	
Total			6,513.4						0.05%	0%

ASTM C 123 Lightweight Particles in Aggregate			
CMB Log In No.:	17TJ003	Date:	2-Nov-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia - Lookout Quarry	Date Received:	
Sampled By:	R.H.	Material Type:	No. 67 Coarse Agg.

Date Tested: 1-Nov-16

ASTM C 123 USING ZINC BROMIDE FOR A SPECIFIC GRAVITY OF 2.40

Nominal Maximum Size of Aggregate / Sieve Size (Square Openings)	Test Material Retained on	Min. Mass of Test Sample, g	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percentage Loss			Percentage of Lightweight Particles
50.0 mm (2 in.) or Larger	4.75 mm (No.4)	10,000							
25.0 to 37.5 mm (1 to 1 1/2 in.)	4.75 mm (No.4)	5,000							
12.5 to 19.0 mm (1/2 to 3/4 in.)	4.75 mm (No.4)	3,000	4136.90	4131.34	5.56	0.13%			
9.5 mm (3/8 in.)	4.75 mm (No.4)	1,500							
4.75 mm (No. 4) or Smaller	300 µm (No. 50)	200							
Total			4136.90	4131.34	5.56	0.13%			0.1%

Date Tested: 31-Oct-16

ASTM C 123 USING ZINC CHLORIDE FOR A SPECIFIC GRAVITY OF 2.00

Nominal Maximum Size of Aggregate / Sieve Size (Square Openings)	Test Material Retained on	Min. Mass of Test Sample, g	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percentage Loss			Percentage of Lightweight Particles
50.0 mm (2 in.) or Larger	4.75 mm (No.4)	10,000							
25.0 to 37.5 mm (1 to 1 1/2 in.)	4.75 mm (No.4)	5,000							
12.5 to 19.0 mm (1/2 to 3/4 in.)	4.75 mm (No.4)	3,000	3977.80	3977.68	0.12	0.00%			
9.5 mm (3/8 in.)	4.75 mm (No.4)	1,500							
4.75 mm (No. 4) or Smaller	300 µm (No. 50)	200							
Total			3977.80	3977.68	0.12	0.00%			0.0%

ASTM C 127 Worksheet			
CMB Log In No.:	17TJ003	Date:	11-Oct-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Tiftonia - Lookout Quarry	Date Received:	
Sampled By:	RH	Material Type:	No. 67 Coarse Agg.

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.	
RUN 1	3,731.3	3,757.0	2,356.4	2.664	2.682	2.714	0.69%	23.3	24.00	
RUN 2	3,975.6	4,003.1	2,512.4	2.667	2.685	2.717	0.69%	23.0	24.50	
	AVERAGE			2.67	2.68	2.72	0.7%	23.2	24.25	

ASTM C 88 Soundness of Aggregates Work Sheet

by USE of :	X	Magnesium Sulfate		Sodium Sulfate	
CMB Log In No.:	17TJ003		Date:	5-Dec-16	
District:			Tested By:	CEERD-GM-C	
Material Supplier:	Tiftonia - Lookout Quarry		Date Received:		
Sampled By:	RH		Material Type:	No. 67 Coarse Agg.	

Sieve Size std.	Sieve Size mm	Grading of Original Sample, %	Sieve Used to Determine Loss	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percent Passing Designated Sieve After Test	Weighted Percentage Loss	Sample Basket Number (s)
4.0	100	0.0%	3.00 in.						
3.5	90	0.0%	3.00 in.						
3.0	75	0.0%	2.50 in.						
2.5	63	0.0%	2.00 in.						
2.0	50	0.0%	1.25 in.						
1.5	37.5	0.0%	1.25 in.						
1.0	25	0.0%	5/8 in.						
3/4	19	2.9%	5/8 in.	667.7	623.1	44.60	6.7%	0%	
1/2	12.5	41.0%	5/16 in.	667.7	623.1	44.60	6.7%	3%	No. 35
3/8	9.5	25.1%	5/16 in.	332.0	299.5	32.50	9.8%	2%	No. 33
No. 4	4.75	28.1%	No. 5	300.3	263.3	37.00	12.3%	3%	No. 32
No. 8	2.36	2.0%	No. 8	300.3	263.3	37.00	12.3%	0%	
No. 16	1.18		No. 16						
No. 30	600 µm		No. 30						
No. 50	300 µm		No. 50				NV		
No. 100	150 µm								
Minus No. 100	150 µm								
Total								9%	

Note: Use the percentage loss of the next smaller size if a size contains less that 5% of the original sample as received. (See 11.1.3.4)

Qualitative Examination of Coarse Sizes Greater than 19mm (3/4 in.)

Sieve Size	Splitting		Crumbling		Cracking		Flaking		Total No. Of Particles Before Test
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
63 mm (2.5 in.) to 37.5 mm (1.5 in.)									
37.5 mm (1.5 in.) to 19.0 mm (3/4 in.)							5	11%	44

Date:	1.302	1.298	1.299	1.299	1.298		
Specific Gravity of Solution:	69	69	70	70	70	X	New Solution
Solution Temp. C / F :	1	2	3	4	5		Filtered Solution
Cycle No.:	1	2	3	4	5		

A.4 Monteagle sand

ASTM C 136, ASTM C 117, & ASTM C 40 WORKSHEET			
CMB Log In No.:	17TJ001	Date:	2-Nov-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Monteagle	Date Received:	
Sampled By:	RH	Material Type:	Fine Agg.

ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates

			Date Tested:	3-Oct-16			Date Tested:	3-Oct-16			
			Run 1				Run 2				
Sieve Size			Individual		Cumulative		Individual		Cumulative		Average
std.	mm	F.M.	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Percent Passing
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%
No. 4	4.75	x	8.70	1.68%	1.68%	98.32%	8.30	1.70%	1.70%	98.30%	98%
No. 8	2.36	x	47.40	9.17%	10.85%	89.15%	44.50	9.13%	10.83%	89.17%	89%
No. 16	1.18	x	43.30	8.38%	19.23%	80.77%	41.00	8.41%	19.24%	80.76%	81%
No. 30	600 µm	x	78.00	15.09%	34.32%	65.68%	73.70	15.11%	34.35%	65.65%	66%
No. 40	425 µm		113.10	21.88%	56.20%	43.80%	106.70	21.88%	56.23%	43.77%	44%
No. 50	300 µm	x	99.20	19.19%	75.39%	24.61%	93.60	19.20%	75.43%	24.57%	25%
No. 100	150 µm	x	96.40	18.65%	94.04%	5.96%	91.00	18.66%	94.09%	5.91%	6%
No. 200	75 µm		22.00	4.26%	98.30%	1.70%	20.80	4.27%	98.36%	1.64%	1.7%
Pan			1.70	0.33%	98.63%		1.50	0.31%	98.67%		
Total			509.80	98.63%			481.10	98.67%			
Fineness Modulus:					2.355				2.356		2.36

x = Sieves used to calculate fineness modulus			Run 1		Run 2	
			Original Dry	Acceptance Range	Original Dry	Acceptance Range
Yes	No	*Results for ASTM C 136 No. 200 include ASTM C 117 Results.*	Mass, g	525.2	Mass, g	495.4
X			516.9	494.6	487.6	466.6

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:	30-Sep-16		
Procedure B		Washed with Wetting Agent							
	Original Dry Mass, g		Dry Mass After Wash, g		Mass Loss, g		Percent Loss		Average
Run 1	516.9		509.9		7.0		1.35%		1.4%
Run 2	487.6		481.0		6.6		1.35%		

ASTM C 40 Organic Impurities in Fine Aggregate in Concrete							
	Date Started:	31-Oct-16	Date Ended	30-Sep-16		Organic Plate No.:	1
	Date Tested:	7-Oct-16					

ASTM C 142 Clay Lumps and Friable Particles in Aggregates								
Sieve Size (Square Openings)		Min. Mass of Test Sample, g	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percent Passing Designated Sieve After Test		Percent of Clay Lumps & Friable Particles
Fine Aggregate	Finial Washing							
Retained on the 1.18mm (No. 16)	850 µm (No.20)	25	68.2	68.1	0.10	0.15%		0.1%

ASTM C 123 Lightweight Particles in Aggregate			
CMB Log In No.:	17TJ001	Date:	2-Nov-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Monteagle	Date Received:	
Sampled By:	RH	Material Type:	Fine Agg.
Date Tested: 1-Nov-16	ASTM C 123 USING ZINC BROMIDE FOR A SPECIFIC GRAVITY OF 2.40		

Nominal Maximum Size of Aggregate									
Sieve Size (Square Openings)	Test Material Retained on	Min. Mass of Test Sample, g	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percentage Loss			Percentage of Lightweight Particles
50.0 mm (2 in.) or Larger	4.75 mm (No.4)	10,000							
25.0 to 37.5 mm (1 to 1 1/2 in.)	4.75 mm (No.4)	5,000							
12.5 to 19.0 mm (1/2 to 3/4 in.)	4.75 mm (No.4)	3,000							
9.5 mm (3/8 in.)	4.75 mm (No.4)	1,500							
4.75 mm (No. 4) or Smaller	300 µm (No. 50)	200	254.00	253.46	0.54	0.21%			
Total			254.00	253.46	0.54	0.21%			0.2%

Date Tested: 31-Oct-16	ASTM C 123 USING ZINC CHLORIDE FOR A SPECIFIC GRAVITY OF 2.00

Nominal Maximum Size of Aggregate									
Sieve Size (Square Openings)	Test Material Retained on	Min. Mass of Test Sample, g	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percentage Loss			Percentage of Lightweight Particles
50.0 mm (2 in.) or Larger	4.75 mm (No.4)	10,000							
25.0 to 37.5 mm (1 to 1 1/2 in.)	4.75 mm (No.4)	5,000							
12.5 to 19.0 mm (1/2 to 3/4 in.)	4.75 mm (No.4)	3,000							
9.5 mm (3/8 in.)	4.75 mm (No.4)	1,500							
4.75 mm (No. 4) or Smaller	300 µm (No. 50)	200	250.30	250.07	0.23	0.09%			
Total			250.30	250.07	0.23	0.09%			0.1%

ASTM C 128 Worksheet			
CMB Log In No.:	17TJ001	Date:	6-Oct-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Monteagle	Date Received:	
Sampled By:	RH	Material Type:	Fine Agg.

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	1	505.20	1262.20	1575.90	502.20	2.622	2.638	2.664	0.60%	23.1	24.50
2	2	502.80	1478.80	1790.60	500.00	2.618	2.632	2.657	0.56%	23.1	24.50
AVERAGE						2.62	2.64	2.66	0.6%	23.1	24.50

ASTM C 88 Soundness of Aggregates Work Sheet									
by USE of :		X	Magnesium Sulfate			Sodium Sulfate			
CMB Log In No.:		17TJ001				Date:	5-Dec-16		
District:						Tested By:	CEERD-GM-C		
Material Supplier:		Monteagle				Date Received:			
Sampled By:		RH				Material Type:	Fine Agg.		
Sieve Size		Grading of Original Sample, % Retained	Sieve Used to Determine Loss	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percent Passing Designated Sieve After Test	Weighted Percentage Loss	Sample Basket Number (s)
std.	mm								
4.0	100	0.0%	3.00 in.						
3.5	90	0.0%	3.00 in.						
3.0	75	0.0%	2.50 in.						
2.5	63	0.0%	2.00 in.						
2.0	50	0.0%	1.25 in.						
1.5	37.5	0.0%	1.25 in.						
1.0	25	0.0%	5/8 in.						
3/4	19	0.0%	5/8 in.						
1/2	12.5	0.0%	5/16 in.						
3/8	9.5	0.0%	5/16 in.						
No. 4	4.75	1.7%	No. 5	100.00	61.90	38.10	38.1%	1%	
No. 8	2.36	9.1%	No. 8	100.00	61.90	38.10	38.1%	3%	No. 8 E1
No. 16	1.18	8.4%	No. 16	100.00	68.70	31.30	31.3%	3%	No. 16 D3
No. 30	600 µm	15.1%	No. 30	100.00	90.80	9.20	9.2%	1%	No. 30 C2
No. 50	300 µm	19.2%	No. 50	100.00	99.10	0.90	0.9%	0%	Np. 50 B8
No. 100	150 µm								
Minus									
No. 100	150 µm								
Total								8%	

Note: Use the percentage loss of the next smaller size if a size contains less that 5% of the original sample as received. (See 11.1.3.4)

Qualitative Examination of Coarse Sizes Greater than 19mm (3/4 in.)									
Sieve Size	Splitting		Crumbling		Cracking		Flaking		Total No. Of Particles Before Test
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
63 mm (2.5 in.) to 37.5 mm (1.5 in.)									
37.5 mm (1.5 in.) to 19.0 mm (3/4 in.)									
Date:		21-Nov-16	22-Nov-16	28-Nov-16	29-Jan-16	30-Nov-16			
Specific Gravity of Solution:		1.302	1.298	1.299	1.299	1.298	X	New Solution	
Solution Temp. C / F :		69	69	70	70	70		Filtered Solution	
Cycle No.:		1	2	3	4	5			

A.5 Sequatchie sand

ASTM C 136, ASTM C 117, & ASTM C 40 WORKSHEET			
CMB Log In No.:	17TJ005	Date:	2-Nov-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Sequatchie	Date Received:	
Sampled By:	RH	Material Type:	Fine Agg.

ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates

			Date Tested:	14-Oct-16			Date Tested:	14-Oct-16			
			Run 1				Run 2				
Sieve Size			Individual		Cumulative		Individual		Cumulative		Average
std.	mm	F.M.	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Mass Retained,g	Percent Retained	Percent Retained	Percent Passing	Percent Passing
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%
No. 4	4.75	x	24.80	4.99%	4.99%	95.01%	22.80	4.49%	4.49%	95.51%	95%
No. 8	2.36	x	67.20	13.53%	18.52%	81.48%	72.20	14.23%	18.73%	81.27%	81%
No. 16	1.18	x	41.70	8.40%	26.92%	73.08%	40.20	7.92%	26.65%	73.35%	73%
No. 30	600 µm	x	38.70	7.79%	34.71%	65.29%	40.30	7.94%	34.59%	65.41%	65%
No. 40	425 µm		63.20	12.72%	47.43%	52.57%	66.00	13.01%	47.60%	52.40%	52%
No. 50	300 µm	x	102.50	20.64%	68.07%	31.93%	105.20	20.74%	68.34%	31.66%	32%
No. 100	150 µm	x	134.20	27.02%	95.09%	4.91%	135.90	26.79%	95.13%	4.87%	5%
No. 200	75 µm		18.00	3.62%	98.71%	1.29%	18.40	3.63%	98.76%	1.24%	1.3%
Pan			1.00	0.20%	98.91%	0.01	1.10	0.22%	98.97%	0.01	
Total			491.30	98.91%			502.10	98.97%			
Fineness Modulus:					2.483				2.479		2.48

x = Sieves used to calculate fineness modulus			Run 1		Run 2	
			Original Dry	Acceptance Range	Original Dry	Acceptance Range
Yes	No	*Results for ASTM C 136 No. 200 include ASTM C 117 Results.*	Mass, g	506.5	Mass, g	517.4
X			496.7	476.9	507.3	487.2

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:	13-Oct-16		
Procedure B		Washed with Wetting Agent							
	Original Dry Mass, g		Dry Mass After Wash, g		Mass Loss, g		Percent Loss		Average
Run 1	496.7		491.7		5.0		1.01%		1.0%
Run 2	507.3		502.3		5.0		0.99%		

ASTM C 40 Organic Impurities in Fine Aggregate in Concrete

	Date Started:	13-Oct-16	Date Ended	14-Oct-16		Organic Plate No.:	1
	Date Tested:	7-Oct-16					

ASTM C 142 Clay Lumps and Friable Particles in Aggregates

Sieve Size (Square Openings)		Min. Mass of Test Sample, g	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percent Passing Designated Sieve After Test		Percent of Clay Lumps & Friable Particles
Fine Aggregate	Finial Washing							
Retained on the 1.18mm (No. 16)	850 µm (No.20)	25	76.5	76.3	0.20	0.26%		0.3%

ASTM C 123 Lightweight Particles in Aggregate

CMB Log In No.:	17TJ005	Date:	2-Nov-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Sequatchie	Date Received:	
Sampled By:	R.H.	Material Type:	Fine Agg.

Date Tested: 1-Nov-16

ASTM C 123 USING ZINC BROMIDE FOR A SPECIFIC GRAVITY OF 2.40

Nominal Maximum Size of Aggregate		Min. Mass of Test Sample, g	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percentage Loss			Percentage of Lightweight Particles
Sieve Size (Square Openings)	Test Material Retained on								
50.0 mm (2 in.) or Larger	4.75 mm (No.4)	10,000							
25.0 to 37.5 mm (1 to 1 1/2 in.)	4.75 mm (No.4)	5,000							
12.5 to 19.0 mm (1/2 to 3/4 in.)	4.75 mm (No.4)	3,000							
9.5 mm (3/8 in.)	4.75 mm (No.4)	1,500							
4.75 mm (No. 4) or Smaller	300 µm (No. 50)	200	252.40	250.28	2.12	0.84%			
Total			252.40	250.28	2.12	0.84%			0.8%

Date Tested: 31-Oct-16

ASTM C 123 USING ZINC CHLORIDE FOR A SPECIFIC GRAVITY OF 2.00

Nominal Maximum Size of Aggregate		Min. Mass of Test Sample, g	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percentage Loss			Percentage of Lightweight Particles
Sieve Size (Square Openings)	Test Material Retained on								
50.0 mm (2 in.) or Larger	4.75 mm (No.4)	10,000							
25.0 to 37.5 mm (1 to 1 1/2 in.)	4.75 mm (No.4)	5,000							
12.5 to 19.0 mm (1/2 to 3/4 in.)	4.75 mm (No.4)	3,000							
9.5 mm (3/8 in.)	4.75 mm (No.4)	1,500							
4.75 mm (No. 4) or Smaller	300 µm (No. 50)	200	250.60	250.04	0.56	0.22%			
Total			250.60	250.04	0.56	0.22%			0.2%

ASTM C 128 Worksheet			
CMB Log In No.:	17TJ005	Date:	14-Oct-16
District:		Tested By:	CEERD-GM-C
Material Supplier:	Sequatchie	Date Received:	
Sampled By:	RH	Material Type:	Fine Agg.

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	1	500.00	1263.30	1570.90	494.40	2.570	2.599	2.647	1.13%	23.2	24.00
2	2	507.60	1479.00	1791.90	502.10	2.579	2.607	2.654	1.10%	23.2	24.00
		AVERAGE				2.57	2.60	2.65	1.1%	23.2	24.00

ASTM C 88 Soundness of Aggregates Work Sheet

by USE of :	X	Magnesium Sulfate		Sodium Sulfate	
CMB Log In No.:	1TJ005		Date:	5-Dec-16	
District:			Tested By:	CEERD-GM-C	
Material Supplier:	Sequatchie		Date Received:		
Sampled By:	RH		Material Type:	Fine Agg.	

Sieve Size std.	Sieve Size mm	Grading of Original Sample, %	Sieve Used to Determine Loss	Weight of Test Fractions Before Test, g	Weight of Test Fractions After Test, g	Mass Loss After Test, g	Percent Passing Designated Sieve After Test	Weighted Percentage Loss	Sample Basket Number (s)
4.0	100	0.0%	3.00 in.						
3.5	90	0.0%	3.00 in.						
3.0	75	0.0%	2.50 in.						
2.5	63	0.0%	2.00 in.						
2.0	50	0.0%	1.25 in.						
1.5	37.5	0.0%	1.25 in.						
1.0	25	0.0%	5/8 in.						
3/4	19	0.0%	5/8 in.						
1/2	12.5	0.0%	5/16 in.						
3/8	9.5	0.0%	5/16 in.						
No. 4	4.75	4.7%	No. 5	100.00	31.60	68.40	68.4%	3%	No. 4 Round 25
No. 8	2.36	13.9%	No. 8	100.00	38.90	61.10	61.1%	8%	No. 8 B1
No. 16	1.18	8.2%	No. 16	100.00	56.90	43.10	43.1%	4%	No. 16 D4
No. 30	600 µm	7.9%	No. 30	100.00	90.70	9.30	9.3%	1%	No. 30 C1
No. 50	300 µm	20.7%	No. 50	100.00	95.80	4.20	4.2%	1%	No. 50 B4
No. 100	150 µm								
Minus									
No. 100	150 µm								
Total								17%	

Note: Use the percentage loss of the next smaller size if a size contains less than 5% of the original sample as received. (See 11.1.3.4)

Qualitative Examination of Coarse Sizes Greater than 19mm (3/4 in.)

Sieve Size	Splitting		Crumbling		Cracking		Flaking		Total No. Of Particles Before Test
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
63 mm (2.5 in.) to 37.5 mm (1.5 in.)									
37.5 mm (1.5 in.) to 19.0 mm (3/4 in.)									

Date:	21-Nov-16	22-Nov-16	28-Nov-16	29-Jan-16	30-Nov-16		
Specific Gravity of Solution:	1.302	1.298	1.299	1.299	1.298	X	New Solution
Solution Temp. C / F :	69	69	70	70	70		Filtered Solution
Cycle No.:	1	2	3	4	5		

Appendix B: Petrography Reports

B.1 Tiftonia Coarse Aggregate

WPF Report

Scan ID: Tif 16.xrdml

Scan Parameters: 2.511°/69.99°/0.01671°/219.71(s), ω=1.255678°/34.99573°, φ=0.0°, I(p)=38834/268, Co(45kV,40mA), Saturday,

☑ Zero Offset = -0.25 (0.0114) ☑ Displacement = 0.2483 (0.0117) ☐ Beam Spill-Off below 0.0°
☑ Kα2 Peaks Present ☐ Kα2/Kα1 Ratio = 0.5 ☐ X-Ray Polarization = 1.0

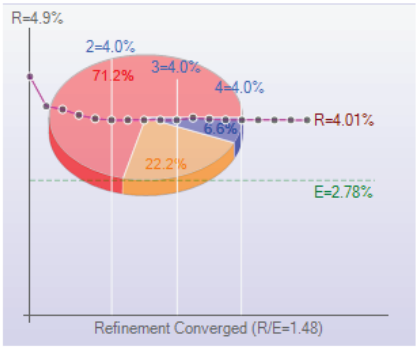
Geometry: Diffractometer Lp Fitted-Range: 3.5 - 69.0° BG-Model: Polynomial (7) λ: 1.78899 Å (Co)

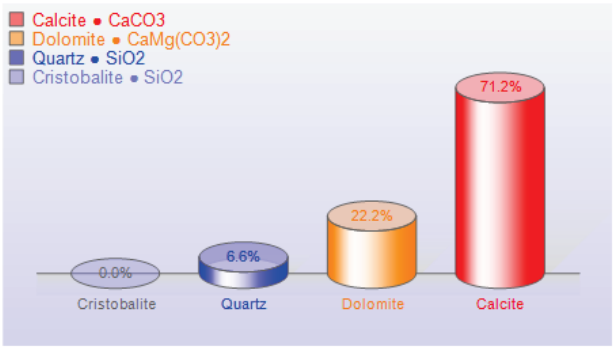
PSF: pseudo-Voigt Broadening: Individual FWHM Curve Instrument: Constant FWHM = 0.1°

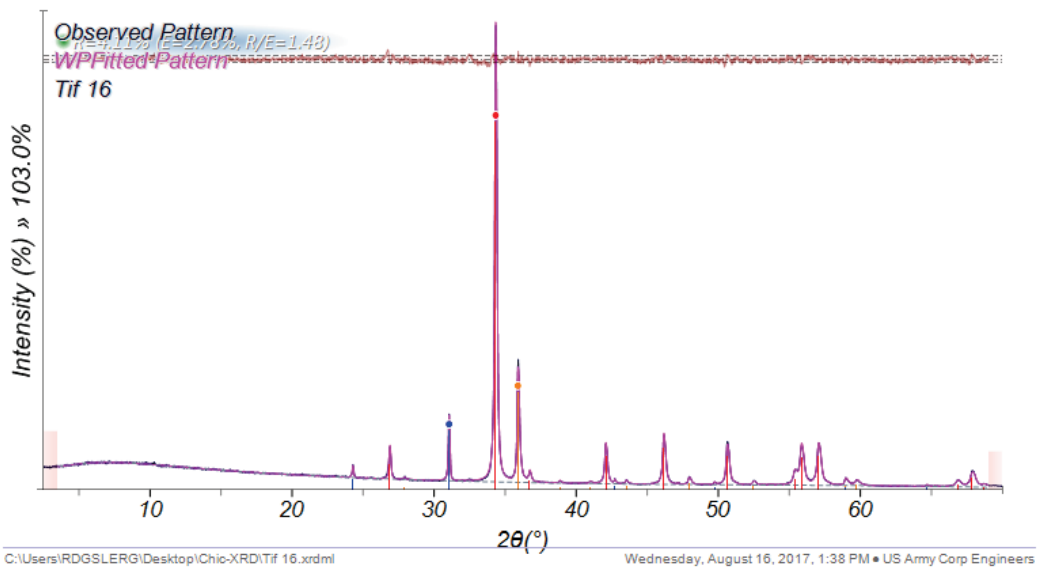
Phase ID (4)	Chemical Formula	PDF-#	NP	Wt% (esd)	RIR
Calcite	CaCO3	01-072-1214	11	71.2 (0.2)	3.20
Cristobalite	SiO2	98-001-0969	3	0.0 (0.0)	2.44
Dolomite	CaMg(CO3)2	01-089-5862	11	22.2 (0.1)	2.78
Quartz	SiO2	01-085-0794	4	6.6 (0.1)	3.11

XRF(Wt%): CaO=46.7%, SiO2=6.6%, MgO=4.9%, CO2=41.9%

Refinement Converged (R/E=1.48), ♣ Round=4, Iter=3, P=29, R=4.11% (E=2.78%, EPS=0.5)







C:\Users\RDGSLERG\Desktop\Chic-XRD\Tif 16.xrdml Wednesday, August 16, 2017, 1:38 PM • US Army Corp Engineers

WPF Report

Scan ID: Tif 30.xrdml

Scan Parameters: 2.511°/69.99°/0.01671°/219.71(s), ω=1.255678°/34.99573°, φ=0.0°, I(p)=43441/264, Co(45kV,40mA), Saturday,

☑ Zero Offset = -0.25 (0.0134) ☑ Displacement = 0.2474 (0.0137) ☐ Beam Spill-Off below 0.0°
☑ Kα2 Peaks Present ☐ Kα2/Kα1 Ratio = 0.5 ☐ X-Ray Polarization = 1.0

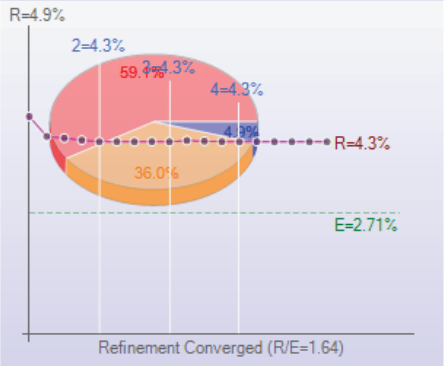
Geometry: Diffractometer Lp Fitted-Range: 3.5 - 69.0° BG-Model: Polynomial (7) λ: 1.78899 Å (Co)

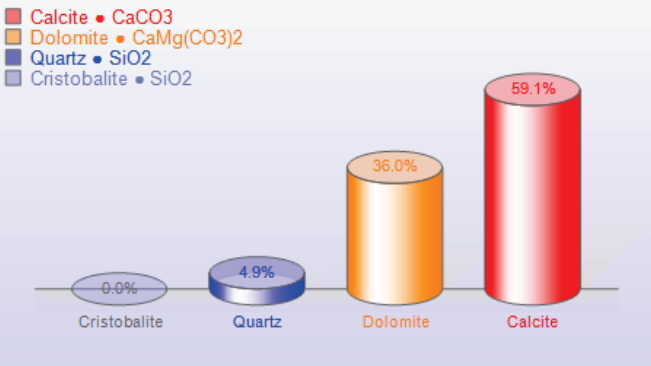
PSF: pseudo-Voigt Broadening: Individual FWHM Curve Instrument: Constant FWHM = 0.1°

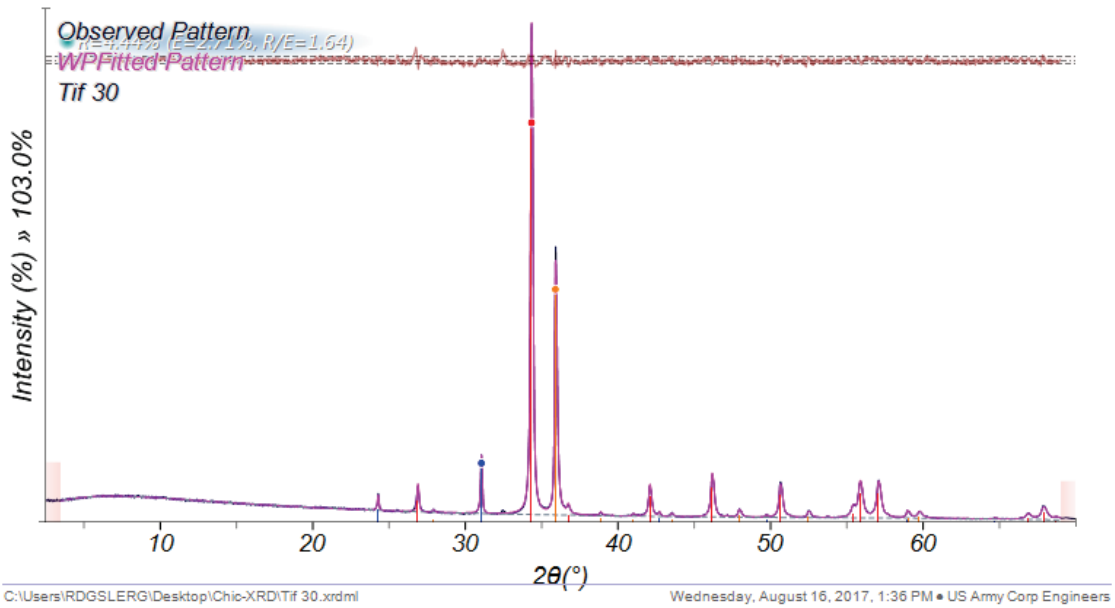
Phase ID (4)	Chemical Formula	PDF-#	NP	Wt% (esd)	RIR
Calcite	CaCO3	01-072-1214	11	59.1 (0.1)	3.20
Dolomite	CaMg(CO3)2	01-089-5862	11	36.0 (0.1)	2.78
Quartz	SiO2	01-085-0794	4	4.9 (0.0)	3.11
Cristobalite	SiO2	98-001-0969	3	0.0 (0.0)	2.44

XRF(Wt%): CaO=44.1%, SiO2=4.9%, MgO=7.9%, CO2=43.2%

Refinement Converged (R/E=1.64), ♣ Round=4, Iter=4, P=29, R=4.44% (E=2.71%, EPS=0.5)







C:\Users\RDGSLERG\Desktop\Chic-XRD\Tif 30.xrdml Wednesday, August 16, 2017, 1:36 PM • US Army Corp Engineers

WPF Report

Scan ID: Tif 50.xrdml

Scan Parameters: 2.511°/69.99°/0.01671°/219.71(s), ω=1.255678°/34.99573°, φ=0.0°, I(p)=41247/264, Co(45kV,40mA), Saturday,

☑ Zero Offset = -0.2215 (0.0619) ☑ Displacement = 0.2279 (0.0588) ☐ Beam Spill-Off below 0.0°
☑ Kα2 Peaks Present ☐ Kα2/Kα1 Ratio = 0.5 ☐ X-Ray Polarization = 1.0

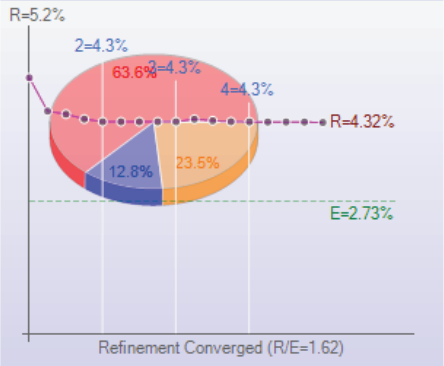
Geometry: Diffractometer Lp Fitted-Range: 3.5 - 69.0° BG-Model: Polynomial (7) λ: 1.78899 Å (Co)

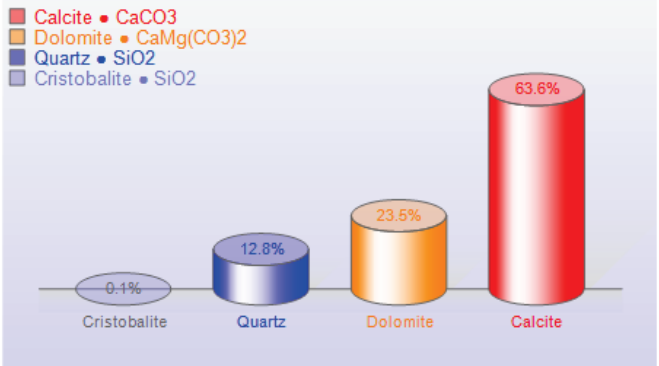
PSF: pseudo-Voigt Broadening: Individual FWHM Curve Instrument: Constant FWHM = 0.1°

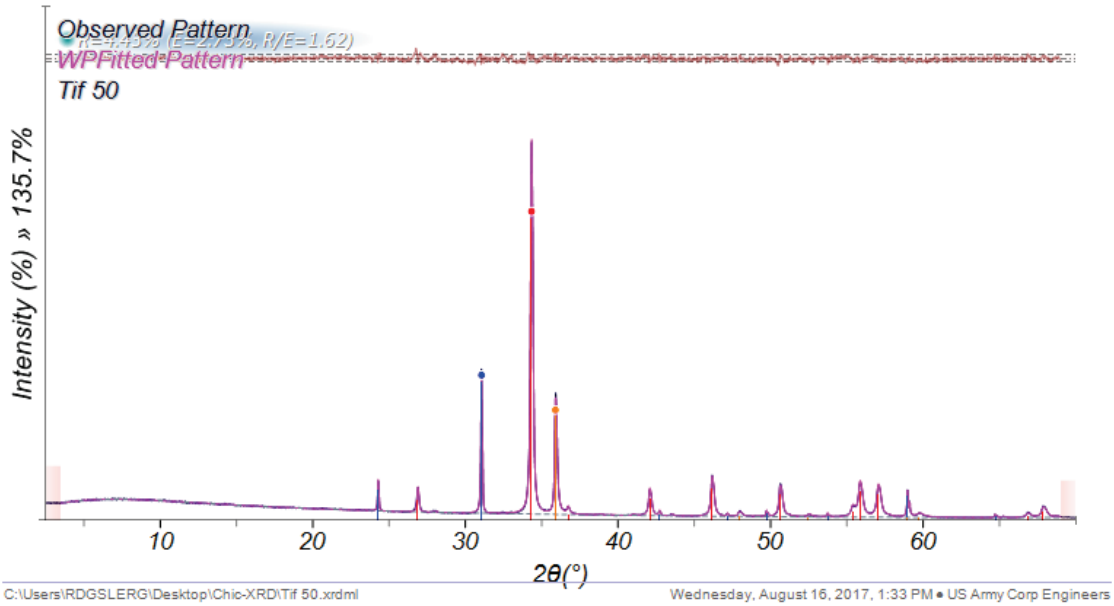
Phase ID (4)	Chemical Formula	PDF-#	NP	Wt% (esd)	RIR
Calcite	CaCO3	01-072-1214	11	63.6 (0.2)	3.20
Quartz	SiO2	01-085-0794	11	12.8 (0.1)	3.11
Dolomite	CaMg(CO3)2	01-089-5862	11	23.5 (0.1)	2.78
Cristobalite	SiO2	98-001-0969	3	0.1 (0.0)	2.43

XRF(Wt%): CaO=42.8%, SiO2=12.9%, MgO=5.1%, CO2=39.2%

Refinement Converged (R/E=1.62), ♣ Round=4, Iter=3, P=34, R=4.43% (E=2.73%, EPS=0.5)







C:\Users\RDGSLERG\Desktop\Chic-XRD\Tif 50.xrdml Wednesday, August 16, 2017, 1:33 PM • US Army Corp Engineers

WPF Report

Scan ID: Tif 100.xrdml

Scan Parameters: 2.511°/69.99°/0.01671°/219.71(s), ω=1.255678°/34.99573°, φ=0.0°, I(p)=28175/281, Co(45kV,40mA), Saturday,

☑ Zero Offset = -0.248 (0.0092) ☑ Displacement = 0.25 (0.0093) ☐ Beam Spill-Off below 0.0°

☑ Kα2 Peaks Present ☐ Kα2/Kα1 Ratio = 0.5 ☐ X-Ray Polarization = 1.0

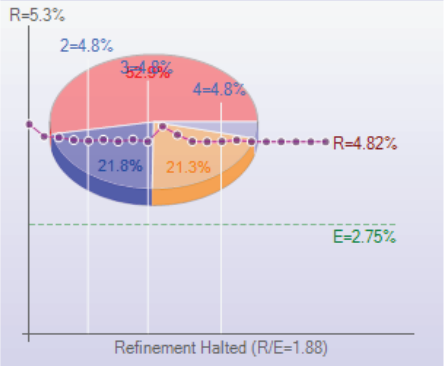
Geometry: Diffractometer Lp Fitted-Range: 3.5 - 69.0° BG-Model: Polynomial (7) λ: 1.78899 Å (Co)

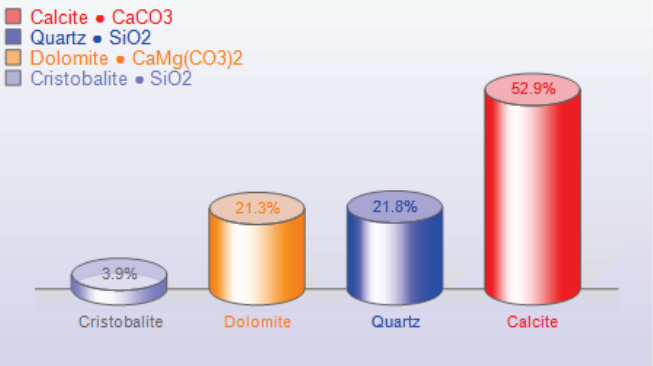
PSF: pseudo-Voigt Broadening: Individual FWHM Curve Instrument: Constant FWHM = 0.1°

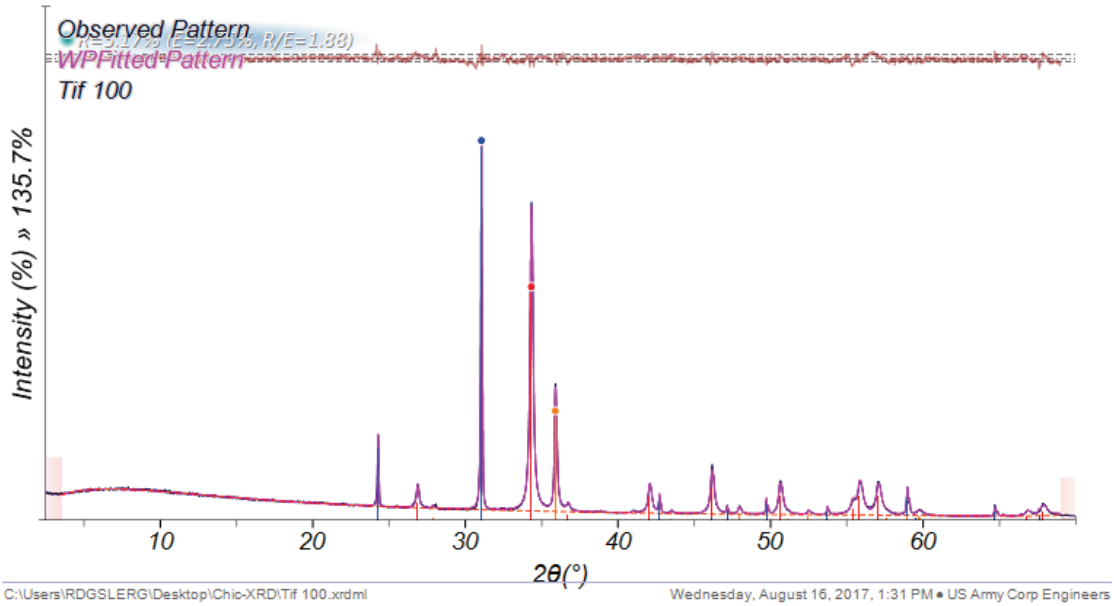
Phase ID (4)	Chemical Formula	PDF-#	NP	Wt% (esd)	RIR
Calcite	CaCO3	01-072-1214	11	52.9 (0.2)	3.20
Quartz	SiO2	01-085-0794	9	21.8 (0.1)	3.11
Dolomite	CaMg(CO3)2	01-089-5862	6	21.3 (0.1)	2.78
Cristobalite	SiO2	98-001-0969	4	3.9 (0.4)	14.76

XRF(Wt%): CaO=36.1%, SiO2=25.8%, MgO=4.7%, CO2=33.5%

Refinement Halted (R/E=1.88), ♣ Round=4, Iter=6, P=32, R=5.17% (E=2.75%, EPS=0.5)







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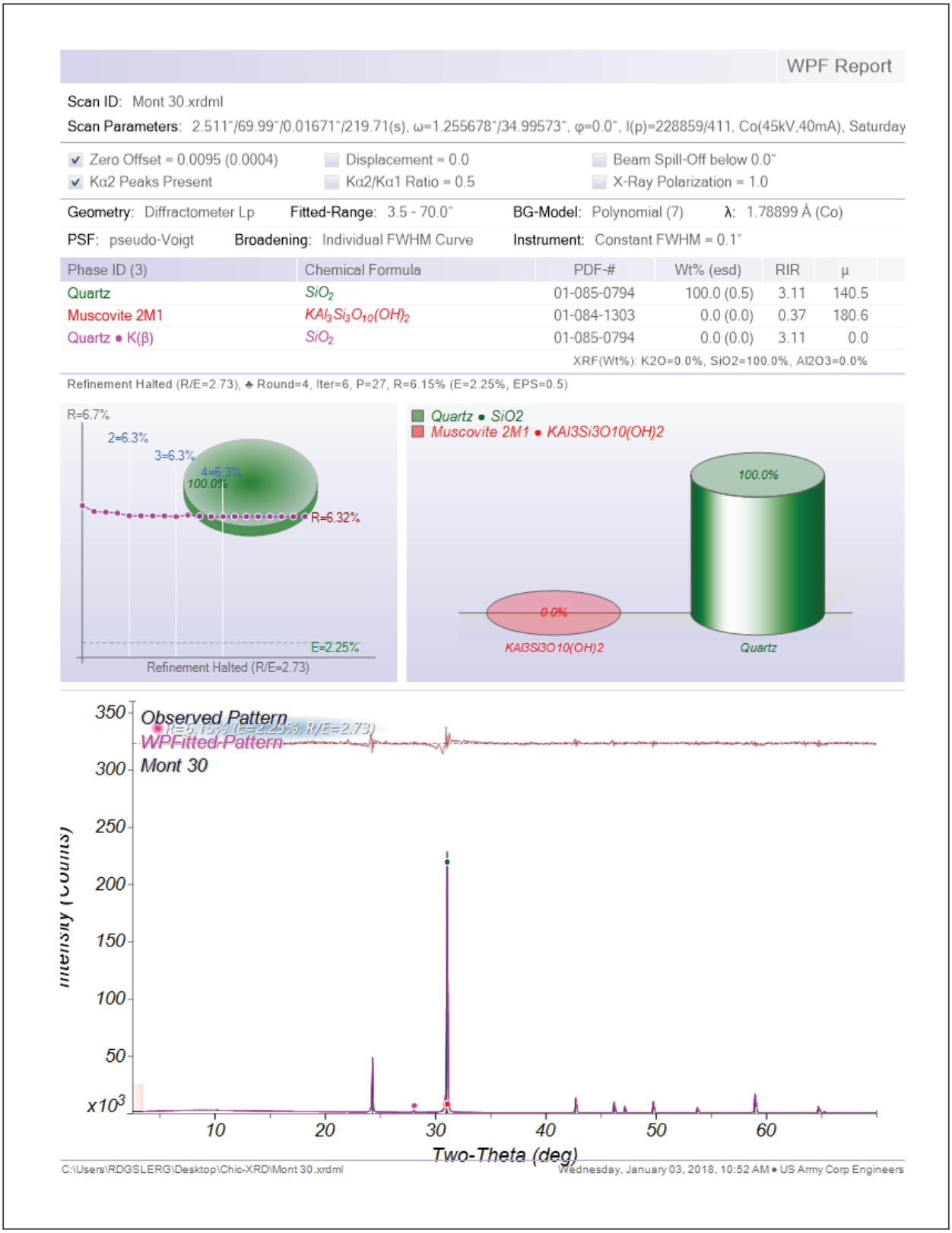
B.2 Monteagle sand



WPF Report

Scan ID: Mont 50.xrdml

Scan Parameters: 2.511°/69.99°/0.01671°/219.71(s), ω=1.255678°/34.99573°, φ=0.0°, I(p)=229099/339, Co(45kV,40mA), Saturday

☑ Zero Offset = 0.0189 (0.0003) ☐ Displacement = 0.0 ☐ Beam Spill-Off below 0.0°
☑ Kα2 Peaks Present ☐ Kα2/Kα1 Ratio = 0.5 ☐ X-Ray Polarization = 1.0

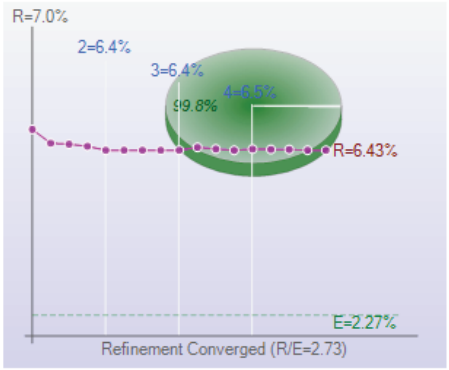
Geometry: Diffractometer Lp Fitted-Range: 3.5 - 70.0° BG-Model: Polynomial (7) λ: 1.78899 Å (Co)

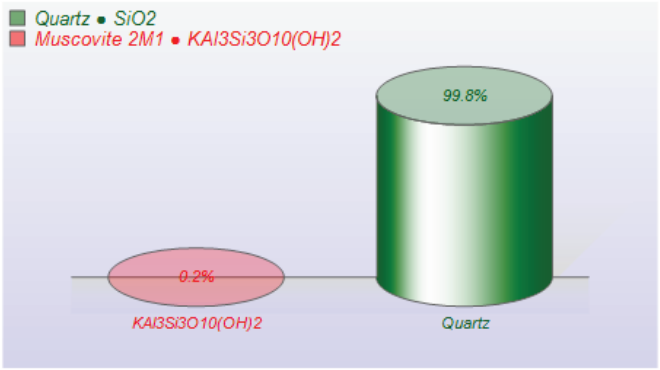
PSF: pseudo-Voigt Broadening: Individual FWHM Curve Instrument: Constant FWHM = 0.1°

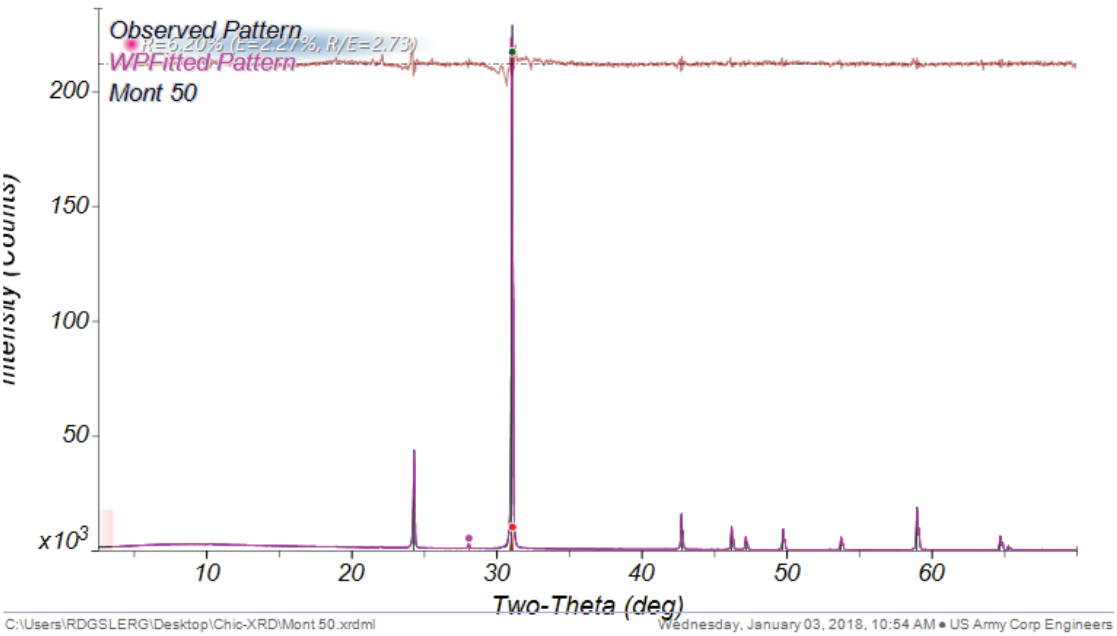
Phase ID (3)	Chemical Formula	PDF-#	Wt% (esd)	RIR	μ
Quartz	SiO_2	01-085-0794	99.8 (0.6)	3.11	140.5
Muscovite 2M1	$KAl_3Si_3O_{10}(OH)_2$	01-084-1303	0.2 (0.0)	0.37	180.6
Quartz • K(β)	SiO_2	01-085-0794	0.0 (0.0)	3.11	0.0

XRF(Wt%): K2O=0.0%, SiO2=99.9%, Al2O3=0.1%

Refinement Converged (R/E=2.73), ♣ Round=4, Iter=3, P=27, R=6.2% (E=2.27%, EPS=0.5)







C:\Users\RDGSLERG\Desktop\Chic-XRD\Mont 50.xrdml Wednesday, January 03, 2018, 10:54 AM • US Army Corp Engineers

WPF Report

Scan ID: Mont 100.xrdml

Scan Parameters: 2.511°/69.99°/0.01671°/219.71(s), ω=1.255678°/34.99573°, φ=0.0°, I(p)=212429/351, Co(45kV,40mA), Saturday

☑ Zero Offset = -0.0006 (0.0004) ☐ Displacement = 0.0 ☐ Beam Spill-Off below 0.0°
☑ Kα2 Peaks Present ☐ Kα2/Kα1 Ratio = 0.5 ☐ X-Ray Polarization = 1.0

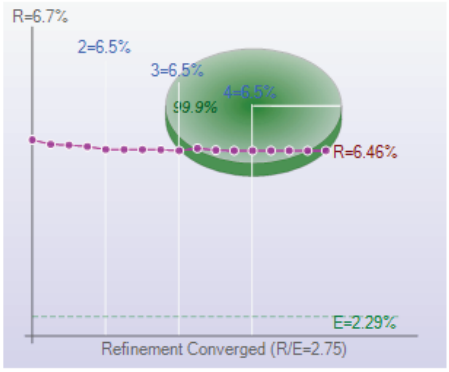
Geometry: Diffractometer Lp Fitted-Range: 3.5 - 70.0° BG-Model: Polynomial (7) λ: 1.78899 Å (Co)

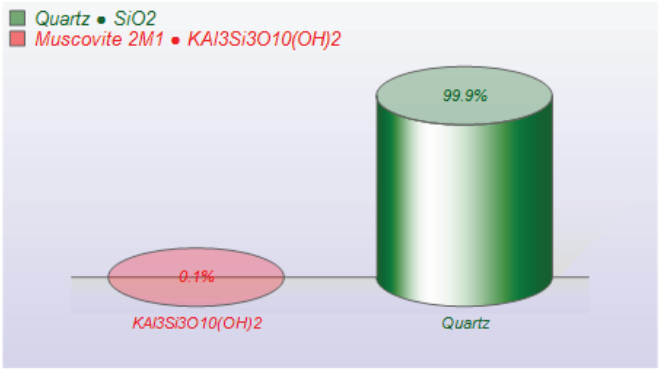
PSF: pseudo-Voigt Broadening: Individual FWHM Curve Instrument: Constant FWHM = 0.1°

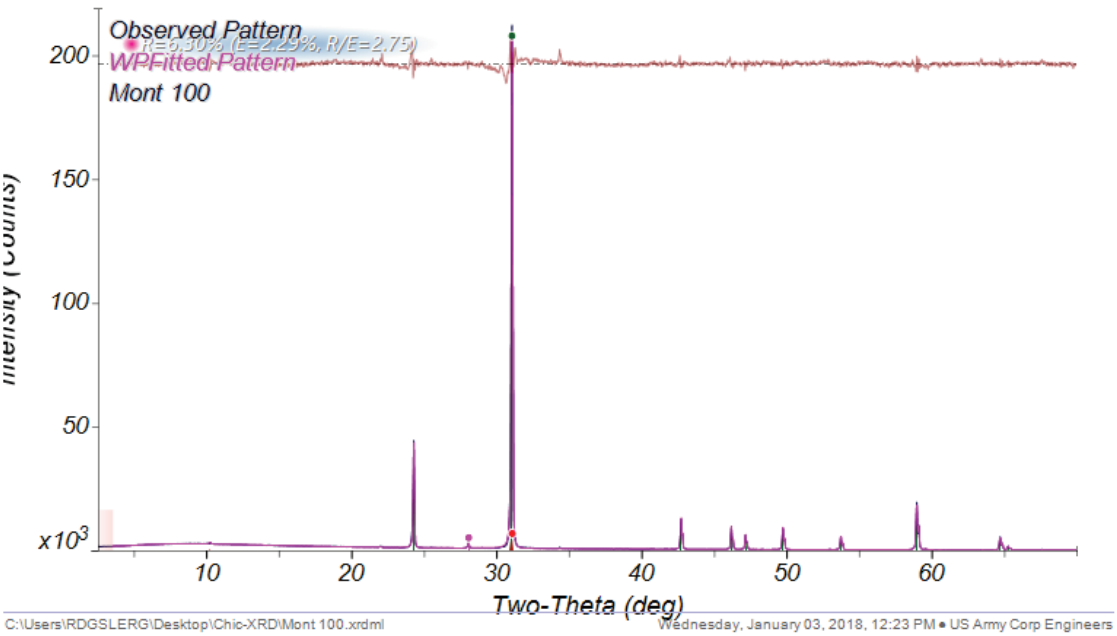
Phase ID (3)	Chemical Formula	PDF-#	Wt% (esd)	RIR	μ
Quartz	SiO_2	01-085-0794	99.9 (0.5)	3.11	140.5
Muscovite 2M1	$KAl_3Si_3O_{10}(OH)_2$	01-084-1303	0.1 (0.0)	0.37	180.6
Quartz • K(β)	SiO_2	01-085-0794	0.0 (0.0)	3.11	0.0

XRF(Wt%): K2O=0.0%, SiO2=99.9%, Al2O3=0.1%

Refinement Converged (R/E=2.75), ♣ Round=4, Iter=3, P=27, R=6.3% (E=2.29%, EPS=0.5)







C:\Users\RDGSLERG\Desktop\Chic-XRD\Mont 100.xrdml Wednesday, January 03, 2018, 12:23 PM • US Army Corp Engineers

B.3 Sequatchie sand

WPF Report

Scan ID: Sq 30.xrdml

Scan Parameters: 2.511°/69.99°/0.01671°/219.71(s), ω=1.255678°/34.99573°, φ=0.0°, I(p)=197552/519, Co(45kV,40mA), Friday, J

☑ Zero Offset = 0.0078 (0.0005) ☐ Displacement = 0.0 ☐ Beam Spill-Off below 0.0°
☑ Kα2 Peaks Present ☐ Kα2/Kα1 Ratio = 0.5 ☐ X-Ray Polarization = 1.0

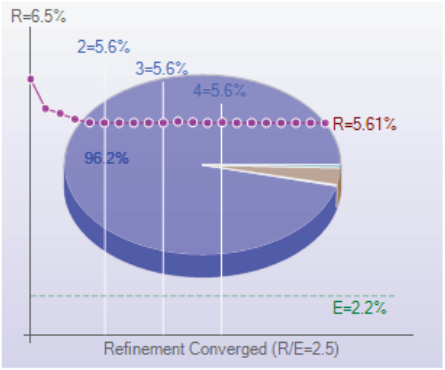
Geometry: Diffractometer Lp Fitted-Range: 2.5 - 70.0° BG-Model: Polynomial (7) λ: 1.78899 Å (Co)

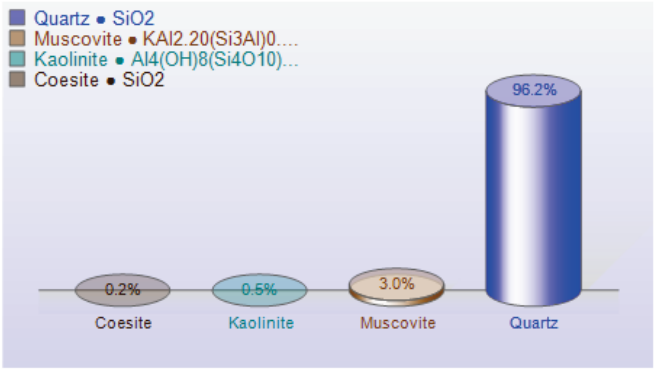
PSF: pseudo-Voigt Broadening: Individual FWHM Curve Instrument: Constant FWHM = 0.1°

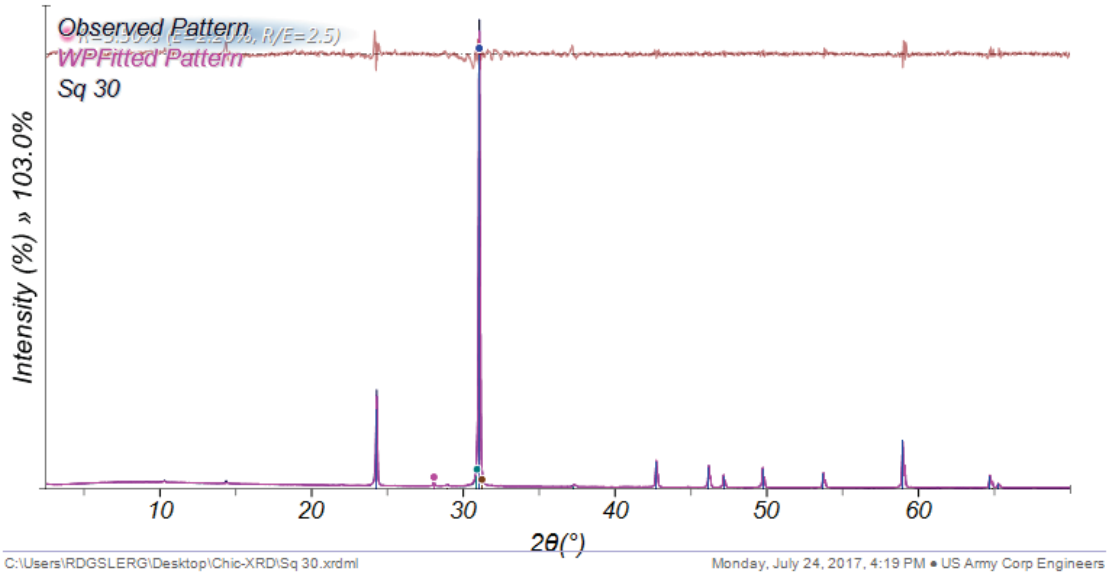
Phase ID (5)	Chemical Formula	PDF-#	NP	Wt% (esd)	RIR
Quartz	SiO2	01-075-0443	9	96.2 (0.5)	3.04
Coesite	SiO2	98-001-0554	3	0.2 (0.1)	1.56
Muscovite	KAl2.20(Si3Al)0.975O10((OH)1.72O(	01-089-5401	6	3.0 (0.1)	0.43
Kaolinite	Al4(OH)8(Si4O10)	01-078-2109	6	0.5 (0.0)	0.82
Quartz • K(β)	SiO2	01-075-0443	*18	0.0 (0.0)	3.04

XRF(Wt%): K2O=0.4%, SiO2=98.0%, Al2O3=1.4%

Refinement Converged (R/E=2.5), ♣ Round=4, Iter=6, P=39, R=5.5% (E=2.20%, EPS=0.5)







C:\Users\RDGSLERG\Desktop\Chic-XRD\Sq 30.xrdml Monday, July 24, 2017, 4:19 PM • US Army Corp Engineers

WPF Report

Scan ID: Sq 50.xrdml

Scan Parameters: 2.511°/69.99°/0.01671°/219.71(s), ω=1.255678°/34.99573°, φ=0.0°, I(p)=216944/361, Co(45kV,40mA), Friday, J

☑ Zero Offset = 0.0111 (0.0005) ☐ Displacement = 0.0 ☐ Beam Spill-Off below 0.0°

☑ Kα2 Peaks Present ☐ Kα2/Kα1 Ratio = 0.5 ☐ X-Ray Polarization = 1.0

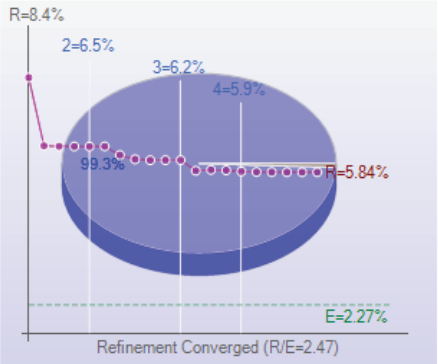
Geometry: Diffractometer Lp Fitted-Range: 2.5 - 70.0° BG-Model: Polynomial (7) λ: 1.78899 Å (Co)

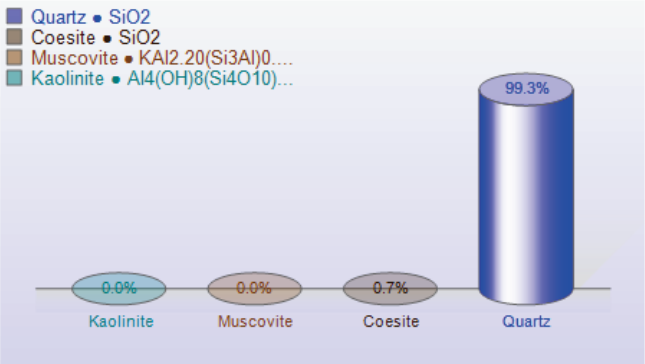
PSF: pseudo-Voigt Broadening: Individual FWHM Curve Instrument: Constant FWHM = 0.1°

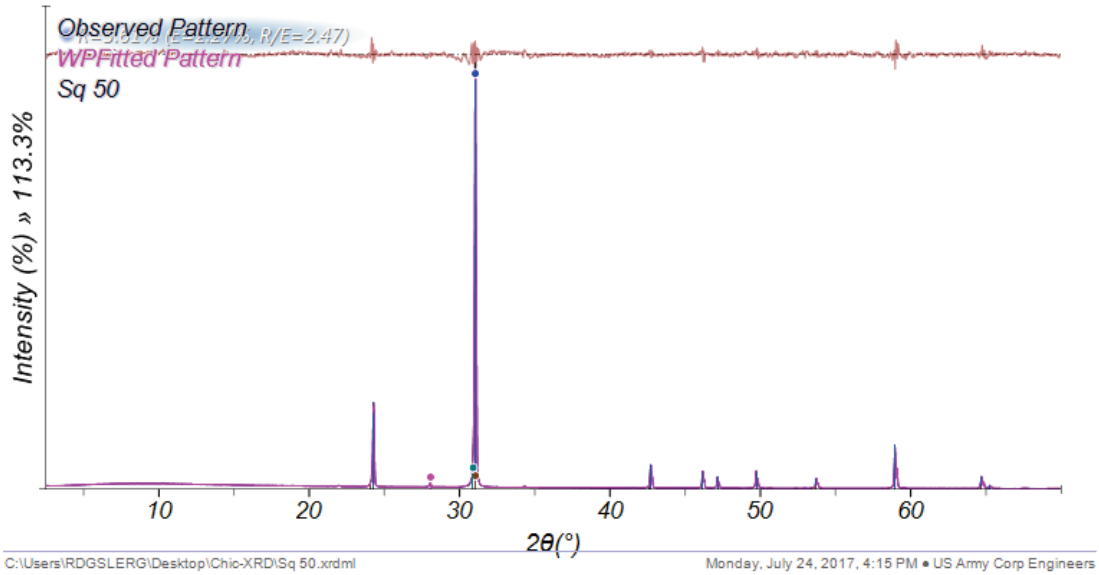
Phase ID (5)	Chemical Formula	PDF-#	NP	Wt% (esd)	RIR
Quartz	SiO2	01-075-0443	9	99.3 (0.6)	3.04
Muscovite	KAl2.20(Si3Al)0.975O10((OH)1.72O(	01-089-5401	6	0.0 (0.0)	0.43
Kaolinite	Al4(OH)8(Si4O10)	01-078-2109	6	0.0 (0.0)	0.82
Coesite	SiO2	98-001-0554	3	0.7 (0.0)	1.56
Quartz • K(β)	SiO2	01-075-0443	*18	0.0 (0.0)	3.04

XRF(Wt%): K2O=0.0%, SiO2=100.0%, Al2O3=0.0%

Refinement Converged (R/E=2.47), ♣ Round=4, Iter=4, P=40, R=5.61% (E=2.27%, EPS=0.5)







C:\Users\RDGSLERG\Desktop\Chic-XRD\Sq 50.xrdml Monday, July 24, 2017, 4:15 PM • US Army Corp Engineers

WPF Report

Scan ID: Sq 100.xrdml

Scan Parameters: 2.511°/69.99°/0.01671°/219.71(s), ω=1.255678°/34.99573°, φ=0.0°, I(p)=208513/364, Co(45kV,40mA), Friday, J

☑ Zero Offset = 0.0094 (0.0004) ☐ Displacement = 0.0 ☐ Beam Spill-Off below 0.0°

☑ Kα2 Peaks Present ☐ Kα2/Kα1 Ratio = 0.5 ☐ X-Ray Polarization = 1.0

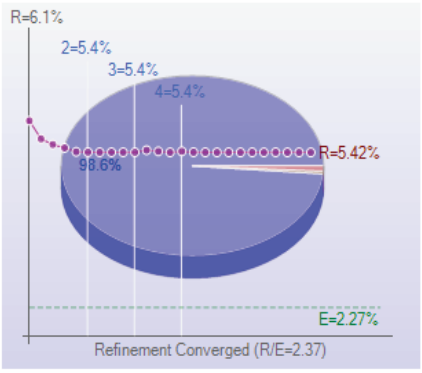
Geometry: Diffractometer Lp Fitted-Range: 2.5 - 70.0° BG-Model: Polynomial (7) λ: 1.78899 Å (Co)

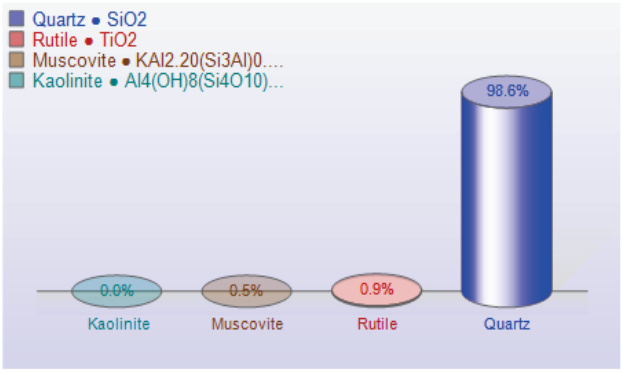
PSF: pseudo-Voigt Broadening: Individual FWHM Curve Instrument: Constant FWHM = 0.1°

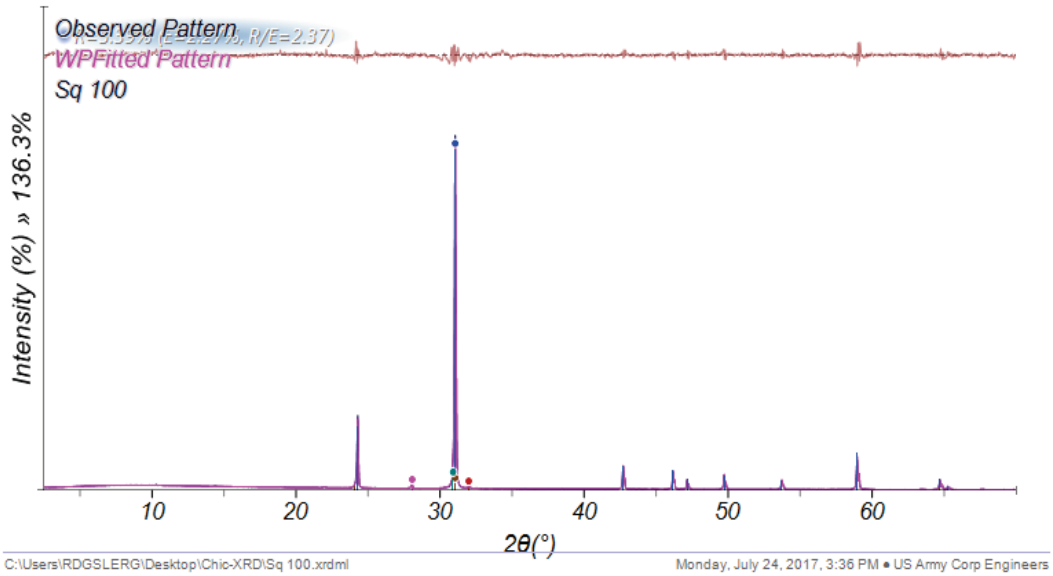
Phase ID (5)	Chemical Formula	PDF-#	NP	Wt% (esd)	RIR
Quartz	SiO2	01-075-0443	9	98.6 (0.5)	3.04
Muscovite	KAl2.20(Si3Al)0.975O10((OH)1.72O(	01-089-5401	3	0.5 (0.0)	0.43
Kaolinite	Al4(OH)8(Si4O10)	01-078-2109	3	0.0 (0.0)	0.82
Rutile	TiO2	01-073-2224	3	0.9 (0.0)	3.60
Quartz • K(β)	SiO2	01-075-0443	*18	0.0 (0.0)	3.04

XRF(Wt%): TiO2=0.9%, K2O=0.1%, SiO2=98.8%, Al2O3=0.2%

Refinement Converged (R/E=2.37), ♣ Round=4, Iter=3, P=35, R=5.39% (E=2.27%, EPS=0.5)







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Appendix C: Cementitious Material Reports

C.1 Cement reports in accordance to ASTM C150

Figure C1. Lafarge Portland Cement Type I/II Joppa Plant, IL.

US Army Corps of Engineers BUILDING STRONG®

Report on Test Specification: ASTM C150, Standard Specification for Portland Cement

Performing Organization:	Sponsoring Organization:
US Army Engineer Research and Development Center Geotechnical and Structures Laboratory (CEERD-GMC) 3909 Halls Ferry Road Vicksburg, MS 39280-6199	US Army Corps of Engineers Nashville District 110 9th Ave South, Nashville, TN 37203

Material Description: Portland Cement, Type II (MH)
Manufacturer: Lafarge
Location: Joppa Plant, IL
CMB Serial Number: 170023
Project: Chickamauga L&D

Chemical Analysis	Test Results	Spec. Limits: Type II
SiO_2, %	21.24	-
Al_2O_3, %	2.64	6.0% max
Fe_2O_3, %	4.3	6.0% max
CaO, %	64.97	-
MgO, %	2.4	6.0%, max
SO_3, %	2.79	3.0%, max
Na_2O, %	0.06	-
K_2O, %	0.17	-
Equivalent Alkalies (as Na_2O), %	0.17	0.6%, max
TiO_2, %	0.18	-
P_2O_5, %	0.11	-
Loss on Ignition, %	0.91	3.0% max
Physical Analysis	**Test Results**	**Spec. Limits: Type II**
Heat of Hydration, 7-day, max, kJ/kg; ASTM C1702	180.42	290 kJ/kg, max
Heat of Hydration, 28-day, max, kJ/kg; ASTM C1702	219.77	-
Surface Area, m^2/kg (air permeability); ASTM C204	299	260 m^2/kg, min
Autoclave Expansion, %; ASTM C151	-0.02	0.80%, max
Initial Set, min. (Vicat); ASTM C191	255	45, min
Final Set, min. (Vicat); ASTM C191	310	375, max
Air Content, %; ASTM C185	4.4	12%, max
Compressive Strength, 3-day, psi; ASTM C109	2070	1740 psi, min
Compressive Strength, 7-day, psi; ASTM C109	2390	2760 psi, min
Compressive Strength, 28-day, psi; ASTM C109	4360	4060 psi, min
False Set (final penetration), %; ASTM C451	79	50%, min

Remarks:
Test sample meets all ASTM C150 required limits

Tested by: SLC
Reviewed by: MAR

Information in this report shall not be used in advertising or sales promotion to indicate endorsement of this product by the U.S. Government.

Figure C2. Buzzi Unicem Type I/II Signal Mountain Plant, TN.

US Army Corps of Engineers
BUILDING STRONG®

Report on Test Specification: ASTM C150, Standard Specification for Portland Cement

Performing Organization:	Sponsoring Organization:
US Army Engineer Research and Development Center Geotechnical and Structures Laboratory (CEERD-GMC) 3909 Halls Ferry Road Vicksburg, MS 39280-6199	US Army Corps of Engineers Nashville District 110 9th Ave South, Nashville, TN 37203

Material Description: Type i-II Low Alkali Cement
Manufacturer: Buzzi Unicem
Location: Signal Mountain Plant, Chattanooga, TN
CMB Serial Number: 170019
Project: Chickamauga

Chemical Analysis	Test Results	Spec. Limits: Type II
SiO_2, %	19.77	-
Al_2O_3, %	4.43	6.0% max
Fe_2O_3, %	3.57	6.0% max
CaO, %	62.91	-
MgO, %	3.12	6.0%, max
SO_3, %	2.61	3.0%, max
Na_2O, %	0.11	-
K_2O, %	0.63	-
Equivalent Alkalies (as Na_2O), %	0.52	0.6%, max
TiO_2, %	0.28	-
P_2O_5, %	0.06	-
Loss on Ignition, %	2.04	3.0% max
Physical Analysis	**Test Results**	**Spec. Limits: Type II**
Heat of Hydration, 7-day, max, kJ/kg; ASTM C1702	218.5	290 kJ/kg, max
Heat of Hydration, 28-day, max, kJ/kg; ASTM C1702	249.3	-
Surface Area, m^2/kg (air permeability); ASTM C204	344	260 m^2/kg, min
Autoclave Expansion, %; ASTM C151	0.03	0.80%, max
Initial Set, min. (Vicat); ASTM C191	125	45, min
Final Set, min. (Vicat); ASTM C191	265	375, max
Air Content, %; ASTM C185	7	12%, max
Compressive Strength, 3-day, psi; ASTM C109	3430	1740 psi, min
Compressive Strength, 7-day, psi; ASTM C109	4380	2760 psi, min
Compressive Strength, 28-day, psi; ASTM C109	6070	4060 psi, min
False Set (final penetration), %; ASTM C451	67	50%, min

Remarks:

Test sample meets all ASTM C150 required limits

Tested by: SLC
Reviewed by: MAR

Information in this report shall not be used in advertising or sales promotion to indicate endorsement of this product by the U.S. Government.

C.2 Fly ash report in accordance to ASTM C618

Figure C3. SEFA (TVA) Class F Fly Ash from Cumberland City, TN.

US Army Corps of Engineers BUILDING STRONG.

Report on Test Specification: ASTM C618, Standard Specification for Coal Fly Ash

Performing Organization:	Sponsoring Organization:
US Army Engineer Research and Development Center Geotechnical and Structures Laboratory (CEERD-GMC) 3909 Halls Ferry Road Vicksburg, MS 39280-6199	US Army Corps of Engineers Nashville District 110 9th Ave South, Nashville, TN 37203

Material Description: Class F Fly Ash
Manufacturer: SEFA (TVA) Group
Location: Cumberland City, TN
CMB Serial Number: 170020
Project: Chickamauga L&D

Chemical Analysis	Test Results	Spec. Limits: Class F
SiO_2, %	45.92	-
Al_2O_3, %	18.78	-
Fe_2O_3, %	18.45	-
Sum, %	83.15	70.0%, max
Na_2O, %	0.62	-
K_2O, %	2.32	-
CaO, %	6.25	-
MgO, %	1.91	-
SO_3, %	3.1	5.0%, max
Loss on Ignition, %	1.23	6.0%, max
Moisture Content, %	0.11	3.0%, max
Total Alkalies (as Na2O equivalent), %	2.15	1.5%, max
Physical Analysis	**Test Results**	**Spec. Limits: Class F**
Initial Test	-	
Compressive Strength, 7-day, reference, psi; ASTM C311	4380	-
Compressive Strength, 28-day, reference, psi; ASTM C311	6070	-
Compressive Strength, 7-day, fly ash/cement, psi; ASTM C311	3780	-
Compressive Strength, 28-day, fly ash/cement, psi; ASTM C311	5290	-
Strength Activity Index, 7-day, %; ASTM C311	87	75%, min
Strength Activity Index, 28-day, %; ASTM C311	87	75%, min
Second Test	-	
Compressive Strength, 7-day, reference, psi; ASTM C311		-
Compressive Strength, 28-day, reference, psi; ASTM C311		-
Compressive Strength, 7-day, fly ash/cement, psi; ASTM C311		-
Compressive Strength, 28-day, fly ash/cement, psi; ASTM C311		-
Strength Activity Index, 7-day, %; ASTM C311		75%, min
Strength Activity Index, 28-day, %; ASTM C311		75%, min
Water Requirement, % control; ASTM C311, C109	95	105%, max
Specific Gravity; ASTM C188	2.67	5%, max
Autoclave Soundness, %;	0.02	0.8%, max
Fineness, % retained on #325 sieve; ASTM C311	22.2	34%, max
Fineness (re-test), % retained on #325 sieve; ASTM C311		34%, max
Supplementary Optional Physical Analysis	**Test Results**	**Limits: Class F**
Increase of Drying Shrinkage of Mortar Bars at 28 Days; ASTM C618	0.06	-
Uniformity Requirement, amount of Vinsol; ASTM C618	0.15 g	-
Effectiveness in Controlling ASR at 14 days; ASTM C 618	67 %	-

Remarks:

Buzzi Type I/II project cement used for reference cement
Test results indicate this sample complies with ASTM C618 specifications for Class F Pozzolan.

Tested by: SLC
Reviewed by: MAR

Information in this report shall not be used in advertising or sales promotion to indicate endorsement of this product by the U.S. Government.

C.3 Silica Fume report in accordance to ASTM C1240

Figure C4. Elkem Materials Silica Fume from Pittsburgh, PA.

US Army Corps of Engineers BUILDING STRONG.

Report on Test Specification: ASTM C1240, Silica Fume Used in Cementitious Materials

Performing Organization:	Sponsoring Organization:
US Army Engineer Research and Development Center Geotechnical and Structures Laboratory (CEERD-GMC) 3909 Halls Ferry Road Vicksburg, MS 39280-6199	US Army Corps of Engineers Nashville District 110 9th Ave South, Nashville, TN 37203

Material Description: Silica Fume, Microsilica Grade 965U
Manufacturer: Elkem Materials Inc.
Location: Pittsburgh, PA
CMB Serial Number: 170022
Project: Chickamauga L&D

Chemical Analysis	Test Results	Spec. Limits
SiO_2, %	96.9	85%, max
Al_2O_3, %	0.06	-
Fe_2O_3, %	0.05	-
Sum, %	97.01	-
Na_2O, %	0.02	-
K_2O, %	0.86	-
MgO, %	0.36	-
SO_3, %	0.15	-
Loss on Ignition, %	1.2	6%, max
Moisture Content, %	0.5	3%, max
Physical Analysis	**Test Results**	**Spec. Limits**
Compressive Strength, 7-day, reference, psi; ASTM C311	4490	-
Compressive Strength, 7-day, test, psi; ASTM C311	7280	-
Strength Activity Index, 7-day, %; ASTM C311	162	105%, min
Water Requirement; ASTM C311, C109	*	100-115%
Specific Gravity; ASTM C188	2.32	-
Supplimentary Optional Physical Tests	**Test Results**	**Spec. Limits**
Uniformity Requirement, amount of Vinsol; ASTM C618	0.04 g	-
Effectiveness in Controlling ASR at 14 days; ASTM C618, C311, C441	95 %	80%, min

Remarks:

Buzzi Type I/II project cement used for reference cement
*Following the standard ASTM C1240 method, 2 mL of HRWRA required with test mixture to produce flow limits using 242 mL of water
Test sample meets all ASTM C150 required limits

Tested by: SLC
Reviewed by: MAR

Information in this report shall not be used in advertising or sales promotion to indicate endorsement of this product by the U.S. Government.

C.4 Slag cement report in accordance to ASTM C989

Figure C5. Lafarge South Chicago Plant, IL Slag Cement.

US Army Corps of Engineers
BUILDING STRONG®

Report on Test Specification: ASTM C989, Standard Specification for Slag Cement

Performing Organization:	Sponsoring Organization:
US Army Engineer Research and Development Center	US Army Corps of Engineers
Geotechnical and Structures Laboratory (CEERD-GMC)	Nashville District
3909 Halls Ferry Road Vicksburg, MS 39280-6199	110 9th Ave South, Nashville, TN 37203

Material Description: Ground Granulated Blast-Furnace Slag (GGBFS) Grade 100
Manufacturer: Lafarge
Location: South Chicago Plant, IL
CMB Serial Number: 170021
Project: Chickamauga L&D

Chemical Analysis	Test Results	Spec. Limits: Class F
Sulfide Sulfur (as S), %	0.9	2.5%, max
Sulfate Sulfur (as SO_3), %	1.28	4%, max
Aluminum Oxide (as Al_2O_3), %	10.15	-
Chloride Content of Slag, %	0.05	-
Na_2O, %	0.27	-
K_2O, %	0.49	-
Equivalent Alkalies (total as Na_2O), %	0.59	-
Physical Analysis	**Test Results**	**Spec. Limits: Class F**
Compressive Strength, 7-day, reference, psi; ASTM C311	4380	-
Compressive Strength, 28-day, reference, psi; ASTM C311	6070	-
Compressive Strength, 7-day, slag/cement, psi; ASTM C311	3350	-
Compressive Strength, 28-day, slag/cement, psi; ASTM C311	6050	-
Strength Activity Index, 7-day, %; ASTM C311	82	70%, min
Strength Activity Index, 28-day, %; ASTM C311	99	90%, min
Surface Area, m^2/kg (air permeability); ASTM C204	480	260 m^2/kg, min
Specific Gravity; ASTM C188	3.19	-
Fineness, % retained on #325 sieve; ASTM C311	0.5	20%, max
Air Content, %; ASTM C185	5.7	12%, max

Remarks:

Buzzi Type I/II project cement used for reference cement
Test results indicate this sample complies with ASTM C989 specifications for slag cement grade

Tested by: SLC
Reviewed by: MAR

Information in this report shall not be used in advertising or sales promotion to indicate endorsement of this product by the U.S. Government.

C.5 Limestone report in accordance to ASTM C1271 and D242

GRAIN SIZE DISTRIBUTION TEST DATA 2/13/2017

Project: Chickamauga Lock and Dam
Nashville District
Location: Limestone Powder #170024
Depth: N/A **Sample Number:** 1
Material Description: Silt (ML), Gray
PL: NP **LL:** NV
PI: NP
Tested by: AT **Checked by:** TRJ

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
128.21	0.00	0.00	#10	0.00	100.0
			#16	0.00	100.0
			#30	0.00	100.0
			#50	0.00	100.0
			#200	0.07	99.9

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1			99.9

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}

Fineness Modulus
0.00

CEERD-GEGB

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS

ASTM D 4318

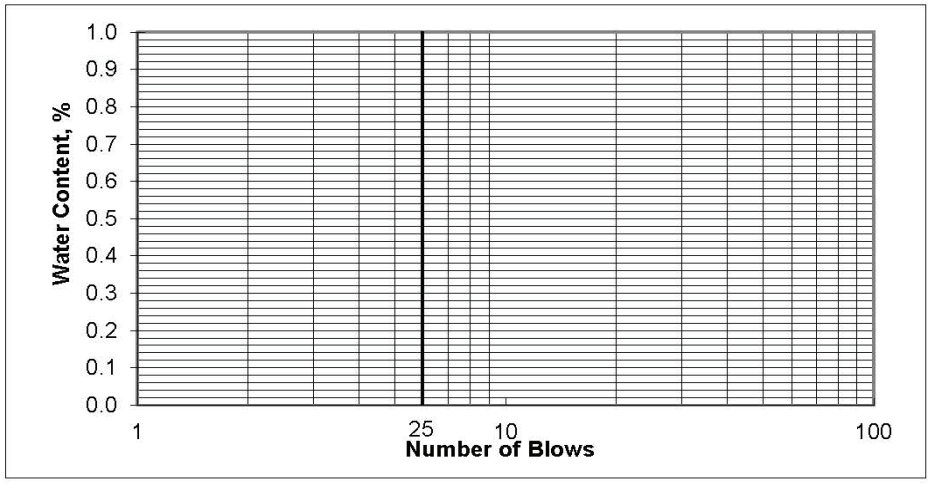
WORK ORDER NO. DP1701 DATE 2/13/2017

PROJECT Chickamauga Lock and Dam, Nashville District

BORING NO. Limestone Powder #170024 SAMPLE NO. 1

LIQUID LIMIT

Run No.	1	2	3	4	5	6	7
Tare No.							
Tare Plus Wet Soil, g							
Tare Plus Dry Soil, g							
Water, g							
Tare, g							
Dry Soil, g							
Water content, %							
Number of Blows							



LL

PL

PI

Symbol from plasticity chart

ML

Plastic LIMIT

Run No.	1	2	3	4	5	6	7
Tare No.							
Tare Plus Wet Soil, g							
Tare Plus Dry Soil, g							
Water, g							
Tare, g							
Dry Soil, g							
Water content, %							
Plastic Limit							

Remarks Non-Plastic Silt (ML), Gray

Technician AT Computed By AT Checked By TRJ

Revised 5/21/09

Unit Conversion Factors

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
cubic yards	0.7645549	cubic meters
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
feet	0.3048	meters
gallons (U.S. liquid)	3.785412 E-03	cubic meters
inches	0.0254	meters
ounces (mass)	0.02834952	kilograms
pounds (mass)	0.45359237	kilograms
yards	0.9144	meters

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Monica A. Ramsey, Tyler R. Johnson, and Erin Rae Reed

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Project Chickamauga Lock and Dam Materials Testing, MIPR W38XDD62530725

14. ABSTRACT

In support of the U.S. Army Corps of Engineers (USACE) Nashville District, a preliminary investigation of concrete materials was conducted pursuant to re-construction at the Chickamauga Lock and Dam located near Chattanooga, TN. Local materials provided to the U.S. Army Engineer Research Development Center (ERDC) for testing included three different coarse aggregate gradations, two fine aggregate sources, two type I/II cements, a fly ash sources, a slag cement, a silica fume, and a limestone powder. Aggregate tests consisted of sieve analysis, specific gravity, absorption, materials finer than No. 200, organic impurities, soundness, LA abrasion, clay lumps and friable particles, flat and elongated particles, lightweight particles, petrography, and freezing and thawing. All cementitious and admixture materials were tested for chemical and physical properties based on appropriate specifications. This report presents the material characteristic results determined by laboratory testing in accordance with American Society for Testing Materials (ASTM) procedures or regulating specification criteria.

15. SUBJECT TERMS

Cementitious materials
Concrete rehabilitation
Aggregates (Building materials)
Testing--Concrete construction
Material testing
Heat of hydration
Admixtures
Chickamauga
Additives--Portland cement--Chickamauga Dam (Tenn.)
Hydraulic structures
Locks and dams
Alkali Aggregate Reaction (AAR)
Chattanooga, TN
Testing--Concrete

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