ERDC/GSL TR-19-37

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Mixture Proportioning and Characterization of Standard Grout Mixtures for Use at Fort Polk

Dylan A. Scott, Rudolph A. Andreatta, Wendy R. Long, Brian H. Green, Vincent P. Chiarito, Kirk E. Walker, Clifton P. Rusche, and Christopher N. Downey

July 2019

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Geotechnical and Structures Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

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Under Cooperative Research and Development Agreements C-13-GSL-06 and C-15-GSL-01

Abstract

The Engineer Research and Development Center, Geotechnical and Structures Lab (ERDC-GSL) has used Fort Polk as a large-scale testing site for many years. Many cementitious materials have been developed for design validation testing. These cementitious materials, their constituents, and their mechanical properties often went undocumented, making it difficult for researchers to replicate or draw comparison from previous testing. This report aims to begin a process of detailed cementitious material reports for all research efforts in the region.

The objective of this report is to document the development of a field castable 6 ksi sanded grout mixture and a 7 ksi sanded grout mixture used in experimental testing programs at Fort Polk in January 2014 and February 2015.

GSL required the development of a 6 ksi and 7 ksi mixture for testing scaled bridge columns. The reduced scaling of the test members resulted in very small rebar spacing. These designs lead to the development of very flowable specialized grouts.

This report details the development of this specialized grout for the purpose of aiding future cementitious mixture developments in the region. These results are applicable to efforts where reduced scaling reduces the spacing between scaled reinforcing where all aggregates in the concrete mix would not fit between reinforcing.

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Preface

This study was conducted for Headquarters, U.S. Army Corps of Engineers under two Cooperative Research and Development Agreements, C-13-GSL-06 and C-15-GSL-01. Vincent P. Chiarito acted as the customers' technical monitor for this study.

The work was performed by the Concrete and Materials Branch of the Engineering Systems and Materials Division (ESMD), U.S. Army Engineer Research and Development Center, Geotechnical and Structures Laboratory (ERDC-GSL). At the time of publication, Christopher M. Moore was Chief, Concrete and Materials Branch (CMB); Justin S. Strickler was Chief, ESMD; and Dr. Michael K. Sharp was the Technical Director for Civil Infrastructure. The Deputy Director of ERDC-GSL was Charles W. Ertle II, and the Director was Bartley P. Durst.

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

Unit Conversion Factors

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
cubic inches	1.6387064 E-05	cubic meters
cubic yards	0.7645549	cubic meters
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
feet	0.3048	meters
foot-pounds force	1.355818	joules
gallons (U.S. liquid)	3.785412 E-03	cubic meters
inches	0.0254	meters
ounces (U.S. fluid)	2.957353 E-05	cubic meters
pounds (force)	4.448222	newtons
pounds (force) per square foot	47.88026	pascals
pounds (force) per square inch	6.894757	kilopascals
pounds (mass)	0.45359237	kilograms
pounds (mass) per cubic foot	16.01846	kilograms per cubic meter
pounds (mass) per square foot	4.882428	kilograms per square meter
yards	0.9144	meters

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1 Introduction

1.1 Background

The Engineer Research and Development Center, Geotechnical and Structures Lab (ERDC-GSL) has used Fort Polk as a large-scale testing site for many years. Over the years, many cementitious materials have been developed for design validation testing that ranges from small arms fire to full scale blast effects. These cementitious materials, their constituents, and their mechanical properties often go undocumented, which makes it difficult for future researchers to replicate or draw comparison from previous testing programs. This report aims to begin a process of detailed cementitious material reports for all research efforts in the Fort Polk region.

In January 2014, Weidlinger Associates, Inc. (WAI*), partnered with the Geotechnical and Structures Laboratory under Cooperative Agreement C-13-GSL-06 for the testing of three variations of a recommended protection design for a specified bridge column against a simulated explosive threat. Each column was outfitted with armoring designs that upon validation was implemented as the final protective design measure. These tests were conducted on reduced-scale replicas of an actual bridge column.

Originally, the construction of the three scaled columns called for a scaled mixture proportion with a target strength of 6,000 psi at 28 days, and with a target elastic modulus to be determined by $E_c = w_c^{1.5} \times 33\sqrt{(f'_c)}$, where w_c is the density of concrete in pounds per cubic foot (pcf). The sieve analysis of the largest aggregate provided for the full-scale mixture had a nominal maximum aggregate size (NMSA) of ¾ inch. The geometry of the scaled column to be cast was approximately 3- by 5- by 21-ft column with a chamfered bottom edge. GSL personnel determined that these members would be best if cast horizontally using steel formwork. The top face of each member was to be left open during placement, and then the armoring design would be implemented prior to initial set. The steel forms for one of the scaled columns can be seen in Figure 1. These columns were designed with a tight reinforcement scheme that that can be seen in Figure 1 as well.

* Now known as Thornton, Tomasetti, Weidlinger Applied Science Practice.

Due to the tight reinforcement configuration seen in Figure 1, it was decided to not include any coarse aggregates in these concrete mixtures. The removal of the coarse aggregate would produce an elastic modulus lower than what would be predicted by the formula above. Therefore, the concrete needed was tested according to ASTM 469 to determine elastic modulus and Poisson's Ratio. This test was performed in addition to standard fresh and hardened property tests detailed in the fresh and hardened property section within this report.

Figure 1. The 6 ksi column geometry (left) and reinforcement (right).

In 2015, in a similar project with the Federal Highway Administration (FHWA) under a partnership between Parsons Brinkerhoff and GSL as part of C-15-GSL-01, it was required to test a different armoring design on a reduced-scale reinforced concrete box-shaped bridge column with chamfered corners and a hollow center. The box-shaped column can be seen in Figure 2. The box column dimensions were approximately 7- by 7- by 17 ft.

Structures and Engineering Branch (StEB) and Concrete and Materials Branch (CMB) personnel determined that due to the hollow cross section and overall length of the specimen that this test article could not be cast vertically or horizontally. These determinations were made after considering safety during test article placement, and concrete consolidation during placement. Therefore, a placement technique was developed that involved pumping the desired mixture into an inclined and fully incased steel formwork. The placement technique is detailed in the 7 ksi field placement section.

Figure 2. The 7 ksi column cross-section (left) and inclined steel formwork (right).

1.2 Objective

The objective of this report is to document the development of a field castable 6 ksi sanded grout mixture and a 7 ksi sanded grout mixture used in full-scale experimental testing programs at Fort Polk in Leesville, LA. To accomplish this objective this report includes:

1. Identifying and sourcing the constituent materials that were used to produce the grout mixtures.
2. Developing and selecting a candidate mixture proportion appropriate for each project's requirements.
3. Mechanical testing of the candidate mixtures to determine the unconfined mechanical properties, and documenting the results.
4. Providing guidance for the placement of each test item using the candidate mixtures produced with the local concrete producer.
5. Mechanical testing of the field cast mixtures to determine the unconfined compressive strength, density, and elastic modulus.

2 Constituent Materials

Although the same ready mix provider, Port Aggregates, Inc., Leesville, LA, was used in both years, there was a substantial change in constituent materials from the 6 ksi mixture developed in 2014 to the 7 ksi mixture developed in 2015. During that span between mixture designs, Port Aggregates, Inc., transferred from using Grace Construction Product's admixtures to using Master Builders Solutions by BASF Corporation admixtures. The concrete sand source was changed as well. These changes are described in each material section below.

2.1 6 ksi sanded grout (2014)

In order to proportion a 7 ksi grout mixture for use at Fort Polk, samples of constituent materials were taken from Port Aggregates, Inc., Leesville, LA, and delivered to the CMB laboratory in Vicksburg, MS. This material was comprised of several constituents including: an ASTM C150 Type I/II Portland cement, silica fume, concrete sand, colloidal silica, water-reducing admixture (WRA), and a high range water reducing admixture (HRWRA). The cement, sand, WRA, and HRWRA were all sampled from Port Aggregates, whereas the silica fume and colloidal silica were supplied by CMB. Material data sheets were also supplied by the manufacturer of each constituent material. This information is available in Appendix A. Information obtained from these data sheets was used in the development of the 6 ksi grout mixture proportion.

A mixture proportion for the actual 6 ksi mixture used in the construction of the full-scale bridge that this experiment was modeling was not provided. Therefore, it was difficult to determine what cementitious materials were used in the full-scale mixture proportion. Fly Ash (preferable class F) is commonly used in mass concrete applications, but the amount of fly ash (if any) used in the full-scale mixture proportion was unknown. The water/cement and cement paste/aggregate ratios were also unknown for the full-scale mixture.

2.2 7 ksi sanded grout (2015)

The proportion for the 7 ksi grout was based off of the 6 ksi sanded grout mixture proportion.

2.3 Portland cement

The cement source stayed the same throughout the 6 ksi and 7 ksi sanded grout design and field placement process. Ash Grove Cement Company located in Foreman, Arkansas produced the Portland cement. Mill tickets detailing the chemical composition of the cement were provided by Port Aggregates, Inc. The cement mill certification can be found in Appendix A.1. Commonly called a Type I/II cement, this cement met the requirements for ASTM C 150 Type I and Type II. A Type I is a standard cement for use when special properties specified for any other type of cement are not required, and Type II is for general use when moderate sulfate resistance is desired. Type I/II cement is common in the southeast United States.

Portland cement chemical analysis certificates are generally published by the manufacturer on a monthly basis. The differences between chemical composition of the cement used during laboratory mixture proportioning and the composition of the cement used during field placement were negligible.

2.4 Silica fume

The silica fume used for both the 6 ksi and 7 ksi sanded grouts was Elkem ES 900W, and was produced by Elkem Silicon Materials.* The ES 900W was purchased directly from Elkem by CMB personnel, and is not supplied by Port Aggregates, Inc. The silica fume was commonly available throughout the United States at that time. It does not meet ASTM C1240 specifications, as it is produced as a byproduct of a zirconium alloys electric arc furnace instead of the specified elemental silicon or ferro-silicon alloys electric arc furnaces. It is however, still a very fine pozzolanic material comprised mostly of amorphous silica. This silica fume is a very light colored grey and has high silica content with low carbon content. A product data sheet can be found in Appendix A.2.

* Note: Elkem ES900W has been discontinued since Elkem's source for this silica fume has become unavailable.

2.5 Aggregates

Only fine aggregate was used in the proportioning of these mixtures. No coarse aggregate was present in any of the mixtures.

2.5.1 6 ksi sanded grout (2014)

The only aggregate used in this mixture proportion was concrete sand known as Grayson Sand. The Grayson Sand was sampled from Port Aggregates, Inc., Leesville, LA. Port Aggregates, Inc., Leesville obtained the Grayson sand from Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, LA region. This sand had a slightly higher percent passing the No. 16 and No. 30 sieve than what is allowed by ASTM C 33.

The Concrete and Materials Branch's aggregate laboratory performed standard characterization tests on the Grayson sand. The results from those tests are documented in Appendix A.3.1.1. This testing was done in accordance with ASTM C 117, C 128, and C 136. CMB's testing showed the same Specific Gravity (SG), a slightly different absorption, and slightly different gradations from the testing performed by Port Aggregates. CMB gradations show about 8.5% more passing through the #30 sieve. The test results for this aggregate as performed by Port Aggregates are listed in Appendix A.3.1.2. Overall, these slight differences should not raise any mixture proportion concerns.

2.5.2 7 ksi sanded grout (2015)

By the end of the 2014 calendar year Port Aggregates, Inc. had stopped using the Grayson sand. In a phone conversation with the Quality Control Manager for Port Aggregates, Inc., Warner Hanks reported, "The Grayson sand is currently too far out of ASTM C 33 compliance, and the supplier is unwilling to correct it." The 'new' sand used in 2015 is Trinity Sand, which is obtained from Trinity Materials, Inc. located in Merryville, LA. An aggregate gradation report was supplied by Port Aggregates for the Trinity sand and can be seen in Appendix A.3.2. Due to project time constraints, this aggregate was not tested by CMB.

2.6 Chemical admixtures

2.6.1 6 ksi sanded grout (2014)

Three chemical admixtures for concrete, Adva© 190, Zyla© 610, Recover©, and Cembinder N8©, were used in the 6 ksi sanded grout mixture proportions. The Adva© 190, Zyla© 610, and Recover© are all produced by Grace Construction Products and were sampled from the Port Aggregates, Inc., Leesville batch plant. Adva© 190 is advertised by the producer as a HRWRA meeting the criteria for ASTM C 494 (ASTM 2013f) type A and type F admixtures. Zyla© 610 is advertised as a WRA meeting the criteria for ASTM C 494 (ASTM 2013f) type A and type D admixture. Recover© is advertised as a hydration stabilizer meeting the criteria for ASTM C 494 (2013a) type D admixtures. Product data sheets provided by Grace Construction Products for each of these three admixtures are included in Appendix A.4.1.

The Cembinder N8© is produced by AkzoNobel. It is an alkaline, aqueous dispersion of colloidal silica that is approximately 50% solids by weight. Cembinder N8© is a specialty product designed for use in concrete to control stability segregation and water loss. This admixture was primarily used in these mixture proportions in an effort to avoid segregation and bleeding. It was batched as a percent replacement of total cement, whereas all other admixtures were batched as fluid ounces per 100 kilograms of cement. This product was purchased directly from AkzoNobel, and was taken to the Port Aggregates, Inc., Leesville batch plant by CMB personnel. CMB personnel manually dosed the Cembinder N8© into the concrete mixture.

Amber Defoamer was used to reduce the air content of these mixtures. A data sheet for this defoaming agent is unavailable since the product was discontinued. It was not used in the 7 ksi mixtures.

2.6.2 7 ksi sanded grout (2015)

Between the field placement of the 2014 scaled-bridge columns and the initial 2015 efforts, Port Aggregates switched from Grace Construction Products admixtures to Master Builders Solutions by BASF admixtures. These changes were incorporated into the mixture proportion. The new WRA became Pozzolith 80, and the HRWRA became PS 1466. These products performed comparably to the Grace Construction Products admixtures used

the previous year. The data sheets are included in Appendix A.4.2. PS 1466 has since been renamed to MasterGlenium 1466.

3 Testing Procedures

The testing procedures stayed the same for both 2014 and 2015 efforts. The fresh and hardened property results for each trial mixture can be found in their respective appendices. The testing results for the field cast mixtures will be discussed in the field placement section.

3.1 Fresh properties

The fresh properties measured were temperature, slump, air content, and unit weight. Fresh temperature was recorded in accordance with ASTM C 1064. Slump was determined in compliance with ASTM C 143. Also, each mixtures' respective flow was measured post slump by using a yard stick to measure the circumference of the slump. These data are presented in the appendices as "Flow." Air content was measured using the pressure method outlined in ASTM C 231. Unit weight was measured in accordance with ASTM C 138.

3.2 Hardened properties

Three hardened properties were measured. Hardened density was measured in compliance with ASTM C 39. Unconfined compressive strength (UCS) was determined in accordance with ASTM C 39. The static modulus of elasticity was determined according to ASTM C 469.

4 Mixture Proportioning

4.1 6 ksi sanded grout mixture proportioning (2014)

4.1.1 6 ksi selection criteria

Due to the amount of time required to conduct and analyze Elastic Modulus and Poison's ratio (E&P) testing on specimens, UCS and slump tests were critical measurements for refining mixture proportions. The design UCS for this mixture was 6 ksi at 28 days age, with a tolerance of +/- 500 psi. A slump of at least 10 inches (in.) or greater was also desired due to the difficulty of casting a large column that was expected to have a very tight steel rebar reinforcement spacing. The densities were recorded for each mixture as well.

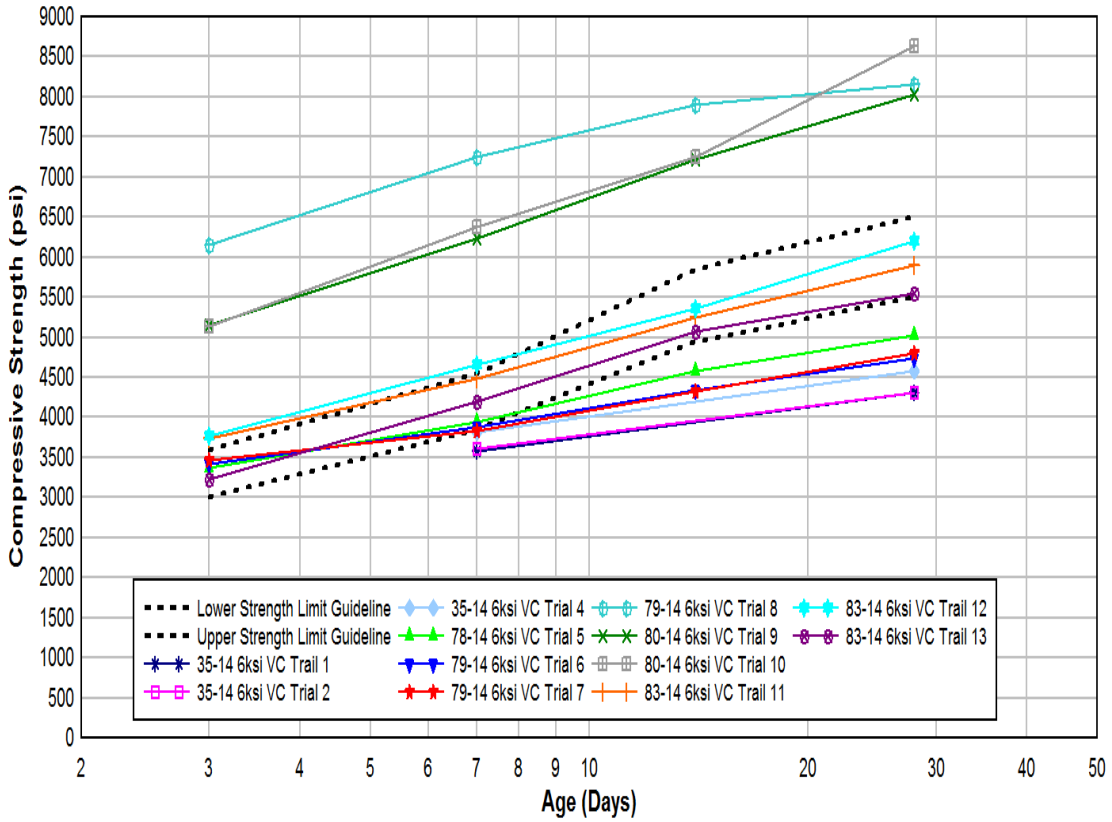
4.1.2 6 ksi aggregate selection and optimization

The tight rebar reinforcement configuration influenced the reason the mixture was designed with only concrete sand. By designing the mixture with concrete sand as the only aggregate, it was known that the concrete density would be reduced and the resulting modulus could be reduced as well. The material deficiencies from only using a fine aggregate were considered; however, it was decided that the ability to fully cast each test specimen without the potential for any major voids would be more beneficial.

4.1.3 6 ksi trial mixture compressive strength results

Figure 3 depicts the strength development with the time each of the thirteen trial batches were cast in the CMB laboratory. Trial (T) 3 was never cast due to fresh property results obtained during the casting of Trials 1 and 2. Information on the mixture proportions, unconfined compressive strength, and fresh properties of each batch can be found in Appendix B.1. Trial 12 was ultimately selected as the optimal mix design for field placement.

Figure 3. Summary of UCS results of Fort Polk 6 ksi sanded grout trials cast in Vicksburg, MS.



4.2 7 ksi sanded grout mixture proportioning (2015)

4.2.1 7 ksi selection criteria

Similar to the 6 ksi selection criteria, the UCS and slump tests were critical measurements for refining mixture proportions. The design UCS for this mixture was 7 ksi at 28 days age, with a tolerance of +/- 500 psi. However, the target strength age was reduced to 14 days due to scheduling constraints for the placement and full-scale testing with funds that needed to be executed within the fiscal year.

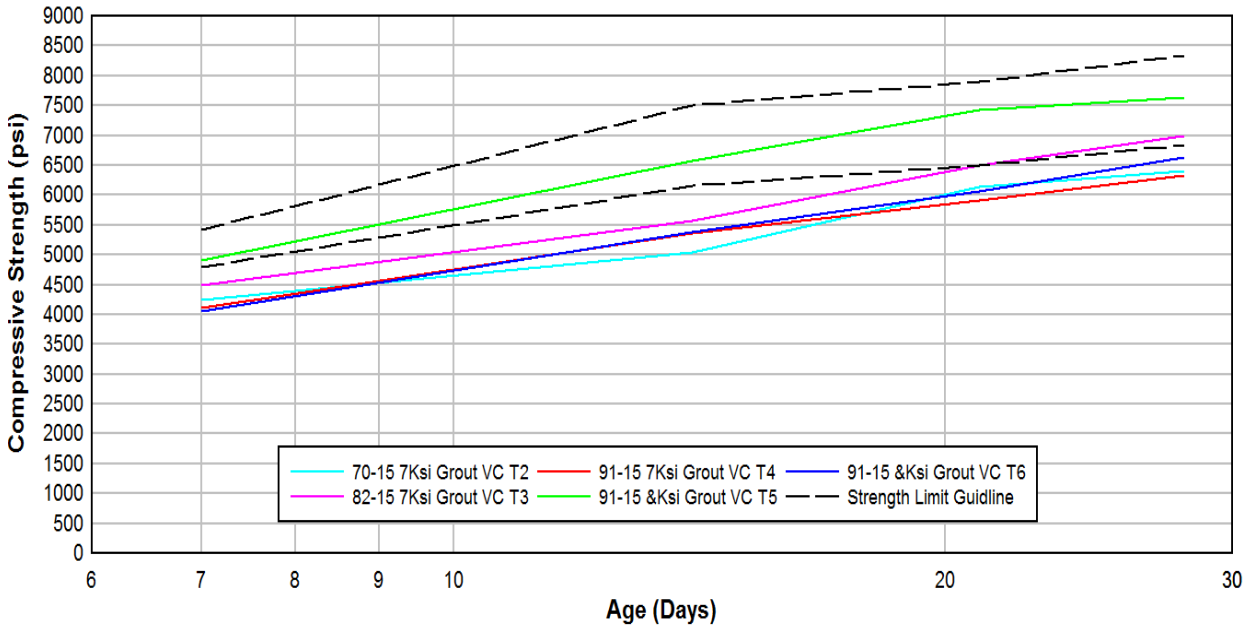
4.2.2 7 ksi aggregate selection and optimization

Aggregate selection criteria for the 7 ksi mixture remained consistent with that of the 6 ksi mixture. The fine aggregate source for Port Aggregates did change, and this change is discussed in the Constituent Materials section of this report.

4.2.3 7 ksi trial mixture compressive strength results

Figure 4 depicts the strength development with time of each of the six trial batches cast in the Concrete and Materials Laboratory. In Trial 1 the aggregates fell out of solution so no cylinders were cast for that trial mixture. Information on the mixture proportions, unconfined compressive strength, and fresh properties of each batch can be found in Appendix D.2.

Figure 4. Summary of UCS results of Fort Polk 7 ksi sanded grout trials cast in Vicksburg, MS.



5 Field Concrete Placements

5.1 6 ksi field placement

The steel formwork, with steel reinforcing in place, for the three 6 ksi reduced-scale bridge pillars was delivered to Range 15A at Fort Polk from the Tennessee Valley Authority (TVA) a week prior to the casting dates. TVA constructed the formwork, fabricated the steel reinforcing cages, and placed the assembled reinforcing steel cages into the formwork according to ERDC specifications, approved by the customer. Since these columns were to be cast horizontally, each column was placed directly on a level casting slab previously constructed on Range 15A. The columns were aligned so that the concrete trucks would have easy access from the service road. The chute was placed over the back third of each pillar, and the driver was instructed to pull forward as the column began to fill. Each pillar was cured with wet burlap, plastic, and insulation for 7 days.

The 6 ksi field placements occurred on April 22nd, 23rd, and 24th of 2014. These mix designs were based off of the Trial 12 mixture proportion. Original plans were to cast 7.5 cubic yards per placement. Pillar 2 (P2) was cast on April 22nd, Pillar 3 (P3) on the 23rd, and Pillar 1 (P1) was cast on the 24th. Silica fume, Recover, and Amber Defoamer were loaded manually by CMB personnel at the batch plant.

During the batching of P2 the ready mix plant over-batched the cement by several hundred pounds, because of this the mix design was adjusted to an 8.6 cubic yard volume. Upon arrival, the mixture was too fluid and the aggregates were borderline segregated. An extra 3% of Cembinder N8 (approximately 150 lbs) was added to the mixture onsite to counteract segregation concerns. There was no segregation after the Cembinder addition. The adjusted proportions for P2 can be seen in Table 1 along with the casting proportions of P3 and P1. Measured aggregate moisture content was 3.16%.

P3 was batched with a significant reduction in HRWRA to alleviate segregation concerns. It was reduced from a 12.5 fluid ounce per 100 pounds of cement dose to a 4 fluid ounce per 100 pounds of cement dose. Also, 18 gallons (gal) of water was held out at the batch plant as further precaution. This mix arrived at Range 15A too stiff, therefore, 10 gal of the held out water was added and the ADVA dose was increased from 4 to 8 fluid

ounces per 100 pounds of cement (approximately 15 lbs). P3 was successfully cast just as the ready mix truck became empty. Measured aggregate moisture content was 4.87%.

P1 was batched according to the final proportions of P3. No additional water or admixture had to be added onsite. The volume cast was increased from 7.5 to 8.5 cubic yards. Measured aggregate moisture content was 1.58%.

Table 1. The 6 ksi field cast mixture proportions in pounds.

Material	112-14 6 ksi P2 (8.6 cu yd)	113-14 6 ksi P3 (7.5 cu yd)	114-14 6 ksi P1 (8.5 cu yd)
Cement (lb)	5,585	4,727	5,358
Silica Fume (lb)	201	177	201
Sand (lb)	21,805	19,352	21,203
Water (lb)	2,955	2,408	3,448.4
Cembinder N8 (fl oz)	6,866	3,742	4,241
ADVA 190 (fl oz)	788	207	470
Zyla 610 (fl oz)	416	363	412
Recover (fl oz)	257	207	225
Amber Defoamer (fl oz)	42	37	42

Table 2 shows the UCS for the 6 ksi field cast mixtures. P2 is within design tolerance, and P3 is barely above tolerance. However, P1 compressive strengths came in a couple hundred psi below tolerance. After reviewing field notes it was determined the moisture content for P1 lowered by a couple of percentage points from the previous two days. Moisture readings were taken as the sand was going up the conveyor belt to the silo each day. This drop was due to a new shipment of the Grayson sand being delivered the afternoon before. The sand silo was not emptied the previous afternoon, and it is likely that the sand batched into the mixture had a higher moisture content than what was measured on the conveyor belt. This led to unaccounted water being introduced into the mixture and a drop in strength outside of the target tolerance. Table 3 provides the fresh properties measured onsite for each mixture. Young's Modulus and Poisson's ratio results are presented in Table 4. These results were very

consistent for P2, P3, and P1. Some Poisson's ratios were excluded from the average due to slippage during testing.

Table 2. The 6 ksi field cast hardened property data.

Break Age (Days)	112-14 6 ksi VC P2 (psi)	113-14 6 ksi VC P3 (psi)	112-14 6 ksi VC P1 (psi)
7	5,670	4,710	3,810
14	5,435	5,750	4,740
28	6,020	6,530	5,210
Shot	6,395	6,570	5,330
Average Hardened Density (lb/cu ft)	139.1	138.3	137.6

Table 3. The 6 ksi field cast fresh properties.

	112-14 6 ksi VC P2	113-14 6 ksi VC P3	112-14 6 ksi VC P1
Slump (in.)	11	10.25	10.25
Air Content (%)	1.0	2.4	1.2
Temperature (F)	78.4	79.4	73.4
Unit Weight (lb/cu ft)	138	136.4	135.2

Table 4. The 6 ksi field cast 28 day elastic modulus data.

	Young's Modulus, E (psi)	Poison's Ratio, μ (in./in.)
112-14 VC P2 #1	3.48E+06	0.147868434
112-14 VC P2 #2	3.52E+06	0.131984071
112-14 VC P2 #3	3.31E+06	0.130809571
Average P2	3.44E+06	0.136887359
113-14 VC P3 #1	3.77E+06	0.165007054
113-14 VC P3 #2	3.75E+06	0.202970124
113-14 VC P3 #3	3.69E+06	0.165062242
Average P3	3.74E+06	0.165034648
114-14 VC P1 #1	2.93E+06	0.129754527
114-14 VC P1 #2	3.33E+06	0.095604724
114-14 VC P1 #3	3.31E+06	0.130809571
Average P1	3.19E+06	0.130282049
Excluded values due to slippage during tests.		
Outliers and could possibly be excluded from average.		

5.2 7 ksi field placement

The steel form sealed structure was unloaded from a flatbed trailer using a 60 ton crane, and the structure was then placed upon timber matting that was approximately 1 ft. thick. The south end of the structure was placed on a single mat while the north end was placed on a double stack of the timber mats, giving a slight angle of about a foot throughout the length of the structure. The angling of the structure before grout placement was strategic to aid in consolidation of the grout. The structure was fabricated with 2 in. ball valves on both end caps of the steel structure. Keeping the structure at an angle throughout the entirety of the grout placement ensured that the gravity of the grout being placed would force the in-trapped air to travel to the inclined side of the structure where ball valves and vent pipes had been fabricated to the structure allowing it to vent. Additional wooden blocks were placed underneath the structure to give the bottom of the form more support and prevent sagging caused by the weight of the steel and grout. Figure 5 shows the inclined steel form.

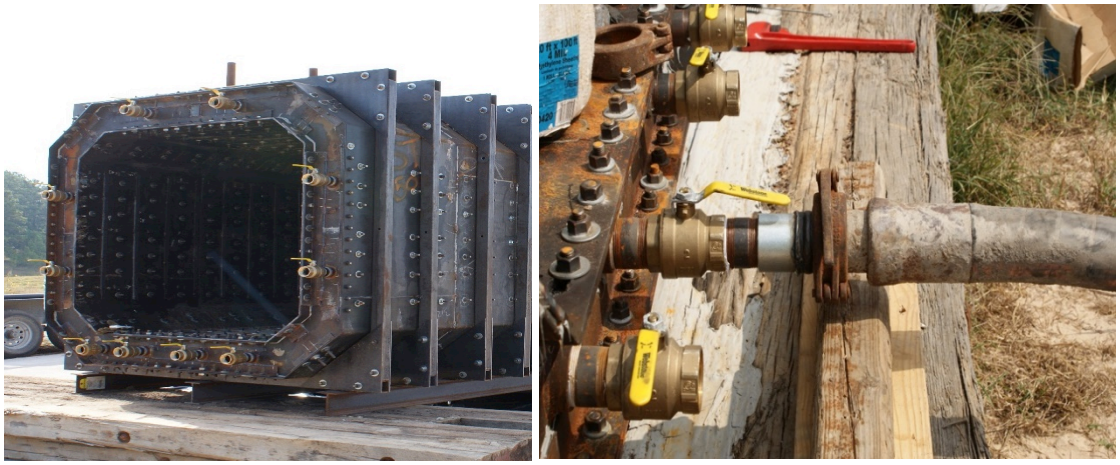
Figure 5. Inclined 7 ksi steel form.

The 7 ksi grout placement took place on 6 October 2015. CMB personnel went to Port Aggregates, Inc. to oversee batching, and to batch the silica fume and Cembinder N8© manually. This process followed the same procedures for the previously discussed 6 ksi placements. Two 8 cu yd batches were cast concurrently. Both truckloads were batched with a 15 gal water hold out. Ten gal was added to T1 onsite, and 20 gal was added to T2 on-

site. This put T1, 5 gal under design, and T2, 5 gal over design. The 10 extra gal in T2 was caused by a longer wait time, and the grout beginning to heat up as shown by the fresh temperature measurement in Table 6.

The grout was transported after batching to Range 15A, and the ready mix trucks were positioned so they could discharge the grout into the hopper of a 32 m concrete pump truck. The pump truck was equipped with a 4 in. pump line that was reduced down to a 2 in. fitting. The fitting was then attached to 2 in. pipe nipples that were screwed into the ball valves located on the lower end on the structure. Figure 6 shows the ball valve arrangement on both end caps and the concrete pump hose to ball valve connection.

Figure 6. Ball valve arrangement (left) and ball valve connection (right).



The concrete pump hose was connected to the bottom right side ball valve on the declined side. At this point all of the remaining ball valves on both end caps were open. A steady pumping speed of approximately 15 seconds per pump stroke was applied. The steel forms were monitored for leaks and level progress throughout the pumping process. As the grout was pumped though the structure and reached the level on an open ball valve, that ball valve was closed and sealed off once a steady flow of the grout was seen through the valve's 2 in. opening. Figure 7 shows the grout flowing through a ball valve on the inclined side. This process was maintained throughout the entirety of the placement. Once the level reached the top, the ventilation pipes located on the top of the inclined side were monitored to ensure no in-trapped air during the final stages.

Figure 7. Grout flowing through the first ball valve located on the inclined side.

Once the sealed structure was completely filled with grout and all valves were closed, the sides of the structure was lightly tapped with steel hammers. This would help remove any air voids that may remain. After approximately 5 minutes of tapping, the top two center ball valves of the inclined side were opened halfway. Another pump stroke was applied. The valves were closed off mid stroke forcing the rest through the top ventilation pipes. This ensured that the entire structure was completely filled with grout. The steel forms were then left in place for 7 days while the grout cured.

Table 5 gives the hardened property data for the two field cast 7 ksi grout trucks. T1 is within the 14 day desired design tolerance. T2 was a few hundred psi below design tolerance. This is due to the extra water batched into the mixture. Both batches met the original 28 day design tolerance. Also, it is worth noting the lower densities of the 7 ksi grout versus the 6 ksi grout. This is attributed to the lack of defoamer in the 7 ksi grout, and a much higher air content that can be seen in Table 3 and Table 6. Table 7 gives the Elastic Modulus and Poisson's Ratios for both batches of the 7 ksi grout. The modulus results are very consistent, and some Poisson's Ratios were excluded due to slippage during testing.

Table 5. The 7 ksi field cast hardened property data.

Break Age (Days)	279-15 7 ksi VC T1 (psi)	279-15 7 ksi VC T2 (psi)
3	4,830	4,470
7	5,370	5,130
14	6,590	6,130
28	7,150	6,800
Average Hardened Density (lb/cu ft)	132.4	130.8

Table 6. The 7 ksi field cast fresh properties.

	279-15 7 ksi VC T1	279-15 7 ksi VC T2
Slump (in.)	10	9.5
Air Content (%)	8.3	8.8
Temperature (F)	88.7	95.6
Unit Weight (lb/cu ft)	130	127.6

Table 7. The 7 ksi field cast Young's Modulus and Poisson's Ratio.

	Young's Modulus, E (psi)	Poisson's Ratio, μ (in./in.)
279-15 7 ksi VC T1	4.10E+06	0.2354
279-15 7 ksi VC T1	3.94E+06	0.1601
279-15 7 ksi VC T1	4.02E+06	0.3692
Average T1	4.02E+06	0.1978
279-15 7 ksi VC T2	4.28E+06	0.1898
279-15 7 ksi VC T2	4.38E+06	0.2882
279-15 7 ksi VC T2	4.42E+06	0.2349
Average T2	4.36E+06	0.2124
Excluded values due to slippage during tests.		

6 Conclusions

In January of 2014 and again in February of 2015 the ERDC under two separate partnering agreements developed a 6 ksi and 7 ksi mixture for the purpose of testing scaled bridge columns at Fort Polk near Leesville, LA. Due to the reduced scaling of the test members there were very intricate rebar patterns with very small rebar spacing. The intricacies of these designs lead to the needed mixture proportions being very flowable specialized grouts that used materials sampled from Port Aggregates, Inc. in Leesville, LA. These constituents were used with other specialized additives not available at Port Aggregates, Inc. The test members for each program were then successfully cast in April of 2014 and October of 2015 at Range 15a at Fort Polk. This report detailed the development of these specialized grouts for the purpose of aiding future cementitious mixture developments in the region. The knowledge gained from the mixture proportioning and field application of these highly flowable specialized grouts will aid in future physical model construction and grout pumping applications.

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Appendix A: Constituent Materials

A.1 Cements

ASH GROVE CEMENT COMPANY

ASH GROVE

4343 Highway 108
Foreman, Arkansas 71836
Phone: 870-542-3040

Type I/II (Low Alkali)

Production Period: July 1 thru July 31, 2015 Date: 8/7/2015

The following information is based on average test data during the production period. The data is typical of cement shipped from the Foreman, Arkansas plant. Individual shipments may vary.

STANDARD REQUIREMENTS
ASTM C150/C150M-09

CHEMICAL

Item	A.S.T.M. Test Method	Spec. Limit	Test Result
SiO_2 (%)	C114	*A*	20.05
Al_2O_3 (%)	C114	*A*	5.00
Fe_2O_3 (%)	C114	*A*	3.72
CaO (%)	C114	*A*	64.00
MgO (%)	C114	6.0 max	1.00
SO_3 (%)	C114		3.18
Loss on ignition (%)	C114	3.0 max	2.35
Na_2O (%)	C114	*A*	0.18
K_2O (%)	C114	*A*	0.55
Insoluble Residue (%)	C114	0.75 max	0.41
CO_2 (%)	C114	*A*	1.14
Limestone (%)	C114		3.0
$CaCO_3$ in limestone (%)	C114		86.48
Potential compounds (%)[D]			
C_3S	C114	*A*	55
C_2S	C114	*A*	14
C_3A	C114		7
C_4AF	C114	*A*	11
$C_3S + 4.75\ C_3A$	C114		88

PHYSICAL

Item	A.S.T.M. Test Method	Spec. Limit	Test Result
Air content of mortar (volume %)	C185	12 max	8
Fineness (cm^2/g):			
Air permeability	C204	2800 min	4504
Autoclave expansion (%)	C151	0.80 max	0.00
Compressive strength (psi)			
1 Day	C109	*A*	2930
3 Days	C109	1740 min	4646
7 Days	C109	2760 min	5481
Time of setting (minutes) (Vicat)			
Initial: Not less than	C191	45	117
Not more than		375	117
Mortar Bar Expansion (%)	C1038	0.020 max	0.002

OPTIONAL REQUIREMENTS
ASTM C150/C150M-09, Tables 2 and 4

CHEMICAL

Item	A.S.T.M. Test Method	Spec. Limit	Test Result
$C_3S + C_3A$ (%)	C114	*A*	
Equivalent alkalies (%)	C114	0.60	0.54

PHYSICAL

Item	A.S.T.M. Test Method	Spec. Limit	Test Result
False set (%)	C451	*B*	68
Heat of hydration (kJ /kg)			
7 days	C186	*A*	

A = Not applicable.
B = Limit not specified by purchaser, test result provided for information only.
C = Test results for this period not available.
D = Adjusted per Annex A1.6 M85

We certify that the above described cement, at the time of shipment, meets the chemical and physical requirements of ASTM C150/C150M-09 (Types I/II) and AASHTO M85-07 (Type I/II), or (other)_____specification.

Signature: Floyd Arnold

Floyd Arnold
Title: Chief Chemist

ASH GROVE CEMENT COMPANY

4343 Highway 108
Foreman, Arkansas 71836
Phone: 870-542-3040

Type I/II (Low Alkali)

Production Period: July 1 thru July 31, 2015 **Date: 8/7/2015**

The following information is based on average test data during the production period. The data is typical of cement shipped from the Foreman, Arkansas

Additional Data
M85

Inorganic Processing Addition Data	
Type	Limestone
Amount(%)	2.99
SiO_2 (%)	8.08
Al_2O_3 (%)	2.55
Fe_2O_3 (%)	1.45
CaO (%)	46.25
SO_3 (%)	0.43

Base Cement Phase Composition	
C_3S	57
C_2S	14
C_3A	7
C_4AF	11

Signature: Floyd Arnold

Floyd Arnold
Title: Chief Chemist

A.2 Silica fume

INTERNAL PRODUCT SPECIFICATION

PRODUCT:
ES-900 W

Characteristic	Min	Max
SiO2 (%)	85.5	
pH	3.0	10.0
Carbon (%)		0.70
Moisture (%)		0.50
+45µm (%)		7.0
Bulk Density (Lb/Cft)	16	40

A.3 Aggregates

A.3.1 6 ksi aggregate

A.3.1.1 6 ksi aggregate CMB testing

Serial No.:	140043	TPP:		Date:	10-Apr-14	Tested By:	CEERD-GM-C			
WIC:		District:		Contract No.:						
Producer:	Grayson, Port Aggregates, Leesville, L			Date Recd:	Mar-14					
Sampled By	Dylan Scott			Matl Type:	fine aggregate					
ASTM C 136 Sieve Analysis:										
	Run 1		Cumulative Percent		Run 2		Cumulative Percent			
Sieve Size	Mass Ret, g	% Ret.	Ret.	Pass	Mass Ret, g	% Ret.	Ret.	Pass	Avg	C33
3/8 in.	2.1	0.41%	0.41%	99.59%	0.00	0.00%	0.00%	100.00%	100%	100
No. 4	19.7	3.87%	4.28%	95.72%	15.90	3.14%	3.14%	96.86%	96%	95/100
No. 8	31.0	6.09%	10.38%	89.62%	33.90	6.70%	9.85%	90.15%	90%	80/100
No. 16	29.5	5.80%	16.17%	83.83%	28.60	5.66%	15.50%	84.50%	84%	50/85
No. 30	68.0	13.36%	29.53%	70.47%	68.00	13.45%	28.95%	71.05%	71%	25/60
No. 50	260.3	51.15%	80.68%	19.32%	260.30	51.47%	80.42%	19.58%	19%	5/30
No. 100	93.8	18.43%	99.12%	0.88%	94.20	18.63%	99.05%	0.95%	1%	0/10
No. 200	4.4	0.86%	99.98%	0.02%	4.70	0.93%	99.98%	0.02%	0%	
Pan	0.1	0.02%	100.00%		0.10	0.02%	100.00%			
Total	508.90				505.70					
Fineness Modulus:										
ASTM C 117 Minus 75um (No. 200)										
OD Mass, g	510.90	Mass Aft, g	509	Mass Loss, g	1.9	% Loss:	0.37%			
OD Mass, g	517.90	Mass Aft, g	506.3	Mass Loss, g	11.6	% Loss:	2.24%		1.3%	
ASTM C 128 Bulk Specific Gravity & Absorption:					Run 1	Run 2				
Flask No.					3	94			Avg	
SSD Mass, g					501.60	508.10				
Mass Flask+Water, g					679.40	680.50				
Mass Flask+Water+Material, g					988.80	994.20				
Mass Displaced Water, g					192.20	194.40				
Water Temp C					21.0	21.8				
Relative Density (Bulk Specific Gravity)(SSD)					2.610	2.614				
SSD Mass, g					501.60	508.10				
Oven Dry Mass, g					498.10	504.86				
Moisture Loss, g					3.50	3.24				
Absorption					0.70%	0.64%			0.7%	

A.3.1.2 6 ksi aggregate, Port Aggregates, Inc. testing

Material Data Sheet

Typical Properties

Product Code: GRAYSON SAND
Project:
Requested by:
Contractor:
Samples Taken STOCKPILE
Compiled by: W. HANKS

GRADATION SIEVE SIZE		AGGREGATE							
		Spec.	Avg.						
IN.	MM.	% Passing							
1/2"	12.5	***	100.0						
3/8"	9.5	***	100.0						
#4"	4.8	***	98.2						
#8"	2.4	***	92.4						
#16"	1.2	***	86.0						
#30"	0.6	***	62.5						
#40"	0.41	***	29.1						
#50"	0.29	***	13.3						
#100"	0.15	***	5.1						
#200"	0.07	***	0.0						
Bulk (SSD) Gs			2.62	ASTM C 127					
Bulk Gs			2.63	ASTM C 127					
Absorption			0.5	ASTM C 127					
LA Abrasion			NA	ASTM C 535					
Magnesium Sulfate Soundness			NA	ASTM C 88					
Formation									
Liquid Limit			NA	ASTM D 4318					
Plastic Limit			NA	ASTM D 4318					
Plastic Index			NA	ASTM D 4318					
Unit Wt.	Loose PCF		98.7	ASTM C 29					
	Rodded PCF		101.6	ASTM C 29					

A.3.2 7 ksi aggregate

MATT MENU SELECTION – 2 | Louisiana Department of Transportation and Development | DOTD 03-22-0745 Metric/English Rev. 11/98

AGGREGATE TEST REPORT | Clear Worksheet

Metric / English E (M or E - Located on Mat Menu)

Project No. | **Material Code** | **Lab No.**

Date Sampled 8/6/2015 | **Submitted By** | Quantity

Purp Code 1 | **Source Code** | **Spec Code** | P.O. No.

Date Tested 8/6/2015 | Ident | **Plant Code** | Frict Rating | (1-4)

Item No. | Date Rec'd (lab) | Sampled By: **O. DEVILLE**

Remarks 1 **Fine Agg. Trinity Sand**

Tested By **C. HEBERT** Date **8/6/2015** Checked By **W. HANKS** Date **8/7/2015**

DOTD TR 102, 112, 113 & 309

Unit 1 1= grams 2 = pounds

Sieve mm	Sieve in.	Mass (Wt) Retained	% Retained	% Coarser	% Passing
63	2 1/2	0			
50	2	0			
37.5	1 1/2	0			
31.5	1 1/4	0			
25.0	1	0			
19.0	3/4	0			
16.0	5/8	0			
12.5	1/2	0			
9.5	3/8	0			
4.75	No. 4	12.1	2.27829	2.27829	98
Mass(Wt.) Matl. In pan					
Accum. Total					
Initial Dry Total Mass, (Wt)				% Diff:	

Unit 1 1= grams 2 = pounds

Sieve mm/µm	Sieve No.	Mass (Wt) Retained	% Retained	% Coarser	% Passing
2.36	8	33.1	6.232348	8.510638	91
2.00	10	0		8.510638	
1.18	16	41.7	7.851629	16.36227	84
600	30	89	16.75767	33.11994	67
425	40	143.5	27.01939	60.13933	40
300	50	112.1	21.10714	81.24647	19
180	80	0		81.24647	
150	100	95.6	18.00038	99.24685	1
75	200	3.6	0.677838	99.92468	0
53	270			99.92468	
Mass(Wt.) Matl. In pan		0.4	0.075315	100	
Decant Loss		0.00			
Accum. Total		531.10			
Initial Dry Total Mass, (Wt)		531.5		% Diff:	0.0752587
Dry Mass (Wt) After Wash					

DOTD TR 428

Liquid Limit | Plastic Limit

No. of Blows | Mass Cup + Wet Soil, g

Mass Cup + Wet Soil, g | Mass Cup + Dry Soil, g

Mass Cup + Dry Soil, g | Mass Water

Mass Water | Cup No.

Factor | Mass Cup, g

Cup No. | Mass Dry Soil

Mass Cup, g | % Moisture

Mass Dry Soil

% Moisture | **Plastic Index**

Absorption, % (T84 or T85)	
Spec. Grav SSD (T84 or T85)	
Spec. Grav APP (TR 300)	
Effective Spec Grav (TR 300)	
Opt Moist Content, % (TR 418)	
Maximum Density (TR 418) kg/m^3 (lb/ft^3)	
Lab Comp Method (TR 418)	
Cement, % (TR 432 or SPECIFIED)	
Lime, % (TR 416 or SPECIFIED)	
Other (Additives) Code	%
Clay Lumps, % (TR 119)	
Friable Particles, % (TR 119)	
Clay Lumps & Friable Particles, % (TR 119)	
Flat or Elongated Part, % (TR 119)	
Coal & Lignite, % (TR 119)	
Glassy Particles, % (TR 119)	
Iron Ore, % (TR 119)	
Wood, % (TR 119)	
Total (Clay Lumps, Fri. Part., Iron Ore, Coal & Lignite, Wood), % (TR 119)	
Foreign Matter, % (TR 109)	
Clam Shell, % (TR 110)	
Soundness, % Loss (T 104)	
Abrasion, % Loss (T 96)	
Colorimetric Test (1 = Pass, 2 = Fail) (T 21)	
Asphalt Content, % (TR 307)	
Retained Asphalt Coating, % (TR 317)	
Percent Crushed (TR 306)	
Retained Marshall Stability (TR 313)	
Resistivity, ohm - cm (TR 429)	
pH (TR 430)	
Organic Content, % (TR 413)	
Sand Equivalent (TR 120)	

Remarks 2: **PASSED ALL SCREENS**

Approved By: **Date:**

A.4 Chemical admixtures

A.4.1 6 ksi chemical admixtures

A.4.1.1 6 ksi HRWRA

Grace Concrete Products

GRACE

ADVA® 190

High-range water-reducing admixture

ASTM C494 Type A and F, and ASTM C1017 Type I

Product Description

ADVA® 190 is a polycarboxlate-based high-range water-reducing admixture specifically formulated to meet the needs of the concrete industry. It is a low viscosity liquid, which has been formulated by the manufacturer for use as received. ADVA 190 is manufactured under closely controlled conditions to provide uniform, predictable performance and is formulated to comply with specifications for Chemical Admixtures for Concrete, ASTM Designation C494 as a Type A and F, and ASTM C1017 Type I admixture. ADVA 190 does not contain intentionally added calcium chloride. One gallon weighs approximately 8.8 lbs (1.1 kg/L).

Uses

ADVA 190 superplasticizer produces concrete with extremely workable characteristics referred to as high slump. It also allows concrete to be produced with very low water/cement ratios for high strength.

While ADVA 190 is ideal for use in any concrete where it is desired to minimize the water/cementitious ratio yet maintain workability, ADVA 190 is primarily intended for use in ready-mix concrete, but may also be used in other applications such as precast concrete and self-consolidating concrete.

Addition Rates

ADVA 190 superplasticizer addition rates can vary with type of application, but will normally range from 3 to 15 fl oz/100 lbs (195 to 980 mL/100 kg) of cementitious. In most instances, the addition of 3 to 6 fl oz/100 lbs (195 to 375 mL/100 kg) of cementitious will be sufficient. At a given water/cementitious ratio, the slump required for placement can be controlled by varying the addition rate. Should conditions require using more than the recommended addition rates, please consult your Grace representative.

ADVA 190 dosage requirements may also be affected by mix design, cementitious content and aggregate gradations. Please consult with your Grace Construction Products representative for more information and assistance.

Product Advantages

- Highly efficient, producing high slump concrete at very low dosages
- Provides a combination of slump life with near neutral set time
- Consistent air entrainment
- Consistent performance across cement chemistries
- Concrete finishes easily without stickiness, spotty set or tearing

Compatibility with Other Admixtures and Batch Sequencing

ADVA 190 is compatible with most Grace admixtures as long as they are added separately to the concrete mix. However, ADVA products are not recommended for use in concrete containing naphthalene-based admixtures including Daracem® 19 and Daracem 100, and melamine-based admixtures including Daracem ML 330 and Daracem 65. In general, it is recommended that ADVA 190 be added to the concrete mix near the end of the batch sequence for optimum performance. Different sequencing may be used if local testing shows better performance. Please see Grace Technical Bulletin TB-0110, *Admixture Dispenser Discharge Line Location and Sequencing for Concrete Batching Operations* for further recommendations. ADVA 190 should not come in contact with any other admixture before or during batching, even if diluted in mix water.

Pretesting of the concrete mix should be performed before use and as conditions and materials change in order to assure compatibility with other admixtures, and to optimize dosage rates, addition times in the batch sequencing and concrete performance. For concrete that requires air entrainment, the use of an ASTM C260 air-entraining agent (such as Daravair® or Darex® product lines) is recommended to provide suitable air void parameters for freeze-thaw resistance. Please consult your Grace representative for guidance.

Packaging & Handling

ADVA 190 is available in bulk, delivered by metered tank trucks, in 330 gal (1250 L) disposable totes, and in 55 gal (210 L) drums.

It will begin to freeze at approximately 32°F (0°C), but will return to full strength after thawing and thorough agitation. In storage, and for proper dispensing, ADVA 190 should be maintained at temperatures above 32°F (0°C).

Dispensing Equipment

A complete line of accurate, automatic dispensing equipment is available.

ADVA 190 ASTM C494 Type F High-Range Water Reducer Test Data

	US Units		Metric	
	Control	ADVA 190	Control	ADVA 190
Cement (pcy) (kg/m³)	517	517	307	307
Coarse aggregate (pcy) (kg/m³)	1944	1944	1153	1153
Fine aggregate (pcy) (kg/m³)	1144	1214	679	720
Water (pcy) (kg/m³)	235	204	396	344
w/cm	0.455	0.405	0.455	0.405
Slump (inches) (mm)	3.75	3.5	95	90
Plastic air (%)	5.5	5.4	5.5	5.4
Compressive strength				
1 day (psi) (MPa)	1860	2670	12.8	18.4
7 day (psi) (MPa)	4520	5530	31.2	38.1
28 day (psi) (MPa)	5440	6690	37.5	46.1
Initial set time (hr:min)	4:02	3:55	4:02	3:55
Length change 28 day (%)	-0.031	-0.028	-0.031	-0.028
Freeze-thaw resistance (RDME %)	92	98	92	98

www.graceconstruction.com

North American Customer Service: 1-877-4AD-MIX1 (1-877-423-6491)

GRACE

A.4.1.2 6 ksi WRA

Grace Concrete Products

GRACE

ZYLA® 610
Water-reducing admixture
ASTM C494 Type A and D

Product Description

ZYLA® 610 water-reducing admixture is a proprietary formulation incorporating highly purified specialty organic chemicals. ZYLA 610 promotes more complete hydration of Portland cement and has no effect on concrete air entrainment. The ZYLA product line of water reducers is specially formulated to have a synergistic effect with polycarboxylate-based mid-range and high-range water reducers that improve flat-work finishability. This product does not contain intentionally added chloride and as such is essentially chloride free. It is manufactured under rigid controls that provide uniform, predictable performance. ZYLA 610 is supplied as a light brown, low viscosity liquid, and is ready-to-use as received. One gallon weighs approximately 9.1 lbs (1.09 kg/L).

Product Advantages

- No impact on concrete air content
- Better control of water reduction and setting times as compared to traditional lignin-based water reducers
- Synergistic performance of polycarboxylate-based mid-range and high-range water reducers, which includes water reduction and concrete strength and air control
- In the hardened state, improves the compressive and flexural strengths at all ages of concrete versus traditional lignin-based water reducers

ZYLA 610 meets the requirements of *Specification for Chemical Admixtures for Concrete*, ASTM Designation C494 as Type A and Type D admixtures. Please consult your Grace representative for guidance on the ZYLA product line.

Uses

ZYLA 610 is used to produce concrete mixes with lower water content (typically 3% to 10% reduction), greater plasticity and higher compressive strengths. ZYLA 610 is suitable for normal weight and light weight concrete in ready-mix, precast and prestressed applications.

Finishability

The unique chemistry of ZYLA 610 positively impacts the finishability of concrete by providing a creamier and more homogenous texture, with more uniform and increased bleed rate relative to traditional lignin-based water reducers. The influence of ZYLA 610 on the finishability of lean mixes has been particularly noticeable. Floating and troweling, by machine or hand, imparts a smooth, close tolerance surface.

Addition Rates

The addition rate range of 3 to 5 fl oz/100 lbs (195 to 325 mL/100 kg) of cement or cementitious is typical for most applications. However addition rates of 2 to 7 fl oz/100 lbs (130 to 455 mL/100 kg) of cement or cementitious may be used if local testing shows acceptable performance. Pretesting is required to determine the appropriate addition rate for desired performance. The optimum addition rate depends on the other concrete mixture components, job conditions, and desired performance characteristics.

Compatibility with Other Admixtures and Batch Sequencing

ZYLA 610 is compatible with most Grace admixtures as long as they are added separately to the concrete mix, usually through the water holding tank discharge line. In general, it is recommended that ZYLA 610 be added to the concrete mix near the end of the batch sequence for optimum performance. Different sequencing may be used if local testing shows better performance. Please see Grace Technical Bulletin TB-0110, *Admixture Dispenser Discharge Line Location and Sequencing for Concrete Batching Operations* for further recommendations. ZYLA 610 should not come in contact with any other admixture before or during the batching process, even if diluted in mix water.

Pretesting of the concrete mix should be performed before use, and as conditions and materials change in order to assure compatibility, and to optimize dosage rates, addition times in the batch sequencing and concrete performance. For concrete that requires air entrainment, the use of an ASTM C260 air-entraining agent (such as Daravair® or Darex® product lines) is recommended to provide suitable air void parameters for freeze-thaw resistance. Please consult your Grace representative for guidance.

Packaging & Handling

ZYLA 610 is available in bulk, delivered by metered tank trucks, in 275 gal (1,040 L) totes, and in 55 gal (210 L) drums. It will freeze at about 23.7°F (-4.6°C), but will be completely uniform after thawing and thorough agitation.

Dispensing Equipment

A complete line of accurate, automatic dispensing equipment is available. ZYLA 610 may be introduced to the concrete mix through the water holding tank discharge line. The ZYLA product line is formulated to be free of sediment.

Specifications

Concrete shall be designed in accordance with *Standard Recommended Practice for Selecting Proportions for Concrete*, ACI 211.

The water-reducing admixture shall be ZYLA 610, as manufactured by Grace Construction Products, or equal. The admixture shall not contain calcium chloride as a functional ingredient. ZYLA 610 will not promote corrosion of reinforcing steel embedded in concrete. It shall be used in strict accordance with the manufacturers' recommendations. The admixture shall comply with ASTM Designation C494, Type A water-reducing and Type D water-reducing and retarding admixtures. Certification of compliance shall be made available on request.

The admixture shall be delivered as a ready-to-use liquid product and shall require no mixing at the batching plant or job site.

www.graceconstruction.com

North American Customer Service: 1-877-4AD-MIX1 (1-877-423-6491)

GRACE

A.4.1.3 6 ksi hydration stabilizer

Grace Concrete Products

GRACE

RECOVER®
Hydration stabilizer
ASTM C494 Type D

Product Description

Recover® is a ready-to-use aqueous solution of chemical compounds specifically designed to stabilize the hydration of Portland cement concretes. The ingredients are factory pre-mixed in exact proportions under strict quality control to provide uniform results. One gallon weighs approximately 9.6 lbs (1.15 kg/L).

Recover is approved by ASTM C494 as a Type D retarder.

Uses

Recover is used to stabilize mixer wash water and returned or leftover concrete for extended periods, allowing for use of the materials when specified or allowed. It is also used where controlled extended set of concrete is needed. It is the concrete user's responsibility to determine if leftover, returned or extended-set concrete is specified or allowed.

Wash Water

For wash water applications, Recover is used to eliminate the need to discharge wash water from the mixer. This allows the wash water to be used as mix water in the next batch of concrete produced, and prevents the residual plastic concrete from hardening. Stabilization of up to 96 hours is possible depending on dosage rate.

Returned Concrete

For returned or leftover concrete, Recover is used to prevent plastic concrete from reaching initial set. This allows the concrete to be stored in a plastic state and then used when specified or allowed. The use of this concrete may require the addition of freshly batched concrete and/or an accelerator such as Daraccel® or PolarSet®. Stabilization of concrete for up to 96 hours is possible depending on dosage rate. Use prevents the waste of unused concrete.

Set Time Control

Recover is also used in situations where a controlled set time extension is required. Examples include: extended hauls, large continuous pours or pre-batching of concrete for later use.

Product Advantages

- Eliminates the need to discharge wash water from the mixer
- Prevents the waste of unused concrete
- Provides predictable extended set for continuous placement on mass concrete and tremie projects, or on long hauls to remote sites

Performance

Recover stabilizes the hydration process of Portland cement preventing it from reaching initial set. This stabilization is not permanent and is controlled by dosage rate. For wash water, the Recover treated water is mixed or sprayed in a specific manner to thoroughly coat the interior of the mixer. The water is used as mix water in the next batch of concrete produced, which then scours the unhardened material from the interior of the mixer. Stabilization of returned or leftover concrete with Recover maintains the plasticity of the concrete for the desired storage duration. This stabilized concrete then resumes normal hydration when the Recover dosage effects subside, or when it is activated by the addition of fresh concrete and/or an accelerator. The result can be concrete with normal plastic and hardened properties.

Addition Rates

Addition rates of Recover for wash water range from 6 to 128 fl oz (180 to 3800 mL) per treatment. The amount used will depend on the specific materials involved, mixer type and stabilization period. Addition rates for returned or leftover concrete will range from 3 to 128 fl oz/100 lbs (195 to 8350 mL/100 kg) of cement. The amount used will depend on the specific materials involved, concrete age, temperature conditions and stabilization period. For applications requiring set time extensions well in excess of 4 hours, Recover may be used at addition ranges from 5 to 50 oz/100 lbs (325 to 3260 mL/100 kg) of cement. For use as a traditional ASTM Type D retarder, Recover may be used at addition rates of 2 to 6 oz/100 lbs (130 to 390 mL/100 kg) of cement. Proper dosage rate selection can only be achieved through pretesting. Consult your local Grace admixture representative.

Compatibility with Other Admixtures and Batch Sequencing

Recover is compatible with most Grace admixtures as long as they are added separately to the concrete mix, usually through the water holding tank discharge line. In general, it is recommended that Recover be added to the concrete mix near the end of the batch sequence for optimum performance. Different sequencing may be used if local testing shows better performance. Please see Grace Technical Bulletin TB-0110, *Admixture Dispenser Discharge Line Location and Sequencing for Concrete Batching Operations* for further recommendations. Recover should not come into contact with any other admixture before or during the batching process, even if diluted in mix water.

Pretesting of the concrete mix should be performed before use, and as conditions and materials change in order to assure compatibility, and to optimize dosage rates, addition times in the batch sequencing and concrete performance. For concrete that requires air entrainment, the use of an ASTM C260 air-entraining agent (such as Daravair® or Darex® product lines) is recommended to provide suitable air void parameters for freeze-thaw resistance. Please consult your Grace representative for guidance.

Packaging & Handling

Recover is available in bulk, delivered by metered tank trucks and 55 gallon (210 L) drums. Recover will freeze, but will return to full effectiveness after thawing and thorough mechanical agitation.

Dispensing Equipment

A complete line of Grace dispensing equipment is available for Recover. This includes the Reach 360™ System which uses an innovative spray wand technology to simplify wash water procedures.

www.graceconstruction.com

North American Customer Service: 1-877-4AD-MIX1 (1-877-423-6491)

Recover-5I Printed in U.S.A. 11/07 FA/LI/1M

GRACE

A.4.1.4 Colloidal silica

AkzoNobel

SAFETY DATA SHEET

Cembinder N8

Version 1 | Revision Date 04/28/2015 | Print Date 02/12/2016 | US / Z8

1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	Cembinder N8
Product Use Description	:	Inorganic binder, surface modifier and flocculating agent.
Chemical characterization	:	Amorphous Silica, aqueous colloidal solution.
Company	:	Akzo Nobel Pulp and Performance Chemicals Inc. Parkway Place Suite 1200 1850 Marietta GA 30067 United States
Telephone	:	+17705780858
Fax	:	+17705781359
E-mail address	:	psra.ppc@akzonobel.com
Emergency telephone	:	US CHEMTREC +1-800-424-9300 Internat'l +1-703-741-5971 (collect calls accepted) CANADA CANUTEC +1-613-996-6666

2. HAZARDS IDENTIFICATION

Emergency Overview

Appearance	Clear liquid
Color	clear, cloudy
Odor	slight

GHS Classification

Not a hazardous substance or mixture.

GHS Label element

Not a hazardous substance or mixture.

Potential Health Effects

Inhalation	:	May cause respiratory tract irritation.
Skin	:	Causes mild skin irritation.
Eyes	:	May cause eye irritation.
Ingestion	:	May cause irritation of the mucous membranes.
Aggravated Medical Condition	:	None known.

A.4.2 7 ksi chemical admixtures

A.4.2.1 - ksi HRWRA

BASF
We create chemistry

3

03 30 00	Cast-in-Place Concrete
03 40 00	Precast Concrete
03 70 00	Mass Concrete

MasterGlenium® 1466
High-Range Water-Reducing Admixture
Formerly PS1466*

Description
MasterGlenium 1466 ready-to-use high-range water-reducing admixture is a new generation, patent pending admixture based on polycarboxylate chemistry. MasterGlenium 1466 admixture is very effective in producing concretes with different levels of workability.

MasterGlenium 1466 admixture is particularly effective in improving concrete mixtures with reduced portland cement contents without compromising 28-day strength requirements. MasterGlenium 1466 admixture meets ASTM C 494/C 494M requirements for Type A, water-reducing, and Type F, high-range water-reducing, admixtures.

Applications
Recommended for use in:
- Concrete with varying water reduction requirements (5-40%)
- Concrete where high flowability, increased stability and durability are needed
- Producing self-consolidating concrete (SCC)
- Strength-on-demand concrete, such as 4x4™ Concrete
- Pervious concrete

Features
- Maximum dosage effectiveness for a given water reduction
- Controlled rheology
- Robust air-entraining admixture compatibility
- Improved strength development

Benefits
- Can be used in a wide variety of concrete mixtures as a Type A or Type F admixture
- Improved finishability and surface appearance
- Mixture development flexibility for cement reductions and/or increased use of supplementary cementitious materials

Performance Characteristics
Compressive Strength: Concrete produced with MasterGlenium 1466 admixture achieves significantly higher 28-day compressive strength compared to plain concrete and concrete mixtures containing naphthalene, melamine, and early generation polycarboxylate high-range water-reducing admixtures.

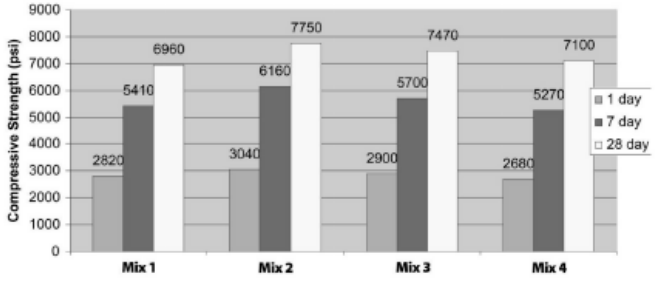
Mixture Data: Type I portland cement; Ambient Temperature, 70 °F (21 °C)

Mix 1: 620 lb/yd³ (367 kg/m³); w/c = 0.43; Conventional PC HRWR

Mix 2: 620 lb/yd³ (367 kg/m³); w/c = 0.43; MasterGlenium 1466

Mix 3: 600 lb/yd³ (356 kg/m³); w/c = 0.44; MasterGlenium 1466

Mix 4: 580 lb/yd³ (344 kg/m³); w/c = 0.46; MasterGlenium 1466



MASTER® BUILDERS SOLUTIONS

MasterGlenium 1466 Technical Data Sheet

Guidelines for Use

Dosage: MasterGlenium 1466 admixture has a recommended dosage range of 2-10 fl oz/cwt (130-650 mL/100 kg) of cementitious materials. For most applications, dosages in the range of 2-6 fl oz/cwt (130-390 mL/100 kg) will provide excellent performance. Because of variations in concrete materials, job site conditions and/or applications, dosages outside of the recommended range may be required. In such cases, contact your local sales representative.

Mixing: MasterGlenium 1466 admixture can be added with the initial batch water or as a delayed addition. However, optimum water reduction is generally obtained with a delayed addition.

Product Notes

Corrosivity – Non-Chloride, Non-Corrosive: MasterGlenium 1466 admixture will neither initiate nor promote corrosion of reinforcing steel embedded in concrete, prestressing steel or of galvanized steel floor and roof systems. Neither calcium chloride nor other chloride-based ingredients are used in the manufacture of MasterGlenium 1466 admixture.

Compatibility: MasterGlenium 1466 admixture is compatible with most admixtures used in the production of quality concrete, including normal, mid-range and high-range water-reducing admixtures, air-entrainers, accelerators, retarders, extended set control admixtures, corrosion inhibitors, and shrinkage reducers.

Do not use MasterGlenium 1466 admixture with admixtures containing naphthalene sulfonate. Erratic behaviors in slump, workability retention and pumpability may be experienced.

Storage and Handling

Storage Temperature: MasterGlenium 1466 admixture must be stored at temperatures above 40 °F (5 °C). If MasterGlenium 1466 admixture freezes, thaw and reconstitute by mechanical agitation. **Do not use pressurized air for agitation.**

Shelf Life: MasterGlenium 1466 admixture has a minimum shelf life of 6 months. Depending on storage conditions, shelf life may be greater than standard. Please contact your local sales representative regarding suitability for use and dosage recommendations if the shelf life of MasterGlenium 1466 admixture has been exceeded.

Packaging

MasterGlenium 1466 admixture is supplied in 55 gal (208 L) drums, 275 gal (1040 L) totes and by bulk delivery.

Related Documents

Safety Data Sheets: MasterGlenium 1466 admixture

Additional Information

For additional information on MasterGlenium 1466 admixture or its use in developing concrete mixtures with special performance characteristics, contact your local sales representative.

The Admixture Systems business of BASF's Construction Chemicals division is the leading provider of solutions that improve placement, pumping, finishing, appearance and performance characteristics of specialty concrete used in the ready-mixed, precast, manufactured concrete products, underground construction and paving markets. For over 100 years we have offered reliable products and innovative technologies, and through the Master Builders Solutions brand, we are connected globally with experts from many fields to provide sustainable solutions for the construction industry.

A.4.2.2 7 ksi WRA

BASF
We create chemistry

3

03 30 00	Cast-in-Place Concrete
03 40 00	Precast Concrete
03 70 00	Mass Concrete

MasterPozzolith® 80

Water-Reducing Admixture

Formerly Pozzolith 80*

Description

MasterPozzolith 80 ready-to-use, liquid admixture is used for making more uniform and predictable quality concrete.

MasterPozzolith 80 admixture meets ASTM C 494/C 494M requirements for Type A, water-reducing, Type B, retarding, and Type D, retarding and water-reducing, admixtures.

Applications

Recommended for use in:

- Prestressed concrete
- Precast concrete
- Reinforced concrete
- Shotcrete
- Lightweight concrete
- Pumped concrete
- 4x4™ Concrete
- Pervious concrete
- Self-consolidating concrete (SCC)

Features

- Reduced water content required for a given workability
- Controlled setting characteristics – normal or retarded

Benefits

- Increased compressive and flexural strengths
- Improved workability
- Reduced segregation
- Flexibility in the scheduling of placing and finishing operations
- Offsets effects of early stiffening during extended delays between mixing and placing
- Helps eliminate cold joints
- Full-form deflection can take place (before concrete sets) in extended pours for bridge decks, cantilevers, nonshored structural elements, etc.
- Peak temperature and/or rate of temperature rise lowered in mass concrete thereby reducing thermal cracking

Performance Characteristics

Rate of Hardening: The temperature of the concrete mixture and the ambient temperature affect the hardening rate of concrete. At higher temperatures, concrete stiffens more rapidly which may cause problems with placing and finishing. The dosage range of MasterPozzolith 80 admixture can be varied to provide the desired setting characteristics.

Guidelines for Use

Dosage: Depending on the setting characteristics desired, MasterPozzolith 80 admixture is recommended for use within the dosage range of 3-10 fl oz/cwt (195-650 mL/100 kg) of cementitious materials for most concrete mixtures using average concrete ingredients. Because of variations in job conditions and concrete materials, dosages other than the recommended amounts may be required. In such cases, contact your local sales representative.

MASTER® BUILDERS SOLUTIONS

MasterPozzolith 80 Technical Data Sheet

Product Notes

Corrosivity – Non-Chloride, Non-Corrosive: MasterPozzolith 80 admixture will neither initiate nor promote corrosion of reinforcing steel in concrete. This admixture does not contain intentionally-added calcium chloride or other chloride-based ingredients.

Compatibility: MasterPozzolith 80 admixture may be used in combination with any BASF admixtures. When used in conjunction with other admixtures, each admixture must be dispensed separately into the mixture.

Storage and Handling

Storage Temperature: MasterPozzolith 80 admixture should be stored above freezing temperatures. If MasterPozzolith 80 admixture freezes, thaw at 35 °F (2 °C) or above and completely reconstitute by mild mechanical agitation. **Do not use pressurized air for agitation.**

Shelf Life: MasterPozzolith 80 admixture has a minimum shelf life of 18 months. Depending on storage conditions, the shelf life may be greater than stated. Please contact your local sales representative regarding suitability for use and dosage recommendations if the shelf life of MasterPozzolith 80 admixture has been exceeded.

Packaging

MasterPozzolith 80 admixture is supplied in 55 gal (208 L) drums, 275 gal (1040 L) totes and by bulk delivery.

Related Documents

Safety Data Sheets: MasterPozzolith 80 admixture

Additional Information

For additional information on MasterPozzolith 80 admixture or its use in developing a concrete mixture with special performance characteristics, contact your local sales representative.

The Admixture Systems business of BASF's Construction Chemicals division is the leading provider of solutions that improve placement, pumping, finishing, appearance and performance characteristics of specialty concrete used in the ready-mixed, precast, manufactured concrete products, underground construction and paving markets. For over 100 years we have offered reliable products and innovative technologies, and through the Master Builders Solutions brand, we are connected globally with experts from many fields to provide sustainable solutions for the construction industry.

Limited Warranty Notice

BASF warrants this product to be free from manufacturing defects and to meet the technical properties on the current Technical Data Guide, if used as directed within shelf life. Satisfactory results depend not only on quality products but also upon many factors beyond our control. BASF MAKES NO OTHER WARRANTY OR GUARANTEE, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO ITS PRODUCTS. The sole and exclusive remedy of Purchaser for any claim concerning this product, including but not limited to, claims alleging breach of warranty, negligence, strict liability or otherwise, is shipment to purchaser of product equal to the amount of product that fails to meet this warranty or refund of the original purchase price of product that fails to meet this warranty, at the sole option of BASF. Any claims concerning this product must be received in writing within one (1) year from the date of shipment and any claims not presented within that period are waived by Purchaser. BASF WILL NOT BE RESPONSIBLE FOR ANY SPECIAL, INCIDENTAL, CONSEQUENTIAL (INCLUDING LOST PROFITS) OR PUNITIVE DAMAGES OF ANY KIND.

Purchaser must determine the suitability of the products for the intended use and assumes all risks and liabilities in connection therewith. This information and all further technical advice are based on BASF's present knowledge and experience. However, BASF assumes no liability for providing such information and advice including the extent to which such information and advice may relate to existing third party intellectual property rights, especially patent rights, nor shall any legal relationship be created by or arise from the provision of such information and advice. BASF reserves the right to make any changes according to technological progress or further developments. The Purchaser of the Product(s) must test the product(s) for suitability for the intended application and purpose before proceeding with a full application of the product(s). Performance of the product described herein should be verified by testing and carried out by qualified experts.

* Pozzolith 80 became MasterPozzolith 80 under the Master Builders Solutions brand, effective January 1, 2014.

Appendix B: Mixture Proportions, Unconfined Compressive Strength, and Fresh Properties of Trial Batches

B.1 6 ksi grout trial mixtures

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 6ksi Sanded Grout — Grayson Concrete Sand
Mixture No. 035-14 vc-T1
Proportioned: 04-Feb-14
6ksi Sanded Grout for use at Fort Polk

1. MIXTURE PROPORTIONS

Material	Aggregate, % by vol.	Aggregate, % by wt.	Solid Volume ft^3	Solid Volume m^3	Mass, S.S.D. lb/yd^3	Mass, S.S.D. kg/m^3	Bulk Sp. Gr. S.S.D.	Absorption, %
Portland cement			3.490	0.129	686	407	3.15	
Fine aggregate	100.0	100.0	14.789	0.548	2427	1441	2.63	0.50
Batch water			7.695	0.285	480	285	1.0	
Cembinder N8					224.9 fl. oz	8.7 Ltrs		
Air			1.026	0.038				
Totals:	100	100	27	1	3594	2133		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2133 / 133.1
W/(C+M), by weight:	0.700	Cementitious Factor, kg/m^3 (lb/yd^3):	407 / 686

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content[b] %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi)[c] 7-day[d]	28-Day			
1	0.0	0	-0.2	0	0.0%	3570	4320			

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Grayson concrete sand, Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, Louisiana region
CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas
POZZOLANS: n/a

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders
b aggregate correction factor = 0.2 percent applied
c Elkem ES900W Silica fume has been discontinued.
d Specimens cured at 72°F in 100% relative humidity room

**Fresh properties not measured for this trial.

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 6ksi Sanded Grout — Grayson Concrete Sand
Mixture No. 035-14 vc-T2
Proportioned: 04-Feb-14
6ksi Sanded Grout for use at Fort Polk

1. MIXTURE PROPORTIONS

Material	Aggregate, % by vol.	Aggregate, % by wt.	Solid Volume ft^3	Solid Volume m^3	Mass, S.S.D. lb/yd^3	Mass, S.S.D. kg/m^3	Bulk Sp. Gr. S.S.D.	Absorption, %
Portland cement			3.414	0.126	671	398	3.15	
Silica Fume				0.004		9	2.25	
Fine aggregate	100.0	100.0	14.759	0.547	2422	1438	2.63	0.50
Batch water			7.695	0.285	480	285	1.0	
Cembinder N8					90 fl. oz	3.5 Ltrs		
Air			1.026	0.038				
Totals:	100	100	27	1	3589	2130		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2130	133.0
W/(C+M), by weight:	0.700	Cementitious Factor, kg/m^3 (lb/yd^3):	407	671

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c] 7-day	28-Day			
1	0.0	0	-0.2	0	0.0%	3610	4310			

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Grayson concrete sand, Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, Louisiana region
CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas
POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders
b aggregate correction factor = 0.2 percent applied
c Elkem ES900W Silica fume has been discontinued.
d Specimens cured at 72°F in 100% relative humidity room

**Fresh properties not measured for this trial.

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 6ksi Sanded Grout — Grayson Concrete Sand
Mixture No. 035-14 vc-T4
Proportioned: 04-Feb-14
Port Aggregates Leesville, La

1. MIXTURE PROPORTIONS

Material	Aggregate, %		Solid Volume		Mass, S.S.D.		Bulk Sp. Gr.	Absorption,
	by vol.	by wt.	ft^3	m^3	lb/yd^3	kg/m^3	S.S.D.	%
Portland cement			3.515	0.130	691	410	3.15	
Silica Fume				0.004		9	2.25	
Fine aggregate	100.0	100.0	14.656	0.543	2405	1428	2.63	0.50
Batch water			7.695	0.285	480	285	1.0	
Cembinder N8					92.6 fl. oz	3.6 Ltrs		
Air			1.026	0.038				
Totals:	100	100	27	1	3592	2132		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2132 133.1
W/(C+M), by weight:	0.680	Cementitious Factor, kg/m^3 (lb/yd^3):	419 691

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c]				
						7-Day	28-Day			
1	0.0	0	-0.2	0	0.0%	3820	4580			

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Grayson concrete sand, Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, Louisiana region
CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas
POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;
Zyla 610, Water Reducing Admixture, Grace Chemical Company

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders
b aggregate correction factor = 0.2 percent applied
c Elkem ES900W Silica fume has been discontinued.
d Specimens cured at 72°F in 100% relative humidity room

**Fresh properties not measured for this trial.

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 6ksi Sanded Grout Grayson Concrete Sand
Mixture No. 078-14 vc-T5
Proportioned: 19-Mar-14
Port Aggregates Leesville, La

1. MIXTURE PROPORTIONS

Material	Aggregate, %		Solid Volume		Mass, S.S.D.		Bulk Sp. Gr.	Absorption,
	by vol.	by wt.	ft^3	m^3	lb/yd^3	kg/m^3	S.S.D.	%
Portland cement			3.405	0.126	669	397	3.15	
Silica Fume				0.004		9	2.25	
Fine aggregate	100.0	100.0	15.174	0.562	2481	1472	2.63	0.50
Batch water			7.290	0.270	455	270	1.0	
Cembinder N8					224.3 fl. oz	8.7 Ltrs		
Water Reducing Admixture					46.7 fl. oz	1.8 Ltrs		
Air			1.026	0.038				
Totals:	100	100	27	1	3620	2148		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2148	134.1
W/(C+M), by weight:	0.665	Cementitious Factor, kg/m^3 (lb/yd^3):	406	669

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c]				
						3-day	7-Day	14-Day	28-Day	
1	9.3	3.8	3.6	136	101.4%	3370	3950	4580	5030	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Grayson concrete sand, Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, Louisiana region
CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas
POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;
Zyla 610, Water Reducing Admixture, Grace Chemical Company

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders
b aggregate correction factor = 0.2 percent applied
c Elkem ES900W Silica fume has been discontinued.
d Specimens cured at 72°F in 100% relative humidity room

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 6ksi Sanded Grout Grayson Concrete Sand
Mixture No. 079-14 vc-T6
Proportioned: 20-Mar-14
Port Aggregates Leesville, La

1. MIXTURE PROPORTIONS

Material	Aggregate, %		Solid Volume		Mass, S.S.D.		Bulk Sp. Gr.	Absorption,
	by vol.	by wt.	ft^3	m^3	lb/yd^3	kg/m^3	S.S.D.	%
Portland cement			3.424	0.127	673	400	3.15	
Silica Fume				0.004		9	2.25	
Fine aggregate	100.0	100.0	15.829	0.586	2588	1536	2.63	0.50
Batch water			6.615	0.245	413	245	1.0	
Cembinder N8					225.6 fl. oz	8.7 Ltrs		
Water Reducing Admixture					48.2 fl. oz	1.9 Ltrs		
High Range Water Reducing Admixture					20.6fl. oz	0.8 Ltrs		
Air			1.026	0.038				
Totals:	100	100	27	1	3689	2189		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2189	136.7
W/(C+M), by weight:	0.600	Cementitious Factor, kg/m^3 (lb/yd^3):	408	673

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c]				
						3-day	7-Day	14-Day	28-Day	
1	7.5	8.7	8.5	129.6	94.8%	3420	3880	4340	4740	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Grayson concrete sand, Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, Louisiana region
CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas
POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;
Zyla 610, Water Reducing Admixture, Grace Chemical Company; ADVA 190, High Range Water Reducing Admixture, W. R. Grace

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders
b aggregate correction factor = 0.2 percent applied
c Elkem ES900W Silica fume has been discontinued.
d Specimens cured at 72°F in 100% relative humidity room

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 6ksi Sanded Grout Grayson Concrete Sand
Mixture No. 079-14 vc-T7
Proportioned: 20-Mar-14
Port Aggregates Leesville, La

1. MIXTURE PROPORTIONS

Material	Aggregate, %		Solid Volume		Mass, S.S.D.		Bulk Sp. Gr.	Absorption,
	by vol.	by wt.	ft^3	m^3	lb/yd^3	kg/m^3	S.S.D.	%
Portland cement			3.394	0.126	667	396	3.15	
Silica Fume				0.004		9	2.25	
Fine aggregate	100.0	100.0	15.590	0.577	2549	1513	2.63	0.50
Batch water			6.885	0.255	430	255	1.0	
Cembinder N8					223.6 fl. oz	8.6 Ltrs		
Water Reducing Admixture					47.8 fl. oz	1.8 Ltrs		
High Range Water Reducing Admixture					20.5fl. oz	0.8 Ltrs		
Air			1.026	0.038				
Totals:	100	100	27	1	3661	2173		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2173 135.6
W/(C+M), by weight:	0.630	Cementitious Factor, kg/m^3 (lb/yd^3):	405 667

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c]				
						3-day	7-Day	14-Day	28-Day	
1	9.5	6.9	6.7	130.8	96.4%	3470	3830	4320	4810	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Grayson concrete sand, Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, Louisiana region
CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas
POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;
Zyla 610, Water Reducing Admixture, W. R. Grace; ADVA 190 High Range Water Reducing Admixture, W. R. Grace

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders
b aggregate correction factor = 0.2 percent applied
c Elkem ES900W Silica fume has been discontinued.
d Specimens cured at 72°F in 100% relative humidity room

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 6ksi Sanded Grout — Grayson Concrete Sand
Mixture No. 079-14 vc-T8
Proportioned: 20-Mar-14
Port Aggregates Leesville, La

1. MIXTURE PROPORTIONS

Material	Aggregate, % by vol.	Aggregate, % by wt.	Solid Volume ft^3	Solid Volume m^3	Mass, S.S.D. lb/yd^3	Mass, S.S.D. kg/m^3	Bulk Sp. Gr. S.S.D.	Absorption, %
Portland cement			3.733	0.138	734	435	3.15	
Fine aggregate	100.0	100.0	15.680	0.581	2564	1522	2.62	0.50
Batch water			6.561	0.243	409	243	1.0	
Cembinder N8					384.9 fl. oz	14.9 Ltrs		
Water Reducing Admixture					51.4 fl. oz	2 Ltrs		
High Range Water Reducing Admixture					198.2fl. oz	7.7 Ltrs		
Defoamer					5.2fl. oz	0.2 mL		
Air			1.026	0.038				
Totals:	100	100	27	1	3707	2200		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2200 137.3
W/(C+M), by weight:	0.558	Cementitious Factor, kg/m^3 (lb/yd^3):	435 734

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c] 3-day	7-Day	14-Day	28-Day	
1	10.0	3.2	3	140	101.9%	6150	7260	7900	8160	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Grayson concrete sand, Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, Louisiana region
CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas
POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;
Zyla 610, Water Reducing Admixture, W. R. Grace; ADVA 190 High Range Water Reducing Admixture, W. R. Grace

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders
b aggregate correction factor = 0.2 percent applied
c Elkem ES900W Silica fume has been discontinued.
d Specimens cured at 72°F in 100% relative humidity room

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 6ksi Sanded Grout — Grayson Concrete Sand

Mixture No. 080-14 vc-T9

Proportioned: 21-Mar-14

Port Aggregates Leesville, LA

1. MIXTURE PROPORTIONS

Material	Aggregate, % by vol.	Aggregate, % by wt.	Solid Volume ft^3	Solid Volume m^3	Mass, S.S.D. lb/yd^3	Mass, S.S.D. kg/m^3	Bulk Sp. Gr. S.S.D.	Absorption, %
Portland cement			3.779	0.140	743	441	3.15	
Silica Fume				0.005		11	2.25	
Fine aggregate	100.0	100.0	15.281	0.566	2499	1483	2.63	0.50
Batch water			6.777	0.251	423	251	1.0	
Cembinder N8					671.5 fl. oz	26 Ltrs		
Water Reducing Admixture					53.4 fl. oz	2.1 Ltrs		
High Range Water Reducing Admixture					173fl. oz	6.7 Ltrs		
Defoamer					5.4fl. oz	0.21 Ltrs		
Air			1.026	0.038				
Totals:	100	100	27	1	3684	2186		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2186 136.5
W/(C+M), by weight:	0.555	Cementitious Factor, kg/m^3 (lb/yd^3):	452 743

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c] 3-day	7-Day	14-Day	28-Day	
1	9.5	3.1	2.9	138	101.1%	5160	6230	7220	8020	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Grayson concrete sand, Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, Louisiana region

CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas

POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;

Zyla 610, Water Reducing Admixture, W. R. Grace; ADVA 190 High Range Water Reducing Admixture, W. R. Grace

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders

b aggregate correction factor = 0.2 percent applied

c Elkem ES900W Silica fume has been discontinued.

d Specimens cured at 72°F in 100% relative humidity room

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 6ksi Sanded Grout — Grayson Concrete Sand
Mixture No. 080-14 vc-T10
Proportioned: 21-Mar-14
Port Aggregates Leesville, La

1. MIXTURE PROPORTIONS

Material	Aggregate, % by vol.	Aggregate, % by wt.	Solid Volume ft^3	Solid Volume m^3	Mass, S.S.D. lb/yd^3	Mass, S.S.D. kg/m^3	Bulk Sp. Gr. S.S.D.	Absorption, %
Portland cement			3.518	0.130	692	410	3.15	
Silica Fume				0.007		15	2.25	
Fine aggregate	100.0	100.0	15.602	0.578	2551	1514	2.63	0.50
Batch water			6.669	0.247	416	247	1.0	
Cembinder N8					564.6 fl. oz	21.8 Ltrs		
Water Reducing Admixture					50.2 fl. oz	1.9 Ltrs		
High Range Water Reducing Admixture					217fl. oz	8.4 Ltrs		
Defoamer					5.3fl. oz	0.2 Ltrs		
Retarder					20.8fl. oz	0.8 Ltrs		
Air			1.026	0.038				
Totals:	100	100	27	1	3685	2187		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2188 136.6
W/(C+M), by weight:	0.580	Cementitious Factor, kg/m^3 (lb/yd^3):	426 692

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c] 3-day	7-Day	14-Day	28-Day	
1	11.0	2.1	1.9	138.8	101.6%	5140	6380	7250	8630	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Grayson concrete sand, Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, Louisiana region
CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas
POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;
Zyla 610, Water Reducing Admixture, W. R. Grace; ADVA 190 High Range Water Reducing Admixture, W. R. Grace

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders
b aggregate correction factor = 0.2 percent applied
c Elkem ES900W Silica fume has been discontinued.
d Specimens cured at 72°F in 100% relative humidity room

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 6ksi Sanded Grout Grayson Concrete Sand

Mixture No. 083-14 vc-T11

Proportioned: 24-Mar-14

Port Aggregates Leesville, La

1. MIXTURE PROPORTIONS

Material	Aggregate, %		Solid Volume		Mass, S.S.D.		Bulk Sp. Gr.	Absorption,
	by vol.	by wt.	ft^3	m^3	lb/yd^3	kg/m^3	S.S.D.	%
Portland cement			3.392	0.126	667	396	3.15	
Silica Fume				0.007		15	2.25	
Fine aggregate	100.0	100.0	15.087	0.559	2467	1464	2.63	0.50
Batch water			7.317	0.271	457	271	1.0	
Cembinder N8					499 fl. oz	19.3 Ltrs		
Water Reducing Admixture					48.4 fl. oz	1.9 Ltrs		
High Range Water Reducing Admixture					103.8fl. oz	4 Ltrs		
Defoamer					5.1fl. oz	0.2 Ltrs		
Retarder					26.7fl. oz	1 Ltrs		
Air			1.026	0.038				
Totals:	100	100	27	1	3615	2146		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2147 134.0
W/(C+M), by weight:	0.660	Cementitious Factor, kg/m^3 (lb/yd^3):	411 667

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c]				
						3-day	7-Day	14-Day	28-Day	
1	10.5	1.8	1.6	136.8	102.1%	3740	4480	5250	6020	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Grayson concrete sand, Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, Louisiana region

CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas

POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;

Zyla 610, Water Reducing Admixture, W. R. Grace; ADVA 190 High Range Water Reducing Admixture, W. R. Grace

Retarder, Recover, W.R. Grace

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders

b aggregate correction factor = 0.2 percent applied

c Elkem ES900W Silica fume has been discontinued.

d Specimens cured at 72°F in 100% relative humidity room

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 6ksi Sanded Grout Grayson Concrete Sand
Mixture No. 083-14 vc-T12
Proportioned: 24-Mar-14
Port Aggregates Leesville, La

1. MIXTURE PROPORTIONS

Material	Aggregate, %		Solid Volume		Mass, S.S.D.		Bulk Sp. Gr.	Absorption,
	by vol.	by wt.	ft^3	m^3	lb/yd^3	kg/m^3	S.S.D.	%
Portland cement			3.396	0.126	668	396	3.15	
Silica Fume				0.007		15	2.25	
Fine aggregate	100.0	100.0	15.406	0.571	2519	1495	2.63	0.50
Batch water			6.993	0.259	436	259	1.0	
Cembinder N8					499.6 fl. oz	19.3 Ltrs		
Water Reducing Admixture					48.5 fl. oz	1.9 Ltrs		
High Range Water Reducing Admixture					124.7fl. oz	4.8 Ltrs		
Defoamer					4.9fl. oz	0.19 Ltrs		
Retarder					26.7fl. oz	1 Ltrs		
Air			1.026	0.038				
Totals:	100	100	27	1	3648	2165		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2166 135.2
W/(C+M), by weight:	0.630	Cementitious Factor, kg/m^3 (lb/yd^3):	411 668

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c]				
						3-day	7-Day	14-Day	28-Day	
1	10.5	2.3	2.1	136.8	101.2%	3760	4670	5350	6230	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Grayson concrete sand, Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, Louisiana region
CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas
POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;
Zyla 610, Water Reducing Admixture, W. R. Grace; ADVA 190 High Range Water Reducing Admixture, W. R. Grace
Retarder, Recover, W.R. Grace

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders
b aggregate correction factor = 0.2 percent applied
c Elkem ES900W Silica fume has been discontinued.
d Specimens cured at 72°F in 100% relative humidity room

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 6ksi Sanded Grout Grayson Concrete Sand
Mixture No. 083-14 vc-T13
Proportioned: 24-Mar-14
Port Aggregates Leesville, La

1. MIXTURE PROPORTIONS

Material	Aggregate, %		Solid Volume		Mass, S.S.D.		Bulk Sp. Gr.	Absorption,
	by vol.	by wt.	ft^3	m^3	lb/yd^3	kg/m^3	S.S.D.	%
Portland cement			3.402	0.126	669	397	3.15	
Silica Fume				0.007		15	2.25	
Fine aggregate	100.0	100.0	14.833	0.549	2425	1439	2.63	0.50
Batch water			7.560	0.280	472	280	1.0	
Cembinder N8					552.3 fl. oz	21.4 Ltrs		
Water Reducing Admixture					48.6 fl. oz	1.9 Ltrs		
High Range Water Reducing Admixture					83.3fl. oz	3.2 Ltrs		
Defoamer					5.3fl. oz	0.21 Ltrs		
Retarder					7fl. oz	0.3 Ltrs		
Air			1.026	0.038				
Totals:	100	100	27	1	3591	2131		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2131	133.1
W/(C+M), by weight:	0.680	Cementitious Factor, kg/m^3 (lb/yd^3):	412	669

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c]				
						3-day	7-Day	14-Day	28-Day	
1	10.3	1.9	1.7	135.6	101.9%	3230	4190	5070	5700	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Grayson concrete sand, Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, Louisiana region
CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas
POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;
Zyla 610, Water Reducing Admixture, W. R. Grace; ADVA 190 High Range Water Reducing Admixture, W. R. Grace
Retarder, Recover, W.R. Grace

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders
b aggregate correction factor = 0.2 percent applied
c Elkem ES900W Silica fume has been discontinued.
d Specimens cured at 72°F in 100% relative humidity room

B.2 7 ksi grout trial mixtures

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 6ksi Sanded Grout — Trinity Concrete Sand
Mixture No. 070-15 7Ksi Grout-T1
Proportioned: 11-Mar-15
Port Aggregates Leesville, La

NO CYLINDERS CAST - MIX HAD AGGREGATE FALL OUT

1. MIXTURE PROPORTIONS

Material	Aggregate, %		Solid Volume		Mass, S.S.D.		Bulk Sp. Gr.	Absorption,
	by vol.	by wt.	ft^3	m^3	lb/yd^3	kg/m^3	S.S.D.	%
Portland cement			3.745	0.139	736	437	3.15	
Silica Fume				0.005	19	11	2.25	
Fine aggregate	100.0	100.0	15.316	0.567	2504	1486	2.63	0.50
Batch water			6.777	0.251	423	251	1.0	
Cembinder N8					665.5 fl. oz	25.7 Ltrs		
High Range Water Reducing Admixture					166.2fl. oz	6.4 Ltrs		
Defoamer								
Retarder								
Air			1.026	0.038				
Totals:	100	100	27	1	3683	2185		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2185 136.4
W/(C+M), by weight:	0.560	Cementitious Factor, kg/m^3 (lb/yd^3):	448 755

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c] 3-day	7-Day	14-Day	28-Day	
1	0.0	0	-0.2	0	0.0%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Grayson concrete sand, Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, Louisiana region
CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas
POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;
Zyla 610, Water Reducing Admixture, W. R. Grace; ADVA 190 High Range Water Reducing Admixture, W. R. Grace
Retarder, Recover, W.R. Grace

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders
b aggregate correction factor = 0.2 percent applied
c Elkem ES900W Silica fume has been discontinued.
d Specimens cured at 72°F in 100% relative humidity room

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 6ksi Sanded Grout Trinity Concrete Sand

70-15 7ksi Grout VC-T2

Proportioned: 11-Mar-15

Port Aggregates Leesville, La

1. MIXTURE PROPORTIONS

Material	Aggregate, %		Solid Volume		Mass, S.S.D.		Bulk Sp. Gr.	Absorption,
	by vol.	by wt.	ft^3	m^3	lb/yd^3	kg/m^3	S.S.D.	%
Portland cement			3.745	0.139	736	437	3.15	
Silica Fume				0.005	19	11	2.25	
Fine aggregate	100.0	100.0	15.316	0.567	2504	1486	2.63	0.50
Batch water			6.777	0.251	423	251	1.0	
Cembinder N8					665.5 fl. oz	25.7 Ltrs		
Water Reducing Admixture					75.5 fl. oz	2.9 Ltrs		
High Range Water Reducing Admixture					32.5fl. oz	1.3 Ltrs		
Defoamer								
Retarder								
Air			1.026	0.038				
Totals:	100	100	27	1	3683	2185		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2185 136.4
W/(C+M), by weight:	0.560	Cementitious Factor, kg/m^3 (lb/yd^3):	448 755

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c]				
						3-day	7-Day	14-Day	28-Day	
1	10.5	4.2	4	135.2	99.1%	4250	5040	6130	6390	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Grayson concrete sand, Larry Grayson & Son Trucking in the greater Alexandria/Woodworth, Louisiana region

CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas

POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;

Zyla 610, Water Reducing Admixture, W. R. Grace; ADVA 190 High Range Water Reducing Admixture, W. R. Grace

Retarder, Recover, W.R. Grace

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders

b aggregate correction factor = 0.2 percent applied

c Elkem ES900W Silica fume has been discontinued.

d Specimens cured at 72°F in 100% relative humidity room

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 7ksi Sanded Grout Trinity Concrete Sand

Mixture No. 082-15 7Ksi Grout-T3

Proportioned: 23-Mar-15

Port Aggregates Leesville, La

1. MIXTURE PROPORTIONS

Material	Aggregate, %		Solid Volume		Mass, S.S.D.		Bulk Sp. Gr.	Absorption,
	by vol.	by wt.	ft^3	m^3	lb/yd^3	kg/m^3	S.S.D.	%
Portland cement			3.813	0.141	750	445	3.15	
Silica Fume				0.005	19	12	2.25	
Fine aggregate	100.0	100.0	15.246	0.565	2493	1479	2.63	0.50
Batch water			6.777	0.251	423	251	1.0	
Cembinder N8					655.5 fl. oz	25.4 Ltrs		
Water Reducing Admixture								
High Range Water Reducing Admixture					53.8fl. oz	2.1 Ltrs		
Defoamer								
Retarder								
Air			1.026	0.038				
Totals:	100	100	27	1	3685	2187		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2187 136.5
W/(C+M), by weight:	0.550	Cementitious Factor, kg/m^3 (lb/yd^3):	456 769

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c]				
						7-day	14-Day	21-Day	28-Day	
1	10.3	5	4.8	136.4	99.9%	4490	5580	6500	6990	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Trinity concrete sand, obtained from Trinity Materials, Inc. located in Merryville, Louisiana

CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas

POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;

Zyla 610, Water Reducing Admixture, W. R. Grace; ADVA 190 High Range Water Reducing Admixture, W. R. Grace

Retarder, Recover, W.R. Grace

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders

b aggregate correction factor = 0.2 percent applied

c Elkem ES900W Silica fume has been discontinued.

d Specimens cured at 72°F in 100% relative humidity room

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 7ksi Sanded Grout Trinity Concrete Sand

Mixture No. 091-15 7Ksi Grout-T4

Proportioned: 01-Apr-15

Port Aggregates Leesville, La

1. MIXTURE PROPORTIONS

Material	Aggregate, %		Solid Volume		Mass, S.S.D.		Bulk Sp. Gr.	Absorption,
	by vol.	by wt.	ft^3	m^3	lb/yd^3	kg/m^3	S.S.D.	%
Portland cement			3.842	0.142	755	448	3.15	
Silica Fume				0.000		0	2.25	
Fine aggregate	100.0	100.0	15.355	0.569	2511	1490	2.63	0.50
Batch water			6.777	0.251	423	251	1.0	
Cembinder N8					665.5 fl. oz	25.7 Ltrs		
Water Reducing Admixture					45.3 fl. oz.	1.8 Ltrs		
High Range Water Reducing Admixture					22.7fl. oz	0.9 Ltrs		
Defoamer								
Retarder								
Air			1.026	0.038				
Totals:	100	100	27	1	3689	2189		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2189 136.7
W/(C+M), by weight:	0.560	Cementitious Factor, kg/m^3 (lb/yd^3):	448 755

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c] 7-day	14-Day	21-Day	28-Day	
1	9.0	5.7	5.5	133.6	97.8%	4100	5360	5920	6323	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Trinity concrete sand, obtained from Trinity Materials, Inc. located in Merryville, Louisiana

CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas

POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;

Zyla 610, Water Reducing Admixture, W. R. Grace; ADVA 190 High Range Water Reducing Admixture, W. R. Grace

Retarder, Recover, W.R. Grace

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders

b aggregate correction factor = 0.2 percent applied

c Elkem ES900W Silica fume has been discontinued.

d Specimens cured at 72°F in 100% relative humidity room

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 7ksi Sanded Grout — Trinity Concrete Sand

91-15 7ksi Grout VC T5

Proportioned: 01-Apr-15

Port Aggregates Leesville, La

1. MIXTURE PROPORTIONS

Material	Aggregate, % by vol.	Aggregate, % by wt.	Solid Volume ft^3	Solid Volume m^3	Mass, S.S.D. lb/yd^3	Mass, S.S.D. kg/m^3	Bulk Sp. Gr. S.S.D.	Absorption, %
Portland cement			4.112	0.152	809	480	3.15	
Silica Fume				0.006	21	12	2.25	
Fine aggregate	100.0	100.0	14.936	0.553	2443	1449	2.63	0.50
Batch water			6.777	0.251	389	251	1.0	
Cembinder N8					730.8 fl. oz.	28.3 Ltrs		
Water Reducing Admixture					83.0 fl. oz.	3.2 Ltrs		
High Range Water Reducing Admixture					41.5 fl. oz.	1.6 Ltrs		
Defoamer								
Retarder								
Air			1.026	0.038				
Totals:	100	100	27	1	3694	2192		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2186 136.4
W/(C+M), by weight:	0.510	Cementitious Factor, kg/m^3 (lb/yd^3):	492 830

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c] 7-day	14-Day	21-Day	28-Day	
1	9.5	5.5	5.3	134.4	98.5%	4910	6570	7420	7630	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Trinity concrete sand, obtained from Trinity Materials, Inc. located in Merryville, Louisiana

CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas

POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;

Zyla 610, Water Reducing Admixture, W. R. Grace; ADVA 190 High Range Water Reducing Admixture, W. R. Grace

Retarder, Recover, W.R. Grace

REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders

b aggregate correction factor = 0.2 percent applied

c Elkem ES900W Silica fume has been discontinued.

d Specimens cured at 72°F in 100% relative humidity room

REPORT OF CONCRETE MIXTURE PROPORTIONS

Project: Fort Polk 7ksi Sanded Grout — Trinity Concrete Sand
91-15 7ksi Grout VC T6
Proportioned: 01-Apr-15
Port Aggregates Leesville, La

1. MIXTURE PROPORTIONS

Material	Aggregate, % by vol.	Aggregate, % by wt.	Solid Volume ft^3	Solid Volume m^3	Mass, S.S.D. lb/yd^3	Mass, S.S.D. kg/m^3	Bulk Sp. Gr. S.S.D.	Absorption, %
Portland cement			3.745	0.139	736	437	3.15	
Silica Fume				0.005	19	11	2.25	
Fine aggregate	100.0	100.0	15.317	0.567	2505	1486	2.63	0.50
Batch water			6.777	0.251	332	251	1.0	
Cembinder N8					665.5 fl. oz.	25.7 Ltrs		
Water Reducing Admixture					45.3 fl. oz.	1.8 Ltrs		
High Range Water Reducing Admixture					22.7 fl. oz.	0.9 Ltrs		
Air			1.026	0.038				
Totals:	100	100	27	1	3682	2185		

2. MIXTURE CHARACTERISTICS

S/A, % :by volume	100.0%	Theo. Unit Wt., kg/m^3 (lb/ft^3)	2186 136.4
W/(C+M), by weight:	0.560	Cementitious Factor, kg/m^3 (lb/yd^3):	448 755

3. TEST RESULTS

Batch Number	Slump in.	Air Content %	Air Content %	Unit Weight lb/ft^3	Relative Yield	Unconfined Compressive Strength, MPa (psi) [c] 7-day	14-Day	21-Day	28-Day	
1	6.5	6.6	6.4	133.2	97.6%	4060	5390	6070	6630	

4. MATERIALS:

COARSE AGGREGATE: None

FINE AGGREGATE: Trinity concrete sand, obtained from Trinity Materials, Inc. located in Merryville, Louisiana
CEMENT: Type I/II, Ash Grove Cement Company., Foreman, Arkansas
POZZOLANS: Elkem ES900W silica fume

Admixture: Cembinder N8, AkzoNobel used as a Viscosity Modifying Admixture to help keep sand in suspension;
Zyla 610, Water Reducing Admixture, W. R. Grace; ADVA 190 High Range Water Reducing Admixture, W. R. Grace
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REMARKS:

a Compressive strength tests made on nominal 4 x 8-in. cylinders
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c Elkem ES900W Silica fume has been discontinued.
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Dylan A. Scott, Rudolph A. Andreatta, Wendy R. Long, Brian H. Green, Vincent P. Chiarito, Kirk E. Walker, Clifton P. Rusche, and Christopher N. Downey

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14. ABSTRACT

The Engineer Research and Development Center, Geotechnical and Structures Lab (ERDC-GSL) has used Fort Polk as a large-scale testing site for many years. Many cementitious materials have been developed for design validation testing. These cementitious materials, their constituents, and their mechanical properties often went undocumented, making it difficult for researchers to replicate or draw comparison from previous testing. This report aims to begin a process of detailed cementitious material reports for all research efforts in the region.

The objective of this report is to document the development of a field castable 6 ksi sanded grout mixture and a 7 ksi sanded grout mixture used in experimental testing programs at Fort Polk in January 2014 and February 2015.

GSL required the development of a 6 ksi and 7 ksi mixture for testing scaled bridge columns. The reduced scaling of the test members resulted in very small rebar spacing. These designs lead to the development of very flowable specialized grouts.

This report details the development of this specialized grout for the purpose of aiding future cementitious mixture developments in the region. These results are applicable to efforts where reduced scaling reduces the spacing between scaled reinforcing where all aggregates in the concrete mix would not fit between reinforcing.

15. SUBJECT TERMS

Aggregates (Building materials)—Testing; Fort Polk (La.), Cement composites—Testing; Grout (Mortar)--Testing

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