March 27, 2015

Mr. Jody Wall
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Subject: **Interim Report of ASTM C330**
Carolina Stalite Fine Lightweight Aggregate
TEC Services Project No: 04-0514
TEC Services Sample ID: 14-1001

Dear Mr. Wall:

Testing, Engineering and Consulting Services, Inc. (TEC Services) is an AASHTO R18, ANS/ISO/IEC 17025:2005, and Army Corps of Engineers accredited laboratory. TEC Services is pleased to present this interim report of our testing on the fine lightweight aggregate submitted to our laboratory on November 20, 2014. The results of this testing pertain only to the samples tested. The aggregate was tested in accordance with ASTM C330-14 *Standard Specification for Lightweight Aggregates for Structural Concrete* as authorized by the service agreement (TEC-PRO-04-0514) dated March 29, 2005.

This specification covers lightweight aggregates intended for use in structural concrete in which the prime considerations are reducing the density while maintaining the compressive strength of the concrete. The maximum and minimum requirements for this specification are presented in Section 4 *Chemical Composition* and Section 5 *Physical Properties* of ASTM C330 and are reported in Table 1. Based on the results to date, the Fine lightweight aggregate submitted to our laboratory meets and/or exceeds the requirements of ASTM C330.

Table 1: Summary of Test Results

Section 4 - Chemical Composition	Test Results	ASTM C330 Requirements
Organic Impurities (Color change)	<1	3 (max)
Staining (Stain index)	0	60 (max)
Loss on Ignition	1.10	5% (max)
Section 5 – Physical Properties		
Clay Lumps and Friable Particles (Dry mass)	0.4%	2% (max)
Bulk Density lbs/ft3(kg/m^3)	59 (945)	70 (1121) (max)
Density Factor (Specific Gravity, OD)	1.63	----
Density Factor (Specific Gravity, SSD)	1.88	----
72-hour Absorption	14.9 %	----
Compressive Strength (Based off of Equilibrium Density) psi(MPa)	3,740 (25.8)	2,930 psi (20.2MPa) (min)
Splitting Tensile (Based off of Equilibrium Density) psi/(MPa)	395(2.73)	309 psi (2.13MPa) (min)
Drying Shrinkage	-0.025 %	-0.070 % (max)
Popouts	No Popouts	0
Grading	See Section 5.1.2 Below	
Resistance to Freezing and Thawing	Ongoing	----

Concrete mixtures containing the Fine lightweight aggregate will be batched in order to make test specimens for compressive strength, splitting tensile, drying shrinkage and resistance to freezing and thawing. The material sources and amount of material used in the concrete mix are reported in Table 2. The fresh plastic properties are reported in Table 3.

Concrete Mix Proportions

Table 2: Mix Proportions

Material	Source	Amount Lb. (kg)
Portland Type I/II Cement	Lehigh, Leeds	564 (256)
Fine Lightweight Aggregate	Carolina Stalite	1209 (548)
#57 Standard Aggregate	Vulcan Lithonia	1172 (532)
Air Entrainment	Vinsol Resin	1.95 oz/yd^3
Water Reducer	Type F – High Range	0.25 oz/yd^3
Water	Lawrenceville City Water	315 (143)
	Total	3260 (1479)

Table 3: Fresh Properties

Slump (inches)	4"(100mm)
Unit Weight (lbs/ft^3)	121.3 lbs./ft^3(1943kg/m^3)
Air Content (%)	5.5
Concrete Temperature (°F)	70 (21°C)

Organic Impurities

Organic impurities were determined in accordance with ASTM C40-11 *Standard Test Method for Organic Impurities in Fine Aggregates for Concrete*. The presence of organic impurities were evaluated by comparing the color of the supernatant liquid of the test sample to the Organic Plate Glass Color Standard; if the color of the supernatant liquid is darker than Organic Plate No. 3 the fine aggregate shall be considered to possible contain injurious organic impurities. The fine lightweight aggregate produced a supernatant liquid lighter in color than Organic Plate No. 1 indicating that the aggregate does not contain injurious organic impurities.

Iron Staining

Potential of staining from iron compounds was determined in accordance with ASTM C641-09 *Standard Test Method for Iron Staining Materials in Lightweight Concrete Aggregates*. The visual classification method was used and we determined that the filter paper after test most resembled the staining index of 0 which is the lowest staining reference. The maximum allowed visual staining index allowed by C330 is 60.

Loss on Ignition

The loss on ignition values were determined in accordance with ASTM C114-13. *Standard Test Methods for Chemical Analysis of Hydraulic Cement*. The fine lightweight aggregate had a loss on ignition of 1.10 percent.

Clay Lumps and Friable Particles

Testing for clay lumps and friable particles were determined in accordance with ASTM C142-10 *Standard Test Method for Clay Lumps and Friable Particles in Aggregates*. Test results are reported in Table 4.

Table 4 – Clay Lumps and Friable Particles

Size of Particles Making Up Sample	Grading of Original Sample *(% Retained)*	Mass of Test Fractions Before Test (*g*)	% Passing Designated Sieve After Test	Weighted Percent Loss
Retained on No. 16 (1.18 mm)	47.1	26.4	0.8	0.38
			Total Weighted % Loss	**0.4**

Grading

The grading shall conform to the requirements in table 1 of ASTM C330. The grading and the required grading range are reported in Table 5.

Table 5: Grading and Suggested Range

Sieve Size	% Passing	Required % passing (¾ " to #4)
#8 (2.36mm)	88.2	-
#16 (1.18mm)	52.9	40-80%
#50 (300µm)	20.9	10-35%
#100 (150µm)	12.6	5-25%
#200 (75µm)	7.7	-

Bulk Density (dry-loose)

The dry, loose bulk density of the aggregate was tested in accordance with ASTM C29 - 09 *Standard Test Method for Bulk Density (Unit Weight) & Voids in Aggregate*. The bulk density was determined to be 59 lbs/ft^3 (945 kg/m^3). The maximum bulk density for fine aggregate, allowed in ASTM C330 is 70 lbs/ft (1121 kg/m^3).

Density Factor

The density factor was tested in accordance with ASTM C128-12 *Standard Test Method for Density, Relative Density (Specific Gravity) & Absorption of Fine Aggregate.* The sample was dried to a constant mass and soaked for 72 hours. The specific gravity and absorption is reported in Table 6.

Table 6: Specific Gravity & Absorption

Specific Gravity (OD)	Specific Gravity (SSD)	72-hour Absorption (%)
1.63	1.88	14.9

Calculated Equilibrium Density

The oven-dry density of the concrete mixture was calculated by the mixture quantities, aggregate moisture content, and the volume of the concrete batch. The calculated equilibrium density of 109.3 lb/ft³ (1789kg/m^3) was calculated by adding 3 lb/ft³ to the calculated oven-dry density. The calculated equilibrium density is used to determine the specification requirements for the compressive and split tensile strengths.

Compressive Strength and Splitting Tensile Strength

Compressive Strength

For a concrete with combinations of normal weight and lightweight aggregates and a calculated equilibrium density of 109.3 lb/ft^3(1751kg/m^3), the minimum compressive strength is 2930 psi (20.2MPa). This was calculated by interpolation from the values presented in Table 7. The specimens tested were 4" x 8" cylinders and the results are reported in Table 8.

Table 7: Equilibrium Density

Calculated Equilibrium Density lbs/ft^3(kg/m^3)	Compressive Strength Requirements Psi (MPa)
109.3 (1,751)	2,930 (20.2)

Table 8: Compressive Strength Results

Sample ID	Compressive Strength Psi (MPa)
14-1001-A	3,720 (25.6)
14-1001-B	3,690 (25.4)
14-1001-C	3,800 (26.2)
Average	**3,740 (25.8)**

Splitting Tensile

Concrete with combinations of normal weight and lightweight aggregates and a calculated equilibrium density of 109.3 lb/ft^3, the minimum splitting tensile strength is 309 psi (2.13MPa). The specimens tested were 6" x 12" cylinders and the results are reported in Table 9.

Table 9: Splitting Tensile Strength Result

Sample ID	Splitting Tensile Strength psi(MPa)
14-1001-1	365 (2.52)
14-1001-2	345 (2.38)
14-1001-3	450 (3.10)
14-1001-4	425 (2.93)
14-1001-5	385 (2.65)
14-1001-6	390 (2.69)
14-1001-7	380 (2.62)
14-1001-8	425 (2.93)
Average	**395 (2.73)**

Drying Shrinkage

Three length change beams (4" x 4" x 11¼") were moist cured for seven days. Upon the completion of the 7 day moist curing an initial reading was obtained, which was used as the base length for the drying shrinkage calculations. The samples were then placed in a curing cabinet maintained at 100 ± 2°F with a relative humidity of 32 ± 2% for 28 days.

Table 9: Drying Shrinkage at 28 Days

Sample ID	Length Change at 28 Days (%)
14-1001 (1)	-0.025
14-1001 (2)	-0.025
14-1001 (3)	-0.026
Average	**-0.025**

Resistance to Freezing and Thawing

The freeze-thaw samples were tested in accordance with ASTM C666-03 (2008) *Resistance of Concrete to Rapid Freezing and Thawing – Procedure A (freezing and thawing in water)* with the curing modifications listed in ASTM C330. The freeze-thaw testing is currently ongoing.

We appreciate the opportunity to provide our services to you on this project. Should you have any questions or comments regarding this report, please feel free to contact us at your convenience

Sincerely,

TESTING, ENGINEERING AND CONSULTING SERVICES, INC.

Steven Maloof
Project Manager

Shawn McCormick
Laboratory Principal