March 27, 2015

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Subject: **Interim Report of ASTM C330**
Carolina Stalite ⅜ Inch Coarse Lightweight Aggregate
TEC Services Project No: 04-0514
TEC Services Sample ID: 14-1000

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 ⅜-inch 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 ⅜-inch 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	0.4	5% (max)
Section 5 – Physical Properties		
Clay Lumps and Friable Particles (Dry mass)	0.1%	2% (max)
Bulk Density lbs/ft3(kg/m^3)	50 (804) (max)	55 (881) (max)
Density Factor (Specific Gravity, OD)	1.47	----
Density Factor (Specific Gravity, SSD)	1.66	----
72-hour Absorption	12.9 %	----
Compressive Strength (Based off of Equilibrium Density) psi(MPa)	4,350 (29.9)	3400psi (23.4MPa) (min)
Splitting Tensile (Based off of Equilibrium Density) psi/(MPa)	390 (2.69)	317psi (2.18MPa) (min)
Drying Shrinkage	-0.013 %	-0.070 % (max)
Popouts	No Popouts	0
Grading	See Section 5.1.2 Below	
Resistance to Freezing and Thawing	Ongoing	----

Concrete mixtures containing the ⅜-inch 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 Aggregate	Lambert, Natural Sand	1333 (605)
3/8-inch Lightweight Aggregate	Carolina Stalite	980 (444)
Air Entrainment	Vinsol Resin	1.85 oz/yd³
Water Reducer	Type F – High Range	1.57 oz/yd³
Water	Lawrenceville City Water	295 (134)
	Total	3172 (1439)

Table 3: Fresh Properties

Slump (inches)	3”(75mm)
Unit Weight (lbs/ft^3)	116.5 lbs./ft^3(1866kg/m^3)
Air Content (%)	6.25
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 ⅜-inch 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 ⅜-inch lightweight aggregate had a loss on ignition of 0.4 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
⅜ to No. 4 (9.5 to 4.75 mm)	80.1	1002.7	1002.0	0.06
			Total Weighted % Loss	**0.1**

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 (⅜" to #4)
½ in (12.5mm)	100	100%
$^{3}/_{8}$ in (9.5mm)	98.7	80-100%
#4 (4.75mm)	18.6	5-40%
#8 (2.36mm)	6.8	0-20%
#16 (75µm)	5.8	0-10%
#200 (75µm)	4.8	0-10%

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 50 lbs/ft^3 (804 kg/m^3). The maximum bulk density for coarse aggregate, allowed in ASTM C330 is 55 lbs/ft (881 kg/m^3).

Density Factor

The density factor was tested in accordance with ASTM C127-12 *Standard Test Method for Density, Relative Density (Specific Gravity) & Absorption of Coarse 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 (%)
1.46	1.656	12.86

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 111.7 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 111.7 lb/ft^3(1789kg/m^3), the minimum compressive strength is 3,340 psi (23.0MPa). 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)
111.7(1770)	3,340(23.0)

Table 8: Compressive Strength Results

Sample ID	Compressive Strength psi(MPa)
14-1000-1	4,140(28.5)
14-1000-2	4,350(29.9)
14-1000-3	4,560(31.4)
Average	**4350(29.9)**

Splitting Tensile

Concrete with combinations of normal weight and lightweight aggregates and a calculated equilibrium density of 111.7 lb/ft^3, the minimum splitting tensile strength is 317 psi (2.19MPa). 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)
14-1000-1	390 (2.69)
14-1000-2	430 (2.96)
14-1000-3	285 (1.96)
14-1000-4	415 (2.86)
14-1000-5	350 (2.41)
14-1000-6	380 (2.62)
14-1000-7	385 (2.65)
14-1000-8	480 (3.31)
Average	**390 (2.69)**

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 (%)
14-1000 (1)	-0.011
14-1000 (2)	-0.012
14-1000 (3)	-0.017
Average	**-0.013**

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