August 7, 2024

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Subject: **Final Report of ASTM C330**
Carolina Stalite ¾ Inch Coarse Lightweight Aggregate
SGS TEC Services Project No: 04-0514
SGS TEC Services Sample ID: 24-363-34

Dear Mr. Hammill:

SGS, Testing Engineering and Consulting Services (SGS, TEC Services) is an AASHTO R18, ANS/ISO/IEC 17025:2017, and an Army Corps of Engineers accredited laboratory. SGS, TEC Services is pleased to present this report of our testing on the ¾-inch lightweight aggregate submitted to our laboratory in February of 2024. The results of this testing pertain only to the samples tested. The aggregate was tested in accordance with ASTM C330-23 *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 5 *Chemical Composition* and Section 6 *Physical Properties* of ASTM C330 and are reported in Table 1. Based on the results, the ¾-inch lightweight aggregate submitted to our laboratory meets and/or exceeds the requirements of ASTM C330.

Table 1: Summary of Test Results

Section 5 - Chemical Composition	Test Results	ASTM C330 Requirements
Organic Impurities (Color change)	**< 1**	3 (max)
Staining (Stain index)	**0**	60 (max)
Loss on Ignition	**0.19**	5% (max)
Section 6 – Physical Properties		
Clay Lumps and Friable Particles (Dry mass)	**0.2 %**	2% (max)
Bulk Density (Loose)	**53 lb/ft^3**	55 lb/ft^3 (max)
Relative Density (Specific Gravity) (Saturated Surface-dry)	**1.53**	----
Relative Density (Specific Gravity) (Oven-Dry)	**1.49**	---
72-Hour Absorption	**4.9**	----
Compressive Strength (Requirement based off Calculated Equilibrium Density)	**4,670**	3,340 psi (min)
Splitting Tensile (Requirement based off Calculated Equilibrium Density)	**455**	317 psi (min)
Drying Shrinkage	**-0.017**	-0.070 % (max)
Popouts	**No Popouts**	No Popouts
Grading	See Section 5.1.2 Below	
Resistance to Freezing and Thawing - Average Relative Dynamic Modulus (%)	**99**	---

Test Results

Organic Impurities

The organic impurities were tested in accordance with ASTM C40-20 *Standard Test Method for Organic Impurities in Fine Aggregates for Concrete*.

Requirement – Lightweight aggregate subjected to the test for organic impurities shall not produce darker color than standard.

Result – The lightweight aggregate **did not show any color change**.

Iron Staining

The staining testing was tested in accordance with ASTM C641-23 *Standard Test Method for Iron Staining Materials in Lightweight Concrete Aggregates.*

Requirement – Lightweight aggregate shall have a stain index of less than sixty.

Result – The lightweight aggregate showed no stain, which indicates an **index of 0.**

Loss on Ignition

The loss of ignition was tested in accordance with ASTM C114-23 *Standard Test Methods for Chemical Analysis of Hydraulic Cement.*

Requirement – Lightweight aggregate shall have a loss of ignition not more than five percent.

Result – The lightweight aggregate had a loss on ignition of **0.19 percent.**

Clay Lumps and Friable Particles

The clay lumps and friable particles was tested in accordance with ASTM C142-17 *Standard Test Method for Clay Lumps and Friable Particles in Aggregates*.

Requirement – The amount of clay lumps and friable particles shall not exceed two percent by dry mass.

Results – The lightweight aggregate had **0.2 percent** clay lumps and friable aggregate.

Grading

The grading was tested in accordance with ASTM C136-19 *Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates*. The grading shall conform to the requirements in Table 1 of ASTM C330. The Grading and the required grading are reported in Table 2.

Table 2: Grading & Required Grading

Sieve Size	% Passing	Required % passing (¾ "to #4)
1 in (25mm)	100.0	100
¾ in (19mm)	98.0	90-100
½ in (12.5mm)	77.1	---
$^{3}/_{8}$ in (9.5mm)	55.3	10 - 50
#4 (4.75mm)	9.3	0-15
#8 (2.36mm)	5.3	---

Bulk Density (Loose)

The oven dried loose bulk density was tested in accordance with Method C-Shoveling of ASTM C29-23 *Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate.*

Requirement – The maximum bulk density (loose) for coarse aggregate is 55 lb/ft^3.

Result – The lightweight aggregate had an average bulk density (loose) of **53 lb/ft^3.**

Specific Gravity & Absorption

The relative density and absorption were tested in accordance with ASTM C127-15 *Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate*. The sample was dried to a constant mass and soaked for 72 hours. The specific gravity and absorption are reported in Table 3.

Table 3: Specific Gravity & Absorption

Absorption after 72-hour Soak (percent)	Relative Density (Specific Gravity) (Oven-Dry)	Relative Density (Specific Gravity) (Saturated Surface-Dry)
4.9	1.49	1.53

Concrete mixtures containing the lightweight aggregate were batched 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 4. Fresh properties are reported in Table 5.

Table 4: Mix Proportions

Material	Source	Amount (pcy)
Portland Type I/II Cement	Cemex, Clinchfield	564
Fine Aggregate	Lambert, Natural Sand	1,415
¾-inch Lightweight Aggregate	Carolina Stalite	903
Air Entrainment	Vinsol Resin	1.2 oz/yd³
Water Reducer	Type F – High Range	4.2 oz/yd³
Water	Lawrenceville City Water	277
	Total	3,159

Table 5: Fresh Properties

Slump (inches)	2.00
Unit Weight (lb/ft^3)	117.2
Air Content (%)	6.50
Concrete Temperature (°F)	73

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 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

The compressive strength was tested in accordance with ASTM C39-21 *Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.*

Requirement – For a concrete with combinations of normal weight and lightweight aggregates and a calculated equilibrium density of 111.7 lb/ft^3, the minimum compressive strength is 3,340 psi. This was calculated by interpolation from the values presented in section 6.2.1 and are reported in Table 6. The specimens tested were 4" x 8" cylinders and the results are reported in Table 7.

Table 6: Compressive & Splitting Tensile Strength Requirements

Calculated Equilibrium Density (lbs/ft^3)	Splitting Tensile Strength Requirements (psi)	Compressive Strength Requirements (psi)
115	330	4,000
110	310	3,000

Table 7: Compressive Strength Results

Sample ID	Compressive Strength (psi)
A	4,530
B	4,770
C	4,770
D	4,590
Average	**4,670**

Splitting Tensile

The splitting tensile strength was tested in accordance with ASTM C496-17 *Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.*

Requirement – For a 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. The specimens tested were 6" x 12" cylinders and the results are reported in Table 8.

Table 8: Splitting Tensile Strength Result

Sample ID	Splitting Tensile Strength (psi)
1	410
2	500
3	495
4	435
5	445
6	435
7	520
8	405
Average	**455**

Drying Shrinkage

The drying shrinkage testing was tested in accordance with C157-17 *Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete* and modified per ASTM C330. 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. Results listed in Table 9.

Requirement – The drying shrinkage of the concrete specimens shall not exceed 0.07% at 28 days.

Table 9: Drying Shrinkage at 28 Days

Sample ID	Length Change at 28 Days (%)
(1)	-0.016
(2)	-0.017
(3)	-0.017
Average	**-0.017**

Popouts

Requirement – There shall be no popouts observed after test concrete made with the tested lightweight aggregate is subjected to an autoclave in accordance with ASTM C151-09 *Standard Test Method for Autoclave Expansion of Hydraulic Cement.*

Result – **No popouts were observed.**

Resistance to Freezing and Thawing

The freeze-thaw samples were tested in accordance with ASTM C666-15 *Resistance of Concrete to Rapid Freezing and Thawing – Procedure A (freezing and thawing in water)* with the curing modifications listed in ASTM C330. Test results are reported in Table 10.

Table 10– Freeze-Thaw Testing – Cast Concrete Samples (3 beams)

Total Cycles Completed	Fundamental Transverse Frequency, khz			Relative Dynamic Modulus (%)			Weight Change (% loss)			Length Change (inches)		
	Beam 1	Beam 2	Beam 3	Beam 1	Beam 2	Beam 3	Beam 1	Beam 2	Beam 3	Beam 1	Beam 2	Beam 3
0	1.997	1.997	1.997	100	100	100	0.0	0.0	0.0	0.0	0.0	0.0
300	1.953	1.997	1.997	96	100	100	0.3	0.2	0.0	0.0	0.0	0.0
Average Relative Dynamic Modulus				**99**			**0.3**			**0.0**		

We appreciate the opportunity of providing our services to you. If you have any questions pertaining to this report or need any additional information, please do not hesitate to call us.

Sincerely,

SGS, TEC SERVICES, INC.

Caleb Howard
Project Manager

James G. McCants III
Laboratory Manager, Chemist