



November 4, 2003

Mr. Jody Wall
Carolina Stalite
P.O. Box 186
Gold Hill, North Carolina 28071

Subject: Freeze Thaw Testing of Concrete Containing $\frac{3}{8}$ " and $\frac{1}{2}$ " Carolina Stalite Aggregates
ASTM C 666-97 *Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing (Procedure A)*
MACTEC Project No. 6136-03-0041
MACTEC Laboratory No. 03-185

Dear Mr. Wall:

MACTEC Engineering and Consulting, Inc. (MACTEC) has completed freeze-thaw testing of test specimens made from two concrete mixtures using light-weight coarse aggregates provided by you. The testing was performed in accordance with ASTM C 666-97 *Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing (Procedure A-Freezing and Thawing in Water)*. The curing process was modified in accordance with ASTM C 330-03 *Standard Specification for Lightweight Aggregates for Structural Concrete* section 8.6 due to the use of lightweight aggregates in the concrete mixtures. The specimens, having nominal dimensions of 3 by 4 by 16 inches, were prepared in MACTEC's laboratory in Atlanta in accordance with ASTM C 192-00 *Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory* following the mix design provided by Carolina Stalite.

Materials in Concrete Mixture

Materials

Type I Cement
Coarse Aggregate
Fine Aggregate
Water
Darex AEA
WRDA 35

Manufacturer

Lafarge Atlanta Plant
Carolina Stalite
Martin Marietta – Waugh AL.
City of Atlanta
Grace Construction Products
Grace Construction Products

Mixture Proportions and Properties:

Mixture ID 1

Cement: **705 lbs**
 $\frac{3}{8}$ inch Coarse Aggregate: **900 lbs**
Fine Aggregate: **1263 lbs**
Water: **317 lbs**
Darex AEA: **0.4 ounces/cwt**
WRDA 35: **4 ounces/cwt**

Slump: **4.25 inches**
Unit Weight: **116.7 pcf**
Air Content: **5.8 %**

Mixture ID 2

Cement: **705 lbs**
 $\frac{1}{2}$ inch Coarse Aggregate: **900 lbs**
Fine Aggregate: **1240 lbs**
Water: **300 lbs**
Darex AEA: **0.4 ounces/cwt**
WRDA 35: **4 ounces/cwt**

Slump: **5 inches**
Unit Weight: **114.3 pcf**
Air Content: **6.75 %**

Test Results:

The results of the testing are listed in the following table:

Mixture ID	Specimen A			Specimen B			Average durability factor (%)	Average mass change (g)
	Durability factor (%)	Initial mass (g)	Mass change (g)	Durability factor (%)	Initial mass (g)	Mass change (g)		
1	99	6005	+26	99	5999	+31	99	+29
2	99	5858	+32	99	5842	+26	99	+29

We appreciate the opportunity to provide our services to you on this project. If you have any questions regarding this report please feel free to contact the undersigned.

Sincerely,

MACTEC ENGINEERING AND CONSULTING, INC.



Shawn P. McCormick
Lab Manager



Jon A. Jonsson
Staff Engineer

July 6, 2005

Mr. Jody Wall
Carolina Stalite
P.O. Box 186
Gold Hill, North Carolina 28071

Phone: 1(704) 279-8614

Subject: **Report of ASTM C 330-04 *Standard Specification for Lightweight Aggregates for Structural Concrete on ¾ Inch Coarse Aggregate***
TEC Services Project No.: 05-0514
TEC Services Sample ID: 05-032

Dear Mr. Wall:

Testing Engineering & Consulting Services Inc. (TEC Services) is pleased to present this report of our testing of ¾ inch lightweight aggregate submitted to our laboratory. The aggregate was tested in accordance to ASTM C 330-04 *Standard Specification for Lightweight Aggregates for Structural Concrete* as authorized by the service agreement (TEC-PRO-04-0514) signed by you on March 29, 2005.

This specification covers lightweight aggregates intended for use in structural concrete in which prime considerations are reducing the density while maintaining the compressive strength of the concrete. ASTM C 330-03 states the maximum and minimum requirements in section 4 *Chemical Composition* and section 5 *Physical Properties*

Summary of Test Results

Section 4 - Chemical Composition	Test Results	ASTM C 330-04 Requirements
Organic Impurities (Color change)	0	3 max
Staining (Stain index)	0	60 max
Loss on Ignition	0.41%	5% max
Section 5 – Physical Properties		
Clay Lumps and Friable Particles (Dry mass)	0.1%	2% max
Bulk Density (Loose)	44 lbs/ft ³	55 lbs/ft ³
Compressive Strength (Based off of Equilibrium Density)	4180 psi	2800 psi
Splitting Tensile (Based off of Equilibrium Density)	355 psi	305 psi
Drying Shrinkage	-0.024	0.07% max
Popouts	0	0
Grading	See Section 5.1.2 Below	
Resistance to Freezing and Thawing	104 %	----

Concrete mixes containing the ¾ inch lightweight aggregate had to be batched in order to make test samples for compressive strength, splitting tensile, drying shrinkage and resistance to

freezing and thawing. Table 2 lists the materials used, source and amounts of materials used in the concrete mix. Table 3 shows the wet properties of each mix.

Concrete Mix Proportions

Table 2: Mix Proportions

Material	Source	Amount (lbs)
Cement	Lafarge	564
Fine Aggregate	Phenix Sand	1400
¾ inch Lightweight Aggregate	Carolina Stalite	875
Water	Lawrenceville City Water	325
Total		3077

Table 3: Wet Properties

Slump, inches	3
Unit Weight, Lbs/ft ³	112.7
Air Content, %	6.5
Temperature, F	72

Test Results

Section 4.1.1 Organic Impurities

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

Result- ¾ inch lightweight aggregate **did not show any color change.**

Section 4.1.2 Staining

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

Result- ¾ inch lightweight aggregate showed **no stain** which indicates an index of zero.

Section 4.1.3 Loss on Ignition

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

Result- ¾ inch lightweight aggregate had a loss on ignition of **0.41 percent.**

Section 5.1.1 Clay Lumps and Friable Particles

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

Results- 3/4 inch lightweight aggregate had **0.1 percent** clay lumps and friable aggregate.

Section 5.1.2 Grading

The grading shall be by mutual agreement between interested parties. The Grading and the suggested range are listed in Table 4.

Table 4: Grading and suggested range

Seive Size	% Retained	% Range Suggested
1 in	100	100
3/4 in	94	90-100
1/2 in	44	
3/8 in	23	10-50
#4	5	0-15
Pan	0	0-10

Section 5.1.4 Bulk Density (Loose)

Requirement- Maximum Bulk density (loose) for fine aggregate is 55 lbs/ft³.

Result- 3/4 inch lightweight aggregate had an average bulk density (loose) of **44 lbs/ft³**.

Equilibrium Density

The equilibrium density of the concrete must be determined in order to determine the requirements for the compressive strength and split tensile. This was performed on the four by eight inch cylinders that were used for the compressive strength. The results of the equilibrium density are presented in Table 5.

Table 5: Equilibrium Density of the Compressive Strength Specimens

Specimen ID	Equilibrium Density, lbs/ft ³
05-032-A	107.9
05-032-B	108.1
05-032-C	108.9
Average	108.3

Section 5.2.1 Compressive Strength and Splitting Tensile Strength

Compressive Strength

Requirement- For a concrete with an equilibrium density of 108.3 lbs/ft³, the minimum compressive strength is 2800 psi. This was calculated by interpolation. The specimens were four by eight cylinders. The range is given in Table 6.

Table 6: Compressive Strength Requirements.

Equilibrium Density, lbs/ft ³	Compressive Strength Requirements, psi
110	3000
105	2500

Results are listed in Table 7.

Table 7: Compressive Strength Results.

Sample ID	Compressive Strength, psi
05-032-A	4110
05-032-B	4330
05-032-C	4090
Average	4180

Splitting Tensile

Requirement- For a concrete with an equilibrium density of 108.3 lbs/ft³, the minimum splitting tensile strength is 305 psi.

Results- The specimen were six by twelve cylinders. The results are listed in Table 8.

Table 8: Splitting tensile strength result.

Sample ID	Splitting Tensile Strength, psi
05-032-1	345
05-032-2	355
05-032-3	330
05-032-4	335
05-032-5	320
05-032-6	405
05-032-7	380
05-032-8	365
Average	355

Section 5.2.3 Drying Shrinkage

Three by three by 11 ¼ inch length change beams were moist cure for seven days. An initial reading was taken at seven days and the samples were then placed in a 50 percent humidity chamber.

Drying shrinkage shall not exceed 0.07 % when compared to the initial reading at seven day moist cure at twenty-eight of shrinkage results are presented in Table 9.

Table 9: Drying Shrinkage at 28 days.

Concrete Age	28 Days
Curing Method	Air Cured
Date	April 13, 2005
Sample ID	Length Change (%)
05-032-A	-0.025
05-032-B	-0.023
Average	-0.024

Section 5.2.4 Popouts

Requirement- There shall be no popouts observed after test concrete made with the tested lightweight is subjected to an autoclave in accordance with ASTM C 151.

Result - **No popouts were observed.**


Section 5.2.5 Resistance to Freezing and Thawing

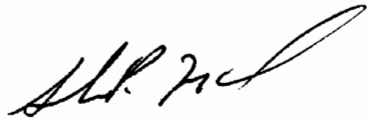
Requirement – Satisfactory performance for intended use.

Results - Relative Dynamic Modulus = 104%

We, at TEC Service, Inc., appreciate Carolina Stalite for selecting us as your independent laboratory. If there are any question please fill free to call.

Sincerely,


Kevin Lee McCray
Senior Technician


Shawn P. McCormick
Lab Manager

July 6, 2005

Mr. Jody Wall
Carolina Stalite
P.O. Box 186
Gold Hill, North Carolina 28071

Phone: 1(704) 279-8614

Subject: **Report of ASTM C 330-03 *Standard Specification for Lightweight Aggregates for Structural Concrete on ½ Inch Coarse Aggregate***
TEC Services Project No.: 05-0514
TEC Services Sample ID: 05-031

Dear Mr. Wall:

Testing Engineering & Consulting Services Inc. (TEC Services) is pleased to present this report of our testing of ½ inch lightweight aggregate submitted to our laboratory. The aggregate was tested in accordance to ASTM C 330-03 *Standard Specification for Lightweight Aggregates for Structural Concrete* as authorized by the service agreement (TEC-PRO-04-0514) signed by you on March 29, 2005.

This specification covers lightweight aggregates intended for use in structural concrete in which prime considerations are reducing the density while maintaining the compressive strength of the concrete. ASTM C 330-03 states the maximum and minimum requirements in section 4 *Chemical Composition* and section 5 *Physical Properties*.

Summary of Test Results

Section 4 - Chemical Composition	Test Results	ASTM C 330-04 Requirements
Organic Impurities (Color change)	0	3 max
Staining (Stain index)	0	60 max
Loss on Ignition	0.23%	5% max
Section 5 – Physical Properties		
Clay Lumps and Friable Particles (Dry mass)	0.1%	2% max
Bulk Density (Loose)	45 lbs/ft ³	55 lbs/ft ³
Compressive Strength (Based off of Equilibrium Density)	3890 psi	2900 psi
Splitting Tensile (Based off of Equilibrium Density)	370 psi	310 psi
Drying Shrinkage	-0.026	0.07% max
Popouts	0	0 max
Grading	See Section 5.1.2 Below	
Resistance to Freezing and Thawing	98 %	----

Concrete mixes containing the ½ inch lightweight aggregate had to be batched in order to make test samples for compressive strength, splitting tensile, drying shrinkage and resistance

to freezing and thawing. Table 2 lists the materials used, source and amounts of materials used in the concrete mix. Table 3 shows the wet properties of each mix.

Concrete Mix Proportions

Table 2: Mix Proportions

Material	Source	Amount (lbs/yd ³)
Cement	Lafarge	564
Fine Aggregate	Phenix Sand	1400
1/2 inch Lightweight Aggregate	Carolina Stalite	875
Water	Lawrenceville City Water	323
Total		2597

Table 3: Wet Properties

Slump, Inches	2.25
Unit Weight, Lbs/ft ³	113.4
Air Content, %	7
Temperature, F	72

Test Results

Section 4.1.1 Organic Impurities

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

Result- 1/2 inch lightweight aggregate **did not show any color change**.

Section 4.1.2 Staining

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

Result- 1/2 inch lightweight aggregate showed **no stain** which indicates an index of zero.

Section 4.1.3 Loss on Ignition

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

Result- 1/2 inch lightweight aggregate had a loss on ignition of **0.23 percent**.

Section 5.1.1 Clay Lumps and Friable Particles

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

Results- 1/2 inch lightweight aggregate had **0.1 percent** clay lumps and friable aggregate.

Section 5.1.2 Grading

The grading shall be by mutual agreement between interested parties. The Grading and the suggested range are listed in Table 4.

Table 4: Grading and suggested range

Seive Size	% Retained	% Range Suggested
3/4 in	100	100
1/2 in	90	90-100
3/8 in	57	40-80
#4	8	0-20
#8	3	0-10
Pan	0	0-10

Section 5.1.4 Bulk Density (Dry Loose)

Requirement- Maximum Bulk density (loose) for fine aggregate is 55 lbs/ft³.

Result- 1/2 inch lightweight aggregate had an average bulk density (loose) of **45 lbs/ft³**.

Equilibrium Density

The equilibrium density of the concrete must be determined in order to determine the requirements for the compressive strength and split tensile. This was performed on the four by eight inch cylinders that were used for the compressive strength. The results of the equilibrium density are presented in Table 5.

Table 5: Equilibrium Density of the compressive strength specimens

Specimen ID	Equilibrium Density, lbs/ft ³
05-031-A	109.2
05-031-B	108.8
05-031-C	108.8
Average	108.9

Section 5.2.1 Compressive Strength and Splitting Tensile Strength

Compressive Strength

Requirement- For a concrete with an equilibrium density of 108.3 lbs/ft³, the minimum compressive strength is 2900 psi. This was calculated by interpolation. The specimens were four by eight cylinders. The range is given in Table 6.

Table 6: Compressive Strength Requirements.

Equilibrium Density, lbs/ft ³	Compressive Strength Requirements, psi
110	3000
105	2500

Results are listed in Table 7.

Table 7: Compressive Strength Results.

Sample ID	Compressive Strength, psi
05-031-A	3930
05-031-B	3860
05-031-C	3890
Average	3890

Splitting Tensile

Requirement- For a concrete with an equilibrium density of 108.3 lbs/ft³, the minimum splitting tensile strength is 310 psi.

Results- The specimen were six by twelve cylinders. The results are listed in Table 8.

Table 8: Splitting tensile strength result.

Sample ID	Splitting Tensile Strength, psi
05-031-1	405
05-031-2	480
05-031-3	330
05-031-4	300
05-031-5	290
05-031-6	405
05-031-7	365
05-031-8	395
Average	370

Section 5.2.3 Drying Shrinkage

Three by three by 11 1/4 inch length change beams are moist cure for seven days. An initial reading is taken at seven days then is placed in a 50 percent humidity chamber.

Drying shrinkage shall not exceed 0.07 % when compared to the initial reading at seven day moist cure at twenty-eight of shrinkage results are presented in Table 9.

Table 9: Drying Shrinkage at 28 days.

Concrete Age	28 Days
Curing Method	Air Cured
Date	April 13, 2005
Sample ID	Length Change (%)
05-032-A	-0.027
05-032-B	-0.026
05-032-C	-0.025
Average	-0.026

Section 5.2.4 Popouts

Requirement- There shall be no popouts observed after test concrete made with the tested lightweight is subjected to an autoclave in accordance with ASTM C 151.

Result- **No popouts were observed.**

Section 5.2.5 Resistance to Freezing and Thawing


Requirement – Satisfactory performance for intended use.

Results - Relative Dynamic Modulus = 98%

We, at TEC Service, Inc., appreciate Carolina Stalite for selecting us as your independent laboratory. If there are any question please fill free to call.

Sincerely,


Kevin Lee McCray
Senior Technician


Shawn P. McCormick
Lab Manager