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## Supplemental Technical Specification for

# Lightweight Aggregates

SCDOT Designation: SC-M-203-5 (7/17)

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### 1.0 DESCRIPTION

1.1 Furnish all necessary materials, loading, hauling, placing and compacting lightweight aggregates (either manufactured or natural) for use as fill materials in accordance with the project plans and this Supplemental Technical Specification. The material requirements presented in this specification are appropriate for borrow materials placed in unreinforced or reinforced embankments; Reinforced Soil Slopes (RSSs); Mechanically Stabilized Earth (MSE walls); or placed as retained materials.

### 2.0 TESTING STANDARDS

2.1 The latest edition of the testing standards indicated in this specification shall be used. Substitution of standards will require the prior written approval of the Materials and Research Engineer (MRE) with concurrence of the Geotechnical Engineer-of-Record (GEOR). The Contractor shall provide copies of all substituted standards to the Resident Construction Engineer (RCE) if requested. The RCE will provide the copies to the MRE and GEOR for approval and concurrence.

### 3.0 MATERIAL

#### 3.1 General

The lightweight aggregate must be either manufactured materials or be naturally occurring. Wood fiber, blast furnace slag, fly ash, shredded tires, expanded polystyrene (EPS), crushed or ground glass or boiler slag will not be allowed. The material must be subangular to angular conforming to ASTM D2488, Table 1. The lightweight aggregate must have a proven record of durability. Lightweight aggregates manufactured from recycled, waste or natural materials shall meet South Carolina Department of Health and Environmental Control (SCDHEC) and the U.S. Environmental Protection Agency (EPA) regulations and standards as a non-hazardous material. Lightweight aggregates shall meet the limits established by the EPA for primary and secondary drinking water standards. Lightweight aggregates manufactured using recycled glass shall meet the following requirements:

- Maximum lead content less than 5 parts per million (ppm)
- Maximum silver content less than 5 ppm

Lightweight aggregate materials shall consist of 2 general types: coarse lightweight aggregate and fine lightweight aggregate.

#### 3.2 Coarse Lightweight Aggregate

3.2.1 The coarse lightweight aggregates shall meet the requirements for aggregates having Size Nos. 3, 4, 5, 57, and 67 as defined in ASTM D448. In addition, aggregate meeting the

requirements of 6M as defined in the SCDOT Standard Construction Specifications (latest edition) may be used.

3.2.2 In addition, the coarse lightweight aggregate shall conform to the following requirements:

- Organic Content (ASTM D2974 (AASHTO T267)): Organic content shall be less than 1.0 percent (weight of organic material to weight of total sample).
- Soundness Loss (ASTM C88 (AASHTO T104)): Soundness loss shall be less than 12 percent for coarse lightweight aggregates when subjected to 5 cycles of Sodium Sulfate. Alternatively, the soundness loss shall be less than 18 percent for coarse lightweight aggregates when subjected to 5 cycles of Magnesium Sulfate.
- Los Angeles Abrasion: Abrasion loss shall be less than 45 percent, use ASTM C535 on No. 3 and 4 coarse lightweight aggregates and use ASTM C131 on No. 5, 57, 6M and 67 coarse lightweight aggregates.
- Dry loose unit weight (ASTM C29 (AASHTO T19)): The dry loose unit weight must be less than 55 lbs/ft<sup>3</sup>. Report the absorption (ASTM C127 (AASHTO T85)).
- In-place density: (ASTM D4253 and D4254): The in-place compacted total unit weight (including any absorbed water) shall be at least 15 lbs/ft<sup>3</sup> and no greater than 65 lbs/ft<sup>3</sup>. Material must be compacted to a minimum 65% relative density as determined by ASTM D4253 and D4254. Use a vibratory table when determining the maximum index density and unit weight in accordance with ASTM D4253. Determine the minimum index density and unit weight in accordance with ASTM D4254. Provide amount of adsorbed water as determined using ASTM C127; however, modify the procedure of ASTM C127 to revise the immersion time from 24 hours to 168 hours (7 days).
- Angle of Internal Friction (ASTM D3080 (AASHTO T236)): The minimum angle of internal friction must be 36 degrees. Test sample shall be compacted to 65% relative density as determined by ASTM D4253 and D4254. The normal force used for this testing shall be 250, 500, 1,000 and 2,000 pounds per square foot (psf).

### 3.3 Fine Lightweight Aggregate

3.3.1 The fine lightweight aggregates shall meet the specification requirements as indicated in the following table.

Sieve Size	Percent Passing
<sup>3</sup> / <sub>4</sub> inch	100.0
No. 4	20.0 – 100.0
No. 40	0.0 – 60.0
No. 100	0.0 – 30.0
No. 200	0.0 – 15.0
<b>Liquid Limit</b>	≤ 30
<b>Plasticity Index</b>	6 max.
<b>Organics</b>	1 max.

3.3.2 The fine lightweight aggregate shall conform to the following requirements:

- Organic Content (ASTM D2974 (AASHTO T267)): Organic content shall be less than 1.0 percent (weight of organic material to weight of total sample).
- Soundness Loss (ASTM C88 (AASHTO T104)): Soundness loss shall be less than 10 percent for fine lightweight aggregates when subjected to 5 cycles of Sodium Sulfate. Alternatively, the soundness loss shall be less than 15 percent for fine lightweight aggregates when subjected to 5 cycles of Magnesium Sulfate.
- Los Angeles Abrasion (ASTM C131): Abrasion loss shall be less than 45 percent.
- Dry loose unit weight (ASTM C29 (AASHTO T19)): The dry loose unit weight must be less than 65 lbs/ft<sup>3</sup>. Report the absorption (ASTM C127 (AASHTO T85)).
- In-place density: (ASTM D4253, and D4254): The in-place compacted total unit weight (including any absorbed water) shall be at least 20 lbs/ft<sup>3</sup> and no greater than 70 lbs/ft<sup>3</sup>. Material must be compacted to a minimum 65% relative density as determined by ASTM D4253 and D4254. Use a vibratory table when determining the maximum index density and unit weight in accordance with ASTM D4253. Determine the minimum index density and unit weight in accordance with ASTM D4254. Provide amount of adsorbed water as determined using ASTM C128; however, modify the procedure of ASTM C128 to revise the immersion time from 24 hours to 168 hours (7 days).
- Angle of Internal Friction (ASTM D3080 (AASHTO T236)): The minimum angle of internal friction must be 32 degrees. Test sample shall be compacted to 65% relative density as determined by ASTM D4253 and D4254. The normal force used for this testing shall be 250, 500, 1,000 and 2,000 pounds per square foot (psf).

### **3.4 Special Requirements**

3.4.1 In addition to meeting the requirements for either coarse or fine lightweight aggregates listed above, depending on the proposed application additional testing will be required and is discussed in the following paragraphs.

#### **3.4.2 Reinforced Embankments and RSSs**

3.4.2.1 Internal friction angle shall not be less than the value specified on the plans as determined by the standard direct shear test, ASTM D3080 (AASHTO T236). The normal force to be used during testing will be determined by the GEOR and will be shown on the plans. Test sample shall be compacted to 65% relative density as determined by ASTM D4253 and D4254.

3.4.2.2 If geosynthetic reinforcement is used, pH is the only electro-chemical property required. If metallic reinforcement is used then all of the electro-chemical properties indicated below are required to be met, except as noted.

- pH values between 5.0 and 10.0 for metallic reinforcements, pH values between 3.0 and 9.0 for polyester, and pH values greater than 3.0 for polypropylene and high density polyethylene. Prepare coarse lightweight aggregate samples in accordance with SC-T-143 and test to determine the pH value using ASTM D1293. Prepare and

test fine lightweight aggregate samples in accordance with AASHTO T289 (ASTM D4972).

- Resistivity values shall be greater than 3,000 ohm-cm. If the resistivity value is greater than 5,000 ohm-cm, then chloride and sulfate testing will not be required. Prepare coarse lightweight aggregate samples in accordance with SC-T-143 and test to determine the resistivity value using ASTM D1125. Soak (submerged) fine lightweight aggregates samples in a closed container using either distilled or deionized water for a minimum of 7 days and surface dry immediately prior to conducting resistivity testing. Test fine lightweight aggregate samples in accordance with AASHTO T288 and report either the total mass tested per resistivity reading or the total amount of water added per resistivity reading.
- Chloride values shall be less than 100 ppm. Prepare coarse lightweight aggregate samples in accordance with SC-T-143 and test to determine the chloride content using ASTM D512. Prepare and test lightweight fine aggregate samples in accordance with AASHTO T291.
- Sulfate values shall be less than 200 ppm. Prepare coarse lightweight aggregate samples in accordance with SC-T-143 and test to determine the sulfate content using ASTM D516. Prepare and test fine lightweight aggregate samples in accordance with AASHTO T290 (ASTM C1580).

3.4.2.3 Lightweight aggregates when used to construct either reinforced embankments or RSSs shall have the pullout friction factor,  $F^*$ , and the scale effect correction factor,  $\alpha$ , determined by laboratory testing from pullout tests prior to final acceptance. Use the selected lightweight aggregate and reinforcing material for the pullout tests. Conduct the pullout testing at the confining pressures specified by the GEOR and indicated on the plans. Document the lightweight aggregate's angle of internal friction, gradation,  $F^*$  and  $\alpha$ . The pullout coefficients shall be determined by using the quick effective stress pullout tests (ASTM D6706 - *Measuring Geosynthetic Pullout Resistance in Soil*).

### 3.4.3 MSE Walls

3.4.3.1 Internal friction angle shall not be less than the value specified on the plans as determined by the standard direct shear test, ASTM D3080 (AASHTO T236). The normal force to be used during testing will be determined by the GEOR and will be shown on the plans. Test sample shall be compacted to 65% relative density as determined by ASTM D4253 and D4254.

3.4.3.2 If geosynthetic reinforcement is used pH is only electro-chemical property required. If metallic reinforcement is used then all of the electro-chemical properties indicated below are required to be met, except as noted.

- pH values between 5.0 and 10.0 for metallic reinforcements, pH values between 3.0 and 9.0 for polyester, and pH values greater than 3.0 for polypropylene and high density polyethylene. Prepare coarse lightweight aggregate samples in accordance with SC-T-143 and test to determine the pH value using ASTM D1293. Prepare and test fine lightweight aggregate samples in accordance with AASHTO T289 (ASTM D4972).

- Resistivity values shall be greater than 3,000 ohm-cm. If the resistivity value is greater than 5,000 ohm-cm, then chloride and sulfate testing will not be required. Prepare coarse lightweight aggregate samples in accordance with SC-T-143 and test to determine the resistivity value using ASTM D1125. Soak (submerged) fine lightweight aggregates samples in a closed container using either distilled or deionized water for a minimum of 7 days and surface dry immediately prior to conducting resistivity testing. Test fine lightweight aggregate samples in accordance with AASHTO T288 and report either the total mass tested per resistivity reading or the total amount of water added per resistivity reading.
- Chloride values shall be less than 100 ppm. Prepare lightweight coarse aggregate samples in accordance with SC-T-143 and test to determine the chloride content using ASTM D512. Prepare and test fine lightweight aggregate samples in accordance with AASHTO T291.
- Sulfate values shall be less than 200 ppm. Prepare coarse lightweight aggregate samples in accordance with SC-T-143 and test to determine the sulfate content using ASTM D516. Prepare and test fine lightweight aggregate samples in accordance with AASHTO T290 (ASTM C1580).

3.4.3.3 Lightweight aggregates when used to construct MSE walls shall have the pullout friction factor,  $F^*$ , and the scale effect correction factor,  $\alpha$ , determined by laboratory testing from pullout tests determined prior to final acceptance. Use the selected lightweight aggregate and reinforcing material for the pullout tests. Conduct the pullout testing at the confining pressures specified by the GEOR and indicated on the plans. Document the lightweight aggregate's angle of internal friction, gradation,  $F^*$  and  $\alpha$ . The pullout coefficients shall be determined by using the quick effective stress pullout tests (ASTM D6706 - *Measuring Geosynthetic Pullout Resistance in Soil*).

## 4.0 CONSTRUCTION

4.1 Place the lightweight aggregate in uniform layers no more than 12 inches in depth (loose thickness). Compact the lightweight aggregates to the density required in project plans. Use vibratory plate compactors for coarse lightweight aggregates placed in confined areas where vibratory compacts will not fit. Use vibratory compactors that meet the requirements for the compaction of fine lightweight aggregate. Take all necessary precautions when working on or near the lightweight aggregate to ensure that the material is not over compacted. Do not operate construction equipment, other than for placement and compaction, on the exposed lightweight aggregate. Low ground pressure equipment (D6 LGP or lighter) is recommended for spreading and placing the lightweight aggregate.

## 4.2 Testing Frequency

4.2.1 Test all lightweight aggregate during initial source evaluation or if a change in source is requested. Meet the lightweight aggregate requirements indicated above depending on the anticipated application of the aggregate. Sample lightweight aggregate material once every 2,000 cubic yards and test for gradation. Sample lightweight aggregate material once every 5,000 cubic yards and test for internal friction angle, organic content, electro-chemical testing (if the aggregate is being used in reinforced slopes, RSS or MSE walls). Additional testing will be required if the source of the lightweight aggregate changes or if a variation in the material gradation or composition is observed.

## **5.0 METHOD OF MEASUREMENT**

**5.1** Measure the quantity of lightweight aggregate by the cubic yard (CY) when included in the Contract. The quantity of lightweight aggregate is measured from cross-sections by the method of average-end-areas, complete and accepted.

## **6.0 BASIS OF PAYMENT**

**6.1** Payment is full compensation for obtaining, hauling and placing the lightweight aggregate and all other materials, labor, equipment, tools, supplies and incidentals necessary to satisfactorily complete the work as required in the Plans, Project Specifications and other terms in the Contract.

**6.2** Payment will be made under:

<b>Item No.</b>	<b>Pay Item</b>	<b>Pay Unit</b>
2033020	Borrow Excavation - Lightweight	CY