Expanded Shale, Clay and Slate Institute
Rotary Kiln Structural Lightweight Aggregate

Information Sheet 6660.0
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The Use of Expanded Shale, Clay and Slate Lightweight Aggregates in Granular Geotechnical Fills

For over 50 years Rotary Kiln produced Expanded Shale, Clay & Slate (ESCS) Lightweight Aggregate has been effectively used to solve geotechnical engineering problems and to convert unstable soil into usable land. Lightweight aggregate can reduce the weight of compacted geotechnical fills by up to one-half. It is commonly used behind retaining walls and mechanically stabilized earth (MSE) walls to help reduce both vertical and lateral loads. Where thermal stability is required, lightweight aggregate provides significantly greater thermal resistance compared to soil, sand or gravel fill. This inert, durable, stable, free-draining and environmentally friendly aggregate is extremely easy to handle and provides economical long-term solutions for geotechnical challenges.

Lightweight fill materials are commonly evaluated using the following tests:

AASHTO T288 Standard Test Method for Determining Minimum Laboratory Soil Resistivity

AASHTO T289 Standard Test Method for Determining the pH of Soil for Use in Corrosion Testing

AASHTO T290 Standard Test Method for Determining Water-Soluble Sulfate Ion Content in Soil

AASHTO T291 Standard Test Method for Determining Water-Soluble Chloride Ion Content in Soil

These procedures are designed for testing soils as described in the title of each of the test methods. The test methods do not accurately determine the performance of granular fills. These methods all require the grinding of the submitted material down to a sample that will pass a No. 10 sieve, which does not represent the actual particle size specified or supplied for geotechnical applications. The properties evaluated in these test methods are not appropriate to determine a geotechnical fill's compatibility with earth retention systems found on the market today. Since the backfill material is not a soil, the test methods need appropriate modifications to reflect the use of granular fills. These modifications are outlined below.

Modification to Test Methods for Granular Fills
AASHTO T288
Standard Test Method for Determining Minimum Laboratory Soil Resistivity

ESCSI recommends the use of test methods that are appropriate for aggregates as used in a specific application. The AASHTO T288 test method determines the minimum resistivity of soil in a slurry condition. This condition does not exist in lightweight aggregate fills. Therefore, ESCSI does not recommend T288 for evaluating the resistivity of lightweight aggregate. The most accurate method for determining electrical resistivity is to test under field conditions. For this type of testing use ASTM G 57, "Field Measurement of Soil Resistivity using the Wenner Four-Electrode Method." This test can also be run on stockpiled material at the lightweight aggregate manufacturer's facility. For laboratory evaluation, resistivity testing should utilize a method that evaluates aggregates without modification of particle size or grading, such as ASTM G187 Standard Test Method for Measurement of Soil Resistivity Using the Two-Electrode Soil Box Method, with the modifications shown below in *italics*.

Modification to Test Methods for Granular Fills
ASTM G187
Standard Test Method for Measurement of Soil Resistivity
Using the Two-Electrode Soil Box Method

6. Apparatus

6.2 Two-electrode soil box—Two-electrode soil boxes can be constructed in various sizes provided the inside dimensions are known. Design and construction shall incorporate materials that are durable and capable of being machined appropriately. The two end plate electrodes shall be constructed of a clean, polished corrosion-resistant metal or alloy (that is, AISI Designation Type 304 or 316 Stainless Steel) that will not form a heavy oxide film or otherwise add significant resistance. The body of the soil box shall be constructed of a material that is non-conductive and able to maintain its desired dimensions (polycarbonate plastics). The soil box shall be readily cleanable to avoid contamination by previous samples. *The box shall contain a drain set into the bottom to allow for the drainage of water. The drain shall have an inside diameter of 9.5-mm +/- 2-mm. Minimum volume and dimensions for the resistivity box are noted in Table 1.*

	Minimum Values	
Nominal Maximum Aggregate Size	*Capacity of Measure*	*Height of Box*
mm	*m^3 (L)*	*mm*
12.5	*0.0028 (2.8)*	*37.5*
25.0	*0.0093 (9.3)*	*75.0*
37.5	*0.014 (14)*	*112.5*
75.0	*0.028 (28)*	*225.0*
100.0	*0.070 (70)*	*300.0*
125.0	*0.100 (100)*	*375.0*

TABLE 1
Minimum Dimensions

10. Procedure

10.1 Procure an aggregate sample large enough for testing to accommodate the soil box *used. Refer to ASTM D-75 for the appropriate representative sample size based on the maximum particle size of the aggregate.*

10.2 Examine the sample for the presence of foreign material such as roots, twigs, and so forth, which shall be removed from the sample.

10.3 Sample preparation:

10.3.1 When testing open graded aggregates: Fill the soil box by adding three equal increments of aggregate. Compact each increment as densely as possible by using a jigging procedure by alternately lifting and dropping opposite sides of the soil box a height of 1 inch for 25 cycles, making certain that voids are eliminated. Continue this filling procedure until the soil box is slightly over full with aggregate. Utilizing a straightedge; level off the excess compacted material so that it conforms to the total volume of the soil box. Add the water chosen from Section 7 until the soil box is full. Cover and allow to soak for 24 +/- 1 hour prior to testing. Add water as needed to maintain 100% saturation and help the ionic components of the aggregate go into solution and keep the box full of water prior to testing.

NOTE 1: Other soil box resistivity measurement techniques and equipment are available. More detailed procedures related to the addition of water and compaction of the soil may be employed in controlled laboratory investigations which should be defined in reporting the results. Where resistivity information is included in published information, the measurement techniques used should be defined.

10.4 *Remove the cover.*

10.5 Connect the soil resistance meter to the soil box as shown in Fig. 1.

10.6 *Open the drain on the resistivity box.*

10.7 *Within 30 seconds of the time the water level falls below the base of the soil box record the resistance measurement*. Multiply the measurement value by the appropriate soil box factor to obtain the aggregate resistivity. *This procedure will allow for a resistivity measurement of the aggregate in a saturated-drained condition*.

10.8 When requested to supply as-received sample results perform the same procedures of steps 10.1-10.4 but eliminate the addition of water and soaking.

10.9 The resistance measurement using the two-electrode soil box will include the resistance between the two electrodes and the interface resistance between the sample and the electrode.

Modification to Test Methods for Granular Fills
AASHTO T289
Standard Test Method for Determining the pH of Soil for Use in Corrosion Testing

ESCSI recommends the use of test methods that are appropriate for aggregates as used in a specific application. Testing for pH should utilize a test method that evaluates aggregates without modification of particle size or grading such as South Carolina DOT Test Method SC T 143 shown below. ESCSI's suggested modifications to SC T143 are shown in *italics*.

Method of Preparing Coarse Aggregate Sample for pH and Resistivity Testing in the Laboratory SC T 143

1. Scope

This test method outlines the procedure for preparing a sample of coarse aggregate for the purpose of testing pH and resistivity when used as backfill for MSE walls. A sample weighing 2000 grams is required.

2. Referenced Documents

2.1 ASTM Standards D1125 Standard Test Method for Electrical Conductivity and Resistivity of Water D1293 Standard Test Method for pH of Water

3. Apparatus

3.1 One gallon (3.8 litres) wide-mouth plastic jug with lid

3.2 Coarse filter paper (Fisher Q8 or equivalent)

3.3 Electronic scales or balance

4. Test Specimens

4.1 Select a representative sample of coarse aggregate representing a mass equivalent of 2,000 grams of normal weight aggregate.

*When preparing lightweight aggregates in accordance with testing procedures, it is essential to calculate and prepare the aggregate samples to correlate to the intended **volume** of aggregate to reagent ratio called for in the standard. The ratio of relative densities will adjust the mass to properly reflect the same volume of material.*

M_e*= 2,000 grams* (RD_{LWA}/ RD_{NWA})

M_e *= calculated equivalent mass*

RD_{LWA} *= Relative Density (SSD) of the sample*

RD_{NWA} *= Relative Density (SSD) of Normal weight aggregate = 2.65*

Weigh the calculated equivalent mass M_e *of the ESCS granular fill material for testing. Put the test sample into the 1-gallon jug.*

5. Procedure

5.1. Weigh the coarse aggregate sample to the nearest gram.

5.2 Place the coarse aggregate sample into the 1-gallon jug. Add an equal weight of deionozed or distilled water to the sample and let stand for 30 minutes.

5.3 At the end of the 30 minute period, place the lid on the jug and agitate the mixture for 3 minutes.

5.4 Repeat this agitation at the 2 and 4 hour intervals.

5.5 Upon completion of the 4 hour interval agitation, allow the sample to stand for 20 hours so the solids will settle out.

5.6 At this time, remove a sufficient quantity of the solution and filter through a coarse filter paper to obtain the supernate to be tested for pH according to ASTM D1293.

6. Calculations

None.

7. Report

None.

Modification to Test Methods for Granular Fills
AASHTO T 290
Standard Test Method for Determining Water-Soluble Sulfate Ion Content in Soil

ESCSI recommends modifying T290 as shown below in *italics* when testing open-graded lightweight aggregate.

7. INITIAL PREPARATION OF TEST SAMPLES

7.1 A representative test sample of the amount required to perform the tests shall be obtained with a sampler, or by splitting or quartering. *Aggregates shall be tested as intended for use, without modification of particle size or grading*.

7.2 *Determine the Saturated Surface Dry Relative Density of the sample as outlined in ASTM C127 Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate.*

13. TEST PROCEDURE

13.1 *When preparing lightweight aggregates in accordance with the procedures of AASHTO or ASTM Standard Method of Test, it is essential calculate and prepare the aggregate samples to correlate to the intended* ***volume*** *of aggregate to reagent ratio called for in the standard. The ratio of relative densities will adjust the mass to properly reflect the same volume of material.*

$$M_e = 100 \text{ grams } (RD_{LWA} / RD_{NWA})$$

M_e = *calculated equivalent mass*

RD_{LWA} = Relative Density (SSD) of the sample = calculated value from Section 7.2

RD_{NWA} = Relative Density (SSD) of Normal weight aggregate = 2.65

Weigh the calculated equivalent mass M_e of the ESCS granular fill material for testing. Put the test sample into a 500-mL beaker

13.2 Add 300mL of distilled water. Stir for 60 seconds after placing sample into the beaker and stir for 60 seconds every 15 minute interval. Soak the sample for at least 1.0 hours but no more than 1.25 hours.

14. CALCULATION

14.1 S = grams of sample used

$$\frac{M_e \text{ of ESCS}}{S} = \frac{300\text{mL water}}{30\text{ mL aliquot}}$$

23. TEST PROCEDURE

23.1 *When preparing lightweight aggregates in accordance with the procedures of AASHTO or ASTM Standard Method of Test, it is essential calculate and prepare the aggregate samples to correlate to the intended **volume** of aggregate to reagent ratio called for in the standard. The ratio of relative densities will adjust the mass to properly reflect the same volume of material.*

M_e= 100 grams (RD_{LWA}/ RD_{NWA})

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RD_{LWA} = Relative Density (SSD) of the sample = calculated value from Section 7.2

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Weigh the calculated equivalent mass M_e of the ESCS granular fill material for testing. Put the test sample into a 500-mL beaker

23.2 Add 300mL of distilled water. Stir for 60 seconds after placing sample into the beaker and stir for 60 seconds every 15 minute interval. Soak the sample for at least 1.0 hours but no more than 1.25 hours.

24. CALCULATION

24.1 S = grams of sample used

e.g. $\frac{M_e \textit{ of ESCS}}{S} = \frac{\text{300mL water}}{\text{50 mL aliquot}}$

Modification to Test Methods for Granular Fills
AASHTO T291
Standard Test Method for Determining
Water-Soluble Chloride Ion Content in Soil

ESCSI recommends modifying T290 as shown below in *italics* when testing open-graded lightweight aggregate.

7. INITIAL PREPARATION OF TEST SAMPLES

7.1 A representative test sample of the amount required to perform the tests shall be obtained with a sampler, or by splitting or quartering. *Aggregates shall be tested as intended for use, without modification of particle size or grading.*

7.2 *Determine the Saturated Surface Dry Relative Density of the sample as outlined in ASTM C127 Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate.*

13. TEST PROCEDURE

13.1 *When preparing lightweight aggregates in accordance with the procedures of AASHTO or ASTM Standard Method of Test, it is essential calculate and prepare the aggregate samples to correlate to the intended **volume** of aggregate to reagent ratio called for in the standard. The ratio of relative densities will adjust the mass to properly reflect the same volume of material.*

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Weigh the calculated equivalent mass M_e of the ESCS granular fill material for testing. Put the test sample into a 500-mL beaker

13.2 Add 300mL of distilled water. Stir for 60 seconds after placing sample into the beaker and stir for 60 seconds every 15 minute interval. Soak the sample for at least 1.0 hours but no more than 1.25 hours.

14. CALCULATION

14.1 $\frac{M_e \text{ of ESCS}}{S} = \frac{300\text{mL water}}{30\text{ mL aliquor}}$

22. TEST PROCEDURE

22.1 *When preparing lightweight aggregates in accordance with the procedures of AASHTO or ASTM Standard Method of Test, it is essential calculate and prepare the aggregate samples to correlate to the intended **volume** of aggregate to reagent ratio called for in the standard. The ratio of relative densities will adjust the mass to properly reflect the same volume of material.*

M_e*= 100 grams* (RD_{LWA}/ RD_{NWA})

M_e *= calculated equivalent mass*

RD_{LWA} *= Relative Density (SSD) of the sample = calculated value from Section 7.2*

RD_{NWA} *= Relative Density (SSD) of Normal weight aggregate = 2.65*

Weigh the calculated equivalent mass M_e of the ESCS granular fill material for testing. Put the test sample into a 500-mL beaker

22.2 Add 300mL of distilled water. Stir for 60 seconds after placing sample into the beaker and stir for 60 seconds every 15 minute interval. Soak the sample for at least 1.0 hours but no more than 1.25 hours.

24. CALCULATION

24.1 S = grams of sample used

e.g. $\frac{M_e \text{ of ESCS}}{S} = \frac{300\text{mL water}}{50\text{ mL aliquot}}$