Lightweight Expanded Shale, Clay and Slate Aggregate for Geotechnical Applications

General Information

Compacted fills using Expanded Shale, Clay and Slate (ESCS) lightweight aggregates are approximately half the weight of fills using common materials. The load reduction, coupled with the high internal friction angle of the lightweight aggregate can reduce vertical and lateral forces by more than one-half. ESCS has been used to solve numerous geotechnical engineering problems and to convert soft and unstable soil into usable property. Since ESCS aggregate has high thermal resistivity, it provides durable, inorganic insulation around water and steam lines, and other thermally sensitive elements. ESCS aggregates provide a practical, reliable and economical geotechnical solution.

General Engineering Properties of ESCS 3/4" to No. 4 Aggregate Grading*

Aggregate Property	Measuring Method	Test Method	Commonly Used Specifications for ESCS	Typical Values For ESCS Aggregate	Typical Design Values For Ordinary Fills
Soundness Loss	Magnesium Sulfate	AASHTO T 104	<30%	<6 %	<6 %
Abrasion Resistance	Los Angeles Abrasion	ASTM C 131	<40 %	20 - 40%	10 - 45%
Chloride Content	Chloride Content of Soils	AASHTO T 291	<100 ppm	10 - 70 ppm	
Grading	Sieve Analysis	ASTM C 136	Comment No. 1	Comment No. 1	
Compacted In-Place Bulk Density (Unit Weight)	Density Test	Comment No. 2	<70 lb/ft^3	40 - 65 lb/ft^3 Moist	100-130 lbs/ft^3
Stability (Phi Angle, ϕ)	Direct Shear Test Consolidated Drained Triaxial-Consolidated Drained	ASTM D 3080 Comment 3 Corps of Engineers EM 1110-2-1906 Appendix X Comment 3	Comment No. 3	35° - 45° +	30° - 38° (fine sand - sand & gravel)
Loose Bulk Density (Unit Weight)	Loose	ASTM C 29	Dry <50 lb/ft^3 Saturated <65 lb/ft^3	Dry 30 - 50 lb/ft^3	89 -105 lb/ft^3
pH	pH Meter	AASHTO T 289	5 - 10	7.0 - 10	5 - 10

*For Other Gradings See Comment No. 1

For Metric Conversion See Comment No. 5

Specifying ESCS Geotechnical Fill

Consult your expanded shale, clay or slate producer, preferably during the conceptual design phase of a project, for precise information on aggregate grading, bulk density (unit weight), in-place compacted density, friction angle, thermal conductivity, and placement method. The ESCS producer often has the ability to offer a variety of grading options. Use this versatility to specify the optimum material for any given application. As with ordinary aggregates, the engineering properties of ESCS vary depending on aggregate sources and grading.

Guide Specifications for Lightweight Geotechnical Applications

Aggregate

Lightweight aggregate shall be Expanded Shale, Clay or Slate (ESCS) produced by the rotary kiln process and meeting the requirements of ASTM C 330. Lightweight aggregate shall have a proven record of durability, and be non-corrosive, with the following properties:

Aggregate Physical Properties

A1 Soundness Loss: The maximum soundness loss shall be 30% when tested, with 4 cycles of Magnesium sulfate, in accordance with AASHTO T 104.

A2 Abrasion Resistance: The maximum abrasion loss shall be 40% when tested in accordance with ASTM C 131.

A3 Chloride Content: The maximum chloride content shall be 100 ppm when tested in accordance with AASHTO T 291.

A4 Grading: Aggregate grading comes in a wide variety of sizes and is specified based on performance needs. Grading shall be tested in accordance with ASTM 136. (*See Comment No. 1*)

Project Performance Specification

B1 In-place bulk density (unit weight): The maximum in-place compacted moist density shall be _____ lbs/ft^3 when tested in accordance with the method specified by the engineer. (*See Comment No. 2*)

B2 Stability (Phi angle, Φ): The minimum angle of internal friction Φ shall be _____ degrees when tested in accordance with the method specified by the engineer. (*See Comment No. 3*)

Construction

C1 Method of Construction: Lightweight fill shall be placed in uniform layers. The actual lift thickness, and exact number of passes by equipment used will be determined by the engineer, depending on the project requirements (i.e., stability, compaction, density).

In confined areas vibratory plate compaction equipment shall be used (5 hp to 20 hp) with a minimum of two passes in 6” lifts for a 5 hp plate and 12” lifts for a 20 hp plate.

The contractor shall take all necessary precautions when working adjacent to the lightweight fill to ensure that the material is not over compacted. Construction equipment, other than for placement and compaction, shall not operate on the exposed lightweight fill.

C2 Aggregate loose bulk density (unit weight): The maximum aggregate loose bulk density _____ shall be _____ lbs/ft^3 when tested in accordance with ASTM C 29. (*See Comment No. 4*)

Comments

1. Grading: ESCS aggregates are available in a wide variety of grading, therefore it is essential the specifier contact the ESCS supplier for the gradings that are available in a given location. Some common gradings are 3/4" to No 4, 1/2" to No. 4, 3/8" to No. 8, 3/8" to 0, 2" to 3/4", 2" to 0 or blends of these. ESCS aggregate suppliers can be found on ESCSI's website at **www.escsi.org.**

2. Several methods have been used to determine the in-place moist bulk density (unit weight) of a given aggregate, therefore contact the ESCS producer for recommendation on local practices. The following methods have proven performance:

   A. The lightweight aggregate producer shall submit verification of a compacted moist density of less than _____lb/ft^3 when measured by a one point proctor test conducted in accordance with a modified version of ASTM D 698 "Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort." Because of the cohesionless nature of coarse lightweight aggregate, the standard shall be modified as follows: The aggregate sample shall be placed in a 0.5 cubic foot bucket at the moisture content that the aggregate will be delivered to the jobsite. The sample shall be placed in three equal layers and compacted by dropping a 5.5 pound rammer from a distance of 12 inches 25 times on each layer (AASHTO T-99 modified as above).

   B. Material shall be compacted to a minimum 65% relative density as determined by ASTM 4253 and D 4254. Determine the maximum index density and unit weight by using a vibratory table when tested in accordance with ASTM D 4253. The minimum index density and unit weight is determined when aggregate is tested in accordance with ASTM D 4254.

3. ESCS Lightweight Aggregate has been tested by both Direct Shear and Triaxial test methods. With either method, the phi angle will vary in both ordinary and ESCS fill, depending on test procedure, aggregate grading, particle angularity, amount of compaction and amount of consolidating stress applied during the test. Design and specify the minimum phi angle appropriate for the project design and material(s) that are contemplated for use in the project. Contact the ESCS supplier(s) for specific properties of their materials.

   Direct Shear: The minimum angle of an internal friction shall be tested in accordance with ASTM D 3080 on a saturated representative sample (with particles larger than 0.75 inch removed) and tested in a round or square shear box that is a minimum of 12 inches across. Follow the procedure in D 3080 or shear the box at a rate of 0.01 inches per minute at normal loads of 250, 500 and 1,000 pounds per square foot.

4. For quality control and shipment quantities, the purchaser and supplier should agree on a maximum delivered loose bulk density (unit weight).

5. To convert bulk density (unit weight) in lb/ft^3 to metric kg/m^3, multiply by 16. To convert inches (in) to millimeters (mm) multiply by 25.4.

REFERENCE DOCUMENTS

ASTM Documents:

C 29 Standard Test Method for Unit Weight and Voids in Aggregate.

C 88 Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.

C 131 Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregates by Abrasion and Impact in the Los Angeles Machine.

C 136 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

C 330 Standard Specification for Lightweight Aggregate for Structural Concrete.

D 698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft.-lbf/ft^3 (600 kN-m/m^3).

D 3080 Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions.

D 4253 Standard Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

D 4254 Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

AASHTO Documents:

T 99-01 Standard Method of Test for Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in) Drop

T 104 Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate

T 260 Standard Method of Test for Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials.

T 288 Standard Method of Test for Determining Minimum Laboratory Soil Resistivity.

T 289 Standard Method of Test for Determining ph of Soil for Use in Corrosion Testing

T 291 Standard Method of Test for Determining Water Soluble Chloride Ion Content in Soil

T 290 Standard Method of Test for Determining Water Soluble Sulfate Ion Content in Soil

US Army Corps of Engineers Documents:

Engineer Manual, EM 1110-2-1906 Laboratory Soils Testing. Appendix X, Consolidated Drained Triaxial Test

Additional Information
Expanded Shale, Clay and Slate Institute
801-272-7070 • www.escsi.org