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Standard Guide for Characterization of Inorganic Process Wastes for Use as Structural Fill[1]

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1. Scope

1.1 This guide provides guidance for use of selected process wastes as structural fills by listing representative test methods for predicting and evaluating those physical characteristics of waste that are related to the integrity of fills and to protection of ground and surface waters.

1.2 Table 1 lists references which provide engineering practices and test procedures that may be applied to process waste for use as structural fill.

1.3 This guide includes approaches for the environmental assessment of process wastes prior to application.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C294 Descriptive Nomenclature for Constituents of Concrete Aggregates

C295 Guide for Petrographic Examination of Aggregates for Concrete

C593 Specification for Fly Ash and Other Pozzolans for Use With Lime for Soil Stabilization

C821 Specification for Lime for Use with Pozzolans

D420 Guide to Site Characterization for Engineering Design and Construction Purposes (Withdrawn 2011)[3]

D421 Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants

D422 Test Method for Particle-Size Analysis of Soils

D559 Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures (Withdrawn 2012)[3]

D560 Test Methods for Freezing and Thawing Compacted Soil-Cement Mixtures (Withdrawn 2012)[3]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3))

D854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D1140 Test Methods for Amount of Material in Soils Finer than No. 200 (75-µm) Sieve

D1452 Practice for Soil Exploration and Sampling by Auger Borings

D1556 Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method

D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))

D1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils

D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D1633 Test Methods for Compressive Strength of Molded Soil-Cement Cylinders

D2049 Test Method for Relative Density of Cohesionless Soils (Withdrawn 1984)[3]

D2166 Test Method for Unconfined Compressive Strength of Cohesive Soil

D2167 Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D2434 Test Method for Permeability of Granular Soils (Constant Head)

D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

D2573 Test Method for Field Vane Shear Test in Cohesive Soil

D2664 Test Method for Triaxial Compressive Strength of Undrained Rock Core Specimens Without Pore Pressure Measurements (Withdrawn 2005)[3]

[1] This guide is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.03 on Treatment, Recovery and Reuse.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

D2850 Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils
D2937 Test Method for Density of Soil in Place by the Drive-Cylinder Method
D3080 Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions
D3974 Practices for Extraction of Trace Elements from Sediments
D3987 Test Method for Shake Extraction of Solid Waste with Water
D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D5084 Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
D6938 Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *cemented materials, n*—materials consisting of one or more substances that develop hardness by chemical reaction after placement of the material in a fill.

3.1.2 *coarse material, n*—material coarser than a No. 200 (75-μm) U.S. standard sieve.

3.1.3 *effective coefficient of permeability, n*—the coefficient of permeability that characterizes a fill and is the result of combined materials characteristics and construction techniques including compaction, capping, placement of impermeable layers, etc.

3.1.4 *fill material, n*— material used in the construction of a structural fill.

3.1.5 *fine material, n*— material finer than No. 200 (75-μm) U.S. standard sieve.

3.1.6 *leachate, n*—liquid that has percolated through or passed over a solid waste or other medium and contains dissolved or suspended materials, or both, from the medium.

3.1.7 *process waste, n*—inorganic by-product materials such as mine tailings, culm piles, coal processing conversion and combustion wastes, cement and limekiln dust, by-product gypsum, and chemically treated compositions made from these wastes or waste mixtures.

3.1.8 *structural fill, n*—man-made deposits of solid materials. Examples include backfills, landfills, embankments, earth dams, linings and blankets, foundations, canals, road base, footings, and trenches.

4. Significance and Use

4.1 This practice is intended for inorganic process wastes that can be used as replacements for natural material such as soil or rock suitable for construction applications. Selection of appropriate and feasible fill materials and selection of applicable materials, tests, and specifications to facilitate construction and environmental protection are the responsibility of the design engineer. This practice is intended to encourage wider utilization of waste materials.

5. Determination of Material Characteristics

5.1 Table 1 contains representative test methods recommended for determining and evaluating characteristics of process wastes, of either candidate or in situ fill materials. Appropriate numerical values of materials characteristics will vary depending on design requirements and are selected on the basis of accepted engineering practice and regulatory requirements. Testing of process wastes that may result in chemical reactions or contain cementitious materials should be performed on specimens that have been cured and aged to duplicate in situ conditions as closely as possible. Examples of such test procedures are listed in Table 1 under Cemented Materials. Cured specimens carefully removed from the fill may be used in carrying out the laboratory or field procedures (Table 1). Solubility of the waste material must be suitable for the intended use.

TABLE 1 Representative Test Methods Recommended for Determining and Evaluating Characteristics of Process Wastes Suitable for Fill Construction

Characteristics	Test Methods[A]
General:	
Laboratory Procedures:	
Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soils Constants	D421
Particle-Size Analysis of Soils	D422
Liquid Limit of Soils	D4318
Plastic Limit and Plasticity Index of Soils	D4318
Terminology Relating to Soil, Rock, and Contained Fluids	D653
Moisture-Density Relations of Soils Using 5.5 lb Rammer and 12-in. Drop	D698
Specific Gravity of Soils	D854
Amount of Materials in Soils Finer than the No. 200 Sieve	D1140
Moisture-Density Relations of Soils Using 10 lb. Rammer and 18-in. Drop	D1557
Laboratory Determination of Moisture Content of Soil	D2216
Classification of Soils for Engineering Purposes	D2487
Description of Soils	D2488
Field Procedures:	
Investigating and Sampling Soil and Rock for Engineering Purposes	D420

TABLE 1 *Continued*

Characteristics	Test Methods[A]
Soil Investigation and Sampling by Auger Borings	D1452
Density of Soil In Place by Sand-Cone Method	D1556
Penetration Test and Split-Barrel Sampling of Soils	D1586
Thin-Walled Tube Sampling of Soils	D1587
Density of Soil in Place by Rubber-Balloon Method	D2167
Density of Soil In Place by Drive-Cylinder Method	D2937
In-Place Density and Water Content of Soil and Soil- Aggregate by Nuclear Methods (Shallow Depth)	D6938
Field Permeability Tests in Boreholes	(7)
Materials:	
Coarse Materials:	
Relative Density of Cohesionless Soils	D2049
Permeability of Granular Soils, Constant Head	D2434
Direct Shear Test of Soils under Consolidated Drained Conditions	D3080
Fine Materials:	
Unconfined Compressive Strength of Cohesive Soil	D2166
Permeability of Fine Materials, Falling Head	(5)
Permeability of Fine Materials, Flexible Wall	D5084
Field Vane Shear Test in Cohesive Soil	D2573
Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression	D2850
Cemented Materials:	
Wetting-and-Drying Tests of Compacted Soil-Cement Mixtures	D559
Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures	D560
Compressive Strength of Molded Soil-Cement Cylinders	D1633
Permeability of Fine Materials, Falling Head	(5)
Triaxial Compressive Strength of Undrained Rock Core Specimens Without Pore Pressure Measurements	D2664
Fly Ash and Other Pozzolans for Use with Lime	C593
Lime for Use with Pozzolans	C821
Descriptive Nomenclature for Constituents of Natural Mineral Aggregates	C294
Petrographic Examination of Aggregates for Concrete	C295
Anhydrous Minerals and Organic Materials as Sources of Distress in Concrete, W. C. Hansen	(1)
Reactions of Aggregates Involving Solubility, Oxidation, Sulfates, or Sulfides, Richard C. Mielenz	(2)
The Handbook of Concrete Aggregates—A Petrographic and Technological Evaluation, L. Dolar Mantuani	(3)
Environment	
Extraction Procedures:	
Extraction of Trace Elements with Sediments	D3974
Shake Extraction of Solid Waste with Water	D3987
EPA Extraction Procedure	(6)

[A] Test Methods are ASTM procedures except as noted.

5.2 Some by-product and waste materials contain constituents that may produce volume changes that would not be detected by the standard procedures listed in Table 1. Volume increases may be caused by chemical reactions such as oxidation or hydration and by long-time increases in moisture content. Decreases in volume and loss of stability can result from drying over a long period of time or from the dissolution of soluble constituents. Problems may also result from other effects of chemical and physical weathering processes or from attack by fill constituents on structures with which it is in contact. Wastes that have no prior performance record should be subjected to chemical, geotechnical, and petrographic studies to determine the presence of constituents known to produce such effects. Information helpful in such investigations may be found in Descriptive Nomenclature C294, Guide C295, and in the literature by Hansen (**1**),[4] Mielenz (**2**), and Mantuani (**3**).

6. Construction Practice

6.1 Construction of a fill with process waste should conform to standard practices employed with conventional fill materials. Methods such as those described in the *U.S. Department of the Interior Earth Manual* (**4**) and the *Corps of Engineers Soil Testing Manual* (**5**) are suitable construction practices. Inspection of the fill should be made during construction to ensure that fill construction specifications are fulfilled.

[4] The boldface numbers in parentheses refer to the list of references at the end of this standard.

7. Environmental Considerations

7.1 Unless otherwise preapproved for application as structural fill, all process wastes and process materials under consideration for use as structural fill should be evaluated to assess their environmental impact prior to use. Testing may consist of a combination of batch (shake) extraction, column or percolation test, or tank leach test depending on the specifics of the proposed placement (e.g., fill permeability, fill geometry, water contact mode, infiltration rate, etc). The user is advised to contact local, state and federal environmental agencies about regulations dealing with the testing and evaluation of process wastes and materials for fill application.

7.2 Process wastes identified as hazardous waste or otherwise regulated waste may not be acceptable for use as structural fill. The user is advised to contact local, state, and federal agencies regarding regulations dealing with potential placement of hazardous or regulated material.

7.3 Process wastes and materials that may cause adverse environmental impact when placed as structural fill may not be acceptable as fill materials without additional considerations (e.g., underlayment, leachate collection, monitoring and mitigation processes). If such materials are proven or suspected to result in measureable environmental impact, the user is advised to contact local, state, and federal environmental agencies regarding regulations on testing, evaluation and application.

REFERENCES

(1) Hansen, W. C., " Anhydrous Minerals and Organic Materials as Sources of Distress in Concrete," *Highway Research Record No. 43*, National Research Council/Transportation Research Board, 1983, pp. 1–7.

(2) Mielenz, R. C., " Reactions of Aggregates Involving Solubility, Oxidation, Sulfates, or Sulfides," *Highway Research Record No. 43*, National Research Council/Transportation Research Board, 1983, pp. 8–18.

(3) Mantuani, L. D., *The Handbook of Concrete Aggregates—A Petrographic and Technological Evaluation*, Noyes Publication, Mill Rd., Park Ridge, NJ, 07656, 1983.

(4) *U.S. Department of the Interior, Earth Manual*, (Second Edition), 1974.

(5) Corps of Engineers Soil Testing Manual, 1110-2, 1906.

(6) *Resource Conservation and Recovery Act, Federal Register*, Environmental Protection Agency, EPA Publication No. SW-846, Sept. 13, 1979.

(7) *Field Permeability Tests in Boreholes, U.S. Dept. of Interior, Federal Registar, U.S. Government Printing Office, Superintendent of Documents, Washington, DC.*