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

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1. Scope

1.1 This practice 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 Some process wastes may produce leachate that exceeds environmentally acceptable limits. Special provisions are included to accommodate this class of materials (see 7.2).

2. Referenced Documents

2.1 *ASTM Standards:*

C 294 Descriptive Nomenclature for Constituents of Natural Mineral Aggregate[2]

C 295 Guide for Petrographic Examination of Aggregates for Concrete[2]

C 593 Specification for Fly Ash and Other Pozzolans for Use with Lime[3]

C 821 Specification for Lime for Use with Pozzolans[3]

D 420 Guide to Site Characterization for Engineering, Design, and Construction Purposes[4]

D 421 Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[4]

D 422 Test Method for Particle-Size Analysis of Soils[4]

D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[4]

D 559 Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures[4]

D 560 Test Methods for Freezing and Thawing Compacted Soil-Cement Mixtures[4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[4]

D 698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))[4]

D 854 Test Method for Specific Gravity of Soils[4]

D 1140 Test Method for Amount of Material in Soils Finer Than the No. 200 (75-μm) Sieve[4]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[4]

D 1556 Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method[4]

D 1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))[4]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[4]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[4]

D 1633 Test Method for Compressive Strength of Molded Soil-Cement Cylinders[4]

D 2049 Test Method for Relative Density of Cohesionless Soils[5]

D 2166 Test Method for Unconfined Compressive Strength of Cohesive Soil[4]

D 2167 Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method[4]

D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock[4]

D 2217 Practice for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[4]

D 2434 Test Method for Permeability of Granular Soils (Constant Head)[4]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[4]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[4]

D 2573 Test Method for Field Vane Shear Test in Cohesive Soil[4]

D 2664 Test Method for Triaxial Compressive Strength of Undrained Rock Core Specimens Without Pore Pressure Measurements[4]

D 2850 Test Method for Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression[4]

[1] This practice is under the jurisdiction of ASTM Committee D-34 on Waste Management and is the direct responsibility of Subcommittee D34.06 on Recovery and Reuse.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.01.

[4] *Annual Book of ASTM Standards*, Vol 04.08.

[5] Discontinued—See *1983 Annual Book of ASTM Standards.* Vol 04.08. Replaced by D4253.

D 2922 Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)[4]
D 2937 Test Method for Density of Soil in Place by the Drive-Cylinder Method[4]
D 3017 Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)[4]
D 3080 Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions[4]
D 3974 Practice for Extraction of Trace Elements from Sediments[6]
D 3987 Test Method for Shake Extraction of Solid Waste with Water[7]
D 5084 Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter[8]

3. Terminology

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

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

3.3 *effective coefficient of permeability*—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.

3.4 *fill material*— material used in the construction of a structural fill.

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

3.6 *leachate*—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.

3.7 *process waste*— 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.

3.8 *structural fill*— 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.

[6] *Annual Book of ASTM Standards*, Vol 11.02.
[7] *Annual Book of ASTM Standards*, Vol 11.04.
[8] *Annual Book of ASTM Standards*, Vol 04.09

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	D 421
Particle-Size Analysis of Soils	D 422
Liquid Limit of Soils	D 4318
Plastic Limit and Plasticity Index of Soils	D 4318
Terminology Relating to Soil, Rock, and Contained Fluids	D 653
Moisture-Density Relations of Soils Using 5.5 lb Rammer and 12-in. Drop	D 698
Specific Gravity of Soils	D 854
Amount of Materials in Soils Finer than the No. 200 Sieve	D 1140
Moisture-Density Relations of Soils Using 10 lb. Rammer and 18-in. Drop	D 1557
Laboratory Determination of Moisture Content of Soil	D 2216
Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants	D 2217
Classification of Soils for Engineering Purposes	D 2487
Description of Soils	D 2488
Field Procedures:	

TABLE 1 *Continued*

Characteristics	Test Methods[A]
Investigating and Sampling Soil and Rock for Engineering Purposes	D 420
Soil Investigation and Sampling by Auger Borings	D 1452
Density of Soil In Place by Sand-Cone Method	D 1556
Penetration Test and Split-Barrel Sampling of Soils	D 1586
Thin-Walled Tube Sampling of Soils	D 1587
Density of Soil in Place by Rubber-Balloon Method	D 2167
Density of Soil and Soil-Aggregate in Place by Nuclear Methods	D 2922
Density of Soil In Place by Drive-Cylinder Method	D 2937
Moisture Content of Soil and Soil-Aggregate In Place by Nuclear Methods	D 3017
Field Permeability Tests in Boreholes	**(7)**
Materials:	
Coarse Materials:	
Relative Density of Cohesionless Soils	D 2049
Permeability of Granular Soils, Constant Head	D 2434
Direct Shear Test of Soils under Consolidated Drained Conditions	D 3080
Fine Materials:	
Unconfined Compressive Strength of Cohesive Soil	D 2166
Permeability of Fine Materials, Falling Head	**(5)**
Permeability of Fine Materials, Flexible Wall	D 5084
Field Vane Shear Test in Cohesive Soil	D 2573
Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression	D 2850
Cemented Materials:	
Wetting-and-Drying Tests of Compacted Soil-Cement Mixtures	D 559
Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures	D 560560
Compressive Strength of Molded Soil-Cement Cylinders	D 1633
Permeability of Fine Materials, Falling Head	**(5)**
Triaxial Compressive Strength of Undrained Rock Core Specimens Without Pore Pressure Measurements	D 2664
Fly Ash and Other Pozzolans for Use with Lime	C 593
Lime for Use with Pozzolans	C 821
Descriptive Nomenclature for Constituents of Natural Mineral Aggregates	C 294
Petrographic Examination of Aggregates for Concrete	C 295
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	D 3974
Shake Extraction of Solid Waste with Water	D 3987
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 C 294, Guide C 295, and in the literature by Hansen **(1)**,[9] 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.

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

7. Special Provisions

7.1 Materials having predicted in situ coefficients of permeability less than 1×10^{-7} cm/s and adequate engineering properties, including shear strength, compressibility, soluble salts, etc. (see Table 1, Materials) may be suitable for fill construction when placed a minimum of 5 ft (1.5 m) above the historical high-water table.

7.2 The following provisions apply when process wastes used as fill materials produce concentrations of constituents in the leachate that exceed acceptable limits as determined by Test Method D 3987 or the EPA method **(6)**.

7.2.1 Fills having predicted effective coefficients of permeability greater than 1×10^{-5} cm/s shall have environmentally acceptable underdrain and leachate collection and disposal systems.

7.2.2 Fills having predicted effective coefficients of permeability less than 1×10^{-5} cm/s do not require leachate collection and treatment systems provided that surfaces exposed to the environment are sloped so that the minimum predicted runoff from the surfaces is 90 % of the incident precipitation and provided the materials are placed a minimum of 5 ft (1.5 m) above the historical high-water table where the coefficient of permeability of the subsoil is greater than 1×10^{-5} cm/s.

7.3 In situ monitoring of fill permeability and integrity may be required during and following fill construction to ensure that the performance of the fill as constructed is adequate. The design, implementation, and interpretation of in situ permeability tests shall be accomplished under the direction of the engineer.

NOTE 1—These special provisions are industry standards. The user is advised to contact local, state, and federal environmental agencies about the regulations dealing with the placement of regulated materials outside the limits of a permitted landfill.

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.