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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Practice for Characterizing Fly Ash for Use in Soil Stabilization[1]

This standard is issued under the fixed designation D 5239; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This practice covers procedures for characterizing fly ash to be used in soil stabilization. This practice lists representative test methods for determining the chemical, physical, and cementitious properties of fly ash. A broad guideline is provided in X1 that explains the significance of these properties in soil stabilization.

1.2 The values stated in SI units are to be regarded as the standard. The inch-pound equivalents are shown for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 25 Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime[2]

C 109 Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)[2]

C 114 Test Methods for Chemical Analysis of Hydraulic Cement[2]

C 150 Specification for Portland Cement[2]

C 191 Test Method for Time of Setting of Hydraulic Cement by Vicat Needle[2]

C 265 Test Method for Calcium Sulfate in Hydrated Portland Cement Mortar[2]

C 305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency[2]

C 311 Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete[3]

C 593 Specification for Fly Ash and Other Pozzolans for Use with Lime[2]

C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete[3]

C 821 Specification for Lime for Use with Pozzolans[2]

C 977 Specification for Quicklime and Hydrated Lime for Soil Stabilization[2]

D 653 Terminology Relating to Soil, Rock and Contained Fluids

D 1293 Test Methods for pH of Water[4]

D 3551 Practice for Laboratory Preparation of Soil-Lime Mixtures Using a Mechanical Mixer[5]

3. Terminology

3.1 *Definitions*—Except as follows in 3.2, all definitions are in accordance with Terminology D 653.

3.2 *non self-cementing fly ash*—fly ash produced from the combustion of pulverized or crushed coal. This fly ash has pozzolanic properties and no self-cementing properties.

3.2.1 *self-cementing fly ash*—fly ash produced from the combustion of pulverized or crushed coal. This fly ash, in addition to having pozzolanic properties, sets and hardens by chemical interaction with water and is capable of doing so under water.

3.2.2 *stabilizing admixtures*—admixtures used to improve soil properties such as increased soil freeze-thaw durability, stiffness, and strength; reduction of permeability, plasticity, and swelling; increased control of soil compressibility and moisture.

4. Significance and Use

4.1 This practice is intended for use with fly ash that can be used separately or along with other stabilizing admixtures to improve soil properties.

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization Admixtures.

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

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

[4] *Annual Book of ASTM Standards*, Vol 11.01.

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

*** A Summary of Changes section appears at the end of this standard.**

4.2 The characterization of the physical and chemical properties of the fly ash should assist in the evaluation of the fly ash for soil stabilization.

4.3 This practice is not intended to limit the flexibility of design in soil stabilization. The degree of success attained in soil stabilization is highly dependent on the particular combination of soil, fly ash, and other additives and the construction procedure used. Demonstrated sound engineering procedures that result in appropriate physical characteristics are acceptable. The selection of appropriate materials, applicable tests, acceptance criteria, and specification is the responsibility of the design engineer.

5. Fly Ash Quality Assurance Program

5.1 *Pre-Qualification*—A fly ash is pre-qualified if it is sampled in accordance with Method C 311 and a quality history is made available consisting of six months of recent test results. The type of tests performed and their frequency shall be acceptable to the purchaser.

NOTE—The intent of the quality history is not to accept or reject the fly ash with regard to specified limits but to provide an evaluation of the fly ash and its uniformity.

5.2 *Project*—During the project, spot checking of a pre-qualified fly ash shall occur at the sampling and testing frequency established by the purchaser. A fly ash that is not pre-qualified shall be sampled at the source at a minimum frequency of one sample for each (91 mg) 100 tons made available for sale and be sampled at the job site at a minimum frequency of one sample for every (23 mg) 25 tons. The type of tests performed and their frequency shall be acceptable to the purchaser.

6. Determination of Fly Ash Characteristics

6.1 Determine loss on ignition, moisture, and major oxides in accordance with Method C 311.

6.2 *Free Lime*—Determine the free lime content in fly ash in accordance with available Lime Index Method of Test Method C 25 (Hydrated Lime Procedure).

6.3 *Fineness*—Determine the amount retained when wet sieved on a 45 um (No. 325) sieve in accordance with the procedure described in Method C 311.

6.4 *Self-Cementing Properties*—Determine the self-cementing properties of fly ash by the compressive strength method given in Test Method C 109 except use no sand nor Portland cement and mixtures shall contain fly ash plus tap water at water-to-fly ash weight ratio of 0.35. Test compressive strength at one and seven days. Mix the paste in accordance with Method C 305. Mixing time may have to be modified for quick-setting fly ashes.

6.4.1 *Very Self-Cementing Fly Ash*—Compressive strengths greater than (345 MPa) 500 psi at seven days.

6.4.2 *Moderately Self-Cementing Fly Ash*—Compressive strengths greater than or equal to (70 MPa) 100 psi but less than or equal to (345 MPa) 500 psi at seven days.

6.4.3 *Non Self-Cementing Fly Ash*—Compressive strengths less than (70 MPa) 100 psi at seven days.

6.5 *Lime-Pozzolanic Activity*—Determine the lime-pozzolan strength development in accordance with Specification C 593. For purposes of standardization, the lime must meet Specification C 821.

6.6 *Strength Activity Index with Portland Cement*—Determine the strength activity index with Portland Cement in accordance with Method C 311.

6.7 *Setting Time*—Determine the set of fly ash-water pastes at water-to-fly ash weight ratio of 0.35 by vicat needle in accordance with Test Method C 191.

6.8 *pH*—Determine the pH of the fly ash by adding 20 g fly ash to 80 mL distilled water. Stir the mixture to disperse the fly ash. Leave the covered beaker undisturbed for 2 h and then determine pH in accordance with Test Method D 1293.

6.9 *Sulfates*—Determine water-soluble sulfates in accordance with Test Method C 265 except stir 1 g fly ash into 100 mL distilled water for 2 min and filter and wash the residue thoroughly with 3 to 10 mL aliquots of room temperature water using a rapid-filtering, acid-washed filter paper folded inside a fine-textured acid-washed filter paper.

6.9.1 Determine total sulfate in accordance with Method C 311.

7. Report

7.1 The report of the physical and chemical analysis of the fly ash shall include the sampling date and location, the identity of tests performed, and shall provide a summary of the essential data as outlined in Section 6.

8. Keywords

8.1 fly ash; pozzolan, self-cementing fly ash; soil; soil stabilization

APPENDIX

(Nonmandatory Information)

X1. SOIL STABILIZATION WITH FLY ASH

X1.1 *Non Self-Cementing Fly Ash Stabilization:*

X1.1.1 Non self-cementing fly ash, by itself, has little effect on soil stabilization. It is a poor source of calcium and magnesium ions. The particle size of fly ash may exceed that of the voids in fine-grained soils, precluding its use as a filler. However, this fly ash in poorly graded sandy soils may be a suitable filler and, as such, may aid in compaction, may increase density, and may decrease permeability.

X1.1.2 *Non Self-Cementing Fly Ash Mixed With Cement or Lime*—The advantage of adding fly ash to fine-grained soils, along with cement or lime, is for its pozzolanic properties and improved soil texture. Some clays are pozzolanic in nature and

only require lime to initiate the pozzolanic reaction. The use of this fly ash is suitable with clays requiring lime modification, provided lime is added to promote the pozzolanic reaction. If lime is required, it should be added to the soil 24 h prior to fly ash addition.

X1.2 *Self-Cementing Fly Ash Stabilization:*

X1.2.1 This fly ash is a better source of calcium and magnesium ions although not as good as lime or Portland cement. Self-cementing fly ash contains varying amounts of free (uncombined) lime (0 to 7 % CaO by weight) that can provide cation exchange and ion crowding to fine-grained soils when used in significant amounts. It has been used successfully to control swell potential of expansive soils. It has also been used to stabilize coarse-grained soils.

NOTE X1.1—Though some fly ashes have up to 35 % CaO (elemental chemical analysis), most of the calcium is combined as calcium aluminates, calcium silicates, and calcium sulfate.

X1.2.2 The retardation of some very self-cementing fly ashes, using retardation agents, such as: sodium borate, sodium citrate, citric acid, or commercial retarding admixtures, may be necessary to delay the hydration reactions sufficiently to obtain adequate mixing and compaction in the field. Since the effect of retarders is variable, checks of strength and time of set should be performed on trial batches for each fly ash.

SUMMARY OF CHANGES

Committee D 18 has identified the location of selected changes to this standard since the last issue D 5239 – 92 that may impact the use of this standard.

(*1*) SI units were made the standard.

(*2*) Referenced Documents section was corrected to match actual titles of standards.

(*3*) Added D 653 to Referenced Documents and modified Section 3 Terminology to reflect addition, renumbering subsequent additions.

(*4*) Deleted extraneous word in new section 3.2.3 stabilizing admixtures (erosion).

(*5*) Changed wording in section 6.2 to correspond with referenced test method.

(*6*) In section 6.3 replaced D 422 with C 311 which is the preferred test for fineness of fly ash. Also removed D 422 from Referenced Documents section.

(*7*) Updated section 6.6 to reflect corrective title of tests as referenced in C 311.

(*8*) Summary of changes section was added.