



Designation: C311/C311M – 24

Standard Test Methods for Sampling and Testing Coal Ash or Natural Pozzolans for Use in Concrete<sup>1</sup>

This standard is issued under the fixed designation C311/C311M; 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.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

1. Scope\*

1.1 These test methods cover procedures for sampling and testing coal ash and raw or calcined pozzolans for use in concrete.

1.2 The procedures appear in the following order:

|                                                                                                                                | Sections  |
|--------------------------------------------------------------------------------------------------------------------------------|-----------|
| Sampling                                                                                                                       | 7         |
| CHEMICAL ANALYSIS                                                                                                              |           |
| Reagents and apparatus                                                                                                         | 10        |
| Moisture content                                                                                                               | 11 and 12 |
| Loss on ignition                                                                                                               | 13 and 14 |
| Silicon dioxide, aluminum oxide, iron oxide, calcium oxide, magnesium oxide, sulfur trioxide, sodium oxide and potassium oxide | 15        |
| Available alkali                                                                                                               | 16 and 17 |
| Ammonia                                                                                                                        | 18        |
| PHYSICAL TESTS                                                                                                                 |           |
| Density                                                                                                                        | 19        |
| Fineness                                                                                                                       | 20        |
| Increase of drying shrinkage of mortar bars                                                                                    | 21 – 23   |
| Soundness                                                                                                                      | 24        |
| Air-entrainment of mortar                                                                                                      | 25 and 26 |
| Strength activity index                                                                                                        | 27 – 30   |
| Water requirement                                                                                                              | 31        |

Effectiveness of Coal Ash or Natural Pozzolan in Controlling Alkali-Silica Reactions 32

Effectiveness of Coal Ash or Natural Pozzolan in Contributing to Sulfate Resistance 34

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

NOTE 1—Sieve size is identified by its standard designation in Specification E11. The alternative designation given in parentheses is for information only and does not represent a different standard sieve size.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 The text of this standard references notes and footnotes that provide explanatory information. These notes and footnotes (excluding those in tables) shall not be considered as requirements of this standard.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>  
C109/C109M Test Method for Compressive Strength of

<sup>1</sup> These test methods are under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and are the direct responsibility of Subcommittee C09.24 on Supplementary Cementitious Materials.

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<sup>2</sup> 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.

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



Hydraulic Cement Mortars (Using 50 mm [2 in.] Cube Specimens)

**C114** Test Methods for Chemical Analysis of Hydraulic Cement

**C125** Terminology Relating to Concrete and Concrete Aggregates

**C150/C150M** Specification for Portland Cement

**C151/C151M** Test Method for Autoclave Expansion of Hydraulic Cement

**C157/C157M** Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

**C185** Test Method for Air Content of Hydraulic Cement Mortar

**C188** Test Method for Density of Hydraulic Cement

**C204** Test Methods for Fineness of Hydraulic Cement by Air-Permeability Apparatus

**C219** Terminology Relating to Hydraulic and Other Inorganic Cements

**C226** Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Hydraulic Cement

**C227** Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method) (Withdrawn 2018)<sup>3</sup>

**C430** Test Method for Fineness of Hydraulic Cement by the 45- $\mu$ m (No. 325) Sieve

**C441/C441M** Test Method for Effectiveness of Pozzolans or Ground Blast-Furnace Slag in Preventing Excessive Expansion of Concrete Due to the Alkali-Silica Reaction

**C595/C595M** Specification for Blended Hydraulic Cements

**C604** Test Method for True Specific Gravity of Refractory Materials by Gas-Comparison Pycnometer

**C618** Specification for Coal Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

**C670** Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

**C778** Specification for Standard Sand

**C1012/C1012M** Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution

**C1437** Test Method for Flow of Hydraulic Cement Mortar

**C1697** Specification for Blended Supplementary Cementitious Materials

**D1426** Test Methods for Ammonia Nitrogen In Water

**D4326** Test Method for Major and Minor Elements in Coal Ash By X-Ray Fluorescence

**E11** Specification for Woven Wire Test Sieve Cloth and Test Sieves

2.2 *ACI Document*.<sup>4</sup>

**ACI 201.2R** Guide to Durable Concrete

### 3. Terminology

#### 3.1 Definitions:

3.1.1 For definitions of terms used in this test method, refer to Terminology **C125** and Terminology **C219**.

#### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *bottom ash, n*—ash that results from the process of combustion of ground or powdered coal that is not transported by 24 flue gases.

3.2.1.1 *Discussion*—This definition of bottom ash does not include the residue resulting from: (1) fluidized bed combustion, (2) the burning of municipal solid waste or any other refuse with coal, or (3) the burning of industrial or municipal solid waste in incinerators.

3.2.2 *coal ash, n*—fly ash and bottom ash resulting from the process of combustion of ground or powdered coal obtained either from current power plant production or harvested from landfills or impoundments.

3.2.3 *composite sample, n*—a sample that is constructed by combining equal portions of grab or regular samples.

3.2.4 *established source, n*—a source for which at least six months of continuous production quality assurance records from a test frequency required for a new source are available, sampled at the source.

3.2.5 *grab sample, n*—a sample that is taken in a single operation from a conveyor delivering to bulk storage, from bags, or from a bulk shipment.

3.2.5.1 *Discussion*—A grab sample may or may not reflect the composition or physical properties of a single lot of coal ash or natural pozzolan. This type of sample can be used to characterize small amounts of material.

3.2.6 *new source, n*—a source for which less than six months of production records are available, sampled at the source.

3.2.7 *regular sample, n*—a sample that is constructed by combining equal portions of grab samples that were taken at predetermined times or locations from any single lot of material.

### 4. Significance and Use

4.1 These test methods are used to develop data for comparison with the requirements of Specification **C618** or Specification **C1697**. These test methods are based on standardized testing in the laboratory and are not intended to simulate job conditions.

4.1.1 *Strength Activity Index*—The test for strength activity index is used to determine whether coal ash or natural pozzolan results in an acceptable level of strength development when used in concrete. Since the test is performed with mortar, the results may not provide a direct correlation of how the coal ash or natural pozzolan will contribute to strength in concrete.

4.1.2 *Chemical Tests*—The chemical component determinations and the limits placed on each do not predict the performance of a coal ash or natural pozzolan in concrete, but collectively help describe composition and uniformity of the material.

### 5. Materials

5.1 *Graded Standard Sand*—The sand used for making test specimens for the activity index shall be natural silica sand conforming to the requirements for graded standard sand in Specification **C778**.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

<sup>4</sup> Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, <http://www.aci-int.org>.