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# Standard Guide for Evaluation of Alternative Supplementary Cementitious Materials (ASCM) for Use in Concrete<sup>1</sup>

This standard is issued under the fixed designation C1709; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 1. Scope\*

1.1 This guide is intended to provide a technical approach to the evaluation of alternative supplementary cementitious materials such as pozzolans and hydraulic materials that fall outside the scope of Specifications C618, C989/C989M, C1240, and C1866/C1866M. This guide provides the initial steps for a comprehensive evaluation of an ASCM that provides due diligence for its specific intended uses in concrete; however, it does not evaluate conformance to all possible performance criteria for all types of concrete mixtures.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 Performing the tests or meeting the test limits in this guide should not imply that the material tested meets the requirements of Specifications C618, C989/C989M, C1240, and C1866/C1866M. These materials should not be represented as such and each specific source is to be evaluated separately.

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 *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.*

<sup>1</sup> This guide is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.24 on Supplementary Cementitious Materials.

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## 2. Referenced Documents

### 2.1 *ASTM Standards:*<sup>2</sup>

- C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens
- C78/C78M Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
- C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50 mm] Cube Specimens)
- C114 Test Methods for Chemical Analysis of Hydraulic Cement
- C125 Terminology Relating to Concrete and Concrete Aggregates
- C138/C138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- C143/C143M Test Method for Slump of Hydraulic-Cement Concrete
- C157/C157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
- C186 Test Method for Heat of Hydration of Hydraulic Cement (Withdrawn 2019)<sup>3</sup>
- C204 Test Methods for Fineness of Hydraulic Cement by Air-Permeability Apparatus
- C231/C231M Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- C232/C232M Test Method for Bleeding of Concrete
- C311/C311M Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete
- C403/C403M Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance

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

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

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

- C430** Test Method for Fineness of Hydraulic Cement by the 45- $\mu\text{m}$  (No. 325) Sieve
- C457/C457M** Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete
- C469/C469M** Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
- C618** Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
- C666/C666M** Test Method for Resistance of Concrete to Rapid Freezing and Thawing
- C672/C672M** Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals (Withdrawn 2021)<sup>3</sup>
- C989/C989M** Specification for Slag Cement for Use in Concrete and Mortars
- C1012/C1012M** Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution
- C1064/C1064M** Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
- C1202** Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
- C1218/C1218M** Test Method for Water-Soluble Chloride in Mortar and Concrete
- C1240** Specification for Silica Fume Used in Cementitious Mixtures
- C1293** Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction
- C1543** Test Method for Determining the Penetration of Chloride Ion into Concrete by Ponding (Withdrawn 2019)<sup>3</sup>
- C1556** Test Method for Determining the Apparent Chloride Diffusion Coefficient of Cementitious Mixtures by Bulk Diffusion
- C1567** Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
- C1585** Test Method for Measurement of Rate of Absorption of Water by Hydraulic-Cement Concretes
- C1679** Practice for Measuring Hydration Kinetics of Hydraulic Cementitious Mixtures Using Isothermal Calorimetry
- C1702** Test Method for Measurement of Heat of Hydration of Hydraulic Cementitious Materials Using Isothermal Conduction Calorimetry
- C1866/C1866M** Specification for Ground-Glass Pozzolan for Use in Concrete
- D3987** Practice for Shake Extraction of Solid Waste with Water
- D4326** Test Method for Major and Minor Elements in Coal Ash By X-Ray Fluorescence

### 3. Terminology

#### 3.1 Definitions:

3.1.1 For definitions of terms used in this guide, refer to Terminology **C125**.

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

3.2.1 *alternative supplementary cementitious materials (ASCM)*, *n*—inorganic materials that react pozzolanically or hydraulically, and beneficially contribute to the strength, durability, workability, or other characteristics of concrete, and does not meet Specifications **C618**, **C989/C989M**, **C1240**, and **C1866/C1866M**.

### 4. Significance and Use

4.1 Supplementary cementitious materials (SCM) covered under existing ASTM specifications are fly ash, slag cement, raw and calcined natural pozzolans including calcined clays, silica fume, and ground-glass pozzolan. The use of these materials, and limits established in existing specifications, are based on data obtained from research programs, field testing, and long term performance monitoring. Performance of SCM in specific concrete mixtures is commonly verified through preconstruction testing. This guide provides an approach to assessing the properties of materials that are not covered under existing specifications, and for assessing the performance of those materials in concrete.

4.2 If an ASCM does not yet have a significant record of performance in concrete, a comprehensive evaluation based on this Guide should be undertaken, and it should be recognized that this ASCM might be introduced for a specific project or into a limited marketplace to initially demonstrate its performance. The user should bear in mind the intended end use of the ASCM and use appropriate test methods to establish its suitability. An ASCM that demonstrates good performance through a comprehensive evaluation as outlined in this guide could then be considered to have access to broader markets and could be considered for inclusion in an ASTM standard for SCM. For this reason, the test program to demonstrate acceptable performance should include concrete mixtures with a range of characteristics specific to the ASCM's intended use.

4.3 In the absence of long-term durability or acceptable field performance, prospective users are advised to apply appropriate risk management and engineering practice in the use of an ASCM.

### 5. Evaluation Program

5.1 *Classification of Materials*—The performance of the evaluated ASCM should be compared to that of one of the existing types of SCM as listed in **1.1**. The ASCM should not be classified as being a variant of, or equivalent to, an existing type of SCM. The material should be described as an “alternative supplementary cementitious material (ASCM).” The process that is responsible for generating the ASCM should be indicated on any reports such that any significant variations in that process would be noted when it occurs.

#### 5.2 Evaluation of the Material:

5.2.1 *General*—Evaluate the ASCM in a comprehensive laboratory test program followed by field trials. A sample of the ASCM used for this evaluation should be representative of its source. A phased program suitable for many types of ASCMs is as follows:

Stage I—Characterization of the Material

Stage II—Determination of Suitable Fineness

Stage III—Testing to Specification **C618**, **C989/C989M**, **C1240**, or **C1866/C1866M**

Stage IV—Concrete Performance Tests

Stage V—Field Trials and Long-Term Performance and Durability

**5.2.2 Stage I: Characterization of the Material**—Conduct a chemical analysis of the material. The chemical analysis should include the quantity of major, minor, and trace element constituents using any relevant method including x-ray fluorescence, atomic absorption spectroscopy, inductively coupled plasma spectroscopy, and any appropriate standard methods in Test Methods **C114**, **C311/C311M**, and **D4326**. When interpreting the data, consideration should be given to the potential for the compounds present to be injurious to the hydration of cement or properties of the concrete. If such compounds are present, then suitable tests should be conducted to determine the “availability” of these compounds to participate in hydration reactions.

**5.2.3 Stage II: Determination of Suitable Fineness**—If the production process of the ASCM includes size classification or crushing and grinding, guidance for the selection of the suitable fineness can be obtained from compressive strength, durability, and workability tests on mortar made with ASCM and hydraulic cement. It can be expected that for most ASCMs, fineness will play a major role in the level of performance of the ASCM in concrete. The appropriate fineness for the desired property should be selected by the manufacturer.

Useful data will be obtained from the testing of several levels of fineness or specific surface area, and several different particle size distributions of the ASCM. Fineness and specific surface area can be measured using the appropriate test methods in Test Methods **C311/C311M**, **C204**, and **C430**, or gas absorption BET (Brunauer, Emmett and Teller) technique for specific surface area. Particle size distribution can be measured by laser diffraction particle size analyzer; or other appropriate test methods.

Mortar tests should comply with Test Method **C109/C109M**. The test program should include a control portland cement mortar mixture for comparison with a similar test mixture made with an ASCM at the typical proposed replacement level. Compressive strength tests should be made at 1, 3, 7, and 28 days, and may include other appropriate long-term test ages.

**5.2.4 Stage III: The ASCM should be tested for comparison with the chemical, physical, and uniformity requirements of Specification C618** (including the supplemental optional physical requirements), **C989/C989M**, **C1240**, or **C1866/C1866M**. In addition, determine and report the following:

- (1) Chlorides (Test Method **C1218/C1218M**)
- (2) Free calcium oxide (Test Methods **C114**, Section 28)
- (3) Soluble alkalis (Test Method **C114**)
- (4) Leachable heavy metals (Test Method **D3987**)

(5) Air void stability—For ASCM similar to fly ash, the stability of the air bubbles formed during mixing a paste suspension may be an indication of the air void stability in concrete made with the same materials. In this test, 60 mL of distilled water is placed in a 250 mL wide-mouth glass jar. Then, 30 g of ASCM is added to the water. The jar is capped and vigorously shaken for 15 s. A measured quantity of

air-entraining admixture is then added, and the jar is shaken for an additional 15 s. The jar is then placed upright for 30 s, and then the cap is removed. If the foam is breaking rapidly or if voids appear on the water mixture surface after 30 s, add more air-entraining admixture, and repeat the shaking and observation procedure. Continue to incrementally add air entraining admixture until the foam is stable for 30 s, and then shake the mixture for an additional 15 s. The foam is in a stable state when the foam is not breaking rapidly and no voids in the foam appear on the water mixture surface for at least 60 s. Measure and report on the quantity of air-entraining admixture required to maintain the foam in a stable state and the amount of time that the foam remained in a stable state.

**5.2.5 Stage IV: Concrete Performance Tests**

**5.2.5.1 General**—A series of mixtures should be tested. The performance of the ASCM in fresh and hardened concrete should be evaluated in a broad range of concrete mixtures to reflect the intended use of the material. The test program should include at least one commercially available SCM conforming to an applicable standard similar to the ASCM, commonly used admixtures and control mixtures without the ASCM.

**5.2.5.2 Concrete Mixture Proportions**—A series of mixtures should be proportioned with total cementitious materials content varying from 200 to 400 kg/m<sup>3</sup>. Concrete tested for resistance to freezing and thawing is to have an air content and water-cementitious material ratio in accordance with applicable codes and specifications appropriate for the executed exposures. The concrete should be proportioned so the cementitious fraction contains a range of ASCM contents that bracket the intended level of use. The test program should include mixtures with various types of commonly used chemical admixtures to determine compatibility. Mortar of the proposed mixtures can be screened for compatibility using Test Method **C1679**. Commonly used chemical admixtures include air entraining agents, water reducers, setting time accelerators and setting time retarders. The test report should include information on the mixture proportions, water-cementitious material ratio, yield, density and source of materials.

**5.2.5.3 Fresh Concrete Testing**—The following tests should be performed to evaluate the effects of the ASCM on the properties of freshly mixed concrete:

- (1) slump, air content, and temperature (Test Method **C143/C143M**, **C231/C231M** and **C1064/C1064M**)
- (2) time of setting (Test Method **C403/C403M**)
- (3) fresh density (Test Method **C138/C138M**)
- (4) bleeding (Test Method **C232/C232M**)

**5.2.5.4 Hardened Concrete and Mortar Testing**—The following tests should be performed to evaluate the effects of the ASCM on the properties of the hardened concrete:

- (1) compressive strength (Test Method **C39/C39M**) at 1, 3, 7, 28, 90 days, and 1 year
- (2) flexural strength (Test Method **C78/C78M**) at 28 days
- (3) length change (drying shrinkage) (Test Method **C157/C157M**)
- (4) air void system parameters (Test Method **C457/C457M**)
- (5) modulus of elasticity (Test Method **C469/C469M**)