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Standard Specification for Ground-Glass Pozzolan for Use in Concrete[1]

This standard is issued under the fixed designation C1866/C1866M; 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~~ Scope*

1.1 This specification covers ground-glass pozzolans for use in concrete where pozzolanic action is desired. This specification applies to ground glass from sources that consist of container glass, plate glass, or E-glass.

1.2 The standard references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

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 may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. If required results obtained from another standard are not reported in the same system of units as used by this standard, it is permitted to convert those results using the conversion factors found in the SI Quick Reference Guide.[2]

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.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50 mm] Cube Specimens)
C125 Terminology Relating to Concrete and Concrete Aggregates
C150/C150M Specification for Portland Cement
C204 Test Methods for Fineness of Hydraulic Cement by Air-Permeability Apparatus
C311/C311M Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete
C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C1069 Test Method for Specific Surface Area of Alumina or Quartz by Nitrogen Adsorption
C1293 Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction

[1] This specification 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] Annex A in Form and Style for ASTM Standards, ~~www.astm.org/COMMIT/Blue_Book.pdf~~https://www.astm.org/media/pdf/bluebook_FormStyle.pdf

[3] 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**

C1567 Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
C1778 Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete

2.2 *ACI Standards:*[4]
318-2019 Building Code Requirements for Structural Concrete and Commentary

2.3 *CSA Standards:*[5]
A3003 Chemical Test Methods for Cementitious Materials for Use in Concrete and Masonry (Contained in CSA A3000 Cementitious Materials Compendium)
A3004-A4 Glass Content by the modified McMaster method (Contained in CSA A3000 Cementitious Materials Compendium)

3. Terminology

3.1 *Definitions:*

3.1.1 For definition of terms used in this specification, refer to Terminology C125.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *container glass, n*—recycled soda-lime-silica glass material that is derived from bottles, jars, and other glass containers, and is obtained from material recovery facilities (MRFs) or from deposit, redemption-based, or other recovery programs.

3.2.2 *E-glass, n*—post-industrial glass material obtained from producers of glass fiber reinforcement.

~~3.2.3 *ground-glass pozzolan, n*—finely divided amorphous silica product that results from the processes of separating, cleaning, grinding, and milling manufactured glass products to produce a material with pozzolanic properties.~~

3.2.3 *material recovery facility, n*—specialized plant that receives, separates, and processes post-consumer recyclable materials including container glass, obtained from curbside or other deposit and redemption-based recovery programs, for raw feedstock to manufacturers.

3.2.4 *plate glass, n*—soda-lime-silica glass material obtained from producers of, or recyclers of, glass products, such as windows for automobiles or buildings.

4. Classification

4.1 *Type GS*—Ground soda-lime-silica glass that meets the applicable requirements for this Type as given herein. Typical sources of Type GS glass are container glass and plate glass.

NOTE 1—Total equivalent alkali range of this ground glass type is 10-15%, reported as Na_2O_{eq}. See Appendix X1 for information on alkali-silica reactivity.

TABLE 1 Chemical Requirements

	Classification	
	Type GS	Type GE
Silicon dioxide (SiO_2), min %	60.0	55.0
Aluminum oxide (Al_2O_3), max %	5.0	15.0
Calcium oxide (CaO), max %	15.0	25.0
Iron oxide (Fe_2O_3), max %	1.0	1.0
Sulfur trioxide (SO_3), max %	1.0	1.0
Total equivalent alkalies, Na_2O_{eq}, max %[A]	15.0	4.0
Moisture content, max %	0.5	0.5
Loss on ignition, max %[B]	0.5	0.5

[A] Na_2O_{eq} % = Na_2O + 0.658K_2O. See Notes 1 and 2 for total equivalent alkali content ranges.
[B] Loss on ignition shall be conducted at 600° C in accordance with CSA A3003.

[4] www.concrete.org/store.aspx
[5] https://store.csagroup.org/

4.2 *Type GE*—Ground glass that meets the applicable requirements for this Type as given herein. The typical source of Type GE glass is waste fibers from producers of glass fiber reinforcement.

NOTE 2—Total equivalent alkali range of this ground glass type is 0-1%, reported as Na_2O_{eq}.

5. Chemical Composition

5.1 Ground-glass pozzolan shall conform to the chemical requirements given in Table 1 for testing in accordance with Test Methods C311/C311M. Optional chemical requirements are shown in Table 2, tested in accordance with CSA A3004-A4 modified McMaster method.

TABLE 2 Optional Chemical Requirements[A]

	Classification	
	Type GS	Type GE
Amorphous Content[B], min %	95	95

[A] This optional requirement applies only if requested by the purchaser.
[B] Testing in accordance with CSA A3004-A4 modified McMaster method.

6. Physical Properties

6.1 Ground-glass pozzolans shall conform to the physical requirements given in Table 3 for testing in accordance with Test Methods C311/C311M. Optional physical requirements are shown in Table 4, also for testing in accordance with Test Methods C311/C311M.

TABLE 3 Physical Requirements

	Classification	
	Type GS	Type GE
Fineness		
Amount retained when wet-sieved on 45 µm (No. 325 sieve), max %	5.0	5.0
Strength activity index		
With portland cement, at 7 days, min % of control	75[A]	75[A]
With portland cement, at 28 days, min % of control	85[A]	85[A]
Water requirement, max % of control	Report Only	Report Only
Relative Density	Report Only	Report Only

[A] Meeting both the 7-day and 28-day strength activity index is required for specification compliance.

NOTE 3—The strength activity index with portland cement is not to be considered a measure of the compressive strength of concrete containing the ground-glass pozzolan. The mass of ground-glass pozzolan specified for the test to determine the strength activity index with portland cement is not necessarily the proportion to be used in the concrete for the work. The optimum amount of ground-glass pozzolan for any specific project is determined by the required properties of the concrete and other constituents of the concrete and is to be established by testing. Strength activity index with portland cement is a measure of reactivity with a given cement and is subject to variation depending on the source of both the ground-glass pozzolan and the cement.

NOTE 4—Relative density values for specific Type GS and GE pozzolans have been reported by suppliers to be 2.51 and 2.55, respectively.

TABLE 4 Optional Physical Requirements[A,B]

	Classification	
	Type GS	Type GE
Specific surface[C]	Report Only	Report Only
Effectiveness in Contributing to Sulfate Resistance[D] :		
Expansion of test mixture[E,F] :		
For Sulfate Exposure Class S1, after 6 months, max %	0.10	0.10
For Sulfate Exposure Class S2, after 6 months, max %[G]	0.05	0.05
For Sulfate Exposure Class S2, after 12 months, max %[G]	0.10	0.10
For Sulfate Exposure Class S3, after 18 months, max %	0.10	0.10

[A] These optional requirements apply only if requested by the purchaser.
[B] Supplier shall state the relative amount of ground glass used to demonstrate conformance with Table 4. See Example Supplier's Report in Appendix X2.
[C] Determined by Test Method C204 or Test Method C1069. Specific surface results shall indicate the test method used.
[D] Ground-glass pozzolan shall be considered effective only when used at percentages, by mass, of the total cementitious material within 2% of those that are successful in the test mixtures, or between two percentages that are successful, and when the C3A content of the project cement is less than, or equal to, that used in the test mixtures. See Appendix X2 of Test Method C311/C311M.
[E] Sulfate resistance testing shall be performed using Procedure A (absolute limits) from Specification C618, Table 3, and in accordance with Test Methods C311/C311M, Section 34. (See also Test Methods C311/C311M, Appendix X2).
[F] Sulfate exposure classes are defined in Table 19.3.1.1 of ACI 318-2019.
[G] Meeting the 6-month or 12-month expansion limit indicates specification compliance.

7. Sampling and Testing

7.1 Sample and test in accordance with the requirements of Test Methods C311/C311M, replacing the quantities of fly ash and natural pozzolans used in testing with ground-glass pozzolan, unless otherwise specified in this specification.

7.2 A reference portland cement source meeting the standard chemical and physical requirements for Specification C150/C150M, Type I or Type II, including the optional physical requirements of Specification C150/C150M, shall be used for all testing. In addition, requirements of Table 5 of this specification shall be met. Sufficient cement shall be available to avoid changing reference cement more often than every two months. After the initial testing to determine compliance with the compressive strength requirement of Table 5, the reference cement shall be re-qualified at least every six months.

TABLE 5 Alkali and Strength Limits of Reference Portland Cement

Total Equivalent Alkalies (Na_2O_{eq})[A]	
min %	0.60
max %	0.90
Compressive Strength, MPa [psi], min, 28 days[B]	35 [5000]

[A] $Na_2O_{eq} = Na_2O + 0.658\ K_2O$
[B] The minimum strength limit is based on the strength of mortar cubes that are made and tested in accordance with Test Method C109/C109M.

NOTE 5—Different reference cements may produce different strength activity index results. A reference portland cement meeting the requirements of 7.2 is available from Cement and Concrete Reference Laboratory (CCRL), www.ccrl.us.

7.3 Loss on ignition and fineness testing shall be performed daily or on a composite of every 90 Mg [100 tons] of material produced, whichever is more frequent. Unless otherwise required by the purchaser, all other testing specified in Table 1 and Table 3 shall be performed on a composite sample from every 1,800 Mg [2,000 tons]. Relative density shall be reported monthly, or every 2,900 Mg [3,200 tons], whichever is more frequent.

8. Storage and Inspection

8.1 The ground-glass pozzolan shall be stored at the production facility in such a manner as to permit access for inspection and identification of each shipment.

8.2 Inspection of the ground-glass pozzolan shall be made as agreed upon by the purchaser and the supplier as part of the purchase contract.