



Designation: C 593 – 95 (Reapproved 2000)

## Standard Specification for Fly Ash and Other Pozzolans for Use With Lime<sup>1</sup>

This standard is issued under the fixed designation C 593; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This specification covers fly ash and other pozzolans for use with lime in plastic mortars, nonplastic mixtures and other mixtures that affect lime pozzolanic reaction. Evaluation of pozzolans containing available lime, such as Class C fly ash, is given consideration. Pozzolans covered include artificial pozzolans such as fly ash, and natural pozzolans, such as diatomite and pumicite, in either raw or calcined state.

1.2 The following precautionary caveat pertains only to the test method portion, Sections 5 and 10 of this specification: *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.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- C 25 Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime<sup>2</sup>
- C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens<sup>3</sup>
- C 50 Practice for Sampling, Inspection, Packing, and Marking of Lime and Limestone Products<sup>2</sup>
- C 51 Terminology Relating to Lime and Limestone (As Used by the Industry)<sup>2</sup>
- C 109/C 109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)<sup>2</sup>
- C 110 Test Methods for Physical Testing of Quicklime, Hydrated Lime, and Limestone<sup>2</sup>
- C 207 Specification for Hydrated Lime for Masonry Purposes<sup>2</sup>
- C 305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency<sup>2</sup>
- C 311 Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete<sup>3</sup>

- C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials<sup>3</sup>
- C 821 Specification for Lime for Use With Pozzolans<sup>2</sup>
- D 1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup>(2,700 kN-m/m<sup>3</sup>))<sup>4</sup>
- D 5239 Practice for Characterizing Fly Ash for Use in Soil Stabilization<sup>5</sup>

### 3. Terminology

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

3.1.1 *calcined pozzolans*—materials that are produced by calcination of natural siliceous or aluminosiliceous earths, such calcination being for the purpose of activation of pozzolanic properties.

3.1.2 *fly ash*—the finely divided residue that results from the combustion of ground or powdered coal and is transported from the boiler by flue gases. Additional methods for characterization of fly ash can be found in Practice D 5239.

3.1.2.1 *Discussion*—Section 12 provides guidance for determining the available lime index of fly ash, which may affect the desired proportions of fly ash with lime.

3.1.3 *lime*—all classes of quicklime and hydrated lime, both calcitic (high calcium) and dolomitic.

3.1.4 *natural pozzolans*—materials that, in the natural state, exhibit pozzolanic properties, such as some volcanic ash and lava deposits.

3.1.5 *pozzolan*—a siliceous or aluminosiliceous material that in itself possesses little or no cementitious value but that in finely divided form and in the presence of moisture will chemically react with alkali and alkaline earth hydroxides at ordinary temperatures to form or assist in forming compounds possessing cementitious properties.

### 4. Physical Properties

4.1 Pozzolans for use with lime in plastic mortars, when tested in accordance with the procedures of Sections 7-9, shall conform to the requirements prescribed in Table 1.

4.2 Pozzolans for use with lime in nonplastic mixtures shall conform to the requirements of Table 1, except the lime-pozzolan strength requirement, and in addition shall be tested

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<sup>2</sup> Annual Book of ASTM Standards, Vol 04.01.

<sup>3</sup> Annual Book of ASTM Standards, Vol 04.02.

<sup>4</sup> Annual Book of ASTM Standards, Vol 04.08.

<sup>5</sup> Annual Book of ASTM Standards, Vol 04.09.

in accordance with the procedures of Section 10 and shall conform to the following requirements:

Compressive strength, min, psi (MPa)	400 (2.8)
Vacuum saturation strength, min, psi (MPa)	400 (2.8)

NOTE 1—If the minimum value of the vacuum saturation strength specified in 4.2 of this specification is reduced, sufficient documentation shall be provided to the user to enable the determination of a satisfactory minimum residual strength for the given material in its intended use. Such documentation should include at least the following: (1) determination of a minimum residual strength requirement that will enable the material to perform its structural function in the pavement system; and (2) a rational analysis, using actual climatic data, that will show the severity of exposure of the material to cyclic freeze-thaw action.

**TABLE 1 Physical Requirements**

Water-soluble fraction, max, %	10.0
Fineness, amount retained, when wet sieved:	
No. 30 (600- $\mu$ m) sieve, max, %	2.0
No. 200 (75- $\mu$ m) sieve, max, %	30.0
Lime-pozzolan strength, minimum compressive strength, psi (MPa):	
At 7 days, 130 $\pm$ 3°F (54 $\pm$ 2°C)	600 (4.1)
After additional 21 days, 73 $\pm$ 3°F (23 $\pm$ 2°C)	600 (4.1)

## 5. Sampling

5.1 Sample pozzolan in accordance with the applicable provisions of Test Methods C 311, except take one 10-lb (4.5-kg) sample from approximately each 400 tons (350 metric tons) of pozzolan.

5.2 The sampling procedures and techniques shall be consistent from original sample to project completion.

## TEST METHODS

### 6. Significance and Use

6.1 This test method states various procedures that are recommended to quantify various aspects of the lime enhanced pozzolanic reaction. These tests are intended to qualify or quantify sources of fly ash and other pozzolans to meet specified job or project criteria.

### 7. Water-Soluble Fraction

7.1 *Procedure*—Place 10 g of a dried pozzolan sample (dried to constant weight in an oven at 221 to 230°F (105 to 110°C)) in a 200-mL Erlenmeyer flask and add 100 mL of distilled water at 73  $\pm$  3°F (23  $\pm$  2°C). Shake well by hand until no lumps can be observed; then with a mechanical shaker or stirring device, agitate at laboratory room temperature for a period of 1 h. Pour the material into a weighed Gooch or sintered-glass crucible, and wash all residue from the flask into the crucible with distilled water from a wash bottle. Wash the residue in the crucible free of adhering solution by repeated washings with distilled water. Dry the crucible to constant weight in an oven at 221°F (105°C).

7.2 *Calculation*—Calculate the percentage of water-soluble fraction by multiplying the loss in weight in grams by 10.

### 8. Fineness

8.1 Test in accordance with Test Methods C 110, except that the sample shall be 100 g of the dried pozzolan.

## 9. Lime-Pozzolan Strength Development

9.1 Test the pozzolan in accordance with the applicable portions of Test Method C 109 and Practice C 305, and in accordance with the following:

9.2 *Apparatus*:

9.2.1 *Oven*, closed, vapor-type.

9.3 *Materials*:

9.3.1 *Hydrated Lime*—Where possible, the lime shall be the same as that to be used on the job or shall meet the requirements of Specification C 207.

9.3.2 *Sand*—The sand shall be graded standard sand as required by Test Method C 109.

9.4 *Number of Test Specimens*—Three specimens shall be prepared for each age at which a strength test is desired.

9.5 *Proportioning, Consistency, and Mixing of Mortars*—Batches shall be of a size sufficient to make six specimens and shall consist of proportions of dry materials as follows:

Hydrated lime	180 g
Pozzolan (dry basis)	360 g
Graded standard sand	1480 g

9.5.1 The amount of mixing water, measured in millilitres, shall be such as to produce a flow of 65 to 75 as determined in accordance with 9.6, and shall be expressed as weight percent of the combined lime and pozzolan. The lime and pozzolan shall be blended together in a closed container. Mixing shall be done in accordance with the procedure described in Practice C 305, except that it shall be amended to read “Add the blended lime and pozzolan to the water and allow it to stand for 1 min. Then start the mixer and mix at slow speed (140  $\pm$  5 rpm) for 30 s.”

9.6 *Determination of Flow*—Determine the flow in accordance with Test Method C 109, except that the number of drops of the flow table shall be 10 drops in 6 s instead of 25 drops in 15 s. If the flow is less than the specified limit, the material used for the flow test may be returned to the mixing bowl and additional water added, the batch mixed for 1½ min, and a new flow taken. This operation may be repeated until a flow within the specified range is obtained. If the flow exceeds the range specified, discard the batch and give a new batch a new trial until a flow within range is obtained.

9.7 *Molding Test Specimens*—Immediately after the completion of the flow test, mold mortar specimens in accordance with Test Method C 109.

9.8 *Storage of Test Specimens*—When molding is completed, place the filled mold in the vapor immediately above water at 130  $\pm$  3°F (54  $\pm$  2°C) in a closed vapor oven with the top surface protected from the drip. Allow the specimens in the molds to remain in the vapor for a period of 7 days, after which remove them from the vapor and cool to 73  $\pm$  3°F (23  $\pm$  2°C) in air saturated sufficiently that no drying takes place during the cooling. When the specimens are cool, remove them from the molds, and store them at 73  $\pm$  3°F (23  $\pm$  2°C) at 95 to 100 % relative humidity until time of the compressive strength test.

## 10. Compressive Strength Development and Freeze-Thaw Resistance of Nonplastic Mixtures

10.1 *Materials*: