Designation: C311 – 07

Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete[1]

This standard is issued under the fixed designation C311; 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 Department of Defense.

1. Scope*

1.1 These test methods cover procedures for sampling and testing fly ash and raw or calcined pozzolans for use in portland-cement concrete.

1.2 The procedures appear in the following order:

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are provided for information purposes only.

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 and health 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.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C33 Specification for Concrete Aggregates

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

C150 Specification for Portland Cement

C151 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

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)

C430 Test Method for Fineness of Hydraulic Cement by the 45-μm (No. 325) Sieve

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

C618 Specification for Coal Fly 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 Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution

[1] 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.

Current edition approved Dec. 15, 2007. Published January 2008. Originally approved in 1953. Last previous edition approved in 2005 as C311 – 05. DOI: 10.1520/C0311-07.

[2] 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.**

C1157 Performance Specification for Hydraulic Cement
C1437 Test Method for Flow of Hydraulic Cement Mortar
D1426 Test Methods for Ammonia Nitrogen In Water
D4326 Test Method for Major and Minor Elements in Coal and Coke Ash By X-Ray Fluorescence

2.2 *ACI Document:*[3]
ACI 201.2R Guide to Durable Concrete

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

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

3.1.2 *established source*—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.

3.1.3 *grab sample*—a sample that is taken in a single operation from a conveyor delivering to bulk storage, from bags, or from a bulk shipment. Such a sample may, or may not, reflect the composition or physical properties of a single lot of fly ash or natural pozzolan. This type of sample can be used to characterize small amounts of material.

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

3.1.5 *lot*—specific quantity of fly ash or natural pozzolan offered for inspection at any one time. A lot may be one storage bin or the contents of one or more transport units representing material drawn from the same storage bin.

3.1.6 *regular sample*—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. 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 fly ash or natural pozzolan results in an acceptable level of strength development when used with hydraulic cement in concrete. Since the test is performed with mortar, the results may not provide a direct correlation of how the fly 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 fly ash or natural pozzolan with hydraulic cement 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 with lime or portland cement shall be natural silica sand conforming to the requirements for graded standard sand in Specification C778.

NOTE 1—*Segregation of Graded Sand*—The graded standard sand should be handled in such a manner as to prevent segregation, since variations in the grading of the sand cause variations in the consistency of the mortar. In emptying bins or sacks, care should be exercised to prevent the formation of mounds of sand or craters in the sand, down the slopes of which the coarser particles will roll. Bins should be of sufficient size to permit these precautions. Devices for drawing the sand from bins by gravity should not be used.

5.2 *Hydrated Lime*— The hydrated lime used in the tests shall be reagent-grade calcium hydroxide, 95 % minimum calculated as $Ca(OH)_2$(Note 2), and have a minimum fineness of 2500 m^2/kg as determined in accordance with Test Method C204.

NOTE 2—The calcium hydroxide should be protected from exposure to carbon dioxide. Material remaining in an opened container after a test should not be used for subsequent tests.

5.3 *Portland Cement*— The portland cement used in the Strength Activity Index with Portland Cement test shall comply with the requirements of Specification C150 and have a minimum compressive strength of 35 MPa (5000 psi) at 28 days and total alkalies ($Na_2O + 0.658\ K_2O$) not less than 0.50 % nor more than 0.80 %.

5.3.1 The use of a locally available portland cement in the Strength Activity Index or a project cement that does not meet the requirements of the section on Materials is permitted when the variations from the requirements of the section on Materials are reported and when the use of such portland cement is requested.

6. Sample Type and Size

6.1 Grab samples and regular samples shall have a mass of at least 2 kg (4 lb).

6.2 Grab samples or regular samples taken at prescribed intervals over a period of time (see Table 1), may be combined to form a composite sample representative of the fly ash or natural pozzolan produced during that period of time.

6.3 Composite samples shall have a mass of at least 4 kg (8 lb).

6.4 The sampling shall be done by, or under the direction of, a responsible representative of the purchaser.

7. Sampling Procedure

7.1 The fly ash or natural pozzolan may be sampled by any one of the following methods:

TABLE 1 Minimum Sampling and Testing Frequency[A]

Test	Sample Type	Jobsite or New Source[B]	Established Source[B]
Moisture content Loss on ignition Fineness	Regular	Daily or each 90 Mg[C] (100 Tons)	Daily or each 360 Mg[C] (400 Tons)
Density and the other tests in Specification C618, Tables 1 and 2	Composite	Monthly or each 1 800 Mg[C] (2 000 Tons)	Monthly or each 2 900 Mg[C] (3 200 Tons)

[A] It should be noted that the minimum test frequency given in Table 1 is not necessarily the frequency needed for quality control programs on some fly ash or natural pozzolans.
[B] For definitions, refer to the Terminology section.
[C] Whichever comes first.

[3] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, http://www.aci-int.org.

7.1.1 *From Bulk Storage at Point of Discharge or from Rail Cars and Road Tankers*—A sample may be taken by siphon tube during loading or by sampling tube from each loaded car or tanker. If the load is sampled at the point of discharge into the rail car or tanker, the top surface shall be removed to a depth of at least 200 mm (8 in.) before sampling. The sample shall be identified with at least the date and shipment number.

7.1.2 *From Bags in Storage*—The regular sample shall comprise increments of equal size taken by sampling tube from three bags selected at random from one lot of bagged material. The sample shall be identified with date and lot number.

7.1.3 *From Conveyor Delivering to Bulk Storage*—Take one sample of 2 kg (4 lb) or more of the material passing over the conveyor. This may be secured by taking the entire test sample in a single operation, known as the grab sample method, or by combining several equal portions taken at regular intervals, known as the regular sample method. Automatic samplers may be used to obtain samples.

7.2 Samples shall be treated as described in Section 8.

NOTE 3—Some methods of loading or delivery of fly ash or natural pozzolan, particularly from an airstream or conveyor belt, may create stratification or segregation in the material stream. Sampling techniques must be designed to ensure that the sample is representative of the material shipped.

8. Preparation and Storage of Samples

8.1 Prepare composite samples for the tests required in Section 9, by arranging all grab or regular samples into groups covering the period or quantity to be represented by the sample. Take equal portions from each, sufficient to produce a composite sample large enough for the tests required. Mix the composite sample thoroughly.

8.2 Samples shall be stored in clean, airtight containers identified with the source and lot or period of time represented. Untested portions of the sample shall be retained for at least one month after all test results have been reported.

9. Testing Frequency

9.1 *General*—When required, the purchaser shall specify the amount of testing for available alkalies, reactivity with cement alkalies, drying shrinkage, and air-entrainment. Make all other tests on regular or composite samples chosen as specified in Table 1.

CHEMICAL ANALYSIS

10. General

10.1 All apparatus, reagents and techniques shall comply with the requirements of Test Methods C114.

10.2 *Purity of Water*— Unless otherwise indicated, references to water shall be understood to mean distilled water or water of equal purity.

MOISTURE CONTENT

11. Procedure

11.1 Dry a weighed sample, as received, to constant weight in an oven at 105 to 110 °C (221 to 230 °F).

12. Calculation

12.1 Calculate the percentage of moisture to the nearest 0.1 %, as follows:

$$\text{Moisture content, \%} = (A/B) \times 100 \quad (1)$$

where:

A = mass loss during drying, and
B = mass as received.

LOSS ON IGNITION

13. Procedure

13.1 Determine loss on ignition in accordance with the procedures outlined in Test Methods C114, except that the material remaining from the determination of moisture content shall be ignited to constant mass in an uncovered porcelain, not platinum, crucible at 750 ± 50 °C (1382 ± 190 °F).

14. Calculation

14.1 Calculate the percentage of loss on ignition to the nearest 0.1, as follows:

$$\text{Loss on ignition, \%} = (A/B) \times 100 \quad (2)$$

where:

A = loss in mass between 105 and 750 °C (221 and 1382 °F),
B = mass of moisture-free sample used.

SILICON DIOXIDE, ALUMINUM OXIDE, IRON OXIDE, CALCIUM OXIDE, MAGNESIUM OXIDE, SULFUR TRIOXIDE, SODIUM OXIDE AND POTASSIUM OXIDE

15. Procedure

15.1 Determine the percentages of these oxides as required in accordance with the applicable sections of Test Methods C114 for materials having an insoluble residue greater than 1 % (Note 4). Analysts performing sodium oxide and potassium oxide determinations shall observe the precautions outlined in the applicable section of Performance Specification C1157 (refer to the section on Test Methods). Most pozzolans dissolve completely in lithium borate fluxes.

NOTE 4—Rapid and instrumental methods may be employed similar to those in Test Methods C114 and D4326.

AVAILABLE ALKALI

16. Procedure

16.1 Weigh 5.0 g of the sample and 2.0 g of hydrated lime on a piece of weighing paper, carefully mix using a metal spatula, and transfer to a small plastic vial of approximately 25-mL capacity. Add 10.0 mL of water to this mixture, seal the vial by securing the cap or lid to the vial with tape (Note 5), blend by shaking until the mixture is uniform, and store at 38 ± 2 °C.

NOTE 5—To ensure that moisture loss from the paste does not occur, place the sealed vial in a sealable container (such as a small sample or mason jar), add sufficient water to cover the bottom of the container, and seal.

16.2 Open the vial at the age of 28 days and transfer the contents to a 250-mL casserole. Break up and grind the cake with a pestle, adding a small amount of water, if necessary, so that a uniform slurry containing no lumps is obtained (Note 6). Add sufficient water to make the total volume 200 mL. Let stand 1 h at room temperature with frequent stirring. Filter through a medium-textured filter paper onto a 500-mL volumetric flask. Wash thoroughly with hot water (eight to ten times).

NOTE 6—At times it may be necessary to break the vial and peel off the plastic from the solid cake. In such cases, care should be exercised to avoid the loss of material and to remove all solid material from the fragments of the vial. If the cake is too hard to break up and grind in the casserole, a mortar should be used.

16.3 Neutralize the filtrate with dilute HCl (1 + 3), using 1 to 2 drops of phenolphthalein solution as the indicator. Add exactly 5 mL of dilute HCl (1 + 3) in excess. Cool the solution to room temperature and fill the flask to the mark with distilled water. Determine the amount of sodium and potassium oxides in the solution using the flame photometric procedure, described in Test Methods C114, except that the standard solutions shall be made up to contain 8 mL of calcium chloride ($CaCl_2$) stock solution per litre of standard solution, and the solution as prepared shall be used in place of the solution of cement.

NOTE 7—The standard solutions made up with 8 mL of calcium chloride ($CaCl_2$) stock solution contain the equivalent of 504 ppm of CaO. Tests have shown that this amount closely approximates the amount of calcium dissolved in the test solution.

17. Calculation and Report

17.1 Calculate the results as weight percent of the original sample material. Report as equivalent percentage of sodium oxide (Na_2O), calculated as follows:

$$\text{Equivalent } Na_2O, \% = Na_2O, \% + 0.658 \times K_2O, \% \quad (3)$$

AMMONIA

18. Procedure

18.1 Weigh 1.00 g of the fly ash sample into a 125 mL Erlenmeyer flask. Add 100 mL of ammonia-free water. Place a neoprene rubber stopper on the flask and swirl the contents to thoroughly mix the sample and the water.

18.2 Filter the mixture using a medium-textured filter paper and save the filtrate for the ammonia determination.

18.3 Determine the concentration of ammonia in the filtrate in accordance with the procedures outlined in Test Methods D1426, Method A–Direct Nesslerization or Method B–Selective Ion Electrode.

18.4 Calculate the ammonia concentration of the fly ash as follows:

$$Ammonia, mg/kg = N_W \times V_W / W_{fa} \quad (4)$$

where:

N_W = ammonia concentration of the water extract determined by Test Methods D1426, mg/L,
V_W = volume of water used for extracting ammonia from the fly ash sample, mL, and
W_{fa} = Mass of fly ash sample used in the test, g.

PHYSICAL TESTS

DENSITY

19. Procedure

19.1 Determine the density of the sample in accordance with the procedure described in Test Method C188, except use about 50 g of fly ash or natural pozzolan instead of approximately 64 g of cement as recommended in Test Method C188.

FINENESS, AMOUNT RETAINED WHEN WET-SIEVED ON A45-μm (NO. 325) SIEVE

20. Procedure

20.1 Determine the amount of the sample retained when wet-sieved on a 45-μm (No. 325) sieve, in accordance with Test Method C430, with the following exceptions.

20.1.1 Calibrate the 45-μm (No. 325) sieve using a cement standard (SRM 114). Calculate the sieve correction factors as follows:

$$CF = std - obs \quad (5)$$

where:

CF = the sieve correction factor, %, (include a negative sign when appropriate),
std = the certified residue value for the SRM, %, and
obs = the observed residue value for the SRM, %.

20.1.2 Calculate the fineness of the fly ash or natural pozzolan to the nearest 0.1 % as follows:

$$R_C = R_S + CF \quad (6)$$

where:

R_C = corrected sieve residue, %,
R_S = observed residue for the test sample, %, and
CF = the sieve correction factor, %.

If the residue retained for the test sample is equal to zero ($R_S = 0$), then the sieve correction factor shall not be added to the test result to calculate the corrected sieve residue. In such cases, the corrected fineness shall be reported as zero.

NOTE 8—Test Method C430 has been adopted for testing fly ash fineness. However, certain requirements, such as cleaning of sieves and interpretation of the test results, are sometimes not appropriate for fly ashes.

20.2 Numerical examples for calibrating a fineness sieve and calculating the corrected fineness.

20.2.1 Calibrating a fineness sieve (NIST standard reference material SRM 114p was used in this example):

Certified residue retained on a 45−*μm sieve*
= 8.24 % (*obtained from standard certificate*)

Measured residue retained on a 45−*μm sieve*
= 7.12 % (*measured in the laboratory*)

Correction factor (*CF*) = *standard value* (*std*) – *observed value* (*obs*)
= 8.24 – 7.12

= 1.12 %

20.2.2 Calculating a corrected fineness value for a calibrated sieve (fly ash A was used in this example):

Amount of fly ash A retained on the sieve: R_s
= 15.2 % (*expressed as a % of sample mass*)

Corrected sieve residue for fly ash A: $R_c = R_s + CF$
= 15.2 + 1.12
= 16.3 %

INCREASE OF DRYING SHRINKAGE OF MORTAR BARS

21. Test Specimen

21.1 Prepare test specimens in accordance with the procedures described in Test Method C157/C157M, except mold three mortar bars from both the control mix and the test mix using the following proportions:

	Control Mix	Test Mix
Portland cement, g	500	500
Fly ash or natural pozzolan, g	None	125
Graded standard sand, g	1375	1250
Water	sufficient to produce a flow of 100 to 115 %	

22. Procedure

22.1 Cure and measure the test specimens in accordance with Test Method C157/C157M, except that the moist-curing period (including the period in the molds) shall be 7 days, and the comparator reading at the age of 24 ± ½ h shall be omitted. Immediately after taking the comparator reading at the end of the 7-day moist-curing period, store the specimens in accordance with Test Method C157/C157M, and after 28 days of air storage, take a comparator reading for the specimens in accordance with Test Method C157/C157M.

23. Calculation and Report

23.1 Calculate the increase in drying shrinkage of the mortar bars, S_i, as follows:

$$S_i = S_t - S_c \tag{7}$$

where:

S_t = average drying shrinkage of the test specimens calculated as follows, and

S_c = average drying shrinkage of the control specimens calculated as follows:

$$S = \frac{[\text{initial CRD} - \text{CRD}] \times 100}{G} \tag{8}$$

where:

S = drying shrinkage of test or control specimens, %,

initial CRD = difference between the comparator reading of the specimen and the reference bar at 7 days of moist curing,

CRD = difference between the comparator reading of the specimen and the reference bar at 28 days of drying, and

G = the gage length of the specimens 250 mm (10 in.).

23.2 Report the results to the nearest 0.01. If the average drying shrinkage of the control specimens is larger than the average drying shrinkage of the test specimens, prefix a minus sign to the increase of drying shrinkage of mortar bars reported.

SOUNDNESS

24. Procedure

24.1 Conduct the soundness test in accordance with Test Method C151, except that the specimens shall be molded from a paste composed of 25 parts by weight of fly ash or natural pozzolan and 100 parts by weight of a portland cement conforming to Specification C150.

AIR-ENTRAINMENT OF MORTAR

25. Procedure

25.1 Using portland cement conforming to the requirements for Type I or Type II of Specification C150, prepare a test mixture in accordance with Test Method C185, using the following proportions:

	Test Mix
Portland cement, g	300
Fly ash or natural pozzolan	75
20–30 standard sand, g	1125
Water, mL, sufficient to give a flow of 80 to 95	Y
Neutralized Vinsol resin solution, mL,[A] sufficient to produce an air content of 18 ± 3 %	Z

[A] The amount of Vinsol resin solution used shall be considered as part of the mixing water.

25.2 The neutralized Vinsol resin solution used in this section on Air-Entrainment of Mortar shall be either a commercial neutralized Vinsol resin solution or a neutralized Vinsol resin solution prepared in accordance with Specification C226. If it is necessary to dilute either of these solutions, use distilled or demineralized water. (Note 9.)

NOTE 9—Dissolved minerals in drinking water may precipitate Vinsol resin solutions and greatly diminish its air-entraining characteristics.

25.3 Prepare two test mixtures with sufficient neutralized Vinsol resin to produce an air content of 15 to 18 % in the first mix and 18 to 21 % in the second mix. Then, determine by interpolation the amount of Vinsol resin, expressed as weight percent of the cement, required to produce an air content of 18 %.

26. Calculation

26.1 Calculate the air content of the test mixtures as follows:

$$\text{Air content, volume } \% = 100[1 - (W_a/W_c)] \tag{9}$$

$$W_a = W/400 \tag{10}$$

$$W_c = \frac{300 + 1125 + 75 + (300 \times P \times 0.01)}{\left[\left(\frac{300}{3.15}\right) + \left(\frac{1125}{2.65}\right) + \left(\frac{75}{D}\right) + \left(\frac{300 \times P \times 0.01}{1}\right)\right]} \tag{11}$$

where:

W_a = actual weight per unit of volume of mortar as determined by Test Method C185, g/mL,
W = weight of the specified 400 mL of mortar (see Test Method C185), g,
W_c = theoretical weight per unit of volume, calculated on an air-free basis and using the values for density and quantities of the materials in the mix, g/mL,
P = percentage of mixing water plus Vinsol resin solution based on weight of cement, and
D = density of fly ash or natural pozzolan in the mixture, Mg/m^3.

STRENGTH ACTIVITY INDEX WITH PORTLAND CEMENT

27. Specimens

27.1 Mold the specimens from a control mixture and from a test mixture in accordance with Test Method C109/C109M. The portland cement used in the Strength Activity Index test shall comply with the requirements of Specification C150 and with the alkali and strength limits given in the section on Materials. In the test mixture, replace 20 % of the mass of the amount of cement used in the control mixture by the same mass of the test sample. Make six-cube batches as follows:

27.1.1 Control Mixture:

500 g of portland cement
1375 g of graded standard sand
242 mL of water

27.1.2 Test Mixture:

400 g of portland cement
100 g of test sample
1375 g of graded standard sand
mL of water required for flow ± 5 of control mixture

27.2 *Number of Specimens*:

27.2.1 Since Specification C618 specifies that "meeting the 7 day or 28 day Strength Activity Index will indicate specification compliance" only one age might be required. At the option of the producer or the user after preparing six-cube batches, only three cubes of control and test mixtures need to be molded for either 7 or 28 day testing.

28. Storage of Specimens

28.1 After molding, place the specimens and molds (on the base plates) in the moist room or closet at 23.0 ± 2.0 °C (73.4 ± 3 °F) for 20 to 24 h. While in the moist room or closet, protect the surface from dripping water. Remove the molds from the moist room or closet and remove the cubes from the molds. Place and store the cubes in saturated lime water as specified in Test Method C109/C109M.

NOTE 10—Take care to ensure against zones of stratification or pockets of variation in temperature in the curing chamber.

29. Compressive Strength Test

29.1 Determine the compressive strength, as specified in Test Method C109/C109M, of three specimens of the control mixture and three specimens of the test mixture at ages of 7 days, or 28 days, or both, depending upon how many specimens were molded as prescribed in the section on Number of Specimens.

30. Calculation

30.1 Calculate the strength activity index with portland cement as follows:

Strength activity index with portland cement =
$$(A/B) \times 100 \quad (11)$$

where:

A = average compressive strength of test mixture cubes, MPa (psi), and
B = average compressive strength of control mix cubes, MPa (psi).

WATER REQUIREMENT

31. Calculation

31.1 Calculate the water requirement for the Strength Activity Index with Portland Cement as follows:

Water requirement, percentage of control =
$$(Y/242 \times 100) \quad (12)$$

where:

Y = water required for the test mixture to be ±5 of control flow.

EFFECTIVENESS OF FLY ASH OR NATURAL POZZOLAN IN CONTROLLING ALKALI SILICA-REACTIONS (SEE Appendix X1)

32. Procedure

32.1 Determine expansion of mortar made with a fly ash or natural pozzolan and a test cement as a percent of expansion of mortar made with low alkali cement in accordance with Test Method C441 as modified in the following paragraphs:

32.1.1 *Control Mixture*— The control mixture will be made as required in Test Method C441 except that the control cement shall have an alkali content (as equivalent Na_2O) less than 0.60 % (Note 11).

NOTE 11—Generally, the control cement should have an alkali content as equivalent Na_2O between 0.50 and 0.60 %. However, lower alkali control cement may be used, if desired, to demonstrate equivalence.

32.1.2 *Test Mixture Using Fly Ash or Natural Pozzolan*— The combined quantity of cement plus fly ash or natural pozzolan shall total 400 g (see Appendix X1). Use 900 g of borosilicate glass aggregate and sufficient mixing water to produce a flow between 100 and 115 % as determined in accordance with Test Method C1437. The cement used in the test mixture shall have an alkali content greater than that of the cement in the control mixture (Note 12).

NOTE 12—Generally, this test cement will have an alkali content equal to or higher than that used in the job.

32.1.3 Store and measure specimens as required in Test Method C227. Measure length of specimens at ages of 1 and 14 days.