



Designation: C494/C494M – 19

Standard Specification for Chemical Admixtures for Concrete¹

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

1. Scope*

1.1 This specification covers materials for use as chemical admixtures to be added to hydraulic-cement concrete mixtures for the purpose or purposes indicated for the eight types as follows:

- 1.1.1 *Type A*—Water-reducing admixtures,
- 1.1.2 *Type B*—Retarding admixtures,
- 1.1.3 *Type C*—Accelerating admixtures,
- 1.1.4 *Type D*—Water-reducing and retarding admixtures,
- 1.1.5 *Type E*—Water-reducing and accelerating admixtures,
- 1.1.6 *Type F*—Water-reducing, high range admixtures,
- 1.1.7 *Type G*—Water-reducing, high range, and retarding admixtures, and
- 1.1.8 *Type S*—Specific performance admixtures.

1.2 Unless specified otherwise by the purchaser, test specimens for qualifying an admixture shall be made using concreting materials as described in 11.1 – 11.3.

NOTE 1—As discussed in Appendix X2, it is recommended that, whenever practicable, supplementary tests be made by the purchaser using the cement, pozzolan, aggregates, air-entraining admixture, and the mixture proportions, batching sequence, and other physical conditions proposed for the specific work because the specific effects produced by chemical admixtures may vary with the properties and proportions of the other ingredients of the concrete. For example, Types F and G admixtures may exhibit much higher water reduction in concrete mixtures having higher cement contents than that listed in 12.1.1.

NOTE 2—The purchaser should verify that the admixture supplied for use in the work is equivalent in composition to the admixture subjected to test under this specification (see Section 6, Uniformity and Equivalence).

NOTE 3—Admixtures that contain sufficient amounts of chloride may accelerate corrosion of steel reinforcement. Compliance with the requirements of this specification does not constitute assurance of acceptability of the admixture for use in reinforced concrete.

1.3 This specification provides for three levels of testing.

1.3.1 *Level 1*—During the initial approval stage, proof of compliance with the performance requirements defined in Table 1 demonstrates that the admixture meets the require-

ments of this specification. Proof of compliance shall be based on comparisons of the average test results from the batches of test concrete and the average test results from the batches of reference concrete. Admixtures (except for Types B, C, E, and S) shall qualify for provisional compliance if the time of setting, length change, and durability factor meet the physical requirements and any of the alternative compressive strength requirements shown in parentheses in Table 1 are met through the date of provisional acceptance (see Note 4). If subsequent test results at six months or one year fail to meet the requirement of at least 100 % of reference strength, the provisional compliance of the admixture to this standard is withdrawn and all users of the admixture shall be notified immediately. Uniformity and equivalence tests of Section 6 shall be carried out to provide results against which later comparisons shall be made.

NOTE 4—Allowing for provisional compliance while retaining longer term compressive strength requirements promotes more rapid qualification of new materials, but also provides assurance that new admixture technologies will not exhibit unexpected longer term performance. The alternative compressive strength requirements in Table 1 are based on statistical analysis of 103 Specification C494/C494M evaluation tests. The alternative requirements shown in parentheses correspond to a 99 % probability of passing strength requirements at subsequent test ages,² if any one of the requirements is met. There is no requirement that all be met.

1.3.2 *Level 2*—Limited retesting is described in 5.2 – 5.2.2. Proof of compliance with the requirements of Table 1 demonstrates continued conformity of the admixture with the requirements of the specification.

1.3.3 *Level 3*—For acceptance of a lot or for measuring uniformity within or between lots, if specified by the purchaser, the uniformity and equivalence tests of Section 6 shall be used.

1.4 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

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² Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C09-1030. Contact ASTM Customer Service at service@astm.org.

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

systems shall not be combined. Some values have only SI units because the inch-pound equivalents are not used in practice.

1.5 The text of this standard refers to 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.

1.6 The following precautionary caveat pertains only to test method Sections 11 – 18 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use. (Warning—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to exposed skin and tissue upon prolonged exposure.³)*

1.7 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:⁴

- [C33/C33M Specification for Concrete Aggregates](#)
- [C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens](#)
- [C78/C78M Test Method for Flexural Strength of Concrete \(Using Simple Beam with Third-Point Loading\)](#)
- [C125 Terminology Relating to Concrete and Concrete Aggregates](#)
- [C127/C127M Test Method for Relative Density \(Specific Gravity\) and Absorption of Coarse Aggregate](#)
- [C128/C128M Test Method for Relative Density \(Specific Gravity\) and Absorption of Fine Aggregate](#)
- [C136/C136M Test Method for Sieve Analysis of Fine and Coarse 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](#)
- [C150/C150M Specification for Portland Cement](#)
- [C157/C157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete](#)
- [C183/C183M Practice for Sampling and the Amount of Testing of Hydraulic Cement](#)
- [C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory](#)
- [C231/C231M Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method](#)
- [C260/C260M Specification for Air-Entraining Admixtures for Concrete](#)

³ See Section on Safety Precautions, Manual of Aggregate and Concrete Testing, *Annual Book of ASTM Standards*, Vol. 04.02.

⁴ 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.

- [C403/C403M Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance](#)
- [C666/C666M Test Method for Resistance of Concrete to Rapid Freezing and Thawing](#)
- [C1753/C1753M Practice for Evaluating Early Hydration of Hydraulic Cementitious Mixtures Using Thermal Measurements](#)
- [D75/D75M Practice for Sampling Aggregates](#)
- [D891 Test Methods for Specific Gravity, Apparent, of Liquid Industrial Chemicals](#)
- [D1193 Specification for Reagent Water](#)
- [E100 Specification for ASTM Hydrometers](#)
- [E178 Practice for Dealing With Outlying Observations](#)
- [E1252 Practice for General Techniques for Obtaining Infrared Spectra for Qualitative Analysis](#)
- [Manual of Aggregate and Concrete Testing](#)
- 2.2 *American Concrete Institute Standard:*
- [ACI 211.1–91 \(2009\) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete⁵](#)

3. Terminology

3.1 For definitions of terms used in this specification, refer to Terminology [C125](#).

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *accelerating admixture, n*—an admixture that increases the rate of reaction of cementitious materials thus reducing time of setting and increasing the rate of early-age strength development of concrete.

3.2.2 *reference concrete, n*—concrete made without the admixture being evaluated and used as the basis for evaluating the performance of the admixture.

3.2.3 *retarding admixture, n*—an admixture that decreases the rate of reaction of cementitious materials thus increasing time of setting of concrete.

3.2.4 *test concrete, n*—concrete containing the admixture being evaluated.

3.2.4.1 *Discussion*—In the text of this specification, the wording “category of concrete” refers to whether the concrete mixture is the reference concrete or the test concrete.

3.2.5 *water-reducing admixture, n*—an admixture that either increases the slump of freshly mixed concrete without increasing the water content or that maintains the slump with a reduced amount of water due to factors other than air entrainment.

3.2.6 *water-reducing admixture, high range, n*—an admixture that reduces the quantity of mixing water required to produce concrete of a given slump by 12 % or greater.

3.2.7 *water-reducing and accelerating admixture, n*—an admixture that reduces the quantity of mixing water required to produce concrete of a given slump, reduces the time of setting, and increases the rate of early-age strength development.

⁵ Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, <http://www.aci-int.org>.

3.2.8 *water-reducing and retarding admixture, n*—an admixture that reduces the quantity of mixing water required to produce concrete of a given slump and increases the time of setting of concrete.

3.2.9 *water-reducing, high-range, and retarding admixture, n*—an admixture that reduces the quantity of mixing water required to produce concrete of a given slump by 12 % or greater and increases the time of setting of concrete.

3.2.10 *specific performance admixture, n*—an admixture that provides a desired performance characteristic(s) other than reducing water content, or changing the time of setting of concrete, or both, without any adverse effects on fresh, hardened and durability properties of concrete as specified herein, excluding admixtures that are used primarily in the manufacture of dry-cast concrete products.

3.2.10.1 *Discussion*—Other specific performance characteristics include, but are not limited to, shrinkage reduction, mitigation of alkali-silica reaction, and viscosity modification. Admixtures used for the purposes of reducing water content or changing the time of setting of concrete are classified within the Type A through Type G grouping. Plasticizing, water-repellent, and efflorescence-controlling admixtures are examples of admixtures that are used in the manufacture of dry-cast concrete products.

4. Ordering Information

4.1 The purchaser shall specify the type of chemical admixture desired, and in the case of a Type S admixture the specific performance characteristic(s) required.

5. General Requirements

5.1 For initial compliance with this specification, test concrete made with one of the admixtures shown in 1.1 shall conform to the respective requirements prescribed in Table 1.

5.2 The purchaser is allowed to require a limited retesting to confirm current compliance of the admixture to specification requirements. The limited retesting covers physical properties and performance of the admixture.

5.2.1 The physical properties retesting shall consist of uniformity and equivalence tests for infrared analysis, residue by oven drying, and relative density (specific gravity).

5.2.2 The performance property retesting shall consist of water content of fresh concrete, setting time, and compressive strength at 3, 7, and 28 days.

5.3 At the request of the purchaser, the manufacturer shall state in writing the chloride content of the admixture.

5.4 At the request of the purchaser, the manufacturer shall provide data to substantiate the specific performance characteristic(s) stated by the manufacturer for a Type S admixture.

5.5 Tests for uniformity and equivalence, as indicated in Section 6, shall be made on the initial sample and the results retained for reference and comparison with the results of tests of samples taken from elsewhere within the lot or subsequent lots of admixture.

5.6 At the request of the purchaser, the manufacturer shall state in writing that the infrared analysis spectrum, residue by

oven drying, and relative density (specific gravity) of the supplied admixture are within the limits in Section 6 when compared with the initial sample tested under Level 1 of this specification.

6. Uniformity and Equivalence

6.1 If specified by the purchaser, the uniformity of a lot, or the equivalence of different lots from the same source shall be established by complying with the following requirements:

6.1.1 *Infrared Analysis*—The infrared absorption spectra of the initial sample and the test sample, obtained as specified in 18.1, shall be equivalent. Two infrared absorption spectra are considered equivalent if the same infrared absorption frequencies at the same relative intensities are present in both spectra. Refer to Appendix X3 for additional guidance.

6.1.2 *Residue by Oven Drying (Liquid Admixtures)*—When dried as specified in 18.2, the oven-dried residues of the initial sample and of subsequent samples shall be within $\pm 12\%$ of the mid-point of the manufacturer's stated range, but not exceeding the manufacturer's stated limits.

NOTE 5—As an example, for an admixture produced with a residue range from 27 to 35 %, the manufacturer would provide maximum acceptable limits of 27.3 to 34.7 %, representing $\pm 12\%$ of the mid-point of the limits, where the mid-point is 31.0 %.

6.1.3 *Residue by Oven Drying (Nonliquid Admixtures)*—When dried as specified in 18.3, the oven-dried residues of the initial sample and of the subsequent samples shall be within a range of variation not greater than ± 4 percentage points.

6.1.4 *Relative Density (Specific Gravity) (Liquid Admixtures)*—When tested as specified in 18.4, the relative density (specific gravity) of the initial sample and subsequent test samples shall not differ from the mid-point of the manufacturer's stated range by more than 10 % of the difference between the mid-point of the manufacturer's stated range and that of reagent water. If 10 % of the difference between the relative density (specific gravity) of the initial sample and water is less than 0.01, use the value 0.01 as the maximum allowable difference. Reagent water conforming to Specification D1193, Types III or IV, and prepared by distillation ion exchange, reverse osmosis, electro dialysis, or a combination of these procedures is adequate.

6.2 If the nature of the admixture or the analytical capability of the purchaser make some or all of these procedures unsuitable, other requirements for uniformity and equivalence from lot to lot or within a lot shall be established by agreement between the purchaser and the manufacturer.

7. Packaging and Marking

7.1 If the admixture is delivered in packages or containers, the proprietary name of the admixture, the type under this specification, and the net mass or volume shall be plainly marked thereon. Similar information shall be provided in the shipping advices accompanying packaged or bulk shipments of admixtures.

8. Storage

8.1 The admixture shall be stored in such a manner as to permit access for inspection and identification of each

TABLE 1 Physical Requirements^{A, B}

	Type A, Water- Reducing	Type B, Retarding	Type C, Accelerating	Type D, Water- Reducing and Retarding	Type E, Water- Reducing and Accelerating	Type F, Water- Reducing, High-Range	Type G, Water- Reducing, High-Range and Retarding	Type S Specific Perfor- mance
Water content, max, % of reference ^A	95	...	...	95	95	88	88	...
Time of setting, allowable deviation from reference, h:min:								
Initial: at least	...	1:00 later	1:00 earlier	1:00 later	1:00 earlier	...	1:00 later	
not more than	1:00 earlier nor 1:30 later	3:30 later	3:30 earlier	3:30 later	3:30 earlier	1:00 earlier nor 1:30 later	3:30 later	1:00 earlier nor 1:30 later
Final: at least	...	...	1:00 earlier	...	1:00 earlier	...	...
not more than	1:00 earlier nor 1:30 later	3:30 later	...	3:30 later	...	1:00 earlier nor 1:30 later	3:30 later	1:00 earlier nor 1:30 later
Compressive strength, min, % of reference: ^C								
1 day	...	...	...	...	...	140	125	...
3 days	110	90	125	110	125	125	125	90
7 days	110	90	100	110	110	115	115	90
28 days	110 (120) ^D	90	100	110 (120) ^D	110	110 (120) ^C	110 (120) ^D	90
90 days	(117) ^D	n/a	n/a	(117) ^D	n/a	(117) ^C	(117) ^D	n/a
6 months	100 (113) ^D	90	90	100 (113) ^D	100	100 (113) ^C	100 (113) ^D	90
1 year	100	90	90	100	100	100	100	90
Flexural strength, min, % reference: ^C								
3 days	100	90	110	100	110	110	110	90
7 days	100	90	100	100	100	100	100	90
28 days	100	90	90	100	100	100	100	90
Length change, max shrinkage (alternative requirements): ^E								
Percent of reference	135	135	135	135	135	135	135	135
Increase over reference	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Relative durability factor, min % of reference ^F	80	80	80	80	80	80	80	80

^A Requirements in this table apply to the averages of three or more test results for each category of concrete. Comparisons are not to be made between pairs of single test results of reference and test concretes. The indicated maximum water contents are not to be interpreted as requiring exactly that amount; they are maximum values and testing at lower water content is permitted. Further, there is no requirement that either test or reference concretes be prepared at the same water contents. Because requirements in this specification apply to the average test results for each category of concrete, adjustment of mixtures within the tolerances of this specification are permitted if necessary to make the averages fall within requirements.

^B The values in the table include allowance for normal variation in test results. The objective of the 90 % compressive strength requirement for a Type B and Type S admixture is to require a level of performance comparable to that of the reference concrete while allowing for variability in test results.

^C The compressive and flexural strength of the concrete containing the admixture under test at any test age shall be not less than 90 % of that attained at any previous test age. The objective of this limit is to require that the compressive or flexural strength of the concrete containing the admixture under test shall not decrease with age.

^D Alternative requirement. If the physical requirements are met and any of the measured relative strengths are greater than the requirement in parentheses, the admixture shall be considered provisionally to meet the requirements of this specification until the one-year strength test results are obtained.

^E Alternative requirements, see 17.1.4. The % of reference limit applies if length change of reference concrete is 0.030 % or greater; increase over reference limit applies if length change of reference concrete is less than 0.030 %.

^F This requirement is applicable only if the admixture is intended for use in air-entrained concrete that may be exposed to freezing and thawing while wet.

shipment, and in an environment that will protect the admixture from dampness and freezing.

9. Sampling and Inspection

9.1 The purchaser shall be provided the opportunity for sampling and inspection, either at the point of manufacture or at the site of the work, as specified by the purchaser.

9.2 Samples shall be either “grab” or “composite” samples, as specified or required by this specification. A grab sample is

one obtained in a single operation. A composite sample is one obtained by combining three or more grab samples.

9.3 For the purposes of this specification, it is recognized that samples will be taken for two reasons:

9.3.1 *Compliance Tests*—A sample obtained for the purpose of demonstrating compliance of a source or lot of admixture shall meet the applicable requirements of this specification as described in 5.1 through 5.2.2. The sample used to determine conformance with the requirements of this specification shall

be a composite of grab samples taken from multiple locations such that the composite sample will be representative of the lot.

9.3.2 *Uniformity and Equivalence Tests*—If specified by the purchaser, samples taken for the purpose of evaluating the uniformity of a single lot, or equivalence of different lots from one source shall be tested as provided in Section 6. Such samples shall be composite samples from individual lots if different lots from the same source are being compared. If the uniformity of a single lot is being evaluated, grab samples shall be used.

9.4 *Liquid Admixtures*—Liquid admixtures shall be agitated to a homogeneous condition before sampling. Grab samples taken for compliance or uniformity testing shall represent a unit shipment or a single production lot. Each grab sample shall have a volume of at least 0.5 L [1 pt]. At least three grab samples shall be taken. Composite samples shall be prepared by mixing the selected grab samples and sampling the resultant homogeneous mixture to provide at least 4 L [1 gal] for compliance tests. Grab samples shall be taken from different locations distributed throughout the quantity to be represented.

9.4.1 Admixtures in bulk storage tanks shall be sampled equally from the upper, intermediate, and lower levels by means of drain cocks in the sides of the tanks or a weighted sampling bottle fitted with a stopper that can be removed after the bottle is lowered to the desired depth.

9.4.2 Samples shall be stored in airtight containers that are resistant to attack by the admixture.

9.5 *Non-liquid Admixtures*—Grab samples taken for compliance or uniformity testing shall represent not more than 2 Mg [2 tons] of admixture and each grab sample shall be at least 1 kg [2 lb]. At least four grab samples shall be taken. Composite samples shall be prepared by mixing the grab samples selected and the resultant homogeneous mixture sampled to provide at least 2.5 kg [5 lb] for the composite sample. Grab samples shall be taken from different locations distributed throughout the quantity to be represented.

9.5.1 Samples of packaged admixtures shall be obtained by means of a tube sampler as described in Practice C183/C183M.

9.5.2 Samples shall be stored in moisture-proof, airtight containers.

9.6 Samples shall be mixed to a homogeneous condition before testing. If recommended by the manufacturer, the entire sample of a non-liquid admixture shall be dissolved in water before testing.

10. Rejection

10.1 For initial compliance testing, the purchaser is allowed to reject the admixture if it fails to meet any of the applicable requirements for this specification.

10.2 For limited retesting, the purchaser has the right to reject the admixture if it fails to meet any of the requirements of the Uniformity and Equivalence Section and of the applicable parts of Table 1.

10.3 An admixture stored at the point of manufacture, for more than six months before shipment, or an admixture in local storage in the hands of a vendor for more than six months, after completion of tests, shall be retested before use if requested by

the purchaser and the purchaser has the right to reject the admixture if it fails to conform to any of the applicable requirements of this specification.

10.4 Packages or containers varying more than 5 % from the specified mass or volume are allowed to be rejected. If the average mass or volume of 50 packages taken at random is less than that specified, the entire shipment is allowed to be rejected.

10.5 If the admixture is to be used in non-air-entrained concrete, the purchaser has the right to reject the admixture if the test concrete containing it has an air content greater than 3.5 %. If the admixture is to be used in air-entrained concrete, the purchaser has the right to reject the admixture if the test concrete containing it has an air content greater than 7.0 %.

TEST METHODS

NOTE 6—These tests are based on arbitrary stipulations that make possible highly standardized testing in the laboratory and are not intended to simulate actual job conditions. Refer to Appendix X1 for a discussion of the required testing program and how test results are evaluated. Testing personnel should be certified to perform the required tests.

11. Materials

11.1 *Cement*—The cement used in any series of tests shall be a Type I or Type II cement conforming to Specification C150/C150M, or a blend of two or more cements. Each cement of the blend shall conform to the requirements of either Type I or Type II of Specification C150/C150M. If the air content of the reference concrete made without an air-entraining admixture, tested as prescribed in 14.3, is more than 3.5 %, select a different cement, or blend, so that the air content of the reference concrete does not exceed 3.5 %.

11.2 *Aggregates*—The fine and coarse aggregates used in any series of tests shall come from single lots of materials that conform to the requirements of Specification C33/C33M, except that the grading of the aggregates shall conform to the requirements in 11.2.2 and 11.2.3:

11.2.1 *Physical Properties*—Determine the relative density and absorption of the coarse aggregate in accordance with Test Method C127/C127M and of the fine aggregate in accordance with Test Method C128/C128M.

11.2.2 *Fine Aggregate Grading*—Determine the grading and fineness modulus of the fine aggregate in accordance with Test Method C136/C136M. The grading shall conform to the following requirements:

Sieve	Mass Percent Passing
4.75 mm (No. 4)	100
1.18 mm (No. 16)	65 to 75
300 μm (No. 50)	12 to 20
150 μm (No. 100)	2 to 5

11.2.3 *Coarse Aggregate Grading*—The coarse aggregate shall meet the requirements for size number 57 of Specification C33/C33M. Use accepted practices in loading and delivery to avoid segregation.

11.2.4 *Preparation of Coarse Aggregate*—Coarse aggregate from the same lot shall be used for each batch of reference concrete and each batch of test concrete. The quantity of concrete for Level I testing includes at least three batches of the

reference concrete and at least three batches of each test concrete being evaluated. If reference concrete and companion test concrete batches are made the same day, it is permitted to use the same reference concrete to evaluate more than one test concrete. The quantity of coarse aggregate for one set of tests shall be sufficient to make all batches of concrete and provide a sample for performing a sieve analysis.

11.2.4.1 Obtain tared containers, one for each batch of concrete to be made and one for the sieve analysis sample. One or more spare containers are recommended in case a concrete batch has to be discarded. Prepare coarse aggregate for a set as follows: Fill tared containers so that each batch will contain similar particle grading. Accomplish this by taking scoopfuls from the stockpile and placing them successively into each container until all containers have their required mass. See the Appendix of Practice **D75/D75M**, Sampling from Stockpiles, and the *Manual of Aggregate and Concrete Testing* for guidance on procedures to mitigate segregation.

11.2.5 *Verification of Grading*—Test the coarse aggregate samples representing each set in accordance with Test Method **C136/C136M**. Discard any set for which the sample does not comply with size 57 requirements of Specification **C33/C33M**.

NOTE 7—The results required for demonstrating compliance under this specification depend on the uniformity of the aggregate samples prepared and used.

11.3 *Air-Entraining Admixture*—The air-entraining admixture used in the concrete mixtures specified in Section 12 shall conform to Specification **C260/C260M**.

11.4 *Preparation and Batching*—Prepare and weigh all materials in accordance with Practice **C192/C192M**.

12. Proportioning of Concrete Mixtures

12.1 *Proportions*—Concrete shall be proportioned using ACI 211.1 to conform to the requirements described in 12.1.1 – 12.1.4. After evaluation of the trial mixtures, aggregate proportions shall be adjusted as needed to obtain workable, cohesive mixtures with the correct yield to obtain the required cement contents.

12.1.1 The cement content of each batch, based on actual yield, shall be $307 \pm 3 \text{ kg/m}^3$ [$517 \pm 5 \text{ lb/yd}^3$]. The average cement content of the batches of test concrete shall be within 3 kg/m^3 [5 lb/yd^3] of the average cement content of the batches of reference concrete.

12.1.2 For the first trial mixture, refer to the table on volume of coarse aggregate per unit volume of concrete in ACI 211.1 for guidance on the amount of coarse aggregate to use, given a nominal maximum size of 25.0 mm [1 in.] and the fineness modulus of the fine aggregate being used.

12.1.3 For the non-air-entrained mixtures, the air content used in calculating the proportions shall be 1.5 %. For the air-entrained mixtures, the air content used for this purpose shall be 5.5 %.

12.1.4 Adjust the water content to obtain a slump of $90 \pm 15 \text{ mm}$ [$3\frac{1}{2} \pm \frac{1}{2} \text{ in.}$]. The workability of the concrete mixture shall be suitable for consolidation by hand rodding and the concrete mixture shall have the minimum water content possible. Achieve these conditions by final adjustments in the proportion of fine aggregate to total aggregate or in the amount

of total aggregate, or both, while maintaining the yield and slump in the required ranges.

12.2 *Adding Admixture to Test Concrete*—Except for a Type S admixture, add the admixture in the manner recommended by the manufacturer and in the amount necessary to comply with the applicable requirements of the specifications for water reduction or time of setting, or both. If desired by the person or agency for whom the tests are being performed, the admixture is allowed to be added in an amount such as to produce a specific time of setting of the concrete mixture within the limits of the applicable provisions of this specification. A Type S admixture shall be tested at a dosage within the range recommended by the manufacturer for field use.

12.2.1 *Non-Air-Entrained Concrete*—If the admixture is to be tested for use only in non-air-entrained concrete, the average air contents of the test concrete and the reference concrete shall not exceed 3.5 %, and the difference between the average air contents of the two categories shall not exceed 1.0 percentage point. If necessary, the air-entraining admixture shall be added to the reference concrete to obtain an air content within 1 percentage point of the test concrete. Tests for resistance to cyclic freezing and thawing shall not be made.

12.2.2 *Air-Entrained Concrete*—If the admixture is to be tested for use in air-entrained concrete that will be exposed to freezing and thawing while wet, the air content of the reference concrete and test concrete shall be $6.0 \pm 1.0 \%$. The difference between the average air content from the batches of the reference concrete and the average air content from the batches of the test concrete shall not exceed 0.5 percentage points. Air contents of individual pairs of batches of test and reference concretes are not required to fall within the 0.5 % requirement. Tests for resistance to cyclic freezing and thawing shall be conducted in accordance with Test Method **C666/C666M**, Procedure A.

13. Mixing

13.1 Machine mix the concrete in accordance with Practice **C192/C192M**.

14. Tests and Properties of Freshly Mixed Concrete

14.1 Samples of freshly mixed concrete from at least three separate batches for each category of concrete shall be tested in accordance with the methods described in 14.2 – 14.5.

14.2 *Slump*—Test Method **C143/C143M**.

14.3 *Air Content*—Test Method **C231/C231M**.

14.4 *Density of Fresh Concrete*—Test Method **C138/C138M**.

14.5 *Time of Setting*—Test Method **C403/C403M**, except that the temperature of each of the ingredients of the concrete mixtures, just before mixing, and the temperature at which the time-of-setting specimens are stored during the test period shall be $23.0 \pm 2.0 \text{ }^\circ\text{C}$ [$73.5 \pm 3.5 \text{ }^\circ\text{F}$]. Compare the average of the results from the specimens of the test concrete with the average of the results from the specimens of the reference concrete.

14.6 *Water Content*:

14.6.1 Report the water-cement ratio of the concrete, computed to the nearest 0.001, as follows: Determine the net mass