Designation: C494/C494M – 11

Standard Specification for Chemical Admixtures for Concrete[1]

This standard is issued under the fixed designation C494/C494M; 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 This specification covers materials for use as chemical admixtures to be added to hydraulic-cement concrete mixtures in the field 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 This specification stipulates tests of an admixture with suitable concreting materials as described in 11.1-11.3 or with cement, pozzolan, aggregates, and an air-entraining admixture proposed for specific work (11.4). Unless specified otherwise by the purchaser, the tests shall be made using concreting materials as described in 11.1-11.3.

NOTE 1—It is recommended that, whenever practicable, tests be made using the cement, pozzolan, aggregates, air-entraining admixture, and the mixture proportions, batching sequence, and other physical conditions proposed for the specific work (11.4) because the specific effects produced by chemical admixtures may vary with the properties and proportions of the other ingredients of the concrete. For instance, Types F and G admixtures may exhibit much higher water reduction in concrete mixtures having higher cement factors than that listed in 12.1.1.

Mixtures having a high range water reduction generally display a higher rate of slump loss. When high-range admixtures are used to impart increased workability (6 to 8-in. slump [150 to 200–mm]), the effect may be of limited duration, reverting to the original slump in 30 to 60 min depending on factors normally affecting rate of slump loss. The use of chemical admixtures to produce high-slump (flowing) concrete is covered by Specification C1017/C1017M.

NOTE 2—The purchaser should ensure 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 relatively large amounts of chloride may accelerate corrosion of prestressing steel. Compliance with the requirements of this specification does not constitute assurance of acceptability of the admixture for use in prestressed 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 requirements of this specification. Admixtures (except for Types B, C, E, and S) shall qualify for provisional compliance when the physical requirements and any of the alternative compressive strength requirements in Table 1 are met. If subsequent test results at 6 months or one year fail to meet the standard requirement of 100 % of reference strength, the 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 can be made (See Note 4).

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 correspond to a 99 % probability of passing subsequent test age requirements.[2]

1.3.2 *Level 2*—Limited retesting is described in 5.2, 5.2.1 and 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, when 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 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.

[1] This specification is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.23 on Chemical Admixtures.

Current edition approved July 1, 2011. Published August 2011. Originally approved in 1962. Last previous edition approved in 2010 as C494/C494M–10a. DOI: 10.1520/C0494_C0494M-11.

[2] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C09-1030.

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

1.5 The text of this standard references notes and footnotes which 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 the test method sections, 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C33 Specification for Concrete Aggregates
C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens
C78 Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
C136 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 Specification for Portland Cement
C157/C157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
C183 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 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
C260 Specification for Air-Entraining Admixtures for Concrete
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
C1017/C1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete
D75 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
Manual of Aggregate and Concrete Testing

2.2 *American Concrete Institute Standard:*

ACI 211.1–91 Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete[4]

[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.

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

3. Terminology

3.1 *Definitions:*

3.1.1 *accelerating admixture*—an admixture that accelerates the setting and early strength development of concrete.

3.1.2 *retarding admixture*—an admixture that retards the setting of concrete.

3.1.3 *water-reducing admixture*—an admixture that reduces the quantity of mixing water required to produce concrete of a given consistency.

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

3.1.5 *water-reducing and accelerating admixture*— an admixture that reduces the quantity of mixing water required to produce concrete of a given consistency and accelerates the setting and early strength development of concrete.

3.1.6 *water-reducing and retarding admixture*— an admixture that reduces the quantity of mixing water required to produce concrete of a given consistency and retards the setting of concrete.

3.1.7 *water-reducing, high range, and retarding admixture*—an admixture that reduces the quantity of mixing water required to produce concrete of a given consistency by 12 % or greater and retards the setting of concrete.

3.1.8 *specific performance admixture*—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 (See Note 5).

NOTE 5—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 in which each type of admixture shown in 1.1 is used 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 will cover 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 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. Purchasers having special requirements are allowed to require additional tests currently in this standard.

5.3 At the request of the purchaser, when the admixture is to be used in prestressed concrete, the manufacturer shall state in writing the chloride content of the admixture and whether or not chloride has been added during its manufacture.

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 supplied for use in the work.

5.6 At the request of the purchaser, the manufacturer shall state in writing that the infrared analysis spectrum, residue by oven drying, and specific gravity of the admixture supplied for use in the work are within the limits in Section 6 when compared with the initial sample tested under this specification.

6. Uniformity and Equivalence

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

6.1.1 *Infrared Analysis*—The absorption spectra of the initial sample and the test sample, obtained as specified in 18.1, shall be essentially similar.

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 ± 12 % of the mid-point of the manufacturer's stated range, but not exceeding the manufacturer's stated limits (See Note 6).

NOTE 6—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 ± 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 *Specific Gravity (Liquid Admixtures)*—When tested as specified in 18.4, the specific gravity of subsequent test samples shall not differ from the specific gravity of the initial sample by more than 10 % of the difference between the specific gravity of the initial sample and that of reagent water at the same temperature. If 10 % of the difference between the 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, electrodialysis, or a combination of these procedures is adequate.

6.2 When 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 When the admixture is delivered in packages or containers, the proprietary name of the admixture, the type under this specification, and the net weight 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 easy access for proper inspection and identification of each shipment, and in a suitable weathertight building that will protect the admixture from dampness and freezing.

9. Sampling and Inspection

9.1 Every facility shall be provided the purchaser for careful 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 *Quality Tests*—A sample taken for the purpose of evaluating the quality of a source or lot of admixture will be required to meet all the applicable requirements of this specification. Samples used to determine conformance with the requirements of this specification shall be composites of grab samples taken from sufficient locations to ensure that the composite sample will be representative of the lot.

9.3.2 *Uniformity and Equivalence Tests*— When specified by the purchaser, a sample 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 when different lots from the same source are being compared. When the uniformity of a single lot is being determined, grab samples shall be used.

9.4 *Liquid Admixtures*—Liquid admixtures shall be agitated thoroughly immediately prior to sampling. Grab samples taken for quality or uniformity tests shall represent a unit shipment or a single production lot. Each grab sample shall have a volume of at least 1 pt [0.5 L]. A minimum of three grab samples shall be taken. Composite samples shall be prepared by thoroughly mixing the grab samples selected and the resultant mixture sampled to provide at least 1 gal [4 L] for quality tests. Grab samples shall be taken from different locations well 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 packaged in impermeable, airtight containers which are resistant to attack by the admixture.

TABLE 1 Physical Requirements[A]

	Type A, Water Reducing	Type B, Retarding	Type C, Acceler-ating	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 Performance
Water content, max, % of control	95	...	...	95	95	88	88	...
Time of setting, allowable deviation from control, 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 control:[B]								
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)[C]	90	100	110 (120)[C]	110	110 (120)[C]	110 (120)[C]	90
90 days	(117)[C]	n/a	n/a	(117)[C]	n/a	(117)[C]	(117)[C]	n/a
6 months	100 (113)[C]	90	90	100 (113)[C]	100	100 (113)[C]	100 (113)[C]	90
1 year	100	90	90	100	100	100	100	90
Flexural strength, min, % control:[B]								
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):[D]								
Percent of control	135	135	135	135	135	135	135	135
Increase over control	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Relative durability factor, min[E]	80	80	80	80	80	80	80	80

[A] The values in the table include allowance for normal variation in test results. The object of the 90 % compressive strength requirement for a Type B amd Type S admixture is to require a level of performance comparable to that of the reference concrete.

[B] 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.

[C] 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 qualified until the 1-year strength test results are obtained.

[D] Alternative requirements, see 17.1.4, % of control limit applies when length change of control is 0.030 % or greater; increase over control limit applies when length change of control is less than 0.030 %.

[E] This requirement is applicable only when the admixture is to be used in air-entrained concrete which may be exposed to freezing and thawing while wet.

9.5 *Nonliquid Admixtures*—Grab samples taken for quality or uniformity tests shall represent not more than 2 tons [2 Mg] of admixture and shall weigh at least 2 lb [have a mass of at least 1 kg]. A minimum of four grab samples shall be taken. Composite samples shall be prepared by thoroughly mixing the grab samples selected and the resultant mixture sampled to provide at least 5 lb [2.5 kg] for the composite sample. Grab samples shall be taken from different locations well 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.

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

9.6 Samples shall be thoroughly mixed before testing to ensure uniformity. When recommended by the manufacturer, the entire sample of a nonliquid admixture shall be dissolved in water prior to 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 is allowed 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 6 months prior to shipment, or an admixture in local storage in the hands of a vendor for more than 6 months, after completion of tests, shall be retested before use when requested by the purchaser and is allowed to be rejected 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 weight or volume are allowed to be rejected. If the

average weight or volume of 50 packages taken at random is less than that specified, the entire shipment is allowed to be rejected.

10.5 When the admixture is to be used in non-air-entrained concrete, it shall be rejected when the purchaser desires if the test concrete containing it has an air content greater than 3.5 %; when the admixture is to be used in air-entrained concrete, it can be rejected if the test concrete containing it has an air content greater than 7.0 %.

TEST METHODS

NOTE 7—These tests are based on arbitrary stipulations which make possible highly standardized testing in the laboratory and are not intended to simulate actual job conditions.

11. Materials

TESTS NOT FOR A SPECIFIC USE

11.1 *Cement*—The cement used in any series of tests shall be either the cement proposed for a specific use in accordance with 11.4, a Type I or Type II cement conforming to Specification C150, or a blend of two or more cements, in equal parts. Each cement of the blend shall conform to the requirements of either Type I or Type II, Specification C150. If when using a cement other than that proposed for specific work, the air content of the concrete made without 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 concrete will be 3.5 % or less.

11.2 *Aggregates*—Except when tests are made in accordance with 11.4 using the aggregates proposed for a specific use, the fine and coarse aggregates used in any series of tests shall come from single lots of well-graded, sound materials that conform to the requirements of Specification C33, except that the grading of the aggregates shall conform to the following requirements:

11.2.1 *Fine Aggregate Grading*:

Sieve	Weight Percent Passing
No. 4 [4.75-mm]	100
No. 16 [1.18-mm]	65 to 75
No. 50 [300 µm]	12 to 20
No. 100 [150 µm]	2 to 5

11.2.2 *Coarse Aggregate Grading*— The coarse aggregate shall meet the requirements for size number 57 of Specification C33. Take care in loading and delivery to avoid segregation.

11.2.3 The coarse aggregate used for each set of reference concrete and comparable test admixture-treated concrete shall be essentially the same. Therefore, a set of test concrete consists of one reference concrete and as many test admixture-containing concretes as are intended to be compared to that one reference. Thus, coarse aggregate for one set shall consist of enough material for one reference concrete, the test admixture-containing concrete to be compared with that reference and the sample for grading analysis testing.

11.2.3.1 Prepare coarse aggregate for a set, comprising a sample large enough for concrete trials, as follows: Fill tared containers, one each for a sample, a batch of reference concrete and one or more test concretes to the required mass from the aggregate stockpile. Accomplish this by starting with a scoopful into the first container and repeat this procedure until all containers have their required mass. Repeat the process for each of the three or more sets needed. One or more spare sets may be needed. See the Appendix of Practice D75, Sampling from Stockpiles, and the Manual of Aggregate and Concrete Testing for guidance for conditions and procedures.

11.2.4 Test coarse aggregate samples representing each set by Method C136 requirements for the sieves shown below. Discard any set for which the sample does not comply with size 57. Average test results for samples which comply with size 57 for each sieve size. Discard any set for which the sample deviates from this average by more than the amount shown in column 3. Continue the process of preparation, testing and averaging until sufficient sets of aggregate within tolerance are obtained.

Sieve	Specification C33, No. 57 Percent Passing	Maximum variation from average/passing
1½ in. [37.5-mm]	100	0.0
1.00 in. [25.0-mm]	95 to 100	1.0
½ in. [12.5-mm]	25 to 60	4.0
No. 4 [4.75-mm]	0 to 10	4.0
No. 8 [2.36-mm]	0 to 5	1.0

NOTE 8—All of the results required for demonstrating compliance under this specification are dependent on the uniformity of the aggregate samples prepared and used. Careful, skilled and well-supervised work is essential.

11.3 *Air-Entraining Admixture*—Except when tests are made in accordance with 11.4 using the air-entraining admixture proposed for specific work, the air-entraining admixture used in the concrete mixtures specified in Section 12 shall be a material such that when used to entrain the specified amount of air in the concrete mixture will give concrete of satisfactory resistance to freezing and thawing. The material to be so used will be designated by the person or agency for whom the testing is to be performed. If no material is designated, "neutralized Vinsol resin[5]" shall be used. Accomplish neutralization by treating 100 parts of Vinsol resin with 9 to 15 parts of NaOH by mass. In an aqueous solution, the ratio of water to the resinate shall not exceed 12 to 1 by mass.

TESTS FOR SPECIFIC USES

11.4 *Materials for Tests*—The effects of a chemical admixture on the time of setting and water requirement of concrete are known to vary with the time of its addition during the batching and mixing sequence. To test a chemical admixture for use in specific work, the cement, pozzolan, aggregates, and air-entraining admixture used shall be representative of those proposed for use in the work. Add the chemical admixture in the same manner and at the same time during the batching and mixing sequence as it will be added on the job. Proportion the concrete mixtures to have the cement content specified for use in the work. If the maximum size of coarse aggregate is greater than 1 in. [25.0 mm], screen the concrete over a 1-in. [25.0-mm] sieve prior to fabricating the test specimens.

[5] The sole source of supply of Vinsol resin known to the committee at this time is Hercules Inc., Wilmington, DE. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee [1], which you may attend.

11.4.1 *Other Use Conditions*—Other conditions are known to affect the overall suitability of the concrete mixture for specific intended uses. These include the temperature of the materials or the surroundings, the humidity, the length of time between mixing and placing, the amount of mixing activity and other factors. These physical conditions may be incorporated into the tests with intention for indicating the potential interactions. These tests would be only for guidance. After incorporation of such test conditions it would not be suitable to expect compliance with this specification requirement.

11.5 *Preparation and Batching*—Prepare all material and make all weighings as prescribed in Practice C192/C192M.

12. Proportioning of Concrete Mixtures

12.1 *Proportions*—Except when tests are being made for specific uses, all concrete shall be proportioned using ACI 211.1–91 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 contents. Unless otherwise specified, the admixture shall be added with the first increment of mixing water that is added to the mixer.

12.1.1 The cement content shall be 517 ± 5 lb/yd ^{3}[307 ± 3 kg/m^3].

12.1.2 For the first trial mixture, refer to the table on volume of coarse aggregate per unit volume of concrete in ACI 211.1–91 for guidance on the amount of coarse aggregate to use, given the nominal maximum size of the aggregate and the fineness modulus of the fine aggregate being used (see Note 9

NOTE 9—Values in the referenced table of ACI 211.1–91 are intended to ensure workable mixtures with the least favorable combinations of aggregate likely to be used. It is suggested, therefore, that for a closer approximation of the proportions required for this test, the values selected from this table be increased by about 7 for the first trial mixture.

12.1.3 For the non-air-entrained mixtures, the air content used in calculating the proportions shall be 1.5, as shown in Table number 5.3.3 of ACI 211.1–91. 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 3½ ± ½ in. [90 ± 15 mm]. 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 *Conditions*—Prepare concrete mixtures both with and without the admixture under test. Refer herein to the concrete mixture without the chemical admixture as the reference or control concrete mixture. Except in the case of 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. When 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*—When the admixture is to be tested for use only in non-air-entrained concrete, the air content of both the mixture containing the admixture under test and the reference concrete mixture shall be 3.5 % or less, and the difference between the air contents of the two mixtures shall not exceed 1.0. If necessary, the air-entraining admixture shall be added to the reference concrete mixture. Tests for resistance to freezing and thawing shall not be made.

12.2.2 *Air-Entrained Concrete*—When the admixture is to be tested for use only in air-entrained concrete, the air-entraining admixture shall be added to the reference concrete mixture and, if necessary, to the concrete mixture containing the admixture under test in sufficient amounts to produce air contents in the range 3.5 to 7.0 %, except that for tests for resistance to freezing and thawing, the range shall be 6.0 ± 1.0 %. In both cases the difference between the air content of the reference concrete and that of the concrete containing the admixture under test shall not exceed 0.5.

13. Mixing

13.1 Machine mix the concrete as prescribed in 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 condition 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.

14.4 *Time of Setting*—Test Method C403/C403M, except that the temperature of each of the ingredients of the concrete mixtures, just prior to mixing, and the temperature at which the time-of-setting specimens are stored during the test period shall be 73 ± 3 °F [23.0 ± 2.0 °C].

14.5 *Water Content*:

14.5.1 Report the water-cement ratio of the concrete, computed to the nearest 0.001, as follows: Determine the net water content of the batch as the weight of water in the batch in excess of that present as absorbed water in the aggregates. Calculate the actual volume of concrete in the batch by determining the density of concrete in the batch as prescribed in Test Method C138/C138M. Determine the water-cement ratio by dividing the net weight of water by the weight of cement in the batch.

14.5.2 Calculate the relative water content of the concrete containing the admixture under test as a percentage of the water content of the reference concrete as follows: Divide the average water content of all batches of concrete containing the admixture under test by the average water content of all batches of the reference concrete and multiply the quotient by 100.

15. Preparation of Test Specimens

15.1 Make specimens for tests of hardened concrete, representing each test and age of test and each condition of concrete