Designation: C94/C94M – 22

Standard Specification for Ready-Mixed Concrete[1]

This standard is issued under the fixed designation C94/C94M; 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 U.S. Department of Defense.

1. Scope*

1.1 This specification covers ready-mixed concrete as defined in 3.2.2 (Note 1). Requirements for quality of ready-mixed concrete shall be either as stated in this specification or as ordered by the purchaser. When the purchaser's requirements, as stated in the order, differ from those in this specification, the purchaser's requirements shall govern. This specification does not cover the placement, consolidation, curing, or protection of the concrete after delivery to the purchaser.

NOTE 1—Concrete produced by volumetric batching and continuous mixing is covered in Specification C685/C685M. Fiber-reinforced concrete is covered in Specification C1116/C1116M.

1.2 As used throughout this specification the manufacturer produces ready-mixed concrete. The purchaser buys ready-mixed concrete.

1.3 The values stated in either SI units, shown in brackets, 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.

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

1.5 *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 skin and tissue upon prolonged use.[2])

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field

C33/C33M Specification for Concrete Aggregates

C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens

C125 Terminology Relating to Concrete and Concrete 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

C172/C172M Practice for Sampling Freshly Mixed Concrete

C173/C173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

C231/C231M Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

C260/C260M Specification for Air-Entraining Admixtures for Concrete

C330/C330M Specification for Lightweight Aggregates for Structural Concrete

[1] This specification is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.40 on Ready-Mixed Concrete.

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

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

C494/C494M Specification for Chemical Admixtures for Concrete
C567/C567M Test Method for Determining Density of Structural Lightweight Concrete
C595/C595M Specification for Blended Hydraulic Cements
C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C637 Specification for Aggregates for Radiation-Shielding Concrete
C685/C685M Specification for Concrete Made by Volumetric Batching and Continuous Mixing
C989/C989M Specification for Slag Cement for Use in Concrete and Mortars
C1017/C1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete (Withdrawn 2022)[4]
C1064/C1064M Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
C1077 Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
C1116/C1116M Specification for Fiber-Reinforced Concrete
C1157/C1157M Performance Specification for Hydraulic Cement
C1240 Specification for Silica Fume Used in Cementitious Mixtures
C1602/C1602M Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
C1611/C1611M Test Method for Slump Flow of Self-Consolidating Concrete
C1697 Specification for Blended Supplementary Cementitious Materials
C1798/C1798M Specification for Returned Fresh Concrete for Use in a New Batch of Ready-Mixed Concrete
C1866/C1866M Specification for Ground-Glass Pozzolan for Use in Concrete

2.2 *ACI Documents:*[5]
ACI 211.1 Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 211.2 Standard Practice for Selecting Proportions for Structural Lightweight Concrete
ACI 301 Standard Specifications for Structural Concrete
ACI 305.1 Specification for Hot Weather Concreting
ACI 305R Guide to Hot Weather Concreting
ACI 306R Guide to Cold Weather Concreting
ACI 318 Building Code Requirements for Structural Concrete and Commentary

2.3 *Other Documents:*[6]
NIST 105-1 National Institute of Standards and Technology Handbook

3. Terminology

3.1 *Definitions*—The terms used in this specification are defined in Terminology C125.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *concrete, central-mixed, n*—ready-mixed concrete mixed completely in a stationary mixer.

3.2.2 *concrete, ready-mixed, n*—concrete manufactured and delivered to a purchaser in a fresh state.

3.2.3 *concrete, shrink-mixed, n*—ready-mixed concrete partially mixed in a stationary mixer with mixing completed in a truck mixer.

3.2.4 *concrete, truck-mixed, n*—ready-mixed concrete completely mixed in a truck mixer.

3.2.5 *water, target batch, n*—quantity of water to be added to the batch through the water measuring system after compensating for the quantity of ice, if used, surface moisture on the aggregates and water in the admixtures, when applicable, and by subtracting a quantity of water that is anticipated to be added at the job site or in transit to adjust slump or slump flow of the concrete batch.

4. Basis of Purchase

4.1 The basis of purchase shall be a cubic yard or cubic metre of fresh concrete as discharged from the transportation unit.

4.2 The volume of fresh concrete in a given batch shall be determined from the total mass of the batch divided by the density of the concrete. The total mass of the batch shall be determined as the net mass of the concrete in the batch as delivered, including the total mixing water as defined in 9.3. The density shall be determined in accordance with Test Method C138/C138M. The yield shall be determined as the average of at least three measurements, one from each of three different transportation units sampled in accordance with Practice C172/C172M.

NOTE 2—It should be understood that the volume of hardened concrete may be, or appear to be, less than expected due to waste and spillage, over-excavation, spreading forms, some loss of entrained air, or settlement of wet mixtures, none of which is the responsibility of the producer.

5. Materials

5.1 In the absence of designated applicable material specifications, the following material specifications shall be used:

5.2 *Cementitious Materials:*

5.2.1 *Hydraulic Cement*—Hydraulic cement shall conform to Specification C150/C150M, Specification C595/C595M, or Specification C1157/C1157M.

5.2.2 *Supplementary Cementitious Materials*—Coal fly ash or natural pozzolans shall conform to Specification C618. Slag cement shall conform to Specification C989/C989M. Silica fume shall conform to Specification C1240. Ground-glass pozzolan shall conform to Specification C1866/C1866M. Blended supplementary cementitious materials shall conform to Specification C1697.

NOTE 3—Specification C1697 does not apply to the combination of

[4] The last approved version of this historical standard is referenced on www.astm.org.
[5] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, http://www.concrete.org.
[6] NIST Handbook 105-1 (revised 1990), "Specifications and Tolerances for Reference Standards and Field Standard Weights and Measures-1. Specifications and Tolerances for Field Standard Weights (NIST Class F)," National Institute of Standards and Technology., U.S. Dept. of Commerce, http://www.nist.gov/pml/wmd/upload/105-1.pdf.

individually batched supplementary cementitious materials during the manufacture of ready-mixed concrete.

5.3 *Aggregates*—Normal weight aggregates shall conform to Specification C33/C33M. Lightweight aggregates shall conform to Specification C330/C330M and heavyweight aggregates shall conform to Specification C637.

5.4 *Water*—Water shall conform to Specification C1602/C1602M.

5.5 *Air-Entraining Admixtures*—Air-entraining admixtures shall conform to Specification C260/C260M (Note 4).

5.6 *Chemical Admixtures*—Chemical admixtures shall conform to Specification C494/C494M or C1017/C1017M as applicable (Note 4).

NOTE 4—In any given instance, the required dosage of air-entraining, accelerating, and retarding admixtures may vary. Therefore, a range of dosages should be allowed, which will permit obtaining the desired effect.

NOTE 5—Interchanging kinds, characteristics, types, classes, or grades of the materials permitted in ready-mixed concrete may produce concrete of different properties.

5.7 *Returned Fresh Concrete*—Returned fresh concrete, when permitted by the purchaser, shall conform to Specification C1798/C1798M.

NOTE 6—Specification C1798/C1798M provides requirements for using, measuring, and reporting returned fresh concrete. These requirements are in addition to those stated herein. The purchaser may further clarify which concrete within an order, such as specific mixtures or applications, may incorporate returned fresh concrete.

6. Ordering Information

6.1 In the absence of designated applicable general specifications, the purchaser's order shall include the following:

6.1.1 Designated size, or sizes, of coarse aggregate,

6.1.2 Slump, or slumps, desired at the point of discharge from the transportation unit (see Section 7 for acceptable tolerances),

6.1.3 Slump flow, or flows, desired at the point of discharge from the transportation unit (see Section 7 for acceptable tolerances),

6.1.4 Total air content at the point of discharge from the transportation unit for concrete that will be exposed to cycles of freezing and thawing or anticipated exposure of the concrete (see Section 8 for sampling for air content tests and tolerances).

NOTE 7—Table 1 provides total air contents for concrete that vary by exposure condition and aggregate size. Total air contents less than those shown in Table 1 may be specified or used for concrete that is not subject to freezing and thawing. This may be done to improve workability and cohesiveness, reduce the rate of bleeding, reduce the water content for a given consistency, or achieve required lightweight concrete density. Specified total air contents higher than those shown in Table 1 may reduce strength without any further improvement of durability.

Exposure conditions for freezing and thawing environments in Table 1 correspond to the following:

Moderate Exposure—Concrete exposed to freeze-thaw cycles but not in contact with the ground or with limited exposure to water, limiting the ability to cause saturation of a portion of the concrete prior to freezing. The concrete shall not receive deicing salts or other aggressive chemicals. Examples include: exterior beams, columns, walls, girders, footings below the frost line, or elevated slabs where application of deicing salt is not anticipated. The air content requirements for this exposure are consistent with those for Exposure Class F1 of ACI 318.

Severe Exposure—Concrete exposed to freeze-thaw cycles while in contact with the ground or with frequent exposure to water, potentially causing saturation of a portion of the concrete prior to freezing. The concrete may receive deicing chemicals or other aggressive chemicals. Examples include: pavements, bridge decks, curbs, gutters, sidewalks, canal linings, or exterior water tanks or sumps. The air content requirements for this exposure are consistent with those for Exposure Classes F2 and F3 of ACI 318.

6.1.5 Which of Options A, B, or C shall be used as a basis for determining the proportions of the concrete to produce the required quality,

6.1.6 When lightweight concrete is specified, the equilibrium density,

NOTE 8—The density of fresh concrete is the only measurable density of lightweight concrete at the time of delivery. The density of fresh concrete is always higher than the equilibrium or oven-dry density. Therefore, for acceptance of lightweight concrete based on density at the point of discharge from the transportation unit, a relationship between the equilibrium density and density of fresh concrete needs to be established. Definitions of, and methods for determining or calculating equilibrium and oven-dry density, are covered by Test Method C567/C567M.

6.1.7 When high-density or heavyweight concrete is specified, the density of fresh concrete, and

NOTE 9—High-density or heavyweight concrete typically contains aggregate with a relative density of 3.3 or greater conforming to Specification C637. This concrete is used for radiation shielding or other applications where higher density is required by design. For acceptance of density at point of discharge from the transportation unit, a relationship between the fresh density and the density of hardened concrete required by design should be established.

6.1.8 If desired, any of the optional requirements of Table 2 in Specification C1602/C1602M.

6.1.9 Purchaser shall state any drum revolution limit as to when the concrete discharge must begin. If no drum revolution limit is stated by purchaser, the manufacturer shall determine and communicate the limit to the purchaser prior to delivery.

6.1.10 Purchaser shall state a time limit from the start of mixing defined in 12.3 or 12.5 to when the concrete discharge must be completed. If no time limit is stated by purchaser, the manufacturer shall establish and communicate the limit to the purchaser prior to delivery. The time limit to complete discharge shall be stated on the delivery ticket in accordance with 14.1.14.

NOTE 10—This specification previously included a 1 ½ h time limit to end of discharge since its original publication in 1935. There are many

TABLE 1 Total Air Content for Air-Entrained Concrete Exposed to Cycles of Freezing and Thawing

Exposure Condition (See Note 7)	Total Air Content, % Nominal Maximum Sizes of Aggregate, mm [in.]						
	9.5 [⅜]	12.5 [½]	19.0 [¾]	25.0 [1]	37.5 [1½]	50.0 [2]	75.0 [3]
Moderate	6.0	5.5	5.0	4.5	4.5	4.0	3.5
Severe	7.5	7.0	6.0	6.0	5.5	5.0	4.5

options available to the manufacturer to provide the required quality of concrete with end of discharge limits beyond 1 ½ h or less than 1 ½ h. The purchaser should consult with the manufacturer for available options to establish a time limit to end of discharge prior to or at the time concrete is ordered. Selection of a time limit to end of discharge should consider ambient conditions, types of cementitious materials and admixtures used, placement procedures, and projected transportation time between the batch plant and the point of delivery.

6.2 If a project specification applies, the order shall include applicable requirements for the concrete to be produced in compliance with the specification.

6.3 If the type, kind, or class of cementitious materials in 5.2.1 and 5.2.2 are not designated by the purchaser, it is permitted to use cementitious materials in concrete mixtures that will satisfy the concrete properties and other requirements of the purchaser as ordered.

6.4 *Option A:*

6.4.1 When the purchaser requires the manufacturer to assume full responsibility for the selection of the proportions for the concrete mixture (Note 11), the purchaser shall also specify the following:

6.4.1.1 Requirements for compressive strength as determined on samples taken from the transportation unit at the point of discharge in accordance with Section 17 and specimens made, cured, and tested in accordance with Section 18. The purchaser shall specify the requirements in terms of the compressive strength of standard specimens cured under standard laboratory conditions for moist curing (see Section 18). Unless otherwise specified the age at test shall be 28 days.

NOTE 11—The purchaser, in selecting requirements for which he assumes responsibility should give consideration to requirements for workability, placeability, durability, surface texture, and density, in addition to those for structural design. The purchaser is referred to Standard Practice ACI 211.1 and Standard Practice ACI 211.2 for the selection of proportions that will result in concrete suitable for various types of structures and conditions of exposure. The water-cement ratio of most structural lightweight concretes cannot be determined with sufficient accuracy for use as a specification basis.

6.4.2 At the request of the purchaser, the manufacturer shall, prior to the actual delivery of the concrete, furnish a statement to the purchaser, giving the dry masses of cement and saturated surface-dry-masses of fine and coarse aggregate and quantities, type, and name of admixtures (if any) and of water per cubic yard or cubic metre of concrete that will be used in the manufacture of each class of concrete ordered by the purchaser. The manufacturer shall also furnish evidence satisfactory to the purchaser that the materials to be used and proportions selected will produce concrete of the quality specified.

6.5 *Option B:*

6.5.1 When the purchaser assumes responsibility for the proportioning of the concrete mixture, he shall also specify the following:

6.5.1.1 Cement content in kilograms per cubic metre [pounds per cubic yard] of concrete,

6.5.1.2 Maximum allowable water content in litres per cubic metre [gallons per cubic yard] of concrete, including surface moisture on the aggregates, but excluding water of absorption (Note 11), and

6.5.1.3 If admixtures are required, the type, name, and dosage to be used. The cement content shall not be reduced when admixtures are used under this option without the written approval of the purchaser.

6.5.2 At the request of the purchaser, the manufacturer shall, prior to the actual delivery of the concrete, furnish a statement to the purchaser giving the sources, densities, and sieve analyses of the aggregates and the dry masses of cement and saturated-surface-dry masses of fine and coarse aggregate and quantities, type and name of admixture (if any) and of water per cubic yard or cubic metre of concrete that will be used in the manufacture of each class of concrete ordered by the purchaser.

6.6 *Option C:*

6.6.1 When the purchaser requires the manufacturer to assume responsibility for the selection of the proportions for the concrete mixture with the minimum allowable cement content specified (Note 12), the purchaser shall also specify the following:

6.6.1.1 Requirements for compressive strength as determined on samples taken from the transportation unit at the point of discharge in accordance with Section 17 and specimens made, cured, and tested in accordance with Section 18. The purchaser shall specify the requirements for strength in terms of tests of standard specimens cured under standard laboratory conditions for moist curing (see Section 18). Unless otherwise specified the age at test shall be 28 days.

6.6.1.2 Minimum cement content in kilograms per cubic metre [pounds per cubic yard] of concrete.

6.6.1.3 If admixtures are required, the type, name, and dosage to be used. The cement content shall not be reduced when admixtures are used.

NOTE 12—Option C can be distinctive and useful only if the designated minimum cement content is at about the same level that would ordinarily be required for the strength, aggregate size, and slump or slump flow specified. At the same time, it must be an amount that will be sufficient to ensure durability under expected service conditions, as well as satisfactory surface texture and density, in the event specified strength is attained with it. For additional information refer to Standard Practice ACI 211.1 and Standard Practice 211.2 referred to in Note 11.

6.6.2 At the request of the purchaser, the manufacturer shall, prior to the actual delivery of the concrete, furnish a statement to the purchaser, giving the dry masses of cement and saturated surface-dry masses of fine and coarse aggregate and quantities, type, and name of admixture (if any) and of water per cubic yard or cubic metre of concrete that will be used in the manufacture of each class of concrete ordered by the purchaser. He shall also furnish evidence satisfactory to the purchaser that the materials to be used and proportions selected will produce concrete of the quality specified. Whatever strengths are attained the quantity of cement used shall not be less than the minimum specified.

6.7 The proportions arrived at by Options A, B, or C for each class of concrete and approved for use in a project shall be assigned a designation to facilitate identification of each concrete mixture delivered to the project. This is the designation required in 14.1.7 and supplies information on concrete proportions when they are not given separately on each

delivery ticket as outlined in 14.2. A certified copy of all proportions as established in Options A, B, or C shall be on file at the batch plant.

6.8 The purchaser shall ensure that the manufacturer is provided copies of all reports of tests performed on concrete samples taken to determine compliance with specification requirements. Reports shall be provided on a timely basis.

6.9 The manufacturer shall obtain the purchaser's permission to incorporate returned fresh concrete.

7. Slump or Slump Flow

7.1 Unless other tolerances are indicated by the purchaser, the following shall apply.

7.1.1 When slump is stated as a "maximum" or "not to exceed" requirement:

Tolerances for "Maximum" or "Not to Exceed" Slumps

For Slump of:	Tolerance
75 mm [3 in.] or less	+0 and –40 mm [1½ in.]
More than 75 mm [3 in.]	+0 and –65 mm [2½ in.]

7.1.1.1 The maximum or not to exceed slump provision shall be used only if a job site water addition is permitted by the specification in accordance with 12.7.

7.1.2 When slump is stated as a target or nominal slump:

Tolerances for Target or Nominal Slumps

For Slump of:	Tolerance
50 mm [2 in.] and less	±15 mm [½ in.]
More than 50 to 100 mm [2 through 4 in.]	±25 mm [1 in.]
More than 100 mm [4 in.]	±40 mm [1½ in.]

7.1.3 When the purchaser states a slump flow requirement for self-consolidating concrete:

Tolerances for Slump Flow

For Slump Flow	Tolerance
Less than or equal to 550 mm [22 in.]	±40 mm [1 ½ in.]
More than 550 mm [22 in.]	±65 mm [2 ½ in.]

7.1.4 The tolerances for slump or slump flow apply to the values stated in the order when adjustments in accordance with 12.7 and 12.8 are permitted.

7.2 Concrete shall be available within the permissible range of slump or slump flow for a period of 30 min starting either on arrival at the job site or after the initial slump adjustment permitted in 12.7, whichever is later. The first and last ¼ m^3 [¼ yd^3] discharged are exempt from this requirement. If the user is unprepared for discharge of the concrete from the vehicle, the producer shall not be responsible for the limitation of minimum slump or slump flow after 30 min have elapsed starting either on arrival of the vehicle at the prescribed destination or at the requested delivery time, whichever is later.

8. Air-Entrained Concrete

8.1 Unless otherwise specified, for air-entrained concrete the total air contents in Table 1 shall apply based on the exposure condition stated in the purchase order. It is permitted to reduce the total air content values in Table 1 by one percentage point for concretes with a specified compressive strength greater than or equal to 35 MPa [5000 psi]. Total air content that differs from the values in Table 1 is permitted for concrete not exposed to cycles of freezing and thawing (Note 7).

8.2 The air content of air-entrained concrete when sampled from the transportation unit at the point of discharge shall be within a tolerance of ±1.5 of the specified value.

8.3 When a preliminary sample taken within the time limits of 12.7 and prior to discharge for placement shows an air content below the specified level by more than the allowable tolerance in accordance with 8.2, the manufacturer may use additional air entraining admixture to achieve the desired air content level, followed by a minimum of 30 revolutions at mixing speed, so long as the revolution limit of 6.1.9 is not exceeded (see Note 13).

NOTE 13—Acceptance sampling and testing in accordance with Practice C172/C172M is not obviated by this provision. Increasing the air content may increase the slump or slump flow.

9. Measuring Materials

9.1 Except as otherwise specifically permitted, cementitious materials shall be measured by mass. When supplementary cementitious materials are used in the concrete mixtures, the cumulative mass is permitted to be measured with hydraulic cement, but in a batch hopper and on a scale which is separate and distinct from those used for other materials. The mass of the hydraulic cement shall be measured before supplementary cementitious materials. When the quantity of cementitious material exceeds 30 % of the full capacity of the scale, the measured quantity of the hydraulic cement shall be within ±1 % of the required mass, and the cumulative measured quantity of hydraulic cement plus supplementary cementitious materials shall also be within ±1 % of the required cumulative mass at each intermediate weighing. For smaller batches to a minimum of 1 m^3 [1 yd^3], the measured quantity of the hydraulic cement and the measured cumulative quantity of hydraulic cement plus supplementary cementitious materials used shall be not less than the required amount nor more than 4 % in excess. When the purchaser requires alternate methods of measuring cementitious materials, measurement methods and reporting shall be stated in the order (see Note 14).

NOTE 14—Cementitious materials in bags may be used when requested or permitted by the purchaser.

9.2 Aggregate shall be measured by mass. The quantity of aggregate weighed shall be the required dry mass plus the total moisture content (absorbed and surface) of the aggregate.

9.2.1 For individual weigh batchers, the quantity of aggregate weighed shall be within ±2 % of the required mass; except if the required quantity of aggregate is less than 15 % of scale capacity, the quantity of aggregate weighed shall be within ±0.3 % of scale capacity.

9.2.2 For cumulative weigh batchers, if the required quantity of aggregate is equal to or greater than 30 % of the scale capacity, the quantity of aggregate weighed shall be within ±1 % of the required mass at each successive weighing. If the required quantity of aggregate is less than 30 % of the scale

capacity, the quantity of aggregate weighed shall be within ±0.3 % of scale capacity at each successive weighing.

NOTE 15—The batching accuracy limit of 0.3 % of scale capacity establishes a reasonable minimum weighing tolerance that is independent of the quantity of material being weighed.

9.3 Mixing water shall consist of batch water (water weighed or metered at the plant), ice, free moisture on the aggregates, wash water retained in the mixer before batching, water added at the job site in accordance with 12.7 or by an automated truck mixer system in accordance with 12.8, and water introduced from admixtures if the quantity added increases the water-cementitious materials ratio by more than 0.01 (Note 16). The batch water shall be measured by mass or volume to an accuracy of ±1.5 % of the target batch water. Ice shall be measured by mass. In the case of truck mixers, any wash water retained in the drum for use in the next batch of concrete shall be measured; if this proves impractical or impossible the wash water shall be discharged before loading the next batch of concrete. Quantity of mixing water shall be accurate to within ±3 % of the amount established by the designed mixture proportions.

NOTE 16—Mixing water is the total amount of water in a batch less the water absorbed by the aggregates. Mixing water is used to calculate the water-cementitious materials ratio (w/cm).

9.4 Chemical admixtures in powdered form shall be measured by mass. Liquid chemical admixtures shall be batched by mass or volume. Admixtures measured by either mass or volume shall be batched with an accuracy of ±3 % of the total amount required or plus or minus the amount or dosage required for 50 kg [100 lb] of hydraulic cement, whichever is greater.

NOTE 17—Admixture dispensers of the mechanical type capable of adjustment for variation of dosage, and of simple calibration, are recommended.

10. Batching Plant

10.1 Bins with adequate separate compartments shall be provided in the batching plant for fine and for each required size of coarse aggregate. Each bin compartment shall be designed and operated so as to discharge efficiently and freely, with minimum segregation, into the weighing hopper. Means of control shall be provided so that, as the quantity desired in the weighing hopper is approached, the material shall be shut off with precision. Weighing hoppers shall be constructed so as to eliminate accumulations of tare materials and to discharge fully.

10.2 Indicating devices shall be in full view and near enough to be read accurately by the operator while charging the hopper. The operator shall have convenient access to all controls.

10.3 Scales shall be considered accurate if their accuracy is verified through the normally used capacity in accordance with Table 2 and load indicated relative to applied test load is within ±0.15 % of the total capacity of the scale or 0.4 % of the net applied load, whichever is greater. The minimum quantity and sequence of applied test loads used to verify material scales shall conform to Table 2 and its notes.

10.4 All exposed fulcrums, clevises, and similar working parts of scales shall be kept clean. Beam scales shall be equipped with a balance indicator sensitive enough to show movement when a weight equal to 0.1 % of the nominal capacity of the scale is placed in the batch hopper. Pointer travel shall be a minimum of 5 % of the net-rated capacity of the largest weigh beam for underweight and 4 % for overweight.

10.5 The device for the measurement of the added water shall be capable of delivering to the batch the quantity required within the accuracy required in 9.3. The device shall be so arranged that the measurements will not be affected by variable pressures in the water supply line. Measuring tanks shall be equipped with outside taps and valves to provide for checking their calibration unless other means are provided for readily and accurately determining the amount of water in the tank.

NOTE 18—The scale accuracy limitations of the National Ready Mixed

TABLE 2 Minimum Field Standard Weights and Test Loads[A]

Device Capacity	Minimum (in terms of device capacity)		Minimum Loads for Verification of Scale Accuracy
	Field Standard Weights	Test Loads[C]	
0 to 2000 kg [0 to 4000 lb]	100 %	100 %	
2001 to 20 000 kg [4001 to 40 000 lb]	Greater of[B] 10 % or 500 kg [1000 lb]	50 %[D]	Field standard weights or test load to used capacity, if greater than minimum specified. Strain-load tests[E] are permitted to be used above test load minimums. During initial verification, a scale shall be tested to full capacity.

[A] If the configuration and set up of the scale system prevents access or application of adequate field standard weights or if an unsafe condition is created by the verification process then the use of the scale above the verified position shall be discontinued until corrective measures have been completed.
[B] Field standard weights used in verifying accuracy of weighing devices shall comply with requirements of NIST Handbook 105-1.
[C] The term "test load" means the sum of the combination of field standard weights and any other applied load used in the conduct of a test using substitution test methods. Substitution Test—In the substitution test procedure, material or objects are substituted for field standard weights, or a combination of field standard weights and previously quantified material or objects, using the scale under test as a comparator. Additional test weights or other known test loads may be added to the known test load to verify the accuracy of higher weight ranges on the scale.
[D] The scale shall be tested from zero to at least 10 % of scale capacity using field standard weights, and then to at least 50 % of scale capacity using a series of substitution load tests that utilize field standard weights equaling at least 10 % of scale capacity.
[E] A strain-load test shall be conducted to verify the accuracy from 50 % of scale capacity to the used capacity of the scale. At least one load test shall be performed in each quarter of scale capacity. Strain-Load Test—In the strain-load test procedure, an unknown quantity of material or objects are used to establish a reference load or tare to which field standard weights or substitution test loads are added.

Concrete Association Plant Certification meet the requirements of this specification.

11. Mixers and Agitators

11.1 Mixers include stationary mixers or truck mixers. Agitators include truck mixers or truck agitators.

11.1.1 Stationary mixers shall be equipped with a metal plate or plates on which are plainly marked the mixing speed of the drum or paddles, and the maximum capacity in terms of the volume of mixed concrete. If used for the complete mixing of concrete, stationary mixers shall be equipped with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed.

11.1.2 Each truck mixer or agitator shall have attached thereto in a prominent place a metal plate or plates on which are plainly marked the gross volume of the drum, the capacity of the drum or container in terms of the volume of mixed concrete, and the minimum and maximum mixing speeds of rotation of the drum, blades, or paddles. If the concrete is truck mixed as described in 12.5, or shrink mixed as described in 12.4, the volume of mixed concrete shall not exceed 63 % of the total volume of the drum or container. If the concrete is central mixed as described in 12.3, the volume of concrete in the truck mixer or agitator shall not exceed 80 % of the total volume of the drum or container. Truck mixers and agitators shall be equipped with means to readily verify the number of revolutions of the drum, blades, or paddles.

11.2 Stationary and truck mixers shall be capable of producing uniformly mixed concrete within the specified time in 12.3 or the specified number of revolutions in 12.5. The capability to produce and discharge uniformly mixed concrete shall be determined in accordance with Annex A1, if required.

NOTE 19—The sequence or method of charging the mixer will have an important effect on the uniformity of the concrete.

11.3 The agitator shall be capable of maintaining the mixed concrete in a uniformly mixed condition. The capability to maintain and discharge uniformly mixed concrete shall be determined in accordance with Annex A1, if required.

11.4 Slump tests of individual samples can be used to provide a quick check of the probable degree of uniformity. Sampling and testing shall be in accordance with Annex A1. If the difference in slump exceeds the limits in Annex A1, the mixer or agitator shall not be used unless the condition is corrected, except as provided in 11.5.

11.5 Use of the equipment not conforming to 11.2 is permitted if operated with a longer mixing time, a smaller load, or a more efficient charging sequence. If required, the uniformity of concrete shall be evaluated in accordance with Annex A1.

11.6 Mixers and agitators shall be examined or their mass determined as frequently as necessary to detect changes in condition due to accumulations of hardened concrete or mortar and examined to detect wear of blades. If these conditions are considered extensive enough to affect the mixer performance, Annex A1 establishes the basis to determine whether correction of deficiencies is required or if the correction of the deficiencies is adequate.

12. Mixing and Delivery

12.1 Ready-mixed concrete shall be mixed and delivered to the point designated by the purchaser by means of one of the following combinations of operations:

12.1.1 *Central-Mixed Concrete.*

12.1.2 *Shrink-Mixed Concrete.*

12.1.3 *Truck-Mixed Concrete.*

12.2 Mixers and agitators shall be operated within the limits of capacity and speed of rotation designated by the manufacturer of the equipment.

12.3 *Central-Mixed Concrete*—Concrete that is mixed completely in a stationary mixer and transported to the point of delivery either in a truck agitator, or a truck mixer operating at agitating speed, or in non-agitating equipment approved by the purchaser and meeting the requirements of Section 13, shall conform to the following: The mixing time shall be counted from the time all the solid materials are in the drum. The batch shall be so charged into the mixer that some water will enter in advance of the cement and aggregate and the target batch water shall be in the drum by the end of the first one fourth of the specified mixing time; or in accordance with the central concrete mixer manufacturer's recommended charging sequence.

12.3.1 If no mixer performance tests are made, the acceptable mixing time for mixers having capacities of 0.76 m^3 [1 yd^3] or less shall be not less than 1 min. For mixers of greater capacity, this minimum shall be increased 15 s for each cubic metre [cubic yard] or fraction thereof of additional capacity (see Note 20).

NOTE 20—Stationary mixers of similar design bearing a Performance Rating plate of the Concrete Plant Manufacturers Bureau have been tested for their ability to produce uniformly mixed concrete in accordance with Annex A1 for low slump (<50 mm [2 in.]) and normal slump (100–150 mm [4–6 in.]) concrete in a mixing time between 30 and 90 s.

12.3.2 If mixer performance tests have been made in accordance with Annex A1, the acceptable mixing time is permitted to be reduced to the time equal to or greater than that used in the qualification testing. If the mixing time is so reduced the maximum time of mixing shall not exceed this reduced time by more than 60 s for air-entrained concrete. Mixer performance tests shall be repeated whenever the appearance of the concrete or a comparison of coarse aggregate content of separate samples as described in Annex A1 indicates that adequate mixing has not been accomplished.

12.4 *Shrink-Mixed Concrete*—Concrete that is first partially mixed in a stationary mixer, and then mixed completely in a truck mixer, shall conform to the following: The time of partial mixing shall be the minimum time required to intermingle the ingredients. After transfer to a truck mixer the amount of mixing at the designated mixing speed shall be that necessary to meet the requirements for uniformity of concrete as indicated in Annex A1. Additional turning of the mixer, if any, shall be at a designated agitating speed.

12.5 *Truck-Mixed Concrete*—Concrete that is completely mixed in a truck mixer for 70 to 100 revolutions at the mixing speed designated by the manufacturer shall produce uniformly mixed concrete as defined in Annex A1. The start of mixing