



Designation: C 94/C 94M – 03a

## Standard Specification for Ready-Mixed Concrete<sup>1</sup>

This standard is issued under the fixed designation C 94/C 94M; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

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

### 1. Scope

1.1 This specification covers ready-mixed concrete manufactured and delivered to a purchaser in a freshly mixed and unhardened state as hereinafter specified. Requirements for quality of concrete shall be either as hereinafter specified or as specified by the purchaser. In any case where the requirements of the purchaser differ from these in this specification, the purchaser's specification shall govern. This specification does not cover the placement, consolidation, curing, or protection of the concrete after delivery to the purchaser.

1.2 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.

1.3 As used throughout this specification the manufacturer shall be the contractor, subcontractor, supplier, or producer who furnishes the ready-mixed concrete. The purchaser shall be the owner or representative thereof.

1.4 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.

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- C 31/C 31M Practice for Making and Curing Concrete Test Specimens in the Field<sup>2</sup>
- C 33 Specification for Concrete Aggregates<sup>2</sup>
- C 39/C 39M Test Method for Compressive Strength of Cylindrical Concrete Specimens<sup>2</sup>
- C 109/C 109M Test Method for Compressive Strength of

- Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)<sup>3</sup>
- C 138/C 138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete<sup>2</sup>
- C 143/C 143M Test Method for Slump of Hydraulic Cement Concrete<sup>2</sup>
- C 150 Specification for Portland Cement<sup>3</sup>
- C 172 Practice for Sampling Freshly Mixed Concrete<sup>2</sup>
- C 173/C 173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method<sup>2</sup>
- C 191 Test Method for Time of Setting of Hydraulic Cement by Vicat Needle<sup>3</sup>
- C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method<sup>2</sup>
- C 260 Specification for Air-Entraining Admixtures for Concrete<sup>2</sup>
- C 330 Specification for Lightweight Aggregates for Structural Concrete<sup>2</sup>
- C 494/C 494M Specification for Chemical Admixtures for Concrete<sup>2</sup>
- C 567 Test Method for Determining Density of Structural Lightweight Concrete<sup>2</sup>
- C 595 Specification for Blended Hydraulic Cements<sup>3</sup>
- C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete<sup>2</sup>
- C 989 Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars<sup>2</sup>
- C 1017/C 1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete<sup>2</sup>
- C 1064/C 1064M Test Method for Temperature of Freshly Mixed Portland-Cement Concrete<sup>2</sup>
- C 1077 Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation<sup>2</sup>
- C 1157 Performance Specification for Hydraulic Cement<sup>3</sup>

<sup>1</sup> 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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<sup>2</sup> Annual Book of ASTM Standards, Vol 04.02.

<sup>3</sup> Annual Book of ASTM Standards, Vol 04.01.



C 1240 Standard Specification for Use of Silica Fume for Use as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout<sup>2</sup>

D 512 Test Methods for Chloride Ion in Water<sup>4</sup>

D 516 Test Method for Sulfate Ion in Water<sup>4</sup>

2.2 ACI Documents:<sup>5</sup>

CP-1 Technician Workbook for ACI Certification of Concrete Field Testing Technician—Grade I

211.1 Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete

211.2 Standard Practice for Selecting Proportions for Structural Lightweight Concrete

301 Standard Specifications for Structural Concrete

305R Hot Weather Concreting

306R Cold Weather Concreting

318 Building Code Requirements for Structural Concrete and Commentary

2.3 Other Documents:

Bureau of Reclamation Concrete Manual<sup>6</sup>

AASHTO T26 Method of Test for Quality of Water to be Used in Concrete<sup>7</sup>

3. Basis of Purchase

3.1 The basis of purchase shall be the cubic yard or cubic metre of freshly mixed and unhardened concrete as discharged from the mixer.

3.2 The volume of freshly mixed and unhardened concrete in a given batch shall be determined from the total mass of the batch divided by the mass per unit volume of the concrete. The total mass of the batch shall be calculated either as the sum of the masses of all materials, including water, entering the batch or as the net mass of the concrete in the batch as delivered. The mass per unit volume shall be determined in accordance with Test Method C 138/C 138M from the average of at least three measurements, each on a different sample using a 1/2-ft<sup>3</sup> [14-L<sup>3</sup>] container. Each sample shall be taken from the midpoint of each of three different truck loads by the procedure outlined in Practice C 172.

NOTE 1—It should be understood that the volume of hardened concrete may be, or appear to be, less than expected due to waste and spillage,

<sup>4</sup> Annual Book of ASTM Standards, Vol 11.01.

<sup>5</sup> Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333.

<sup>6</sup> Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.

<sup>7</sup> Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001.

over-excavation, spreading forms, some loss of entrained air, or settlement of wet mixtures, none of which are the responsibility of the producer.

4. Ordering Information

4.1 In the absence of designated applicable general specifications, the purchaser shall specify the following:

4.1.1 Designated size, or sizes, of coarse aggregate,

4.1.2 Slump, or slumps, desired at the point of delivery (see Section 6 for acceptable tolerances),

4.1.3 When air-entrained concrete is specified, the air content of the samples taken at the point of discharge from the transportation unit (see Section 7 and Table 1 for the total air content and tolerances) (Note 2),

4.1.4 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, and

4.1.5 When structural lightweight concrete is specified, the mass per unit volume as wet mass, air-dry mass, or oven-dry mass (Note 3).

NOTE 2—In selecting the specified air content, the purchaser should consider the exposure conditions to which the concrete will be subjected. Air contents less than shown in Table 1 may not give the required resistance to freezing and thawing, which is the primary purpose of air-entrained concrete. Air contents higher than the levels shown may reduce strength without contributing any further improvement of durability.

NOTE 3—The mass per unit volume of fresh concrete, which is the only unit mass determinable at the time of delivery, is always higher than the air-dry or oven-dry mass. Definitions of, and methods for determining or calculating air-dry and oven-dry masses, are covered by Test Method C 567.

4.2 Option A:

4.2.1 When the purchaser requires the manufacturer to assume full responsibility for the selection of the proportions for the concrete mixture (Note 4), the purchaser shall also specify the following:

4.2.1.1 Requirements for compressive strength as determined on samples taken from the transportation unit at the point of discharge evaluated in accordance with Section 17. 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 17). Unless otherwise specified the age at test shall be 28 days.

NOTE 4—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

TABLE 1 Recommended Total Air Content for Air-Entrained Concrete<sup>A,B</sup>

Exposure Condition <sup>C</sup>	Total Air Content, %						
	Nominal Maximum Sizes of Aggregate, in. [mm]						
	3/8 [9.5]	1/2 [12.5]	3/4 [19.0]	1 [25.0]	1 1/2 [37.5]	2 [50.0]	3 [75.0]
Mild	4.5	4.0	3.5	3.0	2.5	2.0	1.5
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

<sup>A</sup> For air-entrained concrete, when specified.

<sup>B</sup> Unless exposure conditions dictate otherwise, it is permissible to reduce air contents recommended above by up to 1 % for concretes with specified compressive strength, *f<sub>c</sub>*, of 5000 psi [35 MPa] or above.

<sup>C</sup> For description of exposure conditions, refer to Standard Practice ACI 211.1, Section 6.3.3, with attention to accompanying footnotes.



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.

4.2.2 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. 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.

#### 4.3 Option B:

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

4.3.1.1 Cement content in bags or pounds per cubic yard [kilograms per cubic metre] of concrete,

4.3.1.2 Maximum allowable water content in gallons per cubic yard [litres per cubic metre] of concrete, including surface moisture on the aggregates, but excluding water of absorption (Note 4), and

4.3.1.3 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.

4.3.2 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.

#### 4.4 Option C:

4.4.1 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 5), the purchaser shall also specify the following:

4.4.1.1 Required compressive strength as determined on samples taken from the transportation unit at the point of discharge evaluated in accordance with Section 17. 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 17). Unless otherwise specified the age at test shall be 28 days.

4.4.1.2 Minimum cement content in bags or pounds per cubic yard [kilograms per cubic metre] of concrete.

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

NOTE 5—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 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 4.

4.4.2 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 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.

4.5 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 13.1.7 and supplies information on concrete proportions when they are not given separately on each delivery ticket as outlined in 13.2. A certified copy of all proportions as established in Options A, B, or C shall be on file at the batch plant.

4.6 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.

## 5. Materials

5.1 In the absence of designated applicable specifications covering requirements for quality of materials, the following specifications shall govern:

5.1.1 *Cement*—Cement shall conform to Specification C 150, Specification C 595, or Specification C 1157 (see Note 6). The purchaser shall specify the type or types required, but if no type is specified, the requirements of Type I as prescribed in Specification C 150 shall apply.

NOTE 6—These different cements will produce concretes of different properties and should not be used interchangeably.

5.1.2 *Aggregates*—Aggregates shall conform to Specification C 33 or Specification C 330 if lightweight concrete is specified by the purchaser.

#### 5.1.3 Water:

5.1.3.1 The mixing water shall be clear and apparently clean. If it contains quantities of substances which discolor it or make it smell or taste unusual or objectionable or cause suspicion, it shall not be used unless service records of concrete made with it or other information indicates that it is not injurious to the quality of the concrete. Water of questionable quality shall be subject to the acceptance criteria of Table 2.

5.1.3.2 Wash water from mixer washout operations is permitted to be used for mixing concrete provided tests of wash water comply with the physical test limits of Table 2. Wash water shall be tested at a weekly interval for approximately 4 weeks, and thereafter at a monthly interval provided no single test exceeds the applicable limit (Note 7). Optional chemical



TABLE 2 Acceptance Criteria for Questionable Water Supplies

	Limits	Test Method
Compressive strength, min % control at 7 days	90	C 109/C 109M <sup>A</sup>
Time of set, deviation from control, h: min	from 1:00 early to 1:30 later	C 191 <sup>A</sup>

<sup>A</sup> Comparisons shall be based on fixed proportions and the same volume of test water compared to control mix using city water or distilled water.

limits in Table 3 shall be specified by the purchaser when appropriate for the construction. The testing frequency for chemical limits shall be as given above or as specified by the purchaser.

NOTE 7—When recycled wash water is used, attention should be given to effects on the dosage rate and batching sequence of air-entraining and other chemical admixtures, and a uniform amount should be used in consecutive batches.

5.1.4 *Mineral Admixtures*—Coal fly ash and raw or calcined natural pozzolan shall conform to Specification C 618 as applicable.

5.1.5 *Ground Granulated Blast-Furnace Slag*—Ground granulated blast-furnace slag shall conform to Specification C 989.

5.1.6 *Silica Fume*—Silica Fume shall conform to Specification C 1240.

5.1.7 *Air-Entraining Admixtures*—Air-entraining admixtures shall conform to Specification C 260 (Note 8).

5.1.8 *Chemical Admixtures*—Chemical admixtures shall conform to either Specification C 494/C 494M or C 1017/C 1017M as applicable (Note 8).

NOTE 8—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.

6. Tolerances in Slump

6.1 Unless other tolerances are included in the project specifications, the following shall apply.

6.1.1 When the project specifications for slump are written as a “maximum” or “not to exceed” requirement:

	Specified slump:	
	If 3 in. [75 mm] or less	If more than 3 in. [75 mm]
Plus tolerance:	0	0
Minus tolerance:	1½ in. [40 mm]	2½ in. [65 mm]

This option is to be used only if one addition of water is permitted on the job provided such addition does not increase the water-cement ratio above the maximum permitted by the specifications.

6.1.2 When the project specifications for slump are not written as a “maximum” or “not to exceed” requirement:

Tolerances for Nominal Slumps

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

6.2 Concrete shall be available within the permissible range of slump for a period of 30 min starting either on arrival at the job site or after the initial slump adjustment permitted in 11.7, whichever is later. The first and last ¼ yd<sup>3</sup> or ¼ m<sup>3</sup> 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 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.

7. Air-Entrained Concrete

7.1 When air-entrained concrete is desired the purchaser shall specify the total air content of the concrete. See Table 1 for recommended total air contents (Note 8).

7.2 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.

7.3 When a preliminary sample taken within the time limits of 11.7 and prior to discharge for placement shows an air content below the specified level by more than the allowable tolerance in accordance with 7.2, the manufacturer may use additional air entraining admixture to achieve the desired air content level, followed by a minimum of 30 revolutions at

TABLE 3 Optional Chemical Limits for Wash Water

	Limits	Test Method <sup>A</sup>
Chemical requirements, maximum concentration in mixing water, ppm <sup>B</sup>		
Chloride as Cl, ppm:		D 512
Prestressed concrete or in bridge decks	500 <sup>C</sup>	
Other reinforced concrete in moist environments or containing aluminum embedments or dissimilar metals or with stay-in-place galvanized metal forms	1000 <sup>C</sup>	
Sulfate as SO <sub>4</sub> , ppm	3000	D 516
Alkalies as (Na <sub>2</sub> O + 0.658 K <sub>2</sub> O), ppm	600	
Total solids, ppm	50 000	AASHTO T26

<sup>A</sup> Other test methods that have been demonstrated to yield comparable results are permitted to be used.

<sup>B</sup> Wash water reused as mixing water in concrete is allowed to exceed the listed concentrations if it can be shown that the concentration calculated in the total mixing water, including mixing water on the aggregates and other sources does not exceed the stated limits.

<sup>C</sup> For conditions allowing use of CaCl<sub>2</sub> accelerator as an admixture, the chloride limitation is permitted to be waived by the purchaser.



mixing speed, so long as the revolution limit of 11.7 is not exceeded (see Note 9).

NOTE 9—Acceptance sampling and testing in accordance with Practice C 172 is not obviated by this provision.

## 8. Measuring Materials

8.1 Except as otherwise specifically permitted, cement shall be measured by mass. When mineral admixtures (including ground granulated blast-furnace slag, coal fly ash, silica fume, or other pozzolans) are specified in the concrete proportions, the cumulative mass is permitted to be measured with 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 cement shall be measured before mineral admixtures. When the quantity of cement exceeds 30 % of the full capacity of the scale, the quantity of the cement shall be within  $\pm 1$  % of the required mass, and the cumulative quantity of cement plus mineral admixtures shall also be within  $\pm 1$  % of the required mass. For smaller batches to a minimum of 1 yd<sup>3</sup> [1 m<sup>3</sup>], the quantity of the cement and the cumulative quantity of cement plus mineral admixture used shall be not less than the required amount nor more than 4 % in excess. Under special circumstances approved by the purchaser, cement is permitted to be measured in bags of standard mass (Note 10). No fraction of a bag of cement shall be used unless its mass has been determined.

NOTE 10—In the United States the standard mass of a bag of portland cement is 94 lb [42.6 kg]  $\pm 3$  %.

8.2 Aggregate shall be measured by mass. Batch mass measurements shall be based on dry materials and shall be the required masses of dry materials plus the total mass of moisture (both absorbed and surface) contained in the aggregate. The quantity of aggregate used in any batch of concrete as indicated by the scale shall be within  $\pm 2$  % of the required mass when the mass is measured in individual aggregate weigh batchers. In a cumulative aggregate weigh batcher, the cumulative weight after each successive weighing shall be within  $\pm 1$  % of the required cumulative amount up to that point when the scale is used in excess of 30 % of its capacity. For cumulative weights for less than 30 % of scale capacity, the tolerance shall be  $\pm 0.3$  % of scale capacity or  $\pm 3$  % of the required cumulative weight, whichever is less.

8.3 Mixing water shall consist of water added to the batch, ice added to the batch, water occurring as surface moisture on the aggregates, and water introduced in the form of admixtures. The added water shall be measured by weight or volume to an accuracy of 1 % of the required total mixing water. Added ice shall be measured by weight. In the case of truck mixers, any wash water retained in the drum for use in the next batch of concrete shall be accurately measured; if this proves impractical or impossible the wash water shall be discharged prior to loading the next batch of concrete. Total water (including any wash water) shall be measured or weighed to an accuracy of  $\pm 3$  % of the specified total amount.

8.4 Admixtures in powdered form shall be measured by mass. Liquid admixtures shall be batched by mass or volume. Admixtures, except mineral admixtures (see 8.1), measured by either mass or volume, shall be batched with an accuracy of

$\pm 3$  % of the total amount required or plus or minus the amount or dosage required for 100 lb [50 kg] of cement, whichever is greater.

NOTE 11—Admixture dispensers of the mechanical type capable of adjustment for variation of dosage, and of simple calibration, are recommended.

## 9. Batching Plant

9.1 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.

9.2 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.

9.3 Scales shall be considered accurate when at least one static load test within each quarter of the scale capacity can be shown to be within  $\pm 0.2$  % of the total capacity of the scale.

9.4 Adequate standard test weights shall be available for checking accuracy. 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.

9.5 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 8.3. 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 12—The scale accuracy limitations of the National Ready Mixed Concrete Association Plant Certification meet the requirements of this specification.

## 10. Mixers and Agitators

10.1 Mixers will be stationary mixers or truck mixers. Agitators will be truck mixers or truck agitators.

10.1.1 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. When 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.

10.1.2 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. When the concrete is truck mixed as described in 11.5, or shrink mixed as described in 11.4, the volume of mixed concrete shall not exceed 63 % of the total volume of the drum or container. When the concrete is central mixed as described in 11.3, 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.

10.2 All stationary and truck mixers shall be capable of combining the ingredients of the concrete within the specified time or the number of revolutions specified in 10.5, into a thoroughly mixed and uniform mass and of discharging the concrete so that not less than five of the six requirements shown in Table A1.1 shall have been met.

NOTE 13—The sequence or method of charging the mixer will have an important effect on the uniformity of the concrete.

10.3 The agitator shall be capable of maintaining the mixed concrete in a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity as defined by Annex A1.

10.4 Slump tests of individual samples taken after discharge of approximately 15 % and 85 % of the load will provide a quick check of the probable degree of uniformity (Note 14). These two samples shall be obtained within an elapsed time of not more than 15 min. If these slumps differ more than that specified in Annex A1, the mixer or agitator shall not be used unless the condition is corrected, except as provided in 10.5.

NOTE 14—No samples should be taken before 10 % or after 90 % of the batch has been discharged. Due to the difficulty of determining the actual quantity of concrete discharged, the intent is to provide samples that are representative of widely separated portions, but not the beginning and end of the load.

10.5 Use of the equipment is permitted when operation with a longer mixing time, a smaller load, or a more efficient charging sequence will permit the requirements of Annex A1 to be met.

10.6 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. When such changes are extensive enough to affect the mixer performance, the proof-tests described in Annex A1 shall be performed to show whether the correction of deficiencies is required.

## 11. Mixing and Delivery

11.1 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:

11.1.1 *Central-Mixed Concrete.*

11.1.2 *Shrink-Mixed Concrete.*

11.1.3 *Truck-Mixed Concrete.*

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

11.3 *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 nonagitating equipment approved by the purchaser and meeting the requirements of Section 12, 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 all water shall be in the drum by the end of the first one fourth of the specified mixing time.

11.3.1 Where no mixer performance tests are made, the acceptable mixing time for mixers having capacities of 1 yd<sup>3</sup> [0.76 m<sup>3</sup>] or less shall be not less than 1 min. For mixers of greater capacity, this minimum shall be increased 15 s for each cubic yard [cubic metre] or fraction thereof of additional capacity.

11.3.2 Where mixer performance tests have been made on given concrete mixtures in accordance with the testing program set forth in the following paragraphs, and the mixers have been charged to their rated capacity, the acceptable mixing time is permitted to be reduced for those particular circumstances to a point at which satisfactory mixing defined in 11.3.3 shall have been accomplished. When 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.

11.3.3 *Sampling for Uniformity Tests of Stationary Mixers*—Samples of concrete for comparative purposes shall be obtained immediately after arbitrarily designated mixing times, in accordance with one of the following procedures:

11.3.3.1 *Alternative Procedure 1*—The mixer shall be stopped, and the required samples removed by any suitable means from the concrete at approximately equal distances from the front and back of the drum, or

11.3.3.2 *Alternative Procedure 2*—As the mixer is being emptied, individual samples shall be taken after discharge of approximately 15 % and 85 % of the load. The method of sampling shall provide that the samples are representative of widely separated portions, but not from the very ends of the batch (Note 14).

11.3.3.3 The samples of concrete shall be tested in accordance with Section 17, and differences in test results for the two samples shall not exceed those given in Annex A1. Mixer performance tests shall be repeated whenever the appearance of the concrete or the coarse aggregate content of samples selected as outlined in this section indicates that adequate mixing has not been accomplished.

11.4 *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 minimum required to intermingle the ingredients. After transfer to a truck mixer the amount of mixing at the designated mixing speed will be that necessary to meet the requirements for uniformity of concrete as indicated in Annex A1. Tests to confirm such performance shall be made in accordance with 11.3.3 and 11.3.3.3. Additional turning of the mixer, if any, shall be at a designated agitating speed.