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Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing[1]

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

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1. Scope

1.1 This specification covers concrete made from materials continuously batched by volume, mixed in a continuous mixer, and delivered to the purchaser in a freshly mixed and unhardened state. Tests and criteria for batching accuracy and mixing efficiency are specified herein.

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 nonconformance with the standard.

1.3 This specification 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 this specification.

2. Referenced Documents

2.1 *ASTM Standards:*

C 31/C 31M Practice for Making and Curing Concrete Test Specimens in the Field[2]
C 33 Specification for Concrete Aggregates[2]
C 39/C 39M Test Method for Compressive Strength of Cylindrical Concrete Specimens[2]
C 109/C 109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)[3]
C 127 Test Method for Specific Gravity and Absorption of Coarse Aggregate[2]
C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregates[2]
C 138 Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete[2]
C 143/C 143M Test Method for Slump of Hydraulic-Cement Concrete[2]
C 150 Specification for Portland Cement[3]
C 173 Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method[2]
C 191 Test Method for Time of Setting of Hydraulic Cement by Vicat Needle[3]
C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method[2]
C 260 Specification for Air-Entraining Admixtures for Concrete[2]
C 330 Specification for Lightweight Aggregates for Structural Concrete[2]
C 494/C 494M Specification for Chemical Admixtures for Concrete[2]
C 567 Test Method for Unit Weight of Structural Lightweight Concrete[2]
C 595 Specifications for Blended Hydraulic Cements[3]
C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete[2]
C 989 Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars[2]
C 1017/C 1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete[2]
C 1064/C 1064M Test Method for Temperature of Freshly Mixed Portland Cement Concrete[2]
C 1077 Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation[2]

[2] *Annual Book of ASTM Standards*, Vol 04.02.
[3] *Annual Book of ASTM Standards*, Vol 04.01.

C 1157 Performance Specification for ~~Blended~~ Hydraulic Cement[3]
D 512 Test Methods for Chloride Ion in Water[4]
D 516 Test Method for Sulfate Ion in Water[4]
2.2 *ACI Documents:*[5]
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
214 Recommended Practice for Evaluation of Strength Test Results of 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[6]
AASHTO T 26 Method of Test for Quality of Water to be Used in Concrete[7]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*
3.1.1 *manufacturer, n*—the contractor, subcontractor, supplier, or producer who furnishes the ready-mixed concrete.
3.1.2 *purchaser, n*—the owner, or representative thereof, who buys the ready-mixed concrete.

4. Basis of Purchase

4.1 The basis of purchase shall be the cubic yard or cubic metre of plastic and unhardened concrete as it is continuously discharged from the batching and mixing apparatus.

NOTE 1—It should be understood that the volume of hardened concrete may be, or may 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 are the responsibility of the manufacturer.

4.2 The volume of plastic and unhardened concrete shall be checked daily on projects requiring more than 50 yd^3 [40 m^3] of concrete per day (see 7.4). The amount of various ingredients (cement, fine and coarse aggregate, admixtures, and water) shall be checked as required in 7.5.

4.3 The manufacturer of the concrete shall conduct calibration and mixer efficiency tests at intervals not exceeding 6 months. Data on such tests using materials proposed for use in the project shall be furnished the purchaser upon request.

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 (Note 2). 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 2—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 that 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) indicate that it is not injurious to the quality of the concrete. Water of questionable quality shall be subject to the acceptance criteria of Table 1.

[4] *Annual Book of ASTM Standards,* Vol 11.01.
[5] Available from the American Concrete Institute, 38800 Country Club Drive, Farmington Hills, MI 48331.
[6] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.
[7] Available from the American Association of State Highway and Transportation Officials, 444 N. Capitol St., NW, Suite 225, Washington, DC 20001.

TABLE 1 Acceptance Criteria for Questionable Water Supplies

	Limits	Test Method
Compressive strength, min, % control at 7 days	90	C 109/C 109M[A]
Time of set, deviation from control	from 1:00 earlier to 1:30 later	C 191[A]

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

5.1.3.2 Test results of wash water from mixer washout operations to be used for mixing concrete shall comply with the physical test limits of Table 1. 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 3). Optional chemical limits in Table 2 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 3—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*—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 *Air-Entraining Admixtures*—Air-entraining admixtures shall conform to Specification C 260. (Note 4)

5.1.7 *Chemical Admixtures*—Chemical admixtures shall conform to either Specification C 494/C 494M or C 1017/C 1017M, 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.

6. Ordering Information

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

6.1.1 Designated size or sizes of coarse aggregate,

6.1.2 Slump or slumps desired at the point of delivery (see 10.3),

6.1.3 When air-entrained concrete is specified, the air content of samples taken at the point of discharge from the transportation unit (see 10.4 and Table 3 for the total air content and tolerances) (Note 5),

6.1.4 When structural lightweight concrete is specified, the density as fresh density, equilibrium density, or oven-dry density (Note 6), and

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 (see 6.2, 6.3, or 6.4).

NOTE 5—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 3 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 6—The density of fresh concrete, which is the only density determinable at the time of delivery, is always higher than the equilibrium density, or oven-dry density. Definitions of, and methods for determining or calculating equilibrium density and oven-dry density, are covered in Test Method C 567.

6.2 *Option A*:

6.2.1 When the purchaser requires the manufacturer to assume full responsibility for the selection of the proportions for the concrete mixture, the purchaser shall also specify the following in addition to the requirements of 6.1.1 through 6.1.5:

6.2.1.1 Requirements for compressive strength as determined on samples taken from the mixer at the point of discharge and evaluated in accordance with Section 11. The purchaser shall specify the requirements in terms of the compressive strength of standard specimens cured under standard curing conditions for moist curing. Unless otherwise specified, the age at test shall be 28 days, and

6.2.2 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 mass of cement and saturated surface-dry mass 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.

TABLE 2 Optional Chemical Limits for Wash Water

	Limits	Test Method[A]
Chemical requirements, maximum concentration in mixing water, ppm[B]		
Chloride as C1, ppm:		D 512
Prestressed concrete or in bridge decks	500[C]	
Other reinforced concrete in moist environments or containing aluminum embedments or dissimilar metals or with stay-in-place galvanized metal forms	1000[C]	
Sulfate as SO_4, ppm	3000	D 516
Alkalies as (Na_2O + 0.658 K_2O), ppm	600	
Total solids, ppm	50 000	AASHTO T26

[A] Other test methods that have been demonstrated to yield comparable results are permitted to be used.

[B] 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.

[C] For conditions allowing use of $CaCl_2$ accelerator as an admixture, the chloride limitation is permitted to be waived by the purchaser.

TABLE 3 Recommended Total Air Content for Air-Entrained Concrete[A]

Exposure Condition[B,C]	Total Air Content, % Nominal Max Sizes of Aggregate, in. [mm]						
	⅜ [9.5]	½ [12.5]	¾ [19.0]	1 [25.0]	1½ [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

[A] For air-entrained concrete, when specified.
[B] For description of exposure conditions, refer to ACI Standard Practice 211.1, Section 6.3.3 with attention to accompanying footnotes.
[C] Unless exposure conditions dictate otherwise, it is permissable to reduce air contents recommended above by up to 1 % for concretes with specified compressive strength, f'_c, of 5000 psi [35 MPa] or above.

6.3 *Option B*:

6.3.1 When the purchaser assumes responsibility for the proportioning of the concrete mixture, the purchaser shall also specify the following in addition to the requirements of 6.1.1 through 6.1.5:

6.3.1.1 Cement content in bags or pounds per cubic yard or kilograms per cubic metre of concrete, or equivalent units,

6.3.1.2 Maximum allowable water content in gallons per cubic yard or litres or kilograms per cubic metre of concrete or equivalent units, including surface moisture on the aggregates, but excluding water of absorption (Note 7), and

6.3.1.3 If admixtures are required, the type, name, and dosage range to be used. Those employed for air-entrainment or for control of set (acceleration, retardation) shall have maximum limitations set as to dosage. Admixtures shall not be used as a substitute for a portion of specified amounts of cement without the written approval of the purchaser.

NOTE 7—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 ACI Standard Practice 211.1 for normal weight concrete, and ACI Standard Practice 211.2 for lightweight concrete, 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.

6.3.2 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 mass of cement and saturated surface-dry mass 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.

6.4 *Option C*:

6.4.1 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, the purchaser shall also specify the following in addition to the requirements of 6.1.1 through 6.1.5:

6.4.1.1 Required compressive strength as determined on samples taken from the mixer at the point of discharge and evaluated in accordance with Section 11. The purchaser shall specify the requirements for strength in terms of tests of standard specimens cured under standard curing conditions for moist curing. Unless otherwise specified, the age at test shall be 28 days.

6.4.1.2 Minimum cement content in bags or pounds per cubic yard or kilograms per cubic metre of concrete (Note 8), and

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

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 mass of cement and saturated surface-dry mass 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. 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. Whatever strengths are attained the quantity of cement used shall not be less than the minimum specified.

NOTE 8—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. Attention is directed to ACI Standard Practices 211.1 and 211.2 for additional information on mixture proportions.

6.5 The proportions arrived at by Options A, B, or C for each class of concrete and which are approved for use in a project shall be assigned a designation (7CV.PK7, etc.) to facilitate identification of each concrete mixture delivered to the project. This is the designation required in 15.1.7 and supplies information on concrete proportions when they are not given separately on each delivery ticket as outlined in 15.2. However, each delivery of concrete shall be covered by a delivery ticket showing enough information to establish that the mix conforms to the mix designs previously approved for the work.

6.6 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 will be provided on a timely basis.

7. Measuring Materials

7.1 Cement, fine and coarse aggregates, water, and admixtures shall be measured by mass or by volume. If volume

proportioning is employed, devices such as counters, calibrated gate openings, or flowmeters must be available for controlling and determining the quantities of the ingredients discharged. In operation, the entire measuring and dispensing mechanism must produce the specified proportions of each ingredient.

NOTE 9—The recommendations of the equipment manufacturer in the operation of the equipment and in calibrating and using the various gages, revolution counters, speed indicators, or other control devices should be followed.

7.2 All indicating devices that bear on the accuracy of proportioning and mixing of concrete shall be in full view and near enough to be read by the operator while concrete is being produced. The operator shall have convenient access to all controls.

7.3 The proportioning and indicating devices shall be individually checked by following the equipment manufacturer's recommendations as related to each individual concrete batching and mixing unit. Adequate standard volume measures, scales, and weights shall be made available for the checking accuracy of the proportioning mechanism. The device for the measurement of the added water shall be capable of delivering to the batch the required quantity within the accuracy of ±1 %; the device shall be so arranged that the measurements will not be affected by variable pressures in the water supply line.

7.4 *Yield Check*—Essentially, the volume of concrete discharged from the mixer is checked by first determining the mass of the amount of concrete discharged during some number of revolutions, or as determined by some other output indicator; this is then followed immediately by a determination of the density. The mass of concrete discharged divided by the density is equal to the number of cubic feet or cubic metres mixed and discharged during the chosen interval. The accuracy of the output indicator is thus checked by this expedient.

NOTE 10—It is recommended that about 2.5 to 3.0 ft^3 [0.070 to 0.085 m^3] be discharged for this purpose; this amount of concrete will weigh from 350 to 500 lb [160 to 225 kg] and can be discharged into and contained in a 35 or 55-gal [130 to 210-dm^3] drum or other suitable container which in turn can be placed on a scale of adequate capacity. The output of a batcher-mixer unit may be indicated by the number of revolutions, travel of a belt, or changes in gage readings; if so, these figures should be used as a measure of output.

7.5 *Proportioning Check*—Whenever the sources or characteristics of the ingredients are changed, or the characteristics of the mixture are noted to have changed, the purchaser is permitted to require a check of the fine aggregate content and the coarse aggregate content by use of the washout test. Essentially, in the washout test, 1 ft^3 [0.03 m^3] of concrete is washed through a No. 4 [4.75-mm] sieve and through a No. 100 [150-µm] sieve; that retained on the No. 4 sieve is normally considered coarse aggregate whereas that passing the No. 4 and retained on the No. 100 sieve is considered fine aggregate. Corrections to the quantity of aggregates (per cubic foot or cubic metre of concrete) shall be made if the original sieve analysis of each aggregate is available.

7.6 The rate of water supplied the continuous mixer shall be measured by a calibrated flowmeter coordinated with the cement and aggregate feeding mechanism, and with the mixer. The rate shall be capable of being adjusted in order to control slump at the desired levels and to determine that the water-cement (permitted or required) ratios are being met.

7.7 Liquid admixtures shall be dispensed through a controlled flowmeter.

7.8 Tolerances in proportioning the various ingredients are as follows:

Cement, mass %	0 to +4
Fine Aggregate, mass %	±2
Coarse Aggregate, mass %	±2
Admixtures, mass or volume %	±3
Water, mass or volume %	±1

The tolerances are based on a volume/mass relationship established by calibration of the measuring devices furnished as an integral part of the whole equipment.

NOTE 11—It is noted that to meet these tolerances, attention should be given to:
(*1*) Degree of compaction of the cement,
(*2*) Grading and other physical characteristics of the fine and coarse aggregates,
(*3*) Moisture content and bulking factor of the fine aggregate,
(*4*) Viscosity of the admixture, and
(*5*) Other factors of influence, for example, mechanical condition and weather.

8. Mixing Mechanism

8.1 The continuous mixer shall be an auger-type mixer or any other type suitable for mixing concrete to meet the required consistency and uniformity requirements (see 14.2.3).

8.2 Each batching or mixing unit, or both, shall carry in a prominent place a metal plate or plates on which are plainly marked the gross volume of the unit in terms of mixed concrete, discharge speed, and the mass-calibrated constant of the machine in terms of a revolution counter or other output indicator. The mixer shall produce a thoroughly mixed and uniform concrete.

NOTE 12—Slump and air content tests of samples taken in accordance with 14.2.3 can be made for a quick check of the probable degree of uniformity.

9. Mixing and Delivery

9.1 The batcher-mixer unit shall contain in separate compartments all the necessary ingredients needed for the manufacture of concrete. The unit shall be equipped with calibrated proportioning devices to vary the mix proportions and it shall produce concrete

as required by this specification and those of the project.

9.2 *Cold Weather Concrete*—Concrete delivered in cold weather shall have the applicable minimum temperature indicated in the following table. (The purchaser shall inform the producer as to the type of construction for which the concrete is intended.)

	Minimum Concrete Temperature as Placed			
Section Size, ~~in. [mm]~~ in. [mm]	<12	12 to 36	36 to 72	>72
Temperature, ~~min, °F (°C)~~ min, °F (°C)	55	50	45	40

The maximum temperature of concrete produced with heated aggregates, heated water, or both, shall at no time during its production or transportation exceed 90°F [32°C].

NOTE 13—When hot water is used rapid stiffening may occur if hot water is brought in direct contact with the cement. Additional information on cold weather concreting is contained in ACI 306R.

9.3 The producer shall deliver the concrete during hot weather at concrete temperatures as low as practicable, subject to the approval of the purchaser.

NOTE 14—In some situations difficulty may be encountered when concrete temperatures approach 90°F [32°C]. Additional information may be found in the Bureau of Reclamation Concrete Manual and in ACI 305R.

10. Slump and Air Content

10.1 Slump, air-content, and temperature tests shall be made at the time of placement at the option of the inspector as often as is necessary for control checks. In addition, these tests shall be made, when specified and always when strength specimens are made (11.2).

10.2 If the measured slump, temperature, or air content falls outside the specified limits, a check test shall be made immediately on another portion of the same sample. In the event of a second failure, the concrete shall be considered to have failed the requirements of the specification.

10.3 *Tolerances in Slump*:

10.3.1 Unless other tolerances are included in the project specifications, the following shall apply:

10.3.1.1 When the project specifications for slump are written as a "maximum" or "not to exceed" requirement:

Specified Slump	Tolerance, in. (mm)
3 in. [75 mm] or less	+0–1½ [40]
More than 3 in. [75 mm]	+0–2½ [65]

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.

10.3.1.2 When the project specifications for slump are *not* written as a "maximum" or "not to exceed" requirement:

Specified Slump	Tolerance, in. (mm)
2 in. [50 mm] and less	±½ [15]
~~More than 2 in. [50 mm] through 4 in.~~	~~±1 [25]~~
More than 2 in. [50 mm] through 4 in.	±1 [25]
More than 4 in. [100 mm]	±1½ [40]

10.4 When air-entrained concrete is desired, the purchaser shall specify the total air content of the concrete. See Table 3 for total air content (Note 5).

10.5 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.

11. Strength

11.1 When strength is used as a basis for acceptance of the concrete, standard specimens shall be made and cured under standard curing conditions in accordance with the applicable provisions of Practice C 31/C 31M. The technician performing the strength test shall be certified as an ACI Concrete Laboratory Testing Technician—Grade I or II or by an equivalent written and performance test program.

11.2 One strength test set of two cylinders and the accompanying slump, temperature, and air content tests shall be made for each 25 yd^3 [20 m^3~~]~~] of concrete or fraction thereof, or whenever significant changes have been made in the proportioning controls. There shall be at least one strength test made for each class of concrete placed in 1 day.

11.3 For each strength test, two standard-size cylinders shall be made (see 14.2.2). The test result shall be the average of the strength of the two specimens except that, if any specimen shows definite evidence other than low strength, of improper sampling, molding, handling, curing, or testing, it shall be discarded and the strength of the remaining cylinder shall then be considered the test result.

11.4 The representative of the purchaser shall ascertain and record the delivery ticket number for the concrete and the exact location in the work where the concrete represented by each strength test was deposited.

11.5 To conform to the requirements of this specification, strength tests representing each class of concrete must meet the following two requirements (Note 15):

11.5.1 The average of any three consecutive strength tests shall be equal to, or greater than, the specified strength, f'_c, and

11.5.2 No individual strength test shall be more than 500 psi [3.5 MPa] below the specified strength, f'_C.

NOTE 15—Due to variations in materials, operations, and testing the average strength necessary to meet these requirements will be substantially higher than the specified strength. The amount higher depends upon the standard deviation of the test results and the accuracy with which that value can be estimated from prior data as explained in ACI 318 and ACI 301. Pertinent data is given in Table 4.

12. Failure to Meet Strength Requirements

12.1 In the event that concrete tested in accordance with the requirements of Section 11 fails to meet the strength requirements of this specification, the manufacturer of the concrete and the purchaser shall confer to determine whether agreement will be reached as to what adjustment, if any, shall be made. If an agreement on a mutually satisfactory adjustment cannot be reached by the manufacturer and the purchaser, a decision shall be made by a panel of three qualified engineers, one of whom shall be designated by the purchaser, one by the manufacturer, and the third chosen by these two members of the panel. The question of responsibility for the cost of such arbitration shall be determined by the panel. Its decision shall be binding, except as modified by a court decision.

13. Test Methods and Practices

13.1 Test the concrete in accordance with the following ASTM methods:

13.1.1 *Compression Test Specimens*—Use standard moist curing in accordance with the applicable provisions of Practice C 31.

13.1.2 *Compression Tests*—Test Method C 39/C 39M.

13.1.3 *Yield, Unit Weight*—Test Method C 138.

13.1.4 *Air Content*—Test Method C 138, Test Method C 173, or Test Method C 231.

13.1.5 *Slump*—Test Method C 143/C 143M.

13.1.6 *Temperature*—Test Method C 1064/C 1064M.

13.2 The testing laboratory performing acceptance tests of concrete shall meet the requirements of Practice C 1077.

14. Inspection

14.1 *Materials, Batching Facilities, and Mixing Facilities*—The manufacturer shall afford the inspector all reasonable access (without charge) for obtaining necessary samples of materials used in the concrete, and for making necessary checks of the batching and mixing facilities to determine if the concrete is being produced in accordance with this specification. All tests and inspection shall be so conducted as not to interfere unnecessarily with the batching, mixing, and discharge of the concrete to the purchaser.

14.2 *Fresh Concrete*:

14.2.1 The contractor shall afford the inspector all reasonable access and assistance (without charge) for the procurement of samples of fresh concrete at the time of placement so as to determine conformance of the concrete to this specification.

14.2.2 At any time after at least 2 ft^3 [0.05 m^3] of concrete have been discharged, one sample of concrete shall be taken for the slump test, the air content test, if required, and the strength test. The sample shall be at least 2 ft^3 in volume. Two cylinders

TABLE 4 Overdesign Necessary to Meet Strength Requirements[A]

Number of Tests[B]	Standard Deviation, psi					
	300	400	500	600	700	Unknown
15	470	620	850	1120	1390	[C]
20	430	580	760	1010	1260	[C]
30 or more	400	530	670	900	1130	[C]
	Standard Deviation, MPa					
	2.0	3.0	4.0	5.0		Unknown
15	3.1	4.7	7.3	10.0		[C]
20	2.9	4.3	6.6	9.1		[C]
30 or more	2.7	4.0	5.8	8.2		[C]

[A] Add the tabulated amounts to the specified strength to obtain the required average strengths.

[B] Number of tests of a concrete mixture used to estimate the standard deviation of a concrete production facility. The mixture used must have a strength within 1000 psi of that specified and be made with similar materials. See ACI 318.

[C] If less than 15 prior tests are available, the overdesign should be 1000 psi [7.0 MPa] for specified strength less than 3000 psi [20 MPa], 1200 psi [8.5 MPa] for specified strengths from 3000 to 5000 psi [20 to 35 MPa] and 1400 psi [10.0 MPa] for specified strengths greater than 5000 psi [35 MPa].

for each age of test shall be made. Tests for slump or air content or both shall be started within 5 min of sampling; these tests shall then be completed as expeditiously as possible. Molding of specimens for strength tests shall be started within 15 min of sampling. The time for making these tests and specimens shall be as short as possible.

14.2.3 Samples for determining the uniformity of mixing shall be taken at arbitrarily designated times. After at least 2 ft^3 [0.05 m^3] have been discharged, a sample of at least 4 ft^3 [0.10 m^3] shall be taken followed by another sample being taken no sooner than after 4 min of continuous discharge or 1 yd^3 [0.75 m^3] whichever is smaller. These samples shall be checked for conformance to the criteria set forth in Annex A1.

14.2.4 Tests of concrete required to determine compliance with this specification shall be made by a certified ACI Concrete Field Testing Technician, Grade I or equivalent. Equivalent personnel certification programs shall include both written and performance examinations as outlined in ACI CP-1.

14.3 Laboratory reports of concrete test results used to determine compliance with this specification shall include a statement that all tests performed by the laboratory or its agents were in accordance with the applicable test methods or shall note all known deviations from the prescribed procedures (Note 16). The reports shall also list any part of the test methods not performed by the laboratory.

NOTE 16—Deviation from standard test methods may adversely affect test results.

15. Batch Ticket Information

15.1 The manufacturer of the concrete shall furnish to the purchaser with each increment of discharged concrete, a delivery ticket or a statement of particulars on which is shown the following:

15.1.1 Name of concrete supplier,

15.1.2 Serial number of the delivery ticket or statement,

15.1.3 Date; starting time, and finishing time,

15.1.4 Identification number of batching or mixing equipment, or both,

15.1.5 Name of the purchaser,

15.1.6 Specific designation of the job (name and location),

15.1.7 Specific class or designation of the concrete in conformance with that employed in the job specification, and

15.1.8 Amount of concrete in cubic yards or cubic metres, and reading of the revolution counter or other device that indicates quantity of concrete.

15.2 Additional information designated by the purchaser and required by the job specifications shall be furnished when requested, such as:

15.2.1 Type, brand, and amount of cement,

15.2.2 Type, name, and amount of each admixture,

15.2.3 Information necessary to calculate total mixing water added by the producer. Total mixing water includes free water on the aggregates and water batched by the producer from the mixing equipment or other sources,

15.2.4 Maximum size of aggregate,

15.2.5 Mass or volumes of fine and coarse aggregate,

15.2.6 Notation of calibrated settings for flow control of fine and coarse aggregate, added water, and admixtures,

15.2.7 Ingredients certified as being previously approved, and

15.2.8 Signature or initials of the person operating the batching or mixing apparatus.

16. Keywords

16.1 ready-mixed concrete; testing

ANNEX

(Mandatory Information)

A1. CONCRETE UNIFORMITY REQUIREMENTS

~~A1.1 The variation within a batch as provided in Table A1.1 shall be determined~~

A1.1 Scope

A1.1.1 This annex includes test procedures and uniformity requirements for ~~each property listed as~~ use in the evaluation of concrete produced in conformance with Specification C 685/C 685M by an individual batching-mixing unit, loaded to rated capacity.

TABLE A1.1 Requirements for Within-Batch Uniformity of Concrete[A]

Test	Requirement, Expressed as Maximum Permissible Difference in Results of Tests of 2 Samples Taken from Two Locations in the Concrete Batch
Mass per cubic foot [mass per cubnt, %	1.0
Air content, %	1.0
Aic metre] calculated to an air-free basis, lb/ft^3[kg/m^3]	1.0 [16]
Air free fresh concrete density, lb/ft^3[kg/m^3]	1.0 [16]
Air content, volume % of concrete	1.0
Slump, in. [mm]	
Slump:	
If average slump is 4 in1[100[25]m] or less, in. [mm]	
Average slump 4 in. [100 mm] or less	1.0 [25]
If average slump is 4to 6 in. [100 to 150 mm], in. [mm]	1.5 [40]
Average slump, greater than 4 in. [100 mm]	1.5 [40]
Coarse aggregate content, portion by mass of ea ch sampleretained on No. 4 [4.75-mm] sieve, %	6.0
Coarse aggregate content, percent by mass of concrete	6.0
Densityof air-free mort ar[A] based on average for all comparative samples tested, %	1.6
Seven-day compressive strength, percent of average[A] based on average for all comparative samples tested, %	1.6
Average compressive strength at 7 days for each sample,[B] based on average strength of all comparative test specimens, %	7.5C
Average compressive strength at 7 days for each sample,[B]	7.5

[A] "TA quick test f of the pr Vobariabile uniformity of Cons a batituents in Cch of concrete," D is to tesignati fon 26, Burea uniformity of R thee slaump ationCd oncref the M anual, 7th Ed. Available fr com Superintendent of Documents, U.S. Gove airnm ent Praintied cong Officre, Washington, De.C. 20402.

[B] NCalculated as a percent of the average sstrength for the two samples taken 3 from the batch. Either two or three cylinders will must be molded and tested from each of the two samples.

[C] App frovm the baltch tested. When ofthe mixr requirementsh all bre met, tentative approval should be given pending the resulceipts of the 7-day compre ssive strength test results.

A1.2 Significance b and Use

A1.2.1 These twests and requirements are used to evaluate loading and operating procedures; verify the highest value accuracy of proportioning and indicating systems; and determine if mixing uniformity has been degraded by excessive wear or by accumulations of hardened concrete, or both (Note A1.1).

NOTE A1.1—The method of loading the lowest value obtained from batching-mixing unit, proper maintenance, and other factors may have an effect on the different portions ability of the same batch. unit to produce uniformly mixed concrete. For this specification reason, the comparison will be between two samples, representing use of this test method not only measures the efficiency of the mixer, but also the combined effect of the method of loading and l operating the unit.

A1.2.2 This annex provides additional procedures and cautions that are necessary in the application of existing test methods and

practices when used to determine the batch being tested. Test results conforming uniformity of freshly mixed concrete.

A1.3 Concrete Mixture

A1.3.1 Test a concrete mixture with proportions typical of the anticipated use (Note A1.2).

NOTE A1.2—Recommended test mix parameters are available from the Volumetric Mixer Manufacturers Bureau[8]. Normally, it is not necessary to test all mixtures produced unless they are made with greatly different slump, for instance 1 in. [25 mm] and 6 in. [150 mm]; or greatly different nominal maximum size aggregates such as ⅜ in. [9.5 mm] and 1½ in. [37.5 mm].

A1.4 Testing Apparatus and Materials

A1.4.1 The apparatus and materials shall conform to the limits requirements of the appropriate referenced ASTM Standards.

A1.4.2 Other specival equipment as required by this annex and not specifically described in the referenced ASTM Standards is identified in the subsequent sections.

A1.5 Sampling

A1.5.1 Take samples of the concrete discharge at approximately 15 and 85 % of the unit rated capacity by intercepting the full discharge stream (Note A1.3).

NOTE A1.3—Concrete with slumps over about 5 in. [125 mm] may segregate on the mixer blades or in the chute if discharge is stopped and started during the sampling process. For this reason, all samples should be taken without stopping or starting discharge during the sampling procedure.

A1.6 Slump

A1.6.1 Perform two slump tests listed on each sample in Table A1.1 shall indicate uniform concrete accordance with Test Method C 143/C 143M. Start testing the slump of each sample within 5 min after it was obtained.

A1.6.2 Calculate the limits average of this specification.

A1.2 the two tests performed on each sample.

A1.7 Fresh Concrete Density (Unit Weight)

A1.7.1 Determine the fresh concrete density of each sample in accordance with Test Method C 138. If applicable, using a concrete sample in a *Coarse Aggregate Content*,¼-ft^3 [7-L] air meter container to determine fresh concrete density; then using that same compacted sample to determine air content by Test Method C 231; and then further using that sample to determine the w coarshe aggregate countent percent is not, prohibited (Note A1.4).

NOTE A1.4—Determination of fresh concrete density in a l b arger ½-ft^3 [14-L] container may provide a somewhat more accurate determination. The use of a separate sample of concrete for determination of coarse aggregate content may also improve accuracy, as some segregation or loss of coarse aggregate may occur when striking off the following relations: air content test sample.

A1.7.2 Calculate the fresh concrete density of the sample as follows:

$$D = (M_c - M_m)/V_m \quad \text{(A1.1)}$$

P=(c/b) × 100
Mm

where:
P

where:

D = mass % of coarse aggregate in concrete,
cfresh concrete density (unit weight), lb/ft^3 [kg/m^3],
M_c = saturated surface-dry mass, lb [kg]mass of aggregate retained on the No. 4 [4.75-mm] sieve, resulting from washing all material finer than this sieve from the fresh measure filled with concrete, and

[8] Available from Volumetric Mixer Manufactures Bureau, 900 Spring St., Silver Spring, MD 20910.

~~*b*~~
lb [kg],
M_m = mass of ~~sample of fresh concrete in density container,~~ the measure empty, lb [kg], and
V_m = volume of the measure, ft^3 [m^3].

~~**A1.3** *Density*~~

A1.8 Air Content

A1.8.1 Use Test Method C 231 or Test Method C 173, as applicable, to determine the air content of ~~Air-Free Mortar shall be calculated~~ the concrete.

A1.9 Air Free Fresh Concrete Density (Air Free Unit Weight)

A1.9.1 Calculate the air free fresh concrete density of each sample as follows:

~~$$M = \frac{b - c}{V - ((V \times A/100) + (c/G))}$$~~

$$AFFD = (100 * D)/(100 - A) \quad \text{(A1.2)}$$

D ~~G~~

where: ~~*M*~~
AFFD = ~~density of air-free mortar,~~air free fresh concrete density, lb/ft^3 [kg/m^3]~~,~~
~~*b],*~~
D = ~~mass of~~fresh concrete ~~sample~~ density, lb/ft^3 [kg/m^3] as measured in ~~density container, lb [kg],~~
~~*c A1.7, and*~~
A = ~~a~~ir content, %, as measured in A1.8.

A1.10 Coarse Aggregate Content

A1.10.1 Determine the coarse aggregate content by either the Dry or Wet Method as~~u~~ follows. When the coarse aggregate content is determined from a separate sample of concre~~-~~te not used for~~y~~ other tests, use a minimum sample mass of 25 lb [10 kg] for concrete made with ¾ in. [19.0 mm] or smaller nominal maximum size coarse aggregate, or minimum mass of 50 lb [20 kg] for concrete made with larger aggregate (Note A1.5).

NOTE A1.5—As noted in A1.7.1, the fresh concrete density and air content sample can be used for determination of coarse aggregate content. When this option is chosen, the amount of coarse aggregate recovered may be as little as 14 lb [6.4 kg], and the precision of the sieve analysis determination may be somewhat less than indicated in Test Method C 136.

A1.10.2 Use the mass of the sample as determined in A1.7, or take another portion of the sample in a convenient-sized container and determine the mass of concrete. When concrete contains aggregate larger than 1 in. [25.0 mm] nominal maximum size, use a concrete sample large enough to yield a sample of coarse aggregate for final sieving at least as large as that required by Test Method C 136.

A1.10.3 Wash the sample over a No. 4 [4.75 mm] sieve sufficiently to remove the cement and most of the fine aggregate. Determine the coarse aggregate mass using method A1.10.3.1 or A1.10.3.2.

A1.10.3.1 *Dry Method*—Dry the sample and sieve in accordance with Test Method C 136. Determine CA_{dry}, the dry mass of coarse aggregate retained on the No. 4 [4.75~~-~~ mm] sieve.

A1.10.3.2 *Wet Method*—Continue to carefully sieve the washed sample over the No. 4 [4.75 mm] sieve, ~~lb [kg],~~
~~*V* washing to remove the remainder of the fine aggregate. Determine the mass of the wet sample immersed in water as in Test Method C 127. Determine CA_{SSD}, the saturated surface dry mass of the aggregate retained on the No. 4 [4.75 mm] sieve as follows:~~

$$CA_{SSD} = \frac{C}{\left(1 - \frac{1}{G_{SSD}}\right)} \quad \text{(A1.3)}$$

where:
CA_{SSD} = ~~volume~~saturated surface dry mass of ~~density container, ft^3 [m^3]~~
~~*A the coarse aggregate, lb [kg],*~~

C = ~~air content~~immersed mass of ~~concrete, % measured in accordance with 13.1.4 on sample being tested,~~ the aggregate, lb [kg], and ~~G~~

G_{SSD} = relative density (specific gravity) of ~~coarse~~ the aggregate ~~(SSD), lb/ft^3 [kg/m^3]~~ (SSD).

A1.10.4 Calculate the coarse aggregate content percent by mass, by expressing the mass of coarse aggregate (CA_{dry} or CA_{SSD}) as a percentage of the mass of the original concrete sample.

A1.11 Compressive Strength

A1.11.1 Make and cure a minimum of two cylinders, either 6 by 12 in. [150 by 300 mm] or 4 by 8 in. [100 by 200 mm], from each sample of concrete in accordance with Practice C 31/C 31M. Cure cylinders as required, except that initial curing shall be by immersion in lime water immediately after molding. Maintain the water temperature between the required 60 to 80°F [16 to 27°C] for the initial 24 to 48 h. Finally, cure the cylinders in accordance with Practice C 31/C 31M until ready for testing.

A1.11.2 Test the cylinders at 7 days in accordance with Test Method C 39/C 39M. Average the strength of the 7-day tests of cylinders from each sample and express that value as a percentage of the average of all cylinders made from that batch tested at the same age.

A1.11.3 Examine the results of tests of individual cylinders made from the same sample of concrete and exclude the results from that sample if the range of tests exceeds 8.0 % when two cylinders are tested and 9.5 % when three are tested (Note A1.6)

NOTE A1.6—On the average, these ranges should not be exceeded more than roughly 1 time in 20. The values for permissible ranges of individual cylinders are from the precision statement in Test Method C 39/C 39M. Although the d2s (difference two sigma) values in Test Method C 39/C 39M are for 6 by 12-in. [150 by 300-mm] cylinders, available data suggest that 4 by 8-in. [100 by 200-mm] cylinder results should be only slightly less precise.

A1.12 Required Uniformity

A1.12.1 Units are required to conform to the minimum requirements of Table A1.1.

A1.13 Report

A1.13.1 Report the following information:

A1.13.1.1 Unit identification and rated capacity.

A1.13.1.2 Description of the unit configuration.

A1.13.1.3 Description of the loading and operating procedures.

A1.13.1.4 Unit control settings.

A1.13.1.5 Identification of testing agency or agencies including:

(1) Corporate name and address,

(2) Responsible official,

(3) Indication that all testing personnel are certified as required in 14.2.4, and

(4) Indication that all tests were performed in accordance with the referenced test methods as modified herein.

A1.13.1.6 Concrete test data including:

(1) Individual test results for each slump, air content, fresh concrete density, air free fresh concrete density, coarse aggregate content (including method, wet or dry), and 7-day compressive strength (including cylinder size),

(2) Averages of duplicate tests made on the same sample,

(3) Range of results of tests on the two samples, and

(4) Comparison of that range with the maximum permitted in Table A1.1.