



Designation: C 685/C 685M – 01

Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing¹

This standard is issued under the fixed designation C 685/C 685M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

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

1. Scope

1.1 This specification covers 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 Field²
- C 33 Specification for Concrete Aggregates²
- C 39/C 39M Test Method for Compressive Strength of Cylindrical Concrete Specimens²
- 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 Aggregate²
- C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregates²
- C 138 Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete²
- C 143/C 143M Test Method for Slump of Hydraulic-Cement Concrete²

- C 150 Specification for Portland Cement³
- C 173 Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method²
- C 191 Test Method for Time of Setting of Hydraulic Cement by Vicat Needle³
- C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method²
- C 260 Specification for Air-Entraining Admixtures for Concrete²
- C 330 Specification for Lightweight Aggregates for Structural Concrete²
- C 494/C 494M Specification for Chemical Admixtures for Concrete²
- C 567 Test Method for Unit Weight of Structural Lightweight Concrete²
- C 595 Specification for Blended Hydraulic Cements³
- C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete²
- C 989 Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars²
- C 1017/C 1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete²
- C 1064/C 1064M Test Method for Temperature of Freshly Mixed Portland Cement Concrete²
- C 1077 Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation²
- C 1157 Performance Specification for Hydraulic Cement³
- D 512 Test Methods for Chloride Ion in Water⁴
- D 516 Test Method for Sulfate Ion in Water⁴

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

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 Annual Book of ASTM Standards, Vol 04.02.

³ Annual Book of ASTM Standards, Vol 04.01.

⁴ Annual Book of ASTM Standards, Vol 11.01.

⁵ Available from the American Concrete Institute, 38800 Country Club Drive, Farmington Hills, MI 48331.

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 Manual⁶

AASHTO T 26 Method of Test for Quality of Water to be Used in Concrete⁷

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 yd³ [40 m³] 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.

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.

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.

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),

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.

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 ₂ O + 0.658 K ₂ O), 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 CaCl₂ 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]						
	¾ [9.5]	½ [12.5]	¼ [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 permissible 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.

6.1.4 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.

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 $\pm 1\%$; 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 ft³ [0.070 to 0.085 m³] 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-dm³] 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 ft³ [0.03 m³] of concrete is washed through a No. 4 [4.75-mm] sieve and through a No. 100 [150- μ m] 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