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

This standard is issued under the fixed designation C685/C685M; 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*

~~1.1This~~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 as hereinafter specified. Requirements for quality of concrete shall be either as hereinafter specified or as specified by the purchaser. When the requirements of the purchaser differ from this specification, the purchaser's specification shall govern. This specification does not cover the placement, consolidation, finishing, curing, or protection of the concrete after delivery to the purchaser. 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.

1.4 *This standard does not purport to address all the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* (**Warning**—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged use.[2])

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field
C33 Specification for Concrete Aggregates
C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens
C94/C94M Specification for Ready-Mixed Concrete
C125 Terminology Relating to Concrete and Concrete Aggregates
C127 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates
C138/C138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
C143/C143M Test Method for Slump of Hydraulic-Cement Concrete
C150 Specification for Portland Cement
C173/C173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
C231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
C260 Specification for Air-Entraining Admixtures for Concrete
C330 Specification for Lightweight Aggregates for Structural Concrete
C494/C494M Specification for Chemical Admixtures for Concrete
C567 Test Method for Determining Density of Structural Lightweight Concrete
C595 Specification for Blended Hydraulic Cements

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

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

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

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

C637 Specification for Aggregates for Radiation-Shielding Concrete
C989 Specification for Slag Cement for Use in Concrete and Mortars
C1017/C1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete
C1064/C1064M Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
C1077 Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
C1157 Performance Specification for Hydraulic Cement
C1602/C1602M Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
2.2 *ACI Documents:*[4]
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
304.6R Guide for Use of Volumetric-Measuring and Continuous-Mixing Concrete Equipment
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 [5]
VMMB 100-01 Volumetric Mixer Standards of the Volumetric Mixer Manufacturers Bureau[6]

3. Terminology

3.1 *Definitions:* For definitions of terms used in this specification, refer to Terminology C125.
3.2 *Definitions of Terms Specific to This Standard:*
3.2.1 *manufacturer*, *n—of concrete,* the producer of the concrete.
3.2.2 *purchaser*, *n—of concrete,* the buyer of the concrete.

4. Basis of Purchase

4.1 The basis of purchase shall be the cubic yard or cubic metre of ~~plastic and unhardened~~fresh concrete as it is continuously discharged from the batching and mixing apparatus.
4.2 The volume of ~~freshly mixed and unhardened~~fresh concrete in a given batch shall be determined by, or calculated from, a calibrated indicating device driven directly by the batching 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.

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 C150, Specification C595, or Specification C1157 (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 C150 shall apply.

NOTE 2—These different cements will produce concretes of different properties and should not be used interchangeably.

5.1.2 *Aggregates*—Normal weight aggregates shall conform to Specification C33. Lightweight aggregates shall conform to Specification C330 and heavyweight aggregates shall conform to Specification C637.
5.1.3 *Water*—Water shall conform to Specification C1602/C1602M.
5.1.4 *Ground Granulated Blast-Furnace Slag*—Ground granulated blast furnace slag shall conform to Specification C989.
5.1.5 *Air-Entraining Admixtures*—Air-entraining admixtures shall conform to Specification C260. (Note 3)
5.1.6 *Chemical Admixtures*—Chemical admixtures shall conform to either Specification C494/C494M or C1017/C1017M, as applicable (Note 3).

NOTE 3—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:

[4] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, http://www.aci-int.org.
[5] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.
[6] Available from the Volumetric Mixer Manufacturers Bureau, 900 Spring Street, Silver Spring, MD 20910, www.vmmb.org.

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 1 for the total air content and tolerances) (Note 4),

6.1.4 When structural lightweight concrete is specified, the density as fresh density, equilibrium density, or oven-dry density (Note 5), 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 4—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 5—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 C567.

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 6), 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 6—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 7), 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 7—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.

TABLE 1 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 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.

6.5 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 volume. Devices such as counters, calibrated gate openings, or flowmeters shall be available for controlling and determining the quantities of the ingredients discharged. The entire measuring and dispensing mechanism shall produce the specified proportions of each ingredient within the tolerances in 7.8.

NOTE 8—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~~ 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.

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. For further guidance and a suggested calibration procedure, refer to ACI 304.6R and VMMB 100-01.

NOTE 9—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~~ 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 device for the measurement of water shall be capable of delivering to the batch the required quantity. 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 10—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 11—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]	<12 [<300]	12 to 36 [300 to 900]	36 to 72 [900 to 1800]	>72 [>1800]
Temperature, min, °F (°C)	55 [13]	50 [10]	45 [7]	40 [5]

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 12—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 13—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. [100 mm]	±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 1 for total air content (Note 4).

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 C31/C31M. 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 14):

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 14—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 2.

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

TABLE 2 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].