

ASTM C1116-03: Fiber Reinforced Concrete Type III Specification

ASTM C1116-03 Standard Specification for Fiber-Reinforced Concrete and Shotcrete (Type III)

Full English Version

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1. Scope

1.1 This specification covers fiber-reinforced concrete in all forms that is uniformly mixed when delivered to the purchaser and may be sampled and tested at the point of delivery. This specification does not cover the placing, consolidating, curing, or protecting of fiber-reinforced concrete after delivery to the purchaser.

1.2 Certain sections of this specification are also applicable to fiber-reinforced concrete used for dry-mix shotcrete where sampling and testing of the concrete can only be performed at the point of placement. In such cases, the sections pertaining to batching plants, mixing equipment, mixing and delivery, and measurement of workability and air content do not apply.

1.3 This specification does not cover thin-section glass-fiber-reinforced concrete manufactured by the spray-up process and under the jurisdiction of Subcommittee C27.40 of ASTM.

1.4 The values stated in inch-pound units are to be regarded as standard.

1.5 The following safety precaution statement applies only to the test method sections (Sections 15 and 18) of this specification: This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

This specification references the following ASTM standards:

Standard Designation	Title
A 820	Standard Specification for Steel Fibers for Fiber-Reinforced Concrete
C 31/C 31M	Standard Practice for Making and Curing Concrete Test Specimens in the Field
C 33	Standard Specification for Concrete Aggregates
C 39/C 39M	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
C 42/C 42M	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
C 78	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
C 94/C 94M	Standard Specification for Ready-Mixed Concrete
C 109/C 109M	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
C 138/C 138M	Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

C 143/C 143M	Standard Test Method for Slump of Hydraulic-Cement Concrete
C 150	Standard Specification for Portland Cement
C 172	Standard Practice for Sampling Freshly Mixed Concrete
C 173/C 173M	Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
C 191	Standard Test Method for Time of Setting of Hydraulic Cement by Vicat Needle
C 192/C 192M	Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
C 231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
C 260	Standard Specification for Air-Entraining Admixtures for Concrete
C 330	Standard Specification for Lightweight Aggregates for Structural Concrete
C 387	Standard Specification for Packaged Dry, Combined Materials for Mortar and Concrete

C 494/C 494M	Standard Specification for Chemical Admixtures for Concrete
C 567	Standard Test Method for Density of Structural Lightweight Concrete
C 595	Standard Specification for Blended Hydraulic Cements
C 618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C 637	Standard Specification for Aggregates for Radiation-Shielding Concrete
C 666	Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
C 684	Standard Practice for Making, Accelerated Curing, and Testing of Concrete Compression Test Specimens
C 685/C 685M	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
C 887	Standard Specification for Packaged Dry, Combined Materials for Surface-Bonding Mortar
C 995	Standard Test Method for Flow Time of Fiber-Reinforced Concrete

	Through an Inverted Slump Cone
C 1017/C 1017M	Standard Specification for Admixtures for Use in Producing Flowing Concrete
C 1018	Standard Test Method for Flexural Toughness and First-Crack Strength of Fiber-Reinforced Concrete (Using Beam with Third-Point Loading)
C 1077	Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Construction and Criteria for Laboratory Evaluation
C 1141	Standard Specification for Admixtures for Shotcrete
C 1399	Standard Test Method for Obtaining Average Residual-Strength of Fiber-Reinforced Concrete

3. Terminology

3.1 For the purposes of this specification, the following terms apply:

- **manufacturer:** The contractor, subcontractor, supplier, or producer supplying the fiber-reinforced concrete.
- **purchaser:** The owner or the owner's representative.

4. Classification

4.1 This specification classifies fiber-reinforced concrete or shotcrete according to the type of material from which the fibers are made. The performance of fiber-reinforced concrete or shotcrete is highly dependent on the susceptibility of the fibers to physical damage during mixing or shooting, their chemical compatibility with the

alkaline environment normally present in cement paste, and their resistance to degradation when used in uncracked concrete or encountered in cracked concrete due to exposure conditions such as solutions of carbon dioxide, chlorides, or sulfates in water and oxygen, or ultraviolet light in the atmosphere. The degree of improvement in mechanical properties imparted to concrete or shotcrete by fibers also reflects the material characteristics of the fiber type, with fibers of high modulus of elasticity and tensile strength being more effective on an equivalent volume basis than those of low modulus and strength.

4.1.3 Type III Synthetic Fiber-Reinforced Concrete or Shotcrete: Concrete or shotcrete containing synthetic fibers for which written evidence can be provided showing long-term resistance to aging when in contact with moisture and alkalis present in cement paste or substances present in air-entraining and chemical admixtures (see Note 3 and 4.2).

Note 3: Fibers composed of some polymers may degrade when exposed to moisture, alkalis, or certain components of chemical admixtures. Polyolefin fibers such as polypropylene and polyethylene, nylon fibers, and carbon fibers have demonstrated durability in concrete.

4.2 When the purchaser elects to permit the use of fibers not classified in accordance with 4.1, such as natural fibers, metallic fibers other than steel, carbon fibers, etc., the producer shall furnish satisfactory evidence to the purchaser that the type of fiber proposed will not react adversely with the concrete or shotcrete matrix (including components of any admixtures) or the surrounding environment in the cracked matrix to cause degradation of mechanical properties over time under the exposure conditions of the intended application.

5. Basis of Purchase

5.1 The basis of purchase for conventionally mixed fiber-reinforced concrete shall be the cubic yard or cubic meter of freshly mixed, unhardened concrete.

5.2 For ready-mixed fiber-reinforced concrete, the basis of purchase shall be the net weight of concrete in the delivery batch, or the volume calculated from the quantity delivered and the unit weight. The unit weight shall be determined from the average of at least three measurements, each made on a different sample, in accordance with Test Method C 138/C 138M or C 567. Sampling shall be performed in accordance with Practice C 172.

Note 4: It is understood that the volume of hardened concrete may be or appear to be less than anticipated due to waste and spillage, over-excavation, form expansion, loss of entrained air, or settlement of wet mixtures, none of which are the responsibility of the manufacturer.

5.3 The basis of purchase for fiber-reinforced shotcrete shall normally be the cubic yard or cubic meter. For wet-mix shotcrete, the volume shall be calculated from the quantity delivered and the unit weight. For dry-mix shotcrete, the volume shall be calculated from the weight of the constituent materials and their respective specific

gravities. At the purchaser's option, when the surface to be shot is level and a uniform final thickness is specified, the basis of purchase shall be the square yard or square meter.

6. Ordering Information

6.1 The purchaser shall specify the following:

6.1.1 The type of fiber-reinforced concrete or shotcrete required (see Section 4).

6.1.2 The type of cement desired, otherwise cement shall be Type I conforming to Specification C 150.

6.1.3 The specified size of coarse aggregate.

6.1.4 The slump or flow time required at the point of delivery or, where appropriate, at the point of placement, within the tolerances specified below:

6.1.4.1 Slump shall be specified when the expected slump is 2 in. (50 mm) or more; flow time shall be specified when the expected slump is less than 2 in. (50 mm). Slump or flow time shall not be specified for dry-mix shotcrete.

Note 5: The flow time of fiber-reinforced concrete through an inverted slump cone, determined in accordance with Test Method C 995, is more indicative of the proper workability level for fiber-reinforced concrete placed by vibration than slump (Test Method C 143/C 143M), since such concrete may exhibit very low slump due to the presence of fibers but still be readily consolidable. Mixtures with flow times of 8 to 15 seconds are readily consolidable by vibration. As flow time increases, consolidation becomes more difficult, and if flow time exceeds 30 seconds, consolidation is extremely difficult even with internal vibration. Mixtures with flow times less than 8 seconds shall be evaluated by slump since the flow time is too short to be determined with satisfactory precision or may not be determinable because the fiber-reinforced concrete flows freely through the inverted cone.

6.1.5 The air content when air entrainment is required, based on the air content of samples taken at the point of discharge or, where appropriate, at the point of placement, within the tolerances specified below:

6.1.5.1 Air entrainment shall not be specified for dry-mix shotcrete.

Note 6: In selecting the specified air content, the purchaser shall take into account the exposure conditions to which the concrete will be subjected. Air contents lower than those shown in Table 1 may not provide adequate resistance to freezing and thawing. Air contents higher than the levels shown may reduce strength without further improvement in frost resistance.

Table 1 Recommended Total Air Content for Air-Entrained Concrete

Nominal Maximum Size of Aggregate (in./mm)	Exposure Condition		

	Mild	Moderate	Severe
3/8 (9.5)	4.5%	6.0%	7.5%
1/2 (12.5)	4.0%	5.5%	7.0%
3/4 (19.0)	3.5%	5.0%	6.0%
1 (25.0)	3.0%	4.5%	6.0%
1.5 (37.5)	2.5%	4.5%	5.5%
2 (50.0)	2.0%	4.0%	5.0%
3 (75.0)	1.5%	3.5%	4.5%

A Applicable to specified air-entrained concrete.

B Unless otherwise specified by exposure conditions, the recommended air contents shown above may be reduced by up to 1% for concrete with a specified compressive strength of 5000 psi (34.5 MPa) or greater.

C Refer to Table 5.3.3 of ACI 211.1 for descriptions of exposure conditions, noting the accompanying footnotes.

6.1.7 One of the following three alternatives shall be used as the basis for proportioning fiber-reinforced concrete or fiber-reinforced shotcrete of the required quality.

6.2 Alternative Number 1:

6.2.1 When the purchaser assumes responsibility for mixture proportioning, the purchaser shall also specify the following:

6.2.1.1 Cement content (lb/yd³ or kg/m³).

6.2.1.2 Type and amount of mineral admixture, if required (lb/yd³ or kg/m³, or percent by mass of cement).

6.2.1.3 Maximum permissible mixing water content (gal/yd³ or L/m³), including surface moisture on aggregates but excluding water absorbed by aggregates.

6.2.1.4 Type, name, and dosage range of air-entraining admixture, if required, to achieve the specified air content (see 6.1.4).

6.2.1.5 Type, name, and dosage range of chemical admixture, if required.

6.2.1.6 Type and amount of fibers used (lb/yd³ or kg/m³) (see Section 4, Classification).

Note 8: Dosages of air-entraining admixtures, water-reducing admixtures (including

high-range water-reducing admixtures), accelerators, and retarders required to meet material performance requirements vary. Therefore, dosage ranges shall be specified to ensure that material performance requirements can be satisfied.

Note 9: The purchaser, in selecting requirements for which responsibility is assumed, should consider requirements for workability, placeability, durability, surface texture, and density. The purchaser is referred to ACI Practices 211.1 and 211.2 for guidance in selecting proportions that will produce concrete suitable for various types of construction and exposure conditions.

7. Material Requirements

7.1 Cement

Cement shall conform to the requirements of ASTM C 150 (Portland Cement) or C 595 (Blended Hydraulic Cements).

7.2 Aggregates

7.2.1 Fine aggregate shall conform to the requirements of ASTM C 33.

7.2.2 Coarse aggregate shall conform to the requirements of ASTM C 33, unless specified as lightweight aggregate, in which case it shall conform to ASTM C 330.

7.3 Water

Water shall be clean, free of harmful substances, and suitable for use in concrete production.

7.4 Admixtures

7.4.1 Air-entraining admixtures shall conform to ASTM C 260.

7.4.2 Chemical admixtures shall conform to ASTM C 494/C 494M.

7.4.3 Shotcrete admixtures shall conform to ASTM C 1141.

7.5 Fibers

7.5.1 Type III synthetic fibers shall meet the requirements of Section 4.1.3, with written evidence demonstrating long-term durability in the concrete environment.

7.5.2 Fiber length, diameter, shape, and surface characteristics shall be suitable for the intended application and concrete mixture.

7.5.3 Fibers shall be uniformly dispersed during mixing without forming fiber balls or agglomerations.

8. Mixing Requirements

8.1 Fiber-reinforced concrete shall be mixed in mixing equipment meeting the requirements of ASTM C 94/C 94M or C 685/C 685M.

8.2 Fibers shall be added after the aggregates and cement have been mixed, or at an appropriate stage during mixing to ensure uniform dispersion.

8.3 Mixing time shall be sufficient to ensure uniform blending of all ingredients (including fibers) without causing excessive fiber damage or breakage.

9. Delivery Requirements

9.1 Delivery of fiber-reinforced concrete shall comply with ASTM C 94/C 94M.

9.2 Delivery time shall be minimized to prevent loss of workability before the concrete reaches the placement point.

9.3 For shotcrete, the delivery system shall be suitable for the requirements of the dry-mix or wet-mix process.

10. Workability Requirements

10.1 Slump or flow time shall conform to the provisions of Section 6.1.4, with tolerances as follows:

Specified Value	Tolerance
Slump \leq 4 in. (100 mm)	\pm 1 in. (25 mm)
Slump $>$ 4 in. (100 mm)	\pm 1.5 in. (38 mm)
Flow time \leq 15 s	\pm 5 s
Flow time $>$ 15 s	\pm 10 s

10.2 The manufacturer shall not be responsible for failure to meet slump or flow time requirements more than 30 minutes after the actual arrival time on the job site or the required delivery time.

11. Air Content Requirements

11.1 When air entrainment is specified, total air content measured using Test Method C 173/C 173M or C 231 shall be within a tolerance of \pm 1.5% of the specified value.

12. Sampling Requirements

12.1 Sampling of freshly mixed fiber-reinforced concrete shall comply with ASTM C 172.

12.2 For shotcrete, sampling shall be performed at the point of placement or obtained from corresponding test panels.

13. Acceptance Testing of Hardened Fiber-Reinforced Concrete or Shotcrete

13.1 Materials for preparing test specimens shall be obtained in accordance with the Sampling section of this specification.

13.2 When flexural toughness parameters, first-crack strength, or both, or average residual strength are used as the basis for acceptance of fiber-reinforced concrete or shotcrete, prepare, cure, and test sets of specimens in accordance with Test Method C 1018 or C 1399, as applicable.

13.3 When flexural strength is used as a basis for acceptance, prepare sets of at least three specimens in accordance with the sampling and curing requirements given in Test Method C 1018 and test in accordance with the applicable requirements of Test Method C 42/C 42M or C 78. Specimens representing thin sections (as defined in Test Method C 1018) or specimens representing fiber-reinforced shotcrete of any thickness shall be tested in the as-placed condition and shall not be turned on their side prior to placement on the supporting system. When toughness is important, acceptance shall not be based solely on flexural strength.

Note 15: Test Method C 1018 provides for the determination of flexural strength when requested by the purchaser. For many type-and-quantity fiber combinations,

13.4 When compressive strength is used as part of the basis for acceptance of fiber-reinforced concrete, prepare sets of at least two specimens in accordance with the applicable requirements of Practices C 31/C 31M and C 192/C 192M, cure, and test in accordance with Test Method C 39/C 39M or C 42/C 42M. Acceptance shall not be based solely on compressive strength.

13.5 Test laboratories performing acceptance testing shall comply with the requirements of Practice C 1077.

14. Frequency of Testing

14.1 The frequency of testing for hardened fiber-reinforced concrete or shotcrete shall be as follows:

14.1.1 Batch-Mixing: The frequency of testing shall not be less than one test per 150 cubic yards (115 cubic meters). Each test shall be made from a separate batch. At least one test shall be made for each material classification each day fiber-reinforced concrete is mixed.

14.1.2 Continuous Mixing: One test per 25 cubic yards (19 cubic meters) or fraction

thereof, or when a significant change in mixture proportion control occurs. At least one test shall be made for each material classification each day fiber-reinforced concrete is mixed.

14.1.3 Shotcrete: One test per 50 cubic yards (38 cubic meters) placed, using specimens sawed or cored from the structure or obtained from corresponding test panels. At least one test shall be made for each material classification each day fiber-reinforced shotcrete is produced.

14.2 The purchaser's representative shall determine and record the delivery ticket number or equivalent information and the exact location in the work represented by each test.

15. Evaluation of Test Results

15.1 Test results shall be based on the average of the performance values of the set of hardened concrete specimens constituting the test unit, as defined herein or in the applicable test method.

15.2 If any individual test specimen in a set constituting a test unit shows clear evidence of improper sampling, molding, handling, curing, or testing, it shall be considered defective and discarded, and the average of the performance values of the remaining test specimens shall be taken as the test result. If, on this basis, more than one specimen in a set is found defective, the test result shall be rejected.

15.3 For flexural toughness parameters defined in Test Method C 1018, or average residual-strength values in accordance with Test Method C 1399, the test result shall equal or exceed the specified value at the applicable test age.

Note 16: Toughness requirements shall not be specified when fibers are used solely for the control of plastic shrinkage cracking.

15.4 When durability is part of the acceptance criteria, test a set of three specimens in accordance with Procedure A of Test Method C 666, and the fiber-reinforced concrete shall achieve an average durability factor of at least 80% to demonstrate durability.

16. Certification

16.1 The manufacturer shall furnish the purchaser with a certificate certifying that the fiber-reinforced concrete complies with all requirements of this specification, including the type, quantity, and durability evidence of the fibers.

16.2 The certificate shall include mixing records, test results, and other relevant information.

17. Keywords

accuracy; average residual-strength; certification; fibers; fiber-reinforced concrete;

materials for; scales; testing; toughness.

18. Effective Date and History

This standard was approved on July 10, 2003, and issued in September 2003. Originally approved in 1989. The previous edition was approved in 2002 as C 1116-02.

19. Superseded Version Information

This standard has been superseded and replaced by a newer version. The latest edition is ASTM C1116/C1116M-23, issued on August 1, 2023.

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