



Designation: C1116/C1116M – 23

Standard Specification for Fiber-Reinforced Concrete¹

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1. Scope*

1.1 This specification covers most forms of fiber-reinforced concrete manufactured in accordance with Specification C94/C94M or Specification C685/C685M as modified herein. It does not cover the placement, consolidation, curing, or protection of the fiber-reinforced concrete after delivery to the purchaser.

1.2 Certain sections of this specification are also applicable to fiber-reinforced concrete intended for shotcreting by the dry-mix or to zero-slump, and fiber-reinforced concrete used to manufacture precast elements. In these cases, the sections dealing with batching plant, mixing equipment, mixing and delivery, and measurement of workability and air content, are not applicable.

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

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.5 If required results obtained from another standard are not reported in the same system of units as used by this standard, it is permitted to convert those results using the conversion factors found in the SI Quick Reference Guide.²

1.6 *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, health, and environmental 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 exposure.*³

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:⁴

- A820/A820M Specification for Steel Fibers for Fiber-Reinforced Concrete
- C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field
- 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
- C172/C172M Practice for Sampling Freshly Mixed Concrete
- C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory
- C387/C387M Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar
- C685/C685M Specification for Concrete Made by Volumetric Batching and Continuous Mixing
- C1077 Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
- C1140/C1140M Practice for Preparing and Testing Specimens from Shotcrete Test Panels
- C1385/C1385M Practice for Sampling Materials for Shotcrete

¹ This specification is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.42 on Fiber-Reinforced Concrete.

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² Annex A in Form and Style for ASTM Standards, www.astm.org/COMMIT/Blue_Book.pdf

³ Section on Safety Precautions, Manual of Aggregate and Concrete Testing, *Annual Book of ASTM Standards*, Vol. 04.02

⁴ 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

C1436 Specification Materials for Shotcrete (Withdrawn 2022)⁵

C1550 Test Method for Flexural Toughness of Fiber Reinforced Concrete (Using Centrally Loaded Round Panel)

C1579 Test Method for Evaluating Plastic Shrinkage Cracking of Restrained Fiber Reinforced Concrete (Using a Steel Form Insert)

C1604/C1604M Test Method for Obtaining and Testing Drilled Cores of Shotcrete

C1609/C1609M Test Method for Flexural Performance of Fiber-Reinforced Concrete (Using Beam With Third-Point Loading)

C1666/C1666M Specification for Alkali Resistant (AR) Glass Fiber for GFRC and Fiber-Reinforced Concrete and Cement

D6942 Test Method for Stability of Cellulose Fibers in Alkaline Environments

D7357/D7357M Specification for Cellulose Fibers for Fiber-Reinforced Concrete

D7508/D7508M Specification for Polyolefin Chopped Strands for Use in Concrete

2.2 *European Standard*.⁶

EN 14651 Test Method for metallic fiber concrete – Measuring the flexural tensile strength (limit of proportionality (LOP), residual)

NOTE 1—The performance of fiber-reinforced concrete depends upon the susceptibility of the fibers to physical damage during mixing or shotcreting and to chemical damage on exposure to the cement paste solution, which is highly alkaline and may also contain chlorides, sulfates or oxygen. Improper methods of fiber addition to a concrete batch can lead to balling of some types of fiber; consult manufacturer for advice on the correct method of adding fibers before use. The magnitude of improvements in the mechanical properties of the concrete or shotcrete imparted by fibers are affected by the material characteristics, geometry, and design of the fiber type.

4.1.1 *Type I Steel Fiber-Reinforced Concrete*—Contains stainless steel, alloy steel, or carbon steel fibers conforming to Specification **A820/A820M**.

4.1.2 *Type II Glass Fiber-Reinforced Concrete*—Contains alkali-resistant (AR) glass fibers conforming to Specification **C1666/C1666M**.

4.1.3 *Type III Synthetic Fiber-Reinforced Concrete*—Contains synthetic fibers for which documentary evidence can be produced confirming their resistance to deterioration when in contact with the moisture and alkalis present in cement paste and the substances present in admixtures (see **Note 2** and **4.2**). If Type III fiber-reinforced concrete contains polyolefin fibers, they shall conform to Specification **D7508/D7508M**.

NOTE 2—Fibers such as polyolefins (polypropylene and polyethylene), nylon, and carbon have been shown to be durable in concrete.

4.1.4 *Type IV Natural Fiber-Reinforced Concrete*—Contains natural fibers for which documentary evidence can be produced confirming their resistance to deterioration when in contact with the moisture and alkalis present in cement paste and the substances present in admixtures. If Type IV fiber-reinforced concrete contains cellulose fibers, they shall conform to Specification **D7357/D7357M**.

NOTE 3—The classification, natural fibers, refers to a population of fibers that are manufactured from natural fibrous resources and are used for the first time in concrete. Depending on the initial raw material and the manufacturing process employed to produce the fiber, the final physical and chemical fiber properties in this general classification can vary greatly. Some natural fibers are susceptible to deterioration from exposure to alkalis; Test Method **D6942** may be used to determine the susceptibility of these fibers to deterioration as a result of exposure to alkalis in concrete. Conversely, many other natural fiber types are highly resistant to alkalis and can remain in concrete with no degradation for the complete product life cycle.

4.2 If the purchaser chooses to permit the use of fibers other than those complying with the classifications in **4.1**, the manufacturer or fiber supplier shall show evidence satisfactory to the purchaser that the type of fiber proposed for use shows resistance to deterioration if in contact with the moisture and alkalis present in cement paste and the substances present in admixtures.

5. Basis of Purchase

5.1 The basis of purchase for fiber-reinforced concrete shall be in accordance with the section titled *Basis of Purchase* in Specification **C94/C94M** or Specification **C685/C685M**.

6. Ordering Information

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

6.1.1 Type of fiber-reinforced concrete required. See Section **4**.

3. Terminology

3.1 Definitions

3.1.1 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*—the producer who supplies the fiber-reinforced concrete.

3.2.2 *purchaser, n*—the owner, or representative thereof, who buys the fiber-reinforced concrete.

3.2.3 *fiber ball, n*—entangled clump of fibers that are intended to be dispersed uniformly.

3.2.4 *fiber supplier, n*—the seller who distributes the fiber to the market.

3.2.5 *flexural toughness*—energy absorption of a fiber-reinforced concrete test specimen in the post-crack range as measured by Test Method **C1550** and by Test Method **C1609/C1609M**.

3.2.6 *post-crack flexural performance*—behavior of test specimen after the fiber-reinforced concrete has cracked as measured by Test Method **C1609/C1609M** or EN 14651.

3.2.6.1 *Discussion*—EN 14651 uses a notched beam with center-point loading for measuring flexural strength and post-crack performance of fiber-reinforced concrete.

4. Classification

4.1 This specification classifies fiber-reinforced concrete by the material type of the fiber incorporated.

⁵ The last approved version of this historical standard is referenced on www.astm.org.

⁶ Available from European Standards s.r.o, www.en-standard.eu/store/

6.1.2 Applicable ordering information given in the Section titled *Ordering Information* in Specification **C94/C94M** or Specification **C685/C685M**.

6.2 The purchaser shall specify whether Option A or Option B shall be used as the basis for determining the mixture proportions for the fiber-reinforced concrete.

6.2.1 *Option A: Manufacturer is Responsible for Mixture Proportioning*—If the purchaser requires the manufacturer to assume responsibility for the mixture proportioning, the requirements under Option A of Specification **C94/C94M** or Specification **C685/C685M** shall apply.

6.2.1.1 The purchaser shall specify requirements for post-crack flexural performance or flexural toughness.

(1) Test Method **C1609/C1609M** or EN 14651 shall be used to measure post-crack flexural performance of fiber-reinforced concrete.

(2) Test Method **C1550** shall be used to measure the flexural toughness of fiber-reinforced shotcrete.

(3) Post-cracking flexural performance is not specified if the fiber reinforcement is used only to mitigate plastic shrinkage cracking.

6.2.1.2 All samples shall be obtained in accordance with Practice **C172/C172M**. At the option of the purchaser, compressive strength determined in accordance with Test Method **C39/C39M** shall be specified if the flexural performance requirements are considered inadequate for ensuring the quality of the matrix of the fiber-reinforced concrete. Tests shall be performed after standard moist curing in accordance with Practice **C31/C31M** at 28 days, or other age specified by the purchaser.

NOTE 4—While flexural strength at first peak is affected by the type and amount of fibers, it is more dependent on the characteristics of the mortar or concrete matrix. So, it is recommended that the purchaser, if specifying flexural strength at first peak, consider factors known to influence the strength of ordinary concrete such as, water-cement ratio, maximum size of aggregate, and the presence of chemical admixtures or supplementary cementitious materials.

NOTE 5—To control fiber alignment in preparing test specimens, it is essential to follow the consolidation procedures in the applicable test methods. The standard specimen consolidation procedures found in Practice **C31/C31M** and Practice **C192/C192M**, including rodding and filling the mold in layers, can lead to increased variability and bias of test results with fiber-reinforced concrete.

NOTE 6—Test Method **C1579** can be used to evaluate the effectiveness of fibers in controlling plastic shrinkage cracking.

6.2.2 *Option B: Purchaser is Responsible for Mixture Proportioning*:

6.2.2.1 If the purchaser assumes responsibility for mixture proportioning, the requirements under Option B of Specification **C94/C94M** or Specification **C685/C685M** shall apply.

6.2.2.2 The purchaser shall specify the fiber type in accordance with Section 4 and the amount of fibers per unit volume of fiber-reinforced concrete.

NOTE 7—The purchaser, in selecting requirements for which he assumes responsibility should consider requirements for workability, placeability, durability, surface texture, and density. The purchaser is referred to ACI PRC-211.1⁷ for selecting proportions that will result in

⁷ ACI PRC-211.1-22 “Selecting Proportions of Normal-Density and High-Density Concrete – Guide”, American Concrete Institute (ACI), PO Box 9094,

concrete suitable for various types of structures and conditions of exposure, and to ACI PRC-544.3⁸ for selecting concrete and fiber parameters suitable for fiber reinforced concrete. For guidance on selecting proportions for fiber-reinforced shotcrete, the purchaser is referred to ACI PRC-506.1⁹ and ACI PRC-506¹⁰.

7. Materials

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

7.1.1 Except for fibers, materials for the manufacture of fiber-reinforced concrete shall conform to Specification **C94/C94M**, or Specification **C685/C685M**, and materials for the manufacturer of fiber-reinforced shotcrete shall conform to Specification **C1436**.

7.1.2 *Fibers*—Fibers shall conform to the applicable specifications given in Section 4.

8. Measuring Materials

8.1 Except as otherwise specifically permitted by the purchaser, cement, supplementary cementitious materials, fine and coarse aggregates, mixing water, and admixtures shall be measured in accordance with the applicable requirements of Specification **C94/C94M** or Specification **C685/C685M**.

8.2 Fibers shall be batched by mass or volume with an accuracy of -3% and $+5\%$ of the amount required per batch.

8.3 Fibers shall be measured by mass if fiber-reinforced concrete is produced in accordance with Specification **C94/C94M**. If the fibers are to be measured by mass, bags, boxes, or like containers are acceptable provided that such like containers are sealed by the fiber manufacturer and have the mass contained therein clearly marked. No fraction of a container delivered unsealed, or left over from previous work, shall be used unless weighed.

8.4 Prepackaged, dry, combined materials, including fibers, shall comply with the packaging and marking requirements of Specification **C387/C387M** and shall be accepted for use provided that after addition of water, the resulting fiber-reinforced concrete meets the performance requirements of this specification.

9. Mixing and Delivery

9.1 Batch-mixed fiber-reinforced concrete, whether prepared on site or at a remote location, shall be mixed and delivered to the point designated by the purchaser in accordance with the applicable requirements of Specification **C94/C94M** including the requirements for uniformity in the Annex.

9.2 Continuously mixed fiber-reinforced concrete shall be mixed and delivered to the point designated by the purchaser in accordance with the applicable requirements of Specification **C685/C685M** including the requirements for uniformity in the Annex.

⁸ ACI PRC-544.3-08, Guide for Specifying, Proportioning and Production of Fiber-Reinforced Concrete, American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, www.concrete.org

⁹ PRC-506.1-21, “Fiber-Reinforced Shotcrete—Guide,” American Concrete Institute (ACI), PO Box 9094, Farmington Hills, MI 48333-9094, www.concrete.org

¹⁰ ACI PRC-506-16, “Guide to Shotcrete,” American Concrete Institute (ACI), PO Box 9094, Farmington Hills, MI 48333-9094, www.concrete.org