Designation: C1856/C1856M – 17

Standard Practice for Fabricating and Testing Specimens of Ultra-High Performance Concrete[1]

This standard is issued under the fixed designation C1856/C1856M; 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.

1. Scope

1.1 This practice covers procedures for fabricating and testing specimens in the laboratory and the field using a representative sample of ultra-high performance concrete (UHPC), for the purpose of determining the properties of the material. This practice is applicable to UHPC with a specified compressive strength of at least 120 MPa (17 000 psi), with nominal maximum size aggregate of less than 5 mm [¼ in.] and a flow between 200 and 250 mm [8 and 10 in.] as measured by the modified flow table test described in Section 6.

1.2 The values stated in either SI units 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 non-conformance with the standard.

1.3 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 (**1**).[2]

1.4 *The text of this standard references notes and footnotes that provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of this standard.*

1.5 *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. [WARNING—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to exposed skin and tissue upon prolonged exposure.*[3] *Hand protection should be worn when handling UHPC.]*

1.6 *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]

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field

C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens

C42/C42M Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

C125 Terminology Relating to Concrete and Concrete Aggregates

C157/C157M Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

C191 Test Methods for Time of Setting of Hydraulic Cement by Vicat Needle

C192/C192M Practice for Making and Curing Concrete Test Specimens in the Laboratory

C219 Terminology Relating to Hydraulic Cement

C230/C230M Specification for Flow Table for Use in Tests of Hydraulic Cement

C341/C341M Practice for Preparation and Conditioning of Cast, Drilled, or Sawed Specimens of Hydraulic-Cement Mortar and Concrete Used for Length Change Measurements

C469/C469M Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression

C512/C512M Test Method for Creep of Concrete in Compression

C666/C666M Test Method for Resistance of Concrete to Rapid Freezing and Thawing

C944/C944M Test Method for Abrasion Resistance of Concrete or Mortar Surfaces by the Rotating-Cutter Method

[1] This practice is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.61 on Testing for Strength.

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[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[3] See section on Safety Precautions, *Manual of Aggregates 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.

C1202/C1202M Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
C1437 Test Method for Flow of Hydraulic Cement Mortar
C1609/C1609M Test Method for Flexural Performance of Fiber-Reinforced Concrete (Using Beam With Third-Point Loading)

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this practice, refer to Terminologies C125 and C219.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *concrete, ultra-high performance, n*—a cementitious mixture that has a specified compressive strength of at least 120 MPa [17 000 psi], generally containing fibers and has other properties measured by standard test methods that comply with specified durability, ductility and toughness requirements.

4. Significance and Use

4.1 This practice includes procedures for measuring properties of fresh UHPC and procedures for making and testing specimens of hardened UHPC. The practice refers to existing practices and test methods and includes modifications to these referenced standards for application to UHPC.

5. Sampling of Fresh UHPC

5.1 The sample shall be taken from the mixer following the completion of the mixing cycle.

5.2 The sample shall be of sufficient size to complete the testing and shall be at least 10 L [0.35 ft^3].

6. Testing of Fresh Properties

6.1 *Flow:*

6.1.1 Determine the flow of freshly mixed UHPC in accordance with Test Method C1437, with the following exceptions.

6.1.1.1 The mold and flow table shall meet the requirements of Specification C230/C230M. The concrete pedestal and cork gasket are not required.

6.1.1.2 Fill the mold in a single layer with the fresh UHPC.

6.1.1.3 Do not tamp the UHPC in the mold and do not drop the table.

6.1.1.4 After lifting the mold, wait until a time of 2 min ± 5 s has elapsed.

6.1.1.5 Measure the diameter of the UHPC along the lines of maximum and minimum diameter, with a ruler or tape measure, recording each diameter to the nearest 1 mm [1/16 in.].Calculate the average of the two diameters measured. The flow value is this average.

6.2 *Time of Setting:*

6.2.1 Determine the time of setting in accordance with Test Method C191, except the material used shall be UHPC poured into the conical ring without consolidation and at the given consistency referenced.

NOTE 1—The consistency of the UHPC sample used to determine time of setting should be the consistency specified for the mix or project and not the normal consistency in Test Method C191.

7. Making and Curing Test Specimens

7.1 *General Requirements:*

7.1.1 If making test specimens of UHPC in the field, make and initially cure the specimens in accordance with Practice C31/C31M, with the exceptions described in this Practice.

7.1.2 Make and cure test specimens made in the laboratory in accordance with Practice C192/C192M, with the exceptions described in this Practice.

7.1.3 Obtain specimens from structures in accordance with Test Method C42/C42M.

7.1.4 The size of specimens shall comply with Section 8, as summarized in Table 1.

7.2 *Molding of Specimens:*

7.2.1 Fill cylinder molds in one layer.

7.2.2 Fill prism molds from one end, in one layer.

7.2.3 Consolidate all specimens by tapping the sides of the mold 30 times with the mallet.

7.2.4 Tamping rods and internal vibrators shall not be used in fabricating and consolidating specimens from UHPC.

7.3 *Curing:*

7.3.1 Cure field-fabricated specimens in accordance with Practice C31/C31M and cure laboratory-fabricated specimens in accordance with Practice C192/C192M, with the following exception.

7.3.1.1 Within 1 min after finishing the top surface, cover the specimen to prevent drying of the top surface.

NOTE 2—UHPC contains low quantities of mixing water and virtually no bleed water, resulting in surface drying that may impact the hardened properties, therefore it is important to cover the surface of the specimen with a plastic sheet or equivalent as quickly as possible.

7.4 *Thermal Treatment:*

7.4.1 If required by the specifier of tests, specimens shall be thermally treated after demolding.

7.4.2 If thermal treatment is required, place a temperature sensor at the center of at least one cylinder.

7.4.3 Thermal treatment shall be conducted in accordance with Table 2.

TABLE 1 Summary of Specimen Sizes

Property	Test Method	Nominal Specimen Sizes	Comments
Compressive Strength	C39/C39M	75 mm by 150 mm [3 in. by 6 in.]	
Flexural Strength	C1609/C1609M	See 8.2.2	Sizes change with fiber length
Static Modulus of Elasticity and Poisson's Ratio	C469/C469M	75 mm by 150 mm [3 in. by 6 in.]	
Creep in Compression	C512/C512M	75 mm by 150 mm [3 in. by 6 in.]	At least six specimens
Length Change	C157/C157M or C341/C341M	75 mm by 75 mm by 285 mm [3 in. by 3 in. by 11¼ i n.]	
Resistance to Abrasion	C944/C944M	Minimum size to accommodate the device	
Resistance to Freezing and Thawing	C666/C666M	No limits	Refer to C666/C666M
Penetration of Chloride Ions	C1202/C1202M	100 mm [4 in.] diameter	

TABLE 2 Requirements for Thermal Treatment

Fiber Type	UHPC Temperature Range	Relative Humidity Range	Duration of Thermal Treatment
Metallic	90 ± 3°C [195°F ± 5°F]	95 ± 3%	48 ± 1 h
Non-metallic	60 ± 3°C [140°F ± 5°F]	95 ± 3%	72 ± 1 h

TABLE 3 Dimensions of Beams for Measuring Flexural Strength

Maximum Fiber Length (l_f)	Nominal Prism Cross Section
< 15 mm [0.60 in.]	75 mm by 75 mm [3 in. by 3 in.]
15 mm to 20 mm [0.60 in. to 0.80 in.]	100 mm by 100 mm [4 in. by 4 in.]
20 mm to 25 mm [0.80 to 1.00 in.]	150 mm by 150 mm [6 in. by 6 in]
>25 mm [1.00 in.]	200 mm by 200 mm [8 in. by 8 in.]

7.4.4 During the heating and cooling down periods of the thermal treatment, the rate of the specimen temperature increase or decrease shall not exceed 10°C/h [18°F/h].

7.4.5 During thermal treatment, use embedded instrumentation to record the specimen temperature.

NOTE 3—As a minimum, one specimen cast at the same time, with the same mixture, receiving the same thermal treatment conditions as the other specimens should contain the embedded instrumentation.

8. Testing of Hardened Specimens

8.1 *Compressive Strength:*

8.1.1 Determine the compressive strength in accordance with Test Method C39/C39M, with the exceptions described in this section.

8.1.2 Only 75 mm [3 in.] diameter by 150 mm [6 in.] long cylindrical specimens shall be used for compressive strength testing.

NOTE 4—If molds in SI units are required and not available, the inch-pound mold should be permitted.

8.1.3 Prior to testing, all cylinders shall be end ground such that the ends do not depart from perpendicularity to the axis by more than 0.5° (approximately equivalent to 1 mm in 100 mm [0.05 in. in 5 in.]). The ends of the cylinders shall be ground plane to within 0.050 mm [0.002 in.].

8.1.4 Capping compounds and unbonded neoprene pads shall not be used.

8.1.5 The diameter used for calculating the cross-sectional area of a cylindrical test specimen shall be determined on each cylinder to the nearest 0.1 mm [0.04 in.].

NOTE 5—The diameter is measured to a greater accuracy than Test Method C39/C39M.

8.1.6 *Rate of Loading*—The load shall be applied at a rate of movement (platen to crosshead measurement) corresponding to a stress rate on the specimen of 1.0 ± 0.05 MPa/s [145 ± 7 psi/s].

NOTE 6—Conventional load rates as specified in Test Method C39/C39M would require approximately 15–20 min to complete a test.

NOTE 7—For a 75-mm [3 in.] diameter specimen, the loading rate is 265 ± 13 kN/min [61 500 ± 3 000 lb/min].

8.2 *Flexural Strength:*

8.2.1 Determine the flexural strength of prismatic specimens in accordance with Test Method C1609/C1609M, with the exceptions described in this section.

8.2.2 The prism specimens for measuring the flexural strength shall comply with Table 3.

NOTE 8—The results of flexural test methods are dependent on the size of the specimen (**2**, **3**, **4**). The results obtained using different size molded specimens may not correspond to the performance of larger or smaller molded specimens, concrete in large structural units, or specimens sawn from such units. A difference may also occur because the degree of preferential fiber alignment becomes more pronounced in molded specimens containing fibers that are relatively long compared with the cross-sectional dimensions of the mold (**5**, **6**, **7**, **8**).

8.3 *Static Modulus of Elasticity and Poisson's Ratio:*

8.3.1 Determine the static modulus of elasticity and Poisson's ratio of cylindrical specimens in accordance with test Method C469/C469M, with the exceptions described in this section.

8.3.2 The compressometer and extensometer shall use linear variable differential transformers (LVDTs), or other sensors of equal or greater accuracy for measuring displacement.

8.3.3 The load shall be applied at the rate specified in 8.1.6 of this practice.

8.4 *Creep in Compression:*

8.4.1 Determine the creep in compression of cylindrical specimens in accordance with Test Method C512/C512M, with the exceptions described in this section.

8.4.2 Creep specimen end preparation shall comply with 8.1.3.

8.4.3 At least six 75 mm (3 inch) diameter by 150 mm (6 inch) long cylindrical specimens shall be used to conduct the test.

8.4.4 Creep testing shall be conducted at a sustained load of 40% of the specified compressive strength of the UHPC.

8.5 *Length Change:*

8.5.1 Determine the length change of specimens in accordance with Test Method C157/C157M or C341/C341M, with the exceptions described in 8.5.2.

8.5.2 UHPC specimen size shall be 75 mm by 75 mm by 285 mm [3 in. by 3 in. by 11¼ in.] prisms, fabricated and cured in accordance with Section 7.

8.6 *Resistance to Abrasion:*

8.6.1 If abrasion resistance is required, determine in accordance with Test Method C944/C944M, using a double load of 197 ± 2 N [44 ± 0.4 lbf].

8.7 *Resistance to Freezing and Thawing:*

8.7.1 Determine the resistance to freezing and thawing in accordance with Test Method C666/C666M, Procedure A, with the exceptions described in this section.

8.7.2 Continue testing each specimen until it has been subjected to at least 300 cycles or until its relative dynamic modulus of elasticity, as defined in Test Method C666/C666M, reaches 90%, whichever occurs first, unless other limits are specified.

NOTE 9—Depending on the mixture proportions and curing conditions, the UHPC specimen can contain unhydrated portland cement causing the test results to exhibit increases in the relative dynamic modulus of elasticity due to the possibility of the surrounding water absorption and further hydration of the unhydrated portland cement contained in the specimen (**9**).

8.8 *Indication of Resistance to Chloride Ion Penetration:*

8.8.1 Determine the electrical conductance in accordance with Test Method C1202/C1202M, with the exceptions described in 8.8.2.

NOTE 10—Due to the very low permeability of thermally cured UHPC, the results of Test Method C1202/C1202M may be close to zero or within testing error.

8.8.2 If the UHPC mixture includes metallic fibers, Test Method C1202/C1202M is not applicable.

NOTE 11—Metal fibers can short circuit and result in invalid indications of conductance.

9. Report

9.1 The report shall comply with the requirements specified in the applicable test method or practice.

9.2 Record the sample identification number.

9.3 In the case of field testing, report air temperature and air relative humidity.

9.4 Report the curing conditions for the specimen.

9.5 If thermal curing is specified, report the specimen age when the thermal treatment is started and the time-temperature profile of the specimen, including heating and cooling periods.

9.6 Report results of tests conducted.

9.7 Report any deviations from this practice during specimen preparation or testing.

10. Keywords

10.1 fresh concrete; hardened concrete; specimen fabrication; testing; ultra-high performance concrete

(1) Annex A in Form and Style for ASTM Standards, www.astm.org?COMMIT/Blue_Book.pdf

(2) Tanesi, J., Ardani, A. and Leavitt, J., "Reducing the Specimen Size of Concrete Flexural Strength Test (AASHTO T97) for Safety and Ease of Handling," *Transportation Research Record: Journal of the Transportation Research Board*, No. 2342, Transportation Research Board of National Academies, Washington, D.C., 2013.

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