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Standard Specification for Wet-Cast Precast Modular Retaining Wall Units[1]

This standard is issued under the fixed designation C1776/C1776M; 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 specification covers wet-cast precast modular retaining wall units cast from first-purpose concrete with or without the inclusion of steel reinforcement. The precast units covered by this specification are machine-placed units intended for use in the construction of dry stacked modular retaining wall systems.

1.2 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 the standard.

1.3 *Units*—The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text of the specification, the SI units are shown in brackets. The values stated in each system are not 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.

1.4 *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.*

1.5 *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:*[2]

A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

A706/A706M Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement

A767/A767M Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement

A775/A775M Specification for Epoxy-Coated Steel Reinforcing Bars

A884/A884M Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement

A934/A934M Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars

A1055/A1055M Specification for Zinc and Epoxy Dual-Coated Steel Reinforcing Bars

A1060/A1060M Specification for Zinc-Coated (Galvanized) Steel Welded Wire Reinforcement, Plain and Deformed, for Concrete

A1064/A1064M Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

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

C33/C33M 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

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/C150M Specification for Portland Cement

C173/C173M Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

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

C231/C231M Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

C260/C260M Specification for Air-Entraining Admixtures for Concrete

C494/C494M Specification for Chemical Admixtures for Concrete

C595/C595M Specification for Blended Hydraulic Cements

[1] This test method is under the jurisdiction of ASTM Committee C27 on Precast Concrete Products and is the direct responsibility of Subcommittee C27.20 on Architectural and Structural Products.

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[2] 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.

C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C666/C666M Test Method for Resistance of Concrete to Rapid Freezing and Thawing
C823/C823M Practice for Examination and Sampling of Hardened Concrete in Constructions
C979/C979M Specification for Pigments for Integrally Colored Concrete
C989/C989M Specification for Slag Cement for Use in Concrete and Mortars
C1157/C1157M Performance Specification for Hydraulic Cement
C1611/C1611M Test Method for Slump Flow of Self-Consolidating Concrete

2.2 *ACI Documents:*[3]
ACI 318 Building Code Requirements for Structural Concrete and Commentary

3. Terminology

3.1 *Definitions*—Terminology defined in Terminology C125 shall apply for this specification.

3.2 *Definitions:*

3.2.1 *concrete, first-purpose, n*—hydraulic cement concrete prepared and used for its original intended purpose.

3.2.2 *width, unit, n*—regarding precast modular retaining wall unit dimensions, the term "width" shall refer to the horizontal dimension of the unit measured perpendicular to the face of the wall, from the front face of the unit to the back of the unit.

3.2.3 *height, unit, n*—regarding precast modular retaining wall unit dimensions, the term "height" shall refer to the vertical dimension of the unit as placed in the wall.

3.2.4 *length, unit, n*—regarding precast modular retaining wall unit dimensions, the term "length" shall refer to the horizontal dimension of the unit measured parallel to the running length of the wall face.

3.2.5 *precast modular retaining wall unit, n*—a machine-placed, solid, slotted or hollow, closed-cell, manufactured concrete unit with nominal base length and nominal base width dimensions greater than its vertical height as installed, used in the construction of dry-stacked earth retaining walls.

3.2.6 *precast modular retaining wall unit, wet-cast, n*—a precast modular retaining wall unit, manufactured from concrete using a wet-cast process.

3.2.7 *wet cast, adj*—manufactured concrete products made from fresh concrete with a measurable slump in accordance with Test Method C143/C143M or slump flow in accordance with Test Method C1611/C1611M.

4. Ordering Information

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

4.1.1 Unit type and size with applicable dimensions.

4.1.2 Compressive strength of the concrete used in the manufacture of the precast modular retaining wall units (see 6.1).

4.1.3 Air content of the concrete used in the manufacture of the precast modular retaining wall units (see 6.2).

4.1.4 Surface texture, finish and color of the precast modular retaining wall units (see 8.5).

4.1.5 Other special or custom features.

4.1.6 Certification requirements (see 15.1).

4.1.7 Protective coatings for reinforcing steel, if required (see 5.5.1 and 5.5.2).

5. Materials and Manufacture

5.1 First-purpose concrete used for the production of precast modular retaining wall units under this specification shall be ready-mixed or central-mixed concrete conforming with Specification C94/C94M.

5.2 Cementitious materials shall conform to the following applicable specifications:

5.2.1 *Portland Cements*—Specification C150/C150M.

5.2.2 *Blended Hydraulic Cements*—Specification C595/C595M.

5.2.3 *Hydraulic Cement*—Specification C1157/C1157M.

5.2.4 *Pozzolans*—Specification C618.

5.2.5 *Slag Cement*—Specification C989/C989M.

5.3 *Aggregates*—Aggregates shall conform to the following specifications, except that grading requirements shall not necessarily apply:

5.3.1 *Normal Weight Aggregates*—Specification C33/C33M.

5.4 *Admixtures*—Specification C260/C260M, C494/C494M, or C979/C979M.

5.5 *Steel Reinforcement*—Design, size, configuration, and placement tolerance of reinforcing steel in any given precast modular retaining wall unit is proprietary and shall be determined by the manufacturer based upon the structural requirements of the units produced. The proprietary reinforcement design of the precast modular retaining wall unit(s) shall be prepared and sealed by a licensed professional engineer. Reinforcing steel placed within precast modular retaining wall units for the purpose of resisting loading stress shall conform with the following:

5.5.1 *Reinforcing Bars*—Steel reinforcing bars used as reinforcement in precast modular retaining wall units shall exhibit a minimum yield stress of 60 ksi [420 MPa]. Deformed or plain bars shall meet the requirements of Specification A615/A615M. Reinforcing bars that are welded shall meet the requirements of Specification A706/A706M. Zinc-coated (galvanized) steel reinforcing bars shall meet the requirements of Specification A767/A767M. Epoxy-coated steel reinforcing bars shall meet the requirements of Specification A775/A775M, A934/A934M, or A1055/A1055M as required by the purchaser.

5.5.2 *Welded Wire Reinforcement (WWR)*—Steel welded wire reinforcement (WWR) used in welded reinforcement mats in precast modular retaining wall units shall exhibit a minimum yield stress of 65 ksi [450 MPa]. Deformed or plain WWR

[3] Available from American Concrete Institute (ACI), 38800 Country Club Dr., Farmington Hills, MI 48331-3439, http://www.concrete.org.

shall meet the requirements of Specification A1064/A1064M. Zinc-coated (galvanized) WWR shall meet the requirements of Specification A1060/A1060M. Epoxy-coated WWR shall meet the requirements of Specification A884/A884M.

5.6 *Lifting Devices*—Lifting device(s) for use in final placement of the precast modular retaining wall unit shall meet OSHA requirements documented in "Code of Federal Regulations" Title 29 Part 1926. Manufacturers of lifting devices shall report test data demonstrating the load capacity of the lifting device. Manufacturers of embedded lifting devices shall demonstrate the suitability of protective coatings or added sacrificial section thickness of the lifting device for use in high moisture or other corrosive environments as appropriate to the end use of the precast modular retaining wall unit.

5.7 *Other Constituents*—Post-production applied color stains, integral water repellents, finely ground silica, reinforcing fibers, and other constituents shall be previously established as suitable for use in precast modular retaining wall units and shall conform to applicable ASTM standards.

6. Physical Properties

6.1 *Compressive Strength*—Concrete used in the manufacture of the precast modular retaining wall units shall exhibit a minimum compressive strength of 4,000 psi [28 MPa] when tested in accordance with Test Method C39/C39M at 28 days. Units with a higher compressive strength shall be provided when required by the purchase order or contract.

6.2 *Air Content*—In project locations where repeated freezing and thawing under saturated conditions may occur, air content for the concrete mix shall be provided in accordance with the anticipated exposure condition as defined in Specification C94/C94M. Other air content for the concrete mix shall be provided when required by the purchase order or contract.

7. Dimensions, Mass, and Permissible Variations

7.1 Overall dimensions for height shall differ by not more than ±3⁄16 in. [5 mm], and length shall differ by not more than ±½ in. [13 mm] from the specified standard dimensions.

7.2 Overall dimension for width shall not be more than ½ in. [13 mm] less than the specified standard width. Dimensional tolerance requirements for width shall be waived for architectural surfaces.

7.3 For precast modular retaining wall units with a rectangular exposed face, the diagonal dimensions of the exposed face shall not differ by more than ½ in. [13 mm]. Measurement of the diagonal dimensions of the exposed face shall be exclusive of the architectural face texture.

7.4 Minimum concrete cover over all steel reinforcement types specified in 5.5 shall be 1 in. [25 mm] except where a surface is to be exposed to an aggressive environment such as deicing chemicals or brackish water. Surfaces exposed to an aggressive environment shall provide minimum cover to steel reinforcement of 2 in. [51 mm].

7.5 Precast modular retaining wall units produced with steel reinforcement protruding beyond the manufactured dimensions of the unit for the purpose of connection to adjacent cast-in-place concrete structures shall be allowed under this specification. The minimum cover requirements in 7.4 are waived for the portion of the steel reinforcement that extends beyond the precast modular retaining wall unit.

8. Workmanship, Finish, and Appearance

8.1 Individual precast modular retaining wall units shall not be removed from the form cell until the unit has reached a sufficient compressive strength that will permit the extraction to occur without resulting in damage to the unit. The minimum permissible compressive strength of the precast modular retaining wall unit prior to removal from the form cell shall be established by the manufacturer before the units are cast.

8.2 Test cylinders prepared from concrete used in the production of the precast modular retaining wall units shall demonstrate 100 % of the required minimum 28-day compressive strength prior to shipment or installation of the units.

8.3 All precast modular retaining wall units shall be sound and free of cracks or other defects that interfere with the proper placement of the unit.

8.4 Upon delivery to the purchaser, precast modular retaining wall units to be used in exposed wall construction shall not exhibit chips or cracks in the exposed face or faces of the unit that are not otherwise permitted as follows:

8.4.1 Chips smaller than 1.5 in. [38 mm] in its largest dimension and cracks not wider than 0.012 in. [0.3 mm] and not longer than 25 % of the nominal height of the precast modular retaining wall unit shall be permitted. Likewise, other voids or inconsistencies in the exposed architectural face of the unit smaller than 0.75 in. [19 mm] in its largest dimension shall be permitted.

8.4.2 Cracks that are continuous through any solid element of the precast modular retaining wall unit shall be grounds for rejection of the unit regardless of the width or length of the crack.

8.5 The color and texture of the precast modular retaining wall units shall be selected from the range of colors and textures available from the manufacturer. The finished surface that will be exposed in the final construction shall conform to an approved sample consisting of not less than four (4) units representing the range of texture and color selected by the purchaser.

NOTE 1—Wet-cast, precast modular retaining walls consist of many individual precast modular retaining wall units that are often manufactured with purposeful variations of complementary and/or contrasting textures, colors and finishes. As such, the overall aesthetic appearance to be achieved is represented by the entire retaining wall and not necessarily an individual precast modular retaining wall unit. Minor inconsistencies in the exposed architectural face of an individual unit that may exceed the limitations of 8.4.1 should not automatically require rejection of an individual unit. Instead, the overall aesthetic quality of the constructed retaining wall should also be considered.

9. Sampling

9.1 A minimum of three (3) precast modular retaining wall units shall be randomly selected for measurement of dimensions each time measurements are taken.

10. Frequency of Tests

10.1 Measurements shall be reported on a minimum of three (3) precast modular retaining wall units annually or 1 % of annual production of the unit type, whichever is greater.

10.2 Test cylinders for the purpose of compressive strength testing shall be prepared in accordance with Practice C31/C31M or C192/C192M at the more frequent interval of once per week or once for every 150 yd^3 [115 m^3] of concrete placed.

10.3 Tests for air content shall be conducted at the more frequent interval of once per day or once for every 150 yd^3 [115 m^3] of concrete placed. When air-entrained concrete is not used, no requirement for the testing of air content shall exist.

10.4 Tests for freeze-thaw durability shall be conducted only when specifically requested by the purchaser. When required, freeze-thaw durability tests shall be conducted not more than 24 months prior to delivery of the precast modular retaining wall units represented by the test results.

NOTE 2—Precast products manufactured with air-entrained concrete mixes are not customarily required to submit to testing to demonstrate resistance to freezing and thawing. Durability concerns related to the performance of wet-cast, precast concrete units are usually addressed through specification of the concrete mix design. Additional information regarding concrete mix requirements specific to a range of durability concerns is available in the American Concrete Institute Building Code Requirements for Structural Concrete—ACI 318.

11. Specimen Preparation

11.1 *Compressive Strength*—Test cylinders for compressive strength testing shall be prepared in accordance with Practice C31/C31M or C192/C192M.

11.2 *Freeze-Thaw Durability*—Three (3) test specimens shall be prepared in accordance with Practice C192/C192M for freeze-thaw durability testing.

12. Test Methods

12.1 *Measurement of Dimensions*—Measure dimensions (width, height, and length) in at least three (3) locations on opposite sides of the specimen representing each end of the unit as well as the midpoint to the nearest division required to be reported. Document the location of each measurement on a sketch or photograph of the specimen. Measurements shall not be taken to include intended production variation due to protruding or recessed features of the precast modular retaining unit including, but not limited to, the architectural face texture.

12.1.1 *Measurement Devices*—Devices used to measure specimen dimensions shall have divisions not greater than 1⁄16 in. [1 mm]. Measuring devices shall be discernable and accurate to the division required to be reported. Accuracy of measurement shall be verified at least once annually for each device. Verification records shall include date of verification, person or agency performing verification, identification of the reference standard used, test points used during verification, and readings at test points.

12.1.2 *Reporting of Measured Dimensions*—For each unit measured, report the measured value for the height, length and width, along with the difference between the length of the exposed face diagonals for units with rectangular faces. Report the minimum, maximum and arithmetic mean (average) values for width, height, and length for each unit, the unit identification number, and its date of manufacture.

12.2 *Compressive Strength*—Compressive strength testing shall be conducted in accordance with Test Method C39/C39M.

12.3 *Air Content*—Air content shall be determined by either the pressure method in accordance with Test Method C231/C231M for concrete mix designs utilizing relatively dense aggregate or the volumetric method in accordance with Test Method C173/C173M for concrete mix designs utilizing high porosity aggregate or air-cooled blast furnace slag. A density (unit weight) test, performed in accordance with Test Method C138/C138M, may be substituted for Test Method C231/C231M or C173/C173M only after a correlation between air content and density (unit weight) has been established.

12.4 *Freeze-Thaw Durability*—Tests for freeze-thaw durability shall be conducted in accordance with Test Method C666/C666M, Procedure A. The test specimens shall be aged not less than 14 days at the time the test is commenced. The specified number of cycles at which the test is to be terminated shall be 300 (M=300). No single test specimen shall exhibit a calculated durability factor less than 80. Freeze-thaw durability testing shall be performed on test specimens made with the same materials and concrete mix design as the precast modular retaining wall units represented by the test results.

13. Inspection

13.1 The purchaser or authorized representative shall be accorded proper facilities to inspect and/or sample the precast modular retaining wall units in accordance with Practice C823/C823M at the place of manufacture from the units ready for delivery. Upon request, the purchaser or authorized representative shall be furnished copies of all reported precast modular retaining wall unit measurements and results of concrete tests representing that of the units ready for delivery. At the purchaser's option, the purchaser or authorized representative shall inspect the precast modular retaining wall units and/or sample the units in accordance with Practice C823/C823M upon delivery.

14. Rejection and Rehearing

14.1 At the purchaser's option, precast modular retaining wall units that fail to conform to the requirements of this specification shall be rejected. Rejection shall be reported to the manufacturer or supplier promptly and in writing.

14.2 If a selected precast modular retaining wall unit test specimen fails to conform to the requirements of the specification and is rejected, the manufacturer shall be permitted to remove units from the shipment. A new test specimen shall be selected by the purchaser from the remaining units of the shipment with a similar configuration and dimensions and tested at the expense of the manufacturer. If the second test specimen meets the specified requirements, the remaining portion of the shipment represented by the test specimen shall be deemed to comply with the specified requirements. If the second test specimen fails to meet the specified requirements,