Designation: C1713 – 17

# Standard Specification for Mortars for the Repair of Historic Masonry[1]

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## 1. Scope

1.1 This specification covers mortar for the repair of masonry that was constructed with methods and materials that pre-date the origination of current standards of construction that are compatible with it. The mortar may be used for non-structural purposes such as repointing of the masonry, or for structural purposes such as, but not restricted to, reconstruction or repair of mortar joints that contribute to the structural integrity of the masonry.

1.2 Masonry includes the following units laid in mortar: (*1*) cast stone, (*2*) clay masonry unitsbrick and clay tile, (*3*) concrete masonry units, (*4*) natural stone, and (*5*) terra cotta.

1.3 This specification may be used to pre-qualify mortar for a project.

1.4 Mortars tested using this specification are laboratory-prepared mortars and do not represent in-place, site mortars.

1.5 Use of this specification should be based on a thorough understanding of the function, maintenance, and repair requirements for the preservation and continued performance of the masonry in the context of the building structure and long-term performance. The user of this specification is responsible for examining all criteria and selecting the appropriate mortar formulation and properties required.

1.6 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.7 *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.*

1.8 *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]

C5 Specification for Quicklime for Structural Purposes
C10 Specification for Natural Cement
C61 Specification for Gypsum Keene's Cement
C91 Specification for Masonry Cement
C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
C110 Test Methods for Physical Testing of Quicklime, Hydrated Lime, and Limestone
C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates
C141 Specification for Hydraulic Hydrated Lime for Structural Purposes
C144 Specification for Aggregate for Masonry Mortar
C150 Specification for Portland Cement
C207 Specification for Hydrated Lime for Masonry Purposes
C216 Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)
C270 Specification for Mortar for Unit Masonry
C305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency
C511 Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes
C595 Specification for Blended Hydraulic Cements
C780 Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry
C948 Test Method for Dry and Wet Bulk Density, Water Absorption, and Apparent Porosity of Thin Sections of Glass-Fiber Reinforced Concrete
C979 Specification for Pigments for Integrally Colored Concrete

[1] This specification is under the jurisdiction of ASTM Committee C12 on Mortars and Grouts for Unit Masonry and is the direct responsibility of Subcommittee C12.03 on Specifications for Mortars.

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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.

C1072 Test Methods for Measurement of Masonry Flexural Bond Strength
C1093 Practice for Accreditation of Testing Agencies for Masonry
C1157 Performance Specification for Hydraulic Cement
C1180 Terminology of Mortar and Grout for Unit Masonry
C1329 Specification for Mortar Cement
C1384 Specification for Admixtures for Masonry Mortars
C1400 Guide for Reduction of Efflorescence Potential in New Masonry Walls
C1403 Test Method for Rate of Water Absorption of Masonry Mortars
C1489 Specification for Lime Putty for Structural Purposes
C1506 Test Method for Water Retention of Hydraulic Cement-Based Mortars and Plasters
C1707 Specification for Pozzolanic Hydraulic Lime for Structural Purposes
E96/E96M Test Methods for Water Vapor Transmission of Materials
E2260 Guide for Repointing (Tuckpointing) Historic Masonry

## 3. Terminology

3.1 The terms used in this specification are identified in Terminology C1180.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *aggregate, n*—material as defined in Terminology C1180, but limited to the material groups listed under Section 4 of this specification.

3.2.2 *binder, n*—material as defined in Terminology C1180, but limited to the cementitious material groups listed under Section 4 of this specification to be mixed with potable water.

3.2.3 *curing, n*—process by which a mortar gains its long-term, final-state properties.

3.2.4 *curing time (CT), n*—number of days in which a hardened state sample is cured before testing.

3.2.5 *historic masonry, n*—masonry that may have been constructed with methods and materials that pre-date the origination of current standards.

3.3 *Properties*, as determined by Section 8 of this specification:

3.3.1 *absorption rate (AR), n*—a measure of the hardened mortar's ability to absorb water from a dry condition, measured as the initial flow of water into the mortar, as defined under Test Method C1403 and evaluated at the specified curing time (CT).

3.3.2 *air content, n*—cumulative volume of air in a mortar, as a percentage of the total volume of mortar in its plastic state.

3.3.3 *flexural bond strength (FBS), n*—maximum flexural tensile stress that causes failure of the bond between the mortar and masonry unit in a tested assembly at the specified curing time (CT).

3.3.4 *maximum compressive strength (Fcmx), n*—upper allowable limit on the ultimate strength of a hardened mortar sample subjected to compression measured as force per unit area at the specified curing time (CT).

3.3.5 *minimum compressive strength (Fc), n*—lower allowable limit on the ultimate strength of a hardened mortar sample subjected to compression measured as force per unit area at the specified curing time (CT).

3.3.6 *total porosity, n*—volume percentage of all pores or void space in the mortar at the specified curing time (CT).

3.3.7 *water retention, n*—as defined in Terminology C1180. Test shall be conducted on a sample in its plastic state.

3.3.8 *water vapor permeability (WVP), n*—ability of a mortar to pass water through it in vapor form at the specified curing time (CT).

## 4. Constituent Materials

4.1 *Binder Materials* shall be classified into the following groups:

4.1.1 *Group L*—Lime (non-hydraulic) shall conform to the following specifications:

4.1.1.1 Hydrated Lime shall conform to Specification C207, Types S or SA. Types N and NA hydrated limes are permitted if soaked or shown by test or performance record to be not detrimental to the mortar.

4.1.1.2 Lime putty shall conform to Specification C1489.

NOTE 1—Specification C5, Appendix 1, may be used, and the resulting putty should meet the requirements of Specification C1489.

4.1.2 *Group HL*—Hydraulic Lime shall conform to the following specifications:

4.1.2.1 *Hydraulic Hydrated Lime*—shall conform to Specification C141.

4.1.2.2 *Pozzolanic Hydraulic Lime*—shall conform to Specification C1707.

4.1.3 *Group HC*—Hydraulic Cements shall conform to the following specifications:

4.1.3.1 *Blended Hydraulic Cement*—shall conform to Specification C595.

NOTE 2—Blended hydraulic cement may not be appropriate for structures built before the second half of the 20th century.

4.1.3.2 *Performance Hydraulic Cement*—shall conform to Specification C1157.

NOTE 3—Performance hydraulic cement may not be appropriate for structures built before the second half of the 20th century.

4.1.3.3 *Masonry Cement*—shall conform to Specification C91.

4.1.3.4 *Mortar Cement*—shall conform to Specification C1329.

4.1.3.5 *Natural Cement*—shall conform to Specification C10.

4.1.3.6 *Portland Cement*—shall conform to Specification C150.

NOTE 4—For interior gypsum mortar based systems requiring gypsum cement refer to Specification C61 and consult with the product manufacturer regarding exposure suitability.

4.2 *Aggregates*—Aggregate shall conform to Specification C144. Aggregates that conform to all aspects of Specification C144 except for the gradation limits are permitted if demonstrated by their history of performance under equivalent conditions and mortar formulation to be non-detrimental to the mortar. To determine aggregate gradation, use Test Method C136.

NOTE 5—The need to aesthetically match the color and texture of an

existing mortar may be justification for deviating from the gradation limits of Specification C144.

4.3 *Water*—Water shall be clean and free of oils, acids, alkalies, salts, organic materials, or other substances that are deleterious to mortar or any metal used in the masonry.

4.4 *Admixtures:*

4.4.1 *Admixtures*—shall meet the requirements of Specification C1384. Calcium chloride is not permitted. Other admixtures that are outside the scope of Specification C1384 are permitted if they contain no more than 0.3 % water-soluble alkali and if demonstrated by their history of performance under equivalent conditions and mortar formulation to be non-detrimental to the mortar and items in contact.

4.4.2 *Pigments*—Pigments shall meet the requirements of Specification C979. Pigments which are not described by Specification C979 are permitted if demonstrated by their history of performance under equivalent conditions and mortar formulation to be non-detrimental to the mortar. Pigment addition shall not exceed 10 % by weight of the binder materials except for carbon black which is limited to 2 % unless otherwise demonstrated by history of performance under equivalent conditions and mortar formulation to be non-detrimental to the mortar.

## 5. Mortar Proportioning

5.1 *Binder/Aggregate Ratio:*

5.1.1 Combine the mortars in volume ratios of 1 part total binder materials to 2 to 3½ parts aggregate.

5.1.2 Mortars specified outside volume ratios of 1 part total binder materials to 2 to 3½ parts aggregate shall be permitted if shown by history of use or by mortar testing per this specification to be not detrimental to the mortar.

NOTE 6—Most common mortars have total binder to aggregate ratios of 1 part total cementitious materials to 2½ to 3 part aggregate, whereas some earlier mortars may have ratios as high as 1 to 1.

5.2 *Air Entraining Binders*—Air entraining binders shall not be used in combination with other air entraining binders or with a separate air entrainment admixture.

## 6. Requirements

6.1 *Establishing Mortar Proportions:*

6.1.1 Specify mortars by (*1*) proportion specification, constituent materials and their respective volume proportions, or (*2*) property specification, constituent materials (or proprietary products names) and required properties, in accordance with Table 1.

6.1.1.1 Specifiers using the proportion specification shall select binder and aggregate proportions based upon an established history of performance or testing that documents satisfactory performance of the combinations and proportions specified, and in conformance with Section 5 of this specification.

NOTE 7—WVP of the mortar should be greater than that of the masonry units, and equal to or greater than that of the substrate mortar where present.

NOTE 8—Vapor permeability will generally decrease with increasing hydraulic constituents; however, aggregate gradation and admixtures can greatly influence the value.

## 7. Test Samples and Preparation

7.1 *Material Proportioning*—Laboratory mixed mortar specified by volume proportions shall contain the mortar materials as indicated in the mortar specification. Volume proportions shall be converted to weights using the batch factor calculated as follows:

7.1.1 *Material Proportioning for Test Batches of Mortar:*

7.1.1.1 Batch factor = 1440/ [1280 kg/m$^3$ (bulk density of aggregate) times total aggregate volume proportion].

NOTE 9—A batch size using 1440 g of aggregate will typically result in enough mortar for water retention testing and one set of three 2-in. cubes for compressive strength testing. Several batches with the same water to binder ratio may be necessary to complete all tests.

7.1.1.2 Oven dry and cool to room temperature all aggregate used for test mortars. Mortars preblended with aggregate require no proportioning.

7.1.2 Constituent materials shall have the bulk densities as noted in Table 2.

7.2 *Masonry Units for Use in Water Vapor Permeability and Bond Strength*—Masonry units shall be the actual masonry units to be used in the field, or if unavailable, a brick meeting Specification C216, Grade SW with absorption properties similar to the in-situ masonry units, if known.

7.3 *Mortar Mixing*—Mix the mortar in accordance with Practice C305 with the exception that for Group L and Group HL mortars and those combined mortars at or greater than 45 % lime by binder volume the initial (low speed) mixing time is extended to up to 2 minutes, the resting time is extended to 1.5 minutes, and the final (medium speed) mixing time is extended to up to 8 minutes, as best suits the formulation for complete intermixing of components without segregation or over entrapment of air.

NOTE 10—These time extensions allow for the full wetting of the mortar constituents.

7.4 *Mortar Test Sample Molding:*

7.4.1 For total porosity, absorption rate and compressive strength testing, mold the 2-in. (50-mm) cubes in accordance with Test Method C109/C109M, subsections on Specimen Molds and Molding Test Specimens. For mortars to be used as unit bedding, add enough water to obtain flow of 110 ± 5 %. For mortars to be used as repointing mortars, add enough water to obtain a Vicat Cone Penetrometer value (Test Method C780, Annex A1, Consistency by Cone Penetration Test Method) of 15 mm ± 5 %.

7.4.2 For vapor transmission and bond strength testing mold the samples according to Test Method C1072, with the exception that for the vapor transmission the specimen is two brick, and cheese cloth is to be used as a bond break, and mortar is to have flow values of 120 ± 5%. If the binder material to aggregate volume ratio has not been specified, use a value of 1:3 binder to aggregate ratio measured by volume with sand meeting Specification C144.

7.5 *Sample Demolding*—Table 3 summarizes the demolding time required for different binder combinations.

7.6 *Specimen Storage and Curing*—The storage and curing conditions in Table 3 shall be maintained both before and after demolding, for the duration of the specified Curing Time (CT).