Mortar

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1

C1180-10

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mortar, *n* – a mixture consisting of cementitious materials, fine aggregate, water, with or without admixtures, that is used to construct unit masonry assemblies.

2

Function

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Hold units together

Accommodate unit tolerances

3

Function

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Hold units apart

Provide water penetration resistance

4

4

History

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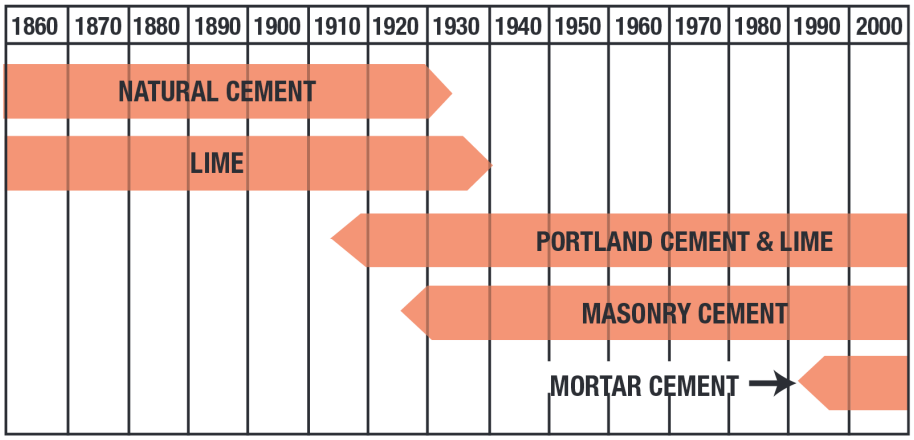

Exhibit 1 Mortar Usage Timeline in the United States

Masonry Mortars – Your Choice, Chris Sieto, Masonry Edge/The Story Pole, Vol. 4, No. 4

5

C270-14

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1. Scope
   - 1.1 This specification covers mortars for use in the construction of non-reinforced and reinforced unit masonry structures. Four types of mortar are covered in each of two alternative specifications: (1) proportion specifications and (2) property specifications.

6

Mortar Types

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M	A1
A	
S	A2
O	
N	B
W	
O	C
R	
K	D

7

Mortar Selection

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MIM suggests the mortar type selected be the weakest that will satisfy structural requirements.

M S N

8

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1.3 When neither proportion or property specifications are specified, the proportion specifications shall govern, unless data are presented to and accepted by the specifier to show that mortar meets the requirements of the property specifications.

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3. Specification Limitations

3.1 Laboratory testing of mortar to ensure compliance with the property specification requirements of this specification shall be performed in accordance with 5.3. The property specification of this standard applies to mortar mixed to a specific flow in the laboratory.

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4.1.1 Cementitious Materials—Cementitious materials shall conform to the following ASTM specifications:

4.1.1.1 Portland Cement (C150)

4.1.1.2 Blended Hydraulic (C595)

4.1.1.3 Hydraulic Cements (C1157)

4.1.1.4 Portland Blast-Furnace Slag Cement (C595)

4.1.1.5 Masonry Cement (C91)

4.1.1.6 Mortar Cement (C1329)

4.1.1.7 Quicklime (C5)

4.1.1.8 Hydrated Lime (C207)

4.1.1.9 Lime Putty (C1489)

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Designation: C 144 – 04

American Association State Highway and Transportation Officials Standard
AASHTO No.: M45-70 (1974)

Standard Specification for Aggregate for Masonry Mortar[1]

This standard is issued under the fixed designation C 144; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers aggregate for use in masonry mortar.

1.2 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.3 The following precautionary caveat pertains only to the test methods portion, Section 7, of this standard. *This standard does not purport to address all of the safety problems, 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

2.1 *ASTM Standards:* [2]

C 40 Test Method for Organic Impurities in Fine Aggregates for Concrete

C 87 Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar

C 270 Specification for Mortar for Unit Masonry

C 404 Specification for Aggregates for Masonry Grout

D 75 Practice for Sampling Aggregates

12

C144-11

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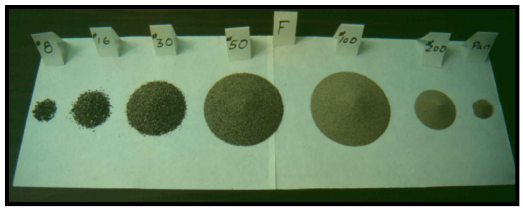
4.4 When an aggregate fails the gradation limits specified in 4.1 and 4.2, its use is permitted provided the mortar can be prepared to comply with the aggregate ratio, water retention, air content, and compressive strength requirements of the property specifications of Specification C270.



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

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4.1.4 *Admixtures*—Admixtures shall not be added to mortar unless specified. Admixtures shall not add more than 65 ppm (0.0065 %) water soluble chloride or 90 ppm (0.0090 %) acid soluble chloride to the mortar's overall chloride content, unless explicitly provided for in the contract documents.

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4.1.4.1 *Classified Admixtures*—Admixtures which are classified as bond enhancers, workability enhancers, set accelerators, set retarders, and water repellents shall be in accordance with Specification C1384.

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4.1.4.2 *Color Pigments*—Coloring pigments shall be in accordance with Specification C979.

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Mortar Color

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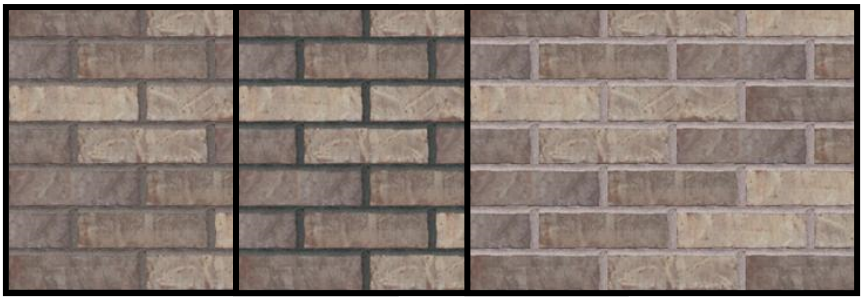

Variety of colors and textures

18

Designation: C 1384 – 02a

Standard Specification for Admixtures for Masonry Mortars[1]

This standard is issued under the fixed designation C 1384; the number immediately following the designation indicates the year of original adoption o
superscript epsilon

TABLE 1 Physical Requirements[A]

	Bond Enhancer	Workability Enhancer	Set Accelerator	Set Retarder	Water Repellent
Compressive strength, min % of reference:					
7 day	80	80	80	70	80
28 day	80	80	80	80	80
Water retention, min % of reference:	report	100	report	report	report
Air content of plastic mortar, %	report	report	report	report	report
Board life, min % of reference	report	120	report	120	report
Time of setting[B], allowable deviation from reference, h: min:					
Initial: at least	...	...	1:00 earlier	1:00[C] later	...
not more than	1:00 earlier nor 1:30 later	1:00 earlier nor 3:30 later	3:30 earlier	8:00[C] later	1:00 earlier nor 1:30 later
Final: at least	...	...	1:00 earlier	...	...
not more than	1:00 earlier nor 1:30 later	1:00 earlier nor 3:30 later	...	8:00[C] later	1:00 earlier nor 1:30 later
Flexural bond strength, min % of reference	110	...	...	...	...
Rate of water absorption max % of reference 24 h	...	...	...	...	50

[A] The values in the table include allowance for normal variation in test results. In addition to meeting the requirements in this table, all admixed mortars must meet the property requirements of Specification C 270.
[B] All time of setting tests shall be performed at 23 ± 3°C (73.4 ± 5.4°F), except those for set accelerators, which shall be performed at 5 ± 2°C (41 ± 3.6°F) as specified in 9.1.5.
[C] The manufacturer's maximum recommended dosage rate shall be used when testing the initial and final set times for a set retarder.

1. Scope *

1.1 This specification pe
mortars. Admixtures are su
C 270 prescribed materials
tious materials that are use
recognized desirable propert
tar.

1.2 This specification doe

NOTE 1—Information on color
tion C 979.

1.3 This specification de
added to the cementitious m
the cementitious materials.

1.4 Acceptance of an adm
in an admixed mortar. Acc
mortar is based on attainmen
to that required for convent
mance of one or more indic
required performance levels

1.5 The values stated in
standard. The values given in parentheses are for information

C 1357 Test Method for Evaluating Masonry Bond

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Requirements

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Mortar Cement | **Portland Cement** | **Hydrated Lime** | **Masonry Cement**

or

or

+

= **MoCM, PCL, MaCM**

Sand **Water**

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Designation: C150/C150M – 11

Standard Specification for Portland Cement[1]

This standard is issued under the fixed designation C150/C150M; 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.

This standard has been approved for use by

1. Scope*

1.1 This specification covers ten types of por
as follows (see Note 2):
1.1.1 *Type I*—For use when the special prope
for any other type are not required.
1.1.2 *Type IA*—Air-entraining cement for the
Type I, where air-entrainment is desired.
1.1.3 *Type II*—For general use, more especiall
erate sulfate resistance is desired.
1.1.4 *Type IIA*—Air-entraining cement for the
Type II, where air-entrainment is desired.
1.1.5 *Type II(MH)*—For general use, more esp
moderate heat of hydration and moderate sulfate
desired.
1.1.6 *Type II(MH)A*—Air-entraining cement
uses as Type II(MH), where air-entrainment is d
1.1.7 *Type III*—For use when high early streng
1.1.8 *Type IIIA*—Air-entraining cement for th
Type III, where air-entrainment is desired.
1.1.9 *Type IV*—For use when a low heat of hydration is

Cement
C115 Test Method for Fineness of Portland Cement by the

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Designation: C 91 – 01

Standard Specification for Masonry Cement[1]

This standard is issued under the fixed designation C 91; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers three types of masonry
for use where mortar for masonry is required.
1.2 The values stated in SI units are to be regarde
standard. Values in SI units shall be obtained by meas
in SI units or by appropriate conversion of measuremen
in other units, using the Rules for Conversion and R
given in IEEE/ASTM SI 10.
1.3 The text of this standard refers to notes and f
which provide explanatory material. These notes and f
(excluding those in tables and figures) shall not be co
as requirements of the standard.
1.4 The following safety hazards caveat pertains
Sections 17 and 18 of this specification. *This standard*
purport to address all of the safety concerns, if any, as
with its use. It is the responsibility of the user of this s
to establish appropriate safety and health practi
determine the applicability of regulatory limitations
use.

2. Referenced Documents

more properties such as setting time, workability, water reten-

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Designation: C 1329 – 05

Standard Specification for Mortar Cement[1]

This standard is issued under the fixed designation C 1329; 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 specifica
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1.3 The text of th
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1.4 The following
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ASTM C 270

Material Requirements

Measuring and Mixing

Proportion Specification
- Proportion in Accordance with Table 1
- No Mortar Tests Required

Property Specification
- Laboratory Tests of Mortar Required to Meet Table 2
- Control Field Proportions to Laboratory Established Mix Design

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C270-14

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TABLE 1 Proportion Specification Requirements (default)

Mortar	Type	Proportions by Volume (Cementitious Materials) Cement[A]	Mortar Cement M	Mortar Cement S	Mortar Cement N	Masonry Cement M	Masonry Cement S	Masonry Cement N	Hydrated Lime or Lime Putty	Aggregate Ratio (Measured in Damp, Loose Conditions)
Cement-Lime	M	1	-	-	-	-	-	-	¼	Not less than 2¼ and not more than 3 times the sum of the separate volumes of cementitious materials
	S	1	-	-	-	-	-	-	over ¼ to ½	
	N	1	-	-	-	-	-	-	over ½ to 1¼	
	O	1	-	-	-	-	-	-	over 1¼ to 2½	
Mortar Cement	M	1	-	-	1	-	-	-	-	
	M	-	1	-	-	-	-	-	-	
	S	½	-	-	1	-	-	-	-	
	S	-	-	1	-	-	-	-	-	
	N	-	-	-	1	-	-	-	-	
	O	-	-	-	1	-	-	-	-	
Masonry Cement	M	1	-	-	-	-	-	1		
	M	-	-	-	-	1	-	-		
	S	½	-	-	-	-	-	1		
	S	-	-	-	-	-	1	-		
	N	-	-	-	-	-	-	1		
	O	-	-	-	-	-	-	1		

[A]Includes Specification C150, C595, and C1157 cements as described in 4.1.1

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Type S Mortar

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PCL

PC	HL	Ratio		Sand
1	¼	3	1 + ¼ = 1¼ x 3 =	3¾

1 : ¼ : 3¾

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TABLE 2 Property Specification Requirements[A]

Mortar	Type	Average Compressive Strength at 28 days, min, psi	Water Retention, min, %	Air Content, max, %[B]	Aggregate Ratio (Measured in Damp, Loose Conditions)
Cement-Lime	M	2500	75	12	
	S	1800	75	12	
	N	750	75	14[C]	
	O	350	75	14[C]	
Mortar Cement	M	2500	75	12	Not less than 2¼ and not more than 3 ½ times the sum of the separate volumes of cementitious materials
	S	1800	75	12	
	N	750	75	14[C]	
	O	350	75	14[C]	
Masonry Cement	M	2500	75	18	
	S	1800	75	18	
	N	750	75	20[D]	
	O	350	75	20[D]	

[A]Laboratory prepared mortar only (see Note 4).
[B]See Note 5.
[C]When structural reinforcement is incorporated in cement-lime or mortar cement mortar, the maximum air content shall be 12%.
[D]When structural reinforcement is incorporated in masonry cement mortar, the maximum air content shall be 18%.

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Canada Property Spec Mortar Compliance

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Table 6
Property specifications: Compressive strength of mortar cubes
(See Clauses 7.2.2.4 and B.1.3.3.4.)

Preparation	Mortar type	Minimum compressive strength, psi	
		7 d test	28 d test
Job prepared or manufactured off-site in a batching plant, mixed to a flow suitable for use in laying masonry units	N	290	508
	S	725	1,233
Laboratory prepared, mixed to a flow of 100 to 115%	N	435	725
	S	1,088	1,813

Converted to psi by the Masonry Institute of Michigan

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Mortar Testing

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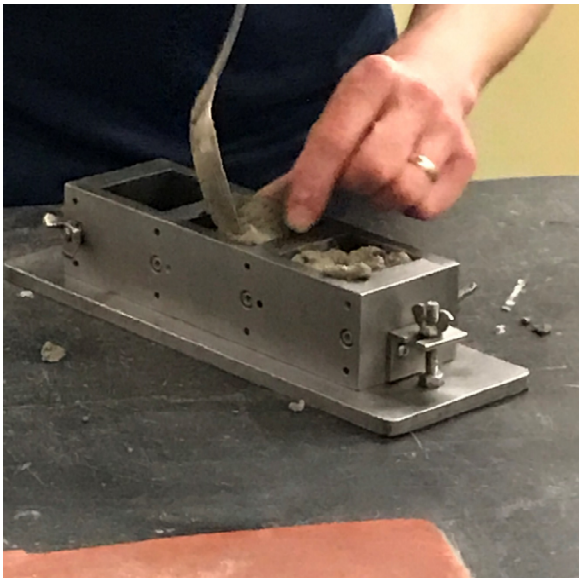

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Mortar Testing

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Mortar Testing

MASONRY Institute of Michigan

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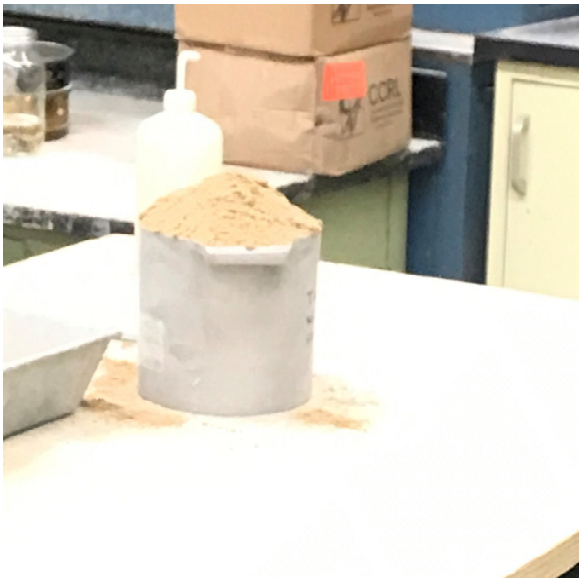
Mortar Testing

MASONRY Institute of Michigan



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7. Construction Practices

7.1 *Storage of Materials*—Cementitious materials and aggregates shall be stored in such a manner as to prevent deterioration or intrusion of foreign material.

41

Gauging the Amount of Sand

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42

Gauging the Amount of Sand

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Gauging the Amount of Sand

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One cubic foot box
Typically 18 shovels will fill 2 ½ to 2 ¾ boxes



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7.3 *Mixing Mortars*—All cementitious materials and aggregate shall be mixed between 3 and 5 min in a mechanical batch mixer with the maximum amount of water to produce a workable consistency. Hand mixing of the mortar is permitted with the written approval of the specifier outlining hand mixing procedures.

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C270-14

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7.4 *Tempering Mortars*—Mortars that have stiffened shall be retempered by adding water as frequently as needed to restore the required consistency. No mortars shall be used beyond 2 ½ h after mixing.

check manufacturers recommendations for colored mortars

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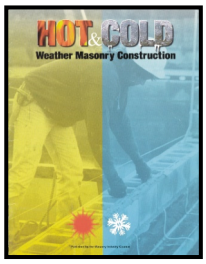
7.5 ***Climatic Conditions*—Unless superseded by other contractual relationships or the requirements of local building codes, hot and cold weather masonry construction relating to mortar shall comply with the Masonry Industry Council's "Hot and Cold Weather Masonry Construction Manual."**



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C270-14

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8. Quality Assurance

8.1 Compliance to this specification is verified by confirming that the materials used are as specified, meet the requirements as given in 2.1, and added to the mixer in the proper proportions…

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Quality Assurance

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ASTM C780 … contains guidance for testing masonry mortars. The mortar aggregate ratio, Annex 4, entails sampling the fresh mortar as mixed, then separating the materials and calculating how much sand it contains relative to cement.

Mortar Testing for Quality Assurance: Best Practices, PCA Masonry Today

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Mortar Testing

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Mortar Testing

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Mortar Testing

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Mortar Testing

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8.4 Test Method C1324 is available to determine the proportions of materials in hardened masonry mortars. There is no ASTM method for determining the conformance of a mortar to the property specifications of Specification C270 by testing hardened mortar samples taken from a structure.

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C1324

MASONRY Institute of Michigan

Designation: C1324 – 10

Standard Test Method for Examination and Analysis of Hardened Masonry Mortar[1]

This standard is issued under the fixed designation C1324; 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 test method covers procedures for petrographic examination and chemical analysis of samples of masonry mortars. Based upon such examination and analysis, proportions of components in masonry mortars can be determined.

NOTE 1—This method is also applicable to hydraulic cement-based stucco and plaster. Some historic mortars may contain non-resolvable constituents that may interfere. However, significant information may be obtained by petrographic examinations.

1.2 Interpretations and calculations of chemical results are dependent upon results of the petrographic examination. The use of the chemical results alone is contrary to the requirements of this test method.

1.3 Procedures for sampling, petrographic examination, chemical analysis, and calculations of component proportions

C125 Terminology Relating to Concrete and Concrete Aggregates
C144 Specification for Aggregate for Masonry Mortar
C270 Specification for Mortar for Unit Masonry
C295 Guide for Petrographic Examination of Aggregates for Concrete
C457 Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete
C823 Practice for Examination and Sampling of Hardened Concrete in Constructions
C856 Practice for Petrographic Examination of Hardened Concrete
C1084 Test Method for Portland-Cement Content of Hardened Hydraulic-Cement Concrete
D1193 Specification for Reagent Water

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Mortar Joints

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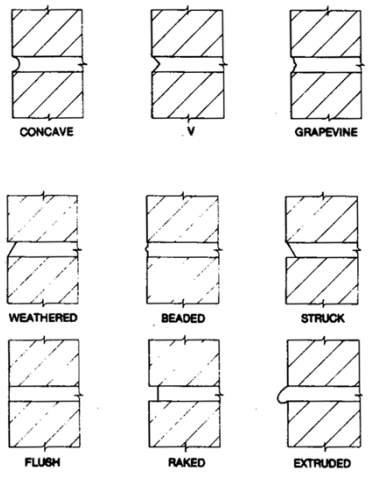
Exterior/Interior
- Concave
- Vee
- Grapevine

Interior
- Weathered
- Beaded
- Struck
- Flush
- Raked
- Extruded



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C270-14

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TABLE X1.1 Guide for the Selection of Masonry Mortars[A]

Location	Building Segment	Mortar Type	
		Recommended	Alternative
Exterior, above grade	Load-bearing wall	N	S or M
	Non-load bearing wall	O[B]	N or S
	Parapet wall	N	S
Exterior, at or below grade	Foundation wall, retaining wall, manholes, sewers, pavements, walks, and patios	S[C]	M or N[C]
Interior	Load-bearing wall	N	S or M
	Non-bearing partitions	O	N
Interior or Exterior	Tuckpointing	See Appendix X3	See Appendix X3

[A]This table does not provide for many specialized mortar uses, such as chimney, reinforced masonry, and acid-resistant mortars.
[B]Type O mortar is recommended for use where the masonry is unlikely to be frozen when saturated, or unlikely to be subjected to high winds or other significant lateral loads. Type N or S mortar should be used in other cases.
[C]Masonry exposed to weather in a nominally horizontal surface is extremely vulnerable to weathering. Mortar for such masonry should be selected with due caution.

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C270-14 (Tuck Pointing)

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X3. TUCK POINTING MORTAR

X3.1 *General*:

X3.1.1 Tuck pointing mortars are replacement mortars used at or near the surface of the masonry wall to restore integrity or improve appearance. Mortars made without portland cement may require special considerations in selecting tuck pointing mortars.

X3.1.2 If the entire wall is not to be tuck pointed, the color and texture should closely match those of the original mortar. An exact match is virtually impossible to achieve.

X3.2 *Materials*:

X3.2.1 Use cementitious materials that conform to the requirements of this specification (C270).

X3.2.2 Use sand that conforms to the requirements of this specification (C270). Sand may be selected to have color, size, and gradation similar to that of the original mortar, if color and texture are important.

X3.3 *Selection Guide*—Use tuck pointing mortar of the same or weaker composition as the original mortar. See Table X3.1.

X3.4 *Materials*—Mortar shall be specified as one of the following:

X3.4.1 The proportion specification of C270, Type ____.

X3.4.2 *Type K*—One part portland cement and 2½ to 4 parts hydrated lime. Aggregate Ratio of 2¼ to 3 times sum of volume of cement and lime.

TABLE X3.1 Guide for Selection of Tuck Pointing Mortar[A]

Location or Service	Mortar Type	
	Recommended	Alternate
interior	O	K,N
exterior, above grade exposed on one side, unlikely to be frozen when saturated, not subject to high wind or other significant lateral load	O	N,K
exterior, other than above	N	O

[A] In some applications, structural concerns may dictate the use of mortars other than those recommended. This table is not applicable to pavement applications.

NOTE X3.1—Type K mortar proportions were referenced in this specification (C270) prior to 1982.

X3.5 *Mixing*:

X3.5.1 Dry mix all solid materials.

X3.5.2 Add sufficient water to produce a damp mix that will retain its shape when pressed into a ball by hand. Mix from 3 to 7 min, preferably with a mechanical mixer.

X3.5.3 Let mortar stand for not less than 1 h nor more than 1½ h for prehydration.

X3.5.4 Add sufficient water to bring the mortar to the proper consistency for tuck pointing, somewhat drier than mortar used for laying the units.

X3.5.5 Use the mortar within 2½ h of its initial mixing. Permit tempering of the mortar within this time interval.

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C1713-12

MASONRY Institute of Michigan

Designation: C1713 – 12

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

This standard is issued under the fixed designation C1713; 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 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.

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

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Mortar Videos

MASONRY Institute of Michigan

- **Mortar Types:** https://www.youtube.com/watch?v=UpWV52f391o
- **Full Joints:** https://www.youtube.com/watch?v=O6X6SQ1K1tY&index=12&list=PLFNNjJXKJ_7Xqq0k5smEBecwXkXrLdWx9
- **Tooling:** https://www.youtube.com/watch?v=FipF36eG2Lw&list=PLFNNjJXKJ_7Xqq0k5smEBecwXkXrLdWx9&index=13

Play all:
https://www.youtube.com/watch?v=23lG_DsLmy8&list=PLFNNjJXKJ_7Xqq0k5smEBecwXkXrLdWx9

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