Assuring Quality of Masonry Mortar

LEARNING OBJECTIVES

- Understand the ASTM standards pertaining to masonry mortar.
- Understand the correct mortar types for various types of masonry construction.
- Understand the various materials for mortar.
- Understand the Quality Assurance options for mortar.
- Understand methods to ensure a consistent mortar appearance.

ASTM Standards

ASTM C270 - Specification for Mortar for Unit Masonry

ASTM C780 – Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry

ASTM C1471 – Specification for Preblended Dry Mortar Mix for Unit Masonry

ASTM C1586 - Guide for Mortar for Unit Masonry

Guide
for
Quality Assurance of Mortars

ASTM C1586

ASTM C 1586

Designation: C1586 – 05 (Reapproved 2011)

Standard Guide for
Quality Assurance of Mortars[1]

3. Significance and Use

3.1 This document is intended to provide guidance and clarification to designers, specifiers, inspectors, testing agencies, producers, and users in specifying and evaluating masonry mortar.

3.2 Users of documents Specification C270 and Test Method C780 often confuse and sometimes inadvertently misuse parts of the two documents when specifying or evaluating masonry mortar. This guide seeks to address specific items within Specification C270 and Test Method C780 to help promote their proper use and interpretation.

Specification
for
Mortar for Unit Masonry

ASTM C270

ASTM C 270

Designation: C270 – 12

Standard Specification for Mortar for Unit Masonry[1]

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.

NOTE 1—When the property specification is used to qualify masonry mortars, the testing agency performing the test methods should be evaluated in accordance with Practice C1093.

Steps in Specifying Mortar

Step 1. Determine Mortar Type

Step 2. Determine Mortar Materials

Step 3. Determine Mortar Specification

Step 4. Determine Mix Proportions

Step 5. Specify a QA Procedure

Step 1

Determine Mortar Type

1. Determine Mortar Type

M . . . . . .2500 psi
A
S . . .. 1800 psi
O
N . . . . . 750 psi

W
O . . . . . 350 psi
R
K . . . . . 75 psi(?)

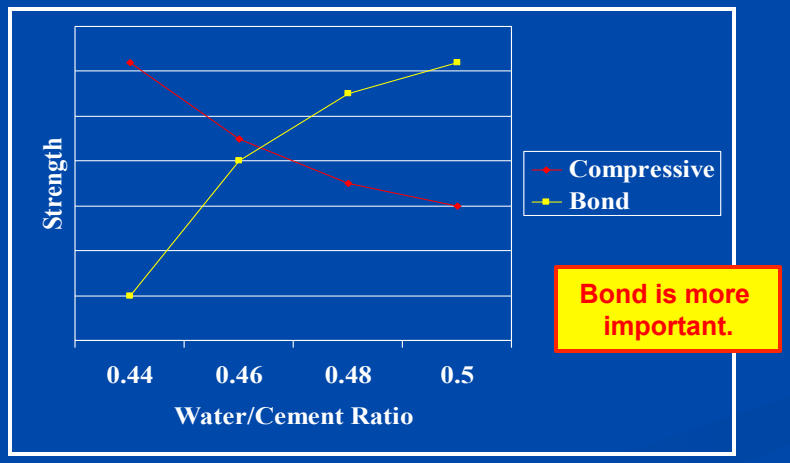
1. Determine Mortar Type

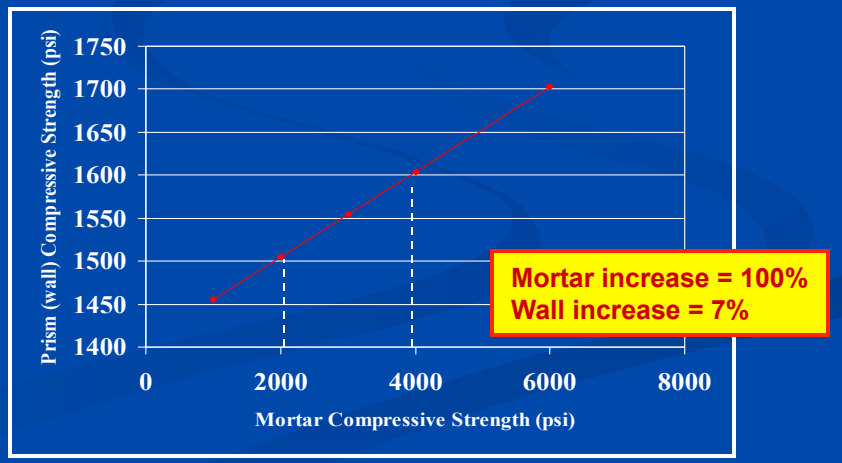
Location	Building Segment	Mortar Type Recommended	Alternative
Exterior	load-bearing wall	N	S or M
	non-load bearing wall	O	N or S
	parapet wall	N	S
	foundation wall, retaining wall, manholes, sewers, pavements, walks & patios	S	M or N
Interior	load-bearing wall	N	S or M
	non-bearing partitions	O	N

1. Determine Mortar Type

5. Requirements

”5.1 ... A mortar type of known higher strength shall not be indiscriminately substituted where a mortar type of anticipated lower strength is specified.”





Step 2

Determine Mortar Materials

2. Determine Mortar Materials

- Portland Cement - ASTM C150
- Hydrated Lime - ASTM C207
- Masonry Cement - ASTM C91
- Mortar Cement - ASTM C1329
- Sand – ASTM C144
- Additives – ASTM C1384
- Pigments – ASTM C979
- Water (Potable)

* Typically, based on experience with local materials and conditions, the masonry contractor is an excellent resource for determining the most appropriate and successful mortar materials and proportions.

Cementitious Materials

Cementitious Materials

Portland Cement and Hydrated Lime

- **Early mortars were hydrated lime and sand.**

  "Hydrated lime contributes to workability, water retentivity, and elasticity. Lime mortars carbonate gradually under the influence of carbon dioxide , a process slowed by cold, wet weather.[1]"

- **The invention of Portland cement enabled mortar to develop greater strengths sooner.**

  Originally, Portland was added to lime plaster as the minority constituent. With the demand for stronger and faster reacting mortar, Portland became the majority constituent.

[1] C270 Appendix X1.

Cementitious Materials

Masonry Cements

- **Type N Masonry cements were developed by the Portland cement industry prior to WWII.**

  "*Masonry cements are proprietary products usually containing portland cement and fines, such as ground limestone or other materials in various proportions, plus additives such as air entraining and water repellency agents.[1]*"

  Combinations of Type N Masonry cement and Portland cements were included as approved combinations in ASTM C270 for higher strength mortars.

- **Type S and M Masonry Cements were developed by the Portland cement industry in the 1950s-1960s.**

  The development of a high-strength Masonry cement eliminated the need to mix 2 cementitious materials on the jobsite, making it more convenient and more consistent.

Cementitious Materials

Mortar Cements

- **Mortar Cements were developed in the late 1980s through the effort of the Masonry Industry Codes Committee.**

  "Mortar cement is a hydraulic cement similar to masonry cement, but the specification for Mortar Cement requires lower air contents and includes a flexural bond strength requirement.[1]"

  Mortar cements have flexural bond strengths equivalent to Portland cement and hydrated lime; and, are approved for use in all seismic zones.

Cementitious Materials

ASTM C270 Permits All Cementitious Types

5. Requirements

"5.1 Unless otherwise stated, a cement/lime mortar, a mortar cement mortar, or a masonry cement mortar is permitted."

Cementitious Materials

PCA MASONRY INFORMATION

"Selecting and Specifying Mortar and Grout for Unit Masonry"

Portland Lime Mortar vs. Mortar Cement Mortar

"Mortar cement mortars are used on an equivalent basis as cement-lime mortars. The specifier should confirm that mortar types and materials indicated in project specifications are consistent with structural design requirements of the masonry."

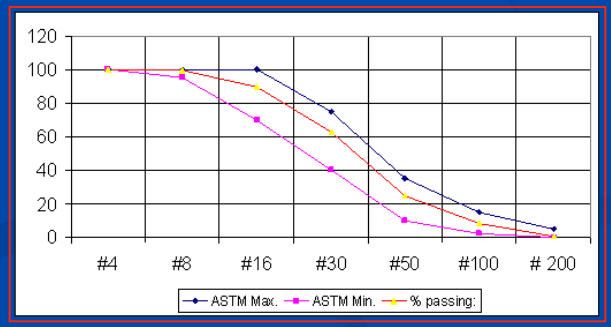
Aggregate for Mortar

Aggregate for Mortar

ASTM C144 – Aggregate for Masonry Mortar

Property Criteria

- Natural or Manufactured Sand
- Gradation ranges for particle size
  - Provision for sands capable of producing a C270 mortar.



- Limits on deleterious substances and organic impurities
- Soundness limits
  - Provision for sands demonstrating 5 year acceptable performance

Step 3

Determine Mortar Specification

ASTM C270 - Two Specifications

- Proportion Specification - based on compliance to proportioning tables.
- Property Specification - based on laboratory results of mortar mixture.
- When neither are specified, the Proportion Specification shall govern.

Proportion Specification

5.2 Proportion Specification — Mortar conforming to the proportion specification shall consist of a mixture of approved materials meeting the proportion requirements in Table 1.

Property Specification

*5.3 Property Specifications— Mortar conformance to the property specifications shall be established by tests of **laboratory** prepared mortar in accordance with Section 6 and 7.2.*

Table 2: Laboratory prepared mortar mixed with a quantity of water to produce a flow of 110 ± 5 %.

Note: This quantity of water is not sufficient to produce a mortar with a workable consistency suitable for laying masonry units in the field. This flow better represents the mortar in the wall.

Step 4

Determine Mix Proportions

Proportion Specification

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

Property Specification

Mortar	Type	Average Compressive Strength at 28 days, min, psi (MPa)	Water Retention, min, %	Air Content, max, %[B]	Aggregate Ratio (Measured in Damp, Loose Conditions)
Cement-Lime	M	2500 (17.2)	75	12	
	S	1800 (12.4)	75	12	
	N	750 (5.2)	75	14[C]	
	O	350 (2.4)	75	14[C]	
Mortar Cement	M	2500 (17.2)	75	12	Not less than 2 ¼ and not more than 3 ½ the sum of the separate volumes of cementitious materials
	S	1800 (12.4)	75	12	
	N	750 (5.2)	75	14[C]	
	O	350 (2.4)	75	14[C]	
Masonry Cement	M	2500 (17.2)	75	18	
	S	1800 (12.4)	75	18	
	N	750 (5.2)	75	20[D]	
	O	350 (2.4)	75	20[D]	

Section 6. Test Methods

6.1 Proportions of Materials for Test Specimens—

Laboratory mixed mortar used for determining conformance to this property specification shall contain construction materials in proportions indicated in project specifications.

6.2 Mixing

6.3 Water Retention

6.4 Air Content

6.5 Compressive Strength

NOTE 1—When the property specification is used to qualify masonry mortars, the testing agency performing the test methods should be evaluated in accordance with Practice C1093.

Masonry Unit Absorption

Masonry unit absorbs moisture from the mortar resulting in a lower W:C ratio.

Step 5

Specify
a
Quality Assurance Procedure

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 Section 2.1, and added to the mixer in the proper proportions.

Proportions of materials are verified by:

- *8.1.1 Implementation and observation ……*
- *8.1.2 Test Method C780 Annex 4, Mortar Aggregate Ratio*
- *8.4 Test Method C1324 Petrographic/Chemical Analysis*

**Compliance to either the Proportion Specification or the Property Specification is obtained by the verification of the mix proportions. There is no approved method to accept the mortar by testing for compression in the field.*

Quality Assurance

8.1.1 Implementation and observation ……

Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Masonry

ASTM C780

ASTM C780

2. Referenced Documents

2.2 The following test methods may be singly or collectively incorporated into the testing to establish mortar composition, …

2.2.1 Annex A1 - Consistency by Cone Penetration ...

2.2.2 Annex A2 - Consistency Retention ...

2.2.3 Annex A3 - Initial Consistency and Consistency

2.2.4 Annex A4 - Mortar Aggregate Ratio Test Method

2.2.5 Annex A5 - Mortar Water Content Test Method

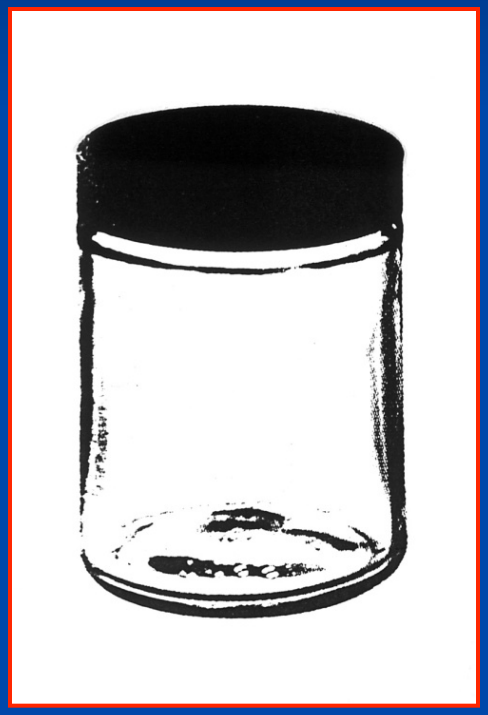
2.2.6 Annex A6 - Mortar Air Content Test Method

2.2.7 Annex A7 - Compressive Strength of Molded Cylinders …

2.2.8 Annex A8 - Splitting Tensile Strength ...

ASTM C780

2.2.4 Annex A4 - Mortar Aggregate Ratio Test Method



*** Compliance to <u>either</u> the Proportion Specification <u>or</u> the Property Specification is obtained by the verification of the mix proportions.**

Quality Assurance

There is a 4th method……..

Preblended Dry Mortar Mixes

Mortar Production Systems

- Traditional Field Mixing
- Preblended Dry Mortar Bags
- Preblended Dry Mortar Silos

Traditional Field Mixing

- Pallets of bagged cement and tons/yards of bulk sand are delivered to the jobsite.
- Proportioning is determined by the number of shovels of sand per bag of cement.
- Water is added and mixed to the appropriate plasticity.

Preblended Dry Mortar in Bags

- The 80# bag contains a blend of specified cement and dry sand, proportioned to meet the specification.
- The bags are added to the masons mixers where water is added and mixed to the appropriate plasticity.
- The benefits include:
  - Accurate proportioning
  - Less waste and clean up
  - Cleaner jobsite
  - Smaller footprint

Preblended Dry Mortar in Silos

- The silo is delivered and set up on the jobsite. The mason's mortar mixer is placed under the boot.
- The mortar is mixed in the same manner as the pre-blended bags.
- The 3000# bag contains a blend of specified cement and dry sand, proportioned to meet the specification.

ASTM C 1714

Designation: C1714/C1714M – 09

Standard Specification for
Preblended Dry Mortar Mix for Unit Masonry[1]

1. Scope

1.1 This specification covers masonry mortars whose materials and design requirements are governed by Specification C270 but are preblended dry in a factory instead of produced from individual raw materials delivered to the job-site.

1.2 The field-sampling, testing, directly comparable test results, packaging, and the traceability of ingredients of preblended dry mortar mix differ from job site mixed mortars and this standard specifically addresses these issues. The tight control of ingredient ratios possible with preblended dry mortar is also covered.

ASTM C 1714

- Produced to meet ASTM C270 criteria
  - Specified mortar type
  - Same mortar materials criteria
  - Same mix proportioning
- Manufacturing process
  - Dry materials measured by weight within tolerances
  - Thoroughly blended under QA/QC conditions
  - Traceability of each batch/run
  - Batch records archived
- Sampling and Testing
  - Proportion specification – verification of ingredient proportions
  - Property specification – ASTM C270 laboratory testing

Questions?

Ensuring Mortar Appearance

Factors Affecting Mortar Color

- Properly mixing the mortar
- Correctly placing flashing & weeps
- Covering materials & walls as built
- Tooling joints properly
- Cleaning masonry effectively
- Curing

Properly mixing the mortar

8.1.1 Implementation and observation ……

Correctly placing flashing & weeps

Tooling

- Tooled when the mortar is “thumb print hard”.
- Too soon will pull a high water content paste to the surface, resulting in a lighter colored joint.
- Too late will prevent the paste to be pulled to the surface, resulting in a darker joint.
- The moisture content and absorption rate of the unit will affect the rate of moisture loss from the mortar to the unit, impacting the time of tooling.

Timing vs. Moisture

A brick prism laid with a single batch of mortar. The top joint was tooled immediately after placement, the remaining mortar joints were tooled at progressively greater time intervals. The only variable was the amount of moisture in the mortar at time of tooling.

Wetter = Lighter

Dryer = Darker

Variable IRA in Units

Variations in the Initial Rate of Absorption at the time of placement will affect the moisture within the brickwork, and could cause mottled mortar joint color.

Cleaning Masonry

Commercial cleaning materials should always be used according to the manufacturer's recommendations.

Determine appropriate water pressure, nozzle type, and distance between wall and nozzle.

THE BRICK INDUSTRY ASSOCIATION

TECHNICAL NOTES on Brick Construction

1850 Centennial Park Drive, Reston, Virginia 20191 | www.gobrick.com | 703-620-0010

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Cleaning Brickwork

Curing

- Weather can affect the final mortar color.
- Temperature affect how the mortar cures, causing slight color variations.
- Mortar cured under different moisture conditions, can cause differences in joint color.
- These differences become less with time as the moisture level stabilizes in the wall.

Moisture Within Mortar Joint

- Avoid making decisions regarding mortar joint color consistency too quickly. Walls should have the opportunity to “mature” through a complete cycle of seasons.
- Decisions to stain or replace sections of mortar too quickly will prevent them from matching adjacent sections of mortar later as they mature.

Predicting Mortar Appearance

Sample Panels

Sample panels built prior to construction, representative of intended materials and conditions are strongly recommended. Varying the moisture content of several bricks within the panel will demonstrate the range of potential color variation in the mortar joints. Panels should be kept on the jobsite until the completion and acceptance of the brickwork.

Questions?

Questions?

This concludes the American Institute of Architects Continuing Education Program.

Thank you for your time!