

Mortar Testing for Quality Assurance: Best Practices

Masonry walls are designed and built every day. Though masonry is a proven construction method, and one of the oldest, specifiers are still faced with the same challenge: how do you call out a mortar and then verify that you are getting what you asked for?

Quality control and quality assurance (QC/QA) are very important activities in construction (see Fig. 1). Following design of a structure, QC/QA is the last link in the chain to assure that buildings and other structures will support the loads to which they are subjected. Masonry mortars are unique. They are mixed on site according to materials specified by the designer,* but weather conditions and other environmental factors can influence the resulting product.

Assuring Quality of Mortar

While visual observation of the batching process is important, it is not practical or necessary for an inspector to watch the proportioning of every batch. One thing that can be done—with quick results—is sample the fresh mortar as mixed and calculate how much sand it contains relative to cement. As long as the individual ingredients all meet their own standards, the only thing to check to assure mortar quality is its proportions. This is exactly what the mortar aggregate ratio does and the process is described in ASTM C 780.

ASTM C 780, Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry, 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. (In order to calculate the M-A ratio, it's also necessary to run the mortar water content test, Annex A5, in conjunction with the M-A test.)

**In North America, specifiers look to two documents to help them develop mortars:*

ASTM C 270, Standard Specification for Mortar for Unit Masonry (United States)

CSA A179, Mortar and Grout for Unit Masonry (Canada)

The Basic Test

1. Take a sample of wet mortar and one of sand.
2. Place samples of mortar into two jars of alcohol. (Alcohol stops cement hydration.) Place sand into a different jar or a plastic bag.
3. Agitate the mortar jars to mix the alcohol throughout the sample, breaking up the cement and sand.
4. For mortar jar #1, the alcohol is burned off in the lab, and the remaining material is oven dried to determine the water content.
5. For mortar jar #2 and jar #3 with sand, wet sieve each sample (see Fig. 2).
For the mortar sample, the finer materials are assumed to represent the cementitious materials and are washed through a sieve to leave the sand particles behind. The sand sample allows for a correction of fine particles.
6. Weigh the sample in various conditions: wet, oven dried, after removal of alcohol. This allows the determination of weight of the dry mortar and dry aggregates.
7. Calculate the mortar aggregate ratio. A simple ratio of sand to cement should give something very close to the mortar proportions originally chosen, such as 3:1.

Recent research has led to some useful tips to improve this test method. The research systematically looked at seven aspects of the test: alcohol concentration, age of mortar at testing, size of the mortar sample, how the sample was dried, time of testing, whether or not the sample was agitated in the jar, and either flaming the sample to burn off deleterious materials or washing it through a sieve to remove the alcohol.



Fig. 1. In the mortar aggregate ratio test, a quality control method for mortar, samples are placed into jars of alcohol to stop cement hydration.



Fig. 2. Wet sieving over a number 100 sieve removes the fine mortar particles to determine how much aggregate is contained in the sample. Incidentally, a sand-only sample is also tested this way to provide a correction factor.

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Best Practices *(continued from page 3)*

The Results

Three variables had a strong effect on the test results:

- test sample within four hours
- use a 500-g sample
- thoroughly agitate the jar with the sample and alcohol

Most important, the testing time should be kept to within four hours. As the sample sits, cement continues to hydrate, and lumps can form. This causes cement particles to be retained on the 100 sieve, which will give a result that indicates that more coarse particles are present, leading to a false M-A ratio.

The second most influential factor was sample size. Although it is possible to take anywhere from 500 g to 700 g, the smaller sample yielded more accurate results. The reason is the same as for the previous factor: less hydration takes place in the smaller sample because the alcohol can be mixed through it more thoroughly.

The third most important factor was agitation of the sample in the alcohol jar. The reason is the same as for the other two. Unwanted hydration is prevented.

Less important factors were the way the sample was dried (hot plates don't work quite as well as ovens) and the age of the mortar at time of testing (it's better to sample fresh mortar than older mortar).

Ongoing work in the ASTM committees that oversee this standard will bring about modifications to make the test the best that it can be, assuring inspectors and building owners that their mortars are just what they wanted. Rather than waiting for the standard to be updated, instituting these slight modifications right away is a way to remain in conformance with the test and assure the best results possible.

For more information about the research project, see PCA SN2767, *Ruggedness Testing of the Mortar Aggregate Ratio Procedure*.

MASONRY *Today*

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