MORTAR FOR MASONRY VENEER

Introduction

This ARRISCRAFT•NOTE discusses the basic principles pertaining to the selection and use of mortar in masonry veneer construction. This paper does not address issues relevant to engineered structural masonry mortars, restoration or other specialty mortars.

The integrity of a masonry veneer assembly relies upon many factors including the proper selection of complementary materials and products, proper configuration of various elements designed to accommodate the different forces acting on the wall, proper workmanship, and suitable environmental conditions during construction.

The mortar is only one component of an entire masonry veneer assembly and must be selected with respect to complementing the other components, such that the entire assembly will provide a long-lasting, aesthetically pleasing building façade over the life of the building.

The earliest mortars were primarily lime-based, utilizing calcium-based materials indigenous to the geographic area of use. At the beginning of the 20th century the introduction of Portland cement to the mix enabled faster initial set and thus faster construction. Today, combinations of Portland cement, lime, sand and water are mixed to specific proportions to achieve the desired properties. The cement adds strength, the lime contributes to the workability and durability and the sand is inexpensive filler. (*Ref. Drysdale, Hamid, Baker; Masonry Structures - Behavior and Design - Second Edition, 1999; pg. 147*)

The Function of Mortar

The mortar's primary function within a wall veneer is to accommodate minor variations in tolerance in unit dimensions, thus helping to resist moisture infiltration. Other functions of mortar are to secure joint reinforcement and metal ties so that they can act integrally with masonry and to facilitate ease of construction.

The weather resistance of a wall is a function of properly tooled mortar joints combined with the incorporation of suitably designed drainage or barrier wall elements. It is not the function of the mortar however to act as a "*glue*" that permanently holds the units in place nor to ensure the monolithic nature of the wall veneer. Other wall elements are relied upon to minimize wall cracking.

For instance, mortar cannot be relied upon to accommodate the significant stresses imposed on masonry veneers as the result of differential movements. That is the function of properly located and constructed movement joints. In fact, it is generally accepted that mortar should be designed as the weaker, sacrificial element in the wall. Thus, any cracking that may result from inadequately accommodated movement will occur along the mortar joints and not through the masonry units themselves. Whereas a cracked mortar joint can easily be re-pointed, replacing masonry units is relatively more difficult and costly.

Mortar Types

Mortar, its production and use are generally specified by reference to specific standards published by either the Canadian Standards Association (CSA A179) or the American Society for Testing and Materials (ASTM C270). There are five basic types of mortar described, although two types in particular are the most commonly used in masonry construction: Type N and Type S.

Type N mortars exhibit good workability in their plastic state and greater flexibility in their hardened state. The increased flexibility better accommodates minor load variations, thus resulting in better joint durability. As such, Type N mortars are ideal for use in non-load bearing veneer applications.

Type S mortars are reasonably workable in their plastic state and exhibit high strength and adequate flexibility in their hardened state. The higher cement content, however, tends to make them slightly less flexible than Type N mortars and more susceptible to the formation of shrinkage cracks. They are commonly used for engineered masonry and below grade applications, although

their use in some veneer construction has proven appropriate.

Specification Conventions
The mortar type should conform to one of two specification conventions: either the Property or the Proportion specification method. Mortars prepared to the Proportion specification method are described as a relative volume of ingredients; whereas, mortar prepared to the Property specification method are described in terms of their expected hardened properties.

Acceptance criteria relative to the specification method used do differ between the CSA and the ASTM reference standards. Design consultants doing cross-border work should be cognizant of these differences and not simply replace one standard reference with the other, while still expecting compliance with the standard with which they are more familiar.

Types of Mortar Mixes
There are a variety of commonly recognized means for the production of masonry mortars. Basically, however, the combination of various cementitious materials with aggregate and water produces a mortar exhibiting distinct properties in the plastic and hardened states.

Today there are generally three basic "recipes" for mortar considered acceptable for use in building construction:

- Portland cement – Lime (PCL);
- masonry cement; and
- mortar cement.

PCL mortars are mixed using the basic original ingredients. The quality and quantity of both the cement and lime in the mix are known and are under the mason's control. Most specifically, the use of a good quality lime within the mortar mixture will assure consistent plasticity and workability, higher water retentivity, high sand-carrying capacity, more flexibility under stress, ease of re-tempering, and will impart autogenous healing qualities to the hardened mortar. (*Ref. Boynton, R.S.; Chemistry and Technology of Lime and Limestone, 1966; pg 396.*)

Empirical observations tend to suggest that PCL mortars exhibit reasonably consistent strength properties in the hardened state and will provide superior durability and flexibility.

Where hairline cracking occurs within the mortar joints due to mortar shrinkage or cyclical movements, the use of a lime-based mortar tends to re-seal the hairline cracks or minute voids in the mortar. This tendency is called autogenous healing and occurs as the lime recarbonates in the mortar mix following cycles of wetting and drying.

Portland cement - lime mortars are particularly well suited for use in masonry veneers where the flexibility and autogenous healing properties of the mortar are used to their best advantage.

Masonry cement is a mixture of Portland or hydraulic cement and plasticizing materials (such as crushed limestone, hydraulic and/or hydrated lime) together with other materials introduced to enhance properties such as setting time, workability, water retention and durability. Manufacturers of masonry cement blend and process the various ingredients in proprietary mixes designed to meet specific requirements for particular properties. Masonry cements tend to optimize the plastic mortar properties, as such; their use is preferred by many masons. Variations in quality and quantity of the basic materials, however, may contribute to a wider variation of the hardened properties between masonry cements produced by different manufacturers.

Mortar cement is similar in concept to masonry cement in that the constituent materials are plant batched and processed. The standards governing their production include additional requirements to those governing masonry cement. Mortar cement was primarily developed to address issues of acceptability under the building code within areas of higher-seismic risk. It is considered to be an enhanced masonry cement.

Selecting the Appropriate Mortar Mix
With exterior masonry veneers it is recommended that the mortar and masonry unit be selected such that their respective properties complement one another. They should work together to ensure a durable, weather-resistant joint.

Mortar for unit masonry veneer should exhibit good workability and board life in its plastic state, and good durability and flexibility in its hardened state. Empirical observations and data suggest that

type N PCL mortar provides the best combination of these key properties.

Portland cement should conform to a recognized standard (either ASTM C150 or CAN/CSA-A5) and would be typically graded as "Normal".

Hydrated lime used in the production of masonry veneer mortars should conform to ASTM C207, Type S. Type N lime should only be used when it is proven not to be detrimental to the performance of the mortar.

Air-entrained lime may be beneficial where freeze-thaw resistance is important but may also result in a reduction of bond and compressive strength. As such, the use of air-entrained lime may be limited by some building codes.

Masonry aggregate, typically well graded sand, should conform to the appropriate governing standard (either ASTM C144 or CSA A179) and should be clean and free of salts and organic contaminants.

In-the-Wall Performance

Quality of Work: Just as with any other type of building construction, good workmanship is critical to the subsequent performance of the masonry veneer. If improperly applied or applied under adverse environmental conditions, the mortar will most likely not perform as intended. The following checklist outlines some basic guidelines for the proper storage, blending and application of mortar and its constituent materials:

- protect the mortar and masonry materials from freezing;
- accurately site measure ingredients by volume using a suitably sized gauge box or hopper;
- use mortar immediately after mixing, re-tempering as necessary and as allowed by local codes or standards. Discard mortar older than 2-1/2 hours;
- place mortar on the units for full bed coverage. Do not slush-fill joints;
- do not break the mortar-unit contact once the masonry units have been set in place. If subsequent adjustment of the units is deemed necessary, remove the masonry units from the wall, clean any old mortar from the surfaces, and reinstall using new mortar; and
- tool mortar joints when thumbprint hard to a tightly compressed, weather-resistant surface.

Mortar-Unit Bond: The mortar-unit bond is just one aspect of a wall's integrity. As stated, the mortar's principle functions in a masonry veneer wall are to accommodate minor construction tolerances and provide long-term protection against the elements. The mortar is not intended to serve as a type of glue that will hold the wall together irrespective of the forces being imposed upon it.

In fact, the mortar joint is designed as the sacrificial element within the masonry veneer. It is expected that some degree of cracking will occur during the service life of the building, and the desired place for such cracks to occur is within the mortar joint rather than within the masonry units themselves.

Essentially mortar bond can be described by the bond strength, extent of bond and bond durability.

Bond Strength is defined as the force required to separate the mortar-unit assembly.

Extent of Bond is defined as the degree of complete and intimate contact between the mortar and the unit.

Bond Durability is defined as the mortar's ability to maintain the integrity of the extent of bond and the bond strength over the service life of the building.

These three characteristics are all affected by the type of mortar used, the type of masonry unit used and the quality of work exercised by the installer.

Mechanical Keying: A common myth within the construction industry is that to achieve adequate bond cores or frogs in the masonry must be filled with mortar. Mortar bond, however, occurs at a microscopic level within the pore structure of the masonry units. As moisture from the mortar is absorbed by the masonry unit, cement particles are drawn into the unit, resulting in a bond between the two materials.

This differs from keying that results from mortar being allowed to harden within a core or frog. When properly detailed and constructed, a mechanical key is unnecessary. However, when detailing is insufficient, mechanical keying may help minimize the displacement of individual units within the wall.

Summary

This ARRISCRAFT•NOTE discusses masonry mortar for use in veneer construction. It discusses the mortar's function in a veneer wall, characteristics affecting mortar bond, mechanical keying, mortar mix criteria and issues of workmanship.

The information and suggestions contained herein are based upon the available data and information published by the listed references and the experience of Arriscraft International architectural and engineering staff. More detailed information may be found by referring to any of the related references listed below.

The information contained herein must be used in conjunction with good technical judgment and a competent understanding of masonry construction. Final decisions on the use of the information contained in this ARRISCRAFT•NOTE are not within the purview of Arriscraft International and must rest with the project designer or owner, or both. It remains the sole responsibility of the designer to properly design the project, ensure all architectural and engineering principles are properly applied throughout, and ensure that any suggestions made by Arriscraft International are appropriate in the instance and are properly incorporated through the project.

Related references

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