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Why use lime-cement mortar?

For better workability, greater bond, and less water penetration

By Dan Walker
Technical Director
Chemstar, Inc.
Henderson, Nevada

Ken Gutschick
Technical Director
National Lime Association
Arlington, Virginia

The first masonry shelters were probably built with stone and mud mortar. Later came clay mortars. Then someone discovered that lime putty made from quicklime produced an excellent mortar. Lime-sand mortar was used for masonry construction until the advent of portland cement in the mid-1800s. If it wasn't for its poor workability, portland cement-sand mortar might have become standard. Portland cement offers excellent compressive strength and sets quickly enough to comply with modern masonry construction practices. But for workability and bond, a plasticizing agent must be added to it.

Therefore, modern masonry mortars are a combination of lime-sand mortar and portland cement, taking advantage of the properties of each. Portland cement, it might be said, became the first modern day admixture to masonry mortar. Currently, numerous admixtures are used in masonry mortar, mainly for economical reasons. None, however, match the properties of lime.

MORTAR PARTICLE SIZES

Size Comparisons (in microns)	
Dolomitic Type S Hydrated Lime	0.08
Masonry Pores	0.25
Portland Cement	40.00
Air Bubbles	100.00
Sand, #16	1,200.00

Figure 1. About 1/500th the size of portland cement particles, lime particles have very high surface areas. Because all these small particles get covered with water, lime holds more water—water needed for good workability.

Lime's superb properties can be shown in both phases of mortar:

- The plastic or putty state
- The hardened state

Both phases are important. Plastic mortar must be just the right consistency for placement. And hardened mortar must hold the brick together while withstanding loads, water, and temperature extremes.

THE PUTTY PHASE

Most important to the masonry contractor is mortar plasticity. Mortar must be easy to place and spread around. Its workability depends on the amount of lubricant or water in the putty. This is where lime plays a role. Lime allows the mortar to hold more water.

Greater water retention

Today, hydrated lime used in masonry mortars must meet the requirements specified in ASTM C 207 (Ref. 1) for Type S hydrated lime. Made from dolomitic quicklime, most Type S hydrated limes used in mortar contain about equal amounts of magnesium hydroxide and calcium hydroxide. These hydroxide particles are 1/500th the size of typical portland cement particles (Figure 1). This means they have very high surface areas on the order of 20 square meters per gram (more than two acres per pound of lime). All these small particles get covered with a thin film of water. Because they have more surface area, they hold more water. More water provides more lubrication between particles, making the mortar more workable (Ref. 2).

Longer board life

Type S hydrated lime holds water for a long time. This is important because many forces work to deplete mortar of its water: A lot of water evaporates, especially in hot, dry weather. The chemical hydration of portland cement removes water, and water tends to bleed to the surface.

If a mortar loses its lubricating water too fast, the mason has problems working with it and must retemper (add more water) often. However, the small lime particles hold onto water tenaciously. And because they can hold more water, more water must be lost before workability is lost.

Stickier mix

The hexagonal platelet shape of the hydroxide particles also helps

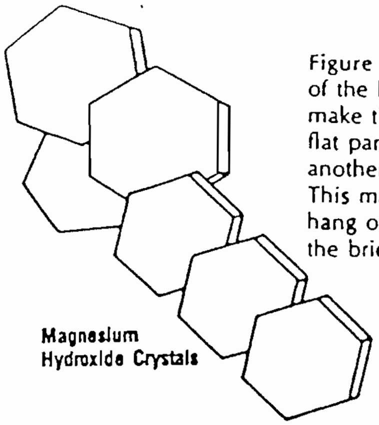

Figure 2. The hexagonal platelet shape of the hydroxide crystals in lime help make the mortar workable. The thin, flat particles slip and slide over one another, but don't separate completely. This makes the mortar sticky enough to hang on the trowel and head joints of the brick.

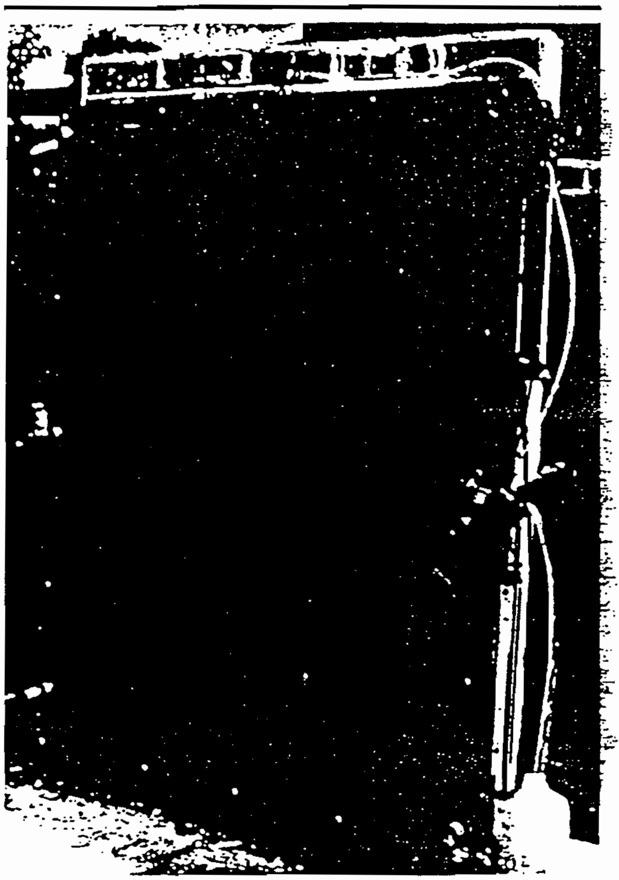

Figure 3. Researchers simulated hurricane-force, wind-driven rain against masonry walls built with various mortar types to test water permeance according to ASTM E 514.

make the mortar more workable (Figure 2). The very thin flat particles slip and slide over one another like graphite lubricants—or a deck of cards (Ref. 2). Throw a deck of cards on a table and you'll find that the deck spreads over a large surface, but the individual cards stay in contact with one another. These hydroxide platelets act the same way. They provide extra lubrication and at the same time give the putty stickiness. A mortar must be reasonably sticky to hang on the trowel and head joints of the brick. If not, the mason loses production time.

More sand-carrying capacity

The large number and small size of lime particles also mean that every sand particle can be coated with lime. Mortar made with lime thus can hold more sand (which reduces costs), without sacrificing workability.

THE HARDENED PHASE

Architects and especially owners are concerned about the performance of hardened mortar. They want the masonry to last. This means the mortar also must last—without cracking, weathering, efflorescence, or water penetration.

Improved bond

In the hardened state the most important property of mortar is its bonding ability. If a masonry wall is to have flexural strength and watertightness, it must hold the bricks together. Dolomitic Type S lime increases the density of mortar, enabling the mortar to achieve more intimate contact with the brick units. The fine-grained magnesium platelets penetrate deep into the microscopic openings in the masonry unit.

These small particles also often provide enough workability to make air entrainment admixtures unnecessary. Mortars made with air-entraining agents (as masonry cement mortars are), are less dense and provide less mortar to brick contact because of the air bubbles. Air bubbles and portland cement particles also are too large to penetrate some of the microscopic openings in the masonry units.

Along with improving workability, lime's good water retention also improves the mortar's bond to the masonry. Immediately after they're laid, masonry units absorb water from the mortar. If the masonry absorbs water too fast, a gap is created at the mortar-brick interface, greatly weakening the bond (Ref. 3). Because lime enables mortar to hold more water for a longer time, fewer gaps (and leaks) occur at the mortar-brick interface.

A study currently underway at the University of Texas at Arlington shows that lime-cement mortars achieve much better brick-mortar bond than masonry cement mortars. Directed by Dr. John Matthys, the study is comparing the performance of ASTM Types N and S mortar made with one Type S lime-cement mortar and eight typical masonry cement mortars (four Type S and four Type N). In 28-day tests, brick assemblages made with lime-cement mortar performed better than assemblages made with masonry cement mortars.

In the ASTM E 514 permeance test (Ref. 5), the single-wythe brick wall assemblages were cured outdoors for 28 days then subjected to a simulated hurricane-force, wind-driven rain for 72 hours (Figure 3). The walls made with

Figure 4. After being subjected to the ASTM E 514 water permeance test, the wall made with lime-cement mortar shows virtually no water leakage (above). The wall made with masonry cement leaked considerably (below).

lime-cement mortar showed virtually no water leakage, whereas all the masonry cement walls leaked considerably (Figure 4).

Matthys also tested 28-day assemblages for shear strength (Ref. 6), flexural bond as measured by the bond wrench test (Ref. 7), and prism compressive strength (Ref. 8). In the shear and bond tests, the lime-cement walls exhibited considerably better strengths than the masonry cement walls. The 28-day compressive strengths of prisms were essentially the same for both types of mortar.

Increased strength

Lime also has cementing properties. Carbonation is the principal cementing reaction. Calcium and magnesium from the hydrated lime react with carbon dioxide from the atmosphere to form calcium magnesium carbonate, a product which adds a modest amount of strength to the mortar. A pozzolanic reaction also takes place: siliceous particles in the mortar and brick react with lime, producing a calcium silicate cementing material. The high pH of the lime makes the siliceous particles more soluble, allowing them to react and form silicates.

More ductility

Lime also makes mortar less rigid, which helps mortar accommodate movements in masonry walls. This has been known for years. In 1960, Dr. Walter C. Voss of the Massachusetts Institute of Technology wrote, "Very slight movements induce higher stresses in more rigid assemblages than they do in assemblages which possess a greater degree of accommodation. Lime aids in producing this resilience and relief" (Ref. 9).

Less efflorescence

Because efflorescence and lime are both white, lime has been said to cause efflorescence. This is not true. Efflorescence is caused by the movement of water into and out of masonry that contains soluble salts. The solubility of lime is very low, and most dolomitic Type S hydrated limes contain very little soluble salts. Because lime makes mortar less permeable, it helps keep out water, helping to prevent efflorescence.

Crack healer

Mortar that contains lime heals itself. Occasionally a small crack or fissure develops in mortar. Water enters the fissure, dissolving minute amounts of calcium from the lime-rich mortar. Water also adsorbs carbon dioxide from the air. The carbon dioxide and calcium react, producing calcium carbonate, which plugs the fissure.

WHY LIME-CEMENT MORTAR?

Type S hydrated lime improves mortar's plasticity, water retention, sand-carrying capacity, bonding, and flexibility. It also helps prevent efflorescence and automatically heals fine cracks. ▲

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LIME PROPERTIES AND MASONRY BONDING

Daniel D. Walker, Jr.
Chemstar, Inc.
Henderson, NV

* A study sponsored by the National Lime Association was made by Dr. John Matthys at the University of Texas, Arlington, concerning the
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performance of portland cement-lime mortars and masonry cement mortars. The results indicated that although both type mortars meet material specifications, there was considerable difference in important properties, such
fuerza de cadena [illegible] de agua fuerza compresiva fuerza de cizallas
as bond strength, water tightness, compressive strength and shear strength. The portland cement-lime mortars were found to be superior in every category. A review of Dr. Matthys' data is discussed.

Principalmente la razón
Primarily the reason for the superior results of portland cement-lime mortars is the lime. Lime provides many versatile properties to mortars, but the most important are bonding and workability. Recent studies of lime and lime-containing mortars using the electron microscope have shown the importance of lime chemistry and lime particle characteristics in developing these most important properties. For example, lime in mortar will have a very high pH, which will cause small amounts of aluminum and silicon from the aggregates and masonry units to dissolve. The calcium from the lime will then chemically combines with the aluminum and silicon to form cementing-type minerals that enhance the bonding strength of masonry. Workability is a function of the lubricating agent, which in the case of mortars is water, and the ability of particles to move easily to provide a plastic mix. It is shown with the microscope that lime particles are very small and have a plate-like structure, which is the reason they slip and slide over each other and give free movement to the mortar mix.