Building Skin Care:

Tips to Maintain Historic Masonry Walls

By Frank Rosario

March breezes eddied in the mansion's courtyard. Two chattering sounds drew my eyes away from my tablet screen to small mortar chunks scattered among windswept leaves at the base of the exterior's rubble wall.

I am the architect tasked with repairs to this grand old house. Despite years of spot-repairs to mortar and sealant joints, leaks through its limestone walls are getting worse. Gazing upward to a parapet 30 feet above my head, I notice the wall surface is pocked with missing mortar and spalled stone. Despite its formidable construction and craftsmanship, this 19th-century stone edifice is giving way to the effects of 150 years of freezing, thawing and rainstorms.

The walls are solid masonry, laid up as multiple wythes of rubble limestone to a thickness of nearly a foot and a half. It is clear that the deterioration is the result of several decades of repointing with a mix of mortar too hard for the stones it was meant to protect. Repairs using 19th-century stonemasonry methods and materials — not 21st-century methods — should go a long way to extend the useful life of an extraordinary example of Americana.

Mortar loss beyond simple weathering is a clue to underlying stresses. Poorly executed attempts at repointing are a predictor of future degradation. To maintain the solid masonry of historic buildings, expertise outside the norms of contemporary construction is necessary.

Time-Tested vs. Contemporary Methods

Solid masonry walls exemplify time-tested methods of dry-stack and mortared-wall construction dating back millennia. Stable height-to-thickness arrangements of stone use friction fits and interlocking patterns to deliver gravity forces to the ground. Mortar facilitates the stacking and fills the joints. In contrast, the stacking of veneer masonry (stone or brick) relies on anchor ties to the back-up framing for stability, though outwardly the veneer may look very similar to a solid wall.

Mortar well-packed into joints keeps wind and rain from entering both wall types. Veneer construction includes an

Stacked stones with pinnings deliver gravity forces to the ground.

Frank Rosario

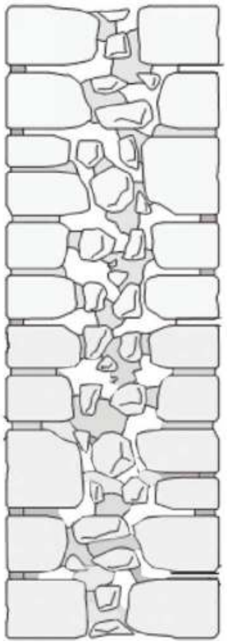

Figure 1: Voids in a solid masonry wall.

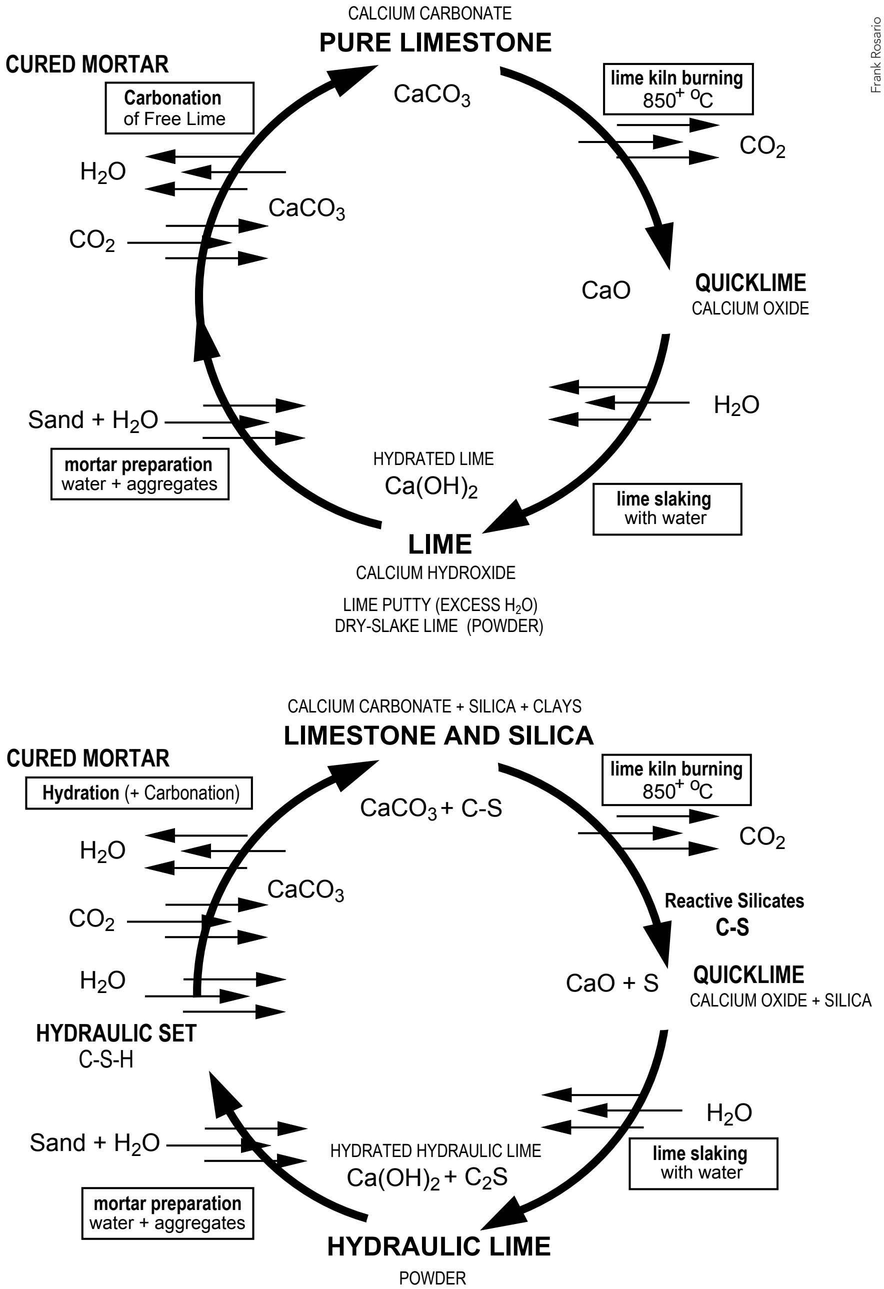

Figure 2: Production and curing of historic lime mortars.

air-and-drainage cavity from which water that gets past the brick or stone is removed via flashing and weeps. Water vapor exits via the mortar joints in both wall types. And while there are voids inside walls of "solid" masonry, water is eliminated by evaporation, not drainage. The solid wall gets wet, holds the moisture within itself for a while, then dries out as relative humidity levels drop and evaporating water escapes via the most accommodating solid material, ideally the mortar. The rate at which this water vapor moves through a solid material is referred to as the material's permeability. Use of a mortar that is harder than the original mortar can change this moisture mitigation dynamic.

The primary component of historic mortars was lime, a man-made product of natural limestone (calcium carbonate or $CaCO_3$) burned at high temperatures. The heat drives off carbon dioxide and any water, leaving calcium oxide, CaO, referred to as quicklime. After cooling, the quicklime was slaked, i.e., soaked in water, to produce lime putty – calcium hydroxide, $Ca(OH)_2$. Lime putty was often left to mature for several months or even years.

At the time of a solid masonry wall's original construction, mortar made of lime putty and sand was installed wet and allowed to cure slowly, hardening over many years from contact with the carbon dioxide in the atmosphere to convert chemically back to limestone, a process referred to as carbonation. Sometimes clay impurities were burned with the crushed limestone to add a cementitious (adhering) quality to the mortar, and thus an accelerated setting time. These "natural cement" hydraulic lime mortars set by reaction with water rather than carbon dioxide and were especially valued where masonry was subjected to constant moisture antithetical to carbonation, such as lighthouses and aqueducts.

With this chemistry in mind, Joseph Aspdin, an English mason, developed a blend of lime, clays and other minerals patented in 1824 under the name portland cement. Mortar mixes of portland cement and lime dramatically reduced the time to build a masonry wall because the stiffer mortar's release of water (hydration) resulted in faster curing than the slow-setting carbonation of lime/sand mortars. Thus the stage was set for an eventual flip of mortar compositions from lime with some cement to cement with some lime. Nevertheless, up until the 1930s many solid masonry walls in the U.S. still utilized mortars with a high proportion of lime. And regardless of

Continued on page 18

While the initial cost is high, repointing of historic masonry walls should not be postponed in favor of less expensive applications of vapor-blocking repellants, which can cause deterioration by trapping moisture.

composition, the mortar was not a glue; it was a bed and a chinking.

Portland cement mortars are formulated in different compressive strengths. Common Type N mortar is the choice for reinforced concrete masonry unit (CMU) load-bearing walls and almost all non-loadbearing veneers. But reckless application of today's ubiquitous Type N mortars for repointing century-old masonry walls leads to catastrophic spalling of brick and stone when vapor seeking the most permeable material exits through the old masonry, breaking it up in the process. Whereas historic mortar joints periodically sacrificed in the drying-out process could be repointed, a spalled brick is a ruined brick. To avoid irreparable failure, original-to-the-wall mortar samples should be extracted and tested for lime volume content and aggregate types to create a mortar that is as close a match as possible.

Assessment and Treatment

Prior to fixing the symptoms of historic wall deterioration, one must identify the causes.

Visual inspection of crumbled mortar and spalled masonry is a start. Has the wall been painted, and if so, is the paint a barrier to evaporation, thus causing spalling? Tapping/sounding masonry faces for hollow-sounding areas can call attention to hidden disintegrated masonry that must be replaced. Look for brittle, cracked sealants that will admit water at window and door perimeters. Is there cement parging over parapet walls? It may no longer be effective if it is riddled with cracks. Staining around gutters, scuppers and downspouts is evidence of routine deluges down the wall face that will wash out even the best mortar. Are there building movement or settlement cracks? If so, repointing the symptom will not resolve the cause. Does the perimeter grade slope toward the base of the masonry wall?

An example of spalled brick yet intact mortar.

Such conditions must be documented and integrated into the scope of repair or repointing will be in vain. After correcting any problems, masons trained and experienced in historic masonry restoration can clean, rebuild and repoint, extending the wall's weathertightness for many years.

Unfortunately, repointing is sometimes postponed in favor of a less costly application of water repellant—or worse, vapor-blocking paint. At best harmless but wholly ineffective, at worst an inhibitor to outward drying, this method does not mitigate unwanted moisture. Masonry conservators have discredited the practice yet it remains.

The Interior Side of Masonry Walls

Drying being the equal-opportunity process that it is, vapor drive will naturally occur to the inside of a building if that space is less humid than the outdoors.

Solid masonry walls with a plaster interior finish allowed this transfer; the walls were able to *breathe*. By offering their occupants relief from the extremes of wind, heat and rain, historic masonry buildings could endure a very long time. For temperature and rain, the single-material wall stores excesses of both in its thick mass, slowly transferring heat via conduction and radiation, and ridding itself of moisture from precipitation and humidity by evaporation.

Contemporary expectations of comfort and finish have introduced add-on construction that interferes with the laws of physics. Of all the insidious "upgrades" made to solid masonry over the last 60 years, the equilibrium-busting introduction of furring and insulation on the interior side of exterior walls has probably been the gravest.

Depending on the detailing and materials, insulation on solid walls can alter the heat transfer and the related drying that the masonry had enjoyed previously. The result threatens the walls with disintegration from the inside out. By insulating its inside face, solid masonry is no longer kept warm in the winter by direct contact with the building's temperate interior. The resulting colder brick or stone surface abutting the insulation can only be kept free of condensing liquid water if the humidity-laden room air is tightly sealed from reaching the masonry. Gaps in and around insulation must be completely sealed for this to occur. Absent expertly executed air barrier detailing, there is a significant potential for freezing and thawing within the masonry.

As with the caveats previously mentioned about repointing, it is imperative that all defects of solid masonry wall be repaired before considering the installation of interior insulation. Otherwise the insulation may alter the drying/conduction gradient and cause degradation.

Properly maintained, masonry walls can preserve the weathertightness of historic buildings for many generations.

Such repairs include the following:

- Cracked, loose and spalled bricks should be replaced.
- Deteriorated mortar, including hairline cracking, should be repointed.
- Loose, torn and degraded sealant beads should be replaced.
- Parapets, gutters and downspouts should be made watertight.
- All other sources for interior wall dampness should be determined and eliminated.
- Mold on interior faces should be mitigated.

To summarize, solid masonry walls with sufficient mass provide low maintenance and resilience due to their behavior as a heat sink and moisture reservoir. In contrast, contemporary masonry veneer construction relies on perfect detailing to thwart the forces of climate and gravity. Maintaining historic solid masonry requires scrutiny of existing conditions, thorough knowledge of its construction and a commitment to get it right. JNIBS

ABOUT THE AUTHOR: Frank Rosario, *AIA, is a Project Manager at Trivers Associates with 40 years of professional work in building construction and materials, including experience in new, renovation and adaptive re-use projects for corporate and institutional clients. He holds a B.A. in Architecture from Washington University and is a member of the Association for Preservation Technology.*

"Building Skin Care: Tips to Maintain Historic Masonry Walls" by Frank Rosario was published in the Winter 2018 issue of the *Journal of the National Institute of Building Sciences (JNIBS)*, a publication of the Washington, D.C.-based National Institute of Building Sciences. The article has been reproduced here with permission from the publisher. Learn more about JNIBS at **http://www.nibs.org/?page=journals**. Subscription information is available at **https://www.nibs.org/?journaldigital** and **https://www.nibs.org/?journalprint**.