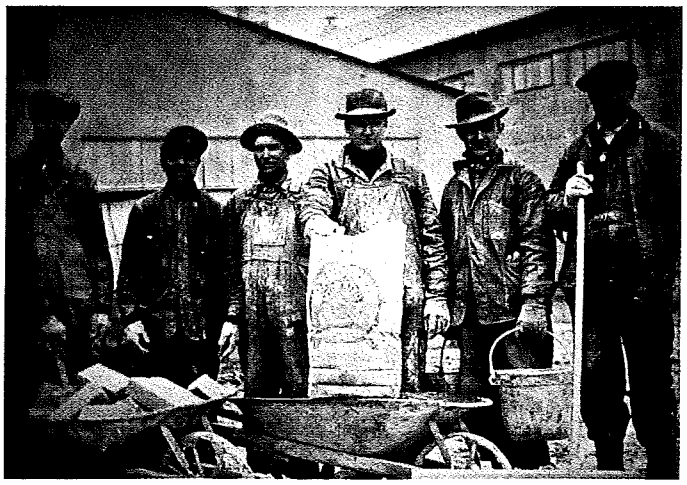
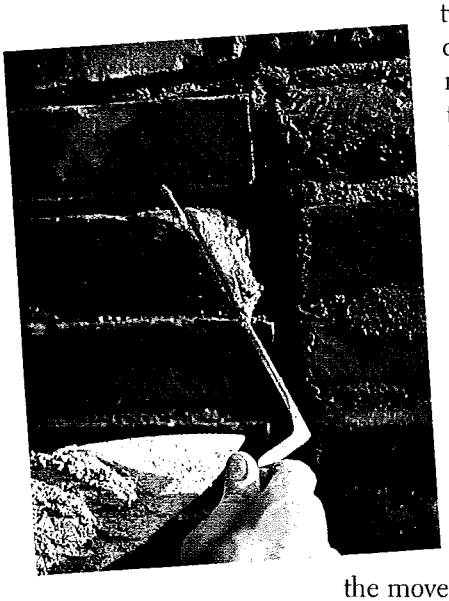


Why Using Modern Mortar Can Damage a Historic House

BY JOHN P. SPEWEIK

REPOINTING RIGHT

THESE DAYS, MASONRY MORTAR comes as bags of premixed powder. Much like baking with a cake mix, you just add water and stir. What you won't read on the bag or learn at a home center is that putting modern mortar between old bricks can be a recipe for disaster. The mortar can crush old masonry and can cause severe moisture problems. Let's review the properties of historic masonry so you can select compatible materials for your old house.



Before you can repoint, you have to determine the right mortar mix to match the existing mortar's color and the hardness of the brick.

Sacrificial Lime

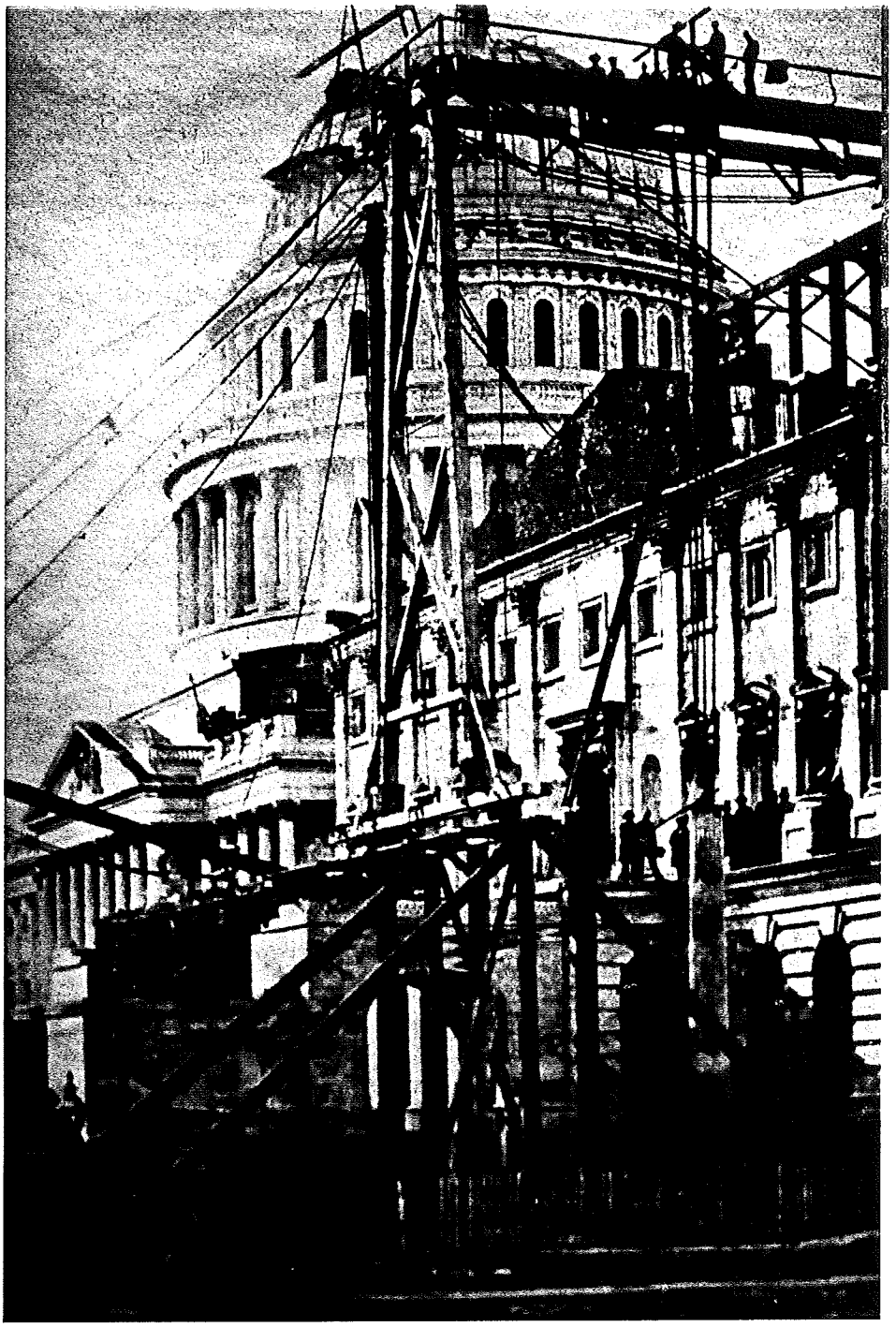
WHETHER YOU'RE REPOINTING A masonry chimney, porch, foundation, or whole walls of an entire house, the mortar must be softer than the brick or stone that it bonds. When masonry expands and contracts during temperature changes, the softest areas absorb the movement. Mortar should also be the easiest exit for moisture inside the building. That means it must be more porous than the masonry units so the potentially damaging water will move through the mortar, not the brick or stone. Mortar, in essence, is sacrificial; it yields to protect the bricks, which is partly why it needs to be repointed every century or so.

Old mortar, made from lime, sand, and water, is softer than historic brick. But modern portland cement mortar can be many times harder. The problem is, if portland cement is used for historic masonry, the bricks become the weakest part of the system. When the wall flexes with climatic change, the bricks absorb the force. This stress can crack, chip, and delaminate the brick. Plus, portland cement mortars do not breathe like lime mortars. Moisture may get trapped in the wall or may be forced into the masonry units. To judge what is right for your old masonry, take a look at the chronology of mortar.

Like a Rock

THE OLDEST ARCHAEOLOGICAL SITES IN THE world are, of course, masonry. From the Egyptian pyramids to the Roman Coliseum, masonry has long been used for civilizations' most important buildings. So we know more about the history of masonry construction than about other, less durable materials.

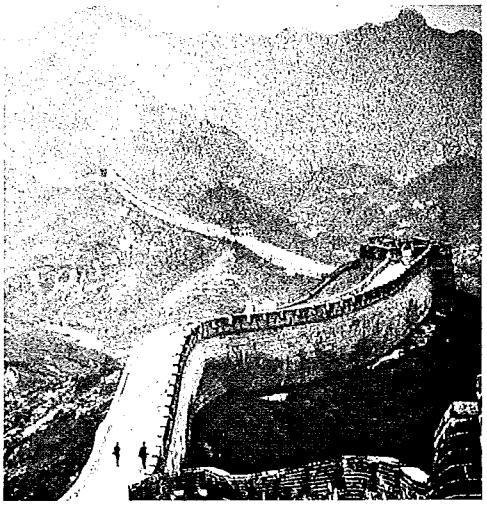
PHOTOGRAPHS COURTESY OF JOHN SPEWEIK UNLESS OTHERWISE NOTED; COURTESY OF GENLIME GROUP (INSET); BY JILL BYLUND (LEFT)



Initially, stone was bedded in mud, used primarily as a lubricant for heaving stones into place. Then builders began to find materials that produced strong mortars: first gypsum (a mineral now used in plaster and drywall), then clay. As early as 2450 B.C., masons began using lime.

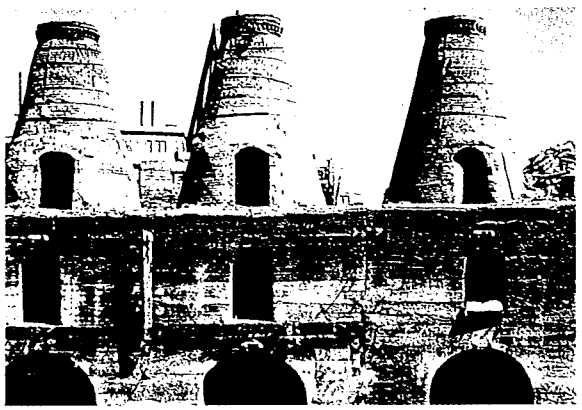
Lime is made from limestone (calcium carbonate), a rock formed from organic materials such as shells and coral. (In fact, oyster shells were also a source of lime for coastal masonry.) The limestone is heated in a kiln to at least 1,650° where the heat drives off carbon dioxide and water, turning limestone into calcium oxide. When you mix lime with water, and it absorbs carbon dioxide from the air, it essentially turns back into limestone.

Historians speculate that ancient civilizations discovered lime when they happened to line their firepits with limestone. After many fires, the limestone turned to lime. Its beneficial qualities must have been apparent when the lime was inadvertently combined with water. Eventually builders figured out that lime made strong mortar when mixed with an aggregate, such as sea shells, clay, or river sand.



Above: The Union Army stood guard as the Capitol was built (with lime mortar). Left: Lime was used in the architecture of ancient Rome, Greece, and Mexico, and in the Great Wall of China. Inset (opposite): Workers pose with their product at a lime plant in Ohio in 1925.

PHOTOGRAPH (GREAT WALL)
COURTESY OF THE NATIONAL LIME ASSOCIATION



Top: The first portland cement factory opened in England in the 1820s. It was the 1870s before portland was manufactured in this country. Above: Kilns burn lime, clay, and other minerals to form portland cement.

Made in America

FLASH-FORWARD TO THE PERIOD when North America's oldest extant housing was being built. The lime manufacturing process had been refined and, by the late-19th century, industrialized. Limestone was mined and burned in hundreds of kilns across the country, then delivered fresh to the construction site in sealed wooden barrels.

This factory-made lime, though, was a far cry from today's ready-to-use mortar. It still had to be *slaked*, combined with water so hydroxides are formed—a caustic chemical interaction which gives off considerable heat and actually causes the mix to boil. The wet lime was left to mature in a pit or wooden box for at least two to 12 weeks, sometimes a year.

Slaking wasn't the only inconvenience for the builder. Laying bricks and stones with lime-based mortar was time-consuming because it cured slowly. A mason might lay only seven to eight courses of brick per day because the lime mortar would not support any more weight without drooping until it began to set.

Portland Trailblazer

MASONS HAD ALWAYS ASSUMED THAT THE best lime came from the purest limestone. That began to change in the early 19th century. In 1824, the English bricklayer Joseph Aspdin patented a formulation of lime and additives that sped the curing process. He named his mix portland cement because it resembled the color of a widely used stone quarried on the island of Portland, off the English coast.

Portland cement consists of specific proportions of limestone, clay, and other minerals fired at more than 2,600°. This firing creates a hard, rocklike material, which is then ground into a fine powder and mixed with 5% gypsum. Portland cement rehardens when mixed with water.

For generations, masons believed portland cement was not as strong as good old-fashioned lime mortar. Very small amounts were imported from Europe, but American

PHOTOGRAPHS COURTESY OF PORTLAND CEMENT ASSOCIATION

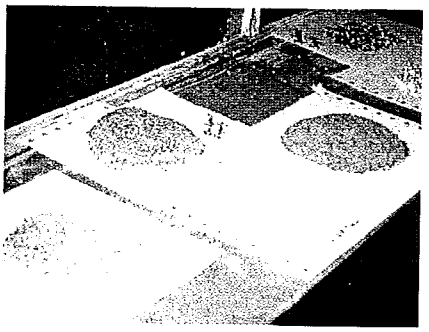
THE RIGHT STUFF

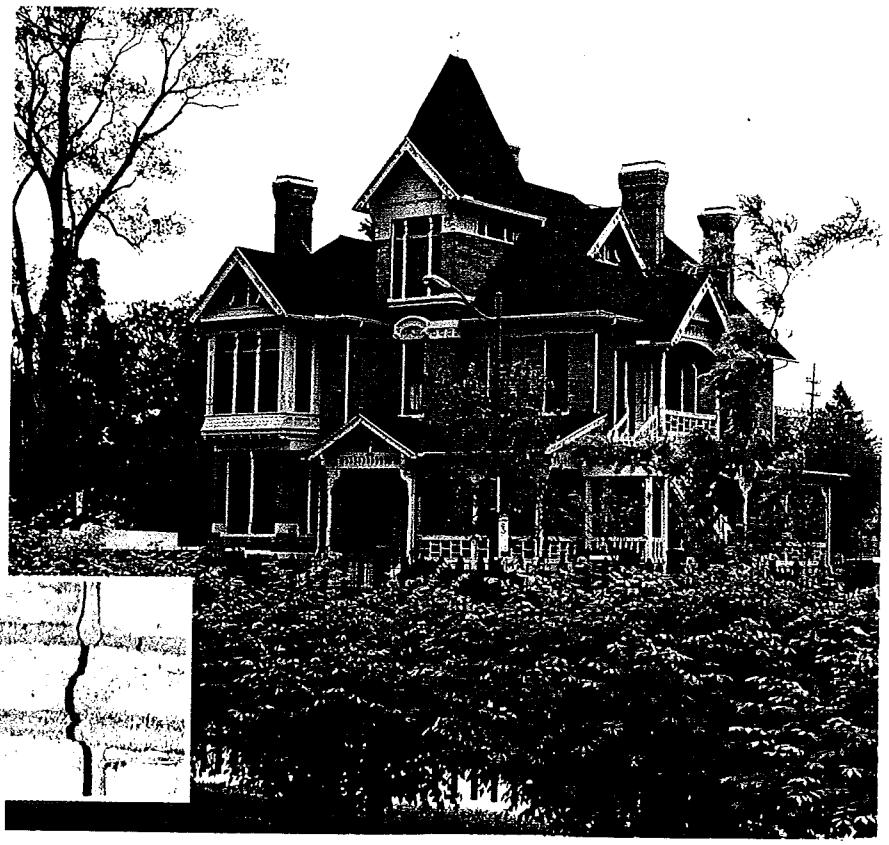
If your old house was built between the 1880s and 1930s, how can you tell what mortar is right? Your mix must meet two criteria: it must be softer and more permeable than the masonry units and it must match the original mortar still inside the walls; inconsistency can cause shifting and trap moisture. The easiest way to insure both criteria is to analyze the existing mortar and reproduce it.

- Investigate the old mortar as you remove it. Lime is pure white, but portland cement is grey (although you can get white portland cement for restoration use).
- Note the way the mortar comes loose. If it dislodges easily with a screwdriver or masonry chisel, it's likely made from lime, or a high lime mix with portland cement. If it's very hard and stubborn, it probably contains a high volume of portland cement.
- Carve a hole in a sound mortar joint with an old penknife. If you can make a hole—even if it's difficult—the mortar is all or mostly lime. If you cannot make a hole, the mortar contains a significant amount of portland cement.
- Take a chunk of solid mortar and drop it on a sidewalk. If it falls with a dull "clunk," it's a high-lime mortar. If it hits with a sharp "ring," it has a lot of portland cement. Next try to crush the mortar. If it falls apart in your hand, it contains a lot of lime. If it breaks under a hammer, but does not crumble, it contains a lot of portland cement.
- Try wetting it and then crushing it in your hands. Lime mortar may break down in water, or a vinegar-and-water solution. If it's portland cement, it won't come apart. A muriatic-acid-and-water solution will separate mortar (see "Color by Numbers," p.50).

Getting a read on mortar may be difficult for an inexperienced repointer. For an absolute determination, send a sample to a laboratory for analysis, where they use petrographic methods (looking at particles under a microscope) or chemical techniques (testing the mortar against a battery of chemicals). For large-scale repointing projects, this cost is relatively small.

Of course, you can also hire a restoration mason or consultant to come on site and investigate. Otherwise, err on the side of soft mortar. Better to have high-lime mortar between machine-age bricks then to have too-hard mortar between soft bricks. The risk is you'll need to repoint sooner—a dilemma that's far preferable to cracked or moisture-damaged masonry units.





Above: Remove some sound mortar to test it. Right: A laboratory has separated mortar into its components. Below: Brick is a beautiful and durable building material, but incompatible mortar can crack it (inset).

PHOTOGRAPHS BY JILL BYLUND

Very few older buildings require complete repointing. Spot repointing is safer, cheaper, and conserves the original building materials.

MORTAR GLOSSARY

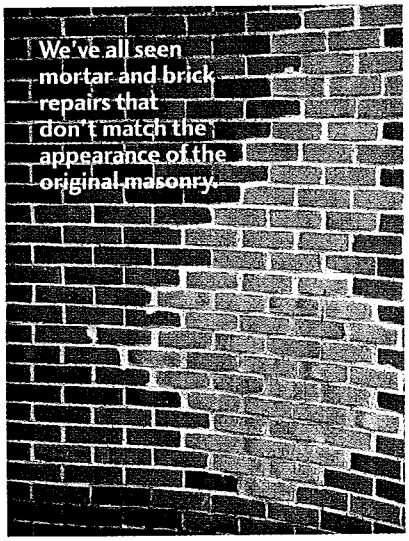
HYDRATED LIME: Today's machine-slaked lime has just enough water to act on the lime, but is still a powder. Hydrated lime was invented in the 1930s to compete with portland cement, which required no slaking.

LIME PUTTY: Slaked lime that has a putty or paste consistency. Increasingly, restorers are turning toward lime putty over dry hydrated lime. Putty re-creates original materials, and bonds better to sand particles than hydrated lime.

MASONRY CEMENT (MORTAR MIX): Premixed, bagged mortar, which contains portland cement and generally sand. It usually does not contain lime, but may include inert additives such as fly ash or ground limestone. This is the easiest product to find and to use, but it's not recommended for any historic masonry.

QUICKLIME: Processed but not hydrated lime. It is made by firing limestone or shells at more than 1,650°. It requires slaking, which causes extreme heat and may splash the caustic material as it boils. (If you're slaking your own mortar, wear a protective suit, gloves, and goggles.) Once it's slaked, lime putty should be allowed to mature for as long as possible before mixing into mortar.

SLAKED LIME: Lime that has been combined with water to prepare it for mixing into mortar. Traditionally, that means lime putty. Modern hydrated lime is mechanically slaked through pressure.


We've all seen mortar and brick repairs that don't match the appearance of the original masonry.

COLOR BY NUMBERS

Matching the color and texture of original mortar is very important for an aesthetic job. Most conservators shun mortar dyes because they can fade and appear splotchy. Better to match the sand and other original ingredients (including clay, lampblack, iron oxides, crushed brick, and powdered coal).

You can analyze mortar to see what components it contains. Fill a mason's jar ¼ with a solution of 3% muriatic acid and water (use proper precautions when working with this acid). Put a handful of old mortar in a cloth and pulverize it with a hammer. Place the crushed mortar into the jar, without the lid, and allow it to bubble. When the bubbles subside, add one cup of water to stop the reaction. Dirt will float to the top and sand will remain on the bottom. Slowly pour the entire mixture through a paper coffee filter. Allow to dry. Then note color and size of the sand particles and other materials used in the original mortar.

builders generally continued to use a straight lime-sand mixture. With the development of compression testing near the turn of the century, the industry realized portland cement was indeed much harder.

Portland cement was first manufactured in America in 1871 in Lehigh Valley, Pennsylvania, but its use did not become truly widespread until the 20th century. As late as 1883, there were only three portland manufacturers in the U.S. If your home was built before 1880, it's a very safe bet that it has a straight lime–sand mortar. By the 1930s, most masons used a mix of equal parts portland cement and lime. In the transitional period, homes might be pure lime, or a wide range of lime-to-portland cement combinations.

Some restorers refuse to use portland cement mortars for any work, including new masonry. As we've seen, portland cement doesn't handle change in climate or structural shifting very well. Lime mortars are more pliable and forgiving. What's more, lime mortars are self-healing. If tiny cracks form between the brick and mortar, rainwater is absorbed into the space. This moisture dissolves minute amounts of lime in the hard mortar, rewetting it and allowing it to reknit. Portland cement mortar cannot reknit once it has cured.

Restoration masons, who specialize in eyeballing historic brick- and stonework, all have there own preferred mortar recipes. These vary by region, age of the building, and the mason's approach. If you're hiring masons to do the project, discuss the mortar mix with them. Armed with the information in this article, be sure they intend a hand-mixed, high-lime approach. Ask proportions they'll use and why. For folks doing the work themselves, you can use a number of testing procedures to evaluate your mortar (see p. 49), or you can hire a restoration consultant to recommend a mix, or even to make the mortar for you.

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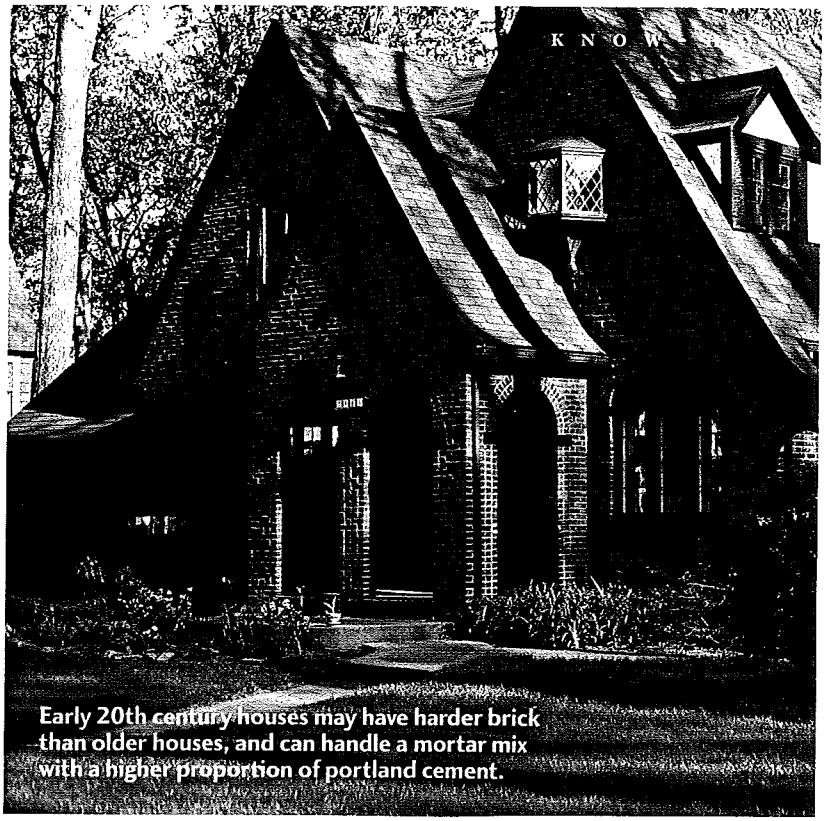

Early 20th century houses may have harder brick than older houses, and can handle a mortar mix with a higher proportion of portland cement.

PHOTOGRAPH BY JILL BYLUND

OLD BRICKS AND MORTAR

The best way to insure a good mortar mix is to reproduce the original mortar. You can also learn a lot by investigating the masonry units. Identifying the three recognizable types of historic brick can help you select a good mortar mix.

SOFT-MUD BRICK: Used before the industrial era (and in some areas through the 19th century), these bricks were made by hand-packing clay into wood molds, then firing in wood- or coal-burning kilns. The bricks are very soft and inconsistent and often have irregular edges. You can use a straight lime–sand mortar—1 part lime and 3 parts sand. Be sure to keep it covered and wet for 72 hours so that the water can carry carbon dioxide to the lime inside the joints. Many restoration masons add some portland cement to speed the curing process. A good range of recipes for soft-mud brick is 1 part white portland cement, 3 parts lime, and 10 to 12 parts sand.

PRESSED BRICK: In the mid-19th century in many areas, machines began pressing the clay into molds. Hotter kilns produced harder brick. The surfaces of these bricks may exhibit streaks from sand or water that was used as a separator. A pressed brick usually has a frog (an indentation in its bed), where a manufacturer might identify itself or date the brick. A good mortar recipe range is 1 part white portland cement, 2 parts lime, and 8 to 9 parts sand.

WIRE-CUT BRICK: By the late 19th century, extrusion machines worked dry clay and squeezed it out under high pressure, like a pasta maker. The resulting slabs of clay were cut by wires, in much the same manner as cheese. These bricks do not have frogs, but they may have holes through the bricks. Use 1 part white portland cement, 1 part lime, and 6 to 7 parts sand.