



TROUBLESHOOTING EXTERIOR MASONRY WALLS

By Michael Gurevich

The oldest construction materials were made out of clay. Three principal forms of clay are used: surface clay, fire clay, and shale. During the manufacturing process, clay is crushed, grinded, mixed with water, formed into a specified shape, and fired in the kiln. The brick industry employs three principal methods of forming brick: extruded, dry-pressed, and molded. Extruded and dry-pressed brick will have cores (holes) to make the firing process more uniform. Cores also save mass during the firing and shipment of brick. The molded brick is always solid but can have one depressed bed side, called the “frog.”

The heart of a brick factory is the kiln, where brick is fired under a temperature of approximately 2000 degrees Fahrenheit (1093 degrees Celsius). A contemporary brick plant has a tunnel kiln with a nonstop firing process. Older plants still operate beehive kilns with a periodic firing process.

Ferrous oxides, such as iron, magnesium, and calcium, form a brick's color during the firing process. Brick will either have a through-body color or a coated face such as glazed, clay coat, and engobe.

In the United States, clay brick is manufactured for different applications in accordance with the American Society for Testing and Materials (ASTM) specifications.

Facing brick is the most commonly used product. The modular brick size is 3-5/8" x 2-1/4" x 7-5/8" (90 mm x 57 mm x 190 mm). Eleven other brick sizes are also in use today.

Decorative brick shapes are available in standard and custom sizes to form certain architectural details such as water tables, arches, copings, and corners. Clay is a popular material that artists use to create brick sculptures and murals.

In Mexico and some southern areas of the United States, an adobe brick is made by a sun-dried molded mix of clay, straw, and water.

Normally, brick is packaged into steel-strapped cubes with openings for forklift handling. The modular brick size has 500 brick units in a standard cube.

To find a good match for a brick replacement, it is necessary to find exactly what kind of brick is being used. Extruded and dry-pressed brick will have perfectly cut edges with an industrial look. Molded brick will have a lip at the edge of a brick perimeter at the unfinished bed side. Molded brick units normally have a colonial appearance.

The next step is to match the size of a replacement brick. Try to stay within the common brick sizes and no extra fee will be charged for the replacement brick units. If odd brick sizes are required, prepare to pay extra dollars for them. A custom-size brick production will require a minimum of 30 to 50,000 bricks in the run.

Most important is to match a color and a texture of a replacement brick. Do not rely on the manufacturer's color catalog cuts for the color representation. Even a good quality color printing will not provide actual brick color appearance. Find the actual brick samples and compare the samples with the existing brick appearance right at the building site. Make sure that the brick sample is not older than 12 months.

The color of the mortar joints for replaced brick masonry should have a perfect match. Twenty percent of a brick wall area built with the standard modular brick size is covered by mortar joints. The color of the mortar joints has a substantial influence on the appearance of the brick color.

Mortar for a brick replacement or a repointing of the mortar joints should be weaker or equal to the existing mortar. The mortar shall have a proportion specification

for the mortar not stronger than the type “N” (Brick Institute of America [BIA] M1-88 Specs) as follows:

| | |
|-------------------------|---------|
| Portland cement | 1 part |
| Hydrated lime, type “S” | 1 part |
| Sand | 6 parts |

The mortar mix should have no additives. Masonry cement should not be allowed for the mortar mix.

Contractors often use waterproofing additives in the mortar mix for repointing. This can limit the breathing ability of the mortar joints and could trap moisture inside. Later, freeze and thaw cycles can deteriorate the moisture-saturated mortar joints. Therefore, waterproofing additives are not recommended for mortar mixes used for the repointing of brick masonry walls. A good reference publication on restoration and mortar joint repointing of brick masonry walls is the *BIA Technical Note on Brick Construction #7F*.

The use of salvage brick is not recommended for brick replacement at the exterior walls. When the brick masonry was originally installed, a bond was developed between the brick units and the mortar joints. The brick unit initially was installed over the bed of mortar and absorbed the mortar’s moisture and cementitious particles within the first 45 to 60 seconds after an installation. The cementitious roots filled the pores of the brick unit, and an original extend of bond was developed, which pro-

vided weather resistance for the brick masonry wall. The old brick masonry could have a very good bond between brick units and mortar joints.

Contractors can clean the brick surfaces that were in contact with mortar joints, but it may be next to impossible to remove cementitious particles from the brick unit pores. The pores of salvaged brick units are partially or completely filled with the original mortar cementitious particles, and if the salvaged brick is installed into the new masonry wall, there will be no more room in the pores of the salvaged brick units to absorb the new mortar’s cementitious particles. Thus, the bond between the salvaged brick unit and the new mortar joint will not be completely developed, and the new masonry wall will leak through the joints between the brick units and the mortar joints.

Most authorities on masonry construction agree that water penetration through masonry walls results from the incompletely filled mortar joints and incomplete bond between brick and mortar. That is, water penetrates through flaws at joints rather than directly through the brick and mortar. Thus, masonry walls of salvaged brick, with their inferior mortar bond, are likely more susceptible to water penetration and weaker under lateral loading than similar masonry of walls constructed of new brick units. The salvage brick could be used for interior walls or for the walls protected from

weather without any problems.

Old brick masonry walls should be evaluated from the structural engineering point of view. Walls can be load bearing or can carry their own weight only. If roof rafters or floor joists are resting on a brick wall, it is a load-bearing wall, and a structural engineer should evaluate the wall conditions.

Solid masonry walls have an exterior wythe called brick veneer that normally is constructed from the face brick. The inner wythes of a wall are called the backup. The backup part of the wall is constructed from brick or terra-cotta units. More recently, cinder block or concrete block walls have been used for the backup part of the masonry wall. The brick veneer is anchored to the backup wall system with brick headers. A common wall has five or six courses of stretchers built with a running bond pattern and one course of headers embedded into the wall backup system. The Flemish bond pattern also has been used for the brick veneer, consisting of alternating stretchers and headers. Invisible diagonal headers are used to anchor the brick veneer with the running bond pattern only.

For replacement of brick veneer today, it is not economical to use real brick header courses. Thus, the stainless steel masonry ties like “Helifix” can be used to anchor the replaced brick veneer to the existing wall backup system.

Vertical, diagonal, and horizontal cracks in brick walls should be properly evaluated.

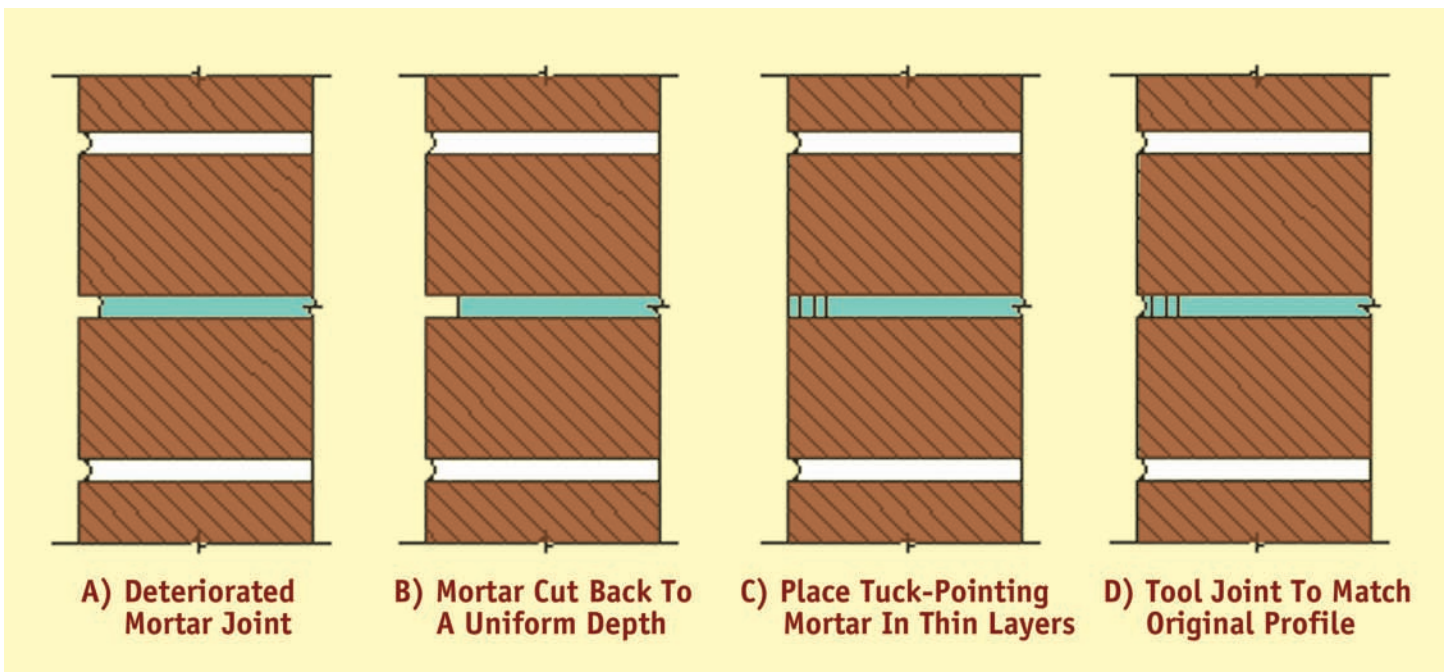


Figure 1: Tuck-pointing mortar joints. (Courtesy Brick Industry Association, Tech Note 7-F.)

| Effects of Moisture Penetration | Sources of Moisture Penetration | | | | | | | | | |
|----------------------------------|--|---|--------------|------------------------------|--|---|----------------|--------------------|---|--|
| | Previous Acid Cleaning See Technical Notes 20 Revised | Previous Sandblasting See Technical Notes 20 Revised | Plant Growth | Deteriorated Sealants/Caulks | Missing/Clogged Weepholes See Technical Notes 21B | Incompletely Filled Mortar Joints See Technical Notes 7B Revised | Capillary Rise | Broken/Loose Units | Different Movement See Technical Notes 18 Series | Missing Flashing See Technical Notes 7 Series |
| Efflorescence (See TN 23 Series) | ● | | ● | ● | ● | ● | ● | ● | | ● |
| Deteriorated Mortar | ● | ● | ● | | | ● | ● | ● | | |
| Spalled Units | | ● | | ● | ● | ● | ● | | ● | ● |
| Cracked Units | | | | ● | ● | ● | ● | | ● | ● |
| Rising Moisture | | | | | ● | | ● | | | ● |
| Corrosion of Back-up Materials | ● | | | ● | ● | ● | ● | ● | ● | ● |
| Mildew/Algae Growth | ● | | | ● | ● | ● | ● | ● | ● | ● |
| Damaged Interior Finishes | ● | | | ● | ● | ● | ● | ● | ● | ● |

Table 1: Possible effects and sources of moisture penetrations. (Courtesy Brick Industry Association, Tech Note 7-F.)

The vertical or horizontal displacement in the crack could give a clue to where the crack originated. Expansion cracks are actually natural expansion joints and should be treated as expansion joints.

Brick masonry normally has moisture expansion and thermal expansion/contraction. This expansion and contraction is absorbed by the brick veneer expansion joints. Along the perimeter of the building, the horizontal bend of the brick veneer located above the top floor windows normally will experience moisture and thermal movement. The brick veneer could expand from the middle of the elevation towards corners and could cause cracks at the building corners. The moisture expansion of a 50' brick veneer wall could be calculated with the Brick Institute of America (BIA) following the formula: $0.0005 \times L = 0.0005 \times 50' \times 12" = 0.30"$ or approximately $1/4"$.


The moisture expansion behavior of the clay brick depends primarily on the raw materials and the brick manufacturer's firing temperatures. The moisture expansion of the clay brick is an irreversible process and most expansion takes place during the first few years. However, the expansion will continue at a much lower rate for the remaining life of the building. The original brick veneer had moisture expansion within the first few years after completion. When

the walls are repaired, the new brick veneer will start to have moisture expansion. Vertical and horizontal expansion joints should be provided between the replaced part of the brick veneer and the remaining brick veneer at the exterior walls. Thus, the replaced part of the brick veneer will be able to move independently from the original brick veneer and limit the number of new cracks.

Many buildings were erected at the turn of the 20th century in the U.S. with non-load-bearing, solid brick masonry walls. Due to age, the solid masonry walls had a tendency to absorb a substantial amount of rainwater. Because of gravity and capillary action, this moisture could migrate down within the brick masonry wall, and be accu-

mulated at the top of steel spandrel beams. Spandrel beam flashing could deteriorate, causing rusting of the steel spandrel beam and cracking of the solid masonry wall supported by this spandrel beam. Additional rainwater could enter the wall system through new cracks and could enter the interior of the building, causing water staining and interior damages.

The author's company developed a new drainage system that could be installed at the top of spandrel beams protecting the steel beams from rusting and eliminating water penetration into the building interior space. This system was installed and successfully tested at a number of projects. The cost of this system installation is approximately \$100 per linear ft. of the wall.

Cleaning of the old brick masonry walls is a very complicated process. A power wash with clean water could destroy the mortar joints or a sand finish at the brick faces. The water pressure at the wall surface should be limited to 400 psi. A chemical solution should be applied over the completely saturated (with clean water), brick masonry wall. Thus, the chemicals will work at the brick surface only and after rinsing with clean water, chemicals will be removed from the wall surface. The best reference publication on the cleaning of brick masonry walls is the BIA *Technical Note on Brick Construction #20*. For information from the Brick Institute of America, phone 703-620-0010. 

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Michael Gurevich's professional career spans 35 years and two continents. He earned structural engineering degrees in Minsk before emigrating from the U.S.S.R. in 1980. Afterwards, Gurevich worked in New York City for structural engineering and architectural firms. Since 1985, he has been involved with exterior masonry wall problems only. During the last 18 years, Gurevich has presented brick masonry technical seminars to over 1,400 groups, and is now associated with the New York City Brickwork Design Center of the Brick Industry Association (BIA). For further information on these seminars, call 212-684-4229.