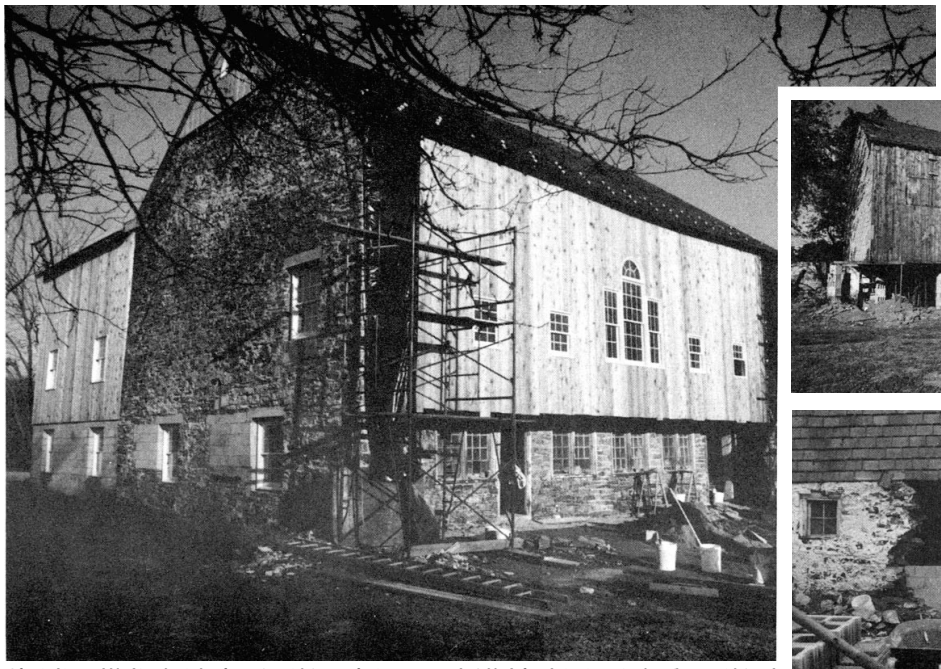
Repairing Stone Foundations



After jacking and blocking the timber frame (top right), new footings are poured. A block foundation is put in place (bottom right) and the original stones are used again to face the wall. The frame is eventually lowered back down.

Correct the cause, not just the symptoms, for lasting stone foundations

by Brian Murphy and Andy deGruchy

In our line of work, we repair or restore stone foundations and above-grade walls, either independently or together on the same project.

Many of the barns in our area in Bucks County, PA., date back more than 100 years, and some go back to the 18th century. While some continue to serve as barns, others have become workshops, homes, and even office buildings. They are called "bank barns," because on one side an earthen embankment leads to the second floor. Most of the barns have 18-inch-thick stone foundation walls that rise as much as 8 to 10 feet above grade on the downhill side and are even with grade on the uphill side (see Figure 1 on next page). The timber-frame wall plates are usually laid on top of the wall in a bed of mortar. When these walls fail, it usually shows up as a bulge in the middle of the foundation wall. Sometimes, a portion of the wall will lean or actually fall away. Occasionally, the entire wall will lean. (It's not unusual to find a combination of these symptoms). Cracks usually accompany these failures as well, but if a crack develops by itself, it is not necessarily cause for alarm.

Finding the Cause of Movement

When we come on a job, the first thing we do is to determine the cause of the problem. Unless the underlying cause is corrected, the damage could reoccur. Water is often to blame. In the case of a bank wall failure (the wall built into the hill), we look to see if gutters are missing. We also look to see if the land around the structure slopes away from rather than toward the wall. Bank barns are typically oriented north to south, with the eastern bank on the north side. If the bank becomes saturated, the repeated freezing and thawing will heave the stone wall. This in turn can push the floor joists and create a corresponding bulge in the framed forebay wall – the wall at the opposite end of the barn – and the foundation wall below it.

Sometimes the gable-end walls move. The problem here is usually that the mortar has eroded in the base of the wall because of improper drainage or underground springs. The problem may also result from tree roots.

To evaluate the severity of the problem, we have to determine the rate at which the wall is moving. Occasionally the owners have taken measurements, which helps. But we usually need to do the detective work ourselves. For example, if a post has been placed against the wall years ago, and its imprint is in the plaster, you can measure the gap to gauge how much the wall has moved since the post was installed. The same is true if a block wall has been built recently abutting the stone wall; any separa-

Figure 1. *A Pennsylvania bank barn gets its name from the earthen embankment on one side. This design allows ground-level access to both the first and second floors. Stone foundations and stone walls are common.*

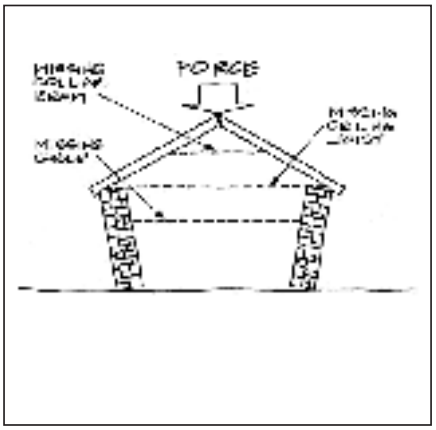


Figure 2. *Missing collar ties, ceiling beams, or other framing components stress not only the frame, but also stone walls and foundations.*

tion can be seen. Sometimes there has been no apparent movement for years; the wall might have stabilized. If the foundation has been whitewashed or stuccoed, you can look for signs of movement. If the wash or stucco that fills a crack shows no sign of further cracking, the movement may have stopped. We recommend no corrective measures on stable foundations.

Even if foundation repair is all we plan to do, we must inspect the entire frame of the barn for joint failures, water damage, and to see if any important structural components have been removed (see Figure 2).

It's important not to mistake an intentionally sloping stone wall for one leaning out of plumb. Some walls have been designed to lean on one or both sides (see Figure 3). If you look at the foundation only from the interior of the barn or house, you may only partly understand a unique wall design and the builder's intention.

Jacking the Frame

To work on the foundation, the frame must be jacked up to give clearance. (For a list of recommended tools see "Equipment for Stone Foundation Repair," page 31.) Even if the frame is intact, jacking it to make foundation repairs can stress joints. To avoid damage during jacking, we temporarily righted the frame using slings, chains, and come-alongs. While doing this, we look to see where the load is carried in the area of the foundation failure. If it is above the weakened foundation section, frame damage may have occurred there. For the most part, the weight in a timber frame structure is almost always transferred straight down through the posts, so we jack below the sill plates under the posts.

To lift the structure, we make holes in the foundation directly below the pressure points. We then insert a 10- to 12-foot I-beam. Cribbing, concrete blocks, or braced posts support one end, and the other end is jacked to lift the frame. Sometimes we do this in a couple of places simultaneously, very slowly, with at least one person up in the frame listening to and watching it for signs of failure. We use 4- to 12-ton hydraulic jacks placed on 1/4-inch steel plates for stability. As we jack, we shim safety posts under the I-beams in case of a problem with a jack.

We determine what height the sill plate should be by sighting down walls at plate level and eyeballing where the foundation is sagging. Or we shoot heights with a sight level. If we meet too much resistance, either because the frame has taken a set or because someone has built onto the frame after it settled, we stop jacking.

Dismantling the Foundation Wall

With jacking completed, we install safety supports so everything is stable, and we start to dismantle the stone wall. This is usually easy, because the mortar, which can be anything from pure dirt to a soft high-lime-content mortar and stones, can be easily pulled out or popped loose with crowbars. We separate the stones as they come out of the wall into four piles:

- Rubble – the mortar and very small stones that are not reusable;
- Face stones – nicely shaped with at least one good face;
- Corners - preferably large, rectangular stones with a good running face and an end face;
- Filler stones – irregularly shaped stones for filling in the interior spaces of the wall with mortar.

Since we relieve pressure from the wall only where it has failed, the stonework farther along the foundation remains tight from the pressure of the frame.

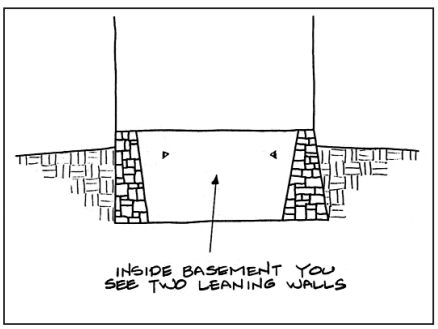


Figure 3. *Two common types of stone foundation walls appear to be leaning, but they are in fact designed with a slope for added stability.*

Working Below Grade

We dig footers down below the frost line. In one or two cases, we've used small backhoes. But since one bad move would dislodge the shoring for the structure and cause a lot of damage, we usually go at it with picks, shovels, and digging bars. We've encountered foundations that stop just below grade, but most go down a couple of feet below grade. Although we sometimes compact soil with a gas-powered jack-rabbit tamper, we're careful not to work ground water up to the surface.

Then we pour a footing. The footing should be twice the thickness of the wall and 6 to 8 inches deep. We use two parallel runs of 1/2-inch rebar – evenly spaced and near the center of the concrete – the entire length of the footing to replace it. When spanning soft soil, we pour a deeper footing and two go in halfway between the first set and the top of the footing.

Sometimes a rebuild is necessary because tree roots have penetrated the wall, causing extensive damage. When there is upheaval from tree roots, we remove the tree, stump, and roots. Then we wait a day or two. If the wall starts to ease down again and appears as if it might drop the rest of the way, we shore the wall up, pour concrete in the hole, let the concrete cure, and work the wall down. Finally we point it up. If the wall won't come down, we do our shoring routine and set up for a foundation rebuild (see Figure 4).

Equipment for Stone Foundation Repair

For Jacking and Stabilizing

- 10- to 12-foot 1-beam
- 1/4-inch steel plates
- 6x6 posts or 8-inch block shoring
- Slings, chains, come-alongs

For Dismantling and Cleanup

- Pick
- Short-handled, pointed shovels
- 3- and 5-foot digging bars
- Crow bar
- 12-pound sledge hammer
- Wheelbarrow and buckets
- Steel stone rake, flat shovel, dust pan, and broom

For Concrete Work

- Measuring tools
- Saw for forms
- 4-foot level
- Magnesium float and stone rake to tough finish

For Stonework

- 4- to 6-pound stone-dressing hammer
- Striking hammer, or 3-pound small sledge
- Brick hammer
- Wide-heel block trowel
- Small pointing trowel
- 1-inch and _-inch slicker or margin trowel
- Mixing tub with at least a 3x2-foot base
- Hoe
- Hawk, wire brush, fine dust brush
- No. 2 round shovel for sand
- Smooth parging trowel
- 5-gallon buckets; three sand, one cement/lime, one water, one junk
- Braided nylon string, utility knife, pencil, and piece of keel
- Plumb bob
- Garden-pump-style sprayer for curing wall

Miscellaneous Materials

- 11/4 -inch concrete nails
- 8d double-headed form nails
- 1/2-inch roofing nails
- Dovetail wall ties
- 4-mil sheet plastic
- 3/8- and 1/2-inch rebar

- A.D.

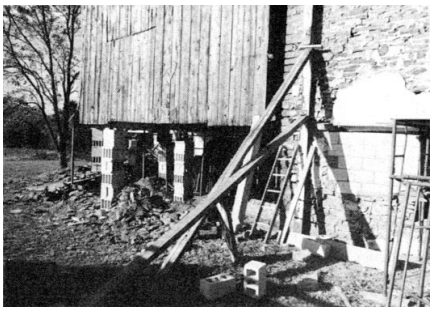


Figure 4. *Shoring existing walls ensures that they are not damaged by stresses caused by work on nearby areas.*

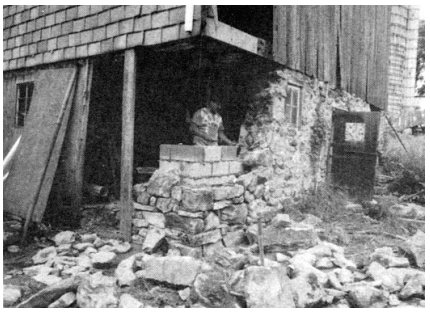


Figure 5. When working in a corner, drop a plumb line from the corner of the frame to a masonry nail set into the footing. Then, run strings horizontally to the existing stonework and blend in the new section of wall.

Rebuilding the Wall

When rebuilding the 18-inch-thick walls, we lay one of the following:

- All stone;
- A course of 8-inch block and a 10-inch stone veneer;
- A double course of 8-inch block.

If we are working on a corner (see Figure 5), we drop a plumb line from the corner of the frame and set a masonry nail into the footing. We start building the corner, either in block or stone, and run string lines horizontally to the existing stonework so that we can blend in the new section of wall. We bring the inside and outside of the new wall up evenly.

For the first course, we lay a full bed of "mud" and choose the flattest stones. The mud should be stiff enough to press into a ball and wet enough to smooth down between stones when pressed with the tip of a trowel. We measure out ingredients for mortar. We use three 5-gallon buckets full of clean, sharp, well-graded bar sand and one 5-gallon bucket filled 3/4 with portland cement and 1/4 with hydrated builder's lime. For block work we use one part portland cement, one part lime, and four parts sand.

We sometimes tie the block into the existing stone wall by driving 3/8-inch rebar through it and into spaces in the existing wall. We tie the rebar into the stone veneer with dovetail ties. When we are two courses from the top, we fill the cores of the block with a mix of one part portland cement, two parts sand, and three parts pea gravel (mixed with enough water to make it flow) to give the wall a uniform mass. This adds stability. Finally we parge the side of the block that will be in contact with the soil and dampproof it, usually with tar.

It's important to lay stones so they would remain in place even if no mortar were used. Don't think of mortar as a "glue" to hold stones in defiance of gravity. Over time, gravity wins. Stones should be laid two over one or half-bonded as in brickwork, with no continuous vertical joints. Using a stone that extends the total thickness of the wall, we tie in every third or fourth course. Mortar and small stones, chips, and shims fill all voids in the wall as it goes up.

Our crews complete only 3 vertical feet of wall a day. That allows the work to set for the next day's work. Otherwise it could topple if mud and stone skid out from under the weight of new stonework above. It's necessary to cover each day's work with plastic and dampen it the next day with a hose on a pump-type garden sprayer.

We build the wall to within an inch of where we have determined the finished height to be.

We cut out mortar joints to a depth of 3/4-inch each day. Then, at the end of the job, we point the entire foundation up to a 1/4-inch recess from the face of the stone. By doing the final pointing all at the same time, we ensure a more uniform mortar color. This is particularly important if the stone will remain exposed.

You can point as you go and wire-and dust-brush finish it at the end of each day. If you do point as you go, the stiffer the mud, the cleaner the pointing will be. If the old wall is stuccoed, we stucco the new wall to blend in. If we put block on the inside of the new wall, we plaster the block, sometimes whitewashing to finish.

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When you are getting ready to lower the structure again, jack the frame 1/4 to 3/8 inch and pack under the sill plate with crumbly stone-laying mortar. We do this quickly. Then we slowly release the jacks simultaneously, so that the pressure on the new wall is even. Properly done stonework (built as if no mud were used) will distribute the weight evenly due to its interlocking design.

We then install perimeter drain lines before backfilling and make sure that the grade slopes away from the barn. If the building lacks gutters, we either install them or highly recommend that the owner does.

When we're done, we have a wall that ought to stand another hundred years – and longer if not tampered with. ■

Brian Murphy and Andy deGruchy both repair stone foundations in Bucks County, Pa. Brian Murphy's company, Murphy Barn Restoration, Ottsville, Pa., concentrates on the timber-frame "bank barns" of Pennsylvania, which all have stone foundations. Andy deGruchy's company, deGruchy Masonry, Quakertown, Pa., concentrates on homes with stone foundations and stone walls.