BUILDING A REINFORCED Concrete Block Wall

I've worked as a mason for 31 years and have kept things interesting by taking on the most unconventional and technically challenging projects I can find, whether in repair, remodeling, or new construction. Recently I did a massive high-end residential job that fit that description well.

by Mike DeBlasio

The project called for two gable-end reinforced masonry walls that would perform an unusual structural function: provide the support necessary to offset the centerlines of two large masonry chimney flues that traveled as far as 8 feet horizontally from the fireplaces they served. This unique arrangement allowed the chimneys to pass through the roof centered on the ridge. The floor and roof framing would also depend on the masonry for structural support, from both sides of the walls.

These functions would place the walls under

Solid grouting and a hefty rebar schedule turn a unit block wall into a monolithic shear wall

not only vertical compression, which unreinforced masonry can handle in spades, but also lateral stresses, which it cannot. Another major concern was wind-loading, which took on added importance because of the walls' size and height.

Regardless of its specific application, reinforcing a block wall to resist lateral and tensile stresses follows the same general, prescriptive steps, which I will cover in this article.

Winter Work

The blockwork was on the critical path; the floor and roof framing could not be completed without it in place. After we built one wall to the next floor height, we removed our scaffolding to allow floor framing to proceed. Meanwhile, we moved to work on the other gable. We started work in the middle of winter and ultimately performed about half of this job under winter conditions.

Figure 1. Completely grout-filled block cells are revealed in a cut made to widen an opening following a change order.

We began by staging both sides of the wall with pipe scaffold and enclosing the perimeter with translucent, fireproof tarps. (Regular poly sheeting, like the blue tarps used everywhere else and commonly used to enclose work areas, is highly flammable and poses a serious risk to workers. Back when I was an apprentice, I witnessed a blue poly tarp enclosure go up in a flash, ignited by an open-flame heater. The crew was fortunate not to have been inside at the time.)

We bridged the span between the staging with "putlogs" — steel scaffolding beams made for this purpose — then decked it over solid with planks, plywood, and more fireproof tarps. This temporary roof completely covered the work area and prevented the tarps from sagging under rain and snow loads. We kept the enclosed area comfortable with propane heaters, which run clean and are easy to maintain.

To protect the sand and cement — not to mention the laborers mixing the mortar and grout — from extremely cold weather, we also set up a heated mortar shack adjacent to the enclosure. Because the construction specifications prohibited all use of winter additives in the mortar and grout, we heated the sand and water prior to mixing. We used an electric-powered 400-pound-capacity Imer mixer (800/275-5463; www.imerusa.com) to eliminate the fumes otherwise produced by a gas-powered mixer. Thus set up, the masons worked through snowstorms and below-freezing temperatures in safety and comfort.

Building a Monolith

Block lay-up began at basement level over a poured concrete footing that measured 36 inches wide by 12 inches thick. Since the footing was placed by the foundation contractor over both undisturbed grade and compacted fill, it was reinforced with various sizes of horizontal rebar. We set L-shaped 18-by-36-inch #5 rebar ties every 16 inches o.c. to coincide with the block cells, connecting the block wall to the footing. The rebar became locked in later, when we grouted the block cells solid (see Figure 1).

Concrete masonry unit (CMU) walls are relatively simple assemblies that rely on mortar to bond the blocks together and light-gauge welded wire that runs horizontally every other course to control the development of shrinkage cracks. A long run of masonry wall should also include a vertical expansion joint every 20 to 30 feet, to absorb the aggregate wall shrinkage and resultant cracking.

Solid grouting of block cells and steel rebar is normally used only in limited areas — vertically at building corners and at large wall openings, and horizontally in bond beams along the top of a wall. A bond beam helps tie the wall together as a structural unit and spread the floor or roof load evenly throughout the blockwork. This basic method creates a reinforced concrete "post-and-beam" framework that's filled in with unreinforced hollow masonry units.

The basic expectation for a conventional, minimally reinforced CMU wall is that it will support a distributed load with redundant compressive strength.

Masonry Shear Wall Details

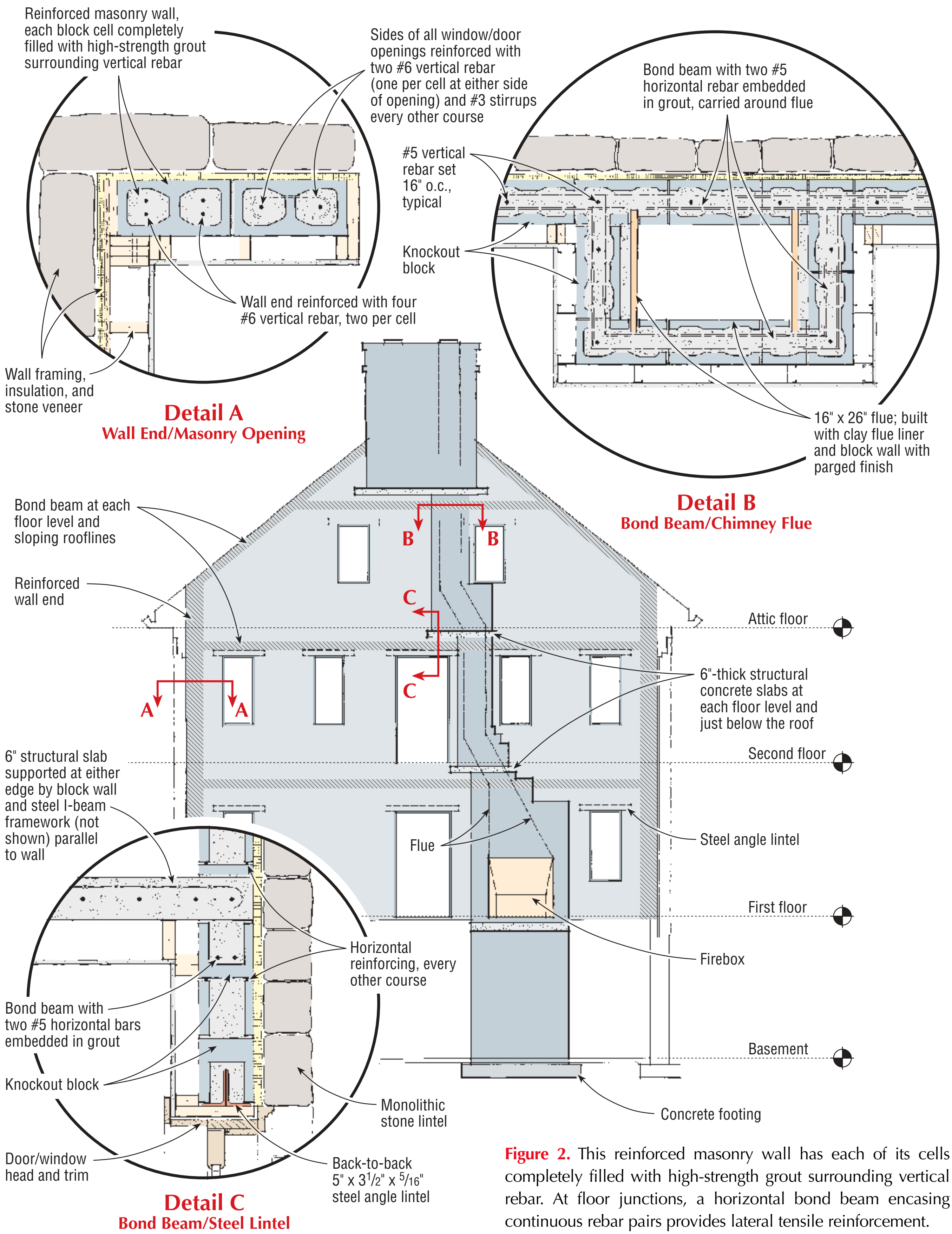

Figure 2. This reinforced masonry wall has each of its cells completely filled with high-strength grout surrounding vertical rebar. At floor junctions, a horizontal bond beam encasing continuous rebar pairs provides lateral tensile reinforcement.

But such a wall has virtually zero tensile strength and therefore can't resist lateral loads or serve as a shear wall. To perform as a shear wall, concrete masonry must be not only built as described above, but also systematically reinforced with steel rebar, with all cells fully grouted. That way, it becomes in effect a monolithic whole, similar to a reinforced cast wall (Figure 2, previous page).

On this job, the walls rose three stories and measured 37 feet long by 49 feet high at the ridge (plus another 12 feet to the chimney tops), with an 8-inch-thick core and a final thickness (including the stone veneer) of about 16 inches. In addition to several window and door openings, oversized fireplaces and flues interrupted each gable to one side of center (Figure 3).

Figure 3. This massive block wall rises three stories from the basement level where it begins. LVL beams anchored into bond beams at each floor level support the joists, while the wall studs are nonbearing. One of the off-center fireplaces can be seen at lower left.

Placing the Rebar

Just prior to grouting a lift, we set the vertical rebar, allowing it to stand 18 to 24 inches higher than the last course of block (Figure 4). This short projection provided sufficient overlap between lifts while still allowing us to lower the block over the rod without too much difficulty. Tie-wire has no reinforcing effect in unifying separate bars; a good overlap is all that's needed.

The vertical rebar schedule called for #5 bars set 16 inches o.c., with four #6 bars set two per cell at the wall ends

Figure 4. A simple overlap in the vertical rebar is all that's needed to provide continuity between lifts. The next course of block can then be lowered over the projecting rods without too much interference.

Figure 5. Stirrups bent from #3 rebar unify the effects of individual bars. Here, the stirrups circle two vertical rod pairs at a wall end, ensuring they will work in concert after the assembly is encased in concrete.

and at either side of every window and door jamb. Additionally, we used #3 stirrups at every other course, 16 inches apart vertically, to reinforce the sides of all openings. Stirrups cause individual rods to work together, increasing their reinforcing effect (Figure 5, previous page).

To consolidate the grout in the cells, we used an Oztec rebar shaker (Figure 6). This tool (800/533-9055; www.oztec.com) has interchangeable heads for various rebar sizes — #6 and #5 rebar, in our case — and works extremely well. We found that it takes two to run the shaker: one person to hold and operate the vibrator, and another to control the head on the rebar. It's a great tool: You can watch the grout puddle right into place. No more hand-shaking rebar for this crew.

At each floor level and at the sloping rooflines, we incorporated a bond beam, using KO block to create a continuous horizontal form (Figure 7). The bond beam contained two #5 horizontal bars embedded in grout, one to each side of the vertical rod. We carried the bond beam around the chimneys, front and back, thus ringing them with rebar (Figure 8).

Bucket Brigade

In typical "high-lift" masonry wall construction, it's most common to lay block to the full height of the wall, then pump grout into the cells from the top down. Because dropped mortar and masonry debris can build up in the cells and block the grout's passage, inspection and cleanout ports are incorporated at or near the bottom course to ensure complete filling. But the various openings, lintels, and intermediate bond beams on this job, along with the fireplace construction, made that approach impractical. Instead, we did the grouting in 3- to 5-foot lifts, which allowed simple, top-down inspection. We moved the grout from mixer to wall in 5-gallon buckets (Figure 9, next page).

Thanks to the volume of job-mixed, 3,000-psi grout needed to completely fill

Figure 6. A rebar shaker quickly consolidates the grout in the cells, ensuring complete filling and embedment while saving time and labor.

Figure 7. The walls between cells in standard 8-inch blocks are kerfed half-height with a masonry blade to create knockout (KO) panels. A course of KO block allows rebar to be completely embedded in grout to form a bond beam.

Figure 8. The chimney flue interrupts the bond beam running through the block wall at each floor level. To ensure the continuity of the load path, the bond beam encircles the flue.

Figure 9. It took more than 30 yards of grout, passed up in buckets, to fill the block shear walls.

Figure 10. To end up in the center of the ridge three stories up, the flue has to stairstep nearly 8 feet laterally (above). A series of structural pads, one at each floor, provides support for the stepped construction. A hand-laid herringbone brick pattern lends an artful touch to the fireboxes (left).

the block cells, the crew members had their hands full. It took as much time to set steel and pour grout as it did to lay the block. On average, we had four or five masons and four to six laborers working on this job. In all, we used six tons of #6 rebar, 10 tons of #5 rebar, and three-quarters of a ton of #3 stirrups. And we mixed and poured 30 to 35 yards of mortar, grout, and concrete.

Stepped Chimney Construction

The most complicated aspect of the two walls was the fireplace and chimney construction. The large fireboxes required 16-by-26-inch flues. Each firebox was located 8 feet off the gable walls' midpoints, which meant that the chimneys had to be progressively offset, floor by floor, by that distance to break through at the roof ridge (Figure 10). One flue moved not only 8 feet laterally along the wall, but also 2 feet through the wall.

Shifting a chimney this distance goes well beyond the supporting capacity gained from a graduated corbeling of the block courses. Instead, we poured 6-inch-thick structural concrete slabs at

Figure 11. A steel frame, offset from the block wall but tied into it, supports the flue mass at each floor level.

Figure 12. Shear anchors and rebar provide a mechanical connection among the steel, concrete, and masonry elements of the chimney. Cement board made a good leave-behind form for the slabs supporting the flue. Insulation wraps the flue tile to allow for thermal expansion.

each floor level and just below the roof. Above the first floor, we reduced the chimney dimensions to minimum size to squeeze past window openings in the wall above. But above the roofline, the chimneys expanded again to finish at approximately 4 by 6 feet, which required a final structural slab just below the rafters.

The structural slabs were supported at either edge by the CMU wall and a W10x22 steel I-beam framework standing parallel to the wall and supported on high-strength steel columns (Figure 11). Smaller, W8x18 I-beams running between the CMU and the main I-beams bordered the slab ends. Shear anchors welded to the I-beam webs locked the steel to the concrete, while rebar set in the slabs and grouted into the masonry completed the tie-in.

We formed the underside of the slabs with cement board. Although plywood is typically used in this application and later removed, cement board works well as a leave-behind form. It's smooth, fireproof, and completely compatible with masonry. Our use of leave-behind forms made it simple to pass the flues through

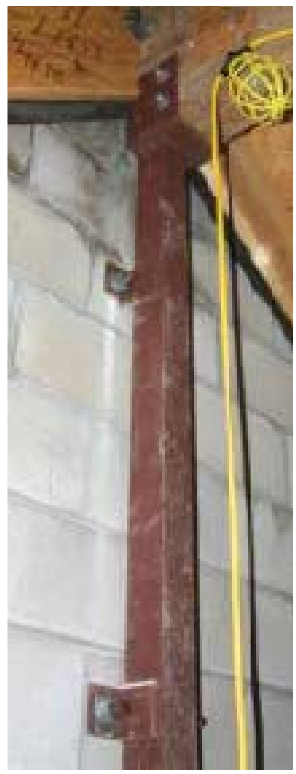

Figure 13. Epoxy-set Hilti HIT anchor rods secure LVL floor girders to the masonry. Asphalt felt provides a capillary break between wood and concrete (above). At right, a saddle-top steel post supports the ridge of a lower roof abutting the masonry gables.

Figure 14. Galvanized steel lintels will support the exterior stone veneer above window openings. The lintel is bolted to the solidly grouted blockwork using epoxy-embedded anchor rods (right). Short lengths of steel lintel stairstep up the gables to support the finished stone veneer (below).

the slabs as needed; cement board cuts easily with a small diamond wheel on a grinder (Figure 12, previous page).

The lower flange of the steel I-beam supported the cement board. To prevent the board from sagging under the weight of the pour, we temporarily propped the undersides of the largest slabs, which measured approximately 8 by 10 feet. The conventional 30-inch-wide hearth slabs required no additional shoring.

Bolting Into Block

To attach the floor framing to the masonry on the interior side, we relied on Hilti's HIT epoxy adhesive anchor-bolt system (Figure 13, previous page). The anchor bolts (800/879-8000; www.us.hilti.com) are especially convenient because you can drill directly through the material that is being fastened into the block without having to remove it to expand the holes in the masonry, as with other anchoring methods.

Exterior Stone Veneer

We used that same Hilti fastener system on the exterior side to mount bearing lintels for the stone veneer above window openings and on the cheeks above lower rooflines (Figure 14). Because building wings extended out under lower rooflines from both masonry gables, we had to provide a means to support the heavy stone veneer on the cheeks above these roofs. We installed short lengths of galvanized steel angle to the blockwork, stairstepping up the roof slope much like step flashing. An orange-colored, rubberized spray-on coating protected all exterior-facing blockwork from moisture penetration, although copper flashing will still serve as the primary barrier against water intrusion in the completed installation.

When this job is completed, we'll have applied approximately 300 tons of stone veneer to the exterior walls, a process I'll discuss in a future article.

Mike DeBlasio *owns and operates M. DeBlasio Inc. in Littleton, Mass.*