BRACING FOAM-SHEATHED WALLS

Though let-in 1x4s and metal straps are commonly used to brace foam-sheathed walls, they can't equal the strength of structural sheathing

by Paul Fisette

All building codes require that walls be braced to resist racking caused by wind loads (see illustration below.) Most *prescriptive* codes recommend one of three options: 1x4 diagonal bracing, 5/8-inch diagonal board sheathing, or 3/8-inch plywood sheathing. Other more progressive *performance-based* codes specify minimum design values for racking resistance, but let you achieve them with almost any materials you choose. For example, you can count the combined contributions of metal strapping, drywall, interior partitions, and ceiling diaphragms.

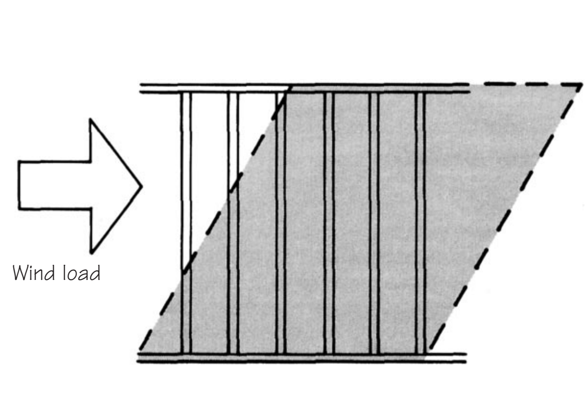
Some foam sheathing manufacturers point to these performance-based measures as proof that a foam-sheathed wall meets code. It's true that with the right floor plan, wall dimensions, and number of wall openings, an unsheathed or foam-sheathed wall might comply with code. But bear in mind that most code officials will require the builder to prove that such an alternative wall bracing system meets the requirements. Usually this means that an engineer must stamp the plans.

For conventional buildings (not those in high-wind or seismic zones), prescriptive bracing codes are based, in large part, on a Federal Housing Administration (FHA) interim standard that dates back to 1949 (a permanent standard was never introduced). This standard established 5,200 pounds as an acceptable level of racking resistance for wood-framed walls. This force does not easily translate to a typical wind speed. Rather, the 5,200-pound base load equals the racking resistance provided by wood-framed walls, sheathed with horizontal boards and braced by 1x4 let-in bracing — a common construction practice in 1949.

Certainly, 1x4 let-in braces have worked well in the past. Older homes built with such bracing have a good track record. But usually these braces are used in conjunction with plywood or board sheathing. Questions arise when you build without structural sheathing.

In this article I will examine four common bracing systems for walls with nonstructural sheathing — 1x4 let-in bracing, metal bracing, diagonal stud bracing, and plywood corners. While builders often turn to let-in or metal braces as substitutes for structural sheathing, neither research nor mathematical calculations support the use of either in unsheathed walls. Using these bracing systems probably won't result in catastrophic failure, but it may result in a steady stream of callbacks for such things as drywall pops, cracked stucco, and windows that bind.

Racking in Frame Walls



Wind loads will cause an unbraced wall to rack, which can cause wall and ceiling finishes to crack and doors and windows to bind.

Let-In Doubts

In 1977, Roger Tuomi and David Gromala, engineers with the U.S. Forest Products Laboratory (FPL), in Madison, Wis., studied let-in bracing. The increased use of nonstructural insulated sheathing during the energy crises of that decade concerned the researchers. Tuomi and Gromala learned that much of a braced wall's racking strength is due to the interaction of board sheathing and let-in bracing. Tuomi and Gromala found that even the clear, straight-grained 1x4 let-in braces used to support their unsheathed test walls provided less than two-thirds of the 5,200-pound value specified by the FHA standard. The #2 Common 1x4s typically found on the job site can hardly resist comparable loads.

Common-grade 1x4 stock is not structurally graded; it is graded only for appearance. Garden variety braces made from #2 Common 1x4s can have 2-inch-wide red knots. That means almost 60% of their cross-sectional dimension is nonstructural. Add to that the structurally weak cross-grain region surrounding the knots and you have a recipe for failure at low-level loading.

In 1983, Ronald Wolfe, another FPL research engineer, evaluated the structural contributions of 1x4-let-in bracing and metal strap bracing in wall systems. According to Wolfe, "off-the-shelf" #2 boards provided only 600 pounds of resistance to horizontal loads, such as those from wind, before failing. According to this test, it would take nine 1x4 let-in braces (without sheathing) to provide the FHA minimum 5,200 pounds of lateral resistance in a wall.

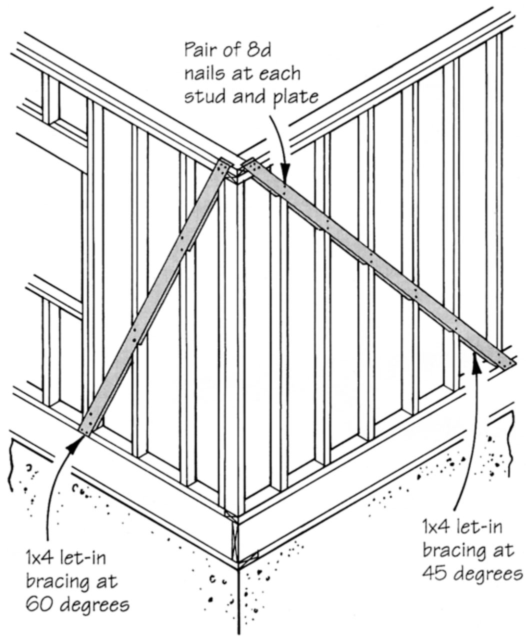
It's worth noting that typical design values for structural members carry a 2.5 factor of safety. Applying this to Wolfe's findings means that 1x4 braces can only muster 240 pounds of design strength. Also, Wolfe's braces were installed at a 45-degree angle in the wall. Braces installed at a 60-degree angle or greater provide far less resistance.

Metal Bracing

Several manufacturers of rigid foam insulation recommend the use of metal bracing when building foam-sheathed walls. However, the product literature depicting this practice may be misleading. Tests conducted by both FPL's Wolfe and Simpson Strong-Tie indicate that metal bracing alone does not meet the FHA minimum standard of 5,200 pounds.

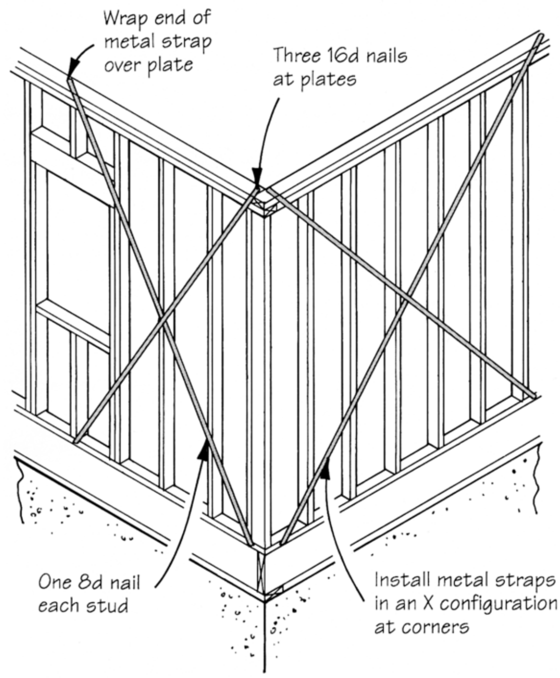
According to Wolfe, a metal strap brace delivers 1,500 pounds of lateral resistance. Simpson Strong Tie assigns an even lower value to

Let-In 1x4 Bracing



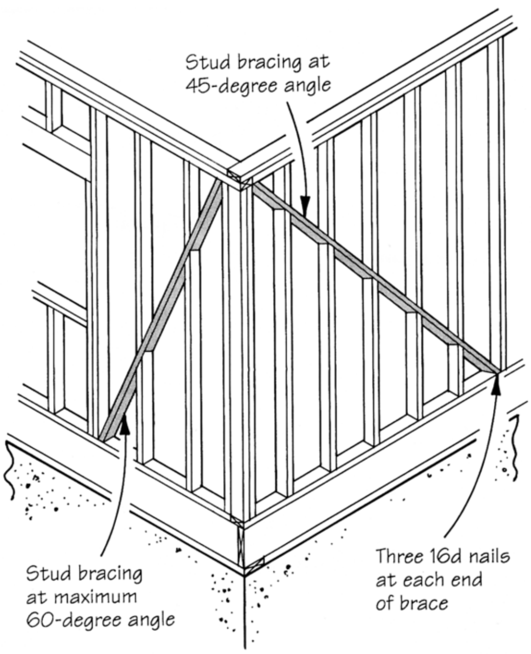
Let-in braces *gained code approval at a time when board sheathing was standard on all homes. With modern plywood sheathing, such let-in bracing is not necessary. With no sheathing or foam sheathing, research indicates that let-in bracing alone does not meet current design values. Where 1x4 braces are a part of your bracing system, use top-grade material, nail each brace with a pair of 8d nails in each stud and plate, and keep the stud spacing to a minimum of 16 inches on-center.*

Flat Metal Bracing



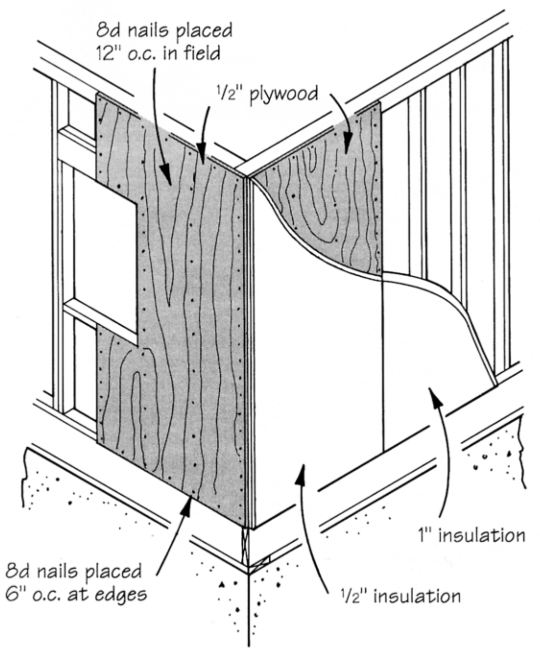
Metal braces *are intended only for temporary bracing during construction, not as a replacement for structural sheathing. Flat metal bracing only resists in tension. To resist wind loads in both directions, install the straps in an X-configuration, and wrap the ends over the top plates to keep the nails from pulling loose. Metal T-bracing is installed in a saw kerf in the stud. This type of bracing provides some resistance in compression, but not enough to replace a structural skin.*

Diagonal Stud Bracing



Diagonal stud bracing *is time-consuming to install but offers adequate racking resistance. For maximum strength, braces should be installed between a 45- and 60-degree angle and extend in one unbroken length from top plate to bottom shoe. Cut the studs to fit around the brace in the same way studs are installed under a sloping gable end.*

Plywood Corner Bracing



Plywood corners *offer adequate racking resistance. For best results, brace at least two opposing corners in each wall and fasten the plywood with 8d nails, spaced 6 inches at the edges and 12 inches in the field. If the wall has several windows or doors, also brace with plywood around the openings.*

metal braces, even to their more substantial T-shaped bracing. Simpson Strong-Tie's product manual clearly states that metal wall braces prevent walls from racking during construction and are not designed to replace load-carrying shear wall components.

In testing, metal braces usually fail due to the nails slipping. So it's the size and number of nails in each brace that determine the design values. Wolfe's metal straps were wrapped over the top and bottom of the wall frame to minimize nail withdrawal.

Also, flat metal braces offer no resistance to compressive loads. So they must be installed in an X configuration at each building corner to resist lateral wind loads from all directions. This guarantees that one leg of the bracing will always be in tension.

Diagonal Stud Bracing

Diagonal stud bracing is a seldom-used but effective wall bracing system that deserves consideration when building foam-sheathed homes. With this technique, studs run diagonally at the corners within the wall cavity. The depth of the brace is perpendicular to the face of the wall.

This technique was once commonly used to brace stuccoed and plastered walls against cracking, but it has been largely abandoned by modern builders since it takes more time. For maximum strength, braces should be installed at a 45-degree angle and extend in one unbroken length from top plate to bottom shoe. Vertical studs are cut to fit around the continuous diagonal brace in the same way studs are installed under a sloping gable end.

This type of stud brace only works in compression, so braces should run in opposing directions from the top plate to the sole plate at each corner. In a 2x6 stud wall spaced 24 inches on-center, a "construction grade" 2x6 brace installed at a 45-degree angle will resist a 5,400-pound design load — above the FHA minimum. This load is computed using design stress values, which include a built-in safety factor. Failure in compression would most likely occur at a much higher level, especially if you use stress-graded lumber.

Plywood Corners

Many builders brace foam-sheathed homes with plywood corners. Typically they install 1/2-inch-thick sheets vertically at the corners and overlay 1/2-inch-thick rigid foam. One-inch-thick foam is then used to sheathe the remainder of the house, leaving the exterior wall surface flush.

Each corner panel will resist an ultimate load of 3,120 pounds when nailed with 8d nails, spaced 6 inches at the edges and 12 inches in the field of the panel. With two opposing corners braced, a wall can resist 6,240 pounds, so it seems to work nicely. Drywall on the inside will add a measure of safety.

Drywall Contribution

Gypsum wallboard is without doubt the most popular interior wall sheathing used in light-frame construction. But rarely is wallboard given the credit it deserves when evaluating the structural integrity of a wall system. Its success depends on orientation. In Wolfe's study, 1/2-inch wallboard provided 150 pounds of resistance per lineal foot of wall length when applied vertically to an 8-foot-high wall, and 250 pounds per foot when applied horizontally. Studies sponsored by gypsum board manufacturers have yielded values as high as 660 pounds per linear foot. The Uniform Building Code recognizes a conservative 100 pounds per linear foot as a structural contribution.

Depending on the floor plan, some codes will also allow for bracing contributions from interior walls, provided the gypsum is fastened according to strict nailing schedules. However, this could be undermined by future renovations. No interior walls can be removed without disturbing the balance, much in the same way a truss can't be cut without interrupting the distribution of forces. While you may get some inspectors to approve such a design, it is much more prudent to rely on the strength of the exterior shell.

Window and Door Openings

Windows, doors, and garage openings will compromise any bracing scheme. Diagonal bracing in particular — whether it is let-in 1x4, metal, or stud bracing — works best at a 45-degree angle, and will add some resistance when installed at angles up to 60 degrees. But anything steeper is nearly worthless. This means that in any wall that relies on diagonal bracing, windows and doors must be kept 6 to 8 feet away from the corners for optimum bracing value. Any cutout for windows and doors also reduces the contributions you get from plywood and drywall. So regardless of the sheathing material you use, if you end up building a wall full of sliders and picture windows, or a second story over a two-car garage, have an engineer check your design. Otherwise you might have to repair more than a few nail pops and stuck doors. ■

Paul Fisette is a wood technologist and director of the Building Materials Technology and Management program at the University of Massachusetts in Amherst.