Building With Structural Foam Panels

Strength, speed, and energy efficiency make foam panels a close competitor to wood frame construction

by Steve Andrews

Builders who use structural foam panels cite a number of advantages: They say panels are stronger, more energy efficient, go up faster, and offer higher, more consistent quality than stick-built houses. Enough homeowners and contractors have been attracted to foam panels to bring regular annual increases in sales of about 25% to the industry, even during recent slow times.

Yet the majority of houses are still stick-built, in part because builders remain skeptical about foam panels. Is this skepticism healthy? Or are those who steer clear of structural stress-skin panels missing a smart building option?

After researching and writing about structural stress-skin panels for several years, I've found no single answer to this question. For some builders, panels are a great boon; for others, they're too limiting or not worth the extra expense. To decide for yourself, you need to consider your receptiveness to new materials, the types of houses you build, and the ease with which your crew can build stick-built systems that compare in energy performance to panels.

Sandwich Panels Vs. Unfaced Panels

There are two types of foam panels designed to carry residential and light-commercial structural loads: sandwich panels and unfaced panels with integral wood or steel framing members. (This article does not cover cladding or curtain-wall foam panels, which are routinely applied over post-and-beam framing.)

Sandwich panels. Structural sandwich panels account for most of the market. They usually consist of two wood facings — typically 7/16-inch OSB — adhered to foam that is 3 1/2 to 11 1/4 inches thick. Sometimes the inside is faced with wallboard, either alone or over the OSB.

This sandwich panel functions as an I-beam, with the facings serving as flanges and the foam as web. Despite the inherent strength of this system, roughly one in four manufacturers add integral studs, usually at panel joints; this approach is often taken to avoid battles with local code officials wary of the panels' lack of framing members. There are probably between 75 and 100 sandwich panel manufacturers in the U.S., and most produce about 30 homes a year.

Unfaced panels. Unfaced structural panels consist of slabs of precut foam notched to accommodate load-bearing metal or wood studs at 16- or 24-inch centers. Walls and ceilings are delivered to the job site in partially or fully assembled sections. Tied together with wood top and bottom plates, the wall components are either tilted by hand or craned into place. The largest producers of unfaced panels are based in Canada, though there are at least two U.S. manufacturers.

The Advantages

Builders and buyers cite four main advantages of structural stress-skin panels.

Speed. Sandwich panels replace three steps in standard construction: framing, sheathing, and insulation. Pop in the windows and you're warm and dry for the next trade.

The actual pace of construction will vary with panel type and size and house design. In general, the simpler the design — few ins and outs, and most or all dimensions in 4-foot increments — the faster it goes up. The more indents and popouts, the more delays.

With complex designs, you can regain some speed advantage if you order precut panels. These are more expensive, but save on-site cutting time. They work well as long as the folks in the factory don't mess up or the client doesn't want to change something between order date and delivery.

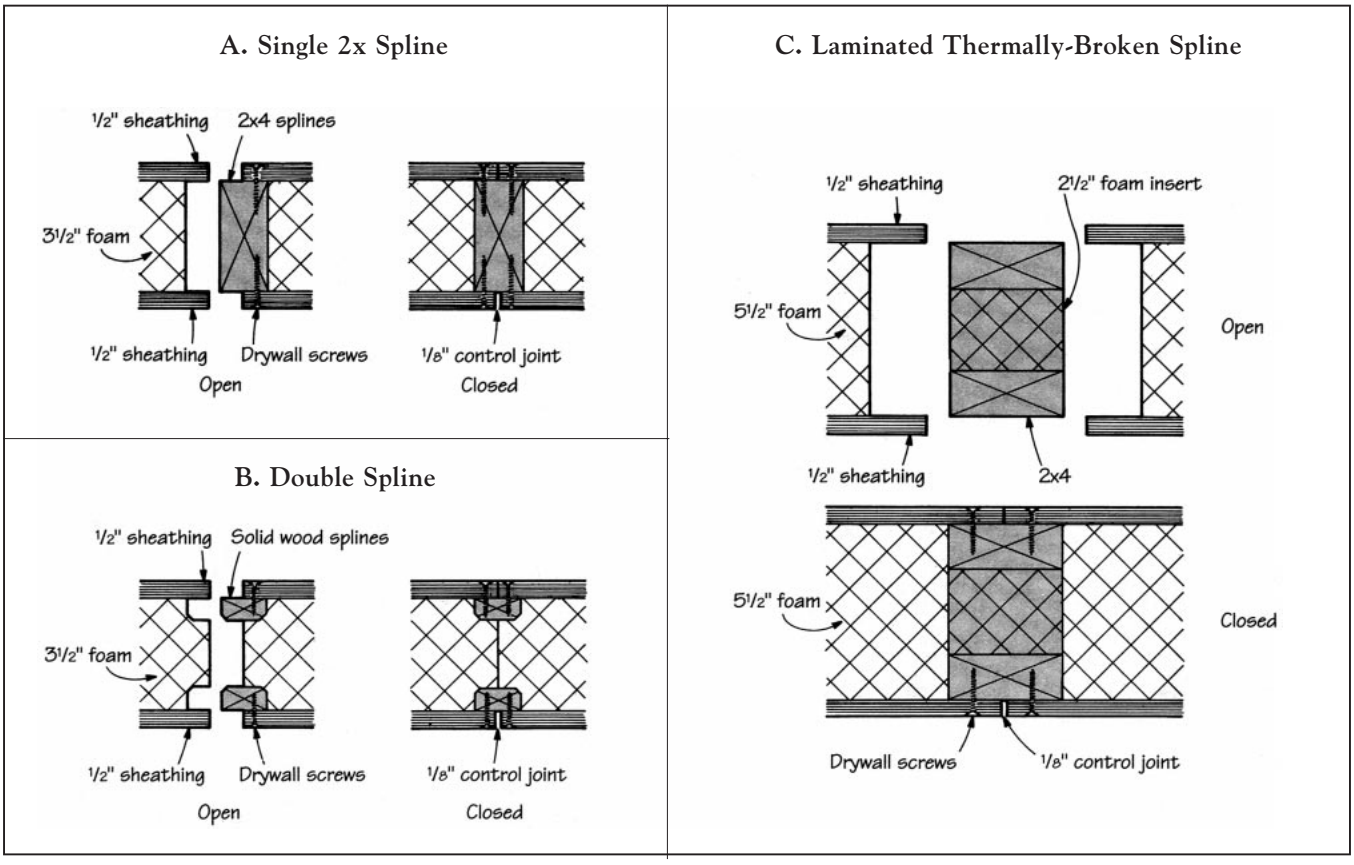
In general, the larger and fewer the panels, the faster the house goes up. Large unfaced wall panels are light enough to erect quickly even without a crane. The largest sandwich panels, however, require a crane, which, depending on the house, you might have to rent for one to three days.

In a fairly simple plan, using large panels — some as large as 8x28 feet — can speed up things enough to justify the cost of the crane. Yet with large custom homes that have a number of offsets, you may not have enough long wall surfaces to justify the use of a crane; in that case, you'd be better off building even the long runs with pieces small enough for your crew to handle.

A house composed of smaller sandwich panels, typically 4x8 feet but sometimes longer, can be erected by hand by crews of two or three in three to ten days. With a somewhat larger crew, you can put up considerably larger panels by hand; depending on labor costs, this can sometimes be the most cost-effective route.

Superior energy performance. Panels improve little upon well-built, super-insulated, stick-framed homes. However, panels clearly outperform the energy systems used by most production builders today. In the few legitimate side-by-side comparisons I know of, panel homes have had significantly lower heating and cooling bills than stick-built houses of similar cost.

It's not that stick-built houses



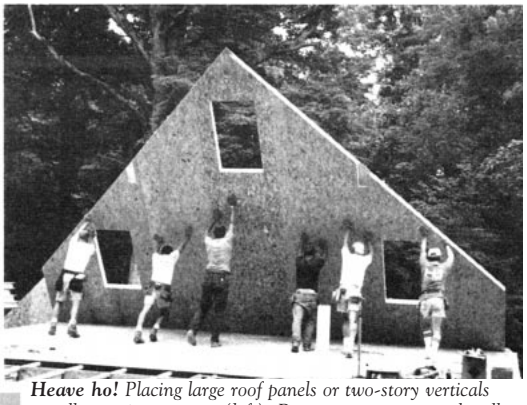
Panel joints. *Manufacturers have developed a dozen ways to connect panels, but three are most common: The single 2x is the simplest and cheapest(A), but slightly compromises insulation value. Thermally-broken double splines (B and C) add a little cost up front, but save energy down the line. All are easy to work with.*

can't be as well-insulated and tight as a stress-skin house; it's just harder to make them that way, for several reasons. For starters, foam panels contain their own gap-free insulation, at high levels. Foams used in panels provide between 25% and 100% higher R-value per inch than fiberglass does. Fiberglass batts give between R-3 and R-3.86 per inch. Molded expanded polystyrene (EPS) gives R-4 per inch, extruded polystyrene R-5, and urethane or polyisocyanurate both supply R-6.

Foam panels also have fewer seams to seal. They do require careful caulking, however, mainly along the seams above and below band joists, and along the tops of walls where one floor meets another.

Finally, most panel systems use very little dimensional lumber, reducing conductive heat loss through framing and infiltration around it.

Strength. When tested to failure, panels exceed minimum standards by huge margins, outperforming frame walls by factors of between two and six, depending on the test. This is underappreciated until a natural disaster strikes. There are several documented cases where panel homes have survived hurricanes, tornadoes, and even the 1989 San Francisco earthquake in good shape, while their stick-framed neighbors suffered serious damage.



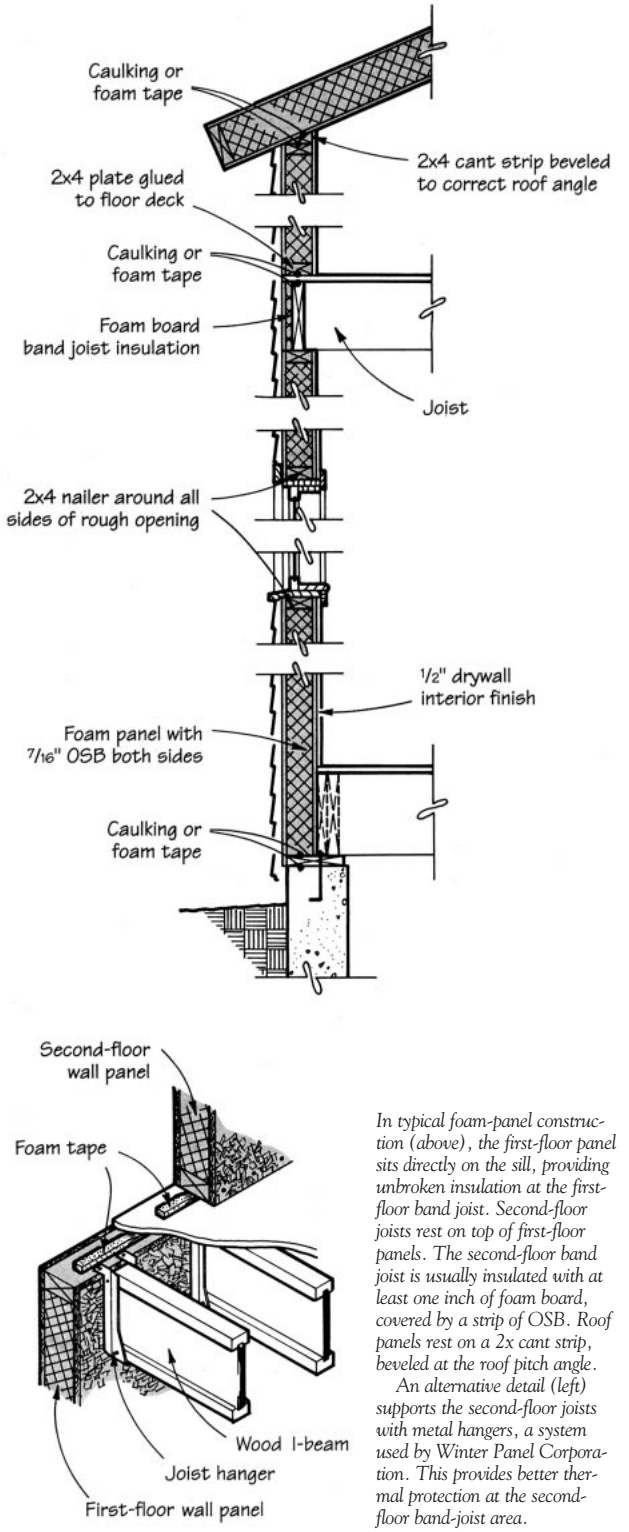
Heave ho! *Placing large roof panels or two-story verticals usually requires a crane (left). But a strong crew can handle some large panels, like this gable end, above, without a crane.*

Costs

When comparing panel house-shell packages against standard frame construction costs, make sure you price systems with comparable energy features. For example, a panel with a 5 1/2-inch EPS core or 3 5/8-inch urethane core should be compared to 2x6 framing with 1-inch rigid foam sheathing (R-23 or better).

When comparing different panel systems, you must again make sure you're comparing apples to apples. On the surface, the simplest approach would be to price panels by the square foot. Listed prices for 5 1/2-inch EPS panels from 16 manufacturers average $2.17 per square foot, ranging from $2.03 to $2.69. But some manufacturers may include certain items as standard — from shop drawings to an on-site factory rep — while others charge extra for them.

For example, the highest minimum price quote above ($2.69) is for panels and splines precut in the factory (gables, plumb cuts for roof panels, and window cutouts are



In typical foam-panel construction (above), the first-floor panel sits directly on the sill, providing unbroken insulation at the first-floor band joist. Second-floor joists rest on top of first-floor panels. The second-floor band joist is usually insulated with at least one inch of foam board, covered by a strip of OSB. Roof panels rest on a 2x cant strip, beveled at the roof pitch angle.

An alternative detail (left) supports the second-floor joists with metal hangers, a system used by Winter Panel Corporation. This provides better thermal protection at the second-floor band-joist area.

Stick Builders Size Up Panels

Contractors who try panel systems don't necessarily swear off stick building forever. But even longtime stick builders have found panels to be a great help on the right jobs.

Don Moody, a contractor since 1956, recently used panels from APC International for his retirement home on an island in Puget Sound. The home, a 2,700-square-foot two-story, went up in a tight spot, with no crane on site to help lift the 8x28-foot panels. The walls had 5 1/2-inch EPS cores, with floors and ceilings 7 1/4 inches thick.

When asked what he liked best about panels, Moody cited ease of construction. "We built the shell for about $11 per square foot of floor area, and that included factory precutting on a lot of ins and outs on walls, and complex roof intersections. It took one carpenter, my wife, and me nine days to put up all the walls and ceilings. On a normal site, where you could use a crane, it would have gone up in four days."

Over on the mainland, Mike Roberts (Cascade Energy Homes), a Bellingham custom builder for 22 years, put up his first panel home in 1990. Roberts said, "The system worked fine. There were a few problems stemming from the shop drawings — we had to fix some precut panels — but that was because it was our first home with panels."

Roberts has built quite a few well-insulated, airtight homes, so he was interested in tracking costs to make a comparison. He calculated that putting panels in the walls and floor of a 1,900-square-foot house cost an extra $3,000. It took his electrician about an extra hour to wire the house ("there was some messing around pulling wires through chases at the corners"), which he figures was fine for the first panel house. He had no problems with code officials.

Denver builder Gene Johnson (Johnson Homes), who has twice used panels for homes in the $200,000 to $800,000 price range, finds that panels compete well with stick framing unless a design has a lot of short offsets. "If you make minor design changes in a home to accommodate the panel, then panels are really easy to work with. It's a little slow for the first home, but after you figure out the system, it works really well. And it's a quality upgrade, because it's warmer and tighter."

Sal Vuocolo, a home builder and distributor of Hearthstone timber frames in Glen Gardner, N.J., has worked with different types of housing packages for years. He feels panels offer an antidote to the falling quality of conventional framing material. That and the energy efficiency advantage impress him enough to recommend panels to clients. But he finds many reluctant to pay for energy upgrades, especially in a market where there is tremendous price cutting. He has also had trouble with skeptical building inspectors.

"Whenever you challenge the established order in the building industry, you have a real struggle," said Vuocolo. "If you have a structural panel product that doesn't have a BOCA code number, you have to work one-on-one to get code approval. It's tedious. There's simply no way to cover the cost of all the time involved."

In central New York State, Roy Hoysradt (Hoysradt Homes) recently finished his third home using sandwich panels from Winter Panel Corp. He was asked to bid on a two-story against modular construction. When the panel bid came in a little higher, he asked the client whether the modular bid included comparable insulation. It didn't, and at equivalent insulation levels the modular couldn't compete, so Hoysradt got the job.

Unlike Vuocolo, Hoysradt says he didn't have any problems with code officials. "They're kind of baffled by the system, but they accepted stamped drawings with no problem."

— S.A.

already made), while the low one ($2.03) is for blanks on which the builder would have to make these cuts at the site.

To level the playing field, try to price panels in one of three ways: uncut blanks, with whatever items are standard; precut panels, with standard items; and erected shell packages per square foot. A final word of warning: Not every manufacturer offers precut panels, and only a few offer the option of erecting the shell.

Placing an Order

A manufacturer will usually take a few days to compile a bid. You'll help yourself on costs if you make certain that all straight wall runs and all ins and outs break down into 4-foot increments.

One other way to save money is to buy panel walls, but use a trussed or conventionally framed roof system. Denver-area builder Jim Lambert (Lambert and Son) tried this approach on a 1,200-square-foot home to save the cost of high-R-value roof panels. (Blown cellulose is a lot cheaper than foam.) The downside, as suggested earlier, is that you have to seal extremely carefully to match the airtightness of the paneled system. And, of course, it takes longer.

Once contracted for, panels are usually ready within two to four weeks, or later, as your schedule requires. Payment schedules vary and are sometimes negotiable. Generally, however, you'll have to put up about 10% payment at order, 25% upon acceptance of a

Foam Panel Tools and Techniques

Using panels for the first time generally requires a few adjustments in the field.

Tool requirements. Working with panels requires a few special tools, such as one or more oversized circular saws, either 12-inch or 16-inch, to cut through the thick panels. You'll also need a small chainsaw to cut window and other openings if you don't have the factory do it. You'll need several caulk guns and plenty of caulk, so you can seal as you build. You'll also need lots of metal connectors, as specified (and possibly supplied) by the panel maker. And you'll want mechanical nailers or staplers, since there is a lot of nailing. The electrician may want a 4-foot drill bit for last-minute electrical changes. Finally, don't forget a sledge to snug up panels as they go in.

Sealing joints. To prevent air movement and create a monolithic wall, every panel attachment system requires use of adhesives and sealants. This takes enough time that when two people are putting up 4x8-foot panels by hand, a third can be applying the adhesives (wood-to-wood connections) and sealants (wood- or foam-to-foam) along the edges of the bottom plate as well as on both sides of the splines where panels meet. This is one more place where using large panels saves labor.

Electrical and plumbing. To make wiring easier, most panel manufacturers offer some type of internal wiring chase. This is typically a 1-inch core running horizontally 12- to 16-inches above the floor, and a vertical core to the floor, either at the center or at one end of each panel. (Long panels have these cores about every 4 feet.) To provide access to these cores, most builders predrill 1-inch holes through the bottom plate and floor deck, at spots corresponding to the vertical cores, before the panel is placed down. Unused cores can be sealed with a bit of expansive foam.

Once the wall is up, you snake cable through the hole and up the vertical chase. When building on a slab, you have to run some wire as the panels go up, working from the bottom up. This can get awkward at the corner; it may be easier to use a baseboard raceway.

Plumbing supplies are best kept out of exterior walls, especially in cold climates. If you simply can't avoid running a vent up an outside wall, order a 2x2-inch chase cut in the foam at the factory. Then mark your plans to make sure you don't forget the special panel.

— S.A.

Cutting. *You'll need an oversized saw to cut any panel. For those too thick for the saw, use a small chainsaw so you don't have to flip every panel for a second cut.*

Notching. *To let in nailers for the window or door frame, you'll have to notch the foam. This is easiest using the hot-wire tool shown here, supplied by most manufacturers.*

Wiring. *Most wall panels come with predrilled chases for electrical wiring. Before setting a panel in place, drill a 1-inch hole through the subfloor to align with the vertical chase in the panel. Fishing wire is then fairly simple.*

set of shop drawings, and the balance on delivery.

Lingering Questions

A few questions about panels persist.

Durability. How long will a panel home last, compared to a stick-built home? Though panel homes haven't been around long enough to provide a definitive answer, results from accelerated aging and field tests are quite positive. Four panels installed in 1968 in a U.S. Forest Products Lab test house were removed a decade later and tested to failure; all exceeded the design load requirement (20 pounds per square foot) by at least a factor of ten.

When panels have failed in the field, it has usually been because quality control was lacking or the panels were used to carry loads they weren't meant to. In a few cases, panels made with the wrong adhesives failed.

If you're thinking about using panels for the first time, visit plant sites for the manufacturers you're considering and compare their quality control programs. Manufacturers who pay an independent firm to oversee quality control will charge more for their products (about 10¢ to 20¢ per square foot), but it may be worth the extra cost. You should also check warranties: Some manufacturers now offer a warranty against delamination. These vary from 15 years (Sunlight Homes) to "the life of the structure" (Insulspan).

Performance in fire. Although unsheathed foams burn readily, panel assemblies actually perform quite well in fires. The Associated Foam Manufacturers subjected EPS panels covered with 5/8-inch drywall and OSB to the standard ASTM 20-minute "full-wall" test (ASTM E-119 series), in which the panel is placed in an oven and exposed to 1,450°F flames over its entire surface for 20 minutes.

When the fire was terminated, the testers stripped away the drywall and OSB and examined the panel. The OSB was still bonded so well to the foam that it had to be ripped away with a prybar. And the panels suffered no core melting, no apparent structural damage, and no deflection, despite being loaded with 21,600 pounds to simulate a three-story building.

EPS panels faced with OSB and drywall have also fared well in an Underwriters Laboratory test called the Room Corner Fire Test, in which a 1,300 to 1,600°F fire is built in the corner of an 8x12-foot room. Fire performance of other foam types is similar.

These tests were done on panels faced on both sides with OSB and on the interior side with drywall. In one test on panels that had only drywall on the inside, the drywall adhesive failed at 215°F, causing the drywall to delaminate; this exposed the foam to the fire, and the wall failed in less than 20 minutes. Unfortunately, this test wasn't as controlled as the others, so it's impossible to say whether this poor performance was due solely to the lack of OSB facing or to other factors as well. But it appears that sandwich panels with OSB beneath the drywall fare better in fires.

A frequent criticism of urethane foam is that in a fire it will release deadly hydrogen cyanide. (Other foams emit mainly carbon monoxide, just as burning wood does.) This is true, but must be balanced against the fact that many other household materials — both the building and its contents — release deadly gases when burning. Before a fire could penetrate to the foam in a urethane panel, it is likely to have consumed a lot of furniture, carpeting and drapes, all of which will be sources of deadly carbon monoxide, not to mention cyanide and other gases.

Chlorofluorocarbons. Many foam panels use extruded polystyrene, polyurethane, or polyisocyanurate foams, which have traditionally been produced with ozone-destroying CFCs and HCFCs. (EPS, or expanded polystyrene, foams are not produced with CFCs.) In response to concern over the ozone layer, foam manufacturers are phasing out the use of these blowing agents, which will probably be completely replaced with ozone-safe substitutes in the next three years.

For the time being, however, most non-EPS foam products do use some ozone-depleting CFCs or HCFCs. HCFCs destroy only about 5% as much ozone as CFCs do, but they still deplete the ozone level and contribute to greenhouse gases. Until all CFCs and HCFCs are eliminated, builders and clients must consider whether gaining foam panels' advantages (energy efficiency being one) is worth losing the ozone. It won't hurt in the meantime to press the industry for more rapid conversion to non-CFC products.

Ants and termites. Panels are as susceptible to carpenter ant and termite infestations as any other wooden structure. These beasties get nourishment from wood, not foam, but their tunneling in the foam can reduce insulation value, drive homeowners crazy (nibble, nibble in the night), and eventually compromise structural integrity. Wherever they reside, you should treat to prevent infestations.

After extensive research efforts, several manufacturers, led by

Remarc and AFM, are treating their panels with insect repellent products. Product testing indicates that manufacturers need to perform a fair amount of research to assure the success of their recipes.

The alternative to treating panels is to cut back on adjacent or overhanging vegetation and treat the ground around the structure, as you would with a stick-built house.

Shingle durability. A light-colored asphalt shingle atop a panel roof system will run up to 20°F hotter than it would over a vented attic. Shingle warranties notwithstanding, this heat will shorten the shingle's lifetime. Case in point: During a routine post-hailstorm roof inspection of a two-year-old roof, an insurance claims adjustor noted that some shingles were much more brittle than others. It turned out that the brittle shingles were above panels, while the others were over a conventional attic.

One moderately expensive solution is to make a cold roof by laying down 1x3-inch furring strips and a layer of 1/2-inch plywood. In this case you should probably provide a continuous ridge vent and screen the low edges to prevent bug residency in the 3/4-inch airspace. The added bonus: Your roof will run cooler in the summer.

The other option is to simply use a conventionally framed or trussed roof, as mentioned before. This will mean more work sealing against air infiltration, but it will save a few bucks and be easier on the shingles.

Visible roof joints. Where panels join together in roofs, you can sometimes see small ridge lines in the shingles. Frank Baker, with Midwest Panel Systems and president of the Structural Insulated Panel Association (formed in 1990), explains that OSB comes out of the manufacturing process extremely dry. If it is installed while still dry, it may expand or creep as it absorbs moisture, causing a bulge where two panels meet. To avoid this, either let the panels acclimate before installation, or leave a 1/4-inch gap along all joints. This can be sealed with an expanding foam sealant. Some panel makers actually leave the OSB slightly short of the panel edges to allow for a little expansion. Baker is hoping that use of OSB delivered at a higher moisture content (8%) might eliminate most of the problem. Ask the manufacturers what they would recommend in your climate. ■

Steve Andrews is a Denver-based residential energy consultant and the author of Foam Panels and Building Systems: Principles and Practice Plus Product Directory *(Cutter Information Corp., Arlington, Mass).*

For More Information

For information on panels or a list of manufacturers, contact:

Structural Insulated Panel Association
1090 Vermont Ave., NW
Suite 1200
Washington, DC 20005
202/408-5003

Selected panel manufacturers:

Sandwich panels

Alchem, Inc.
3617 Strawberry Rd.
Anchorage, AK 99502-7111
907/243-2177

APC International
2280 Grandview Rd.
Ferndale, WA 98248
206/366-3400

R-Control Panels
(18 plants nationwide)
c/o Associated Foam Manufacturers
Box 246
Excelsior, MN 55331
612/474-0809

Atlas Industries
6 Willows Rd.
Ayer, MA 01432
800/343-1437

Enercept, Inc.
3100 Ninth Ave. SE
Watertown, SD 57201
605/882-2222

Foam Laminates of Vermont
P.O. Box 100
Hinesburg, VT 05461
802/453-4438

Harmony Exchange
Rt. 2, Box 843
Boone, NC 28607
704/264-2314

Insul-Kor, Inc.
P.O. Box 116
Elkhart, IN 46514
219/262-3472

Insulspan Panels
(4 plants in Midwest)
c/o Foam Products Corp.
P.O. Box 2217
Maryland Heights, MO 63043
800/824-2211

J-Deck Building Systems
2587 Harrison Rd.
Columbus, OH 43204
614/274-7755

Korwall Industries
326 North Bowen Rd.
Arlington, TX 76012
817/277-6741

Modular Energy Systems
311 East Glen Cove
Mesa, AZ 85201
602/898-7283

Pond Hill Homes
RD 3, Box 467
Blairsville, PA 15717
412/459-5404

Remarc, Inc.
P.O. Box 174
Holderness, NH 03245
603/968-9678

Sunlight Homes
P.O. Box 1569
Bernalillo, NM 87004
800/327-5835

Vermont Stresskin Panels
RR2, Box 2794
Cambridge, VT 05444
802/644-8885

W.H. Porter
4240 North 136th Ave.
Holland, MI 49424
616/399-1963

Winter Panel Corp.
RR 5, Box 168B
Brattleboro, VT 05301
802/254-3435

Unfaced panels

Insul-Wall Ltd.
11 Mosher Dr.
Dartmouth, NS
Canada B3B 1L8
902/468-5470

NASCOR, Inc.
7803P 35th St., S.E.
Calgary, AB T2C 1V3
Canada
403/279-1966

RADVA Corp.
Drawer 2900
Radford, VA 24143
703/639-9091

Wallframe of Southern California
11180 Penrose
Sun Valley, CA 91352
818/768-8100