Building with FOAM-CORE PANELS

With structural insulated panels, you can erect a sturdy, airtight, well-insulated shell in a single step

by Jim LeRoy

I was introduced to foam-core panels in 1982, when my small crew started enclosing timber frames. Over the years we added a second and third crew, and now we have an office, a sales staff that keeps three road crews busy all over the country, and a shop that does panel cutting and design. These days, we build quite a few homes where structural insulated panels, or SIPs, make up the entire structural assembly, with little, if any, other framing. That's the kind of building this story is about.

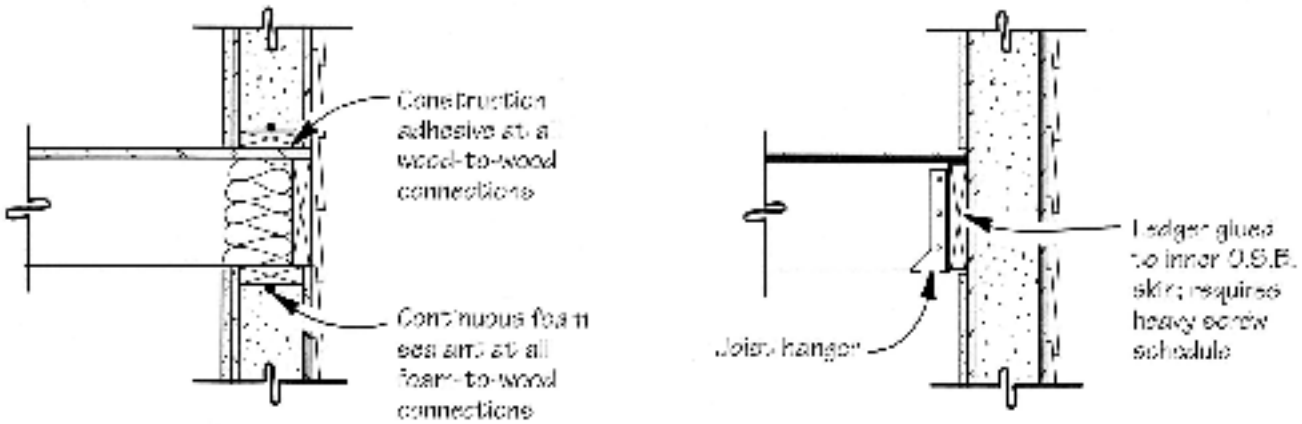
Any house you can stick-build, you can build with structural insulated panels, and in less time. The tools, the materials, and the assembly process are very similar to stick building. If you can get a trained person to help you the first time, you can handle SIPs yourself after that.

You can also familiarize yourself with the process before you start your first job. The Structural Insulated Panel Association (SIPA) offers instruction seminars around the country, and just about every panel manufacturer has a video that shows how to use their panels. For information on SIPA's instructional program, plus a list of panel manufacturers and processors, call SIPA at 202/347-7800.

A Three-Tier Industry

The panel construction industry has three levels: panel manufacturers who produce raw panels in various sizes; panel processors, or "panelizers," who prepare the panels for assembly into houses; and panel erectors, who construct the actual houses on site.

Floor Framing Options



My company is a panel processor, but we also do a lot of site assembly. Here's how it works when we handle a job: After the customer picks a panel manufacturer, our panelizing shop does a panel design and makes out a panel order. The manufacturer ships us the raw panels in any sizes we order, from 4x8 feet to 8x24, and in standard thicknesses from 4 to 10 inches (thicker panels can be special-ordered). Next we fabricate the panels — shape them, cut them to sizes following our CAD design, route out channels for connecting splines and reinforcing members, number each panel, and package the set to make the house shippable. Finally, we truck the package to the site, where either the local builder or one of our crews puts the house together.

Planning for Panels

The design stage is the first place to avoid hitches. We bid a lot of projects that are already in motion, and converting designs that were created for stick construction into workable panel plans often adds cost.

If the customer hands us a typical set of plans intended for a stick-built house, we may have to change them for structural reasons — move walls to pick up roof loads, change basement bearing, and so on. And when we present the modified plans to a building inspector who isn't familiar with panels, he may require an engineer's stamp. If the engineer isn't experienced with panels either, he may have to put some hours into doing the math before he stamps the plans.

Although we can develop a panel package from any set of plans, some snags can be avoided if the designer starts with panel construction in mind. A client who chooses to build a house with SIPs should hire a designer who is experienced with panels; the plans will then require no further modification.

The drawings in this article were based on a set of generic

Figure 2. Just like stick-framed walls, panel walls are assembled on the deck, then lifted into place (left). The foam in the bottom of the panel is recessed to slip over a bottom plate, which is first mounted on the perimeter of the floor deck. Here, a worker installs an air-seal gasket just before the wall is stood up (right).

Figure 1. When combining a conventional floor system with wall panels, it's easiest to platform frame (far left), but this creates a thermal bridge at the band joist. A surface-mounted floor ledger (left) prevents conductive heat loss, but has to be engineered. The author prefers to hang the floor joists from the wall panel top plate with top-flange hangers (photo, above).

details developed by SIPA. Every SIP manufacturer has specific connection details that have been through the code approval process. For any actual project, you should use the appropriate details provided by your panel supplier.

Floor Panels

The engineering involved in a panel floor design sometimes scares people away. But every manufacturer has span tables for its own panels, and once you get used to the rules of thumb, it's simple to make the conversion from stick-framed to panelized.

In general, for typical residential loads, a standard $9^1/_4$-inch-thick SIP can span 12 feet without reinforcement (assuming a total load of 50 pounds per square foot and deflection of L/360). For spans between 12 and 16 feet, we reinforce with internal members every 4 feet inside the panel, using a 2x10, a $9^1/_4$-inch I-joist, or a $9^1/_4$-inch LVL, depending on the loads. We can order panels from the factory with ready-made channels for the reinforcing members or we can rout the panel edges in the shop to receive reinforcing members at the panel-to-panel joints. You slip the wood members in from the end or from the side as you lay the floor on site.

An 8x24-foot panel is the largest size made, so the easiest floor to build with panels is a simple span of 24 feet or less. Supported by a girder at the center point, it needs no reinforcement, and you can boom in a whole floor in a couple of hours.

Longer spans take a little more time. If you want a 28-foot span, you'll use two 14-footers with some internal reinforcement, and place the girder beneath the center break. If you want 32 feet, you've got to use two reinforced 16-footers or introduce a second girder.

Comparing our costs with stick-building cost figures from *Means*, we've calculated that we can build a basic crawlspace floor deck for the same cost as a stick-built floor, and about

Man vs. Machine

For an 8-foot-high wall, you can use a single big panel that's 8 feet high by as much as 24 feet long. But those big panels are too heavy for people to carry around. A 4x8-foot panel is a lifting task for two men — one person could carry it, but we use two. Working by hand, I'll even ask my guys to move 8x8s around. But when the panels are 8x10 feet and larger, you start to need expensive machinery.

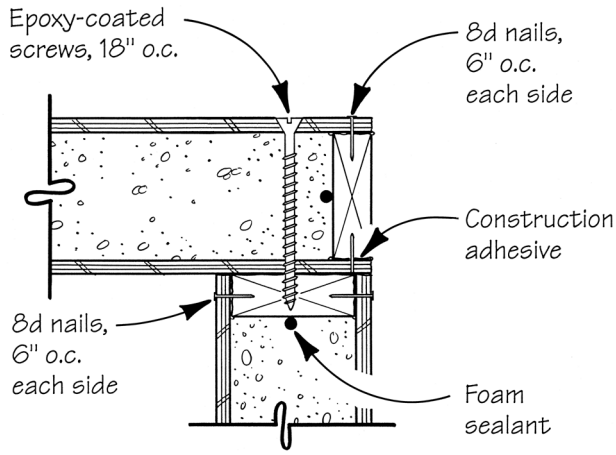
You'll want to assess whether that machinery is worth paying for on a job-by-job basis. A boom truck rents for $75 to $100 an hour, with a minimum half-day rental. That money has to come from somewhere — the equipment can't just augment labor, it has to replace labor.

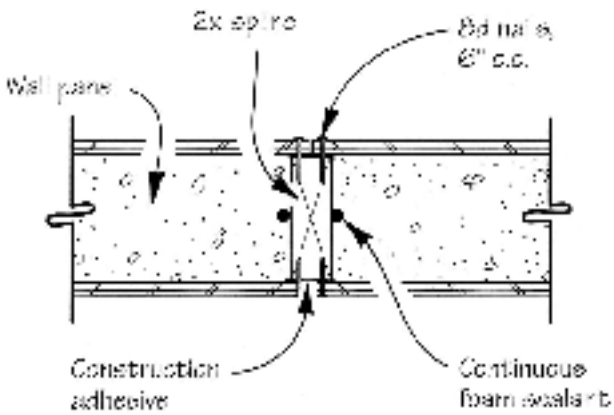
The choice between manual labor and equipment also depends on site conditions and design. For instance, at a heavily wooded location, man-handling small panels may be easier than trying to swing a

boom through the trees. And complicated designs, with many corners and windows, aren't well suited to panelizing large wall systems. In such cases, the most economical way to use the boom truck may be to have it there at the beginning of the job to offload the panels, then bring it back for a half day at the end to set the roof panels.

On the other hand, if you're building a house on an open site, and the design involves mostly long, 8-foot-high walls with normal-sized windows, working with large panels and using lifting equipment throughout the project could be cost-effective.

Wall Connection Details





50% faster — plus it's insulated. (In complicated designs, special cost factors affect every comparison between methods. But for a simple deck, I have no doubt that SIPs are faster, and at least as affordable as stick framing.)

Because of sound transmission, however, foam-core panels don't make a satisfactory interior floor system between occupied spaces. Panels muffle airborne noises, but they readily transmit direct noises such as footsteps. For the second floor, or a first floor over a full basement, I recommend stick framing.

There are a number of ways to combine stick-framed floors and panel wall systems. The easiest is just to use ordinary platform framing, treating the panel wall like any wood-frame wall. However, because that creates a thermal bridge at the band joist, there are some other options worth considering (see Figure 1).

Figure 4. For heavy loading, structural headers slip into recessed pockets in the wall panels. Trimmer studs are embedded in the panel by the panelizer.

Wall Panels

On site, wall framing with SIPs is much like stick building (Figure 2). We typically use panels in 4- or 8-foot widths instead of individual studs, but we lay the panels down on the deck, assemble a wall and stand it up just like framing a stick-built wall. A channel at the bottom of each panel allows the wall to be slipped over its bottom plate and attached with screws through the panel's OSB skin; an identical channel at the top receives a 2-by top plate.

For an 8-foot wall, it's possible to use a single large panel — say, 8x24 feet — instead of assembling several smaller panels on the deck. The problem is these larger panels get too heavy to be lifted and moved around by the crew. So I usually limit the size of the panels we use to 8x8 feet. Occasionally I may ask the crew to handle an 8x12-footer, but any larger than that, and I plan on a boom truck or crane (see "Man vs. Machine").

Joints and corners. Panel-to-panel joints in walls are made with splines — either a nonstructural plywood spline or a structural 2-by spline (Figure 3). The 2-by splines add bearing strength for point loads; for distributed loads, SIP walls with plywood splines have about three times the load-bearing capacity of typical stud walls of the same thickness. There are several types of corner connections. Which one you choose depends mainly on the order of assembly — your panelizer can advise you on that. Interior walls are fastened to exterior walls with screws and glue.

Openings. On our jobs, door and window openings have already been cut out when the panels arrive at the site. Any headers needed are prebuilt, and either come installed in

Figure 3. Corner panels (far left) are commonly attached with long screws through the outside of one panel into the wood member at the end of the adjoining panel. Adjoining wall panels are connected by either structural 2-by splines (left), which can be inserted to carry point loads, or nonstructural plywood splines (photo, above).

the panels or get slipped in as part of the assembly process (Figure 4). For a structural header carrying heavy loads, there may be jacks set into the wall panels going from the floor all the way up to the header. For standard loads, such as a typical floor load, the 2-by member around the perimeter of the window is enough to carry the header. For light loads, such as nonbearing gable walls, no headers are needed as long as there is at least a foot of foam panel left above the opening.

A gable-end wall sometimes has to carry purlins to support the roof panels. In such a case, headers and jacks might be required for strength around openings. But if the roof is supported at the eaves and ridge instead, most gable walls don't need headers in the openings.

Roof Panels

The difficulty of roof construction with SIPs, like roof construction in general, depends on the complexity of the roof. When you build with panels, the ridges and the valleys need to be considered slightly differently than in stick-built construction.

The fundamental difference is that in stick construction, the roof is usually outside the thermal envelope — the insulation is in the attic floor. When you convert a stick-built design to SIP construction, you've got to decide where to put the thermal boundary at the upper part of the building.

A cathedral panel roof is my preference, because that way the thermal envelope takes the shape of the building. A second choice — a stick-built roof or truss with fiberglass or cellulose ceiling insulation — will work, but will not be as airtight as the SIP roof.

For jobs where speed is a priority, however, the fastest method is to stand panel walls, set trusses on the roof, and use blown insulation in the ceiling.

Roof spans. As with floors, a panelized roof must stay within the panels' span capabilities. An unreinforced $9^1/_4$-inch-thick roof panel can span as much as 12 feet between supports (measured horizontally) and internal reinforcement can extend that to 16 feet or longer.

Panels thicker than $9^1/_4$ inches are a custom order, but they are sometimes requested in cold climates. The thicker panels also have greater span capabilities. Bear in mind, however, that roof loads also vary by region — heavy snow or wind loads will change the numbers.

Support. For greater spans, or for unusually heavy loads, you need to provide additional structural support. As with floor panels, you can either strengthen the panels with internal reinforcement or use external framing to support them from below. Any support system you provide can be either a

Figure 5. Roof panels may be supported by rafters spanning from ridge to eaves (left), or by purlins set into gable walls (above). A post in the gable panel below the purlin may or may not be necessary, depending on the calculated roof loads.

Ridge & Eaves Connections

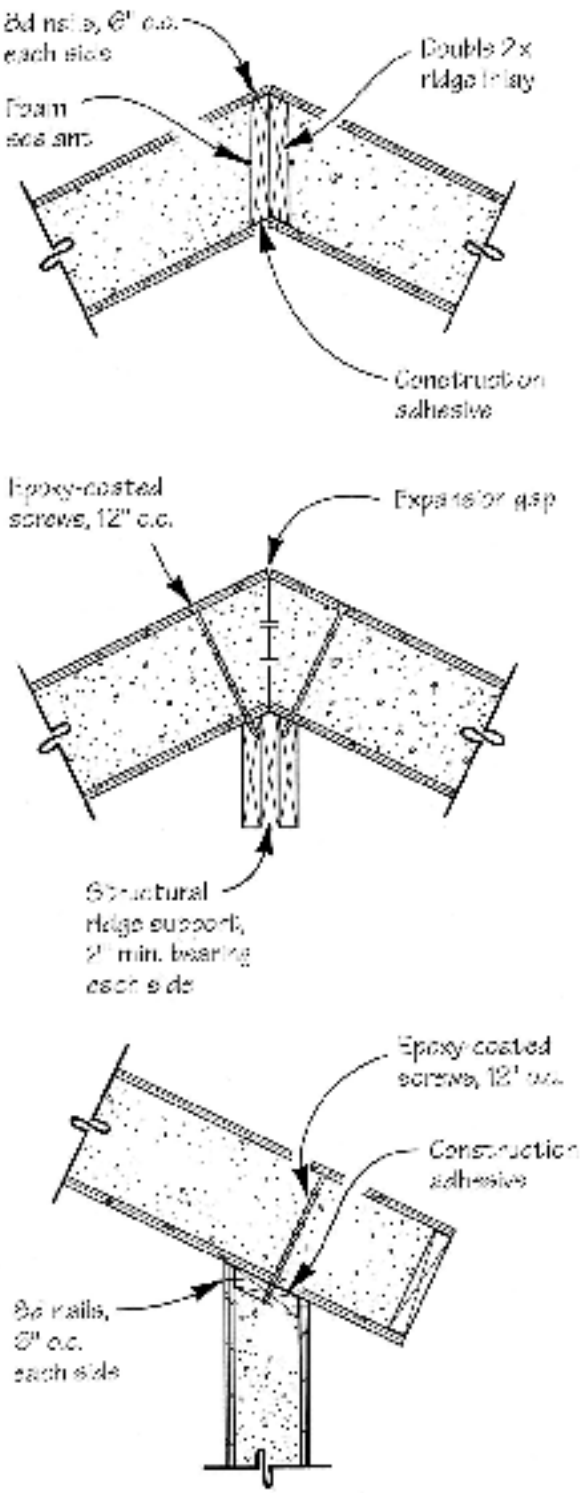


Figure 6. At the ridge, panels can be reinforced internally (top), or supported from below by a ridge beam (center). The author prefers the ridge beam because it prevents thermal bridging. At eaves (above) and gable ends, roof panels extend past wall panels, and are attached with long screws and adhesive.

rafter system, with bearing at ridge and eaves, or a purlin system, with bearing on end walls and intermediate girders or trusses (Figure 5).

Either method will work, and the choice will depend a lot on the shape of the space you're enclosing. Personally, I like to support the roof panels from below rather than reinforce them internally. Making the connections between internally supported panels is more troublesome on site, and the internal reinforcement creates a thermal bridge through the panel (Figure 6).

Every roof design will carry with it particular connection details for rafters, purlins, and panels. Again, if you understand wood framing, you should quickly get the hang of these techniques.

Wrapping Up

My crew usually hits the road when the structure is done, leaving the finish to the general contractor. But in general, details like siding, windows, and trim are no different from conventional construction. Panel manufacturers can give you generic design drawings for trim details, and we can provide our customer with drawings for things like cornice returns and eaves details (Figure 6).

Wiring the house is not any harder than with conventional construction, but it is different. Electricians aren't usually familiar with it, and they'll often pad their bids by a hefty margin just in case.

One of the easiest ways to deal with the wiring is to use wire chases at outlet heights and switch heights (16 inches and 48 inches from the floor), all the way around the perimeter of the building. Vertical wire chases set at regular intervals intersect these horizontal wire chases. You cut your boxes out so that the bottom or the top of the box intersects the wire chase, and you just fish wires from box to box.

We can send the panels with the chases already created on a standard layout. If you have any specialty requests, we can incorporate those, too. The vertical chases are in the panel already — if you want to run a wire at any given location, you just drill through the shoe or the plate before you put that panel in place.

As for the expense, I've met with electricians on the first day of a panel job and watched them drive away from the sites with big smiles on their faces, because they covered themselves with a high price and we quickly explained to them that the wiring was much easier than they had thought.

To bridge the estimating gap, I suggest asking the electrician to bid everything but the rough-in as a fixed price, and give a time-and-materials bid on the exterior-wall outlets and rough wiring. With that arrangement, the first job might cost about 10% more than a traditional house, and on subsequent houses it should drop.

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