Building With Structural Insulated Panels

by Gary Pugh

SIPs produce a tight, well-insulated shell that takes less labor to construct than an equivalent stick-framed building

About 20 years ago, I watched a video about a house being built with structural insulated panels, or SIPs. It was the first time I'd seen the process: Instead of framing one stick at a time, the carpenters were installing entire sections of wall, which had arrived on site sheathed on both sides and insulated.

It impressed me as a faster and better way to build, so I tried SIPs on my very next house. That first one was difficult because I had no one around to explain the technical details. But we stuck with it, and now my company builds only projects that include SIPs.

Figure 1. The most common type of structural insulated panel is produced by sandwiching EPS foam between two sheets of OSB. The face material can also be plywood, steel, or fiber-cement, and the core can be polyurethane.

What Are SIPs?

SIPs are made by bonding a sheet material — OSB, plywood, steel, or fiber-cement — onto both sides of an expanded polystyrene (EPS) or polyurethane foam core. By themselves, these materials are not strong enough to support loads, but once they're made into panels they can be used for structural elements like walls, roofs, and floors. The most common panels consist of OSB over EPS (see Figure 1).

Raw panels are produced in factories and then cut to size in fabrication plants, or sometimes on site.

Size and thickness. OSB-faced panels come in sizes up to 8 feet by 24 feet. Foam cores are sized in thickness to match the width of standard framing lumber; that way, you can reinforce a panel or provide nailing by inserting a piece of framing stock. For example, a 6-inch panel is actually 6½ inches thick, made with a 5½-inch-thick

Figure 2. Panels can be used for any part of the building that isn't curved. The walls and roof of this traditional-style house are made from SIPs.

piece of foam sandwiched between two sheets of 1/2-inch OSB.

Walls are typically made from 4- or 6-inch panels. Floors and roofs might be made from 6-, 8-, 10-, or even 12-inch panels.

Why Use SIPs?

We use SIPs because it takes less time — fewer labor hours — and less skill to assemble precut panels than it does to stick-frame. The parts of the building made from panels are straight and true, and won't shrink or warp. Plus, they are exceptionally well insulated and sealed against air infiltration.

Our clients want their homes to be "green," and SIP buildings qualify because they're energy-efficient and make good use of natural resources. The OSB skin is made from fast-growing trees that are plantation-grown specifically for OSB.

Also, there's very little job-site waste with SIPs; the panels are cut by a fabricator, who can easily recycle cutoffs or use them when smaller panels are called for.

Insulation Value

The R-values associated with various building materials are misleading because they don't reflect how and where the material is installed. For example, 5 1/2-inch fiberglass batts are rated R-19, but a wall insulated with these batts is not R-19, because there will be thermal breaks at every stud, plate, and header.

Whole-wall R-value. A more realistic way to look at insulation is to consider "whole-wall R-value," a method developed at Oak Ridge National Laboratory (ORNL), in Oak Ridge, Tenn., for estimating the R-value of various assemblies. The whole-wall R-value includes the insulation plus everything else that's in the wall.

According to ORNL, a 2x6 wall framed 24 inches on-center with plywood sheathing, drywall, and 5 1/2-inch batts has a whole-wall R-value of 13.7. The same wall built with 6-inch OSB SIPs has a whole-wall R-value of 21.6. Why the difference? The foam in the SIPs has a higher R-value than the batts, and the SIP assembly contains fewer thermal breaks.

Figure 3. Plates are installed first. Here, a 3x6 has been screwed to the deck over a continuous bead of sealant. In preparation for standing the walls, a carpenter runs sealant along the face and edges of the plate (A). The crew then stands the panel over the plate (B), braces it plumb, and nails it to the sides of the plate (C). When walls land on concrete, the plate is installed over a wider strip of pressure-treated plywood, which is also sealed to the concrete (D).

Ordering Panels

It's possible to buy raw panels and cut them to size on site, but it's better to pay a fabricator to do the cutting. Many fabricators have computer-controlled equipment that cuts panels far more accurately than we ever could.

Design. Like any building, a SIP structure starts out as a set of plans. Just about any stick-framed plan can be converted to SIPs (Figure 2, page 2), although it's easier when the initial design is done with panels in mind.

Either way, the first step in any SIP project is to produce a detailed set of shop drawings that show door and window openings, corners, edges, and wiring chases, as well as how the pieces will be joined on site.

Once the drawings are approved, delivery of the panels takes six to eight weeks. The process is a lot like ordering trusses, except in our case we produce the shop drawings in-house.

The fabricator could draw them, but we prefer to do it ourselves because we gain more control over how the panels will go together.

Handling. SIPs arrive at the site on one or more semitrailers. Small panels are light — a 4x8 6-inch panel, for example, weighs about 115 pounds.

Larger panels are heavy, so we rent an all-terrain forklift to handle those.

Floor Structure

SIPs can be installed over any type of floor system. In our area of Northern California, most homes have wood-framed floors on stem-wall foundations with crawlspaces below.

Structurally, there's no reason we couldn't build the floor with SIPs. Doing so would be much faster than stick framing, and the insulation value would be very high.

Figure 4. The OSB and foam were cut from the corner of this SIP shear wall so that a hold-down could be installed. Later the crew will foam in around it and replace the missing OSB.

Figure 5. Panels are connected edge-to-edge with splines. Here, a carpenter prepares to install a block spline over continuous beads of sealant (left). The spline functions as a gusset and is held in place with nails driven first into the loose panel (center) and then into the adjoining panel (right).

But on most projects we still use conventional floor framing; even with the labor savings, SIP floors aren't always cost-effective in a mild climate like ours.

In colder areas, of course, where insulating the floor is a major concern, building a floor with SIPs might make more sense.

Sound transmission. Even if they did cost less, we wouldn't use SIPs for upper floors.

The panels are good at preventing airborne noise from entering through the walls and roof, but walking on them creates a drumming effect that's annoying to the people below.

Setting Walls

Our panels arrive on the job cut to size with door and window openings, but without solid lumber inserted.

The foam is recessed along the edges, so there's room to make insertions: bottom plates to fasten panels to the floor; splines to join them edge-to-edge; and top plates to stiffen the top of the wall and provide nailing for the roof or floor above.

We install these lumber members over beads of sealant (provided by the panel manufacturer), then nail them in place through the face of the panel.

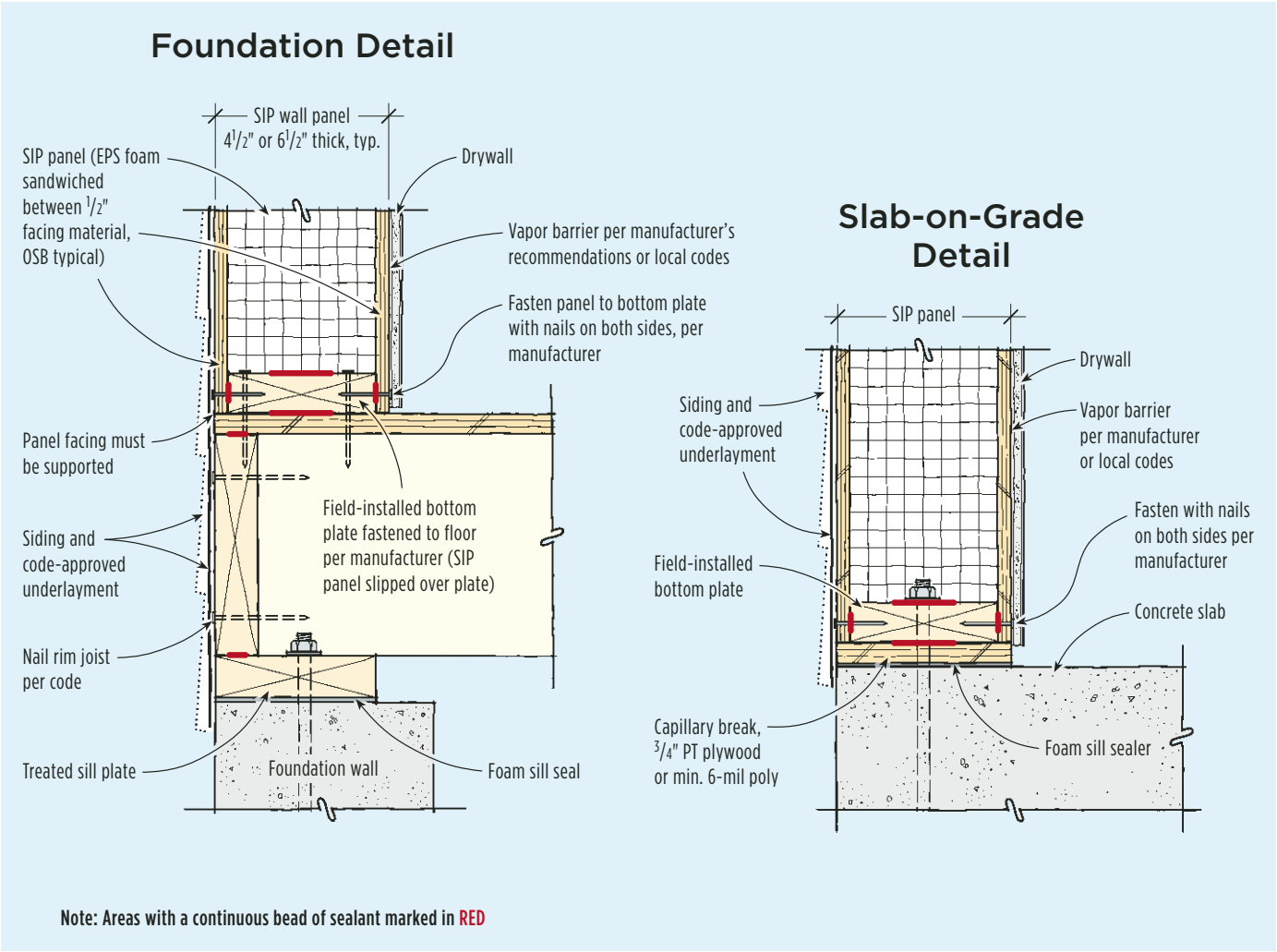
For an extra charge, some manufacturers will install the nailers for you.

Plates. With SIPs, wall plates are nailed, screwed, or bolted to the floor and then the panels are slipped over them.

If the wall lands on a stem wall or slab, the plate and panel must be isolated from the concrete. To do this, we install a strip of pressure-treated plywood — sealed to the concrete with foam sill seal — and then install the plates over a bead of sealant.

Before installing the wall panel, we run sealant along the top and both edges of the wall plate, then stand the panel over it (Figure 3, page 3).

After bracing the panel plumb, we nail



it to the plate through the OSB skin.

Hold-downs. In many regions, this nailed connection is all that's needed to hold panels to the floor or foundation. But we build in a seismically active area, so some of the panels are designated as shear walls and must be tied to the foundation with hold-downs.

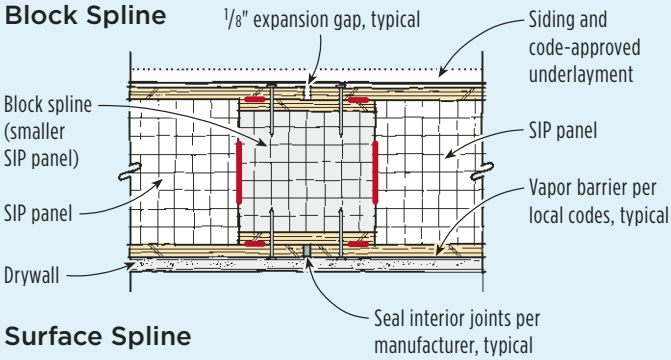
The old way to do this was to connect threaded rods to the foundation and run them all the way up through the panels.

An easier method is to put double studs in the edge of the shear panel, cut a hole in the OSB, remove some of the foam, and install a conventional hold-down inside (Figure 4, page 4).

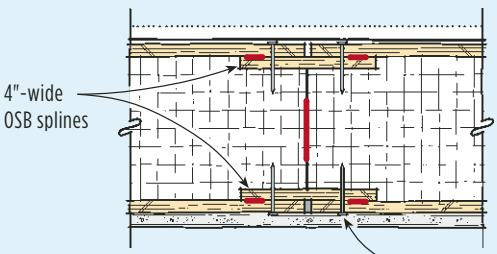
Figure 6. At corners, the crew installs nailers flush to the edge of the panels, butts the panels together (left), and uses screws to fasten through to the nailer beyond (right). These panels are 6 1/2 inches thick, requiring 8-inch-long screws.

Spline Connection Details

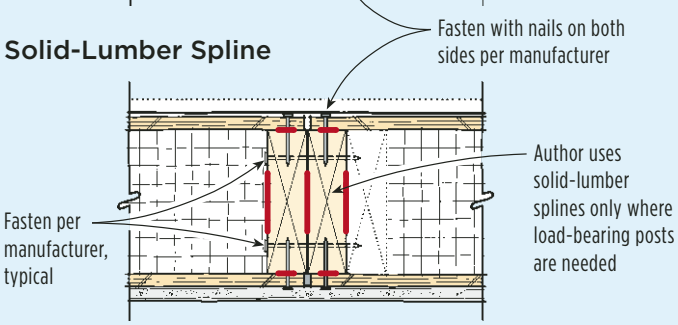
Block Spline



Surface Spline

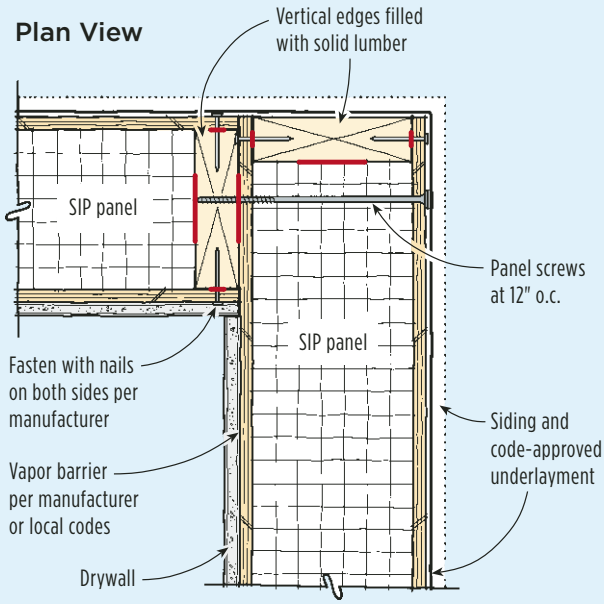


Solid-Lumber Spline



Corner Connection Detail

Plan View



There are many different ways to join panels in the field; it's the responsibility of the fabricator — or an engineer — to specify the best approach for a particular job. Shown here are some common connection details the author often uses on his projects.

Figure 7. Roof panels are lifted with an all-terrain forklift (A) and lowered onto glulam beams and sloped ledgers screwed to the wall panels (B). This carpenter fastens a panel by screwing through to the beam below (C). The parapets terminate with a double top plate, specified by the engineer (D).

The hold-down is then bolted to the foundation and the double studs.

Another method is to run a strap up from the foundation and screw it to the outside of the panel at a double stud.

Joining Panels

We edge-join the panels with splines that fit into slots in adjoining edges and work like gussets. They're installed over beads of sealant and nailed in place through the skin of the panel.

We use three types of splines: solid pieces of lumber; surface splines, which are 4-inch rips of OSB; and block splines, which are basically a smaller SIP that fits inside the edges of adjoining panels (Figure 5, page 4). We prefer the foam block or surface splines because they don't produce thermal breaks.

We use solid lumber splines only where we need a doubled stud to carry a point load.

Solid nailers. Any vertical edge that is not joined to another edge with a spline must be filled with a piece of solid lumber. This provides nailing where there otherwise would be nothing to nail into.

Wall corners are made by butting the edge of one panel into the face of another and then screwing back through into the nailer (Figure 6, previous page). The exposed foam edge of the overlapping panel is filled with lumber to provide nailing for the wall finish.

Once the walls are up, we insert top

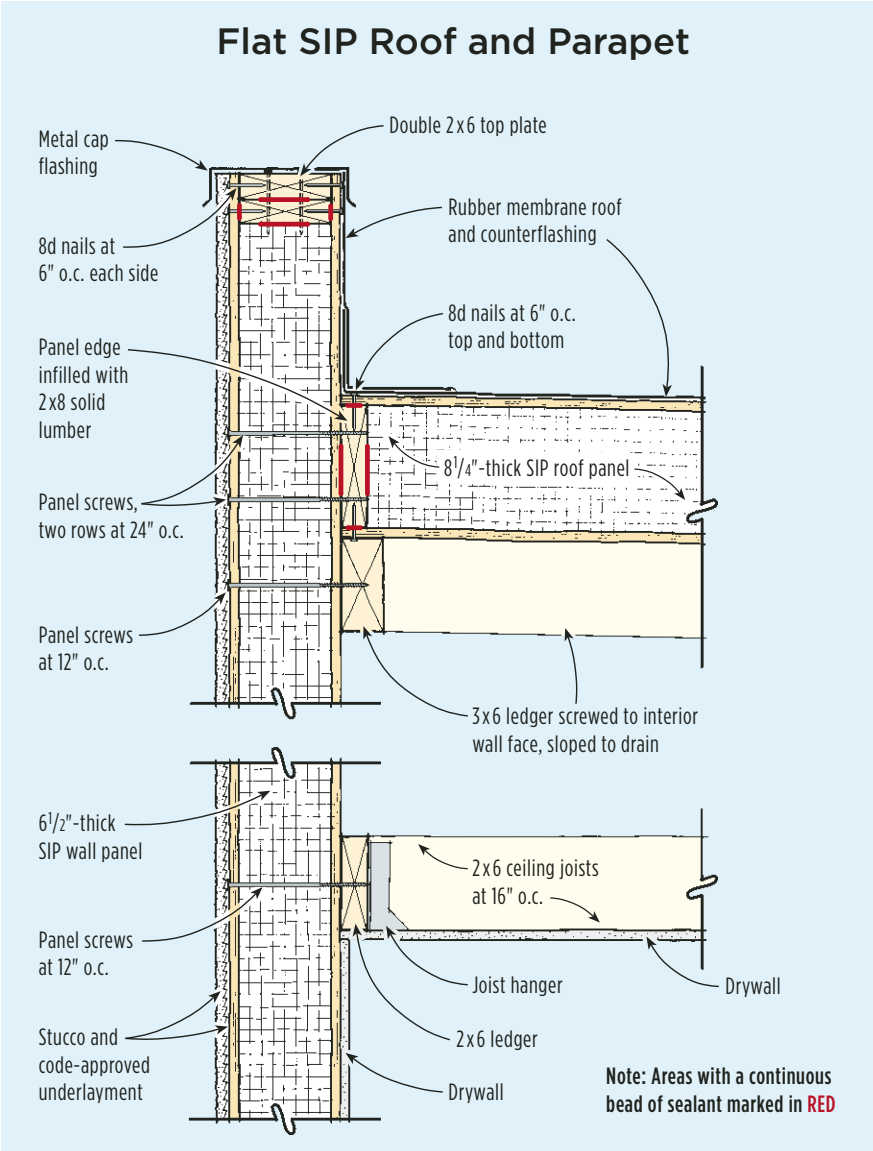


Figure 8. Many of the photos in this story are from a house with a flat SIP roof and parapet walls. The roof panels are supported by ledgers, which provide a slight slope toward drainage scuppers. Inside, the ceiling was dropped to provide space for ductwork and recessed lighting.

plates. This stiffens the walls and provides solid nailing for the second floor or roof.

Sealing the Seams

There are a number of ways to seal the seams between panels. We run beads of panel mastic on mating surfaces, but you can also use polyurethane foam from a can.

As an added measure, some panel manufacturers require you to surface-seal the interior joints by covering them with SIP tape, a type of peel-and-stick membrane. This is primarily a concern with SIP roofs in very cold, wet climates, because warm interior air will carry moisture through the gaps and can cause the outer layer of OSB to rot.

In some locales, the building code may require that you install a continuous vapor barrier inside the building.

And to the extent that it reduces air leakage, a vapor barrier can be an improvement.

But the real issue with SIPs is not moisture diffusion through the panels — it's air leakage at the seams. In most climates, if you properly seal the seams you should not have problems, even without a vapor barrier.

Because SIP buildings are so tight, it is necessary to mechanically ventilate them to remove excess humidity and provide fresh air. The best way to do this is to install a heat-recovery ventilator (HRV).

Figure 9. Mistakes and changes sometimes force the crew to alter panels in the field. Here, a carpenter trims a panel to size (left), then uses an electric hot knife (below) to neatly remove the foam so there will be room for a block spline.

The Roof

If the budget allows, a project might have a SIP roof. A truss roof is cheaper and, if the roof is complicated, easier to install. But a SIP roof is tighter and better insulated.

With a SIP roof, beams are required, except where the panels span from wall to wall. There is typically a bearing ridge and beams at hips and valleys. Roof panels are joined edge-to-edge in the same manner as wall panels, then screwed to the beam or wall below.

Many of the photos in this article are from a house with a flat — or, more accurately, very low-slope — SIP roof surrounded by a short parapet (Figure 7, page 7). The panels are supported by interior beams and ledgers screwed to the inside faces of the walls. The ledgers are sloped to drain the rubber membrane roof toward scuppers in the parapet; inside the house, we dropped the ceilings to make them flat, leaving space for ductwork and wiring above (Figure 8, previous page).

Door and Window Openings

Door and window openings are often cut right through the panel. Headers are not usually necessary unless the opening is more than 5 feet wide and or very close to the top. If the opening's large enough, you can save on material by piecing in around it. In such a case, the edges of the flanking panels should contain full-height studs plus jacks to support a panel or a header and panel above.

Cutting in the field. Occasionally the owner will want to add a window or make slight design changes after the panels are delivered. As long as the changes are minor, we can accommodate them by cutting the panels on site (Figure 9).

After cutting, we use a hot knife to remove foam from the edge so there's room for a spline or nailer.

Because SIP buildings are engineered, we have to get changes okayed.

Effect on Subs

As with any alternative method, using SIPs affects the subtrades.

Drywallers and finish carpenters love SIPs because they are flat and straight and they don't shrink or bow. Also, finding nailing is easy because the panels are continuously sheathed on both sides.

Roofing over SIPs is no different from roofing over any other sheathed roof.

Mechanical trades. Since partition walls in SIP houses are normally stick-framed, the hvac installer can easily run ducts in them. The only time there's a problem is when there's no attic and both the floor and roof are SIPs. Then we have to provide chases.

The plumber is in the same boat as the hvac contractor — most of the pipes go in partition walls. If the kitchen sink is on an outside wall, we either run plumbing through the toe space or bring it up through the bottom of the cabinet (Figure 10, page 10).

We typically build an interior chase for the vent pipe; when necessary, we leave an open space between two panels for pipes, then fill the space later with EPS and spray foam.

Electrical. The electrician faces the greatest challenge because it's hard to avoid putting switches and receptacles in exterior walls.

We order panels with one vertical and two horizontal wire "chases" — 1¼-inch holes that run edge-to-edge through the foam (Figure 11, page 10).

The first horizontal chase is at outlet height, and the second is at switch height.

Figure 10. To avoid putting pipes in the wall, the author had the plumber install the drain and supply lines for a sink just inside the panels at the sink-cabinet location (far left). If plumbing must go in an exterior wall, the author creates a chase by cutting out the panel and removing some of the foam (left). Once rough-in is complete, the author's crew uses spray foam to fill in around the pipes.

Figure 11. Wire chases are provided by panel manufacturers. The electrician accesses the chase by cutting a hole through the OSB and removing some of the foam. He can then fish wires through the chases and connect them to remodeling boxes in the panels.

Since they're marked on the OSB, their location is obvious.

The electrician accesses the chase by cutting a hole through the face of the panel and digging out some of the foam. He is then free to fish wires vertically and horizontally and install remodeling boxes as needed.

When the wiring is done, we seal everything with spray foam.

With a little planning, you can run most of the wire through interior walls and minimize the amount that runs through panels.

Cost

Panels cost more than conventional framing material, but they require less labor.

In my business, building a house with SIPs costs somewhere between 1 percent less to 5 percent more than stick-framing the same plan.

Because a SIP house is tighter and better insulated, we can downsize the hvac system — but we have to install an HRV.

We don't have to hire an insulation contractor, and our dumping fees are lower because there is much less waste.

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