

Building with SIPs



An Introduction to Structural Insulated Panels

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Getting the sun's energy into a building is easy, but making good use of it is both an art and a science. How can this heat energy best be retained in the home for use when you need it? One answer is to use structural insulated panels (SIPs) for some or all of your walls and ceilings.

Good passive solar design starts with a very efficient envelope, comprised of the floor, walls, roof, windows, and doors. Each component plays a distinct role in achieving heat retention. How these parts are incorporated into a solar building will be influenced by overall expense, aesthetics, interior and exterior finishes, and structural load requirements.

Throughout history, methods of building walls have been dictated by the local climate and the natural resources available. Wall building systems have included earthen or rock walls, timber frames with cob infill, solid wood, and modern stick-frame construction. Today, increased demands for labor, material, and energy efficiency are changing the way we build and the materials we build with. Conventional materials, like wood, are being married to new substances to create buildings that are more energy and material efficient than ever before.

SIPs & Solar Energy

I first became involved with SIPs in the late 1970s while designing a passive solar home in Hood River, Oregon. At that time, passive solar homes were using double walls as thick as 12 inches (30 cm) with plastic air barriers and lots of labor to air-seal them. In 1988, I helped erect a SIP-integrated, timber-frame home in central Oregon. It was apparent—here was a simple system that provided superior insulation and exceptional air-sealing in one easy step.

Although SIPs aren't a new technology—they've been around for several decades—they are gaining popularity as an alternative to conventional stick-frame construction. A SIP consists of two outer skins, generally oriented strand board (OSB), with a 4- to 12-inch (13–30 cm) inner core of expanded polystyrene (EPS). Some manufacturers use polyurethane foam or even compressed straw between the OSB skins. The components are pressure-laminated together to make one structural unit.

SIPs offer insulating values from R-15 to R-45, depending on the thickness of the panel. In standard wood-frame construction, one-quarter of the entire wall area can consist

of solid wood, which has a value of only R-1 per inch. Contrary to popular belief, an R-21 batt does not create an R-21 wall. The insulating value of a wall is the R-value of all the materials used. Steady-state R-values, used by code officials, only consider where the insulation is, without accounting for thermal bridging at the studs, headers, or window framing.

SIPs address this problem by providing continuous insulation, with minimal thermal bridging. Six-inch (15 cm) panels have a 58 percent higher whole-wall R-value than a standard 2 by 6 stick-frame wall. SIPs have far fewer interruptions in the insulation, spanning widths from 4 to 24 feet (1.2–7.3 m), while the insulation in stud-framed walls is interrupted every 16 to 24 inches (40–61 cm). This makes SIP structures significantly more airtight, and in turn, makes a building more comfortable and energy efficient. In passive solar designs, the high resistance to heat flow in SIP walls and roofs protects concrete slabs and interior mass from losing heat to the outside environment.

Other Advantages

Besides being well suited for passive solar design, SIPs have other excellent qualities. SIPs can be custom fabricated for each project, making home design and construction as versatile as conventional stick-frame construction.

SIPs can be slightly more expensive than the materials used in stick-frame construction. But by combining three stages of conventional shell construction—framing, sheathing, and insulation—into a single unit, a SIP structure can be erected much faster and with less specialized labor than conventional stick-building methods, cutting construction time and labor costs.

Reducing Infiltration

Leaky walls allow warm or cold air to be sucked through a building, resulting in drafty, uncomfortable, and energy inefficient spaces. Infiltration through standard stud-constructed walls is very difficult to prevent. And although solid wall systems, like SIPs and insulating concrete forms (ICFs), can reduce drafts significantly, any wall penetrations—such as windows and doors—can contribute to leakage in either direction.

To get the best performance from any wall system, these penetrations must be sealed properly. But be sure to provide adequate building ventilation, both for the health of the building and for its occupants. Depending on your climate, this can be accomplished in a variety of ways, from opening a window to installing an efficient heat-recovery ventilator. Current building science indicates 0.33 air changes per hour (ACH) as a good goal for residential construction.



The Sughrue home in Vancouver, Washington, integrates SIPs and recycled timbers for energy and resource efficiency. Built in 1999, heating bills have averaged only US\$350 per year.

And using SIPs typically results in straighter walls than standard stick-framed systems.

Floor and wall SIPs require only standard hand and power tools, with the exception of a beam cutter attachment for a circular saw (like a Prazi beam cutter) and a hot knife if you are fabricating your own wall panels. Roof SIPs need a small boom truck, small crane, or material lift to raise them to roof level.

SIPs meet all building codes and perform well in fire tests. The lack of oxygen within the panels' rigid EPS foam core helps prevent combustion. When covered with an appropriate thermal barrier, like gypsum board, SIPs meet all national fire safety standards and the *International Building Code*.

SIP manufacturers can include wiring chases inside the panels at outlet height in walls, and holes can be cut for outlets where needed. Wiring for light switches, which are generally located near door frames, can be run up the SIP edge before inlaying the door frame. For areas like kitchens where lots of wiring and plumbing are needed, 2 by 4 false walls can be added to the SIP's interior face to accommodate the wires and runs. Plumbing should never be run within SIP walls, just as it should not be run within conventionally framed outer walls. In cold weather, this practice can put pipes at risk for freezing.

Above all, one of the features builders like best about SIPs is the ease with which they integrate with other building systems.

SIPs & Sustainability

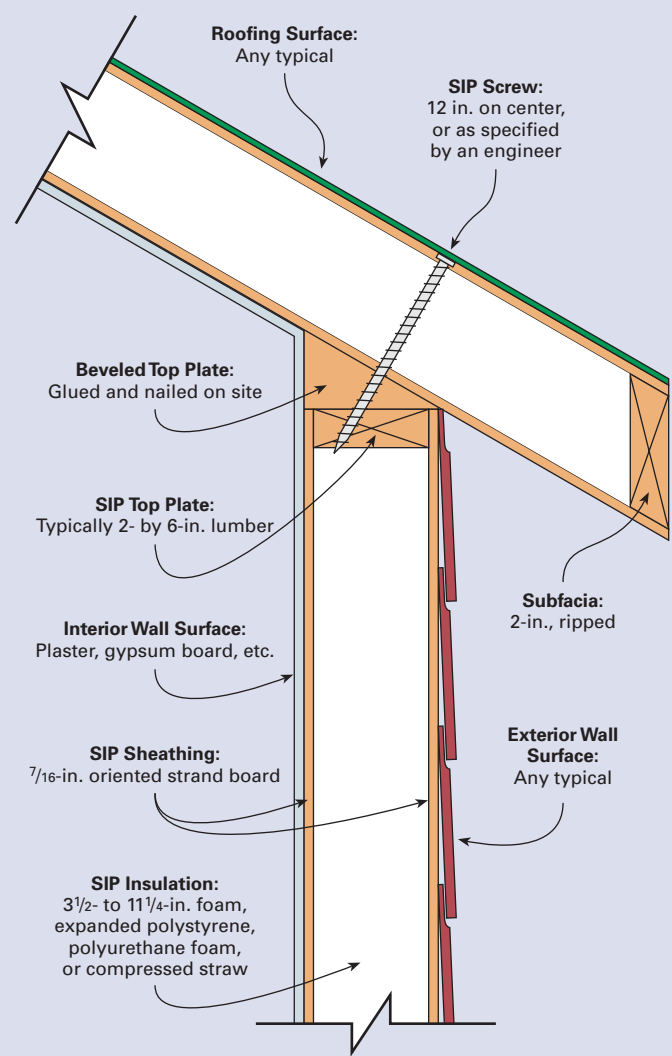
The wood used in SIPs is typically harvested from fast-growing, small-diameter trees instead of from old-growth forests. But experts remain divided over whether SIPs save wood. Although SIP construction generally uses less dimensional lumber (up to 50 percent less than a conventional stick-framed home), overall wood savings may only be about 5 percent, due to the fact that SIPs use wood sheathing on *both* sides of a wall.



With logs having an insulation value of only R-1 per inch of wood, adding SIPs to the roofing system of this home makes the whole building more efficient.

One environmental concern about SIPs is their foam core. Polyurethane foam cores in SIPs used to contain hydrofluorocarbons (HFCs), which cause ozone depletion. However, polyurethane foam production has recently changed and only accounts for a fraction of the SIP market. Most manufacturers use EPS, a thermoplastic that, expanded with pentane and steam, does not use or release any HFCs during its manufacture. Both polyurethane and EPS foams are derived from and manufactured using petroleum,

SIP Wall & Roof Cross-Section



Roof Systems

Many of the criteria that apply to walls also apply to efficient solar roofs—high R-value, low air leakage, ease of construction, and cost. Building science research indicates that putting insulation in the roof plane instead of the ceiling is a superior energy-saving strategy. Keeping the heat and cold out of the building in the first place makes it much easier to control the building's interior temperature.

A couple of strategies already used by timber-framers and log homebuilders can allow you to move the insulation to the roof plane. Timber or log-framed rafters with 2 by 6 wood ceiling boards and a built-up foam roof is one option. Another strategy is to incorporate SIPs with a support system of logs, timbers, glue-lams, or trusses. Depending on the roof design, trusses or hand framing may be the only option. At the very least, use factory trusses with an energy heel so you can get full-depth insulation all the way out to the outside edge of the wall.

which adds another level of complexity to establishing their eligibility as a green building material. And, although EPS is a plastic that can be reclaimed and remanufactured into other products, bonding it to OSB makes it difficult to recycle.

Some experts argue that SIPs' energy savings over a building's lifetime make up for their fossil fuel-based components. "Although it takes about 40 gallons (265 l) of petroleum to make enough foam for a 2,000-square-foot (186 m²) home," says one energy analyst, "using SIPs can save approximately 60 gallons (227 l) in equivalent energy in the building's first year alone." The Florida Solar Energy Center found that using SIP construction can account for household energy savings between 12 and 17 percent.

One alternative to foam-core SIPs is a product called Agriboard (see Access). Agriboard panels use compressed wheat-straw, an agricultural waste material, as the insulative core. The straw is compressed under high temperatures and pressure; no additional binders are needed beyond the

adhesive used to bind the straw core to the OSB. Insulation values, which range from R-14.7 in the 4³/₈-inch (11 cm) panel to R-25 in the 7⁷/₈-inch (20 cm) panel, compare to standard EPS SIPs' values.

"More than 90 percent of the Agriboard panel core is made from a raw waste material—wheat straw—that is annually renewable," says Jesse Kemp, Agriboard's Director of Engineering. "And any waste we produce at the plant can be easily recycled—the waste straw can be put out to let nature take its course." Using waste straw this way gives local farmers an additional cash crop, and, Kemp says, also offers some environmental savings. "The farmers would either have to burn the straw or take the effort to till it under. Both activities create pollution. Instead, we take the waste wheat-straw and put it to good use."

The Best Wall

Besides SIPs, other energy efficient wall systems include insulating concrete forms (ICFs), which consist of a hollow



Versatile SIP gable walls and roofs can accept a variety of interior finishes.

OSB & Off-Gassing

Widely used in manufactured building materials and numerous household products, such as fiberglass insulation, cabinetry, and shelving, formaldehyde's most significant use in homes is as an adhesive binder used in engineered wood products such as particleboard and oriented strand board (OSB).

The Environmental Protection Agency (EPA) classifies formaldehyde as a "probable human carcinogen," exempting it from the Clean Air Act standards that govern hazardous air pollutants. However, the EPA is considering a September 2004 report from the World Health Organization International Agency for Research on Cancer that classifies formaldehyde as a "known human carcinogen."

There are two types of formaldehyde—urea formaldehyde and phenol formaldehyde. Products made with urea formaldehyde can off-gas significant levels of formaldehyde gas. Products made with phenol formaldehyde generally emit much lower levels of the gas.

OSB panels contain a very small percentage of phenol formaldehyde in the resin that helps hold the wood fibers together. Tests of formaldehyde from newly manufactured panels conducted by the EPA showed emissions below 0.1 parts per million. In fact, the levels were so low and so close to background levels in the test chamber that accurate measurements were not possible.

foam-block wall reinforced with rebar and then filled with concrete, or autoclaved aerated concrete (AAC) solid-block walls that offer good insulative value in a lightweight building block. An old idea that is undergoing resurgence is straw bale infill between a load-bearing frame. Other systems also have been designed to improve standard frame walls—one that is gaining popularity is wood framing combined with spray soy-foam and an exterior foam wrap.

So which wall is the best wall? It depends. Make a list of the characteristics that are most important to you and then compare wall systems that you think would work best with your building's design. If you know, for example, that you want to use an earthen clay finish on interior walls or stucco for the exterior finish, perhaps an ICF like Rastra, Apex, or Durisol might be your best choice. If construction speed or high R-value is the most important factor, then having large SIPs with pre-installed lumber delivered to the building site might be your best bet. Whatever the case, before you make a decision, do your research, ask plenty of questions, and get independent third-party opinions.

With sustainable living as the goal, green building, energy conservation, and renewable energy are only part of the larger picture. You will want to take an over-reaching view of your whole construction project as a sustainable process. There is no one perfect building material—only more appropriate products to match your set of parameters and goals.

Access

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Structural Insulated Panel Association, PO Box 1699, Gig Harbor, WA 98335 • 253-858-7472 • Fax: 253-858-0272 • staff@sips.org • www.sips.org • General SIP information

Agriboard Industries, 100 Industrial Dr., Electra, TX 76360 • 866-495-3595 or 940-495-3590 • Fax: 940-495-3597 •

info@agriboard.com • www.agriboard.com • SIPs made with a compressed wheat-straw core

Apex Construction Systems Inc., 15930 SW 72nd Ave., Portland, OR 97224 • 800-252-8784 or 971-222-0006 • Fax: 971-222-0182 • info@apexconsys.com • www.apexconsys.com • Apex-Panel (ICF) systems

Durisol Building Systems Inc., 67 Frid St., Hamilton, Ontario, Canada L8P 4M3 • 905-521-0999 • Fax: 905-521-8658 • info@durisolbuild.com • www.durisolbuild.com • Durisol (ICF) systems

E-Crete • 2151 E. Broadway Rd. #115, Tempe, AZ 85282 • 888-432-7383 or 480-596-3819 ext. 11 • info@e-crete.com • www.e-crete.com • E-Crete (ICF) systems

Florida Solar Energy Center, 1679 Clearlake Rd., Cocoa, FL 32922 • 321-638-1000 • Fax: 321-638-1010 • info@fsec.ucf.edu • www.fsec.ucf.edu

Insulating Concrete Forms • www.icfweb.com • General ICF information

Precision Panel Structures Inc., 1447 E. State St., Eagle, ID 83616 • 208-939-2610 • Fax: 208-939-9905 • info@precisionpanel.com • www.precisionpanel.com

Prazi USA, 246 S. Meadow Rd., Plymouth, MA 02360 • 800-262-0211 or 508-747-1490 • Fax: 508-746-8655 • info@praziusa.com • www.praziusa.com • Prazi beam cutter circular saw attachment

Rastra Corp., 7621 E. Gray Rd. Ste. A1, Scottsdale, AZ 85260 • 877-935-3545 or 480-443-9211 • Fax: 480-443-9228 • info@rastra.com • www.rastra.com • Rastra (ICF) systems

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