

AIRTIGHT WALL CONSTRUCTION

With Structural Insulated Panels

By Al Cobb

INTRODUCTION

Structural insulated panels, or SIPs, have made significant headway in the non-residential construction market in the last ten years. These insulated building panels have long been a favorite of timber framers and custom home-builders, and the recent demand for more energy-efficient buildings has expanded the breadth of applications for the technology. The inherent energy efficiency of the panels has been accompanied by steadily improving fabrication technology, resulting in an envelope system that can reduce labor and material costs.

However, the concept of SIPs is not new. Experiments began in the 1930s at the Forest Products Laboratory to develop wall panels with a portion of the vertical axial load supported by the structural sheathing. With the advent of foam insulation in the 1960s, the first laminated SIPs became available. Throughout the

product's evolution, the concept remained the same: The panels would handle in-plane structural loads without the use of studs while providing continuous insulation with a high-density foam core. (See *Figure 1*.)

Today, SIP manufacturers rely largely on oriented strand board (OSB) for the panel facings. One of the advantages of OSB is that it is available in jumbo 8-ft x 24-ft panels and compatible with nearly any exterior finish. Computer numerically controlled (CNC) fabrication equipment is also becoming the industry standard, allowing SIPs to be fabricated to the exact design of the building with extremely tight tolerances. Large prefabricated panels have major productivity benefits for builders and designers over conventional stud framing. Window openings are precut, and the steps of sheathing and insulating stud walls are eliminated.

A number of different foam materials are used to provide insulating cores ranging from 3 5/8 inches to 11 3/8 inches in thickness (4 1/2-in and 12 1/4-in total panel thickness, respectively), including expanded polystyrene (EPS), extruded polystyrene (XPS), and polyurethane. Type I

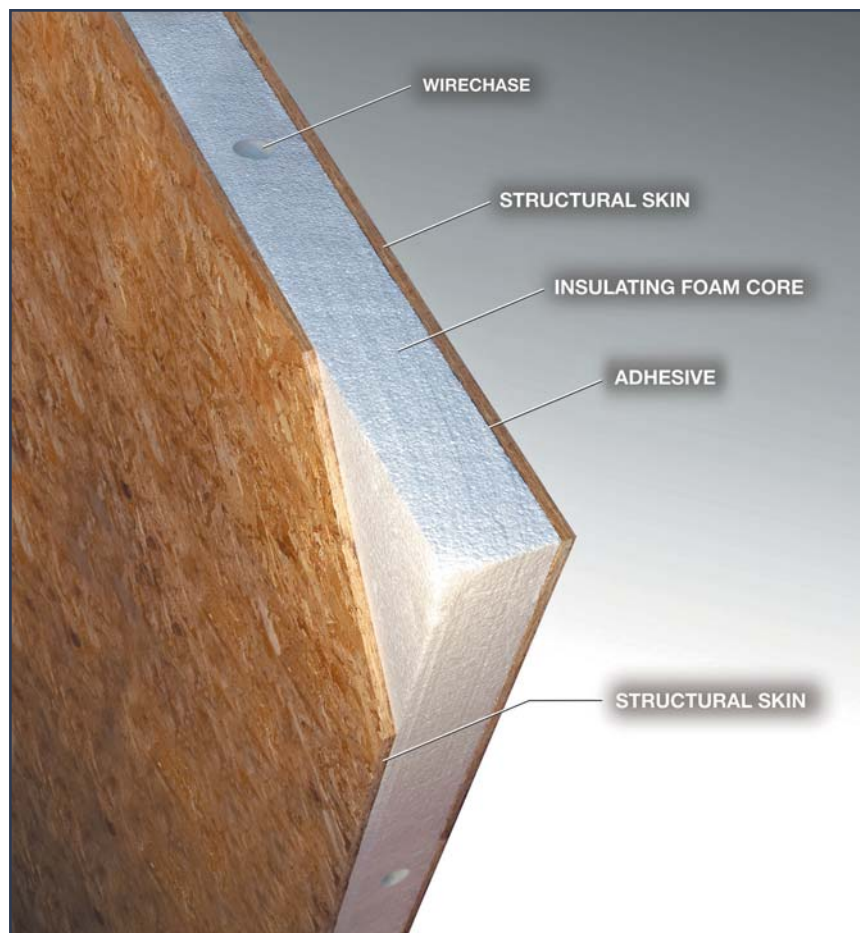


Figure 1 – Components of a structural insulated panel (SIP).

EPS with a density of 0.9 – 1.0 lb per cubic ft (pcf) is most common, providing an R-value of R-3.6 per inch. XPS foam cores are R-5 per inch, and polyurethane foam cores are R-5 or greater per inch, depending on the manufacturer's specific formulation. Polyurethane panels are generally limited to 5 5/8-in core or 6½-in total panel thickness.

The very nature of construction scheduling can make an SIP envelope an attractive alternative. If an SIP package is properly designed and fabricated, an experienced crew can install that package in short order. It is this type of execution that leads many SIP projects to shave days or weeks from a Gantt chart.

For many architects, the time-saving aspect of SIP construction takes second seat to energy efficiency. The emergence of green building rating systems like the U.S. Green Building Council's LEED® program has placed increased importance on a well-insulated and airtight building envelope. Many municipalities have already adopted LEED® mandates for public buildings, and progressive states like Washington and California have passed legislation calling for more rigorous building-energy codes. SIPs offer a method of meeting the building-envelope performance guidelines of these new mandates without adding excessive material and labor costs.



Figure 2 – Wind River Hall student housing at Western Wyoming Community College is a four-story self-supporting SIP building. Kamerman Construction estimated that SIPs shaved two to three weeks from the construction schedule.

STRUCTURAL PROPERTIES OF SIPs IN COMMERCIAL CONSTRUCTION

Within the nonresidential building environment, SIPs have been used for both curtain-wall construction and structural wall assemblies that do not rely on any supporting superstructure. SIPs act in a similar manner to a steel I-beam—the outer facings handle the majority of in-plane loading, while the foam core prevents their flexure. It acts as a syner-

gistic composite, with the whole being stronger than the sum of its parts. (See Figure 2.)

Although this type of construction is popular, it is typically limited by the structural capacities of SIPs to buildings of three



Figures 3A and 3B – Dimensional lumber nailers were attached to the structural steel frame of this Cherokee Nation school in North Carolina. The SIPs were attached to the nailer using SIP screws through the thickness of the panel.



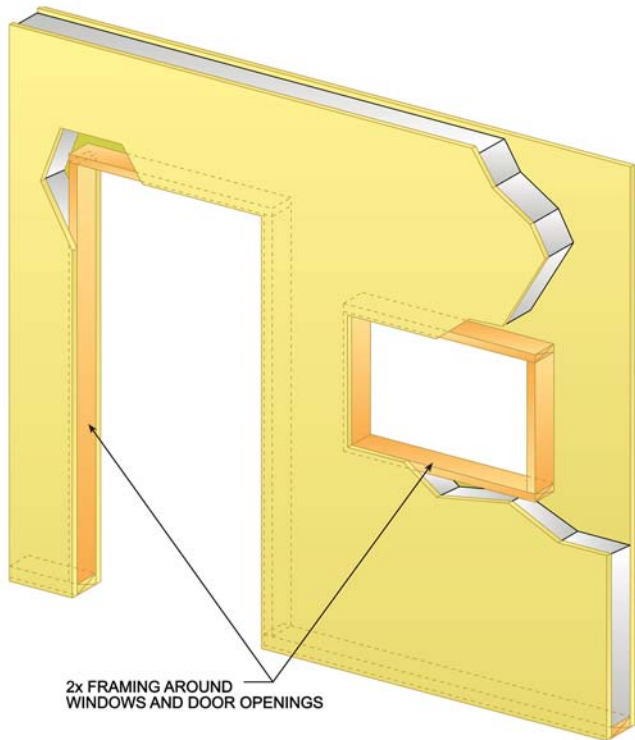


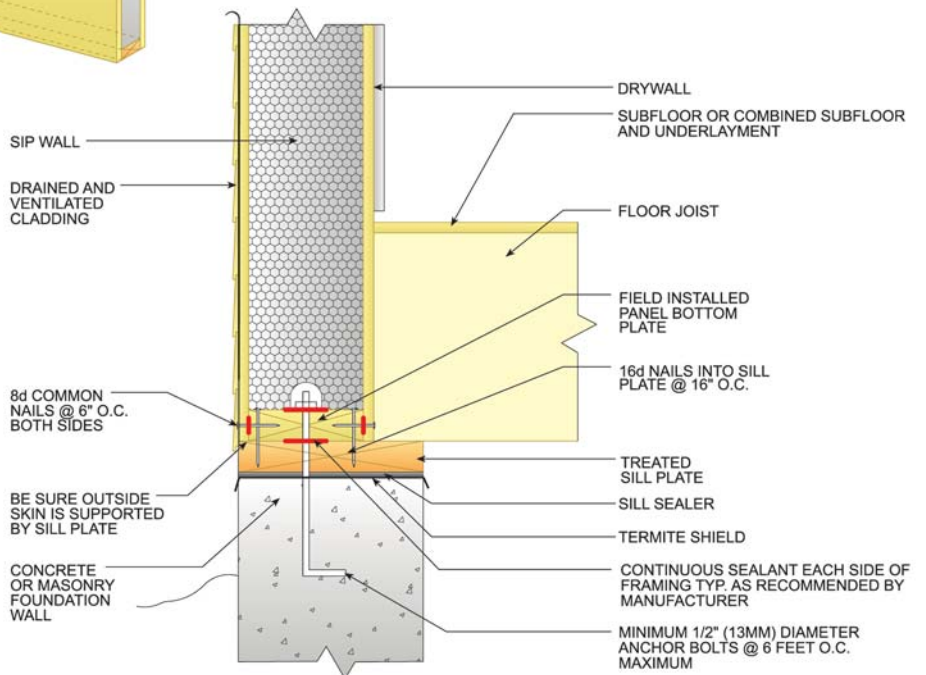
Figure 4A – SIPs are available in thicknesses that correspond to dimensional lumber. Window and door openings are recessed to accept dimensional lumber blocking.

Figure 4B – Wall panel attached to fixed bottom plate. A capillary break must be used between SIPs and concrete.

stories or less. On larger structures, SIPs are attached as a curtain wall to an engineered wood or structural-steel frame.

This marriage of two systems forces the designer to look closely at the interface between panel and frame. If the frame is timber or engineered wood, the attachment mechanism is usually a specialty panel screw, designed for wood penetration, that is screwed through the thickness of the panel into the supporting structure. If the structure requires the SIP to be attached to steel, the attachment method will depend on the steel type and thickness. Mild steel less than 3/16 inch can be penetrated with an industry-standard self-tapping panel screw. However, if the steel is structural grade I-beams and columns, the interface gets a little more involved.

In a recent project in North Carolina, the SIPs used on a new school for the Eastern Band of the Cherokee Nation had



FOUNDATION CONNECTIONS

FOUNDATION CONNECTION DETAIL A

www.rci-online.org

Infrared Inspections, Inc.
 Nationwide Roof Scanning Since 1985

1-800-543-2279
 Info@roofscan.com

Figure 5 – SIPs were used on the 68,000-sq-ft Jacob E. Manch Elementary School in Las Vegas, Nevada. With 500 skylights installed in the SIP roof, the school uses 100% daylighting.



to be attached to a wood nailer that was, in turn, attached to the red iron with powder-actuated fasteners. (See Figures 3A and 3B.)

SIPs themselves are produced in sizes that correspond to standard dimensional lumber, e.g., a 6½-in SIP has a 5 5/8-in thick foam core to coincide with the nominal dimensions of a 2 x 6. The foam core is recessed on all four sides of the panel to accept either dimensional lumber or splines, which are used in panel-to-panel connections. On self-supporting SIP structures, installers will slide the panels over a fixed bottom plate and screw through the panel skins into the bottom plate. Top plates are installed in a similar fashion, allowing SIPs to interface with standard joist or truss-roof systems. Window and door openings are blocked out with dimensional lumber in order to attach the respective hardware. (See Figures 4A and 4B.)

Electrical wiring is run through pre-cut chases in the foam core of the panel. Manufacturers can cut horizontal and vertical chases at custom locations to match the wiring design of the building. Although this often raises concerns with electricians, an independent third-party study conducted by R.S. Means Business Solutions found that wiring SIPs is actually faster than wiring conventional wood framing. (See Figure 5.)


Structural considerations may sometimes be necessary for the attachment of certain exterior finishes or interior cabinets. These typically involve increasing the fastening schedule through simple pullout-resistance calculations.

BUILDING SCIENCE PRINCIPLES OF SIP WALL CONSTRUCTION

From an energy-efficiency perspective, SIP construction has two major advantages: the elimination of thermal bridging through studs and significantly lower air infiltration. The latter is a function of the inherent properties of the SIP and on-site joint sealing practices.

OSB, the most common facing material used with SIPs, has a permeability of less than 1 perm, making it a code-compliant air barrier on both sides of the panel. This is a significant advantage over cavity insulation that depends on drywall and paint for an interior air barrier. The solid-foam core materials used in SIPs do not allow convection inside the wall cavity, which can occur with fiberglass insulation, leading to unseen mold growth when warm air condenses on the inside of the wall sheathing.

Creating a functional air barrier with SIPs depends entirely on proper joint detail-



{ **Guard Your Investment** }


A Tradition of Superior Performance in Harsh Environments

With over 100 years in the tire business and over 25 years as a leading manufacturer of commercial roofing membranes, the name Firestone is synonymous with quality and reliability.

Firestone extends those same traits to Firestone FlashGard Thru-wall Flashing, a high performance, flexible membrane alternative for protecting masonry walls from water damage.

FlashGard Features & Benefits:

- Remains flexible in a wide range of temperatures
- Outstanding expansion and contraction characteristics
- Highly resistant to corrosion, abrasion and wear
- Easily conforms to irregular shapes and contours
- Superior resistance to weathering and ultraviolet radiation
- Economical and easy to install with standard construction tools



Firestone
FlashGard
THRU-WALL FLASHING

The Flexible Solution™

To learn more about FlashGard, visit us at
www.firestonesp.com/rci1

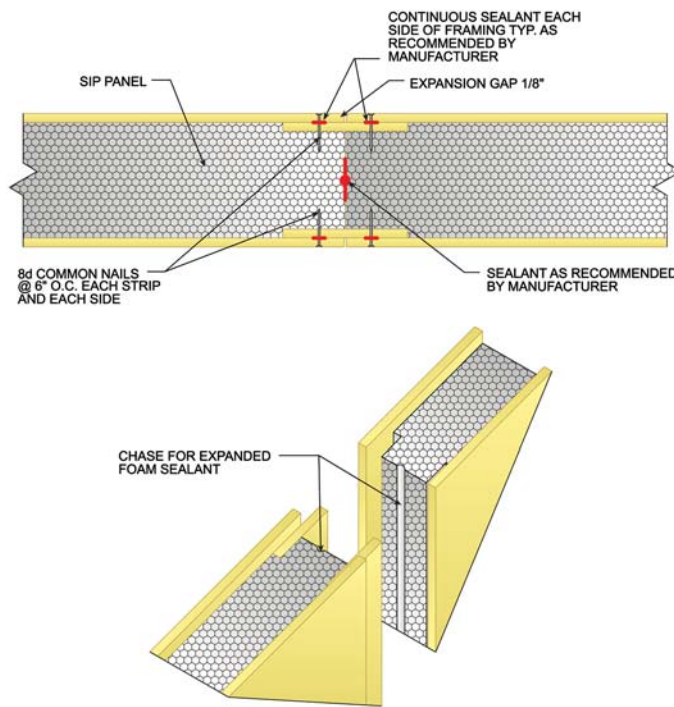
Firestone Specialty Products
800-428-4442 info@firestonesp.com

ing. These sealing details and techniques are both the Achilles heel and the trick to proper performance of the system. If joints are not properly sealed, warm, moist air from the interior can pass through panel joints and condense on the outside skin, potentially causing rotting along the panel joint over time. Depending on climatic conditions and type of exterior cladding specified, the details of a SIP wall may include an added back ventilation of the exterior cladding. It is this detail combined with a rain screen that improves the SIP wall's capacity to deal with accumulated moisture from either internal migration or exterior bulk water.

An experienced installer has a host of techniques used to seal the panels. The most common material is foam-compatible, vapor-impermeable mastic supplied by SIP manufacturers. Mastic is used to seal the foam-to-foam or foam-to-wood intersections. In addition, many of the systems employ either single-component expanding foam or spray polyurethane foam. This material does a wonderful job of expanding into cracks and crevices to ensure an airtight joint. However, it can also be finicky for the untrained installer, resulting in a potential void in the sealing system. (See Figure 6.)

Finally, the industry added a belt-and-suspenders approach to SIP sealing by introducing SIP seam tape. This vapor-barrier material used at panel joints ensures that air cannot move through the system. When using SIP tape, it is important to recognize that SIP wall assemblies need to be able to dry in at least one direction. For example, it would be a mistake to apply SIP tape on one side of the wall with a peel-and-stick impermeable vapor barrier on the other side.

Another issue that has surfaced as a potential concern is panel bowing. This movement is a result of volume changes. As moisture levels rise or fall, the associated expansion of one skin or the other can cause the panel or wall assembly to bow. The greater the span of the wall panel and the thinner the foam core, the greater the



WALL-TO-WALL VERTICAL PANEL CONNECTIONS SURFACE SPLINE FOR VERTICAL SPLICE

Figure 6 – Vertical panel-to-panel connection using a surface spline. Sealing can be done with mastic as panels are assembled, or using expanding foam after panels are in place by drilling access holes into the foam channel.

potential for bowing. The good news is that avoiding the conditions that lead to panel bowing is largely controllable. This would include avoiding thin panels that span great distances (greater than 12 ft), sudden forced heating and dehumidification when the exterior of the wall assembly is at elevated moisture content, and back ventilating the cladding to ensure a controlled and lower level of moisture.


Much of the onus of proper panel performance falls on the installer. Admittedly, the learning curve for installing wall SIPs is not very steep. A qualified carpenter can learn the basics of installing SIP wall

assemblies in only a day or two. But SIPs are not a plug-and-play system. Attention must be paid to proper joint sealing and protection of panels on site to prevent them from absorbing too much moisture.

THE FUTURE OF SIPs

In the last ten years, SIPs have transitioned from a niche industry for custom home-builders to a popular option for all types of residential, multi-family, and commercial construction. With unprecedented interest in green building and proposed building energy-efficiency goals being contemplated by Congress, SIPs and other energy-efficient envelope systems are likely to experience significant growth in the next 20 years. Traditional insulation techniques will simply not be cost-competitive when a higher level of air infiltration resistance is necessary.

Architects, engineers, installers, and other construction industry professionals need to learn the basics of SIP construction to ensure proper

detailing and prevent moisture-related issues in SIP buildings. But preparing for the shift to SIP construction involves more than just the building science of airtight building envelope assemblies; it includes a new way of thinking about design and engineering to make the most of prefabricated components. SIPs represent a paradigm shift in construction technique that removes much of the on site decision making and places the majority of framing fabrication in a controlled environment where greater material and cost efficiencies can be achieved. 

Al Cobb

Al Cobb is director of The SIP School and president of PanelWrights, LLC, a SIP distribution and installation company located in Shenandoah Junction, West Virginia. He has 20 years of experience in SIP design, installation, consulting, and manufacturing.

