Structural Insulated Panels in Alaska

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Abstract

This document provides a brief introduction to structural insulated panels and their use in Alaska.

Keywords: Structural Insulated Panels, Building Envelope, Walls, Roof, Foundation, Cold Climate

List of Acronyms

ACH50	Air Changes per Hour at 50 Pascals of Pressure
BBHA	Bristol Bay Housing Authority
CCHRC	Cold Climate Housing Research Center
EPS	Expanded Polystyrene
HRV	Heat Recovery Ventilator
HVAC	Heating, Ventilation, and Air Conditioning
IBC	International Building Code
IECC	International Energy Conservation Code
IRC	International Residential Code
IRHA	Interior Regional Housing Authority
NIHA	Northwest Inupiat Housing Authority
OSB	Oriented Strand Board
SIP	Structural Insulated Panel
SIPA	Structural Insulated Panel Association
XPS	Extruded Polystyrene

Structural Insulated Panels in Alaska

Structural Insulated Panels, or SIPs, are manufactured building panels that provide both structure and insulation for a building. They have been in use in the building industry for more than 50 years. In Alaska, homebuilders and housing authorities have used SIPs for building projects throughout the state and there are currently two SIP manufacturers in the state.

This report contains information gathered in 2014 through a literature review and interviews with building professionals who use SIPs in cold climates. The first section, *SIP Technology Primer*, provides a general description of SIPs along with their typical applications and commonly recognized advantages and disadvantages. The second section, *SIPs in Cold Climates*, documents their use in Alaska and other Arctic climates.

This document does not explain how to build with SIPs, nor does it critique their use in Alaska. Rather, its purpose is to objectively document information about SIPs for homeowners and builders who are interested in a comprehensive resource on their characteristics and use. Those interested in a shorter consumer's guide on SIPs should refer to the CCHRC snapshot *SIPs in Alaska* included as Appendix B or to the YouTube video (https://www.youtube.com/watch?v=oPHJvxsiv0I).

SIP Technology Primer[1]

Structural Insulated Panels, or SIPs, are manufactured building panels that combine structure, insulation, and sheathing into one product. They can be used in residential construction for the walls, floor, and roof of homes. SIPs are available in a wide range of sizes and R-values and thus can be used in a variety of applications. In the United States SIP, between 1–2% of single-family homes are built with SIPs (Maynard, 2010).

The first SIPs were developed in the 1930s by the Forest Products Laboratory (Green Building Advisor, 2013). Alden B. Dow was the first to use them in a residence in 1952 when he built a home in Midland, Michigan using foam-cored SIPs for the exterior walls, interior partitions, and roof (CMHC, 2001). There were few SIP manufacturers in the United States from the 1950s to the 1980s (Morley, 2000). Today, there are over 20 U.S. SIP manufacturers that are members of the Structural Insulated Panel Association (SIPA, 2014).

Panels are assembled and pre-cut at a manufacturing plant according to plans submitted by a builder – and can include features such as window openings, headers, and posts to the panels (Aldrich, Arena, & Zoeller, 2010). Panels must comply with the fire safety and load-bearing standards of the International Building Code (IBC) and the International Residential Building Code (IRC).

[1] For a more detailed description of Structural Insulated Panels, along with general instructions on using them in construction, please refer to a more detailed text, such as Building with Structural Insulated Panels by Michael Morley, published in 2000 by The Taunton Press in Newton, Connecticut.

Figure 1: SIPs are numbered at the factory so that builders know where to place each panel.
Photo courtesy Dave Miller of Landmark, Inc.

There is one national trade association for SIPs: the Structural Insulated Panel Association, or SIPA. Formed in 1990, SIPA represents manufacturers, suppliers, distributers, design professionals, and builders that work with SIPs. They provide education, training, technical and marketing research, and quality assurance. SIPA research has addressed topics such as R-value and durability tests, and the cause of the failure of some installed SIPs in Juneau in the early 2000s. Their Master Builder program allows installers to learn about design and construction with SIPs, and their annual conference provides an opportunity for continuing education for builders. Another training opportunity is the SIP School, a SIPA member that provides design and building education.

SIP homes can be built following prescriptive code requirements, such as the IRC, but some limitations apply to SIPs that are different than conventional wood-frame construction. For example, SIPs can be used for wall construction in seismic zones A, B, and C following the prescriptive design in the 2009 IRC, but SIP walls require an evaluation report from the manufacturer for demonstrating code compliance in seismic zones D, E and F (SIPA, 2011). They can also be used in retrofits, and SIPA provides an Installation Guide for Retrofitting a Roof and Walls on their website www.sips.org . These panels only have sheathing on one side and are designed to attach over an existing wall or roof. This versatility allows SIPs to be employed in many types of buildings, provided the construction follows manufacturer instruction, local building code, and proper SIP building techniques.

Components

SIPs consist of an insulating core between two layers of sheathing. The materials used for the insulation and the sheathing vary by manufacturer. Typically, the sheathing will be plywood or oriented strand board (OSB). Other sheathing materials include metal and fiberglass, though these are less common for residential construction. Similar to wood-frame construction, a thermal barrier is required for code compliance on the interior side of the walls and roof. For instance, many SIPs made with OSB skins will have a layer of joint-taped gypsum board (e.g. Sheetrock) on the interior OSB surface to serve as a thermal barrier (Aldrich, Arena, & Zoeller, 2010). Alternatively, some manufacturers provide interior composite panels for SIPs that are approved thermal barriers.

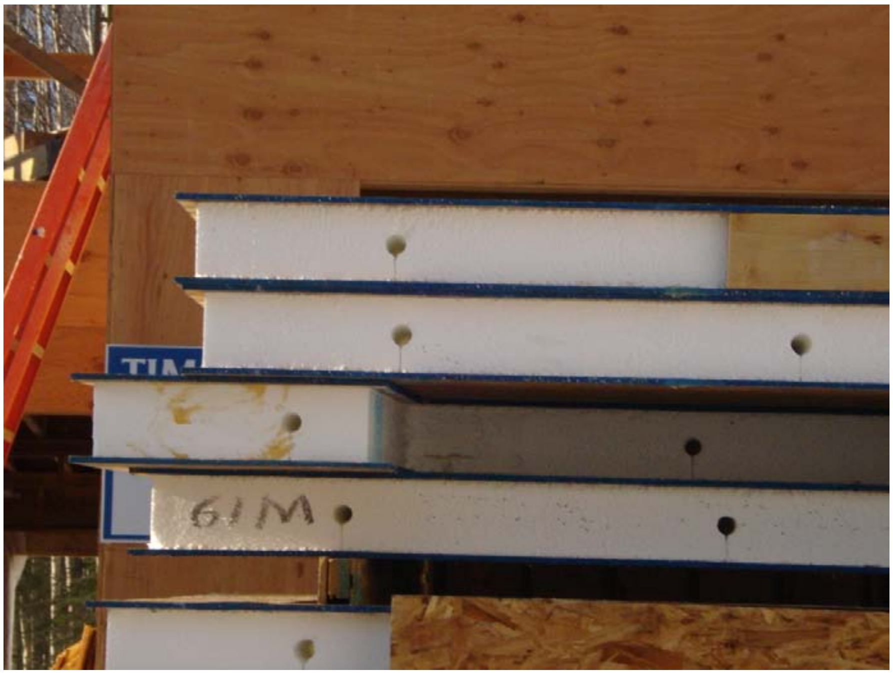

Figure 2: These SIPs on a job site consist of a foam core between two skins of OSB. Photo courtesy Dave Miller of Landmark, Inc.

The insulating foam core can be made of expanded polystyrene (EPS), extruded polystyrene (XPS), or a spray foam such as polyurethane. EPS is a closed-cell foam with an approximate R-value of 3.6 per inch. It is widely available and the least expensive option for the insulating core. Anther advantages of EPS is its low melting point, which means it can easily be altered in the factory or adjusted on-site with heating tools to put in cores for wiring. XPS has a higher R-value (see Table 1) and lower permeability rating[2], along with greater structural strength than EPS. However, it is more expensive and its higher melting point makes on-site adjustments difficult. Both EPS and XPS must be attached to the sheathing with an adhesive, which must be strong enough to prevent the panel from delaminating. With spray polyurethane foam, no adhesive is needed because the foam bonds to the sheathing when it is sprayed into the panel at the manufacturing plant. These insulations have higher R-values, but also have higher melting points and cost more than EPS.

[2] The perm rating for a building material refers to its resistance to the transmission of water vapor. Any material with a rating of 1 or less is considered an adequate vapor retarder. Perm ratings depend on a materials thickness, and the ones listed in Table 1 are for one inch of the insulation. Thicker panels will have lower perm ratings (e.g. 3 inches of EPS is 1 Perm).

Table 1. Characteristics of SIP insulations. Information from (Green Building Advisor, 2013).

Insulation	Approximate R-value/inch	Water Vapor Permeability, (Perm rating of 1 inch)
EPS	3.6	3
XPS	5	1
Polyurethane	6	1

SIPs vary in width, length, and height. Manufacturers offer standard sizes and some allow builders to order custom sizes. Thicknesses for the foam core typically match the nominal width of dimensional lumber; some common thicknesses are 3 ½ inches, 5 ½ inches, 7 $^{3}/_{8}$ inches, and 9 $^{3}/_{8}$ inches (Aldrich, Arena, & Zoeller, 2010). A common size for the length and height of the panel is 4 feet by 8 feet, though panels can be as large as 12 feet by 36 feet.

Construction

Building a home with SIPs requires special considerations beginning at the design phase. SIPs can be used for walls, foundations, and roofs. With any of these uses, the panels must be joined properly for an air-tight seal.

SIP job sites should be able to store delivered panels properly before they are assembled into a house, as panels must be stored carefully so they will not deform or break. Panels should be placed on a level surface and kept off the ground. They should be kept dry as moisture can cause them to swell or warp. Organized storage on site, such as stacking SIPs by layout and so labels are visible, will make the construction process more efficient.

Figure 3: Panels should be protected from moisture when stored on a job site.

Building a SIP home may require a few extra tools than for traditional framing techniques. For instance, nylon webbing, lifting plates, or ratchet straps might be required for moving individual panels and a forklift or crane might be necessary to move large panels or several at a time. Other supplementary tools include a hot wire for removing foam from panel connections and a flex bit for electricians to bore chase holes for wires (Ross, 2007). Safety is also a special concern, since panels are large and heavy compared to stick-framing materials.

Design

A SIP residence begins with the design. SIPs work best when the house is designed around them from the start. For instance, the typical rectangular panels work well with buildings that feature a simple design with 90° angles. Building dimensions can also be planned to accommodate typical panel sizes: in traditional homes, building dimensions will be multiples of panel lengths. Similarly, in timber frame homes, the home dimensions can be planned so a whole number of panels span the distance between the beams. Of course, panels can also be used with more complicated designs, but this increases the potential for waste when the panels must be cut to fit aspects of the design.

The design for a SIP building is made in advance and submitted to the manufacturer. It is advantageous to involve code officials, inspectors, electricians, and HVAC contractors in the planning stage of the building, so that the design plan will be compliant with applicable requirements and include channels for any pipes, wires, and outlets. These channels can be cut in the factory to reduce on-site labor. After the design is submitted to the manufacturer, the manufacturer works with the builder to optimize and finalize the design before making the panels.

Figure 4: Channels for electrical fixtures are pre-cut in the panels at the factory.

After the design is finalized, panels are created in the factory and any extra features such as openings for windows and electrical chases are added. The manufacturer numbers the panels and delivers them to the building site. Manufacturers also provide instructions and optional training to assemble and seal the SIPs. On site, builders must follow the building plan to install the panels in the correct order. After the panels are erected, plumbing and electrical systems are installed in the home.

Walls

SIP walls can rest on a floor deck, concrete slab, concrete footing, or a foundation wall. Detailed instructions for assembling walls are brand-specific and provided by the manufacturer. In general, however, panels are fit onto bottom plates that are attached to the base for the wall as they are erected. Builders should take care to ensure the base for SIP walls is level and square so panels can join together smoothly as they go up in an ordered sequence. Top plates are then installed to join panels together from above.

Figure 5: A house with SIP walls ready for finishing.
Photo courtesy Dave Miller of Landmark, Inc.

For exterior finish, the IRC requires flashing, a water-resistant barrier, and a drainage plane so water does not penetrate the building envelope (Pasma, 2012). The final siding can be vinyl, aluminum, wood, stone, brick, or stucco. On the inside, walls can be finished by hanging drywall, finish lumber, or another interior finish provided that thermal barrier requirements are met. The need for a vapor retarder will depend on the use of the building, local code requirements, and the climate zone. Plywood and OSB can be considered a Class II or III vapor retarder, depending on what test method is used to characterize the sheathing material. In a building or room with high humidity, such as an indoor pool or hot tub, a Class I vapor retarder (e.g. polyethylene sheeting) might be necessary (Pasma, 2012).

Foundation

Certain types of foundations lend themselves to SIPs. For instance, any floor over an unconditioned space, such as a house on pilings, can take advantage of large SIPs that can span the distance between supports. Also, floor SIPs tend to be thicker (and thus have more insulation) than panels that are used for walls. When installing SIPs in a foundation, it is important to ensure that the floor is level. A level floor makes it easy to install the walls – floors that are not level will cause misaligned wall panels that are difficult to seal together.

Roof

Large-panel SIPs can help roof construction move quickly. It is especially important to protect roof panels from moisture as they are exposed to both rain from outside and moisture from inside as air is driven through the roof by the stack effect. SIPs can be built as hot roofs or cold roofs (also called vented roofs). In the hot roof configuration, the exterior panel skin is covered by underlayment and then roofing finish materials. In a cold roof configuration (see Figure 6), furring strips are attached parallel to the roof slope to create an air gap between the panel and an overlying layer of roof sheathing. This air gap is open at the top and bottom of the roof sheathing to create vented channels. Both the panel outer sheathing and the roof sheathing are protected by an underlayment.

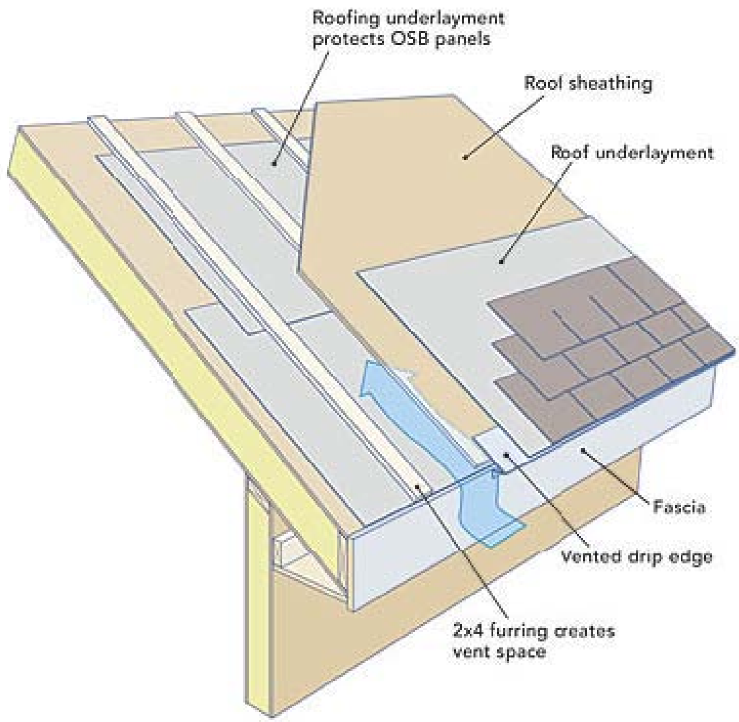

Figure 6: A cold roof assembly with SIPs. Figure courtesy of (Holladay, 2014).

While more material intensive, experts recommend the cold roof option in cold climates to help ensure a durable roof assembly (Holladay, 2014) and the Juneau building code requires venting for SIP roofs (City and Borough of Juneau, 2011). On the interior side, an air and vapor retarder will act as extra insurance against moisture in the home's air, and is required by some Alaska municipalities. For example, the City and Borough of Juneau requires an air-sealed Class I vapor retarder for SIP roofs. Mechanical ventilation, such as an HRV or exhaust fan, will also help to manage humidity levels inside the home.

Sealing

A crucial part of SIPs construction is the seal between adjacent panels. The interior sheathing of the panels serves as a class II vapor retarder, but the joints between the panels can allow air and moisture through if they are not sealed properly to create an air barrier. Other places that must be sealed are the areas where panels connect to windows and doors, and the connections between walls and the floor, and walls and the roof. Air leaks to the inside of the panel lead to condensation, which can cause rotting and structural problems.

Figure 7: Panels must be sealed together where they join.

SIPs are especially vulnerable to moisture at the panel joints. In fact, some builders use redundant sealing (taping over the joint or installing an additional vapor barrier on the interior) to ensure there are no leaks. A blower door test after installation can detect any leaks. Tightly sealed panels allow minimal air leakage, therefore mechanical ventilation is required to manage the moisture level inside the home and provide fresh air to occupants.

Panels are designed to fit together snugly, and manufacturers provide instructions and sometimes the materials to seal panels together. The connection between panels must have both structural attachments, such as a spline that fits into pre-cut channels on the panels, and a method to seal the connection to air and moisture. Three common configurations for spline connections are to use a surface spline, a 2 x board spline, or an insulated block spline (Aldrich, Arena, & Zoeller, 2010) as illustrated in the following diagrams.

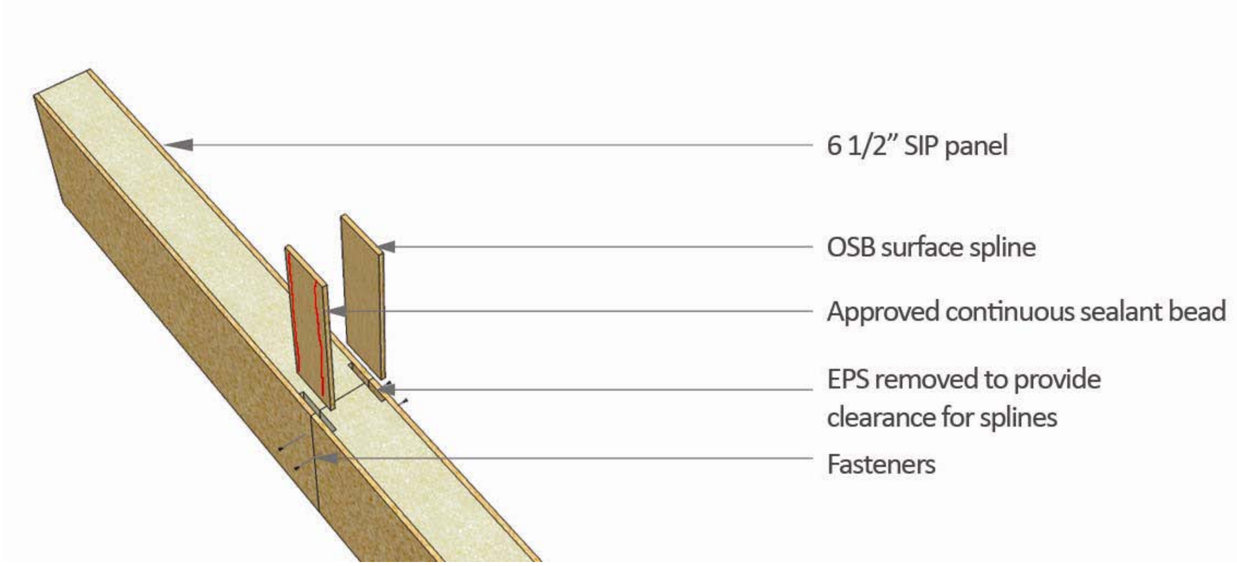

Figure 8: Surface splines are the most common method of sealing panels because this method is inexpensive and seals panels without a thermal bridge. Figure from (Aldrich, Arena, & Zoeller, 2010).

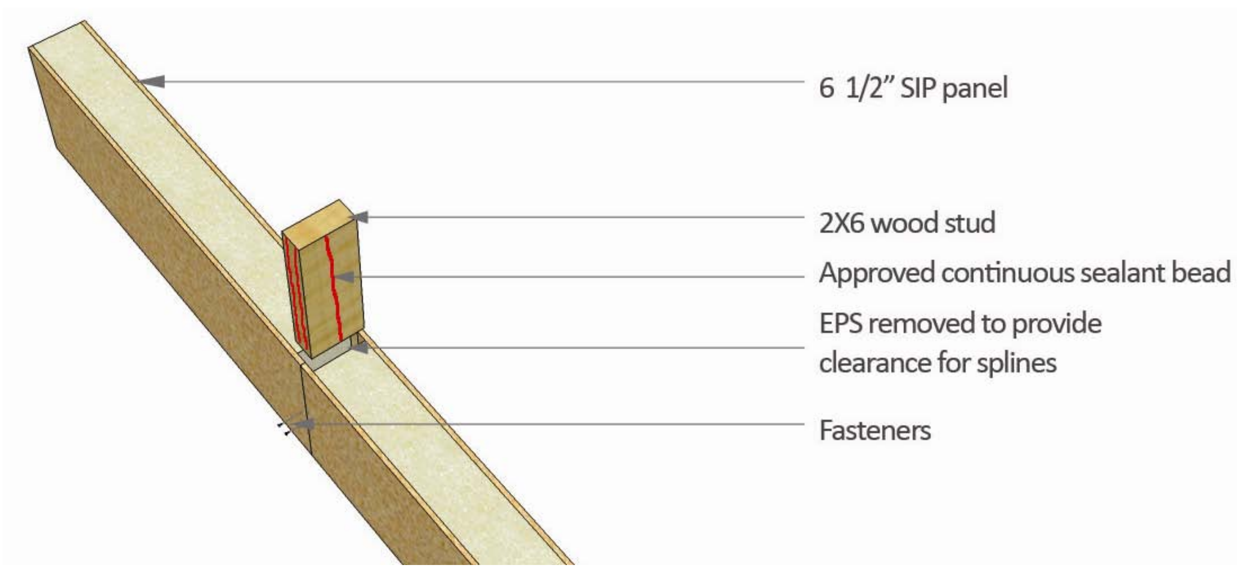

Figure 9: Studs can seal two panels together, but this creates a thermal bridge. Figure from (Aldrich, Arena, & Zoeller, 2010).

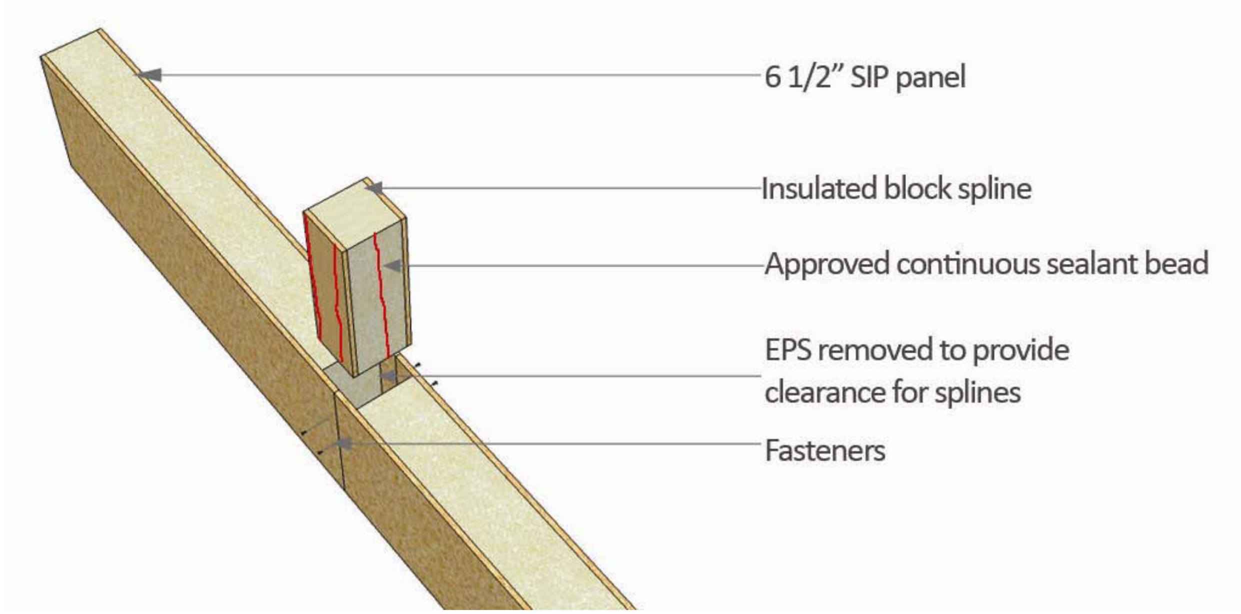

Figure 10: A seal with an insulated block prevents thermal bridging. Figure from (Aldrich, Arena, & Zoeller, 2010).

Splines can be secured with nails or screws after they are installed. At that point, builders use mechanical assistance to ensure a tight connection – employing sledgehammers, wrecking bars, and ratchet straps to ensure the panels are aligned properly.

Final sealing agents can include caulk, adhesive, mastic, or spray foam. Spray foam, which can expand into gaps, is also used for larger voids, such as the area where a sloped roof panel meets a wall panel. With any sealing agent, builders should apply the sealant with proper technique in order to ensure that it will actually seal the joint. For instance, surfaces receiving sealant should be dry, the sealant should be applied at a temperature where it can dry properly, and some sealants will not accommodate panel movement after sealant application. For instance, cured spray foam between two panels will not re-expand if the panels are later adjusted, thus creating a gap in the seal between the panels.

While properly-sealed SIPs act as an air barrier, mistakes in workmanship or sealant failures will allow air and moisture into joints. Some builders choose to tape the panel joints and/or apply a separate vapor retarder over the interior of the panels in order to help ensure that moisture will not pass through the panel joints.

Advantages and Disadvantages

There are several potential advantages to building a SIP home, which can be maximized by builders who have training and experience working with panels. First, correctly constructed and sealed SIP homes will have an airtight, insulated building envelope. The controlled manufacturing process means that insulation will be uniform throughout the envelope. SIP homes, especially those built using larger panels, have fewer studs than framed homes, reducing the thermal bridging that occurs through the envelope.

SIPs also can reduce construction time. For instance, a study of one conventional framed Habitat for Humanity home and one SIP Habitat for Humanity home found that the SIP home was constructed with 65% less on-site labor. The homes were of similar size, and built with comparable crews. The reduction in labor was attributed to the use of jumbo-sized panels, and value-added work such as the installation of window- and door-framing being done at the factory (Mullens & Arif, 2006).

When building a SIP house, the design work happens early in a project, in advance of the construction, so that the correct panels can be ordered from the manufacturer. This minimizes on-site construction time and allows experienced contractors to predict labor costs and scheduling with a high level of accuracy because much of the planning work happens before a crew arrives at the job site. At the building site, workers do not have to keep track of separate materials for insulation, framing, and sheathing. Trained SIP crews can erect panels quickly with manufacturer instructions, even if crew members have little other carpentry experience. Also, because manufacturers use software to optimize panel designs, there is little jobsite waste to remove. Fast construction not only saves on labor costs, but is advantageous for locations with bad weather or a short building season.

The potential for labor savings on a SIP home is balanced by a few other cost considerations. The total cost of the panels is more than just the cost of the materials, because of the sealing materials, design and manufacturing services, and shipping. Larger size panels may require extra equipment and safety precautions on a job site, such as a forklift. Additionally, crews that are unfamiliar with SIPs will require extra time to learn the proper building techniques and safety precautions. Finally, builders must consider that the smaller panel sizes have less potential for time and energy savings: the extra joints as compared to large panels require more time to seal, and there is the possibility of more thermal bridging if panels are joined with a piece of 2x lumber.

SIPs can also present disadvantages in the design phase. While pre-designed buildings can be an advantage in some situations, in others, the builder might desire the flexibility to make on-site changes. For instance, custom builders often save some of the home design for the construction phase, in order to best fit the home to the landscape. SIPs can be modified on-site but this cuts down on the potential for labor and material savings.

SIPs in Cold Climates

Alaska's vast geography and industries provide an opportunity for SIPs to be used for a number of different applications, ranging from the cool, rainy Southeast to the cold dry Interior. This section summarizes the unique aspects of using SIPs in Circumpolar climates.

Manufacturing and Shipping

While some panels, manufactured in-state, travel from the factory to the job site by flatbed truck on the road system, others endure much longer journeys on the way to construction. SIPs travel to job sites in Alaska by land, sea, and air. Alaska builders must account for the extra time spent en route when planning their construction season, and manufacturers must package SIPs to withstand the extra time and exposure during shipment.

The panels are made both within the state and in the Lower 48. Panels from companies such as Premier SIPs make their way to Alaska by barge from Seattle. Other builders use panels that originate in Alaska. In both cases, builders work with the manufacturer on the design of the home and then panels are shipped to the building site.

Currently, there are two SIP manufacturers in Alaska. AlChem, Inc. started manufacturing SIPs in Alaska in the 1970s, and continues to offer them today. In the past, owner Philip Reynolds has provided panels with a urethane core, for military buildings, public housing, and telecommunications structures (P. Reynolds, personal communication, January 15, 2015). More information about these panels is available at AlChem, Inc.'s website: www.alchemincalaska.com .

Alaska Insulated Panels, first founded as R-valued Homes in 1998 by Ron Burkhardsmeier, is a SIP manufacturing plant in Wasilla. Mr. Burkhardsmeier had been building homes using SIPs imported from Canada when he decided to start the manufacturing company to make the product (R. Burkhardsmeier, personal communication, March 31, 2014). The panels he manufactures consist of plywood sheathing and a polyurethane foam core and come in a variety of sizes up to 4 feet by 12 feet and two different widths, 4.5 and 6.5 inches. Mr. Burkhardsmeier offers on-site training on proper methods to erect and seal panels for construction crews new to SIPs. He has sold panels for more than 300 Alaska homes, from Prudhoe Bay to Fairbanks to the Aleutian chain (R. Burkhardsmeier, personal communication, March 31, 2014). More information on the panels is available on website for Alaska Insulated Panels: www.rvaluedhomes.com .

Shipping panels to job sites in Alaska can be challenging due to the large distances between manufacturing plants and homes, and the lack of a road system in remote areas. Panels that come from outside of Alaska are shipped through Seattle. Builders have the option of using a barge to bring them to the port of Anchorage, which takes about two weeks, or paying more to bring them on a three day trip by ship (J. Mayo, personal communication, April 15, 2014). One builder who uses Premier SIPs estimates that it takes roughly 90 days to submit the design to the manufacturer, review the design, and then receive the panels (D. Miller, personal communication, March 27, 2014). Builders must account for this travel time when making construction plans, and also consider how to handle receiving damaged panels as replacement panels may not be readily available.

In Alaska, both in-state and out-of-state panels travel by air, sea, and land to their final destinations. Each shipping method poses unique challenges for builders. For panels being barged to remote communities, construction schedules must be written to accommodate the barge schedule, which may only visit a village once a summer. Panels traveling by air must fit on the plane– a challenge if larger panel sizes are being used for roofs or floors. It can also be more costly to ship panels than to ship unassembled building materials – costs that will need to be made up in labor savings. For air and sea travel, the destination village must have the capacity to transfer the panels to the building site. Finally, panels traveling the road system go by flatbed truck. Building sites on the road system thus require room for the truck to maneuver and contractors must factor into their cost analysis whether all the necessary panels can fit onto one truck (J. Mayo, personal communication, April 15, 2014).

End Uses

SIPs are employed by both private market and large scale home builders in various climates and communities where their advantages and disadvantages become even more apparent. Travel costs are higher due to Alaska's large and varied geography but this same geography also makes the potential for labor savings even greater – a trained local crew can erect homes fast and the contractor does not have to pay highly skilled workers to travel to remote locations. The potential for a highly insulated and uniform building envelope has major gains in a cold climate with a long heating season. However, the cold climate also underscores the importance of quality construction, as, for example, a small air leak in a panel seal can result in large energy costs.

Private market home builders in urban areas with crews that are experienced with SIPs use the panels to cut down on labor costs. For instance, Dave Miller of Landmark, Inc. in Fairbanks uses SIPs to close in the walls and roof of his timber frame homes. He explains from the perspective of a custom home builder that he saves on labor costs because his builders can enclose the timber frame going around the house only twice with SIPs – once to erect the SIPs, and once to put the siding on. Without panels, they have to encircle the house multiple times to install layers of insulation one at a time (D. Miller, personal communication, March 27, 2014).

Figure 11: A timber frame SIP home in Fairbanks. Photo courtesy Dave Miller of Landmark Inc.

In Alaska's rural communities, SIPs can be advantageous because they can be assembled quickly by builders with little carpentry experience, provided that design plans are finalized in advance to allow for manufacturing and shipping. With the short building season and a similar design for several homes, the potential for quick construction by a local crew is an attractive trait that housing authorities in Alaska and Canada are taking advantage of.

Bristol Bay Housing Authority (BBHA), has been using SIPs for over a decade. Their standard practice is to place orders for panels to bid; often, these orders are fulfilled by Premier SIPs. The panels travel to Alaska via Seattle and from there are loaded onto a barge to reach the Bristol Bay region where BBHA employs them for the foundation and exterior walls of single family homes (E. Larson, personnel communication, May 2, 2014).

Panels are also used by the Interior Regional Housing Authority (IRHA), which serves the tribes of the Doyon Region in Interior Alaska. This region encompasses Fairbanks North Star Borough and surrounding remote villages. IRHA began using SIPs in 2004 and now uses them for all its homes in part because their trained crews can erect SIP homes quickly. In remote villages, IRHA uses SIPs for all walls and floors on a post-and-pad foundations. On the road system, SIPs are used for the walls. IRHA aims to have all of their homes rated to 5 or 6 Star (the highest rating based on the Alaska Housing Finance Corporation's Building Energy Efficiency Standards, or BEES) and uses SIPs to achieve this (R. Synder, personal communication, April 28, 2014).The SIPs come from Alaska Insulated Panels in Wasilla, and have worked with the manufacturer to optimize the design of the homes to minimize electrical penetrations to the insulation (C. Thompson, personal communication, April 28, 2014).

Figure 12: An IRHA house being building with SIPs in Fairbanks.

In Canada, the Nunavut Housing Corporation has used SIPs to address the challenges presented by building in the remote communities of North Canada. The region has a large housing need because of several challenges, including the remote Arctic environment, and a level of overcrowding that is twice the Canadian national average (Nunavut Housing Corporation, 2014). They have employed SIPs in several housing projects, including single-family homes, town houses, senior housing, apartments, and staff housing (Hutton, 2011). The SIPs are transported by air or barge (CMHC, 2001).

Nunavut Housing Corporation reports that building with SIPs requires less labor, and units can be closed in in 5-6 days. The panels have adequate structural stability for locations with high winds and are more energy efficient than other construction techniques used by Nunavut Housing Corporation (Barriault, 2011). An evaluation of a construction project in Repulse Bay in 1996 listed the reasons why SIPs are advantageous (CMHC, 2001):

- The material cost was comparable to wood-frame construction: the total cost for a wood-frame home was $104,768; for the SIP home the cost was $107,328.
- The number of labor hours was less than wood-frame construction.
- There was a potential to reduce interim financing costs by eliminating need to store building materials over winter.
- Semi-skilled workers can readily adopt necessary skills to build with SIPs.
- After one year the owners were satisfied with the home, the home used 25% less fuel than similarly sized homes in Repulse Bay, and there was minimal foundation movement and air leakage.

The benefits of using SIPs in another Nunavut project included quick assembly in the short construction season; less on-site labor since the structure, thermal control, air leakage control, and vapor barrier were all incorporated into the SIP system; community members were trained by the manufacturer and employed to help with construction since no skilled labor was needed for the simple installation process; and the pre-fabrication process allowed 142 homes to be stockpiled, crated, and ready for shipping in just five months in 2010 (CMHC, 2013).

On the other hand disadvantages outweighed any savings for another housing authority, the Northwest Inupiat Housing Authority serving Kotzebue and the surrounding villages. They chose to stop using SIPs in 2010 because of the high cost of flying the panels into the communities. NIHA flies in construction material to projects in early May so that all exterior work on new buildings can be completed by mid-September, when the snow season begins. They could ship SIPs for a lower cost on a barge, but it wouldn't arrive until July, which means they lose two months of construction time. Labor costs are higher during in the colder fall months. Also, they found that their crews can build a tighter and better home with wood-frame construction (C. Nelson, personal communication, April 5, 2014). The high freight costs are not unique to Northwest Alaska; Nunavut Housing Corporation also identifies high freight costs, the need for on-site storage, the difficulty of replacing a damaged panel, and the heavy equipment necessary for lifting panels as disadvantages (Barriault, 2011).

Panel Seals

The seal between two panels is the most vulnerable part of SIP construction in heating-dominated climates, because water vapor moves from warm home interiors to the cold, dry outdoor air for a majority of the year. This has been confirmed by research and was starkly illustrated in the field by several high-profile SIP roof failures in Juneau in the early 2000s. Now, builders in Alaska rely on a variety of methods to seal panels, including using a redundant vapor barrier and working with the manufacturer to develop an appropriate sealing technique.

Research and Field Monitoring

The United States Department of Energy illustrated the additional vulnerability of panel seals in cold climates by simulating the moisture durability of a SIP wall in six cities with different climates, including International Falls, Minnesota in International Energy Conservation Code (IECC) zone 7 (Lepage, Schumacher, & Lukachko, 2013). The study includes three sources of moisture for walls: moisture trapped in walls during construction, air leakage condensation, and bulk water leakage. The SIP wall featured 11.25 inches of EPS between OSB sheathings. The center of the panel was used to model the baseline simulation, construction moisture, and bulk water leakage. A joint was modeled to simulate air leakage, since this is the weak point in the wall. The researchers reported that for moisture on the exterior sheathing of the SIP at the time of construction, drying times varied based on outdoor temperature and humidity, with the wall drying to 20% moisture content[3] the slowest in International Falls – the coldest climate considered in the modeling. For air leakage, the simulations modeled a small air leak that bypassed the foam barrier and deposited moisture behind the exterior OSB skin. It was found that SIPs that are not properly sealed would be prone to damage in cold climate zones. In fact, the modeling found moisture contents of over 20% for climate zone 4 and colder when an air leak was introduced into a panel joint. Lastly, bulk water leakage was found to result in significant moisture accumulation since there is minimal ability to dry to the inside and minimal ability to store moisture in the EPS until a time when it can dry. Thus, if bulk water leaks into a panel, there is risk for mold, rot, and delamination of the panel sheathing, regardless of the climate (Lepage, Schumacher, & Lukachko, 2013):

Similarly, Nunavut Housing Corporation has studied SIP hygrothermal performance. Researchers built a test hut in an environmental chamber at Concordia University in Montreal featuring walls (R-40) and a floor (R-50) built with a similar design as one of their demonstration homes in Iqaluit, Nunavut. The joints between panels used wooden I-beams for structural reinforcement, with a layer of EPS insulation between the I-beam and the interior sheathing to serve as a thermal break. All joints were sealed with tape on the interior and exterior and the walls were coated with vapor retarder paint. The test hut was instrumented for temperature, relative humidity, and moisture content, with sensors placed in the interior atmosphere, interior and exterior wall surfaces, and embedded in the EPS in the SIP joints. Then the humidity, temperature, and pressure of the environmental chamber were varied to simulated winter and summer conditions. Simulations were also completed using THERM, a heat transfer modeling software, to analyze heat transfer through the panel joints. The simulations showed that SIPs are suitable for northern housing but the durability of the wall system depends on the airtightness of the joints between the panels. The joining system used was successful at attenuating heat loss and did not have major thermal bridging effects when it was sealed correctly. The THERM modeling also correctly predicted the temperatures of different locations in air-tight panel joints when the joints where subjected to different air pressure differences. On the other hand, the joints with air leaks had unpredictable temperatures (Kayello, Fazio, & Rao, 2013)

In addition to lab testing, Nunavut Housing Corporation conducted field monitoring to assess the performance of two of its housing designs. This monitoring primarily aimed to assess the performance of the attic venting systems, but the authors of the study noted that they were able to attain low air-change values with panels, with the SIP homes achieving less than 0.5 ACH50 on blower door tests, compared to the 2.0

[3] Below a moisture content of 20%, there is little risk of mold growth on the OSB sheathing of the SIP.

ACH50 for framed house design used for remote houses in Quebec (Baril, Fazio, & Rao, 2013). This same attribute was reported by Building America in a publication on a SIP home located in Northern Illinois. Air changes were measured at 0.05 ACH with a blower door test, which was attributed to the use of correctly joined panels for the walls. After one year of monitoring, researchers concluded that the SIPs provided a well-insulated and well-sealed building shell but this did require that builders were trained to properly seal envelope penetrations in new construction practices (Viswanathan, Walker, & Novosel, 2009).

Juneau SIP failures

In Juneau, panel seals came under scrutiny in the early 2000s when many 1990s-era SIP homes began to experience roof failures. (M. George, personal communication, April 10, 2014). Ultimately, sixty or more homes from three different developers (using three different brands of SIPs) required roofing replacements with estimated costs ranging from $90,000 to $120,000 each (Andrews S. , 2001). Multiple investigations were conducted to identify the source of the failures and recommend steps so that the situation would not occur again.

Joseph Lstiburek at Building Science Corporation led the SIPA investigation, which examined approximately 20 multifamily buildings that were constructed prior to 1996 and that had experienced damage due to moisture at the top OSB skin of roof SIPs. The investigation indentified three reasons for the joint failures (SIPA, 2002):

- No sealant was used to make the joint airtight, a failure of workmanship
- Sealant was applied with poor detailing (sealing activities were focused on the cold side of the panel rather than the warm side), also a failure of workmanship
- Sealant was applied properly but failed to adhere, possibly due to weather conditions. Further investigation is needed.

There was no damage on properly sealed joints and other SIP roofs in the area showed no damage. The report concluded that the failures were not attributed to the Juneau climate but instead to poor workmanship. Also, it noted that the lack of a vapor barrier was not a specific cause of the failures because there was no damage away from panel edges (SIPA, 2002).

Another publication, Andrews (2001), provided additional insight from builders, homeowners, inspectors, and SIPs industry representatives. The testimony reinforced the risk of inadquate air sealing between panel joints. However, the severity of the workmanship problems reported in Andrews (2001) extend beyond inadequate or missing sealant, and include flaws such as missing splines, incorrect spline use, and on-site modification of panel joints. The panel connection type also may have been an important factor, as the roof panels with engineered wood splines (e.g. I-beams) seemed to have more failures than panels with dimensional lumber or surface splines. Another relevant factor was the treatment of the SIPs during construction. One homeowner stated that her builder allowed panels to be stored directly on the ground unprotected from rain for weeks, and then left roof panels uncovered by roofing materials when installed for an additional period of several weeks.

While the Juneau roof panel failures have become a prominent example illustrating the risk of improper SIPs installations, similar problems in other cold climate locations illustrate that the potential for failure is not limited to Juneau. Lstiburek stated that he has seen other SIP roof problems in Ontario and coastal

Massachusetts and identified air leakage at the panel joints as a connection between all the cases (Andrews S. , 2001).

The City and Borough of Juneau addressed the reason for the failures and updated their building code to prevent problems from occurring again. It noted that contributing factors to the failures were as follows (City and Borough of Juneau, 2004):

- Lack of a continuous vapor retarder (such as Visqueen) on the warm side of the panels. This allowed moisture from the building interior to penetrate the panel voids and joints
- Failure of sealants in panel joints to adhere to the wood and foam, which allowed moisture to travel through the joint to the top layer of OSB
- Lack of ventilation at the top layer of panels to dispel the moisture

The building code now contains specific requirements for the use of SIPs in roofs, including the use of a vapor barrier on the warm side of the SIP, a cold roof over the panels, and special inspections for roofs built with SIPs (City and Borough of Juneau, 2004).

Alaskan Panel Sealing Practices

There is no statewide building code in Alaska, and SIP builders throughout the state rely on a variety of methods to seal panels.

In some cases, local building code sets a minimum standard for sealing panels. For instance, in Fairbanks, the building plan with SIPs submitted to the City of Fairbanks either requires an engineer’s stamp or sufficient framing detail that the building inspector can determine if the design is suitable (M. Woodrow, personal communication, May 1, 2014). In Anchorage, building inspectors refer to the independent testing of the SIPs manufacturer to determine if an additional vapor barrier is required, as well as if the panels can meet structural and seismic requirements (R. Wehr, personal communication, May 1, 2014). The City of Juneau has more stringent requirements, originating from an investigation of SIP failures that occurred in the city in the early 2000s, as discussed above (City and Borough of Juneau, 2004).

Builders interviewed for this report outlined different methods to seal panels. For example, Bristol Bay Housing Authority seals panels according to the manufacturer instructions, and then installs an additional vapor barrier of 8 mil poly over the SIP (E. Larson, personnel communication, May 2, 2014). IRHA in Interior Alaska worked with the manufacturer, Alaska Insulated Panels, to develop a specific system to seal panels. They rely on the panels to serve as the vapor barrier, so it was necessary to identify a sealing method that would work for their crews and homeowners. The sealing process has changed slightly over the years as IRHA builders have gained experience. For instance, they used to order spray foam from the manufacturer but discovered it would sometimes freeze en route. Now they order their own spray foam separately. They also perform blower door tests to find air leaks and seal them. Generally, their SIP houses test at 1 to 1.5 ACH50 with a blower door test (C. Thompson, personal communication, April 28, 2014).

Summary

Builders in Alaska and other Circumpolar climates use SIPs for buildings ranging from custom homes to remote housing projects. While SIP construction in cold climates is similar to that in other climates in many ways, with builders navigating the same general design and construction process, builders also must pay extra consideration to some details.

Even with in-state manufactured panels, the shipping process often entails more than sending panels on a flatbed truck to their destination. In Alaska, panels travel by land, sea, and air to the building site. Builders and manufacturers must accommodate the extra shipping time and cost while preventing panels from extra weather exposure en route.

Builders employ SIPs in many types of construction in Alaska. The large geography and cold climate of Alaska makes the commonly recognized advantages and disadvantages of building with panels even more apparent. Builders must balance the energy-saving potential of uniformly insulated panels and labor cost savings with high shipping costs and the need for quality construction in an unforgiving climate.

Finally, builders must pay extra attention to panel seals in cold climates, as water vapor is moving from the warm interior to the cold outside air for the majority of the year. Currently, there is no one prescriptive method to seal panels in Alaska. Instead, builders refer to local building code and manufacturer specification as well as developing their own practices to ensure that panels are adequately sealed.

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Appendix A: Interviewees

The following individuals graciously shared their experiences with SIPs in Alaska for this report.

Table 2. Building professionals who were interviewed for this report

Name	Association	Location	Experience
Charlie Nelson	Northwest Inupiat Housing Authority (NIHA)	Kotzebue	NIHA used SIPs in some development projects in the early 2000s.
Daryl Sobek	Insulfoam	Anchorage	Insulafoam's sister company, Premier, is a SIP manufacturer.
Dave Miller	Landmark, Inc.	Fairbanks	Mr. Millers uses SIPs for timber frame homes.
Emil Larson	Bristol Bay Housing Authority (BBHA)	Dillingham	BBHA uses SIPs for their single family homes.
Jim Mayo	Spenard Building Supply	Alaska	Spenard Building Supply distributes Premier SIPs in Alaska.
Kelly Roth	PK Builders	Ketchikan	Mr. Roth has used SIPs for building projects in the past.
Marquam George	University of Alaska Southeast	Juneau	Mr. George participated in the investigation of SIP failures in Juneau in the early 2000s.
Marty Woodrow	Fairbanks Building Department	Fairbanks	Mr. Woodrow is a structural inspector with the City of Fairbanks.
Philip Reynolds	Alchem, Inc.	Anchorage	Alchem, Inc. is a SIP manufacturer.
Rodney Wehr	Anchorage Building Safety	Anchorage	Mr. Wehr is a plan review/inspector for the Municipality of Anchorage.
Ron Burkhardsmeier	Alaska Insulated Panels	Wasilla	Alaska Insulated Panels is a SIP manufacturer.
Russell Snyder	Interior Regional Housing	Fairbanks	IRHA uses SIPs for their

Chris Thompson	Authority (IRHA)	single family homes.

Appendix B: SIPs in Alaska

The short introductory handout to SIPs in Alaska published by CCHRC appears on the following two pages.

Structural Insulated Panels
in Alaska

Structural Insulated Panels, or SIPs, are prefabricated building materials that combine structural elements, insulation, and sheathing into one panel. They can be used for the walls, roof, and floor of a building in place of more traditional construction methods, such as stick-framing. A SIP typically consists of an EPS foam core sandwiched between two OSB panels, although the insulating core and the outer structural elements can be made of different materials.

Building a SIP home begins at the design phase. Builders must work with SIP manufacturers since panels are tailored to a specific building design. Once the plans are complete, the SIPs are made and shipped to the job site. They are labeled so builders know exactly where each panel goes in the building.

Panels must be joined together according to manufacturer specifications as they are erected. For instance, many panels are joined with splines that are secured with screws. Then, the joint between panels is sealed using agents such as caulk, adhesive, mastic, spray foam, or tape. An airtight seal is important to prevent moisture from entering the panel, which can lead to rot. In some buildings, an additional vapor barrier is installed over the SIPs.

Finally, an electrician will install electrical fixtures into pre-drilled cores and pre-cut boxes in the panels. Then finishes can be applied on the interior and exterior. For example, wall SIPS would be covered in dry wall or finishing lumber on the interior and siding on the exterior.

Benefits and Concerns

There are several potential benefits to building with SIPs. For one, the lack of a wall cavity prevents convective heat loss. Also, large panels can have fewer studs than a framed wall, reducing the amount of conductive heat loss through studs (called thermal bridging). Buildings made with SIPs can be erected quickly with a trained crew, a big advantage in a climate with a short building season. Finally, SIPs can provide a uniformly insulated, airtight envelope when correctly installed.

On the other hand, proper assembly and sealing are critical to prevent moisture leakage problems. There is little to no room for on-site flexibility, since panels come pre-cut. An experienced builder who knows how to evaluate the design with the manufacturer and does not cut corners with sealing panel joints is a necessity. SIPs can be either cost-effective or cost-prohibitive, depending on the situation. The design services and shipping costs will cause the price of SIPs to rise above conventional framing materials. However, this can pay off in reduced labor costs if a trained crew erects a building quickly, or if several buildings of the same design are being erected.

Juneau SIPs Failures

Many Alaskans have heard that homes in Juneau experienced SIP roof failures in the early 2000s. A Structural Insulated Panel Association (SIPA) investigation showed that the panel damage was concentrated at the panel seams near the roof ridges and was due to poor workmanship. Some panel joints had no or poorly applied sealant, and sealant had failed to adhere to other panels. The failed roofs were repaired, and the City and Borough of Juneau has taken steps to ensure such failures will not occur again, by requiring a vapor barrier, roof ventilation, and inspection of SIP roofs.

Are SIPs right for your building project?

SIPs are used throughout Alaska by custom home builders, housing authorities, and commercial contractors. Currently, there are two SIPs manufacturers located in the state producing Alaskan-made panels for building projects.

Are you or your contractor familiar with SIPs and how to use them?

First, safety! SIPs are large and heavy compared to stand-alone construction materials, and thus require extra safety considerations, especially when large equipment, such as a crane or forklift, is necessary to move them around on the job site.

Does the job site have access for SIP delivery and storage? Larger size panels may require a flatbed truck for delivery. At the job site, the SIPs should be on a level surface or blocks that are wide enough to support them – not on the ground. They must be kept dry so they don't warp or swell. Planning and organization during delivery and storage will contribute to efficient construction.

Efficient building with SIPs often comes with training and experience, because builders can incorporate SIPs and their potential advantages from the design phase through construction. Many manufacturers provide training, and independent organizations such as the Structural Insulated Panel Association (www.sips.org) and the SIP School (www.thesipschool.com) provide certification classes for working with SIPs.

How will the panels be sealed together?

SIP walls are only as good as the seal between panels. Manufacturers will provide instructions and sometimes materials on how to seal panels together. Many manufacturers will also train builders to ensure the seals are completed properly. Seals can be tested by a blower door test or can be redundantly sealed using tape over the joint to ensure that there are no leaks.

What are the additional shipping costs that come from using SIPs? Are these balanced by labor or efficiency savings?

Builders must consider the advantages to using SIPs at the job site against any added shipping costs. Also, they must consider if the project timeline can accomodate the time required for the panels to be manufactured and delivered to the job site. If the additional shipping costs are not balanced out later in the building process by savings on labor costs or enhanced energy performance of the building, then it is worth considering another building method.

What are the local building policies regarding SIPs?

Local building departments have differing policies regarding the use of SIPs. They range from requiring an engineer's stamp on the plans to more stringent policies such as dictating certain sealant techniques. If you're thinking of building with SIPs, call your local building code office to speak with an inspector about building requirements.

Are you hoping to certify your home with the BEES or Home Energy Rebate Program?

Are you participating in a state rating program, such as the Building Energy Efficiency Standards (BEES), or trying to achieve a certain energy rating with the Home Energy Rebate Program? SIPs can be used to meet these standards. However, to meet all the requirements of these programs you need to consider not just the building envelope but also heating, lighting, and other house characteristics. For more information, visit the Alaska Housing Finance Corporation's webpage www.ahfc.us.