Structural Insulated
Panel Association

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SIPA BEST Program

Building Education with SIPs Training

Study Guide

Lesson 1: Introduction to SIPs

In This Lesson

- History of SIPs
- SIP applications
- Types of SIP core materials
- Types of SIP facing materials

Introduction

Builders everywhere are learning the benefits of building with structural insulated panels (SIPs). SIPs are a panelized building system composed of rigid foam insulation sandwiched between two structural facings, such as oriented strand board (OSB). Although SIPs can be made with a number of different materials, the basic concept remains the same: by distributing the structural loads present in a building over the structural facings, SIPs greatly reduce the number of structural members needed. Less lumber or steel translates to less thermal bridging and better airtightness for a more energy-efficient structure.

This lesson traces the development of SIPs from the 1930's to today's automated fabrication facilities. It also gives an overview of common SIP applications and the different types of materials used to construct SIPs.

Definitions

Structural insulated panel (SIP)	Panelized building system composed of rigid foam insulation sandwiched between two structural facings, such as oriented strand board
Oriented strand board (OSB)	Structural wood panel comprised of wood strands arranged in cross-oriented layers, similar to plywood
R-value	Measure of thermal resistance of a building material, such as insulation
Permeability	Measure of the amount of water vapor that can pass through a specified material in a certain amount of time
Green building	Process of designing and constructing buildings that have a lower impact on the environment

History of SIPs

The history of SIPs originates with a series of test homes constructed at the Forest Products Laboratory in Madison, Wisconsin during the 1930's. Researchers were looking at ways to use wood products more efficiently by designing a panelized wall system where the plywood sheathing carried a portion of the axial load.

Famed architect Frank Lloyd Wright used this concept in his affordable Usonian houses built throughout the 1930's and 1940's. Many of these homes, along with the test homes constructed by the Forest Products Laboratory, are still standing today.

The creation of the modern structural insulated panel is largely credited to Alden B. Dow, one of Wright's students and son of the founder of The Dow Chemical Company. Dow expanded on the ideas and technologies developed by the Forest Products Laboratory to produce the first laminated SIP with a core of insulating foam.

Continued improvements to SIP technology led to a small but vibrant industry that received a major boost from a resurging interest in timber framing in the 1960's and 1970's. Timber frame builders quickly found SIPs an incredibly time-efficient method to enclose timber frame structures. The marriage of cutting edge technology and traditional building techniques provided an effective solution for timber frame builders and propelled SIPs into the residential construction market.

Modern Technology

The SIP industry's next evolutionary milestone came from two major advancements in SIP production. In the 1990's, SIP manufacturers adopted computer numeric control (CNC) fabrication machinery. With the introduction of CNC equipment and other computer technology, manufacturers gained the ability to transfer computer aided design (CAD) files directly into fabrication equipment and cut panels with precise tolerances. CNC automation greatly increased production efficiency and consequently reduced the price of prefabricated SIPs.

At the same time, the oriented strand board (OSB) industry introduced "jumbo" 8-foot by 24-foot structural panels. SIP manufacturers were quick to adopt the larger panels and produce SIPs of the same size, allowing SIP buildings to be constructed faster and with fewer joints. SIP manufacturers again benefited from greater production efficiency and the expanded breadth of building applications now capable with SIP construction.

Green Building

The latest influential event in the growth of the SIP industry is the rise of green building. Since the advent of the first foam core SIP in the early 1950's, SIPs have been an inherently energy-efficient product. The building industry's recent interest in energy efficiency and environmentally sustainable construction has generated unprecedented interest in building with SIPs.

The last twenty years have witnessed the emergence of a handful of voluntary energy efficiency and green building programs, such as ENERGY STAR®, EarthCraft, Green Globes, and the popular LEED body of rating systems. State and local energy codes have increased, and a number of federal, state and local tax incentives are pushing the market toward energy-saving building technologies. Designers and builders using SIPs have an easy time meeting the requirements of these various green building programs and tax incentives with a SIP building envelope.

The Structural Insulated Panel Association (SIPA)

SIPA was formed in 1990 by a group of SIP manufacturers with the goal of increasing the use and acceptance of SIPs through education, collective marketing and technical research. The association now includes suppliers of SIP components, dealer/distributors, builders and design professionals—all devoted to making SIPs the preferred green building system.

SIPA participates in a number of activities to this end, including:

- National marketing campaigns
- Technical research
- Builder and architect education
- Consumer outreach
- Code advocacy

SIP Applications

Walls

SIPs work very well in wall applications. Lesson 2 will cover the structural characteristics of SIPs in more detail, but SIPs are very strong under the axial and racking load conditions present in wall applications, far surpassing standard wood frame construction. SIP walls are available in a variety of thicknesses with different R-values and performance characteristics. SIP walls go up quickly, are extremely straight, and help create an airtight building envelope.

Roofs

In roof applications, SIPs reduce framing time, improve energy efficiency, and create a vaulted or cathedral ceiling. Using a SIP roof also creates a conditioned attic, which has many energy efficiency benefits that will be discussed in greater detail in Lesson 4.

SIP roofs have received criticism in the past, with claims that the product lost its installation efficiency on complicated roof designs. However, today's advanced design software and automated fabrication enable skilled SIP designers and installers to create complex roof lines in a fraction of the time.

Floors

Although it is fairly uncommon, SIPs can be used in floor applications. SIP floors account for only 3 to 4 percent of SIPs produced in North America. SIP floors are typically used over unconditioned space, such as homes built on pilings in unstable soil conditions. In these situations, SIP floors provide excellent insulation and do not squeak.

One of the disadvantages of using SIP floors is the increased risk of water damage to OSB skins during the construction process. Unlike walls or roofs, floors have the ability to pool water and will be exposed for longer periods of time before the building can be dried in. OSB-faced SIPs need to be given adequate time to dry if they are exposed to moisture, or moisture can be trapped under subflooring and floor coverings. OSB facings also have limited point load resistance. For this reason they typically require the application of subflooring on top of the OSB facings to prevent puncture.

Types of SIPs

A structural insulated panel is composed of three components: the outside facing, the inner core, and the adhesive that binds the two together. There are a variety of different facing and core materials offered by SIP manufacturers. Selecting the appropriate type of SIP may depend on individual project conditions, cost and availability.

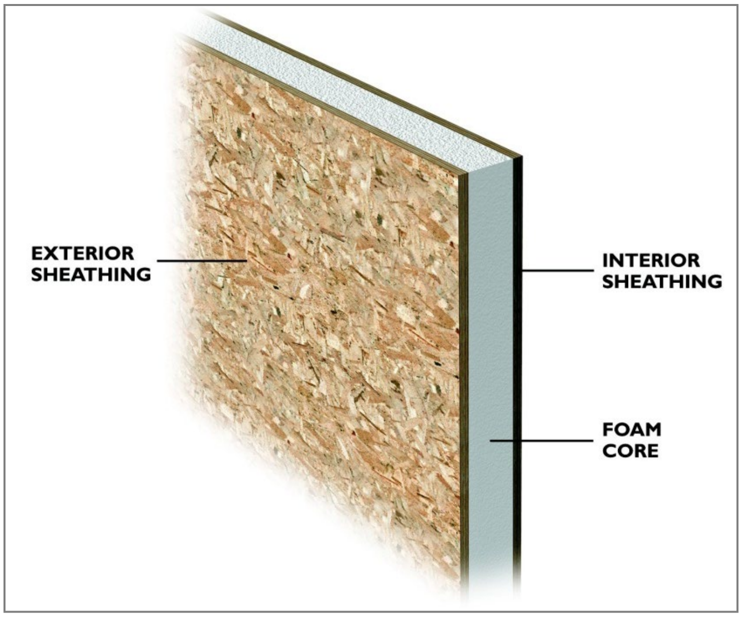

Figure 1: Anatomy of a SIP

SIP Facings

There are a variety of different facing materials offered by SIP manufacturers. The three most commonly used facing materials are OSB, metal, and cementitious or fiber cement panels.

The most popular facing used is OSB, although metal and cementitious facings are often used in situations where working with wood is a disadvantage. In some cases, a finished cladding material, such as drywall or wood paneling, may be used as a SIP facing.

- **Oriented Strand Board (OSB)** – Wood structural panel composed of layered, cross-oriented wood strands and bonded with a moisture-resistant adhesive
- **Metal –** Light gauge metal facings typically come from rolled stock and function as a finish material
- **Cementitious** – Also referred to as fiber cement, cementitious facings are a composite material made of cement, sand and cellulose fibers
- **Finish Materials** – Gypsum wall board or wood paneling is sometimes used as the interior facing in specialty applications where field application would prove difficult

Properties of SIP Facing Materials

Size

OSB facings are the only panel available in the 8-foot by 24-foot jumbo format. Large panels translate to fewer joints and quicker assembly.

Metal panels are made from rolled stock, allowing metal SIPs to be manufactured to almost any easily transportable length, but with a limited width of 4 feet. Cementitious panels are commonly available in 4 by 8-foot sections, and in some cases 4 by 12-foot or 4 by 14-foot sizes.

Ease of Assembly

The ease of assembly will largely depend on the installer's familiarity with wood, metal or cementitious construction. For installers accustomed to wood frame construction, dealing with OSB-faced panels will be the easiest. OSB-faced SIPs are typically assembled using pneumatic nail guns and are relatively easy to handle. Metal and cementitious SIPs are assembled using screws instead of nails.

In the event that SIPs need to modified onsite, OSB skins are easily cut using standard carpentry tools. Metal panels can also be modified with little difficulty, but cementitious panels require specialty tools and onsite dust control for worker safety.

The type of panel facing can also greatly affect the weight of the panels and how materials are handled on the jobsite. OSB-faced SIPs weigh an average of 4 pounds per square foot, meaning a 4 by 8-foot OSB-faced SIP weighs close to 130 pounds and can be moved onsite without handling equipment.

Whereas metal-faced panels are much lighter than OSB-faced panels, cementitious SIPs panels weigh more than twice as much. A 4-foot by 8-foot cementitious SIP weighs over 250 pounds. It is difficult to move around the jobsite and can slow down the installation process.

Moisture

In the construction environment, exposure to moisture is often unavoidable. The OSB used on SIPs is rated Exterior – Exposure 1, meaning it has the ability to withstand temporary exposure to moisture if it is given the opportunity to dry. This needs to be taken into account when detailing and finishing SIP buildings with OSB skins. Proper detailing will be addressed in detail in Lesson 9.

Metal facings are not significantly affected by exposure to moisture. Cementitious skins offer increased moisture resistance, but will expand with the absorption of moisture and contract when drying.

Finish Materials

Metal and cementitious skins have the ability to be used as a finish material. One thing to consider when using panel skins as finish materials is that a major structural element of the building will be exposed to the elements over the life of the structure. Interior finish materials like gypsum wall board or wood panel are exposed to weather on the jobsite and are easily damaged during installation.

Insect resistance

Termites and carpenter ants consume wood and other cellulosic materials. SIPs with metal or cementitious skins do not contain wood and therefore are more termite resistant. For this reason, metal and cementitious SIPs are popular in the Southern U.S. and Central America.

SIP Core Materials

There are three different types of insulating foam used in SIPs: expanded polystyrene (EPS), extruded polystyrene (XPS) and polyurethane. All types of cores offer relatively comparable insulation value and performance characteristics.

Properties of SIP Core Materials

R-value

R-value is a measure of a material's resistance to thermal conductivity. A higher R-value indicates a greater resistance to thermal conductivity and better performance as an insulating material. Traditionally, much emphasis has been placed on R-value in improving the energy efficiency of the building envelope, but more recent studies indicate that air leakage is responsible for as much as 40 percent of a home's heat loss.

Each SIP manufacturer has published R-values that are based on standardized testing methods. EPS foam has the lowest R-value per inch, followed by XPS. Polyurethane foam has the highest R-value per inch of material thickness. This does not mean high R-values cannot be achieved with EPS or XPS SIPs, only that it may require a thicker SIP to achieve the same R-value.

Rigid polyurethane foam undergoes a process known as thermal drift, where the gaseous blowing agent used in the manufacturing process slowly bleeds out of the finished product and reduces its R-value to a certain point. For this reason, SIP manufacturers will reference the steady state R-value or aged R-value that takes this degradation into effect.

Permeability

Permeability is a measure of the amount of water vapor that can pass through a specified material in a certain amount of time. It is measured in perms. A high perm value means moisture transfers through a material or assembly at a fast rate.[1]

Although perm ratings for SIPs will vary by the thickness and type of core material used, all foam-core SIPs have a relatively low perm rating. A 4-inch SIP with OSB facings and an EPS core meets the building code requirements for a vapor retarder (US-IBC-1.0 perms). No additional interior plastic polyethylene vapor barrier is required or desirable, with the exception of subarctic and arctic climates.

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[1] The following material is paraphrased from *Builder's Guide to Structural Insulated Panels (SIPs)* by Joseph Lstiburek. Building Science Press, 2008.

The perm ratings for XPS and polyurethane are lower than EPS, and therefore SIPs with these core materials would have lower perm ratings.

SIPs are typically bilaterally symmetrical in terms of permeability. The resistance to vapor flow is identical from one side of the panel centerline to the next. Wall and roof assemblies are often designed with vapor flow inward or outward, depending on climatic conditions. With SIPs, the resistance to vapor flow inward and outward is the same, allowing the product to be used in virtually any climate zone.[2]

Fire Resistance

There is a lot of misinformation about the fire resistance of SIPs. Fire ratings and fire resistance are a function of the entire wall or roof assembly, not the individual components, such as the SIP cores or facings.

Residential SIP structures typically require the application of a 15-minute fire-resistant thermal barrier on the interior, such as ½-inch-thick gypsum board or a material of equivalent thermal performance. Light commercial or multi-use buildings of Type V Fire Rated construction may require a one-hour fire rating and/or sprinkler systems. When a one-hour fire rated assembly is required, SIP manufacturers can provide tested assemblies for both walls and roofs that meet the one-hour fire resistance tests outlined in ASTM E 119.[3]

As with any fire resistance issue, the local jurisdiction requirements will vary by region. Contact your local building department to determine the requirements in your area.

Core Thickness

The different core materials used in SIPs have vastly different manufacturing processes that determine their maximum available thickness. SIPs with EPS and XPS cores are typically available in sizes ranging from a 3 ½-inch core (4 ½-inch total panel thickness) to a 14-inch core (15-inch total panel thickness). SIPs are often described using nominal sizing, where a nominal 4-inch SIP (4 ½-inch actual total panel thickness) will be used with nominal 2 x 4 dimensional lumber (3 ½-inch actual width) that matches the thickness of the SIP core and fits in panel recesses for end plates, blocking, splines, or other uses.

Polyurethane core panels are commonly available in 3 ½-inch core (4 ½-inch total panel thickness), 5 ½-inch core (6 ½-inch total panel thickness), and 8 ¼-inch core (9 ¼-inch total panel thickness).

Insect Resistance

To prevent the intrusion of termites or carpenter ants, many SIP manufacturers offer EPS cores infused with borates. This treatment is only available on SIPs with EPS cores. Borate-treated EPS

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[2] In subarctic/arctic climates it may be necessary to install a fully adhered impermeable membrane

[3] See SIPA Technical Bulletin No. 2, Fire Safety with Structural Insulated Panel Construction

is not a substitute for proper termite prevention in high-termite areas. Careful termite prevention should be followed, as with any other wood structure.

Summary

Starting in the 1930's, researchers began experimenting with ways that structural sheathing could carry part of the axial loads present in residential structures. That concept has been refined into modern structural insulated panels (SIPs) – a structurally self-sufficient building system that delivers unparalleled energy efficiency and speed of construction. As the SIP industry progressed, the Structural Insulated Panel Association (SIPA) was formed to address industry-wide needs for education, marketing and technical research.

SIPs are available in a number of different material combinations. Selecting the right materials depends on local availability, climate conditions, cost and other factors.

Lesson 2: Basic SIP Design and Engineering

In This Lesson

- Starting a SIP project
- Overview of connection details

Introduction

Although most projects involve an architect or design professional, SIP installers need to be aware of the basic design and engineering principles for SIP construction. This lesson will also cover many of the commonly used connection details. It is important to note that these details are for informational purposes only. When constructing a SIP building, always refer to the panel layout drawings provided with the SIP package for connection methods and fastening schedules. The details in the panel layout drawings are often specific to that particular project and are engineered to meet design loads that vary by location, building type, and local building codes.

All SIPA member manufacturers are required to have published load tables that are verified by third party testing. Make sure you are working with a quality SIP product from a reputable provider and a trained design professional before starting a SIP project.

Definitions

Spline:	Dimensional lumber, engineered wood, or other specialty product used to connect two panels together at in-plane vertical panel connections
Cap plate:	Dimensional lumber ripped to the full width of a SIP wall panel to transfer in-plane loads to the structural facings
Panel screws or SIP screws:	Specialty screws designed for fastening through the thickness of a SIP
Capillary break:	Treated plywood or other material placed over concrete to prevent SIP facings from absorbing moisture
Fascia:	Visible horizontal band along the roof edge, such as the board typically used to cap roof rafters' tails

Starting a SIP Project

Before construction begins on a SIP project, there are a number of special elements that need to be considered during the design phase.

Is This Project Right for SIPs?

Depending on the project, the designer or builder must decide if SIPs are the best option for walls, roofs or floors. SIP floors are typically only used in situations where the underside of the floor is completely exposed to the elements, such as homes built on pilings.

SIP walls can be used in virtually any situation suitable for wood frame construction. SIPs are stronger than conventional wood frame walls and the large sizes offer many advantages for both design and installation.

Deciding whether or not to use a SIP roof will depend on the roof design and how feasible it is to incorporate a supporting structure. There are a number of panel friendly architectural styles, such as craftsman style homes, timber frames, Cape Cods, or A-frames, where vaulted ceilings are much easier to frame and insulate with SIPs. In many cases, roof trusses will fit the design of the home better than a SIP roof system. Hybrid systems, such as SIP walls with a truss roof, or a SIP roof on insulated concrete form (ICF) walls, are an extremely common way to produce high performance homes.

Do I Need a SIP Designer?

If a builder is working with an existing home plan or set of construction documents that were originally designed for conventional wood framing, the drawings will need to be redesigned for SIP construction. This task is typically done by trained SIP design professionals or as a service performed by a SIP provider. The builder, client and architect (if one is involved) will review the SIP designs to ensure consistency with the original construction documents.

Completed SIP layout drawings will include all the critical information needed to install a SIP package. In contrast to architectural drawings or construction documents, the SIP layout drawings show only the SIP building envelope and other structural elements necessary to SIP installation.

Do I Need an Engineer?

Check with your local building code department to determine if an engineering review of the project is required.

SIP Floor Details

In situations where floor SIPs are specified, the SIP designer will determine the appropriate panel thickness based on the distance the floor panel has to span. The designer will also create a foundation connection detail (Figure 5) to ensure adequate bearing on the foundation system. The detail should also protect the SIP from moisture intrusion by sealing against air infiltration and providing a capillary break of treated material between the SIP and any concrete surfaces.

Point loads are always a consideration with SIP floors. A second layer of floor sheathing is typically applied over the SIP floor if a soft floor covering like vinyl or carpet is specified. Point loads in the wall system are also a concern over SIP floors and may require blocking or direct bearing on the foundation.

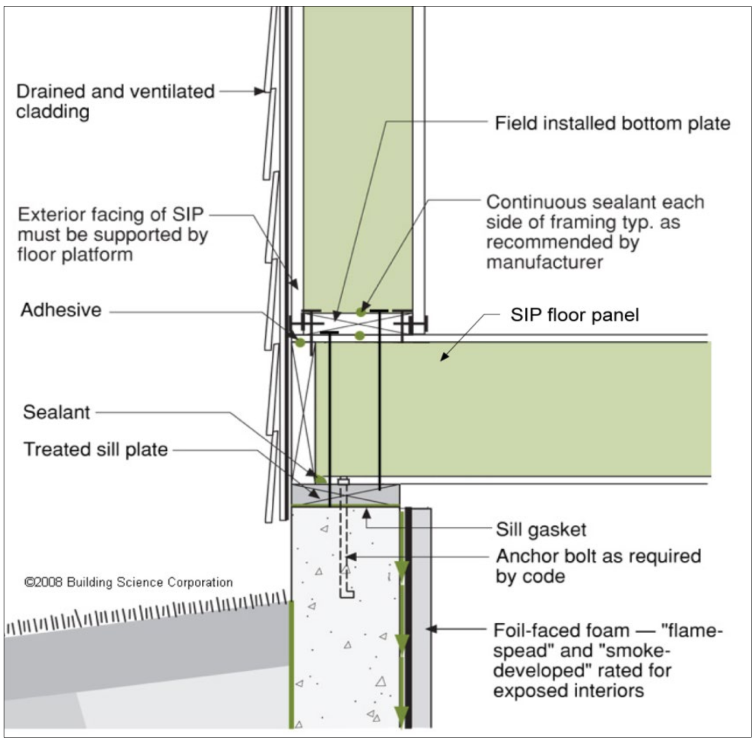

Figure 1: Floor SIP

SIP Wall Details

It often falls under the purview of the designer to determine the thickness of SIP walls. Choosing wall thickness is a function of both insulating ability and structural performance—thicker SIP walls have higher thermal resistance (R-value) and a greater ability to resist transverse loads. Since much of the energy efficiency in a SIP building is achieved through airtightness, it is recommended that designers consider whole-building energy modeling when deciding the required R-value of SIP walls.

Foundation Connection

SIP walls can rest either on top of a platform-framed floor system (Figure 6) or directly on the foundation (Figure 7). Platform-framed floor systems are often a source of air leakage and designing SIP walls to bear directly on the foundation ensures better airtightness. However, working with this detail requires a wider foundation with relatively tight tolerances.

When SIP walls are bearing directly on a concrete foundation or concrete slab, a capillary break of treated plywood or treated lumber must be placed beneath the SIP wall to protect against moisture intrusion.

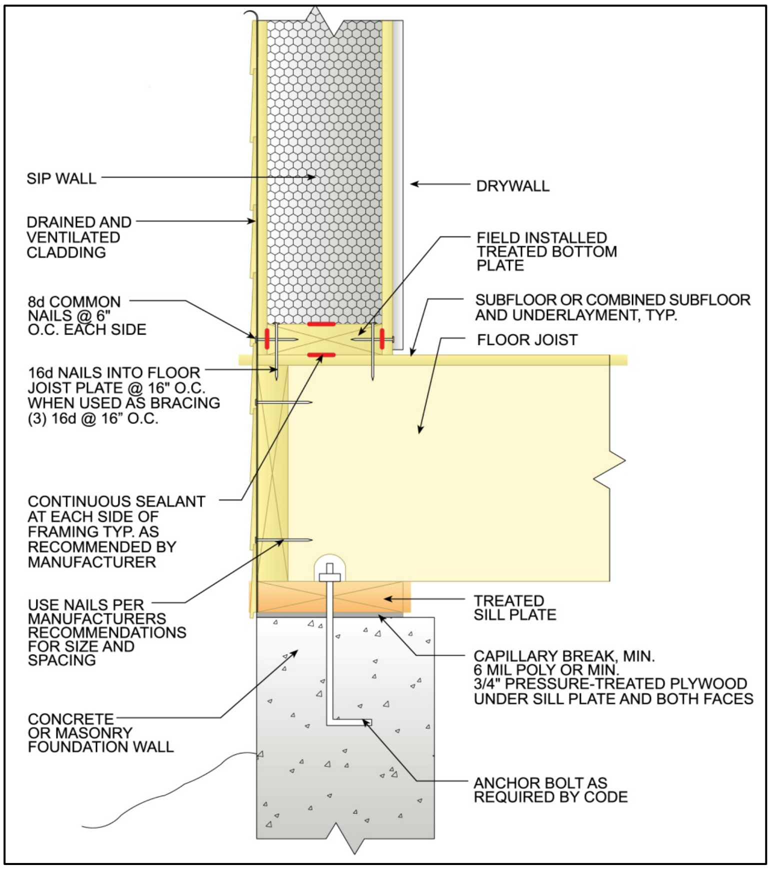

Figure 6: SIP wall on wood frame floor system

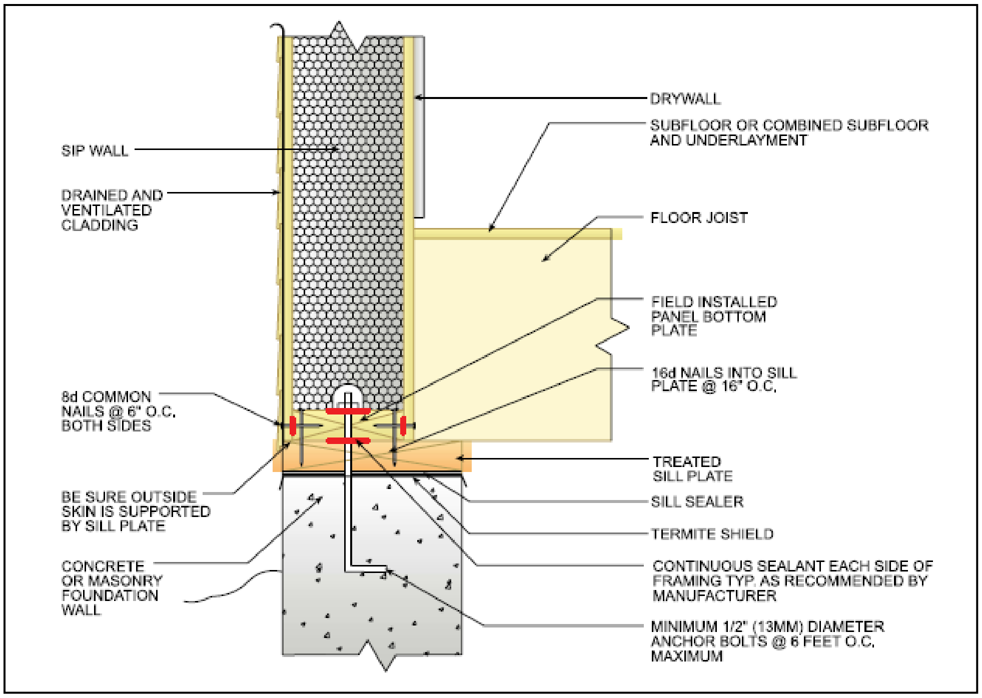

Figure 7: SIP wall resting on foundation

Some SIP manufacturers offer an insulated rim panel that acts as a rim board for a platform-framed floor system (Figure 8). This detail ensures that the rim area is adequately insulated and sealed against air infiltration.

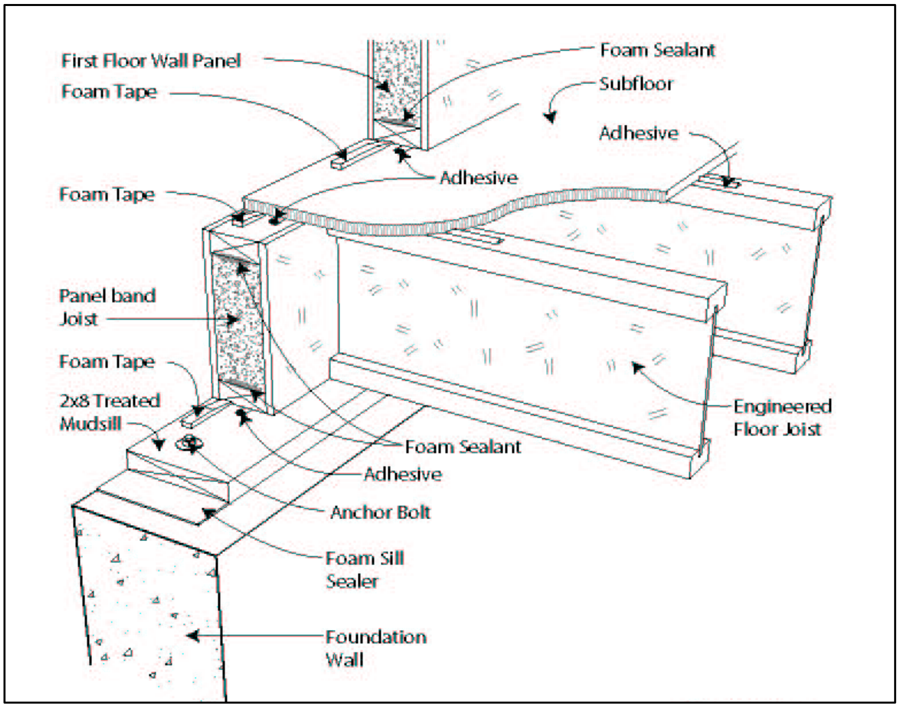

Figure 2: Insulated rim panel

Corner Connection

At the intersection between two perpendicular SIP walls, dimensional lumber end plates are installed in the foam recesses of both walls (Figure 9). The walls are then secured with panel screws. It is important to note that this type of lap detail creates one wall that is shorter than the actual building dimensions.

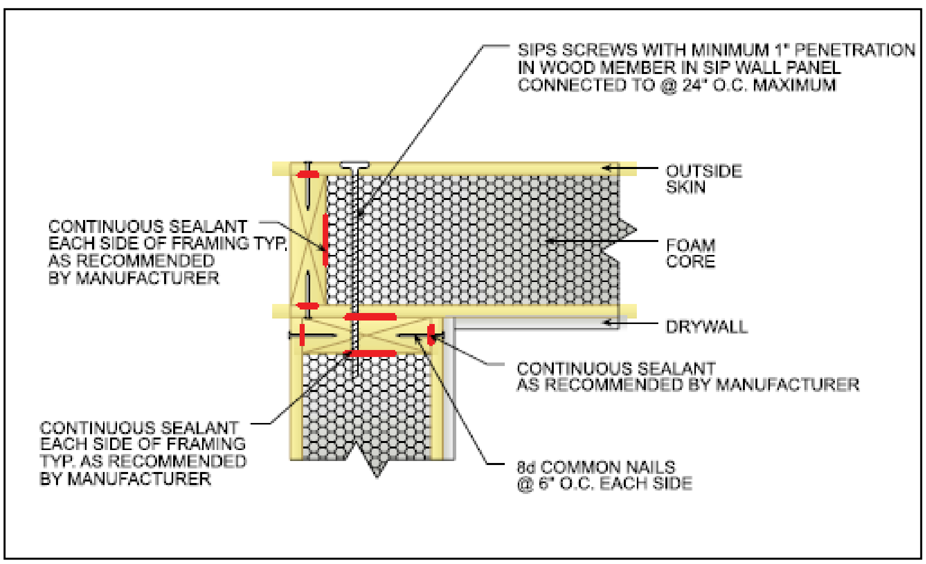

Figure 3: SIP wall corner detail

Interior Walls

Interior partitions are attached to SIPs using a staggered screw pattern on the interior in addition to panel screws from the exterior (Figure 10). Securing interior partitions with panel screws through the thickness of the panel prevents any movement that could result in cracked drywall.

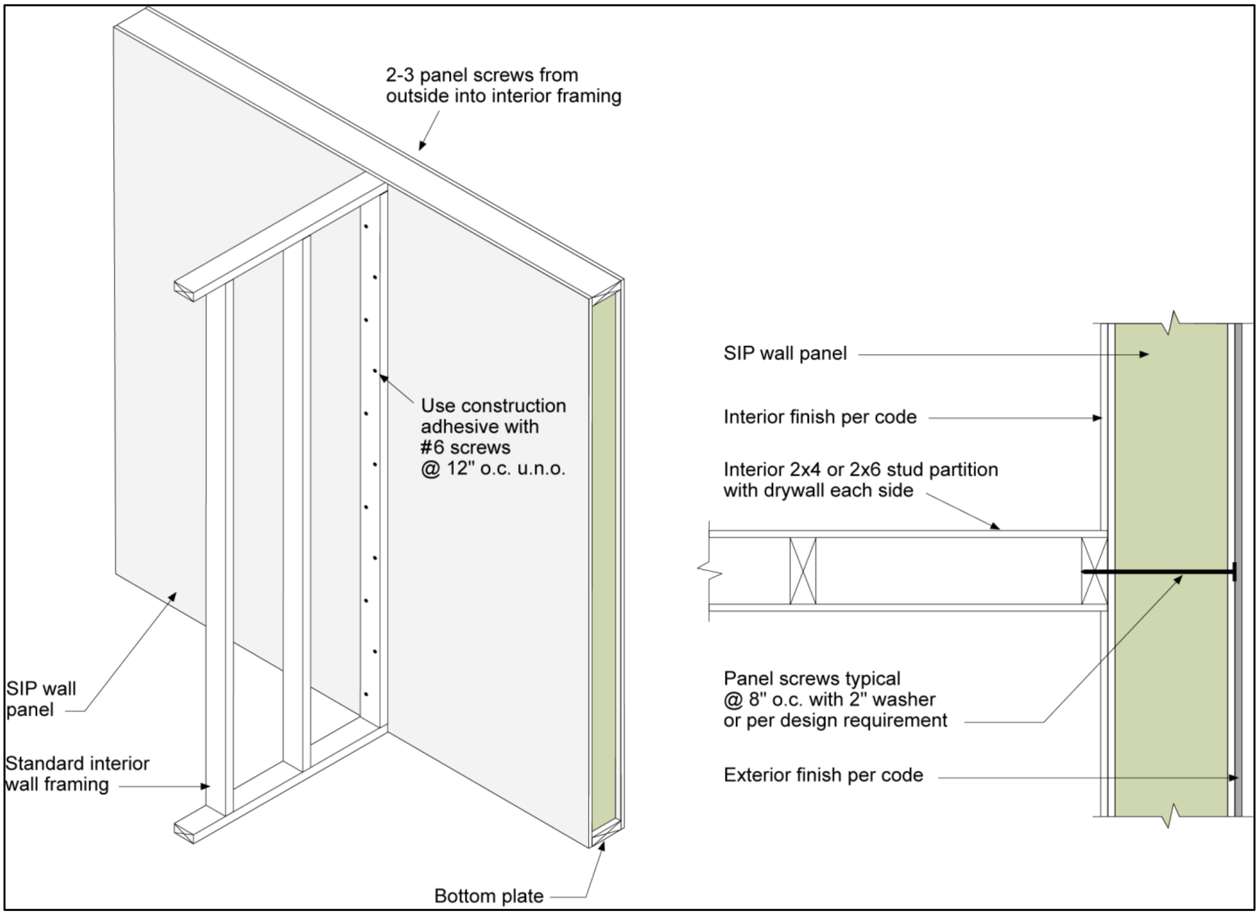

Figure 4: Attaching interior partitions

Spline Connections

Spline connections are used for in-plane connections between panels. Spline details can be used on wall or roof panels. The spline connection details in a SIP layout drawing will also show where sealant needs to be added to ensure an airtight joint. Sealing is one of the most important aspects of SIP installation. Improperly sealed panels can lead to moisture damage, mold, rot and even structural failure.

Surface Spline

A surface spline connection (Figure 11) consists of two strips of OSB or plywood that are inserted into prefabricated slots in the foam core of the SIP. These strips are then nailed through both faces of the panel, creating a secure connection. One of the advantages of this type of panel connection is that it avoids the thermal bridging that can occur with lumber connections.

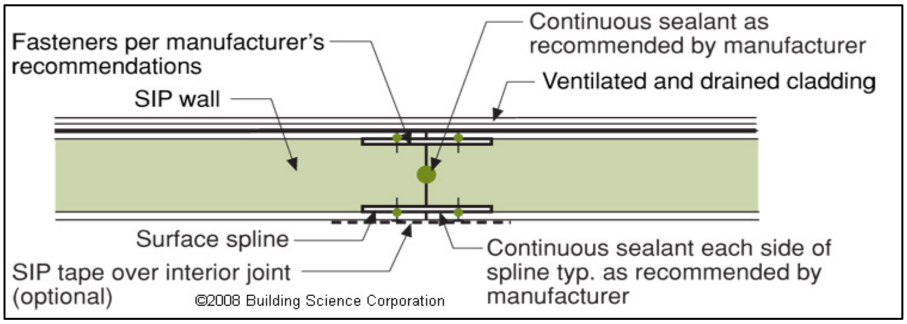

Figure 51: Surface spline

Block Spline

The block spline (Figure 12) functions much like the surface spline, but uses a single spline composed of a foam core with OSB or plywood facings. The spline is nailed in place through the facings of the panel and, like the surface spline, prevents thermal bridging through the panel joint. Sealing methods will be discussed in Lesson 7.

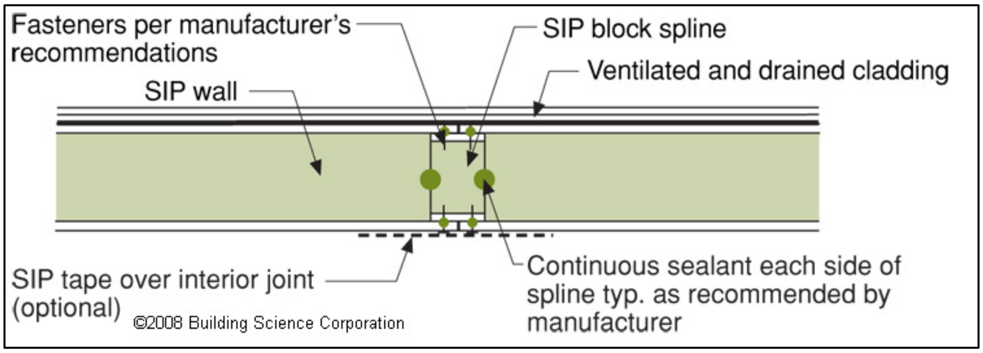

Figure 16: Block spline

Double Dimensional Lumber Spline

In certain situations, a dimensional lumber connection (Figure 13) may be specified to add transverse load resistance or accommodate a point load in a SIP wall. Lumber connections can be made with single dimensional lumber, double dimensional lumber, or engineered wood products such as laminated veneer lumber (LVL). Dimensional lumber splines create a thermal bridge and have the potential to be a source of air leakage if the joint is not properly sealed.

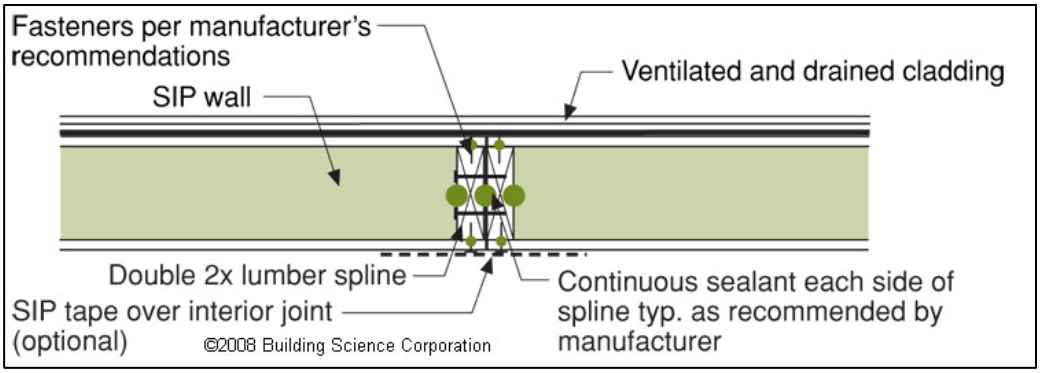

Figure 17: Double dimensional lumber spline

I-Joist Spline

This spline connection (Figure 14) uses an engineered wood I-joist similar to those commonly used for floor joists in residential construction. The I-joist adds strength to the panel connection, but is much lighter than dimensional lumber and easier to handle onsite. And because they are an engineered lumber product, I-joists are straighter and easier to install than sawn lumber.

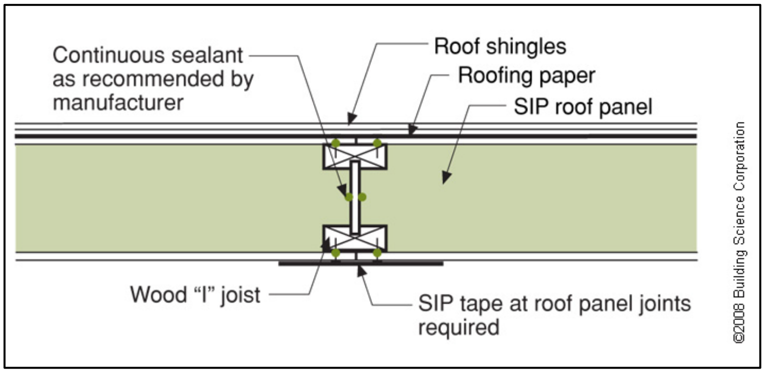

Figure 18: I-joist spline

Intermediate Floor Details

When building with SIP walls, intermediate floors can be framed using either platform framing or a hanging floor system. Platform framing is common in conventional wood construction and involves placing floor joists on top of the SIP wall panel (Figure 15). Depending on loading conditions, a cap plate ripped to the full width of the SIP wall panel may be required. The cap plate is installed over the top plate to give the floor joists full bearing on the inside and outside facings of the SIP wall.

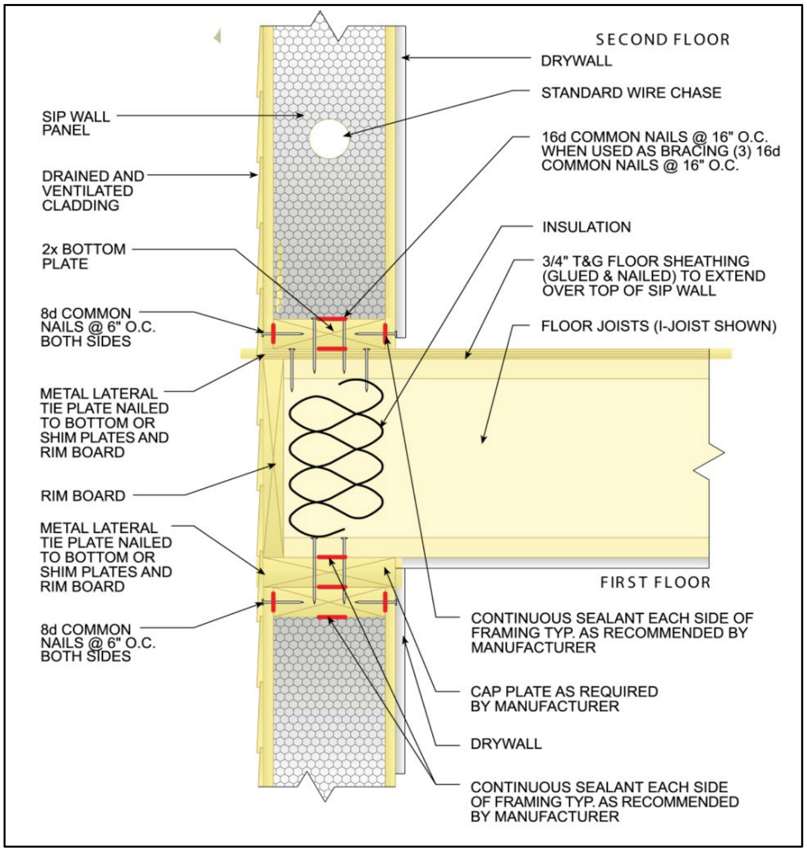

Figure 15: Intermediate platform-framed floor

Another option for intermediate floors is a hanging floor system (Figure 16). This detail uses a top mount joist hanger that is attached to the top of the first floor wall. Hanging floors are typically more energy-efficient because they eliminate any potential air leakage through the floor system or rim joist area.

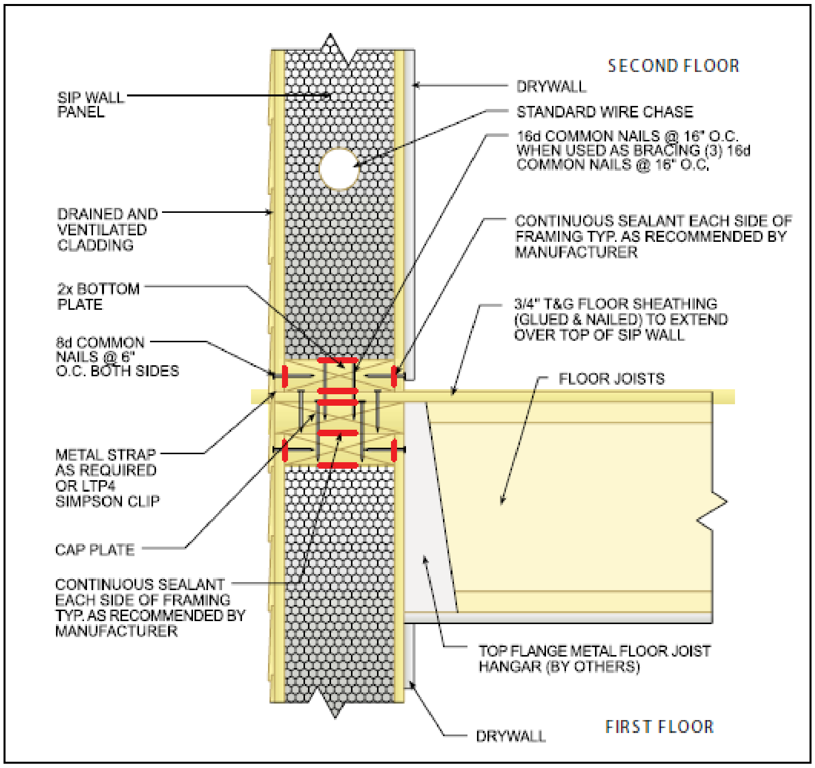

Figure 16: Intermediate hanging floor

Wall-to-Roof Connections

Wall-to-roof connections can be accomplished using a bevel-cut SIP wall or a square-cut SIP wall, depending on the roof pitch, the type of roof system used, and the preference of the SIP manufacturer.

With a bevel-cut treatment, the SIP wall has been cut to the exact pitch of the roof (Figure 17). The top plates placed in the foam recess at the top of the wall panels provide bearing and receive the panel screws used to attach the SIP roof system.

When a SIP roof is placed on a square-cut SIP wall, framing crews need to install bevel-cut solid lumber at the top of the wall to match the roof pitch and provide the roof panels with proper bearing (Figure 18). With either detail, the wall-to-roof connection is a critical sealing area.

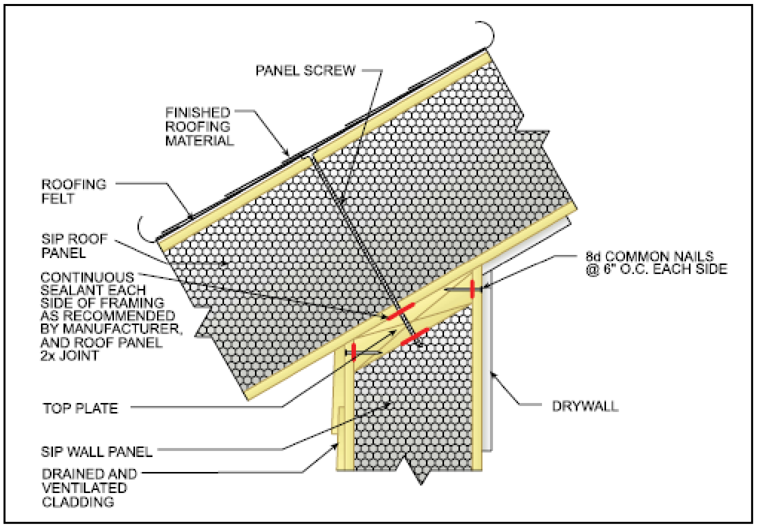

Figure 17: Bevel-cut SIP wall detail

It is common practice for conventional truss roofs to be placed on SIP walls. In this case, a square-cut SIP wall is used along with a cap plate that is ripped to the full width of the SIP wall panel. The cap plate increases the axial load bearing capacity of the SIP wall system by distributing the point loads created by the trusses to the inside and outside facings of the SIP wall system.

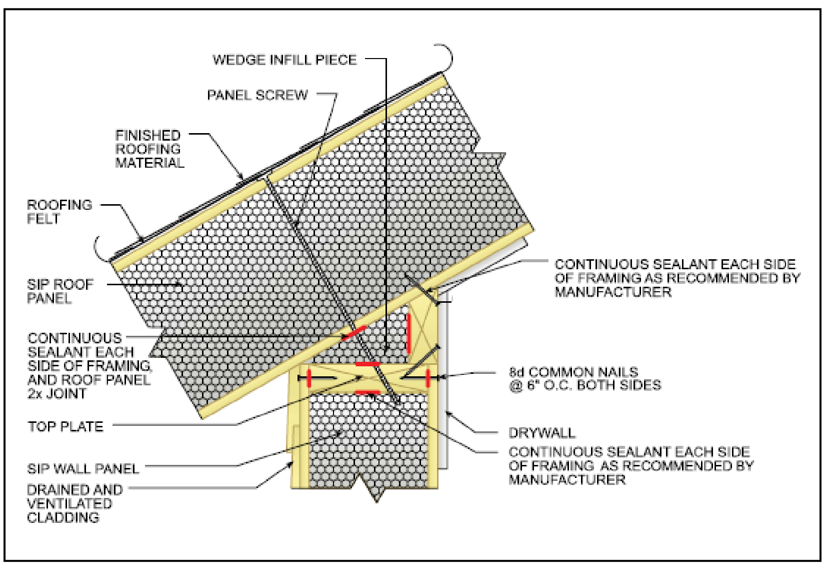

Figure 18: Square-cut SIP wall detail

Other Engineering Considerations for SIP walls

Headers

In many cases, window and door openings can be cut in SIP walls without the need for a structural header. Avoiding structural headers where possible reduces thermal bridging and saves time on the jobsite. SIP manufacturers have conducted testing and published load tables with the maximum allowable spans for door and window openings without the addition of a structural header. These take into consideration the width of the opening and the structural loads acting on the wall.

When those limits are exceeded, designers will specify structural wood headers such as those built from dimensional lumber, engineered wood products, or even manufactured insulated headers. Headers are supported by posts or dimensional lumber embedded in the SIP wall panels on each side of the opening (Figure 19).

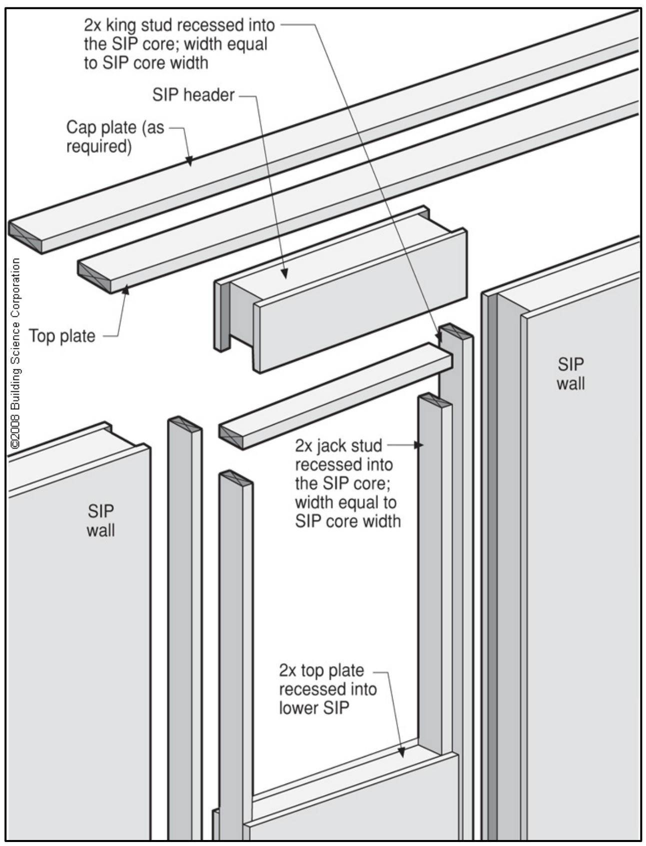

Figure 19: SIP header

Point Loads

Headers are always required when a point load is located above an opening. Point loads are a major consideration for SIP designers, especially when designing a SIP roof system supported by large beams or purlins. Point loads need to be transferred from the roof to the foundation by embedding posts in SIP walls, adding a cap plate to help distribute the load to the SIP facings, or designing loads that can be handled by the SIP wall system alone.

SIP Roof Details

One of the key decisions made by the SIP designer is selecting the roof panel thickness. Thicker SIPs have a higher R-value and can span further distances. When selecting panel thickness, the designer needs to consider the total design loads, whole-building energy modeling, the distance that must be spanned, and the project budget.

When dealing with roof spans, designers also need to look at the type of spline connections used between the roof panels. Dimensional lumber or engineered lumber splines allow panels to span greater distances, but these products decrease energy efficiency by creating a thermal bridge and may add to the cost of the project.

There are many different options for supporting a SIP roof. Ridge beams, purlin beams, and load bearing walls are common elements in designing a system that adequately supports the SIP roof panels and fulfills the building owner's needs for interior space.

Ridge Details

Joining two panels over a ridge beam at the roof peak is a widely-used detail in SIP roof design. Panel screws secure the roof panels to the ridge beam (Figure 20). This is another critical area for air sealing and many SIP manufacturers recommend using specialty SIP tape in addition to expanding foam or mastic sealant.

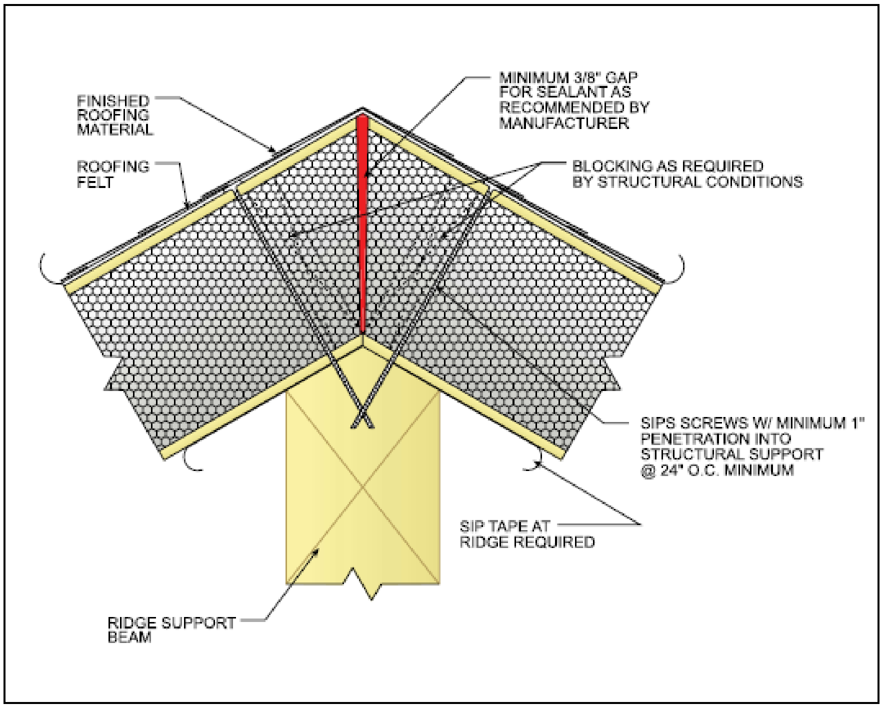

Figure 9: SIP ridge detail

Another option involves two purlin beams that are offset from the roof peak (Figure 21). The offset ridge detail allows for the construction of a false ceiling below the ridge that can be used for mechanical or electrical routing.

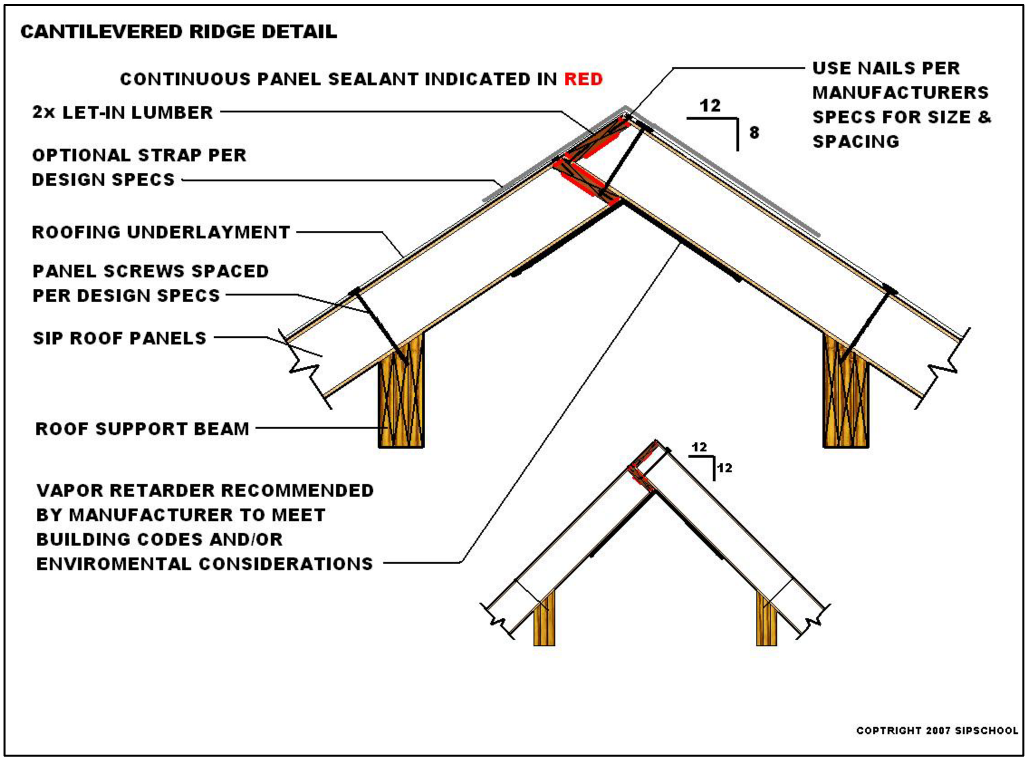

Figure 21: Offset ridge detail

Fascia

Designers are not concerned solely with structural issues. One unique consideration with SIP roof systems from an aesthetic standpoint is how to finish the roof overhang. A plumb cut roof panel will create a thick fascia height greater than the thickness of the SIP roof panel. By leaving the roof panels square cut, overhangs can be framed-out to create a variety of attractive looking designs (Figures 22-23).

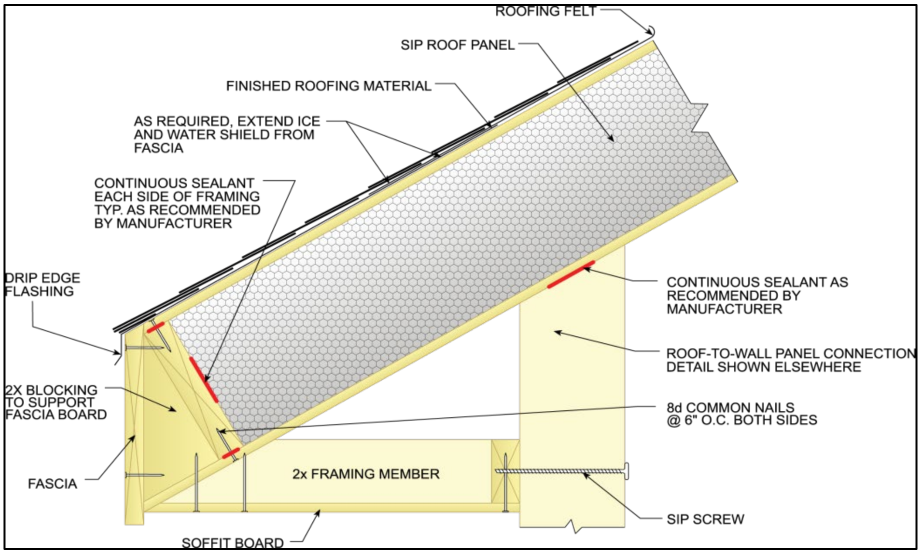

Figure 22: Sample eave detail

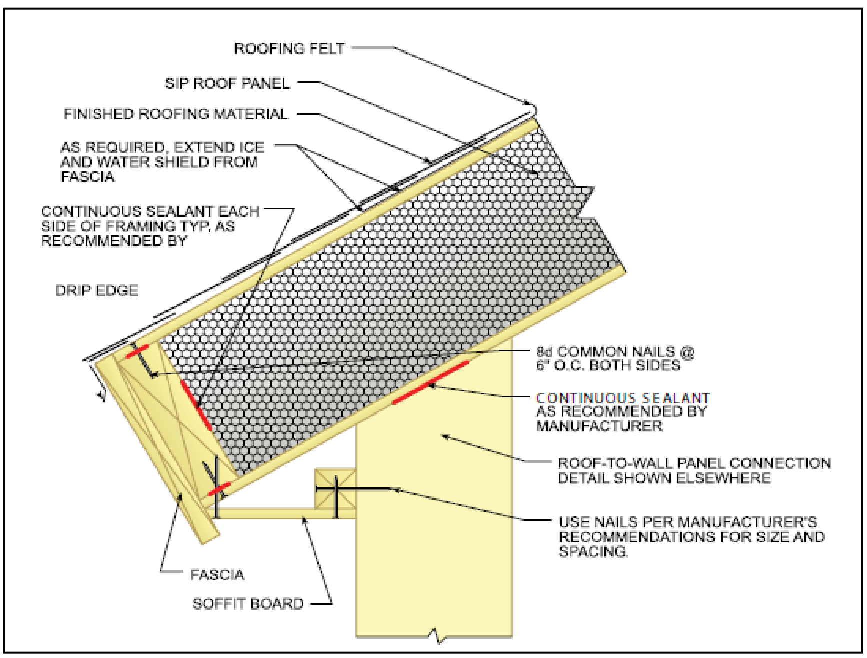

Figure 23: Sample eave detail

Skylights and Roof Penetrations

SIP designers need to carefully consider the placement of roof penetrations. If the design calls for skylights, the exact location and size of the skylight needs to be determined during the design phase because large openings can greatly affect the structural capacity of SIP roof panels. With small penetrations such as plumbing vents, it is recommended that they be consolidated to limit the amount of penetrations that need to be made through the SIP roof panels. Penetrations should never be cut through panel splines and always need to be properly sealed against air leakage and water intrusion.

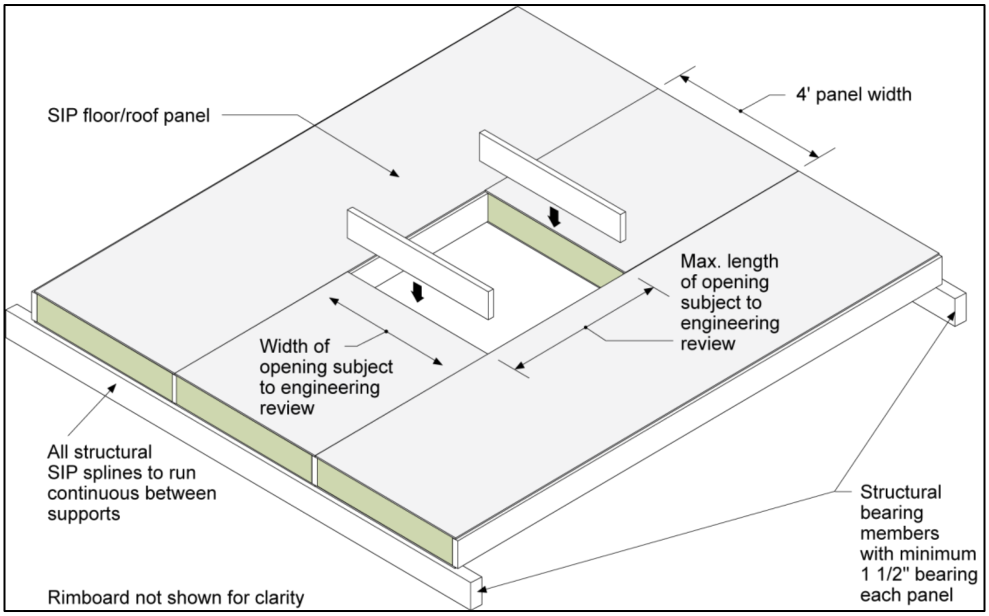

Figure 24: Skylight in a SIP roof

Extreme Engineering

In some regions of the country, high wind loads, snow loads, or seismic conditions require additional design considerations for SIP structures. SIPs are a viable option for nearly every situation where conventional wood framing is used, as long as the structure is properly designed and engineered. A discussion of these techniques is well beyond the scope of this book. If you are building in one of these regions, work with your local SIP manufacturer and building code authority to determine the design requirements.

Summary

When working with SIPs, builders need to be aware of basic SIP design and engineering practices. Unlike site-built construction, working with prefabricated components requires more attention to detail during the design phase and it is likely that builders or installers will participate in the review of panel layout drawings.

Before beginning a SIP project, it is best to find an experienced SIP designer or a SIP provider that offers design services. The SIP designer will convert architectural drawings to panel layout drawings, determine the appropriate panel thickness, and select connection details to meet the specific structural requirements of the building. Connection details and other pertinent information will be included on the panel layout drawings provided with a SIP package.

SIP construction relies heavily on the design phase to ensure that construction goes smoothly. Builders will likely find themselves interfacing with the architect, SIP designer, and SIP manufacturer to arrive at a finalized set of panel layout drawings. It is important for builders to be able to spot design errors or potential constructability issues in the design phase in order to keep the project on budget and meet the needs of the building owner.

Lesson 3: The SIP Order Process

In This Lesson

- Estimating SIP projects
- Selecting a SIP provider
- Types of different SIP packages
- Overview of the SIP order process

Introduction

For many builders making the switch to SIP construction, the design and estimating process can be daunting. Building with SIPs or any other prefabricated component requires more attention to detail during the design phase, and accurately estimating the project can affect the builder's bottom line. This lesson gives an overview of how a SIP project progresses from an architectural drawing to a truckload of prefabricated panels arriving at the jobsite.

Definitions

Area take off:	The quantity of SIPs (measured in square feet) required to complete a SIP project
Blank panels:	Rectangular, non-fabricated SIPs that are cut to fit on the jobsite by the builder
Precut panels:	SIPs that are fabricated to a specific building design by the panel provider
Ready-to-assemble:	Type of SIP package, offered by some SIP providers, that includes preinstalled lumber and splines, headers, sealants, and accessories
Edge treatment:	Process of removing the foam core along the edge of a SIP to accept dimensional lumber blocking, plates, or splines
SIP layout drawings:	Construction document that illustrates the size and location of each SIP along with the necessary construction details

Estimating

Although most panel providers offer estimating services, some experienced SIP builders prefer to conduct estimating in-house. In either case, estimating is typically done by area take off, or the square feet of SIPs required to complete the project. Once the area take off has been calculated, the panel provider can estimate based on cost per square foot.

Quoting a SIP project can be difficult because builders are often asked to provide a quote before the design is 100 percent complete. This is very risky because the final engineering details may require thicker SIPs or additional structural elements that drive the price of a SIP package well beyond what was originally anticipated.

For this reason, many SIP builders prefer to establish a preliminary design contract. In a preliminary design contract, the builder or panel provider will examine the building design and conduct the necessary engineering to produce an accurate estimate for the SIP package.

Finding a Panel Provider

Selecting a panel provider is a key step in building any SIP project. There are a number of SIP manufacturers and dealer/distributors offering a wide range of products and services. When choosing a panel provider, the builder needs to look at the quality of the product, the level of service, and the price.

All SIPA member manufacturers are required to have their products tested by an accredited third party agency and have an ongoing contract with a third party quality control agency. Quality control agencies regularly audit manufacturing facilities and test the SIPs coming off the assembly line to make sure they meet the structural performance metrics published in the company's load design charts. A complete listing of SIPA manufacturers and dealer/distributors is available at www.sips.org.

Another key difference between SIP providers is the level of additional services offered to their customers. These can include SIP design, onsite training, lumber installation, edge preparation, and supplying panel accessories. When evaluating an estimate from a SIP provider, it is important to look at which services are included in the estimate and which will need to be performed onsite.

SIP Design

SIP design is a critical part of estimating and building a SIP project. Design services are offered by many SIP manufacturers and dealers, as well as by independent design professionals.

The SIP layout drawings generated by the SIP designer will be used to estimate the project, gain code approval, fabricate the SIP package, and serve as an installation guide onsite. Overdesigning or excessively conservative engineering can drive the price up and slow down SIP installation.

Engineering

Some jurisdictions require SIP projects to be approved by a licensed engineer. Like design, engineering can have a significant impact on the overall cost of a SIP package. An engineer that is familiar with SIPs is likely to help the builder keep construction costs down by designing to the strengths of a SIP system. Check with your SIP manufacturer or dealer to see if they work with any licensed engineers, or search for one in your area at www.sips.org.

HVAC Analysis

Heating ventilation and air condition (HVAC) is discussed in detail in Lesson 8, but it is an important part of the estimating process because it affects the overall construction budget. SIP buildings are much more airtight and typically require smaller HVAC units. The savings on HVAC equipment partially offset the higher material costs of SIPs when compared to conventional wood frame construction. More importantly, a properly sized HVAC unit reduces the builder's liability by effectively dehumidifying the conditioned space and greatly reducing the risk of mold and mildew.

SIP Fabrication

The level of fabrication offered by the SIP provider affects both the material cost and the labor cost incurred by builders when it comes time to install the SIP package.

Blank Panels

Blank panels cost the least upfront but rarely save builders any money because of the additional labor involved in fabricating panels onsite. Cutting SIPs onsite is a very time consuming process that generates a lot of jobsite waste. Crews cutting panels onsite rarely achieve the same yield as factory fabricators using optimization software that minimizes panel waste.

Precut Panels

Precut panel packages are cut by the panel provider to the specifications outlined in the panel layout drawings. Some providers use automated CNC fabrication machines capable of achieving tolerances unimaginable in field fabrication. This service typically includes edge treatment, where the foam core has been recessed to accept splines or dimensional lumber, but that may not always be the case. It is up to the builder to ascertain exactly what level of fabrication they are receiving to avoid incurring additional onsite labor that was not anticipated when they bid the project.

Ready-to-Assemble

Many manufacturers offer precut SIP packages with lumber preinstalled, known as a ready-to-assemble or ready-to-install package. These packages have splines and dimensional lumber cut to length with installed foam recesses wherever possible prior to erecting the SIPs. Precut headers and accessories are also included.

Accessories

In addition to the level of fabrication, builders also need to look what accessories are included in the estimate. Accessories may include fasteners, SIP screws, mastic sealant, splines, expanding foam sealant, and SIP tape. It is recommended that builders make sure the amount of sealant provided is enough to adequately seal the SIP package as it is assembled.

Order Process

After quoting a SIP project, the builder is often responsible for guiding the project through the final design tasks and initiating the SIP order. Here is a step-by-step example of the SIP ordering process:

1) The SIP provider's quote leads to a contract between the builder and SIP provider
2) The builder receives a finalized set of architectural drawings that need to be converted to SIP layout drawings
3) The completed SIP layout drawings will undergo engineering review
4) The SIP layout drawings will then be reviewed by the customer and/or the project architect
5) Once the drawings are finalized the order is submitted to the SIP provider
6) The SIP provider fabricates the panels and ships them to the jobsite

Summary

Accurate estimating requires establishing a relationship with a reputable SIP provider and determining the exact level of fabrication and additional services included in their estimate for the SIP package. The builder may also be required to coordinate with the SIP designer, engineer, customer, and SIP provider as the project advances. Builders need to be aware of the factors affecting the cost of a SIP project, such as the design, engineering, and HVAC analysis, in order to create an accurate estimate and complete the project under budget.

Lesson 4: SIP Building Science

In This Lesson

- Importance of building science
- Bulk water management
- Controlling water vapor
- Designing assemblies to dry
- Ventilation in airtight buildings

Introduction

Building science is the study of the interaction between a building, its systems, its components, the building occupants, and the surrounding environment. When applied properly, building science can improve a building's durability, occupant comfort, and energy efficiency.

The emergence of building science in residential construction over the last two decades can be traced to some of the unintended consequences of so many new construction technologies. The introduction of thermal insulation, airtight building enclosures and forced air heating systems have made houses more comfortable and energy-efficient, but failing to consider the interrelationships of these systems has caused moisture problems, uncomfortable houses, and dangerous indoor air quality.

SIP homes have very low levels of air infiltration and for this reason moisture accumulation can quickly lead to major problems if the assemblies are not given the capability to dry. By following a few simple rules presented in this section, SIP builders can assemble durable structures that also provide great energy efficiency for homeowners.

Many of the concepts discussed in this lesson are adopted from the *Builder's Guide to Structural Insulated Panels (SIPs)*, by Joseph Lstiburek. This guide gives a more thorough explanation of general building science principles and those specific to SIP construction. It is available for purchase at www.sips.org.

Definitions

Bulk water:	Water in liquid form, such as that deposited on a building from rain, dew, or melting snow
Drainage plane:	Collection of water repellent materials used to protect a building from bulk water, including weather-resistive barriers, flashing and

	exterior cladding materials
SIP tape:	Vapor impermeable peel-and-stick tape used to seal SIP joints
Thermal void:	Gap in the insulating foam core of a SIP that is the result of penetrations, poorly installed splines, or electrical work
Ventilated cladding:	Siding or other exterior finish material with a vented air space separating it from the building's weather-resistive barrier
Vented roofing or cool roof:	Roof assembly with a vented air space separating roofing material from the roof sheathing
Drainage mat:	Woven plastic mesh installed between the weather-resistant barrier and siding to create an air space
Stack effect:	Pressure differences in a home caused by the buoyancy of heated air

Preventing Water Damage

Water damage poses one of the biggest threats to building performance in all types of wood structures. Uncontrolled moisture can lead to rot, mold, indoor air quality issues and even structural failures. With any type of wood construction, builders need to employ strategies that protect against the intrusion of both water vapor and bulk water (rain, snow, sleet).

Bulk Water Management

Building scientist Joseph Lstiburek recommends a "3-D" approach to bulk water management:

- Drainage
- Deflection
- Drying

SIP homes need to be protected by layering materials that allow rain water to drain from a building and be directed away from the site (Figure 1). The collection of water repellent materials, including weather-resistive barriers, flashing and exterior cladding materials, is referred to as the building's drainage plane.

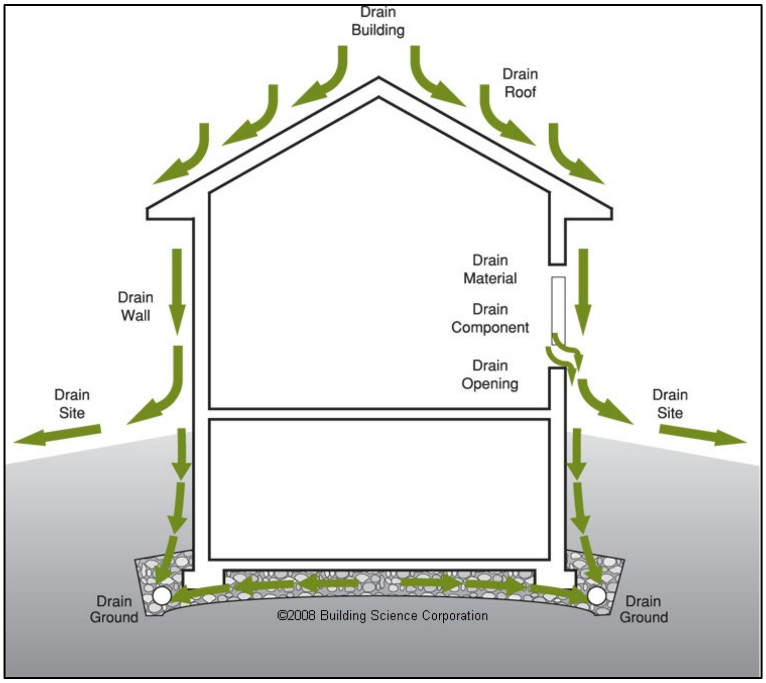

Figure 1: Bulk water management strategy

The most important principle in bulk water management for SIP construction is to create assemblies with a method of drying in the event that bulk water penetrates the drainage plane. It is generally accepted in the building industry that over the life of a structure wall assemblies will be exposed to moisture during service. In many cases they may even start out wet due to exposure during the construction. To ensure building durability and prevent moisture-related problems such as mold and rot, it is crucial that assemblies be designed with the capability to dry.

Materials like the OSB sheathing used in SIPs have the ability to accumulate and store moisture without degrading their performance or service life. Moisture problems occur when the rate of moisture accumulation exceeds the rate of drying, driving moisture levels beyond the safe storage capacity of the material (Figure 2).

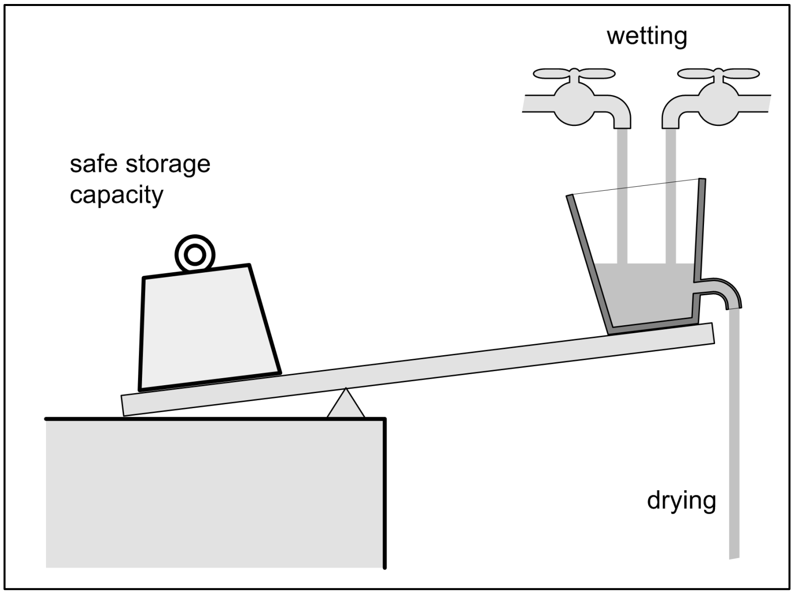

Figure 2: Moisture storage capacity of building materials

Controlling Water Vapor

In addition to controlling water in its solid state, it is equally as important to control water in its gaseous state. Water vapor has the potential to transfer through gaps in the building enclosure, condense into water, and cause major moisture-related problems.

Water vapor can transfer through building materials in two ways: air transport and vapor diffusion. In the case of air transport, pressure differences within a building, or between the interior of the building and the outside, will force air through any gaps or leaks in the building enclosure. Along with the air comes water vapor.

Vapor diffusion is the transfer of water vapor through a solid material due to vapor pressure difference or temperature difference. The rate of diffusion depends on the permeability of the material it is moving through, but because of the relatively low permeability of SIPs, air movement is of much greater concern for SIP building enclosures, as shown in Figure 3.

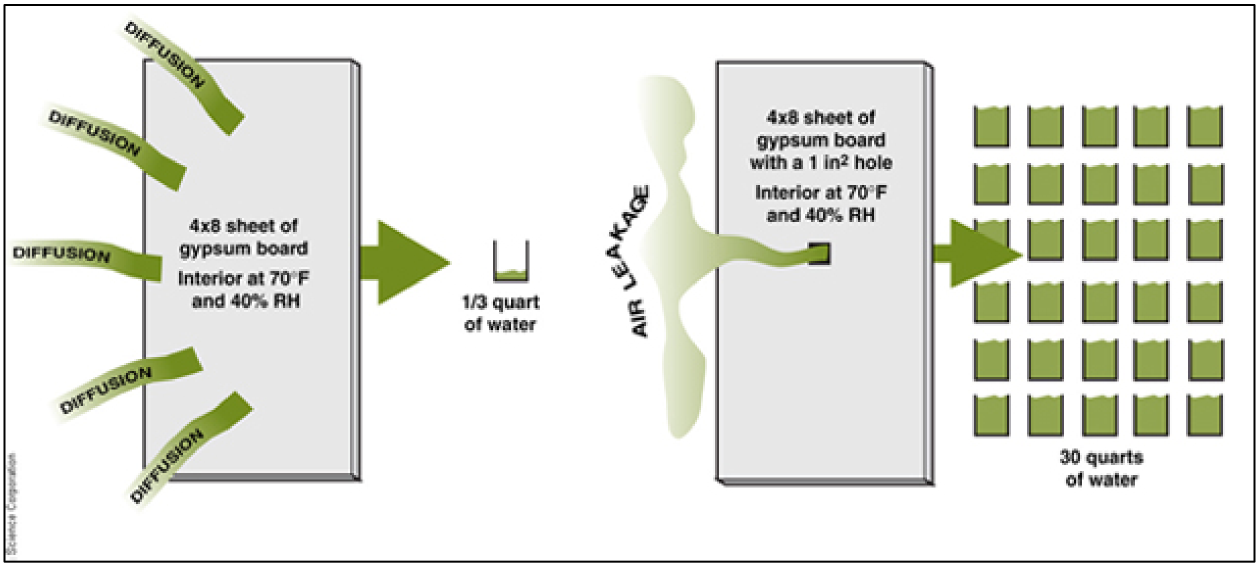

Figure 3: Vapor diffusion versus air transport

Air transport through the building enclosure has negative effects not only from a moisture perspective—it reduces energy efficiency and hampers efforts to control the temperature and humidity in the building.

Best Building Practices

Sealing

SIP homes typically have very low levels of air infiltration compared to traditional wood frame construction. This is because the OSB facings function as a code compliant air barrier and there are no wall cavities for air to move through (Figure 4). The only places where air can move through a SIP building enclosure is at the joints, windows, doors, and penetrations through the building envelope for plumbing, electrical and other needs.

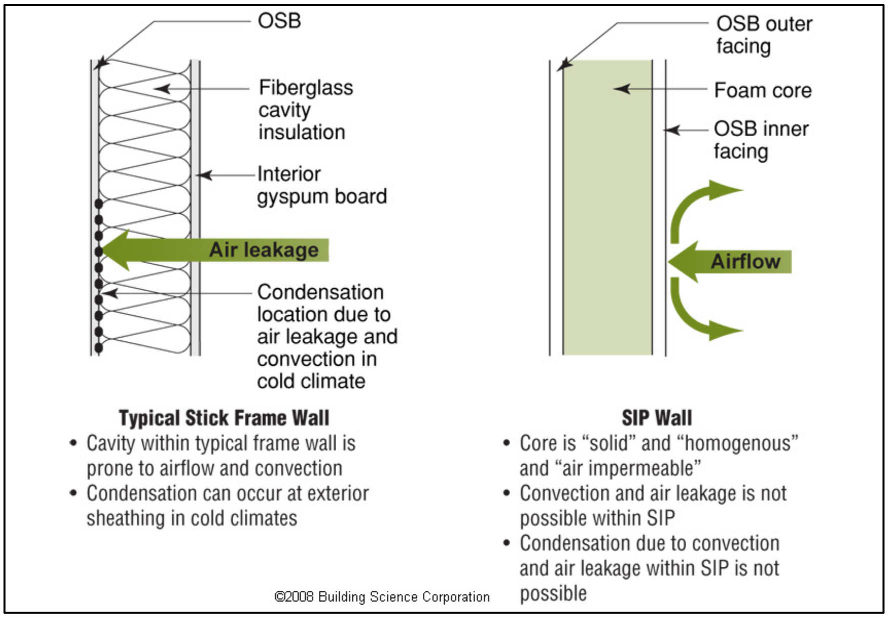

Figure 4: SIP wall as an air barrier

Properly sealing joints is the primary durability concern with SIP building enclosures. Water vapor that makes its way into the joint from either the inside or the outside will condense when it encounters colder temperatures. If not given the ability to dry, repeated condensation can lead to rotting at the SIP joint.

Always follow manufacturer recommendations for sealing panel connections and apply the appropriate sealant where noted in the construction details. It is also the builder's responsibility to inspect a SIP building after the subtrades have completed their work to make sure any penetrations through the building envelope have been properly sealed.

SIP Tape

Many SIP manufacturers recommend applying a peel-and-stick SIP tape to panel joints to provide an additional layer of protection against moisture intrusion.

As a general rule, SIP tape is applied to the "warm side in winter." For cold and mixed climates, this is the interior. In hot humid climates it is the exterior. The joint retains the ability to dry in the opposite direction.

Never apply a vapor barrier on each side of the SIP joint—an example would be SIP tape on the interior of roof joints in a cold climate and a fully adhered roofing membrane on the exterior of the SIP roof panel. If at any point either of the vapor barriers failed, or the materials got wet during construction, the moisture would be trapped in between two materials that prevent it from drying.

Areas of Concern

Thermal Bridges and Voids

In addition to properly sealing the joints between panels and other interfaces, thermal bridges and thermal voids present another potential area for moisture problems.

Thermal bridges occur when dimensional lumber or metal is embedded inside a SIP. This is common with dimensional lumber or engineered splines that are often specified to meet certain structural demands. Sawn lumber has a much lower insulating value than the foam core of a SIP and creates a thermal bridge spanning between conditioned and unconditioned space.

During extreme temperature differences, the higher thermal conductivity of a thermal bridge can move the dew point inside the SIP wall. If the joint is not sealed correctly, water vapor can condense inside the wall.

Thermal voids are gaps in the insulating foam core that are the result of penetrations, poorly installed splines, or electrical work. The lack of insulation allows cold temperatures to extend into the panel and create a dew point where water vapor can condense. Special care should be taken to fill thermal voids with expanding foam and thoroughly seal around dimensional lumber that interfaces with SIPs.

The Stack Effect

Improperly sealed SIP joints, especially at the roof ridge, are a target for vapor intrusion driven by the stack effect. Warm air is more buoyant than cold air, and during the heating season it will rise to the top of a building. This creates a pressure difference that can cause warm air to leak out at the roof ridge and cold air to leak in on the ground floor. Any gaps in the air barrier will create a recipe for condensation, which can lead to rotting at the roof ridge or other roof joints if they are not properly sealed.

In climates with a cooling season, air conditioning can cause a reverse stack effect. Cool air inside the home has a higher density than the warm air outside. Dense, cold air sinks to the bottom of the building, and the resulting pressure difference can pull warm, moist air in through improperly sealed roof joints.

Roof and Wall Ventilation

Walls

To boost the drying capacity of SIP wall assemblies, *Builder's Guide to Structural Insulated Panels (SIPs)* by Joseph Lstiburek recommends that exterior cladding materials be ventilated in regions where annual rainfall exceeds 20 inches. Adding a vented air space behind the cladding system allows for any moisture that penetrates the exterior cladding or enters the wall assembly to dry out.

Details for creating a vented air space for different types of wall cladding systems are covered in Lesson 9.

Roofs

Similar to SIP wall assemblies, it is recommended that SIP roof assemblies be vented in wet climates where annual rainfall exceeds 20 inches. Vented roof systems are often referred to as a "cool roof" and should not be confused with a vented attic.

Traditional truss-framed roofs with the insulation at the ceiling line typically have vented attics, where air circulates in the unconditioned attic space. A SIP roof places the insulation at the roof line and encloses the attic as conditioned space, so it should not be vented under any circumstances. Conditioned attics have many advantages, such as extra living space and the added energy efficiency of locating duct work and/or air handlers in the conditioned space.

The term "cool roof" is somewhat of a misnomer when applied to SIP roof systems because the reason to add roof ventilation has little to do with temperature. Roof ventilation is used primarily to increase drying ability. Should moisture enter the SIP roof system through either a leaky roof or from water vapor making its way into improperly sealed joints, that moisture must have a way to dry or it could potentially cause rot in the SIPs themselves and undermine the structural integrity of the roof system.

Lesson 9 discusses cool roof systems and specifications in greater detail.

Ventilation

As previously discussed, SIP buildings are very airtight, making it necessary to provide mechanical ventilation. Limiting the amount of air leakage in a home allows incoming air to be controlled, filtered and dehumidified by mechanical systems, creating a better level of indoor air quality for occupants.

There are a variety of ways to provide mechanical ventilation in SIP homes. The types of HVAC systems used in SIP homes vary greatly by climate, so it is recommended that SIP builders work with a qualified HVAC professional. HVAC is discussed in greater detail in Lesson 8.

Summary

Understanding the principles of building science is important when dealing with airtight homes. Less air movement through wall and roof assemblies creates greater energy efficiency, but it also limits the assembly's ability to dry. With SIP buildings, it is crucial to protect against bulk water and water vapor, while also detailing assemblies so they can dry if they get wet.

Another key aspect of SIP construction is joint sealing. Working with large panels means there are very few joints, but if these joints are not sealed they are a magnet for vapor intrusion and carry the potential of serious moisture problems after years of occupancy. By paying attention to sealing and detailing, builders can construct SIP buildings that are durable, energy efficient, and provide exceptional indoor air quality.

Lesson 5: SIP Layout Drawings

In This Lesson

- Submitting SIP documentation for a building permit
- Types of SIP layout drawings
- Reviewing SIP layout drawings

Introduction

SIP layout drawings illustrate the size, shape, connection details, and other information needed to properly install a SIP package. For some builders, it is easiest to think of a SIP layout drawing as similar to an engineered truss drawing—it deals with one particular pre-engineered component of the building.

SIP layout drawings are typically provided by the SIP manufacturer or dealer/distributor. These companies often have designers who create the SIP layout drawings based on the architectural drawings for each project. The SIP layout drawings can then be reviewed by the building owner, the architect, the builder or SIP installer, and the local governing body for permit review.

Once approved by all parties, SIP layout drawings can be plugged directly into automated fabrication equipment or used to fabricate the panels by hand. The same drawings will then serve as an installation guide on the jobsite.

Definitions

SIP layout drawings:	Drawings that illustrate the size, shape, rough openings, connection details, and other information needed for SIP installation
By others:	Notation on SIP layout drawings indicating the information for a particular detail or component is provided by another source
Field cut:	Notation on SIP layout drawings designating an element that must be fabricated on the jobsite
Ventilation notes:	Notes referencing a whole-building ventilation standard, specification, or methodology on a SIP layout drawing

Permitting

When applying for a building permit, builders need to submit several pieces of documentation on the SIP system that will be used on the project. It is important to note that these requirements will depend on local building codes and the discretion of the code official.

Code officials may request to see copies of the SIP manufacturer's product data, evaluation report, and load design charts. These materials are readily available from all SIPA member manufacturers.

If the local building code contains strict energy efficiency requirements, code officials may also require SIP performance data or energy modeling of the building.

In other cases, building code officials will request a completed set of SIP layout drawings that have been approved by a licensed architect or engineer. This adds a significant amount of time and money that must be invested prior to receiving a building permit for the project.

Types of SIP Layout Drawings

The level of detail provided on the SIP layout drawings will depend on the SIP provider. Some SIP providers offer colored layout drawings and isometric view, while others may only offer black and white drawings. All SIP layout drawings will include:

- Dimensions of each panel
- Dimensions and location of all rough openings
- Connection details
- Labeling system corresponding to the labels on the SIPs themselves
- Location of electrical chases
- Edge treatment
- Connections with other structural components such as posts, beams, and floor systems

Reviewing SIP Layout Drawings

Reviewing SIP layout drawings is one of the most critical parts of building a SIP project. SIPs can be modified onsite, but to take full advantage of the speed and efficiency of a prefabricated system, it is vitally important that the SIPs arrive at the jobsite cut to the correct dimensions.

Plan review is always done before the panels are fabricated, giving the builder, installer, or other reviewing parties an opportunity to catch mistakes or potential conflicts. Conflicts often occur when SIP installers fail to realize what they are getting, such as expecting SIP overhangs and realizing the panel designer has stopped the SIPs at the roof line and the builder needs to frame the overhangs.

Here is a list of things that SIP installers should examine when reviewing SIP layout drawings:

- Dimensions and locations of rough openings
- Connection details
- Building dimensions
- Overhangs
- Roof pitch
- Fastening schedule

Areas of Concern

In addition to verifying that the SIP layout drawings match the design of the building, builders should also look for the following items and plan their installation accordingly:

"By Others" or "Field Cut"

If a detail is labeled as "By Others" the SIP installer should make sure he has obtained the supporting information. "Field Cut" indicates that a particular panel or other component needs to be fabricated onsite. Both these notations have the potential to cause unexpected delays on the jobsite if they are not acknowledged beforehand.

Over-engineering

On some occasions, an inexperienced architect or engineer may specify unnecessary headers, lumber splines, or posts to increase the structural strength of a SIP system far beyond what is required. An experienced SIP installer will ask the architect or engineer if these features are truly necessary, as they can add significant labor and materials costs.

Roof Support Structure

If the project involves a SIP roof, it is important to review how that roof is being supported and how the SIPs will be connected to the beams, purlins, trusses or other supporting members. If structural beams are included in the SIP package, check the layout drawings to make sure they are the correct size.

Ventilation Notes

Some SIP providers include ventilation notes on the panel layout drawings that require a verification of adequate whole-building ventilation. Adequately exhausting water vapor from the interior of a SIP building is important for long-term durability. Verifying proper ventilation is often tied to the SIP manufacturer's warranty for this reason.

Ventilation notes may list acceptable humidity levels or reference a ventilation standard published by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE). If the note mandates a specific ventilation method or technology, it may be best to consult a qualified HVAC professional to determine if that method is appropriate for the climate zone.

Summary

SIP layout drawings play an important role in the design, fabrication and installation of a SIP package. Working with prefabricated SIPs requires attention to detail during the design phase before panels are cut and shipped. Costly delays can occur if mistakes need to be fixed on the jobsite. To take full advantage of the speed and precision capable with prefabricated SIPs, installers need to carefully review SIP layout drawings and plan their installation accordingly.

Lesson 6: SIP Site Planning and Coordination

In This Lesson

- Delivery, unloading and staging SIPs
- Storing SIPs on the jobsite
- Jobsite safety
- Material handling equipment

Introduction

For the SIP installer, the layout of the jobsite can greatly affect the speed of installation, the type of material handling equipment required, and overall labor costs.

Never bid a SIP installation without first examining the jobsite for any obstacles that could result in added time and labor. Steep hills, dense urban areas, overhead obstructions, or lack of adequate staging space can all affect the efficiency of SIP installation. Also, make sure the jobsite is accessible by large trucks that will deliver SIPs and material handling equipment such as an all terrain forklift or crane.

Definitions

Dunnage:	Dimensional lumber used to keep SIPs off the ground when stored. Also referred to as stickers.
Fork extensions:	Forklift accessory that lengthens forks to support 8-foot-wide SIPs
Spreader bar:	Crane hoisting accessory that distributes load across a SIP or bundle of SIPs to prevent damage when hoisting. Also referred to as a pick bar.
Rough terrain forklift:	Class VII forklift designed for off-road use with a telescoping boom

Delivery, Unloading and Staging

Staging Area

SIP installers are able to achieve remarkable time savings over site-built construction by ordering large-format, prefabricated panels. These large panels take up a lot of space on the jobsite. Installers need to survey the jobsite and identify a staging area where the panels can be unloaded, sorted, and prepared for installation.

SIPs are typically transported on a flatbed semi-truck. When identifying the staging area, installers must consider how close the truck can get to the staging area, and how easily SIPs can be installed from the staging area. This is critical when the installation requires the use of a crane.

Overhead obstructions like tree limbs or power lines can interfere with crane operations. If you are using a crane or other heavy equipment to set panels, make sure the equipment operators are aware of any obstructions ahead of time and plan your jobsite accordingly. Addressing these issues in advance of the SIP delivery will make the installation more efficient.

Figure 1: Staging area for panel sorting and prep

Delivery

The majority of SIP providers deliver SIPs using a common carrier. Working with a common carrier creates plenty of opportunities for a breakdown in communication between the SIP installer, the carrier, and the SIP provider. It is a good idea to obtain a cell phone number for the driver and check that they have good directions to the jobsite. Downtime while waiting for SIPs adds to construction costs, especially when equipment rental is involved.

Most common carriers allow two hours to unload the SIPs once the truck has arrived, or additional charges may be incurred. The SIP installer should have a forklift or other equipment to unload the truck at the jobsite before the truck arrives.

Unloading

Forklifts are the preferred method of unloading SIPs. For 8-foot-wide panels, fork extensions are required.

It is possible to unload panels with a crane, although it is typically less efficient than using a forklift. Crane straps can easily damage panel facings when hoisting bundles of SIPs off the truck. Place dimensional lumber blocking on each corner where the strap comes in contact with the panel skin to protect against damage.

Another option is to use a spreader bar, also called a pick bar, to distribute the load across the stack of SIPs so that panel skins are not damaged by hoisting.

Unloading panels by hand is not recommended and should only be done when jobsite conditions prevent the use of heavy equipment.

SIPs can also be damaged during their loading and transport. This is often caused by overtightening the ratchet straps securing the load to the trailer or inadequate blocking underneath ratchet straps. Take pictures of any damage that occurred during shipping and contact the SIP provider.

SIP Storage

Once they arrive on the jobsite, SIPs need to be protected from the elements. SIPs should be stacked on a level surface and elevated off the ground on dunnage or stickers made of dimensional lumber. When stacking panels, the bottom panel needs to have good firm contact on all pieces of dunnage and the dunnage needs to be wide enough that it will not deform the bottom panel. SIPs longer than 12 feet require at least three pieces of dunnage to keep the panel from bowing.

SIPs also need to be protected from moisture with plastic tarps. Extended exposure to ultraviolet (UV) light will cause the expanded polystyrene foam core of SIPs to discolor, so clear plastic is not recommended during extremely sunny conditions.

Figure 2: SIPs stored off the ground, level, and protected from the elements

Installation Crew

SIP installation crews range from three to five workers for a typical residential project. Each crew should have a crew leader that has completed SIP installation training or is knowledgeable about SIP construction techniques. Despite some claims that SIPs are easy to install or require less skilled labor, all crew members should have basic construction knowledge if they are going to be working on a SIP jobsite.

It may be useful to increase the size of the crew on days when a crane is required in order to maximize efficiency and keep crane rental days to a minimum. When working with a crane, it is fastest to have part of the crew preparing panels on the ground and another part of the crew setting panels on the roof to eliminate downtime.

Safety

Jobsite safety is crucial in all construction work. Workers need to be trained in basic construction safety before working with SIPs. Installing SIPs often involves working on elevated surfaces and it is recommended that all crew members undergo OSHA Fall Arrest Systems training. Since forklifts are a common tool for SIP installers, it is also recommended that SIP installation crews receive their OSHA Powered Industrial Truck Safety Training certification. An untrained forklift operator moving large SIPs can endanger themselves and other crew members.

Many SIP installers have found that the OSHA 10-hour Training for Construction course is a good investment in preventing jobsite accidents. This course is available online and many workers compensation insurers offer it free of charge to their customers.

High winds pose a safety risk when setting large panels by crane. In high wind areas, installers often opt for smaller format SIPs in place of jumbo 8-foot x 24-foot SIPs for ease of installation and better jobsite safety.

Subcontractor Coordination

The SIP builder should discuss several special requirements with subcontractors that will be working on the project. It is advantageous to evaluate the electrical and plumbing plan with the respective subcontractors during the design phase of the project. Any potential issues can be identified and dealt with before the SIP package is ordered.

SIP walls can sit on almost any type of foundation, including block foundations, insulated concrete forms (ICFs), slab on grade, or poured concrete. What is most important is the foundation tolerance. It is more difficult to modify a SIP package to fit a foundation that is out-of-square or out-of-level than with conventional wood frame construction. The general contractor or the SIP installer needs to communicate the level of accuracy needed to the foundation contractor. When onsite modifications are required, it is easier to make a SIP package fit a slightly larger foundation or floor deck than to cut panels to fit a smaller foundation or floor deck.

Material Handling Equipment

SIP installers have three options for handling and placing SIPs on the jobsite: SIPs can be set by hand, with a forklift, or with a crane.

Setting SIPs by Hand

Handling and setting SIPs with manpower alone is difficult, laborious and inefficient. This is typically only done when jobsite conditions prohibit the use of equipment. In this situation, the general contractor or SIP installer hopefully inspected the jobsite while the project was still in the design phase and ordered smaller-format SIPs for easy handling.

Forklifts

The rough terrain forklift, also referred to as an extending boom forklift or Class VII forklift, is the preferred piece of equipment for many SIP installers because of its versatility and relatively low cost. Rough terrain forklifts can be used to unload panels, move panels and other materials around the jobsite, and set panels. Roof panels can also be set with extending boom forklift, depending on the height and amount of reach required.

Forklifts are rated on the length of the extending boom and their weight carrying capacity. The SIP installer should look at both the SIP design and the jobsite layout to determine the appropriate piece of equipment. As with any type of machinery, a trained and certified operator is required.

Cranes

When the height, reach, or weight of panels exceeds the capabilities of a rough terrain forklift, a crane is the best option to place SIPs. There are a wide variety of cranes that can be used on a SIP jobsite. Like forklifts, cranes are typically rated by their reach and load carrying capacity. Most crane rental companies can help installers specify the best type of crane for the job. For the safety of everyone on the jobsite, a trained and certified crane operator is required.

Summary

Like other aspects of SIP construction, a safe and well-organized jobsite depends on planning during the preconstruction phase. It is recommended that SIP builders inspect a jobsite before ordering a SIP package and identify the best panel format and material handling equipment for the conditions. Achieving the speed of construction capable with SIPs is dependent on rigorous planning, careful design, and communication with subcontractors. Ignoring any of these creates the potential for delays and added labor costs.

Lesson 7: SIP Layout and Panel Installation

In This Lesson

- Preparing SIPs for installation
- Rigging SIPs
- Sealing SIPs as they are installed
- Maximizing installation efficiency

Introduction

This lesson covers hands-on tips and techniques for an efficient SIP installation. Prefabricated SIPs can save builders a tremendous amount of time and labor costs over site-built construction, but those time savings depend on a well-organized jobsite and an efficient SIP installation. Simple actions such as reviewing SIP layout drawings, marking panel locations on the floor deck, and making the most out of rented material handling equipment all contribute to a smooth and efficient SIP installation.

Although SIPs can be installed quickly, they also need to be installed correctly. The key to an energy-efficient and durable SIP building enclosure is properly sealing the panels as they are installed. SIP installers need to educate their crew and any subcontractors on the importance of sealing all panel joints and penetrations against air infiltration.

Definitions

SIP mastic:	Specialty caulking designed specifically for SIP construction
Expanding foam:	Polyurethane sealant that expands as the result of a chemical reaction to fill gaps or seal between SIP joints
SIP tape:	Vapor impermeable peel-and-stick tape used to seal SIP joints

Panel Prep

SIP installation begins with reviewing the SIP layout drawings provided with the SIP package. Verify that the labeling system in the drawings matches the panels onsite and nothing is missing. If blank panels were ordered, the drawings will serve as a guide for cutting the panels onsite.

Preparing panels before setting them in place helps installers maximize the efficiency of their installation crew and any equipment that is being rented. It is safer and easier to work on the ground than on rooftops or intermediate floors. Ideally, the crew will do as much work as possible on the ground. This includes installing dimensional lumber or splines, predrilling screws, drilling for electrical, and even preassembly of multiple roof panels. If panels can be joined together on the ground it results in fewer lifts, less rental time for equipment, and greater safety for the crew involved.

Preparing panels on the ground also gives the installer an opportunity to verify panel dimensions and identify any errors in panel fabrication before attempting to place the panel.

Wall Panels

Wall panel installation should start in a corner so that it self-braces the wall system. If using equipment to set panels, consider line of sight and accessibility issues when choosing which part of the building to install first.

SIP wall systems typically require less wall bracing than conventional wood framing, but are more susceptible to the effects of high winds. If windy conditions are expected, make sure the walls are adequately braced.

Rigging

Rigging Methods

Worker safety is the top priority when lifting panels with a crane or forklift. The SIP manufacturer should supply installers with an approved methodology for rigging SIPs. Some SIP providers supply rigging hardware as well.

In addition to the rigging hardware specified by the SIP manufacturer, SIP wall panels can be rigged by looping straps through window and door openings. This should only be done after placing dimensional lumber blocking in the panel recesses to protect the panel edges from strap damage.

Another option is to place straps under a temporary top plate or through holes drilled in the panels. After straps or rigging hardware has been removed, mark the holes so they can be easily located and sealed with expanding foam.

Roof Pitch

On pitched roofs, it is best to rig panels off-center so they will match the pitch of the roof as they are being placed. However, panels rigged at a pitch can spin during windy conditions. If wind is present, it is safer to rig panels without a pitch. A tag line should always be used to help control panels while they are in the air.

Additional Hardware

Another consideration when setting roof panels is maneuvering them into their correct location. Consider adding additional hardware or blocking to the panel on the ground that crew members can use to handle the panel on the roof and get it into place using ratchet straps.

Coordinating Subtrades

SIPs fundamentally change the traditional order of residential construction. Normally, the jobs of insulating and air sealing take place after electrical, plumbing, and HVAC are installed. With SIPs, the insulation and air barrier are installed with the framing system. This creates an opportunity for subcontractors to potentially compromise the thermal integrity of the building envelope.

SIP builders should arrange a preconstruction meeting to educate subcontractors on how their work will interact with the SIP building enclosure. This gives them the opportunity to identify any potential issues with plumbing or electrical routing before the SIP package is ordered.

The SIP installer is also responsible for returning to the jobsite after plumbing, electric and HVAC have been installed to verify that all penetrations through the building envelope have been properly sealed and protected against bulk water. Any gaps in the air barrier can be a source of condensation, leading to mold growth and a costly callback.

Lastly, subcontracted SIP installers need to communicate to the general contractor that no other trades should be on the jobsite during SIP installation so that they can maximize their efficiency. It is commonplace for SIP installers to frame intermediate floors and any load bearing interior partitions to keep the SIP installation on track.

Sealing

Air sealing is the single most important part of SIP construction. It is airtightness that allows SIP homes to achieve such high levels of energy efficiency, occupant comfort and indoor air quality. Failing to properly seal joints in an airtight home can lead to significant liability issues if moisture infiltrates panel joints and causes the OSB facings to rot.

There are many different techniques for sealing the joints between SIPs and other components of the building enclosure. Refer to the connection details on the SIP layout drawings to determine the appropriate sealing method. The four sealing methods used in SIP construction are SIP mastic, expanding foam, SIP tape, and a seal gasket.

SIP Mastic

SIP mastic is a specialty caulking designed specifically for SIP construction. Unlike conventional caulking, it remains pliable, allowing it to maintain an air seal as building components shift or shrink over time.

Mastic is typically used in a three bead system, with one bead on each side of the panel and a third bead down the center of the foam core. Mastic is supplied by most SIP providers. If additional sealant is needed while a SIP installation is in progress, choose a foam-friendly sealant that will not react with the foam core of the SIP.

Expanding Foam

Expanding foam is available in single-component and two-component formulas. Single-component expanding foam comes in an aerosol can and is used to seal between panels or fill gaps of 1 inch or less. For larger voids, two-component foam is required. Before using two-component expanding foam, read the directions and test to make sure the components are mixing properly.

Gaskets

Foam gaskets can also be used to seal the joints between panels. Gaskets are made of closed cell foam and are similar to products such as Sill Sealer, which is commonly used between concrete foundations and sill plates. Gaskets are also useful when attempting to slightly lengthen a SIP wall or roof system by adding width to the joints between panels.

SIP Tape

SIP tape is a vapor impermeable peel-and-stick tape applied over SIP joints. It is often used in conjunction with other sealing methods as an added layer of protection against moisture intrusion in critical areas of a building, such as the roof ridge. Many SIP providers supply SIP tape along with directions for its use.

As discussed in Lesson 4, local climate conditions determine whether SIP tape should be applied to the interior or exterior of a SIP joint. A vapor barrier should never be applied to both sides of a SIP joint because it prohibits drying and can trap moisture inside panel joints. It can be dangerous to apply SIP tape to the interior of roof joints if the SIP roof panels are wet or have a chance of being exposed to bulk water. Ideally, SIP tape should be applied after roofing underlayment or when the roof is completed.

Maximizing Efficiency

There are a number of techniques that experienced SIP installers employ to keep installation moving smoothly:

- **Staging** – organize panels in the order they will be set

- **Line of sight** – think about the order of assembly so walls do not block the crane operator's view or load path

- **Plumbing and straightening walls** – check walls for plumb before securing them to the bottom plate. Trying to straighten walls while attached to bottom plate can create openings for air leakage. Verify walls are plumb and straight before installing the intermediate floors.

- **Avoid sealing too soon** – verify as much as possible before sealing panels. Mark panel locations and rough openings on the floor deck so crews can catch any errors as panels are assembled.

- **Beware of joint growth** – long walls or a series of dimensional lumber splines can lead to slight gaps at panel joints. These gaps combine to add length to a wall or roof plane that requires cutting the last panel to fit.

- **Labeling** – label where top or bottom plates have been drilled for electrical access, as well as any voids that need to be sealed after installation is complete, such as holes created by rigging hardware.

Summary

Assembling prefabricated SIPs is much faster than site-built construction, but builders can further increase jobsite efficiency through jobsite organization, planning, and panel preparation. Carefully reviewing shop drawings and marking panel locations on the floor deck will help catch any errors as panels are being installed. When working with SIP roofs or multistory buildings, as much work as possible should be done on the ground, such as predrilling panel screws, installing splines or blocking, and even preassembling sections of panels. Preparing panels on the ground saves time, improves jobsite safety and minimizes equipment rental time.

Equally important as speed of installation is properly sealing SIPs as they are installed. Sealing is crucial for energy efficiency and long term durability. SIP builders must also take on the task of working with subcontractors that may be unfamiliar with the importance of maintaining a well-sealed SIP building enclosure. It is recommended that SIP builders organize a preconstruction meeting with subcontractors and verify that all penetrations through the building envelope have been properly sealed.

Lesson 8: Integrating Mechanical Systems with SIPs

In This Lesson

- Electrical
- Plumbing
- HVAC system specification
- Combustion appliance safety

Introduction

For SIP installers, the job is not done once the panels are up. In order for a building to function properly as a system, special attention needs to be paid to how the electrician, plumber, and HVAC contractor interact with the SIP building envelope. In traditional wood frame construction, plumbing and electrical work typically precedes the tasks of insulating and air sealing. But with SIPs, each trade runs the risk of creating air leaks that could potentially cause moisture issues over the life of the building.

Scheduling a preconstruction meeting with subcontractors is an excellent way to inform them of the importance of maintaining an airtight building envelope. It also gives everyone a chance to discuss potential issues and correct them before the SIPs are installed. Opening the channel of communication during the design phase and considering the needs of the subtrades during panel installation will make for a smoother, more efficient build for all parties involved.

Definitions

Electrical chase:	Path for electrical wiring drilled through the foam core of a SIP by the SIP manufacturer
Manual J:	Calculation performed by HVAC professionals to size heating and cooling equipment
Blower door test:	Measurement of a home's air leakage conducted by a Home Energy Rater

Electrical

With a little planning and forethought, wiring SIP structures can be done as fast or faster than in a conventional wood frame structure. The SIP installer has the ability to ensure that electrical installation goes smoothly. This starts by establishing an electrical plan with the building owner, architect and electrician during the design phase. During a preconstruction meeting, the exact location of fixtures needs to be determined so electrical chases can be appropriately specified.

Electrical Chases

SIP manufacturers typically cut electrical chases measuring between 1 inch and 1 ½ inches in diameter into the foam core at standard locations: at outlet and switch height for horizontal locations, and at regular intervals for vertical chases. Custom chases can be ordered at any location to meet the electrical requirements of the building, so it is important to establish fixture locations before ordering a SIP package.

Some SIP builders try to minimize the number of chases in the panel to maintain a solid core of insulation. In many cases, chases can be minimized by running wires behind dimensional lumber end plates for switches near doorways, running as many wires as possible through interior partitions or floor systems, and fabricating short chases onsite.

It is relatively easy for SIP installers or electricians experienced with SIP construction to create chases between 2 feet and 3 feet in length on the jobsite. A popular method of doing this is to use a hole saw to access the foam core and a long flexible drill bit to cut the chase. Save the section of the panel facing that was removed with the hole saw so that it can be used along with expanding foam to seal the void once all the wiring has been installed.

SIP Installation

When installing SIPs, it is crucial that crews maintain a continuous electrical chase between floor systems and wall systems, between intermediate floors, or from wall to roof systems. In each case, top and/or bottom plates will need to be drilled as panels are being installed in order to maintain the continuity of the electrical chase. Label the locations where plates have been drilled.

SIP installers may also install wiring in some hard-to-reach locations during SIP installation, such as wiring in the roof panels or at the roof ridge. This also allows the SIP installer to seal these locations during the installation phase as opposed to after all electrical has been installed.

When wires or conduit are placed during SIP installation, make sure the installation crew is aware of where wires and conduit are located so they do not damage wiring with SIP screws or other fasteners.

Plumbing

Like electrical work, plumbing in a SIP building should be examined during the design phase. Plumbing should never be placed in the core of a SIP. The easiest way to avoid doing so is to locate all plumbing in floors and interior partitions.

Where plumbing is required in an exterior wall, it is common to specify a thinner SIP for that section of wall and frame out a surface chase or "wet wall" to house the plumbing. Another commonly used option is to frame a short section of wall with conventional wood framing. Both of these options require some planning and need to be addressed during the preconstruction meeting so the SIP package and other materials can be ordered accordingly.

Every penetration through the SIP building envelope is a potential area for air leakage, so it is best practice to limit the number of penetrations by combining plumbing vents and/or specifying air admission valves. When cutting plumbing penetrations, the opening should be roughly 1 inch in diameter larger than the pipe that will be placed through it. This allows the penetration to be easily sealed with expanding foam.

HVAC

The work of the HVAC contractor is a key component in the long-term durability and occupant comfort of any home. As discussed in Lesson 4, a house functions as a system of interrelated parts that all affect each other. The airtightness of a SIP building enclosure affects the way HVAC systems are designed and specified. It is important to work with a qualified HVAC professional who will specify a system that fits the building's performance characteristics.

HVAC Sizing

For residential buildings, the HVAC professional should perform a Manual J, a calculation method developed by Air Conditioning Contractors of America (ACCA) to determine the appropriate size of the heating or cooling system. This calculation takes into consideration the building size, orientation, insulation levels, windows, air infiltration and local climate characteristics. The completed Manual J calculation will let the builder know what type of equipment to specify and include in their bid for the project. Smaller units can often be used on SIP homes, adding to the cost savings of SIP construction.

Although most reputable HVAC contractors are using this calculation method, there are still contractors that specify equipment using rules of thumb based on the square feet of conditioned space. Since SIP homes are much more airtight than older wood-framed homes, such estimates result in oversized equipment. Oversized systems will heat or cool the conditioned space to the desired temperature in a very short amount of time, but this short cycling reduces both the lifespan and energy efficiency of the equipment.

In cooling situations, oversized air conditioning units cannot adequately dehumidify the conditioned space because they never reach a steady operating state. This can cause a number of problems, including mold, rot, poor indoor air quality, and uncomfortable living conditions for occupants. It is also a serious liability risk to the builder because excess moisture can infiltrate SIP joints.

When conducting a Manual J calculation, make sure the HVAC professional has the proper information about the building, including the R-values of the SIPs that will be used. When doing a preconstruction estimate, assume 1 air change per hour at 50 pascals (ACH50) as the rate of air infiltration. This rate is easily achievable with a complete SIP building enclosure that is properly installed and sealed.

Ducts

Another benefit of SIP construction is that all ductwork is located inside the conditioned space. Ductwork that is inside conditioned space does not have to be insulated, and any duct leakage spills into the home instead of into an unconditioned attic. The airtightness of SIP homes also allows duct runs to be shortened in some situations, adding to the overall cost savings of SIP construction.

Ventilation

Controlled ventilation systems provide fresh air for building occupants and exhaust polluted air to the outside. There is no such thing as building a house too airtight. Issues only arise when irresponsible builders or HVAC contractors fail to provide adequate ventilation in airtight homes.

There are a number of ventilation systems compatible with SIP homes. Systems typically involve incorporating fresh air through the central air handling unit and providing exhaust-only systems in kitchens and bathrooms. Heat recovery ventilators, energy recovery ventilators, automated fan cyclers, and fans equipped with humidistats are all popular options for SIP homes. Ventilation systems vary greatly by climate zone so make sure to discuss ventilation with a qualified HVAC professional.

Testing the Envelope

The exact amount of air infiltration through the building enclosure in a single family home is measured by a blower door test. The test is performed by a certified Home Energy Rater (HERS Rater) as a necessary part of calculating a home's Home Energy Rating (HERS Index) or qualifying for ENERGY STAR. The HERS rater places a calibrated fan system over the home's door and measures the amount of air that passes through the fan to maintain the pressure difference of 50 pascals between the inside and outside of the home.

The test results indicate how much air is leaking through the building enclosure, expressed in cubic feet per minute at 50 pascals (CFM50) or air changes per hour at 50 pascals (ACH50).

Blower door testing can be combined with a smoke stick or fog machine to visibly identify where leaks are in the building envelope. The test should be conducted after electrical and plumbing contractors have completed their work so any unsealed penetrations can be identified and sealed.

Combustion Appliances

Natural gas or propane combustion appliances for hot water heating and space heating need to be sealed combustion, power vented, or direct vented if they are to be placed inside the conditioned space of a SIP home. Combustion ranges should only be used with a range hood that vents directly to the outside. If not vented, combustion appliances pose an air quality risk to occupants and a fire risk if large enough pressure differences occur.

Woodstoves, wood burning fireplaces and natural gas fireplaces also require special considerations in SIP homes. Refer to the *Builder's Guide to Structural Insulated Panels (SIPs)* for more information.

Summary

As discussed in previous lessons, the performance and durability of a SIP building enclosure depends on proper air sealing. This needs to be communicated to any electrical and plumbing subcontractors who may be unfamiliar with SIP construction. It is best to discuss this at a preconstruction meeting, where the electrical and plumbing design of the home is reviewed. Examining the electrical and plumbing plans before ordering a SIP package allows the SIP installer to order custom electrical chases if needed and design for a wet wall or section of wood-framed wall if plumbing must be placed in the exterior walls.

HVAC is equally important to the energy efficiency, durability, and indoor air quality in a SIP home. SIP builders should work with a qualified HVAC contractor that will consider the reduced air infiltration and insulating abilities of a SIP building enclosure when specifying an HVAC system. HVAC contractors can also provide assistance in determining a climate-specific ventilation strategy to provide fresh air for building occupants.

Lesson 9: SIP Finish Material and Detailing

In This Lesson

- Attaching siding
- Detailing for moisture protection
- Interior finishes
- Roofing

Introduction

This lesson covers the application of siding, roofing and interior finishes. With exterior finishes such as brick, siding or roofing, the primary goal is to protect the SIP building envelope from bulk water. Many of the moisture protection strategies discussed in this lesson are explained in greater detail in both Lesson 4 and the *Builder's Guide to Structural Insulated Panels (SIPs)* by Joseph Lstiburek. Although detailing methods vary by geography and climate, all exterior finishes need to drain water away from the structure and facilitate drying.

Definitions

Reservoir claddings:	Exterior cladding materials such as wood siding, stone veneer, and fiber cement that have the ability to store water
Drainage mat:	Woven plastic mesh installed between the weather-resistive barrier and siding to create an air space
Back ventilating:	Providing an air space between exterior claddings and the weather-resistive barrier
Vented roofing or cool roof:	Roof assembly with a vented air space separating roofing material from the roof sheathing
Shingle ridging:	Buckling of asphalt shingles along joints in roof sheathing or SIP roof panels

Wall Cladding and Siding

Moisture Concerns

SIP walls can accept any type of wall cladding commonly used in wood frame construction. Many popular cladding materials are considered reservoir claddings, including wood siding, cedar shingles, fiber cement siding, stucco and manufactured stone veneer. Reservoir claddings have the ability to store water. In some circumstances, water can migrate through these materials into the wall system.

To prevent moisture migration through reservoir claddings, the builder can either apply primer to the back side of the cladding or dissociate it from the wall system by providing an air space. With SIP wall systems, the latter approach of providing a drained and ventilated air space between the SIP and the wall cladding is recommended in areas where annual rainfall exceeds 20 inches. A vented air space allows any moisture that enters the SIP wall system – through bulk water, improperly sealed joints, window leakage or any other method—to dry without threatening the long-term durability of the structure.

Back Ventilating

The method of constructing a vented air space (commonly referred to as "back ventilating") depends on the type of cladding. For wood or fiber cement siding, this is best accomplished by installing the siding over furring strips to create a minimum ¼-inch air space between the siding and the weather-resistive barrier (Figure 1).

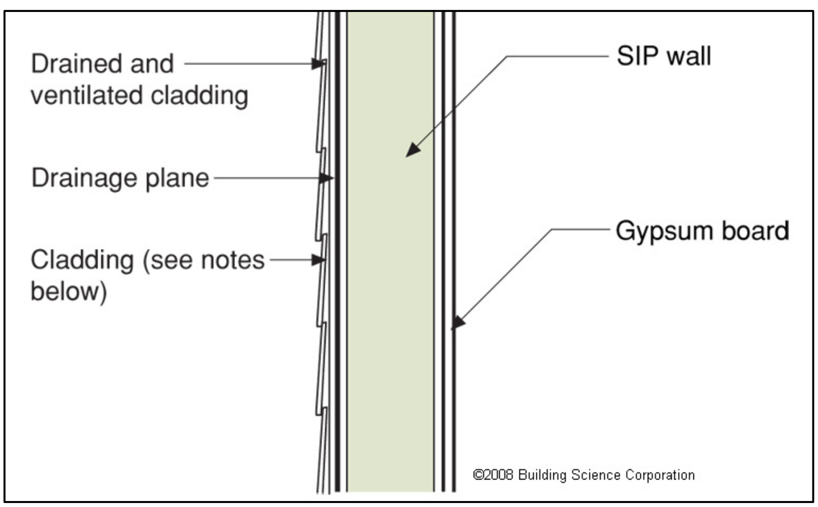

Figure 1: Wood and fiber cement siding

Cedar shingles, traditional stucco and manufactured stone veneers should be installed over drainage mats. Stucco systems require an additional layer of building paper between the drainage mat and the stucco to prevent the mat from becoming clogged with mortar or stucco (Figure 2).

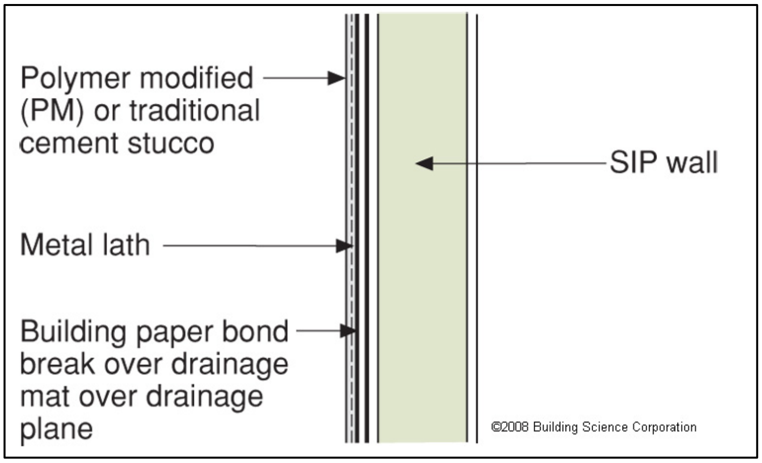

Figure 2: Stucco detailing

Vinyl and aluminum sidings are inherently back ventilated due to their profile and do not require furring strips or a drainage mat.

Fastening Schedule

In the absence of dimensional lumber studs or other structural members, claddings are attached to the exterior facing of the SIP wall. The 7/16-inch OSB offers less pullout resistance and typically requires an increased fastening schedule for most cladding systems. Contact the manufacturer or distributor of the siding to determine the appropriate fastening schedule. If this information is not available, contact the SIP manufacturer.

Windows and Doors

Windows and doors are common locations for moisture issues. As with all detailing on a SIP home, doors and windows need to be properly flashed to protect against bulk water. SIP homes are extremely airtight and any water that gets trapped inside the wall system carries the potential of causing serious moisture-related issues over time. Step-by-step instructions for proper window and door flashing can be found in the *Builder's Guide to Structural Insulated Panels (SIPs).*

Interior Finishes

Pre-Applied Versus Site-Applied

Some SIP manufacturers offer SIPs with a pre-applied interior finish material, such as gypsum wall board or tongue and groove wood paneling. Pre-applied finishes can save time in situations where panels are placed over an exposed timber frame or other structural members. However, weather and other factors can severely damage pre-applied finishes during transport, unloading, staging, and installation. It is best to consider these factors before opting for pre-applied finishes.

Another option is to apply the interior finish material onsite before setting the panels. This limits the amount of time the finish materials will be exposed and potentially damaged. It is important to note that both pre-applied and site-applied finishes can interfere with the use of SIP tape if building in a cold or mixed climate where SIP tape should be applied on the interior.

The third option is to separate the SIPs from the exposed structural members using furring strips (Figure 3). This is a popular option for timber frames because it will accommodate timber shrinkage. If SIPs are fastened to a supporting timber through the pre-applied interior finish, movement or shrinkage of the timber can crack the interior finish material. This method also allows the interior finish material to be installed after the panels are set.

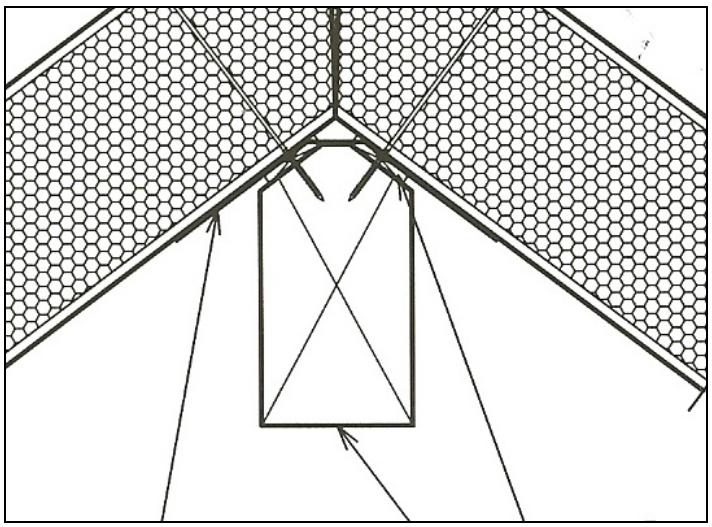

Figure 3: Furring strips beneath roof panels

Exposed Beams and Rafters

Timber frame and traditional craftsman designs often call for exposed beams on the exterior or exposed rafter tails. If possible, extending rafters or beams through the SIP building enclosure should be avoided. These details not only create a thermal bridge to the outside, but as the lumber shrinks or moves over time they open a gateway for air leakage and moisture buildup.

False beams and rafter tails allow builders to achieve the same look without penetrating the building envelope. False rafter tails can even be embedded in the foam core of the SIP if they are specified in the design phase and approved by the engineer.

Figure 4: Embedded rafter tails

Roofing

Any type of roofing commonly used in wood frame construction can be installed over a SIP roof system. Contact the roofing manufacturer for their specifications on how to attach the roofing to SIPs. Metal roofing may require an increased fastening schedule.

Vented roofing is recommended in climates where annual rainfall exceeds 20 inches. Vented roof systems are often referred to as a “cool roof” and should not be confused with a vented attic. The purpose of venting roofing over SIPs is to allow for any bulk water or water vapor that enters the SIP roof system to dry.

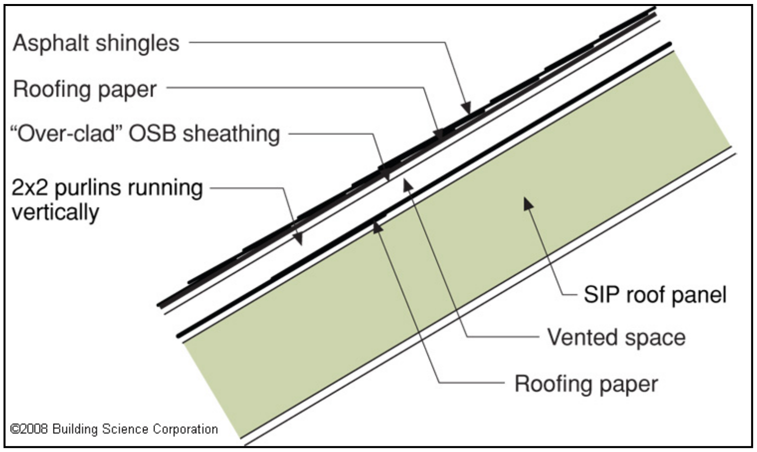

Figure 5: Vented roof with asphalt shingles

The method of constructing a vented roof depends on the type of roofing material used. Asphalt shingles need to be separated from the SIP facing with furring strips, followed by a second layer of roof sheathing and a second layer of roof underlayment (Figure 5). Cedar shingles or cedar shakes should be installed over a drainage mat. Metal roofing should be installed over diagonal furring strips (Figure 6).

Figure 6: Diagonal furring strips under metal roofing

Asphalt Shingles

If building in a dry climate where roof venting is not required, it is important to note that some asphalt shingle manufacturers do not warranty their products over an unvented roof deck if the attic is not vented. Joseph Lstiburek notes in *Builder's Guide to Structural Insulated Panels (SIPs)* that venting or not venting the roof deck results in a minor increase in shingle temperature and a minor decrease in shingle life. However, the color of the shingles, the roof orientation and the building's geographic location all have a much more significant impact on shingle life. He estimates that installing asphalt shingles over an unvented SIP roof deck will result in a reduction of shingle life between one and two years.

Shingle Ridging

Another potential issue with asphalt shingles is shingle ridging. Shingle ridging is a common phenomenon in all types of wood frame construction where the expansion of roof sheathing due to heat and moisture causes shingles to buckle along joints. This is largely an aesthetic issue and has not been shown to have any effect on shingle life or functionality. Shingle ridging does not appear in wood shingles, wood shakes or standing seam metal roofs because these materials absorb any movement without visibly shifting along the panel joint.

Shingle ridging is not very widespread but often draws the attention of homeowners. The only way to prevent shingle ridging is to dissociate the asphalt shingles from the SIP by either constructing a vented roof (see Figure 5) or simply adding an additional layer of roof sheathing that overlaps the existing panel joints.

Summary

Moisture protection is a major concern in any type of wood structure. SIPs are no different—they must be protected against bulk water by siding, roofing, and a weather-resistive barrier. However, SIP homes are more airtight, so any moisture that does make its way through the weather-resistive barrier is more likely to cause problems because there is no airflow to enable drying. For this reason, in wet climates it is recommended that builders back ventilate wall claddings and use a cool roof system.

An increased fastening schedule may also be required when attaching siding or metal roofing over SIPs. This can be obtained from most roofing or siding manufacturers. It is also important to minimize penetrations through the building envelope, seal penetrations where required, and properly flash windows and doors.

Lesson 10: Common Objections for SIP Designs

In This Lesson

- How to sell SIPs to potential homebuyers
- Most common objections to SIP construction

Introduction

Interacting with potential customers and closing sales are unavoidable parts of the homebuilding business. SIPs are a relatively new building system that many homebuyers, architects and general contractors are unfamiliar with. Builders are likely to hear a number of common objections to building with SIPs. This lesson aims to help SIP builders and installers address these objections.

Definitions

Sound Transmission Class (STC):	Measurement of how well a building assembly attenuates airborne sound
Borate-treated foam:	Rigid insulating foam mixed with borates that act as a mechanical irritant to termites and carpenter ants
SIPA Registered Master Builder Program:	Training program for SIP installers administered by the Structural Insulated Panel Association (SIPA)

Common Objections

Price

The most common objection to building with SIPs is that SIPs are too expensive. Determining the relative cost of building with SIPs depends on what building system it is being compared to. In jurisdictions with less strict energy codes, SIPs are often more expensive than code-minimum wood frame construction, but the energy efficiency of a SIP home will save the homeowners money and likely offset the incremental cost.

If the performance standard is raised to ENERGY STAR or a higher level of energy efficiency, SIPs become more cost competitive because wood frame construction often requires additional insulation and air sealing to reach these performance metrics.

Pricing will depend a lot on geography and the supplier, but generally speaking, in an apples-to-apples comparison, SIPs will cost less than building a wood frame house that meets the same energy performance achieved with SIP construction. At higher levels of energy efficiency, such as LEED Platinum, Passive House, or even striving for net-zero energy use, SIPs are often cheaper.

One method of explaining the performance advantages of SIPs to potential customers is to compare the home to an automobile. Very few people drive economy cars. Ask the customer why they purchased a more expensive automobile and they will likely list several performance or comfort advantages of owning a more expensive car. Like their car, the SIP home offers greater efficiency, better performance, and greater comfort than the cheapest building system available.

Another thing to consider when discussing price is labor cost. Labor costs vary greatly by geography, but in some locations high labor costs make building with SIPs much more economical relative to wood framing because they can cut days or weeks off the construction schedule.

Electrical

Many electricians and general contractors imagine that installing electrical wiring in a SIP home will be extremely difficult. If the SIP installer has done their job correctly, the electrical rough-in will go smoothly and take less time than wiring a wood frame house. An independent third party study conducted by R.S. Means found that electricians were actually able to wire a SIP house 11 percent faster.

If the SIP installer examines the electrical plan during the design phase, ensures that the necessary electrical chases are specified in the SIP layout drawings, and labels the chases onsite, there should be no increased fees from the electrical subcontractor. As discussed in Lesson 8, it is recommended that builders schedule a preconstruction meeting with the electrical subcontractor to go over the electrical plan and discuss any potential issues before the SIPs are installed.

Durability

The majority of building failures are the result of moisture. It is a misconception that because SIP homes are energy-efficient, they are less resistant to moisture. Increased energy efficiency standards have pushed all types of home construction towards more airtight building enclosures. Because there is less airflow through wall or roof systems in airtight homes, they need to be detailed to promote drying (see Lessons 4 and 9). A SIP home that is properly detailed is unlikely to experience any long-term durability issues.

Fire

SIP builders often encounter concerns that the foam core will melt or burn in the event of a fire, making the home less fire resistant. As discussed in Lesson 1, building assemblies are tested for fire resistance using standard testing criteria published by the ASTM International. These tests measure the fire resistance of the entire wall or roof assembly, including gypsum wall board (drywall). With gypsum wall board attached to the interior facing, SIPs pass the necessary fire tests for most residential construction. SIP assemblies can also be designed to meet one-hour and even two-hour fire resistance requirements in multifamily or commercial construction.

Strength

The SIP marketplace has been flooded with claims that SIPs are twice as strong, five times as strong, or even ten times as strong as conventional wood framing. These types of comparisons are vague and often erroneous. The strength of SIPs relative to conventional wood framing depends on what type of loading is being compared, the connection details used, the fastening schedule, and a number of other factors.

A good way to respond to this question is simply to state that SIP homes can be engineered to meet the highest wind speeds and seismic conditions in U.S. building codes.

Termites and Carpenter Ants

Termites and carpenter ants are attracted to wood and other cellulosic materials. However, they may burrow through the foam core of SIP wall systems to access food or water. SIP manufacturers prevent this by using borate-treated foam. Borate is not a pesticide, but it acts as a mechanical irritant that deters termites and carpenter ants from tunneling through the foam.

SIP homes are subject to the same risk from termites or carpenter ants as any wood structure. Common termite prevention strategies such as treating the soil around the home and removing brush near the home should be followed in termite-prone areas.

Noise

In the U.S., sound transfer through a wall assembly or building partition is measured by its Sound Transmission Class (STC). This number is derived using standardized tests that measure an assembly's sound resistance at a variety of frequencies. Similar to fire testing, the test is done on the entire wall assembly, and the application of interior or exterior finishes can greatly affect the overall sound resistance.

Individual SIP manufacturers can provide STC data for their products. Generally speaking, SIPs with gypsum wall board attached to the interior perform similar to wood frame wall assemblies.

Many homeowners report that SIP homes are extremely quiet. SIPs tend to excel at blocking high frequency sounds, but do not perform as well with contact sounds (such as rain) or low frequency sounds.

Hard to Modify

Some customers may believe that because SIPs are a prefabricated building system, they will be difficult to modify after the home has been constructed. This is not the case. The inherent structural strength of SIPs allows windows and doors to be added much more easily than with conventional wood framing. With a trained installer, additions and modifications are not a problem in SIP homes.

Limited Design Capabilities

Although some people claim that building with SIPs limits design flexibility, the exact opposite is true. Computer-aided manufacturing allows complex designs to be fabricated with remarkable tolerances that could never be achieved in the field. The more complex the design, the more labor and materials savings are possible with SIPs.

Untrained Workforce

There are a number of training programs available for SIP installers, including the SIPA Registered Master Builder Program, the SIPschool, the United Brotherhood of Carpenters SIP training curriculum, and this SIPA Builder Education with SIPs Training (BEST) program. Many SIP manufacturers offer their own in-house training for builders. Crews unfamiliar with SIP installation can also request onsite assistance from their SIP manufacturer.

Code Approval

All SIPA member manufacturers have conducted third party testing and published the evaluation reports necessary for building code approval.

Mold and Moisture

Another a common misconception is that houses can be built "too tight," resulting in mold growth, poor indoor air quality, or other moisture-related issues. Through stricter energy codes and growing interest in energy efficiency, the building industry is moving towards more airtight construction. Airtight construction actually provides a better opportunity to control mold, moisture, and indoor air quality through mechanical ventilation.

Mold and moisture issues that occur in SIP homes are the result of improperly sealed joints, improper detailing, or poorly specified HVAC systems. Working with a trained installer and a qualified HVAC contractor will prevent any moisture-related issues.

Summary

A home built with SIPs will save homeowners thousands of dollars in energy costs over its lifetime, while also delivering a more comfortable living environment, healthy indoor air quality, and long-term durability. SIPs are a relatively new method of construction, and consequently many homeowners, general contractors, and architects are unfamiliar with it. This unfamiliarity can lead to a number of objections, including price, durability, fire resistance, and others. By becoming aware of these common objections and preparing responses, SIP builders can close sales and provide their customers with durable, energy-efficient SIP homes.

Glossary

Lesson 1

Definitions

Structural insulated panel (SIP)	Panelized building system composed of rigid foam insulation sandwiched between two structural facings, such as oriented strand board
Oriented strand board (OSB)	Structural wood panel comprised of wood strands arranged in cross-oriented layers, similar to plywood
R-value	Measure of thermal resistance of a building material, such as insulation
Permeability	Measure of the amount of water vapor that can pass through a specified material in a certain amount of time
Green building	Process of designing and constructing buildings that have a lower impact on the environment

Lesson 2

Definitions

Spline	Dimensional lumber, engineered wood, or other specialty product used to connect two panels together at in-plane vertical panel connections
Cap plate	Dimensional lumber ripped to the full width of a SIP wall panel to transfer in-plane loads to the structural facings
Panel screws or SIP screws	Specialty screws designed for fastening through the thickness of a SIP
Capillary break	Treated plywood or other material placed over concrete to prevent SIP facings from absorbing moisture
Fascia	Visible horizontal band along the roof edge, such as the board typically used to cap roof rafters tails

Lesson 3

Definitions

Area take off:	The quantity of SIPs (measured in square feet) required to complete

	a SIP project
Blank panels:	Rectangular, non-fabricated SIPs that are cut to fit on the jobsite by the builder
Precut panels:	SIPs that are fabricated to a specific building design by the panel provider
Ready-to-assemble:	Type of SIP package, offered by some SIP providers, that includes pre-installed lumber and splines, headers, sealants, and accessories
Edge treatment:	Process of removing the foam core along the edge of a SIP to accept dimensional lumber blocking, plates, or splines
SIP layout drawings:	Construction document that illustrates the size and location of each SIP along with the necessary construction details

Lesson 4

Definitions

Bulk water:	Water in liquid form, such as that deposited on a building from rain, dew, or melting snow
Drainage plane:	Collection of water repellent materials used to protect a building from bulk water, including weather resistive barriers, flashing and exterior cladding materials
SIP tape:	Vapor impermeable peel-and-stick tape used to seal SIP joints
Thermal void:	Gap in the insulating foam core of a SIP that is the result of penetrations, poorly installed splines, or electrical work
Ventilated cladding:	Siding or other exterior finish material with a vented air space separating it from the building’s weather-resistive barrier
Vented roofing or cool roof:	Roof assembly with a vented air space separating roofing material from the roof sheathing
Drainage mat:	Woven plastic mesh installed between the weather resistive barrier and siding to create an air space
Stack effect:	Pressure differences in a home caused by the buoyancy of heated air

Lesson 5

Definitions

SIP layout drawings:	Drawings that illustrate the size, shape, rough openings, connection details, and other information for a SIP package
By others:	Notation on SIP layout drawing indicating the information for a particular detail or component is provided by another source
Field cut:	Notation on SIP layout drawing designating an element that must be fabricated on the jobsite
Ventilation notes:	Notes referencing a whole-building ventilation standard, specification, or methodology on a SIP layout drawing

Lesson 6

Definitions

Dunnage:	Dimensional lumber used to keep SIPs off the ground when stored. Also referred to as stickers.
Fork extensions:	Forklift accessory that lengthens forks to support 8-foot-wide SIPs
Spreader bar:	Crane hoisting accessory that distributes load across a SIP or bundle of SIPs to prevent damage when hoisting. Also referred to as a pick bar.
Rough terrain forklift:	Class VII forklift designed for off road use with a telescoping boom

Lesson 7

Definitions

SIP mastic:	specialty caulking designed specifically for SIP construction
Expanding foam:	Polyurethane sealant that expands as the result of a chemical reaction to fill gaps or seal between SIP joints
SIP tape:	Vapor impermeable peel-and-stick tape used to seal SIP joints

Lesson 8

Definitions

Electrical chase:	Path for electrical wiring drilled through the foam core of a SIP by the SIP manufacturer
Manual J:	Calculation performed by HVAC professionals to size heating and cooling equipment
Blower door test:	Measurement of a home's air leakage conducted by a Home Energy Rater

Lesson 9

Definitions

Reservoir claddings:	Exterior cladding materials such as wood siding, stone veneer, and fiber cement that have the ability to store water
Drainage mat:	Woven plastic mesh installed between the weather resistive barrier and siding to create an air space
Back ventilating:	Providing an air space between exterior claddings and the weather resistive barrier
Vented roofing or cool roof:	Roof assembly with a vented air space separating roofing material from the roof sheathing
Shingle ridging:	Buckling of asphalt shingles along joints in roof sheathing or SIP roof panels

Lesson 10

Definitions

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