Chapter 2: Basic SIP Design and Engineering

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- 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 chapter 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.

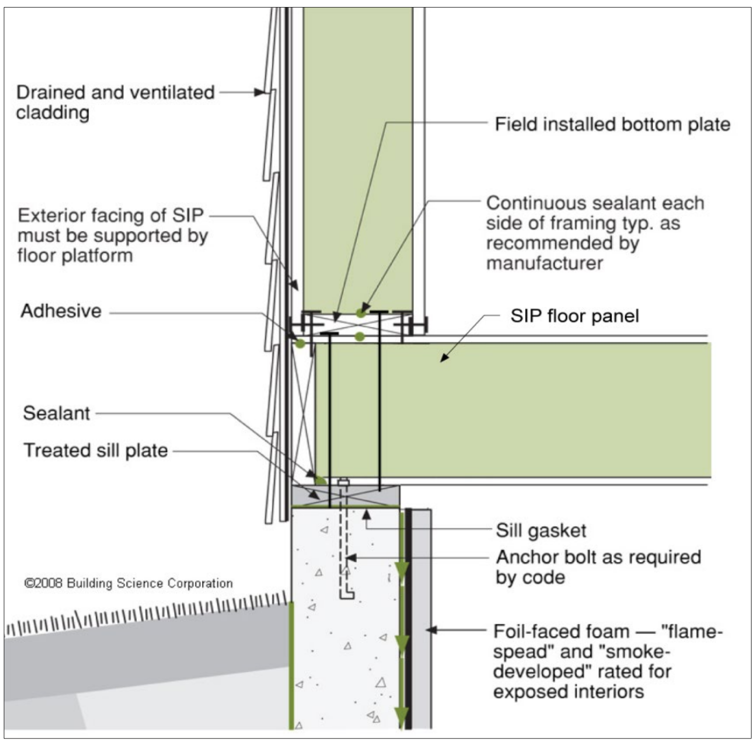

Figure 1: Floor SIP

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.

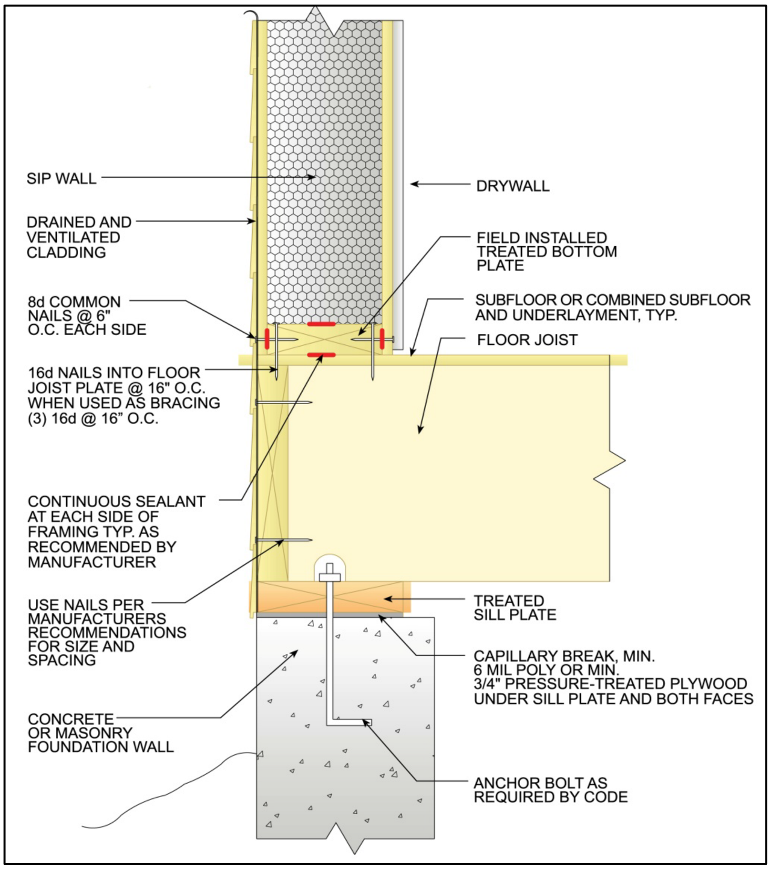

Figure 6: SIP wall on wood frame floor system

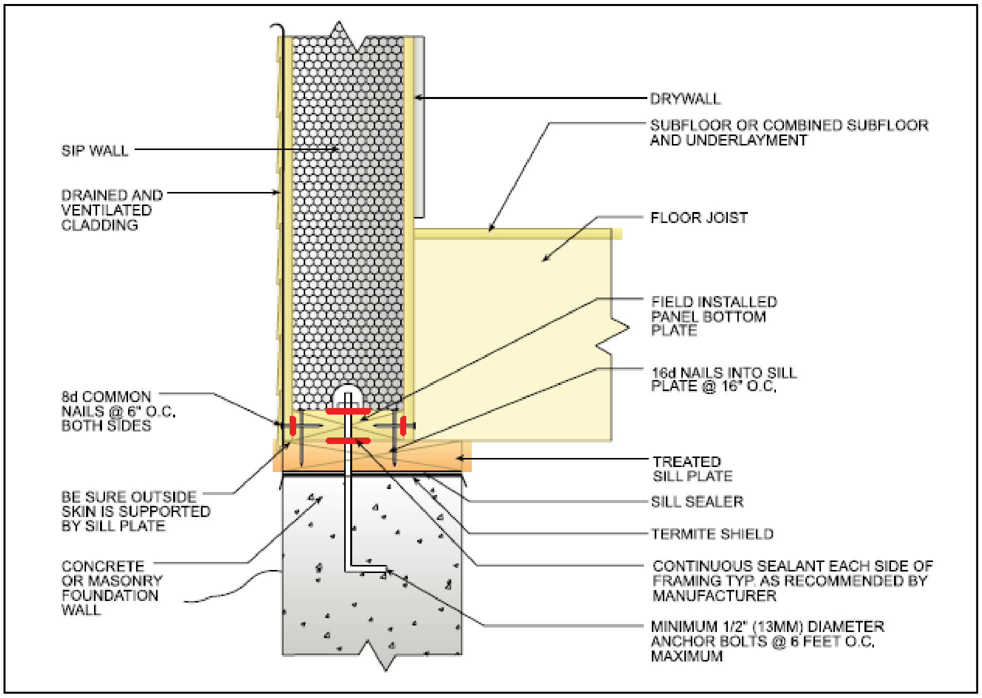

Figure 7: SIP wall resting on foundation

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.

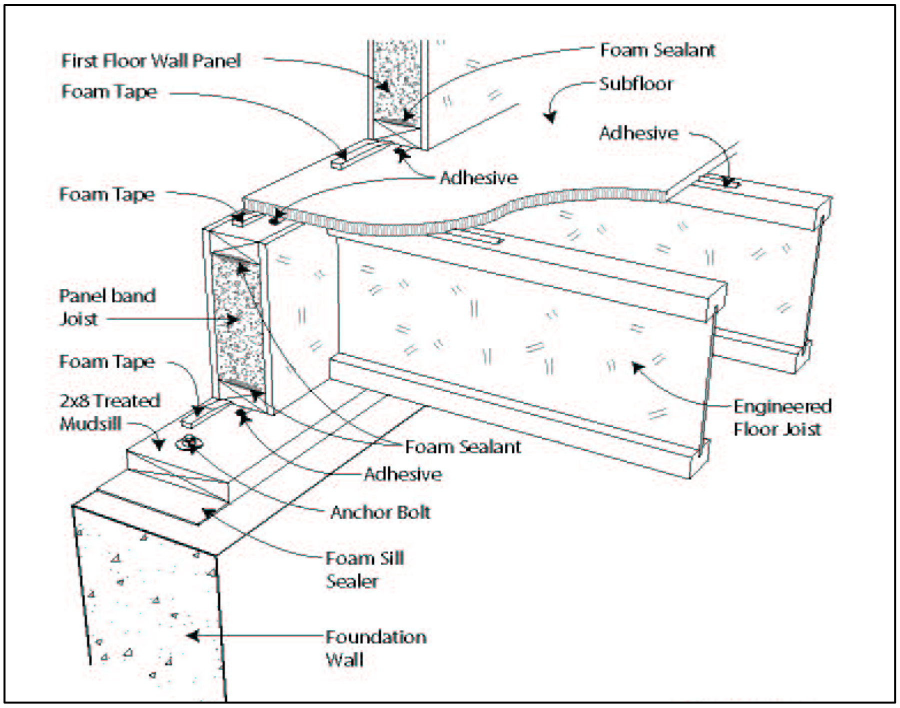

Figure 2: Insulated rim panel

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.

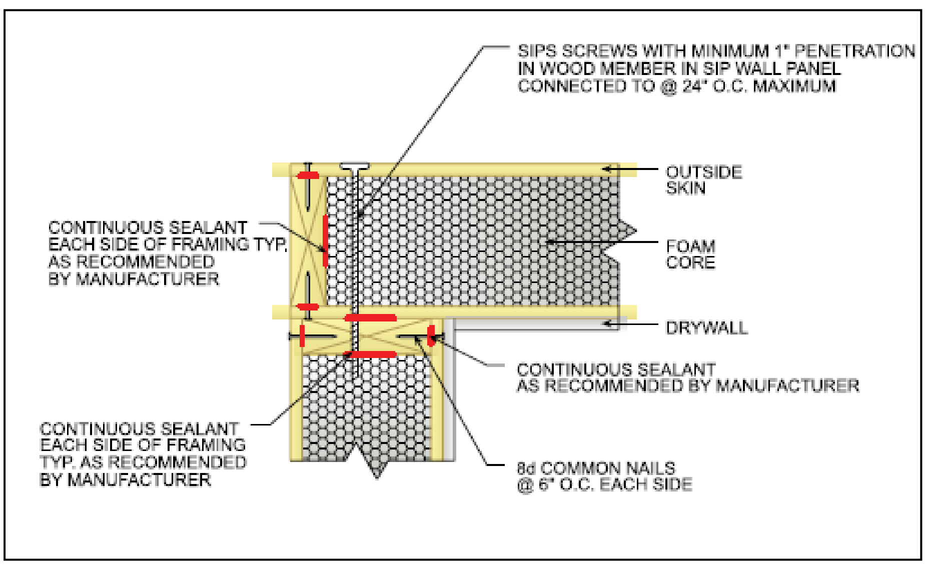

Figure 3: SIP wall corner detail

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.

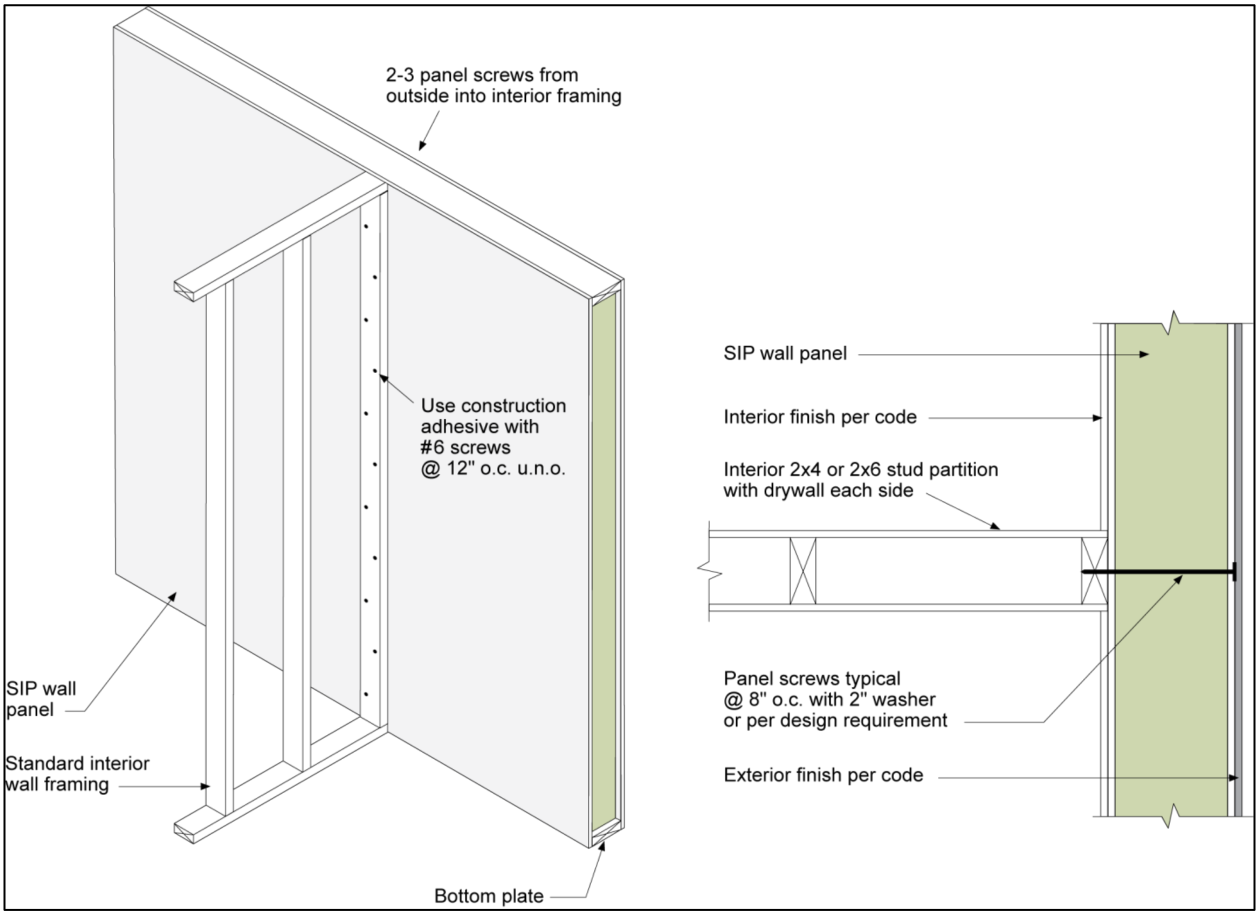

Figure 4: Attaching interior partitions

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.

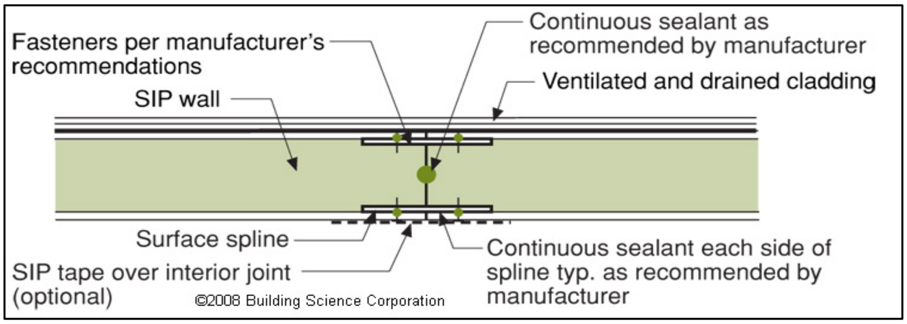

Figure 51: Surface spline

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 Chapter 7.

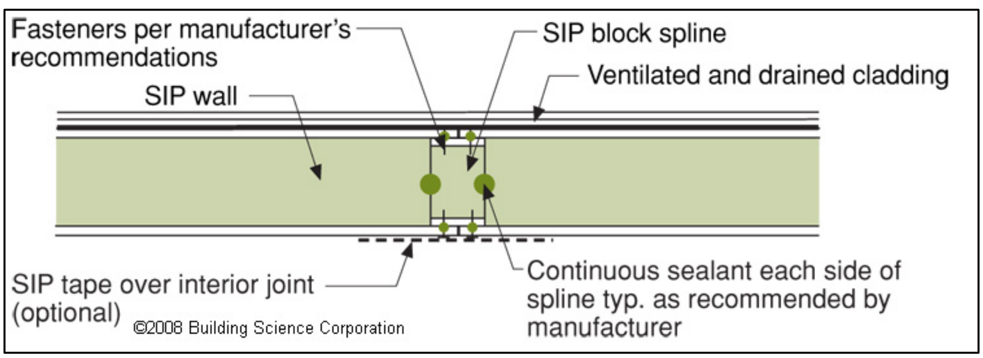

Figure 16: Block spline

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.

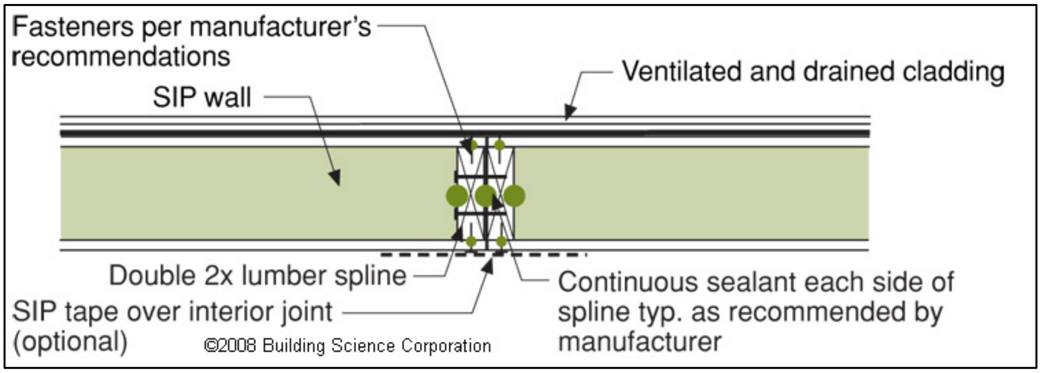

Figure 17: Double dimensional lumber spline

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.

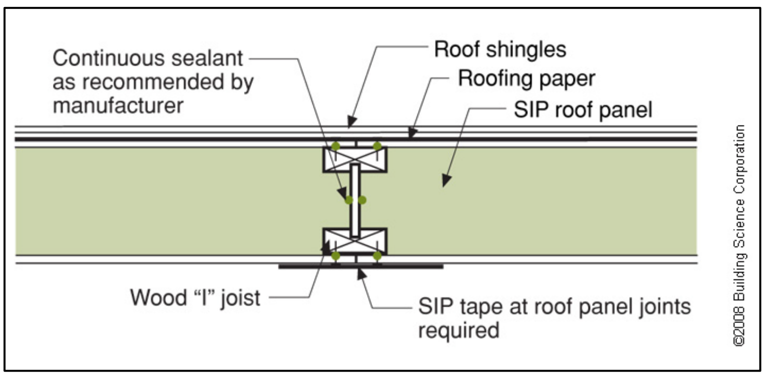

Figure 18: I-joist spline

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.

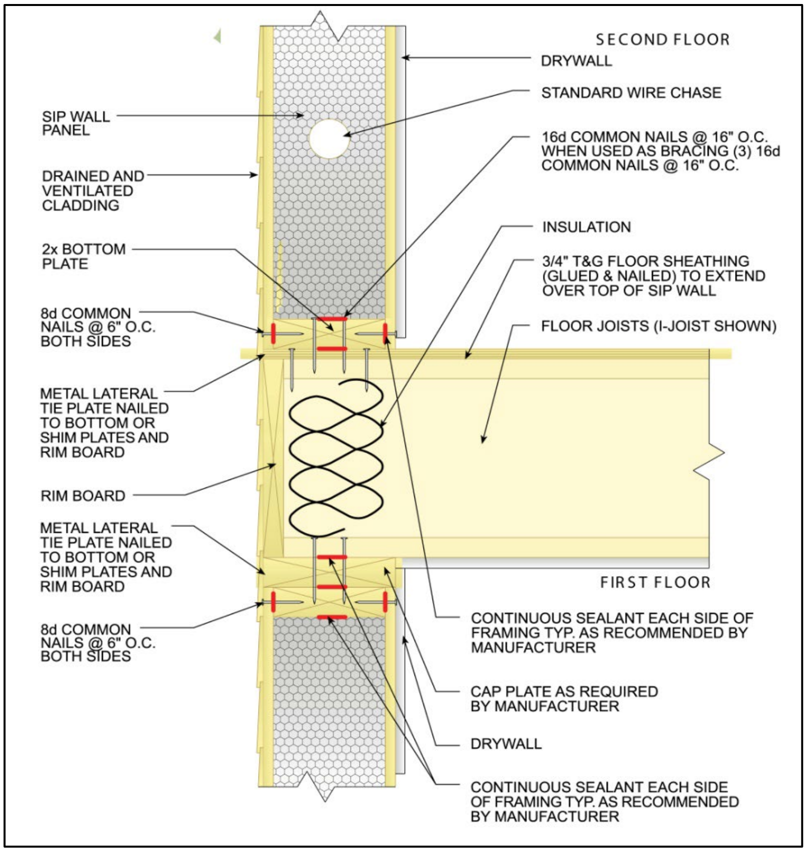

Figure 15: Intermediate platform-framed floor

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.

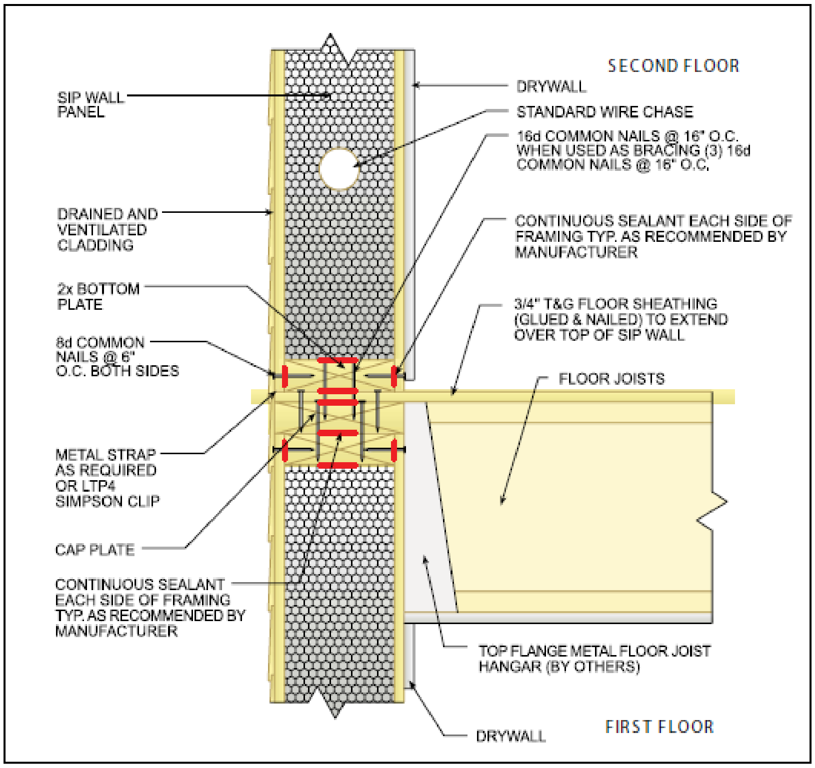

Figure 16: Intermediate hanging floor

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.

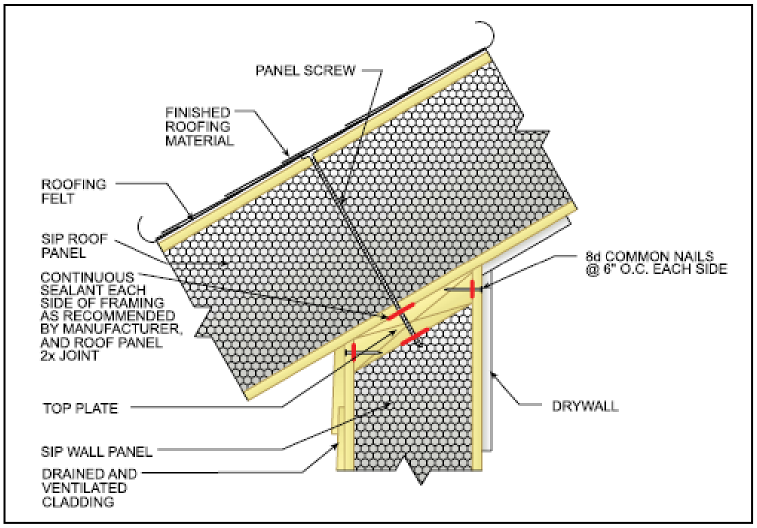

Figure 17: Bevel-cut SIP wall detail

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.

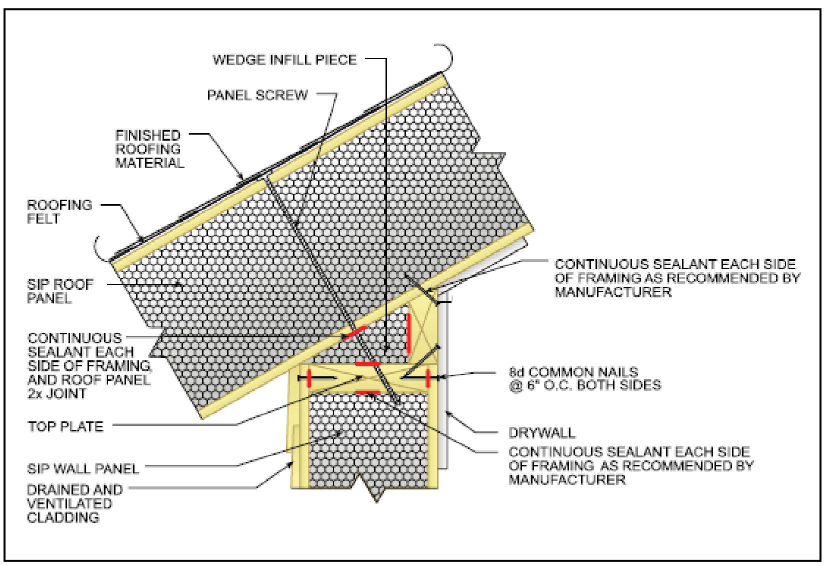

Figure 18: Square-cut SIP wall detail

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).

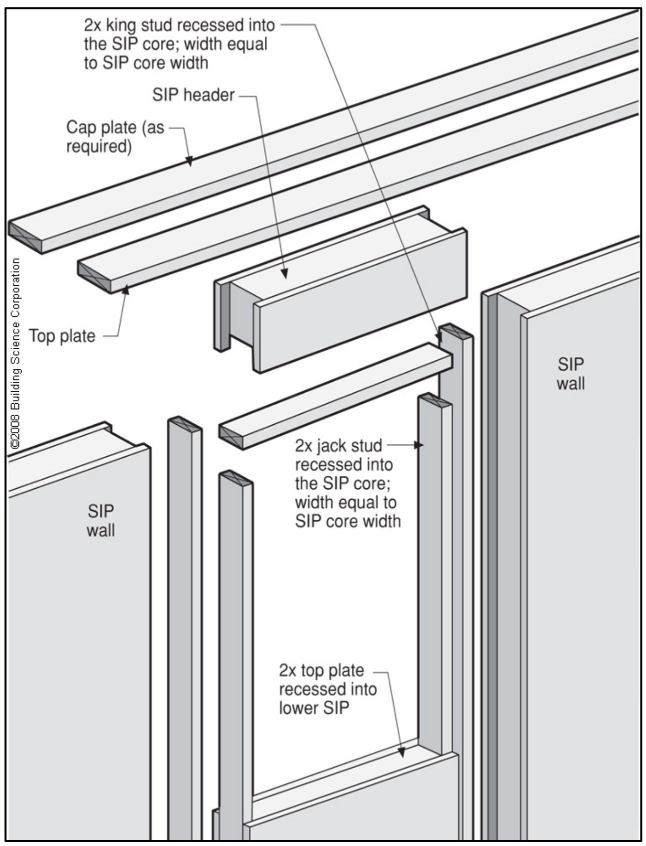

Figure 19: SIP header

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.

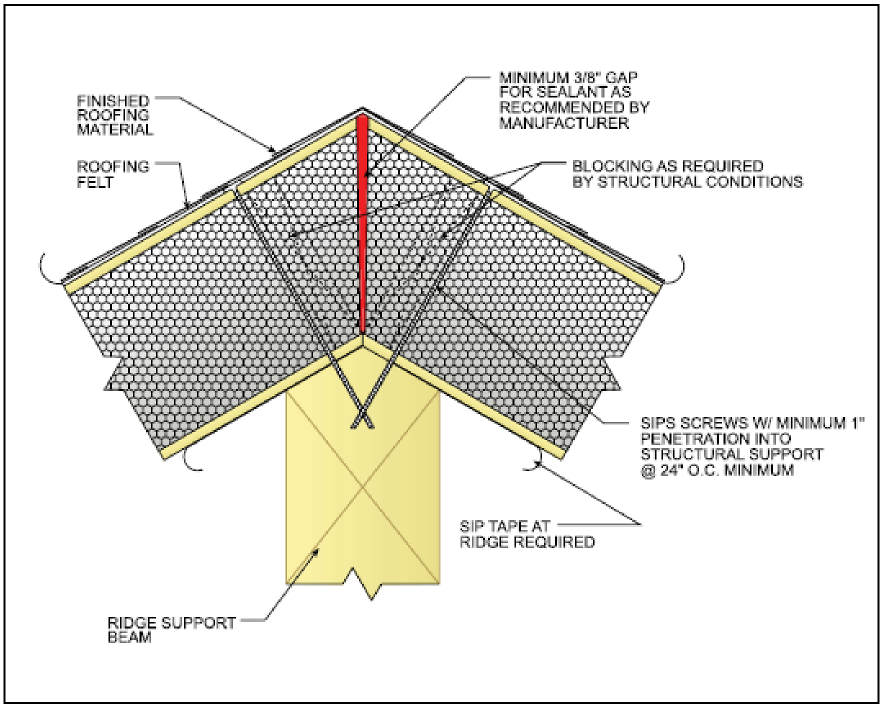

Figure 9: SIP ridge detail

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.

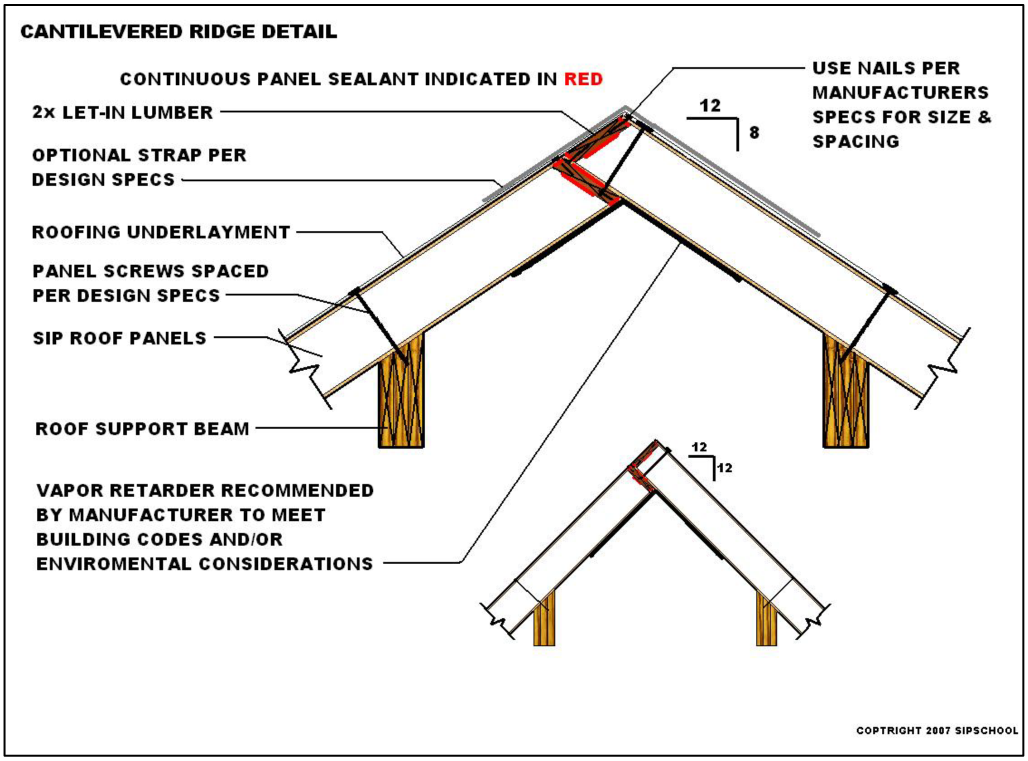

Figure 21: Offset ridge detail

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).

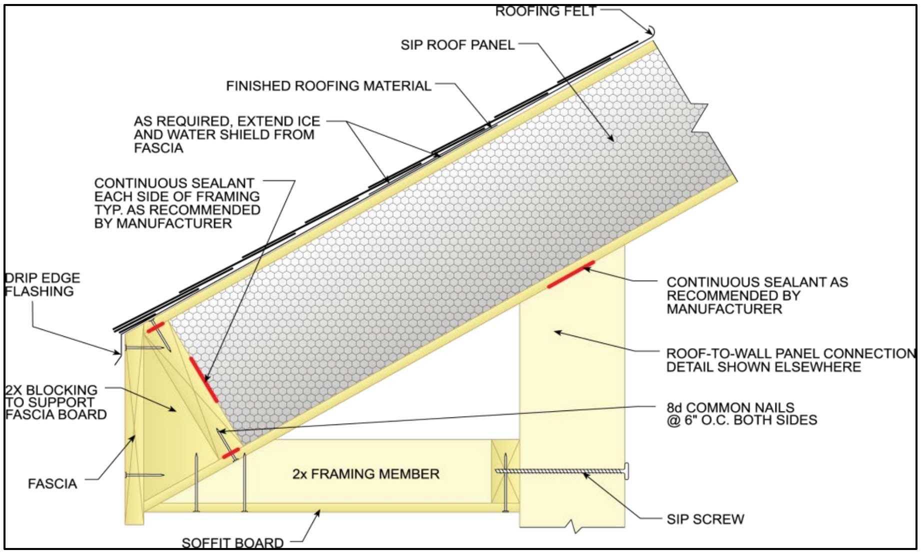

Figure 22: Sample eave detail

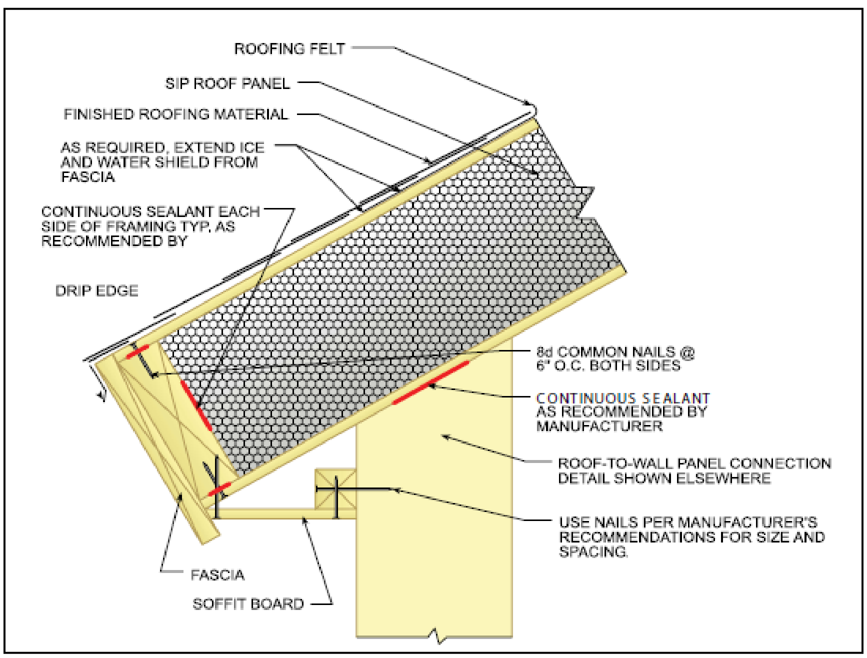

Figure 23: Sample eave detail

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.

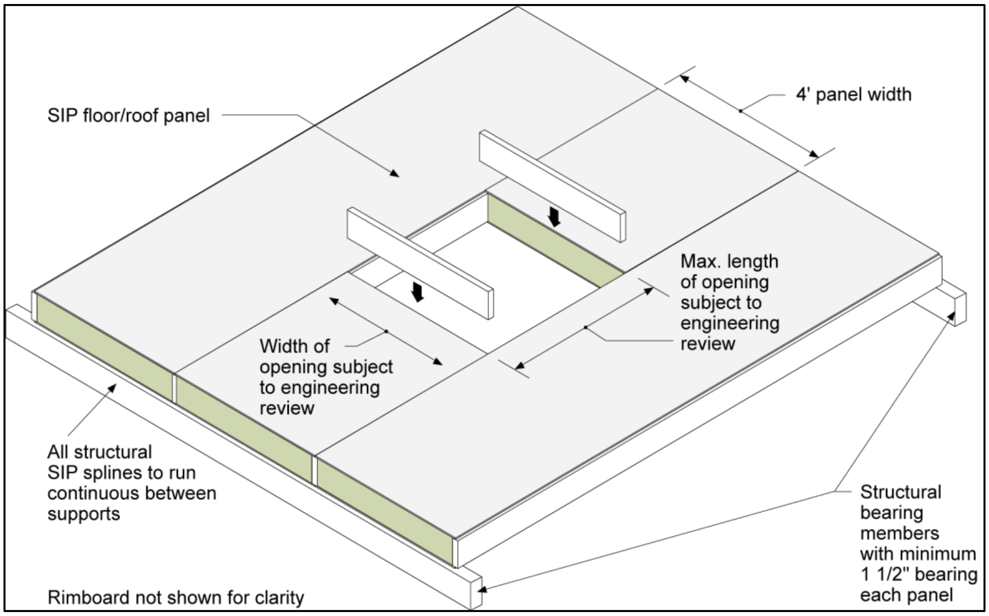

Figure 24: Skylight in a SIP roof

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.