SECTION 1:
Designing with SIPs
Design Considerations

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SIPA
Structural Insulated Panel Association

Designing with SIPs:
DESIGN CONSIDERATIONS

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DESIGN CONSIDERATIONS

This document was created specifically for design professionals by the manufacturing members of the Structural Insulated Panel Association (SIPA). It highlights important considerations during the design phase of a structural insulated panel (SIP) structure. Decades of combined knowledge from SIPA manufacturers will help reduce the learning curve and leverage SIPs' exceptional qualities to achieve the high-performance results owners expect when building with SIPs. The content provides a common industry platform for SIP design. SIPA hopes to make your design role easier and more efficient.

Beaver Island Brewing Co., St. Cloud MN

High-performance building envelopes use SIPs

SIPs yield high-performance building envelopes with energy performance well beyond conventional framing. SIPs provide a core of high R-value solid insulation typically requiring no additional continuous insulation on the building exterior. Elimination of traditional batt or spray insulations eradicates the installation quality challenges these products create and removes the need for insulation subcontractors. The large size of SIPs results in fewer air gaps, reduced thermal bridging from fewer lumber connections (lower framing factor) and elimination of air spaces within the wall cavity. SIPs provide a virtually airtight envelope improving indoor air quality (IAQ) and creating healthier homes and businesses. Airtightness also reduces HVAC sizing and dramatically improves occupant comfort by providing consistent room temperatures, regardless of the number of floors. A SIP's thickness determines its insulation R-value, but the greatest gain comes from the tightness of the engineered design and the other high-performance components (HVAC, windows, etc.) specified by the designer.

SIP performance is based on more than its stated R-value

R-values of SIPs are readily available from SIP manufacturers. These are useful insulation metrics but only one component in the evaluation of a high-performance building envelope. Integration of all system components and airtightness of the envelope assembly are more important considerations for designers seeking performance over individual component metrics. To illustrate this, the Department of Energy's Oak Ridge National Laboratory (ORNL) tested the performance of large section wall assemblies. The resulting whole-wall R-value data revealed that a 4-inch SIP wall rated at R-14 outperformed a 2 x 6-inch wall with R-19 fiberglass insulation. The whole-wall R-value was R-21 for a 6-inch SIP wall or 96 percent higher than the whole-wall R-value of R-11 for the 2 x 6-inch wall using theoretically R-19 fiberglass insulation. ORNL also tested a SIP structure side by side with a conventional 2 x 4 structure to evaluate air leakage. The SIP structure had only 7 percent the air leakage of the conventional structure. In short, unlike for SIPs, joining real-world air-leakage rates and thermal bridging for conventionally framed structures lowers performance far below their theoretically calculated effective insulation R-values. For more information relating to key high-performance building envelope metrics, visit the technical drop-down menu at www.sips.org.

Skokomish Community Center, Shelton WA

Rocky Mountain Institute Innovation Center, Basalt CO

HVAC system rightsizing reduces costs and enhances comfort and performance

SIP envelopes deliver a high-performance, virtually airtight shell. Because of this, the building must have mechanical make-up air. Several options introduce fresh air with varying degrees of complexity and cost. To ensure a balanced HVAC system, consider specifying a Heat Recovery Ventilator (HRV) or Energy Recovery Ventilator (ERV). Superior SIP energy efficiency and airtightness reduce HVAC equipment load and often provide savings via smaller unit requirements. Design should also include HVAC installed inside the conditioned SIP envelope. Conventional practice cannot be used in sizing HVAC equipment for SIP structures. Oversized equipment is not only more costly but cycles on and off frequently for short durations which inhibits the building's ability to dehumidify properly leading to comfort and mold concerns. SIP building designers, HERS raters and HVAC professionals can accurately calculate thermal performance of SIP envelopes using energy modeling with ACCA Manual J or REM/Rate or Ekotrope design software. Actual air leakage performance is best determined by a pre-drywall blower door test. SIP structures typically achieve less than 2.0 air changes per hour (ACH) @50Pa at this stage, but values less than 1.0 ACH50 are often achieved with proper design and installation. While SIPs provide the basis for an airtight structure, overall performance can be compromised if proper consideration for energy load calculation inputs or installation is not given to the other critical system components (e.g. windows, HVAC, plumbing, etc.,).

Kenmore Town Green Community Center, Kenmore WA

SIP structural capabilities cater well to virtually any design

SIP structural capacities comply with building codes through evaluation reports from third-party evaluators including ICC-ES, ICC NTA, Intertek and IAPMO. SIP increased strength over conventional framing enables greater design flexibility. A SIP can span up to 24 feet when incorporating structural connections (splines), eliminating intermediate support structures and creating spectacular vaulted ceilings. Many designs eliminate headers with conscious awareness of where point loads are located, reducing costs, labor and thermal breaks. SIP manufacturers publish charts to determine load capacities and work with designers ensuring code conformance. SIPA manufacturing members are an invaluable resource; each provides understanding on how SIP height, thickness and connection methods affect the structure's design. Manufacturers can provide lists of structural engineers experienced with SIPs.

Lake Chelan Building Supply, Chelan WA

SIPs are typically factory cut for accuracy, quality and reduced onsite labor

The cost and scarcity of construction labor is a challenge; the more that can be done by the SIP manufacturer, the less demand for what has become a scarce resource – jobsite labor. Because SIPs are manufactured in very large sizes (up to 8 x 24 feet), there are fewer connections, resulting in faster installations and a much tighter envelope. Working with SIPA manufacturers, designers can reduce costs by employing common SIP dimensional sizes of 4', 8', 12', 16', etc. in their designs. Factory lumber installations minimize jobsite labor while ensuring joint and boundary connection quality.

SIPs are manufactured using "SIP shop (or panelized) drawings"

SIPA manufacturers convert architectural drawings into SIP shop drawings. Shop drawings specify SIP size, layout, assembly details and installation specifications. They are also used for factory fabrication purposes. Shop drawings are provided to the client, or their authorized representative, for review and approval. Commitment to the drawing review process is crucial. Attention to detail during review ensures fabricated panel accuracy, installation ease and meeting SIP performance expectations. Early interaction with the SIP manufacturer helps design optimization resulting in material cost savings and installation speed. SIPA manufacturers can share samples of SIP shop drawings for your review and understanding.

Living Word Bible Camp, Grand Rapids MN

SIPs are customized to varying levels depending on client needs

SIPA manufacturers offer differing levels of SIP fabrication. They include blank SIPs, prefabricated SIPs and ready-to-assemble (RTA) packages.

BLANK SIPs are the least expensive, but limit your installation speed advantage, create additional waste, and require a higher degree of installation skill as all cutting is performed onsite.

PREFABRICATED SIPs are designed and cut in the factory increasing site installation speed, improving fit and finish.

RTA packages include factory preinstalled internal lumber and headers, maximizing onsite speed and efficiency.

Prefabrication orders are typical, although as labor becomes scarce RTA packages are gaining in popularity. SIPA manufacturers can provide detail concerning benefits of each option.

Roof and wall assemblies

SIPs are compatible with conventional roof and wall claddings. Unlike traditional framing, there is no internal air cavity within the SIP. The foam core of SIPs is solid and continuous throughout the wall and roof, eliminating convection and condensation issues occurring in conventional cavities. It is important to ensure a code-approved weather-resistive barrier is specified under wall claddings and approved underlayments for roof covering. Designing for the appropriate climate zone will help maximize durability. In some climate zones, a back-ventilated assembly may be appropriate. Because SIPs use very little solid lumber, an increased fastener schedule could be required when attaching exterior cladding. Application of fully adhered products to SIP roofs is not recommended. A separation layer should be added between the SIP roof and underlayment to avoid damage to the exterior SIP facing should there be a need to remove and replace the underlayment in the future.

Camp Ronald McDonald, Mountain Center CA

Factory cut electrical chases reduce electrician time in the field

Electrical chases are typically provided by SIPA manufacturers, simplifying electrical rough-in and saving electrician labor by eliminating time spent drilling holes in studs. Vertical and horizontal chases are provided in SIP walls to assist with wiring. Standard practice is to cut chases horizontally at outlet and switch heights. Chases can be added to SIP roofs upon request. Use of surface mounted LED lighting is recommended in place of recessed lighting as it doesn't penetrate the envelope and jeopardize airtightness. Determining electrical requirements prior to SIP manufacturing reduces the inefficiency of field installation. Plan a shop drawing review with the electrician prior to final approvals to verify chase locations, accommodate electrical layout and ensure code compliance.

Sail Newport, Newport RI

Design plumbing into interior walls

Eliminating the possibility of condensation or supply lines freezing within a SIP wall is an important design consideration. Plumbing should be relocated to interior walls wherever possible. If plumbing must be located on an exterior wall, it is recommended that an external chase be installed on the interior side of the SIP wall to conceal plumbing. Plumbing penetrations such as drain waste vent pipes can be placed perpendicularly through SIPs if thoroughly sealed to prevent air infiltration. Consult with a SIPA manufacturer if this is necessary.

To better understand the science of building with SIPs

Review *Builder's Guide to Structural Insulated Panels (SIPs)* by Joseph Lstiburek. This resource provides invaluable assistance in Building Science related details and can be purchased online at Amazon or www.sips.org.

South Dakota Pheasant Acres, Armour SD

Designing with SIPs:
CHECKLIST

The Structural Insulated Panel Association (SIPA) provides this checklist sharing the manufacturing membership's decades of combined knowledge to ensure the best experience and outcome for designers, builders, and owners of structural insulated panel (SIP) buildings. SIPA hopes to make your design-role easier and more efficient.

CHECKLIST

High-Performance SIP Building Envelope

SIPs are used to design high-performance building envelopes offering energy performance beyond conventional framing.

KEY POINTS:

- ☐ 1. SIPs meet and exceed building code thermal envelope requirements and eliminate additional continuous insulation needs on the building exterior.
- ☐ 2. SIPs provide extremely airtight structures, a key component improving indoor air quality (IAQ).
- ☐ 3. SIPs are available in a range of thicknesses delivering exceptional thermal performance.
- ☐ 4. Various SIP connections are available which minimize thermal bridging, lower installation costs, and install and seal with ease.
- ☐ 5. Factory applied rigid foam insulation cores eliminate concerns over quality insulation installation (QII).
- ☐ 6. Reduced HVAC requirements.

ACTION ITEM:

- ☐ Contact a SIPA manufacturing member at www.sips.org to learn about the benefits of SIP construction.

CHECKLIST

HVAC Systems with SIPs

SIP envelopes deliver high-performance, extremely airtight envelopes. The energy efficiency and tightness positively affect the HVAC design resulting in smaller unit requirements.

KEY POINTS:

- ☐ 1. Oversizing equipment jeopardizes building and equipment durability while needlessly increasing expenses.
- ☐ 2. SIP building designers, HERS raters and HVAC professionals must accurately calculate thermal performance of SIP envelopes.
- ☐ 3. An energy model using ACCA Manual J or REM/Design software should be used to verify proper equipment sizing.
- ☐ 4. Airtightness: Actual performance is best determined by a pre-drywall blower door test. A pre-construction estimate of less than 2 ACH is appropriate, and it is common to achieve less than 1 ACH50. Airtightness can be compromised if similar attention is not given to the other system components (e.g. windows, HVAC, plumbing, etc.).
- ☐ 5. Understand the R-value of the SIP provided. SIP R-value changes with thickness and R-values increase when temperatures drop. Code-required R-values are provided at 75˚F, but additional information is available at colder temperatures.
- ☐ 6. High-performance structures designed and built extremely airtight must have make-up air. There are several options with varying degrees of complexity and cost ensuring an HVAC system that will introduce fresh air.
- ☐ 7. Penetrations in the SIP envelope should be sealed to maximize airtightness.

ACTION ITEMS:

- ☐ 1. Work with an HVAC professional who is familiar with high-performing, extremely airtight structures.
- ☐ 2. Keep all HVAC equipment and duct work inside the conditioned SIP envelope.
- ☐ 3. Use energy calculations reflecting proper SIP foam core long-term thermal R-values along with the energy efficiency and the extreme airtightness of the SIP envelope to avoid HVAC equipment oversizing.
- ☐ 4. Consider specifying a heat recovery ventilator (HRV) or energy recovery ventilator (ERV), as referenced in ASHRAE 62.2 guidelines, for balanced fresh make-up air.

CHECKLIST

SIP Structural Capabilities

SIPs have the structural strength to work well in virtually any design.

KEY POINTS:

- ☐ 1. Manufacturers publish construction manuals and load design charts that can be accessed to understand structural capacities.
- ☐ 2. SIPs have been included in the IRC since the 2007 supplement to the 2006 IRC.
- ☐ 3. Structural capacities are recognized for compliance with Model Building Codes in evaluation reports from ICC-ES, ICC NTA, Intertek or IAPMO.
- ☐ 4. The structural capacity of SIPs changes with height/length, thickness and connection method.
- ☐ 5. SIP roofs offer great design flexibility to span long distances. SIPs can be combined with structural splines to span up to 24 feet. Exterior walls, beams, purlins, interior partitions, timber frame, or trusses constructed of either wood or steel are required to support a SIP roof.
- ☐ 6. SIPs are compatible with internal conventional framing.
- ☐ 7. Point loads may dictate the need for additional structural components to be embedded internally. Avoid point loads over openings to allow SIPs to act as the header without the need for additional structural elements.
- ☐ 8. SIP roofs can cantilever past walls to provide overhangs.
- ☐ 9. SIPs can act as their own header minimizing costs and maximizing thermal performance.
- ☐ 10. Wall SIPs may require a cap plate to meet high point load conditions.

ACTION ITEMS:

- ☐ 1. Contact a SIPA manufacturing member at www.sips.org to request their structural information and evaluation report.
- ☐ 2. Engage your SIP manufacturer early in the design to minimize structural redundancy and to provide a list of structural engineers experienced with SIPs.

CHECKLIST

SIP Sizes

SIPs can be manufactured in very large sizes (up to 8 x 24 feet). Large monolithic SIPs provide faster installation and reduce the number of connections which results in a much tighter envelope.

KEY POINTS:

- ☐ 1. Use support spacings of 4’, 8’, 12’, 16’, etc. to maximize efficiency of SIP layout and to reduce costs.
- ☐ 2. SIP roofs are supported by structural elements, either parallel or perpendicular to the ridge. Orientation is a function of the support elements and the spacing.
- ☐ 3. SIPs provide for long spans which may eliminate some conventional roof supports.
- ☐ 4. Wall thickness will generally increase when using SIPs over conventional construction. Extension jambs may be required for window and door detailing.

ACTION ITEMS:

- ☐ 1. Contact a SIPA manufacturing member at www.sips.org to learn about their SIP size capabilities.
- ☐ 2. Use SIPA manufacturer load design charts to verify maximum span for design conditions.

CHECKLIST

SIP Shop Drawings

SIP manufacturers typically convert architectural drawings into SIP shop drawings. Shop drawings specify SIP size, layout, assembly details and installation specifications. They are also used by the SIP manufacturer for accurate CNC fabrication.

KEY POINTS:

- ☐ 1. Depending on complexity of design, need for engineering, permitting, and possible revisions, the development of SIP shop drawings is a process that relies on engagement from those reviewing these drawings on behalf of the building owner.
- ☐ 2. SIP shop drawings are provided for client review and approval.
- ☐ 3. Let the SIP manufacturer do the work of establishing initial SIP layout and associated details.
- ☐ 4. Both SIP wall skins (inner and outer facings) must fully bear on the support deck without any overhang. Detail accordingly.

ACTION ITEMS:

- ☐ 1. Contact a SIPA manufacturing member at www.sips.org and ask for a sample SIP shop drawing for your review and understanding.
- ☐ 2. Involve the SIPA manufacturer early to ensure SIP design optimization. Minor alterations can provide dramatic savings in material costs and speed of installation.

CHECKLIST

SIP Fabrication/Manufacturing

Different levels of SIP fabrication are offered by SIP manufacturers. They include blank SIPs, prefabricated SIPs, and ready to assembly (RTA) packages.

KEY POINTS:

- ☐ 1. Blank SIPs are the least expensive, but limit your speed of installation advantage, create additional onsite waste, and require a higher degree of installation skill as all cutting is performed onsite.
- ☐ 2. Prefabricated SIPs are designed and cut in the factory to increase speed of installation and improved fit and finish on the jobsite.
- ☐ 3. An RTA package includes internal lumber and headers provided and preinstalled in the factory to maximize speed and efficiency onsite.

ACTION ITEM:

- ☐ Contact a SIPA manufacturing member at www.sips.org to learn about their SIP fabrication capabilities.

CHECKLIST

SIP Installation

SIPs are high-performance building envelopes and use of an experienced SIP installer is strongly recommended.

KEY POINTS:

☐ 1. Training programs are available to installers, ensuring that an educated installer understands the importance of proper installing and sealing of the SIP package. Programs include:

- SIPA online training course
- SIPA Registered Master Builder & Designer programs
- SIPschool hands-on field training
- Carpenters International Training Fund (CITF) for SIPs
- SIP manufacturer in-house training programs

☐ 2. Home energy raters verify building air leakage performance with blower door tests and can be found through the RESNET website at www.resnet.us.

ACTION ITEMS:

☐ 1. Mandate experienced SIP installers be used for the SIP erection. Contact SIPA at www.sips.org to find experienced SIP installers.

☐ 2. Specify a HERS rater to perform a blower door test to verify a high-performance envelope was obtained.

CHECKLIST

SIP Roof and Wall Assemblies

SIPs are compatible with conventional roof and wall claddings. As with all high-performance building envelopes, proper detailing is critical.

KEY POINTS:

- ☐ 1. Design for the appropriate climate zone to maximize durability.
- ☐ 2. Do not use low perm underlayments (i.e., ice and water shield) on a SIP roof with the exception of eaves and valleys.
- ☐ 3. Reservoir wall cladding (e.g., brick, stone, cementitious products, stucco, etc.) should have a rainscreen design that allows water to drain and air to circulate while increasing drying.
- ☐ 4. A back-ventilated cladding may be appropriate for some climate zones and moisture regions.
- ☐ 5. Some claddings may require special fastening patterns for attachment to SIP facings.
- ☐ 6. Use code-approved underlayment and roof covering.
- ☐ 7. Application of fully adhered products to SIP roofs is not recommended. A separation layer is recommended to facilitate future roofing (cladding systems) replacement.
- ☐ 8. In climate zones 4 and colder, SIP Tape should be installed on the interior of the structure.
- ☐ 9. Obtain construction language from specification.
- ☐ 10. Consider PV (solar) array attachment to roof SIPs.
- ☐ 11. SIPS and Ridge Vents - SIP roof assemblies can benefit from the use of ridge vents.

ACTION ITEMS:

- ☐ 1. Review *Builder's Guide to Structural Insulated Panels (SIPs)* by Joseph Lstiburek. This resource provides invaluable assistance in Building Science related details and can be purchased online at Amazon or at www.sips.org.
- ☐ 2. Verify manufacturer recommended sealing of SIP joints is completed prior to installation of cladding.
- ☐ 3. Use code-approved weather-resistive barrier under cladding for walls.
- ☐ 4. Follow cladding manufacturer's recommendations for fastening to SIPs. If not available, review fastener capacities of OSB to determine fastening schedule.
- ☐ 5. Provide specific instructions to the wall cladding and roofing trades. This input should be consistent with the detailing needed for the climate and type of cladding.

CHECKLIST

SIP Electrical

Electrical chases are typically provided by the SIP manufacturer to simplify the electrical rough-in, saving the electrician a great deal of time in the field.

KEY POINTS:

- ☐ 1. Vertical and horizontal chases are provided in SIP walls assisting with wiring at outlet and switch heights.
- ☐ 2. Wall and roof chases can be added or removed, prior to SIP manufacture. Shop drawings confirm all chase locations to avoid unnecessary cutting of SIPs in the field. Pre-planning for installation and special chase locations is critical.
- ☐ 3. Electrical chases should be sealed after electrical rough-in inspection to maximize airtightness.
- ☐ 4. An experienced SIP installer is your best insurance that the electrical rough-in will go smoothly.
- ☐ 5. Recessed lights are not recommended for installation in SIP roofs. Use of surface mounted LED lighting is recommended.

ACTION ITEMS:

- ☐ 1. Plan a review of the shop drawings with the electrician to verify chase locations to accommodate electrical layout and code compliance.
- ☐ 2. Consult with your SIP manufacturer concerning electrical chases in roofs.

CHECKLIST

SIP Plumbing

Plumbing should be placed within interior walls to protect the integrity of the high-performance envelope and to avoid the freezing of the supply lines in cold climates.

KEY POINTS:

- ☐ 1. Plumbing is recommended to be placed in interior walls to provide for an optimal exterior building envelope.
- ☐ 2. Minimize roof penetrations and consider consolidating all vents away from south facing roof planes for potential solar array.

ACTION ITEM:

- ☐ If plumbing needs to be placed in exterior walls, consult with SIP manufacturer.

Blue Wave on the Bay, Ashland WI

Blue Wave on the Bay, Ashland WI

Discover how easily you can start or deepen your understanding of designing, installing, and excelling with SIPs in your next commercial or residential project with the decades of industry learnings, tips, and resources at your fingertips:

- SIP Industry AIA/MasterSpec Specification
- Designing with SIPs: Design Considerations
- Building with SIPs: Need to Know
- SIP Design & Builder Best Practices Deeper Dives
- Technical Bulletins
- *Builder's Guide to Structural Insulated Panels (SIPs)* by Joseph Lstiburek of Building Science Corporation
- Building Education with SIPs Training (BEST) Videos and Certification
- AIA Continuing Education Courses, Lunch & Learns and YouTube videos
- Detailed case studies, award-winning project briefs, and SIP project USA map

Get all this and much, much more at www.sips.org

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