SIPs: An Engineer’s Perspective

Tom Moore, PE
Principal at Pinnacle Engineering, Inc
SIPA Board of Directors, Chair of Education Committee, on Technical Committee
Wood & SIP Committee of ASTM
SIP BASICS: WHAT ARE SIPS?

• SIP = Structural Insulated Panel
  • Composite structural panel
  • Rigid foam core - EPS, XPS, or polyurethane
  • Structural facings - usually 7/16” OSB
  • Structural adhesive
WHAT ARE SIPS?

- Rigid Foam Insulation
- Structural Facings
- Structural Adhesive
- Optional Electrical Chase
TYPES OF SIPS?

Insulated metal wall panels
TYPES OF SIPS?

Also available with cementitious skins – cement board, MgO board

Resistant to fire, mold, mildew
Panel joints are designed to reduce thermal bridging where structurally possible and sealed to reduce air infiltration.
SIP BASICS: DETAILS

- SIP screws go through the panels, into structure
- Wood screw point for wood
- Light drill point for metal/light gauge
- Heavy drill point for steel/iron up to ¼” thick
SIP BASICS: DETAILS

- Panel Screw
- Finished Roofing Material
- Roofing Felt
- SIP Roof Panel
- Continuous Sealant Each Side of Framing as Recommended by Manufacturer, and Roof Panel 2x Joint
- Top Plate
- SIP Wall Panel
- Drained and Ventilated Cladding
- 8d Common Nails @ 6” O.C. Each Side
- Drywall
A structural engineer with knowledge of SIP applications should be a part of the design process for any SIP structures.

Prevent the overdesign of the structural system, reduce costs, and meet code minimums.

Consult manufacturer code report and load charts for engineering information (www.sips.org)
Structural Insulated Panels (SIPs) have historically been used more for residential construction than for non-residential construction. However, SIPs are gaining popularity in the commercial arena, especially for school construction. There are several schools throughout the country that have incorporated SIPs. One such school is Silvis Middle School in Silvis (East Moline), IL. This 52,600 square-foot facility was designed with SIP roof panels over metal bar joists, steel beams, and steel columns. SIPs were also used for the exterior walls, creating a full SIP building envelope. It is often assumed that SIP construction is more expensive than other construction methods. However, one of the reasons that SIPs were selected as the method of construction for the Silvis Middle School project was because they were the least expensive of the options that were being considered for the exterior walls.

Using Structural Insulated Panels on Non-Residential Structures

A Case Study

By Thomas A. Moore, P.E., LEED AP

The Role of the SIP Engineer

Structural Insulated Panels are a pre-engineered building component, similar to pre-engineered wood trusses. SIP manufacturers produce SIP shop drawings, which are then reviewed by the project design team. On non-residential projects (and some residential projects), these shop drawings must be stamped engineering. (Note: The engineer must be on site up front, in order to avoid overlap or gaps in the structural design on the project. Ideally, the SIP engineer would only be responsible for the component loads that apply directly to the SIP panels, and not to the global loads that apply to the building as a whole. However, some of these global loads (like shear wall loads) might be calculated by the engineer of record and given to the SIP engineer to check against the capacity of the SIPs.

A Diaphragm is a Diaphragm is a Diaphragm

One structural element that is present on most
ENGINEERING METHODS

- Sample manufacturer load chart from code report
- Loads are calculated per Chapter 16 of the IBC
- 2x4 studs @ 16”oc = 1600plf at 8’-0” tall
- 2x6 studs @ 16”oc = 2600plf up to 12’ tall
- 4.5” SIP = 3600plf at 8’-0” tall

<table>
<thead>
<tr>
<th>Lateral Brace Spacing (ft)</th>
<th>Panel Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4-5/8 inch</td>
</tr>
<tr>
<td>8 WAB³</td>
<td>2320</td>
</tr>
<tr>
<td>8</td>
<td>3630</td>
</tr>
<tr>
<td>10</td>
<td>3260</td>
</tr>
<tr>
<td>12</td>
<td>2810</td>
</tr>
<tr>
<td>14</td>
<td>--</td>
</tr>
<tr>
<td>16</td>
<td>--</td>
</tr>
<tr>
<td>18</td>
<td>--</td>
</tr>
<tr>
<td>20</td>
<td>--</td>
</tr>
</tbody>
</table>

1. Permanent loads, such as dead load, shall not exceed 0.50 times the tabulated load.
2. All values are for normal duration and may not be increased for other durations.
3. Axial loads shall be applied concentrically to the top of the panel through repetitive members spaced not more than 24-inches on center. Such members shall be fastened to a rim board or similar member to distribute along the top of the SIP.
4. The ends of both facings must bear on the supporting foundation or structure to achieve the tabulated axial loads.
5. Tabulated values are based on the strong-axis of the facing material oriented parallel to the span direction. WAB indicates weak-axis bending of the facing material (i.e. the facing material weak-axis is parallel to the span direction).
• Load charts vary by spline type and load type

• This is a block spline and surface spline chart

• Other spline types include I-joist, LVL, and 2x lumber

• 2x10 rafters @ 24”oc max span = 14’-8” for 35psf (#2SYP)

• 10.25” SIP max span for 35psf = 15’-0” (superimposed)
Shear wall components

- OSB skins nailed to lumber at edges and splines at interior joints – similar to typical wood stud shear wall
- Standard SIP shear wall = 380plf
- Wood stud shear wall = 260plf
- 380plf with 4”oc edge nailing
• Shear wall strap diagrams
• Hold down anchors at the ends of shear walls
• Shear plate anchor bolts must resist shear load
- Shear wall values are available to cover all seismic design categories.

- Diaphragm values for wind design for SIP roof panels should be available from the manufacturer.

- Like all shear walls and diaphragms, chord forces are critical. Straps can help transfer these forces across joints in the edge lumber.
• Openings with heavy loads may require structural header

• Some openings possible with SIP acting as header; consult engineer or manufacturer
SIP Screws connect panels to each other and to supporting structure – resisting loads through tension and shear

**PERFORMANCE DATA**

<table>
<thead>
<tr>
<th>Fastener</th>
<th>Tensile Strength</th>
<th>Shear Strength</th>
<th>Head Pull-Thru Values 7/16” OSB</th>
<th>SIP Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIPTP</td>
<td>3380 lbf.</td>
<td>2900 lbf.</td>
<td>545 lbf.</td>
<td>630 lbf.</td>
</tr>
<tr>
<td>SIPLD</td>
<td>3380 lbf.</td>
<td>2900 lbf.</td>
<td>545 lbf.</td>
<td>630 lbf.</td>
</tr>
<tr>
<td>SIPHD</td>
<td>6000 lbf.</td>
<td>3400 lbf.</td>
<td>545 lbf.</td>
<td>630 lbf.</td>
</tr>
</tbody>
</table>

Withdrawal Values in Wood*

<table>
<thead>
<tr>
<th>Specific Gravity</th>
<th>0.67</th>
<th>0.55</th>
<th>0.50</th>
<th>0.46</th>
<th>0.43</th>
<th>0.36</th>
<th>0.31</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SIPTP &amp; SIPLD:</strong></td>
<td>1429</td>
<td>1173</td>
<td>1067</td>
<td>981</td>
<td>917</td>
<td>768</td>
<td>661</td>
</tr>
</tbody>
</table>

*Values are in lb/in. of thread penetration

Withdrawal Values in Steel

<table>
<thead>
<tr>
<th>Type B Corrugated</th>
<th>22 ga</th>
<th>20 ga</th>
<th>18 ga</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SIPLD:</strong></td>
<td>510 lbf</td>
<td>645 lbf</td>
<td>920 lbf</td>
</tr>
<tr>
<td>Structural Steel</td>
<td>16 ga</td>
<td>13 ga</td>
<td>12 ga</td>
</tr>
<tr>
<td><strong>SIPHD:</strong></td>
<td>770 lbf</td>
<td>1130 lbf</td>
<td>1690 lbf</td>
</tr>
</tbody>
</table>

Lateral Load Resistance

<table>
<thead>
<tr>
<th>Fastener</th>
<th>Main Member</th>
<th>Side Member</th>
<th>Load (lbf.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIPTP</td>
<td>SPF 2x4</td>
<td>SIP Panel</td>
<td>943</td>
</tr>
<tr>
<td>SIPLD</td>
<td>22 ga. Corrugated Steel</td>
<td>Nail Base</td>
<td>411</td>
</tr>
<tr>
<td>SIPLD</td>
<td>7/16” OSB</td>
<td>Nail Base</td>
<td>112</td>
</tr>
<tr>
<td>SIPHD</td>
<td>1/8” Structural Steel</td>
<td>SIP Panel</td>
<td>929</td>
</tr>
</tbody>
</table>
American National Standard

Standard for Performance-Rated Structural Insulated Panels in Wall Applications
SIP STANDARDS

Structural Insulated Panels

PRODUCT GUIDE
Use of SIPS in Seismic Design Categories

Building with structural insulated panels (SIPS) in seismic design categories D, E and F is permitted when building code compliance is demonstrated through a manufacturer evaluation report.

Section R613 of the 2009 International Residential Code (IRC). Structural Insulated Panel Wall Construction, has limits for the use of SIPS. Section R613.2 Applicability Limits states that SIPS shall be limited to sites subjected to seismic design categories A, B or C. Some building code jurisdictions have interpreted this to mean that SIPS cannot be used in Seismic Design Categories D, E, and F. In order to clarify this, the ICC staff was asked for an interpretation of this section. The response from Larry Franks of the ICC staff follows:

In response to your question, per your e-mail of March 28, 2011, we offer the following opinion of the meaning and intent of the code on this subject. It is my understanding that your e-mail poses the following question:

Q: Does the 2009 IRC permit structural insulated panel (SIP) wall construction beyond the applicability limits specified in Section R613.2?

A: Yes. Section R613 is a prescriptive design for SIP wall construction based on the limits established in Section R613.2. In accordance with Section R301.1.3, a building that contains structural elements not conforming to the prescriptive limits of the code is acceptable if designed in accordance with accepted engineering practice. Also, Section R104.11 permits the use of SIP wall construction beyond the applicable limits of Section R613.2.

This opinion is based on the information which you have provided. We have made no independent effort to verify the accuracy of this information nor have we conducted a review beyond the scope of your question. As this opinion is only advisory, the final decision is the responsibility of the designated authority charged with the administration and enforcement of this code.
SHOP DRAWINGS
SHOP DRAWINGS
SHOP DRAWINGS
Beyond combining SIPs with wood framing, other structural systems can be combined with SIPs to increase heights and spans in a building:

- Metal framing
- Structural steel
- Pre-engineered buildings
- Timber framing
- Glu-Lams
STRUCTURAL SIP HYBRIDS

Hybrid systems: SIPS with metal framing

Buffalo University Day Care
Buffalo, New York
Kidney Architects
STRUCTURAL SIP HYBRIDS

Hybrid systems: bar joists and structural steel with SIPs

Silvis Middle School, East Moline, IL
Hybrid systems: bar joists and structural steel with SIPs

Silvis Middle School, East Moline, IL
Pre-engineered building with SIPS

SIPS manufacturing plant, Cottonwood, MN
SIPs and timber framing

Darien Nature Center, Darien, CT
SIPs and timber framing

10” SIPs roof panels covering 14,900 square feet of conditioned space, achieving R-values that qualified for tax incentives as an Energy Qualified Cool Roof

Washington Fruit & Produce Corporate Office, Yakima, WA
SIPs with Glu-Lams

Silverwood Park Visitor Center, Minneapolis, MN
CONSTRUCTION METHODS AND SPECIFICATIONS

Specification for SIPS available at www.sips.org

SECTION 06120 – STRUCTURAL INSULATED PANELS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes Structural Insulated Panels (SIP).

B. Related Sections include the following:

1. Section 06100 – Rough Carpentry
2. Section 06130 – Timber Framing

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide SIPs capable of withstanding design loads including dead load, live loads, wind loads and seismic loads. Design loads shall be in compliance with the requirements of the local Building Code.
1.5 QUALITY ASSURANCE

A. SIP Manufacturer shall be a member of the Structural Insulated Panel Association (SIPA).

B. Structural Design: A Professional Engineer shall perform a structural analysis and design of the SIP assemblies in accordance with the design loads.

C. Installation Contractor must have experience on projects of similar size and scope. Lead installer / supervisor shall have a minimum of 3 years experience installing SIPs or have completed a certifying curriculum at a dedicated SIP training program such as those provided by the United Brotherhood of Carpenters and Joiners of America or equivalent.
Coventry Senior Living, Mahtomedi, MN
COMMERCIAL APPLICATIONS

Finn Hill Junior High School, Kirkland, WA
COMMERCIAL APPLICATIONS

Finn Hill Junior High School, Kirkland, WA
COMMERCIAL APPLICATIONS

Aeon Alliance Expansion, Minneapolis, MN
COMMERCIAL APPLICATIONS

Aeon Alliance Expansion, Minneapolis, MN
COMMERCIAL APPLICATIONS

Bend Parks and Recreation, Bend, OR
COMMERCIAL APPLICATIONS

Bend Parks and Recreation, Bend, OR