Structural Insulated Panel Association
The Structural Insulated Panel Association (SIPA) is a non-profit trade association representing manufacturers, suppliers, fabricators/distributors, design professionals, and builders committed to providing quality structural insulated panels for all segments of the construction industry.

www.sips.org

SIPS 101

Bill Chaleff, Chaleff and Rogers, Architects

SIPs 101

– SIP Basics
– Energy Efficiency and Green Building with SIPs
– Engineering for SIPs
– Designing with SIPs
– SIP assembly details and Field Issues

© buildingscience.com
SIPs are a composite structural panel with an insulating core of rigid foam—usually EPS or polyurethane—and structural facings, most commonly of 7/16" thick oriented strand board (OSB).

A BRIEF HISTORY
Development of "stressed-skin" panels for buildings began in the 1930s. Engineering and durability testing was conducted at the Forest Products Laboratory (FPL) in Madison, Wisconsin, a facility operated by the U.S. Forest Service.

FPL tested the concept of using skins to carry a portion of structural loads by building a small house in 1937. Wall studs in the panels were 3/4" x 2 1/2" rather than the usual 2" x 4". First Lady Eleanor Roosevelt dedicated the house, and the structure is currently a daycare center run by the University of Wisconsin.

FPL scientists reasoned that if skins could take part of the structural loads, maybe they could eliminate framing entirely. Engineering theory was developed and tested, and a complete structure was built in 1947 using corrugated paperboard. This structure was heated, humidified, and exposed to Wisconsin weather for 31 years.

The structure was disassembled periodically for testing to observe changes in panel stiffness, and bowing was minimal. In 1969 foam cores were introduced to form the modern structural insulated panel.

SIPS TODAY
- Rigid Foam Insulation
- Structural Facings
- Structural Adhesive
- Optional Electrical Chases

RIGID FOAM CORE
Material may be:
- Expanded Polystyrene (EPS)
- Extruded Polystyrene (XPS)
- Polyurethane
- Polyisocyanurate

SIP STRENGTHS
- Reduced man hours per building, easy to train laborers to install SIPS
- Less site waste, greener product and process
- Better control over indoor air quality
- Design flexibility
- Faster dry in reduces moisture exposure for all products
SIP STRENGTHS
- Straight walls, faster drywall and trim installation
- Reduced callbacks due to nail popping, cracks due to lumber shrinking
- Less building material theft during construction
- Less or no temporary heat required during building in cold climates
- Integrates easily with other building systems

WALL SYSTEMS
A Superior Building Product for Walls:
- Control over materials and labor
- Solves problems prior to construction
- Straighter walls
- Tighter construction, less air infiltration
- Panel thicknesses sized to accept dimensional lumber

ROOF SYSTEMS
A Superior Building Product for Roofs:
- Vaulted ceilings
- Much faster dry-in
- Greater spans
- Pre-insulated
- Pre-engineered
- Tighter construction, less air infiltration
- Panel thicknesses sized to accept dimensional lumber

FLOOR SYSTEMS
A Superior Building Product for Floors:
- Capping crawl spaces
- Pre-insulated
- Simple, easy, and fast
- Pre-engineered
- Solid floors
- Efficient over unconditioned spaces such as a garage
- Panel thicknesses sized to accept dimensional lumber

PANEL SIZES AND THICKNESSES
Typical Panel Sizes
- 4' x 8'
- 4' x 24'
- 8' x 24'
- Up to 9' x 24' custom in some areas

Typical Panel Thicknesses
- 4", 6", 8", 10", 12"

ENERGY EFFICIENCY AND GREEN BUILDING WITH SIPS
**SIPS AS THE BACKBONE OF A GREEN BUILDING STRATEGY**

Starting with SIPs as the primary structural and enclosure system gets your green building project started on the right foot. An efficient building envelope creates design opportunities such as creative daylighting without sacrificing thermal performance.

**INfiltration Reduction**

More than 50% of a home’s total envelope loss may be due to infiltration!

SIPs have:
- Very few gaps
- Industry standard sealing details
- Superior IAQ

**Oak Ridge National Laboratory**

ORNL Studies:
- Test room is 15 times tighter than stick built
- 50–70% annual savings over Model Energy Code
- Framing Factor: 3% vs 15–25% stick


**Infiltration Reduction**

- Low infiltration = shorter duct runs
- All ducts inside conditioned space

**Waste Reduction**

Pre-cut SIPs help to dramatically control and limit site waste.

**SIPS vs. Stick Frame**

SIP construction is a type of shell construction. Point loads are transferred from one member to another.

Stick frame is essentially post and beam construction. Point loads are dispersed in all directions.

© buildingscience.com
BEYOND STICK FRAME

Monocoque construction

SIP: Structural Insulated Panels

- Wikipedia: consist of a sandwich of two layers of structural board with an insulating layer of foam in between.
- A panel acts similar to an I-beam section.
- The strength of a panel is determined:
  - Foam core thickness
  - Skin tensile strength
  - Skin compressive strength
- When a load is applied to the top skin of the panel or I-beam it goes into compression, the bottom skin goes into tension.

Strength Comparison

Wall Axial Load Capacity (plf)_
- Studs 16" OC
- 25 psf Wind Load

Strength Comparison

Roof Transverse Load Capacity (psf)_
- Rafters 24" OC
- I-Joist Splines
- 48" OC

© buildingscience.com
Header Options
- None
- SIP Box Beam
- Insulated Header

No Header
- Only 1 SIP joint allowed above opening

SIP Box Beam Header
- Uses SIP as Box Beam
- Slightly increased thermal bridging

Insulated Header
- Strongest
- R13
- No thermal bridge

Nailers
- Interior Nailers
- Exterior Nailers
- Engineered Lumber Nailers
- Engineered Lumber Splines

Interior or Exterior Nailers
- Double thickness of 7/16” OSB + skin
- Interior, Exterior, or Both
**Engineered Lumber Splines**
- Horizontal or vertical
- LVL or Glulam
- Sized per application

**Embedded Posts**
- Sized per application
- Typically Glulam or PSL

**Splines**
- Surface splines
- Double 2x splines
- Double LVL splines
- Glulam Splines
- I-Joist Splines

**Surface Splines**
- Most common
- Highest Durability
- Lowest Permeability
- Easiest to assemble

**Double 2x Spline**
- Increases axial and transverse strength
- Most difficult to seal

**Glulam Spline**
- Strongest in axial and transverse strength
- OK to seal
I-Joist Spline

- Increases axial and transverse strength
- Adds minimal thermal bridging

Why Use Panels? To Save Fuel

SAVE UP TO HALF of your annual heating costs

National Energy Consumption

- Residential
  - Heating = 31%, 6.7 Quad
  - Cooling = 12%, 2.7 Quad
- Commercial
  - Heating = 14%, 2.5 Quad
  - Cooling = 13%, 2.3 Quad

Why Use Panels? To Save Fuel

Residential Energy Cost per Square Foot
- 1980 $1.92
- 1990 $1.70
- 2000 $1.85
- 2005 $2.31

How Panels Save Energy

Impact of Thermal Bridging

Stick & Infill

How Panels Save Energy

Impact of Thermal Bridging

SIP
Whole Surface vs. Center of Cavity R-Value

Mud Sill, Shoe, & Rim Joist

How Panels Save Energy

Thermally Efficient Structure
No 2nd Floor Rim Joist
Min. Thermal Break for Long Spans

Typical Detail
Wall SIP to Pre-Fab Roof Truss

Truss Roof Attachment

How Panels Save Energy

Very Low Air Infiltration

“Air Leakage Rate is 2nd to None In Vermont”
- Blower door measurement: 326 CFM50
- Natural Air Exchanges per Hour = .04
- 4400 sq. feet of house
Real Numbers
12,000 sqft Industrial Building

$0.56/sqft/year in '07/'08 Season
168kBTU Heat Loss on Design Day

Roof Connection Detail

Installation Techniques

Craning

Installation Techniques

Proper Foaming

Wiring Solutions

Wiring Solutions
Why Use Panels – Construction Costs

To get SIP-like performance w/ stick & infill requires:
– Thicker stud walls w/ rigid insulation
– “Perfectly” installed insulation
  i.e. no crushing around wiring
– Air sealed drywall installation
– Air sealed electrical boxes

Cost would exceed SIP construction

Building Science

Building Science = Health & Durability Issues
– Building Science applies to all structures
– Water is involved in every aspect of Building Science
– We build with wood
  Wet wood is food for fungus & mold
– Fungus & mold on wood is called

Building Science and Structural Insulated Panels (SIPS)

Enclosure Design from a Building Science Perspective

Historical changes
– Buildings are more airtight, have smaller energy ‘flow’
  – reduced ability to dry
– Materials are less moisture tolerance
– People are changing conditions of use
– Performance expectations have increased:
  Comfortable, Healthy, Durable, Resource Efficient

Enclosure requirements
– Control Heat, Air, Moisture (rain, vapor, soil)
  • Heat – continuous layer of insulation
  • Air – continuous air barrier
  • Moisture – drainage plane, capillary breaks

THERMAL CONTROL AND AIRTIGHTNESS

Frame Wall vs. SIP Wall
Thermal Control with SIPs

- SIP panels are air impermeable, solid and homogenous insulation
- As with any panel system, joints are important

Important Details

Roof Design: Vented and Unvented

Either vented ("cold roof") or unvented ("hot roof")

Why vent?
- Cold climates: cold roof surface to control ice dams, vent moisture
- Hot climates: expel solar heated air to reduce cooling

Other issues
- Attic needed for living space
- Roof complexity makes venting difficult
- Locating HVAC system components

SIP Roof – Conditioned Attic Space

SIP Roof – Simple Cold Deck

SIP Roof – Vented-Unvented Hybrid
Applicable Code Sections

2006 International Residential Code for One- and Two-Family Dwellings
- R806.1 Ventilation required
- R806.2 Minimum area
- R806.3 Vent and insulation clearance
- R806.4 Conditioned attic assemblies

2007 Supplement to the International Residential Code
- R806.4 Unvented attic assemblies
- Table R806.4 Insulation for condensation control

Concept: Layering Materials to Shed Water

“3D” Water Management
- Drainage
- Deflection
- Drying

Assemblies Drained and Ventilated

Provide Drainage Plane and Drainage Gap

All claddings should be drained and back-ventilated where annual rainfall exceeds 20 inches

North America Average Annual Rainfall

For Wood and Fiber Cement Siding:
- Install over a 1/4-inch (6mm) spacer strip over a water resistive barrier

For Cedar Shingles, Traditional Stucco, and Manufactured Stone Veneer:
- Install over 3/8-inch (9mm) drainage mat over a water resistive barrier

Vinyl or Aluminum Siding is inherently back-ventilated
Drained and Ventilated Cladding

- Can be used in all regions

Drained and Ventilated Stucco Cladding

- Provide Drainage Plane and Drainage Gap for "Reservoir" Claddings

Water Managed Wall – Brick Veneer

- Provide Drainage Plane and Drainage Gap for "Reservoir" Claddings

Installing a Window with Housewrap

Theory: Diffusion vs. Air Leakage

Building Science with Structural Insulated Panels (SIPs)

WATER VAPOR CONTROL AND DRYING
Air Pressure and Vapor Pressure

Diffusion vs. Air Leakage

SIPs - Bilateral Symmetry

Design for Outward and Inward Drying

Applicable Code Sections

2006 International Residential Code for One and Two-Family Dwellings
- R202 Vapor Retarder
- N1102.5 Moisture Control

2007 Supplement to the 2006 International Residential Code for One and Two-Family Dwellings
- R202 Vapor retarder Class
- N1102.5 Vapor retarders
- N1102.5.1 Class III vapor retarders
- N1102.5.2 Material vapor retarder class
General Principles

- Use sealed combustion, power-vented appliances, no internal venting
- HVAC inside conditioned space
- Provide balanced ventilation system
- Effective ventilation for the whole house
- Properly size HVAC system
- Consider HRV in Cold climates
- Provide supplemental dehumidification in Hot-Humid climates

Combustion Safety

- Vent combustion gasses outside
  - No vent-less appliances
- Use sealed combustion appliances
  - Less “spillage” of exhaust inside
- Provide supply air to all non-sealed combustion appliances
  - They draft better

Use Sealed Combustion and Power-Vented Appliances

Unvented, Conditioned Attic allows HVAC inside conditioned space

Not recommended: HVAC outside conditioned space

Provided Balanced Ventilation System
Indoor Air Quality

Mechanical Ventilation Required!!
Maintain Indoor Humidity @ 50% or less in winter

Consider Heat Recovery in Cold Climates

Effective Distribution and Return Pathways for the Whole House

RESOURCES

Building Science with Structural Insulated Panels (SIPs)

Online Resources
This presentation is available at
www.sips.org
www.buildingscienceseminars.com/presentations
General Building Science
www.buildingscience.com
About SIPs and SIPs Construction
www.sips.org
www.sipschool.org

Available at the SIPA Store – www.sips.org