Build Boston 2008

BUILDING SCIENCE AND STRUCTURAL INSULATED PANELS (SIPS)

Introductions

Moderator

Zack LeRoy
Panel Pros Inc., Keene, NH
zack@panelpros.com
(800) 721-7075

SIPs 101

Bill Chaleff
Chaleff and Rogers, Architects, Watermill, NY
bcarchtx@optonline.net
(631) 726-4477

Introductions

Engineering for SIPs

Paul Malko
Foard Panel, Inc., West Chesterfield, NH
paul@foardpanel.com
(800) 644-8885

Building Science and SIPs

Alex Lukachko
Building Science Corporation, Somerville, MA
alex@buildingscience.com
(978) 589-5100

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.

SIPA Structural Insulated Panel Association

www.sips.org

Bill Chaleff, Chaleff and Rogers, Architects

SIPS 101

SIPs 101

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

WHAT ARE SIPS?

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.

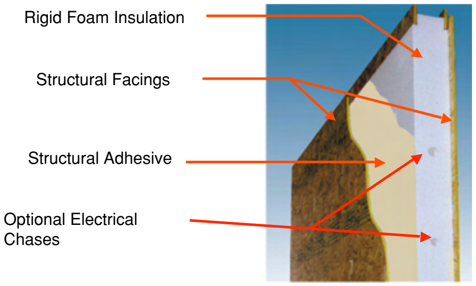
FPL tested the concept of using skins to carry a portion of structural loads by building a small house in 1937. Wall studs in the panels were 3/4” x 2 _,” rather than the usual 2” x 4”. First Lady Eleanor Roosevelt dedicated the house, and the structure is currently a daycare center run by the University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

A BRIEF HISTORY

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 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

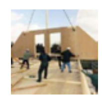
PANEL SIZES AND THICKNESSES

Typical Panel Sizes

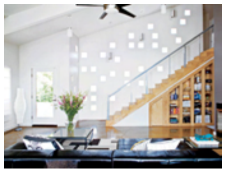
- 4’ x 8’ – 4’ x 24’
- 8’ x 24’
- Up to 9’ x 24’ custom in some areas

Typical Panel Thicknesses

4 _”, 6 _”, 8 _”, 10 _”, 12 _”



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

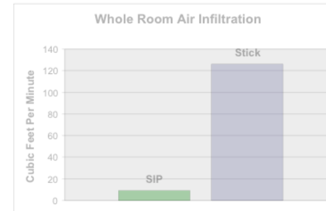
OAK RIDGE NATIONAL LABORATORY

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



Source: *Heating and Blower Door Tests of the Rooms for the SIPA/Reiker Project.* ORNL, March 15, 2002.

INFILTRATION REDUCTION

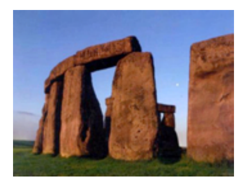
– Low infiltration = shorter duct runs

– All ducts inside conditioned space

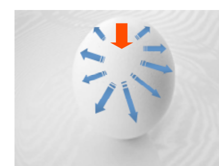
WASTE REDUCTION

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

SIPS VS. STICK FRAME



STICK FRAME
Stick frame is essentially post and beam construction. Point loads are transferred from one member to another.



SIPs
SIP construction is a type of shell construction. Point loads are dispersed in all directions.

BEYOND STICK FRAME

Boston Whaler and the common Refrigerator.

Two SIP structures we've all known and loved for over 50 years.

Monocoque construction

BEYOND STICK FRAME

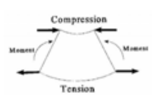
Sometimes, stick frame just won't do.
In these cases, SIPs are the only way to go.

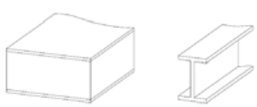
Paul Malko, Foard Panel

Engineering for SIPs

SIP: Structural Insulated Panels

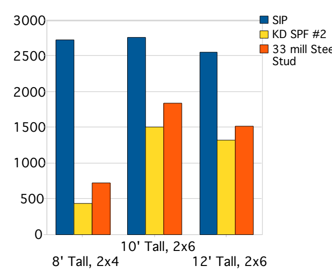
- Wikipedia: consist of a sandwich of two layers of structural board with an insulating layer of foam in between.
- A panel acts similar to an I-beam section.
- The strength of a panel is determined:
  - Foam core thickness
  - Skin tensile strength
  - Skin compressive strength
- When a load is applied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





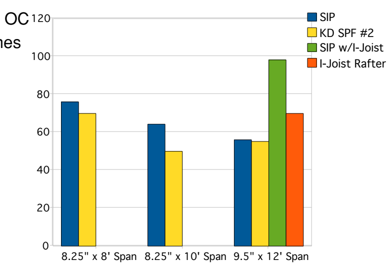
Strength Comparison
Wall Axial Load Capacity (plf)_

- Studs 16" OC
- 25 psf Wind Load



Strength Comparison
Roof Transverse Load Capacity (psf)_

- Rafters 24" OC
- I-Joist Splines 48" OC

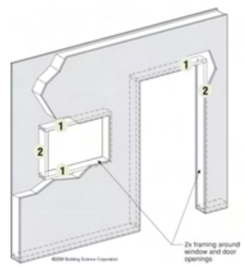


Header Options

- None
- SIP Box Beam
- Insulated Header

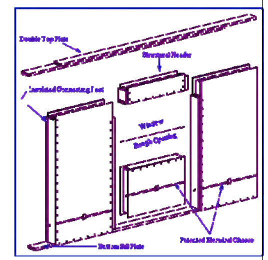
No Header

- Only 1 SIP joint allowed above opening



SIP Box Beam Header

- Uses SIP as Box Beam
- Slightly increased thermal bridging



Insulated Header

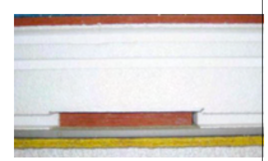
- Strongest
- R13
- No thermal bridge

Nailers

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

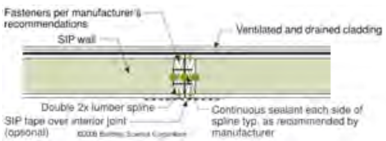
Interior or Exterior Nailers

- Double thickness of 7/16” OSB + skin
- Interior, Exterior, or Both



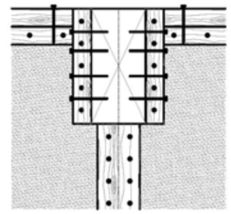
Engineered Lumber Splines

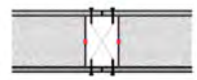
- Horizontal or vertical
- LVL or Glulam
- Sized per applicaiton



Embedded Posts

- Sized per application
- Typically Glulam or PSL



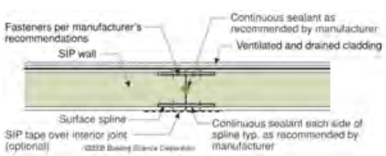


Splines

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

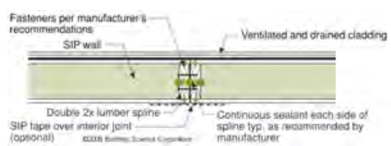
Surface Splines

- Most common
- Highest Durability
- Lowest Permeability
- Easiest to assemble



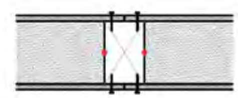
Double 2x Spline
Double LVL Spline

- 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

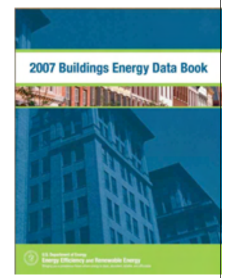
Why Use Panels? To Save Fuel

SAVE UP TO HALF

of your annual heating costs

National Energy Consumption

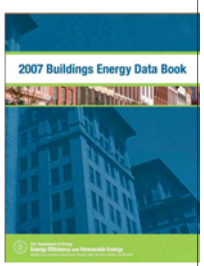
- **Residential**
  - Heating = 31%, 6.7 Quad
  - Cooling = 12%, 2.7 Quad
- **Commercial**
  - Heating = 14%, 2.5 Quad
  - Cooling = 13%, 2.3 Quad



Why Use Panels? To Save Fuel

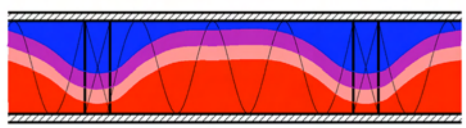
Residential Energy Cost per Square Foot

- 1980 $1.92
- 1990 $1.70
- 2000 $1.85
- 2005 $2.31



How Panels Save Energy

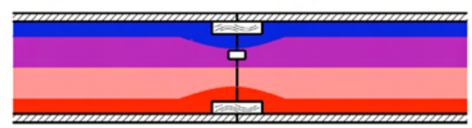
Impact of Thermal Bridging



Stick & Infill

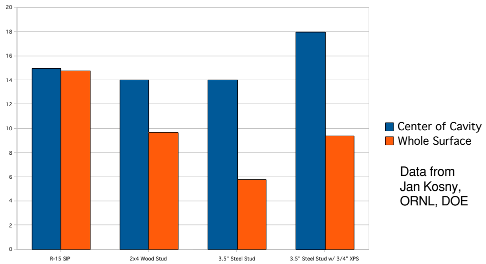
How Panels Save Energy

Impact of Thermal Bridging



SIP

Whole Surface vs. Center of Cavity R-Value



Mud Sill, Shoe, & Rim Joist

How Panels Save Energy

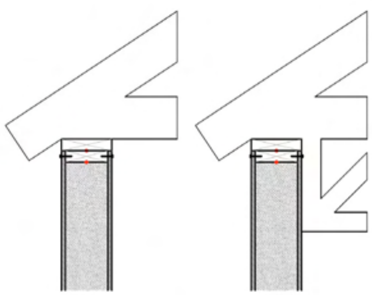
Thermally Efficient Structure

No 2nd Floor Rim Joist

Min. Thermal Break for Long Spans

Typical Detail

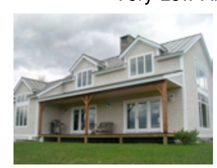
Wall SIP to Pre-Fab Roof Truss



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

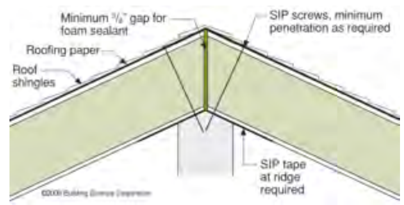
Real Numbers

12,000 sqft Industrial Building

$0.56/sqft/year in '07/'08 Season

168kBTU Heat Loss on Design Day

Roof Connection Detail



Installation Techniques

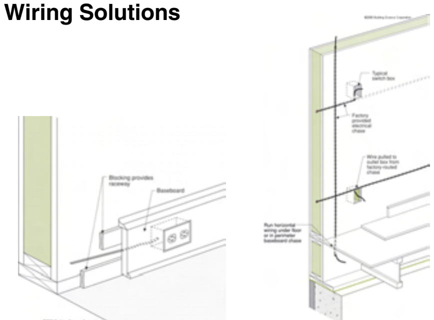
Craning

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

Stick Frame w/ Urethane Spray Insulation, Typar, Cedar Siding

Alex Lukachko, Building Science Corporation

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

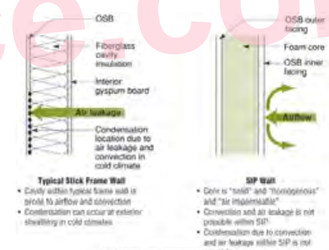
Enclosure requirements

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

Building Science with Structural Insulated Panels (SIPs)

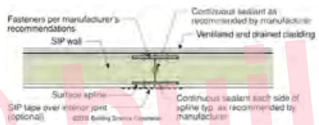
THERMAL CONTROL AND AIRTIGHTNESS

Frame Wall vs. SIP Wall

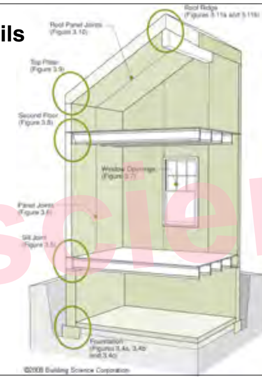


Thermal Control with SIPs

- 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")

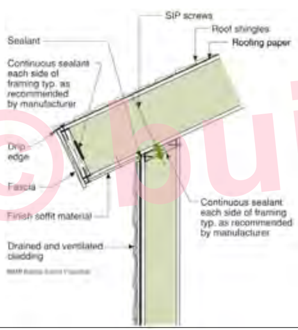
Why vent?

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

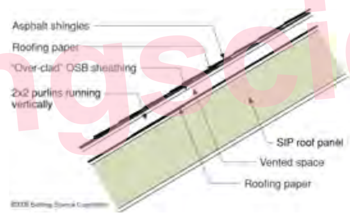
Other issues

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

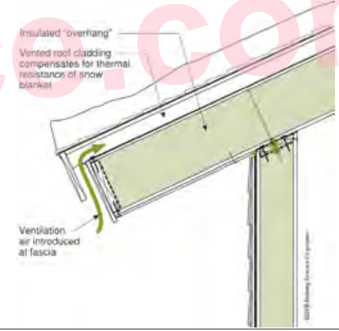
SIP Roof – Conditioned Attic Space



SIP Roof – Simple Cold Deck



SIP Roof – Vented-Unvented Hybrid



Applicable Code Sections

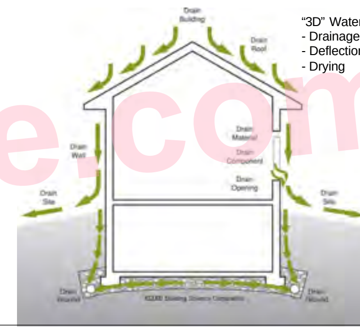
2006 International residential Code for One- and Two-Family Dwellings
- R806.1 Ventilation required
- R806.2 Minimum area
- R806.3 Vent and insulation clearance
- R806.4 Conditioned attic assemblies

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

Building Science with Structural Insulated Panels (SIPs)

RAIN CONTROL AND CLADDINGS

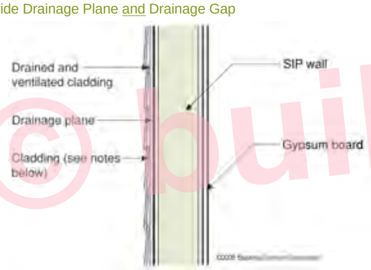
Concept: Layering Materials to Shed Water



"3D" Water Management
- Drainage
- Deflection
- Drying

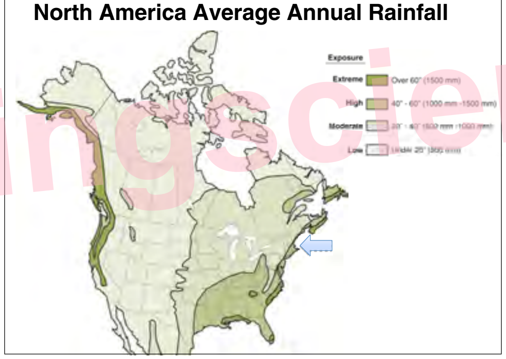
Assemblies Drained and Ventilated

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



Cladding Types and Drainage Gap

Provide Drainage Plane and Drainage Gap

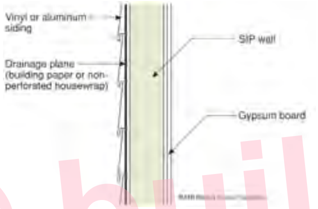
For Wood and Fiber Cement Siding:
-install over a 1/4-inch (6mm) spacer strip over a water resistive barrier

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

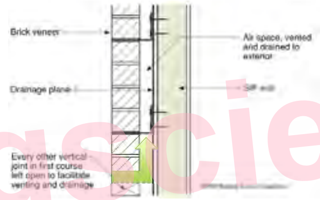
Provide Drainage Plane and Drainage Gap



Can be used in all regions

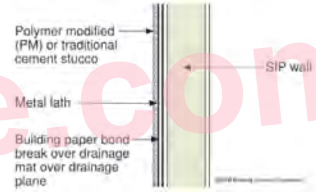
Water Managed Wall – Brick Veneer

Provide Drainage Plane and Drainage Gap for "Reservoir" Claddings



Drained and Ventilated Stucco Cladding

Provide Drainage Plane and Drainage Gap for "Reservoir" Claddings



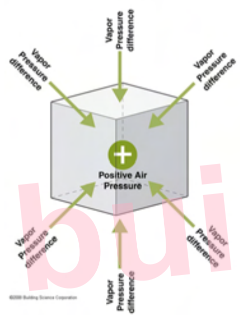
Installing a Window with Housewrap

Building Science with Structural Insulated Panels (SIPs)

WATER VAPOR CONTROL AND DRYING

Theory: Diffusion vs. Air Leakage

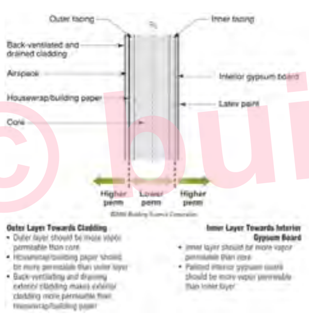
Air Pressure and Vapor Pressure



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

Building Science with Structural Insulated Panels (SIPs)

HVAC FOR AIRTIGHT, ENERGY-EFFICIENT BUILDINGS

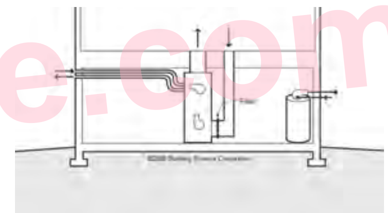
General Principles

- 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

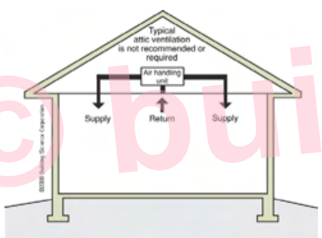
Combustion Safety

- **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

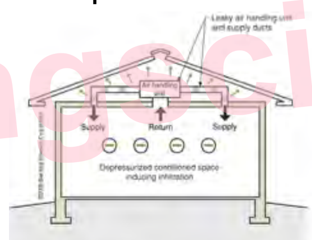


Unvented, Conditioned Attic allows HVAC inside conditioned space



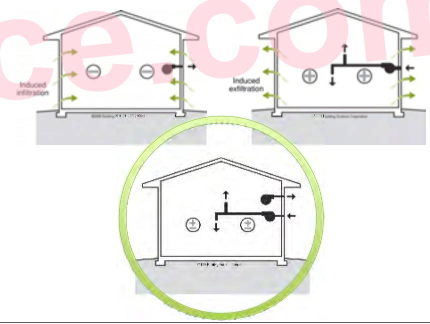
Note: Colored shading depicts the building's thermal enclosure and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

Not recommended: HVAC outside conditioned space



Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

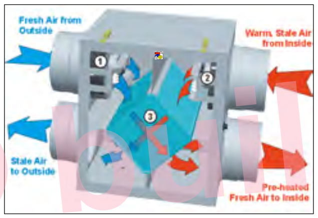
Provided Balanced Ventilation System



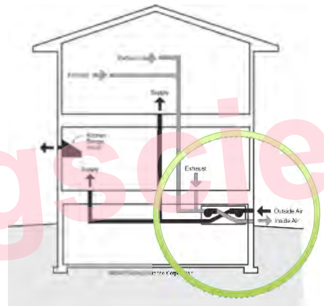
Indoor Air Quality

Mechanical Ventilation Required!!

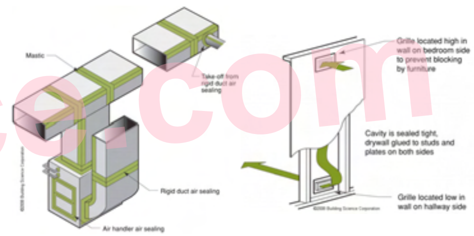
Maintain Indoor Humidity @ 50% or less in winter



Consider Heat Recovery in Cold Climates



Effective Distribution and Return Pathways for the Whole House



Building Science with Structural Insulated Panels (SIPs)

RESOURCES

Available at the SIPA Store – www.sips.org

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