SIPA
Structural Insulated Panel Association

SIPA Annual Meeting 2009

BUILDER'S GUIDE TO STRUCTURAL INSULATED PANELS (SIPs)

Introduction

Alex Lukachko, M.Arch
Building Science Corporation
Somerville, MA | Waterloo, ON
alex@buildingscience.com
(978) 589-5100

www.buildingscience.com

Building Science Approach to SIPs

- Building science background for recommendations made in the Builder's Guide
- Recommendations for Enclosure Design
  - Claddings, drainage planes and drainage gaps
  - Vapor open assembles
- Recommendations for Mechanical Design
  - Combustion safety, mechanical ventilation, and effective distribution
- Top Ten Lists for SIPs

The Five Fundamental Changes to Buildings

1. Increased thermal resistance,
2. A changing of the permeability of the linings that we put on the inside and outside of the building enclosures,
3. The water and mold sensitivity for building materials has been going up,
4. The ability for the building enclosure to store and redistribute moisture is going down, and
5. We now have complex three dimensional airflow networks that inadvertently couple the building enclosure to the breathing zone of the occupied space.

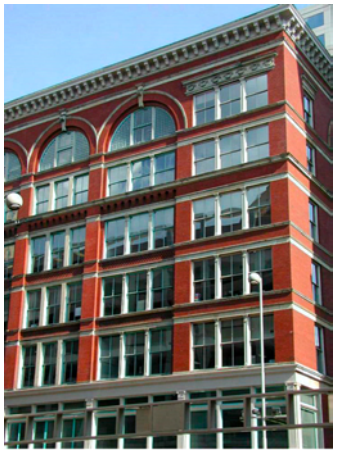
Builder's Guide to Structural Insulated Panels (SIPs)

ENCLOSURE DESIGN

The building enclosure must:

- Hold the building up
- Keep the rain water out
- Keep the ground water out
- Keep the wind out
- Keep the water vapor out
- Let the water and vapor out if they get in
- Keep the soil gas out
- Keep the heat in during the winter
- Keep the heat out during the summer
- Keep the noise out

An Irish Church from 1000 AD composed of just dry-stacked rock. Simple and durable, but hardly comfortable



Solid masonry with generous window area. Durable, functional with moderate R-value.

Light-weight Building 1.0 – The first frame building in Ellicottville, NY (1817) with balloon framing, non-standard wood elements and irregular spacings, fastened with both wood pegs and hand forged iron nails.

Lightweight Building 2.0 – Structural insulated panels form walls and roof, enclosing full volume within thermal envelope. (photo: Al Cobb, SIP School)

Functions of the Enclosure

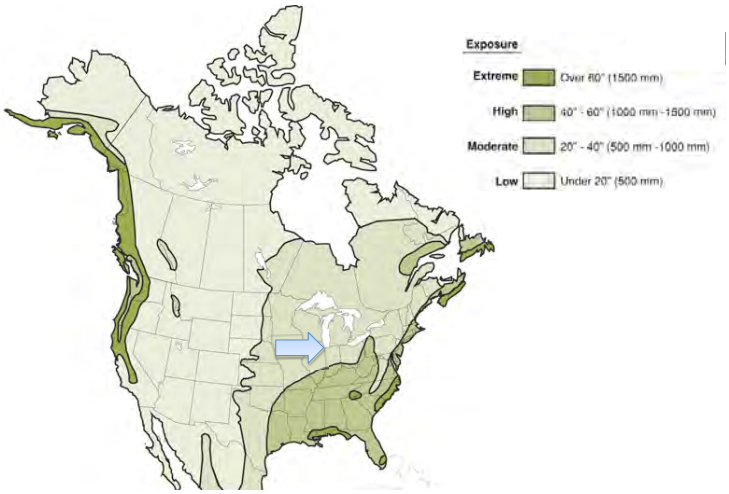
1. Support
2. Control
   - Rain water
   - Air
   - Water vapor
   - Heat
   - Sound
   - Light

   Area of focus for the Builder's Guide
3. Finish

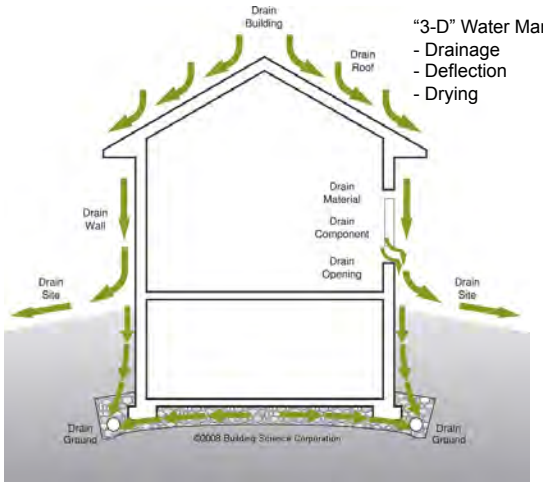
Builder's Guide to Structural Insulated Panels (SIPs)

RAIN WATER CONTROL

North America Average Annual Rainfall



Layering Materials to Shed Water

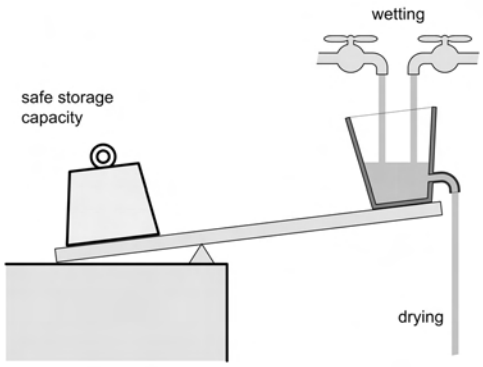


"3-D" Water Management
- Drainage
- Deflection
- Drying

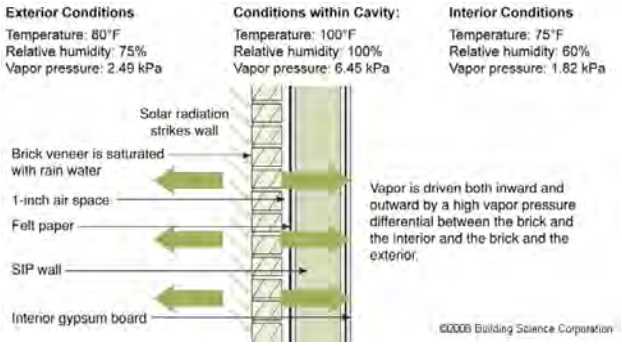
"3-D" approach to rain water management

- Deflection
- Drainage/Storage/Exclusion
- Drying

The Moisture Balance

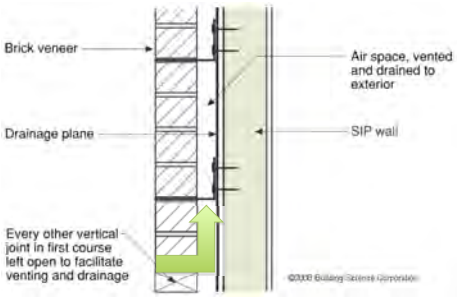


Reservoir Cladding and Solar Driven Moisture



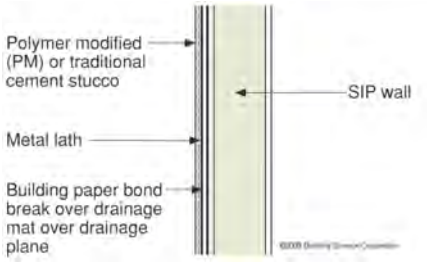
Brick Veneer Walls – "A Big Reservoir"

Provide Drainage Plane and Drainage Gap for "Reservoir" Claddings



Cedar Shingles, Traditional Stucco and Manufactured Stone Veneer Walls

Provide Drainage Plane and Drainage Gap



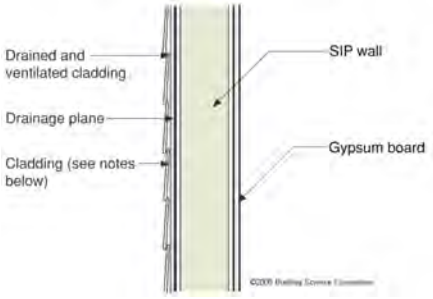
All claddings should be drained and back-ventilated where **annual rainfall exceeds 20 inches**

For Cedar Shingles, Traditional Stucco, and Manufactured Stone Veneer:

-install over 3/8-inch (9mm) drainage mat over a water resistive barrier

Wood or Fiber Cement-clad Walls

Provide Drainage Plane and Drainage Gap



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

For Wood and Fiber Cement Siding:

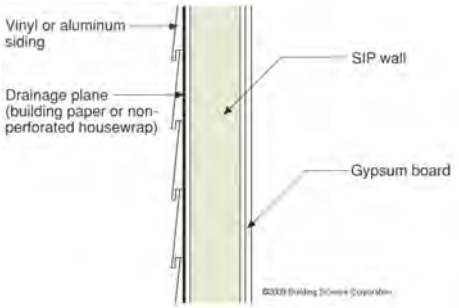
-install over a 1/4-inch (6mm) spacer strip over a water resistive barrier

Drained and Back-ventilated Siding

Drained and Back-ventilated Siding

Vinyl or Aluminum Clad Walls

Provide Drainage Plane and Drainage Gap



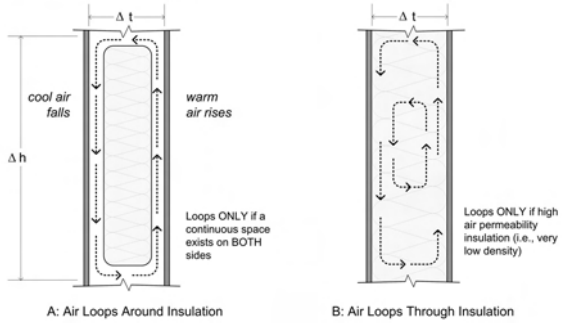
Can be used in all regions

Vinyl or Aluminum Siding is inherently back-ventilated

Builder's Guide to Structural Insulated Panels (SIPs)

AIRTIGHTNESS AND THERMAL CONTROL

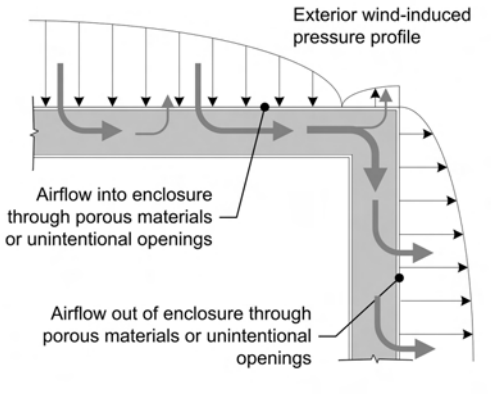
Convective Loops in Air-permeable Insulation



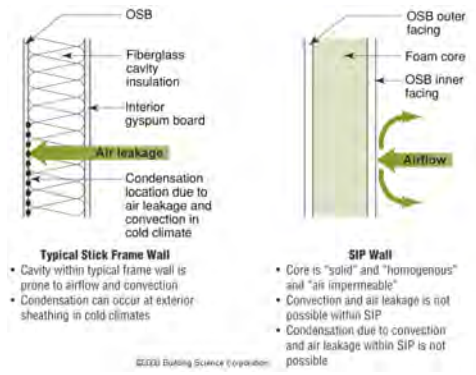
A: Air Loops Around Insulation

B: Air Loops Through Insulation

Wind-washing of Air-permeable Insulation



Frame Wall vs. SIP Wall

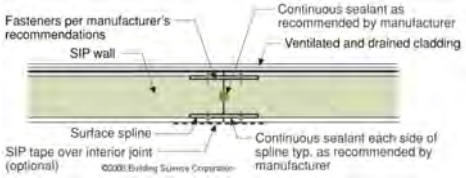


Typical Stick Frame Wall
- Cavity within typical frame wall is prone to airflow and convection
- Condensation can occur at exterior sheathing in cold climates

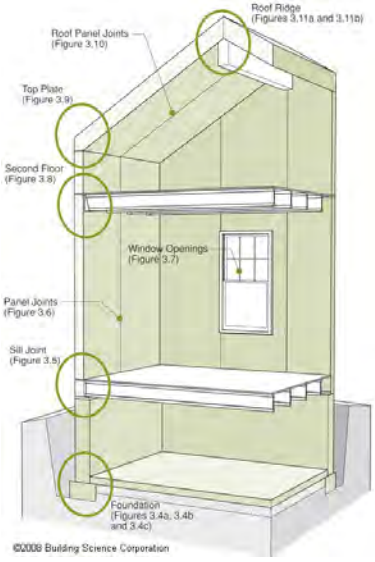
SIP Wall
- Core is "solid" and "homogenous" and "air impermeable"
- Convection and air leakage is not possible within SIP
- Condensation due to convection and air leakage within SIP is not possible

Thermal Control with SIPs

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



Important Details are in the Guide



Builder's Guide to Structural Insulated Panels (SIPs)

CONDITIONED ATTICS

Conditioned Attic Design

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

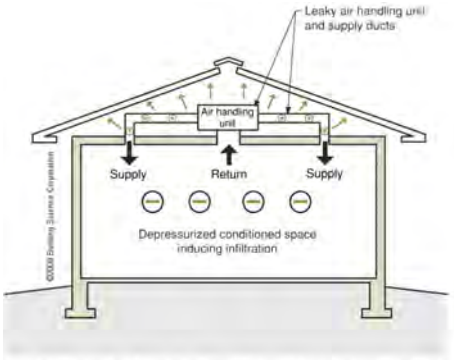
Why vent?

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

Other considerations:

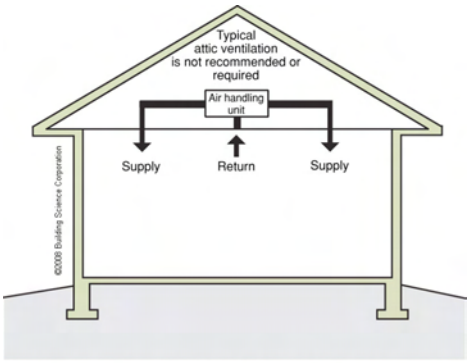
- Attic needed for living space
- Roof complexity makes venting difficult
- Locating HVAC system components

Not recommended: HVAC outside conditioned space



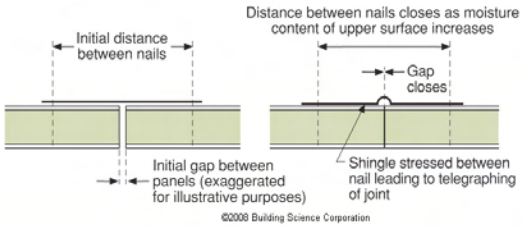
Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

Unvented, Conditioned Attic allows HVAC inside conditioned space

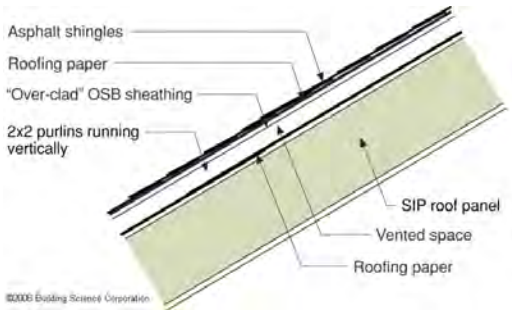


Note: Colored shading depicts the building's thermal enclosure and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

Telegraphing of Panel Joints



SIP Roof – Simple Cold Deck



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

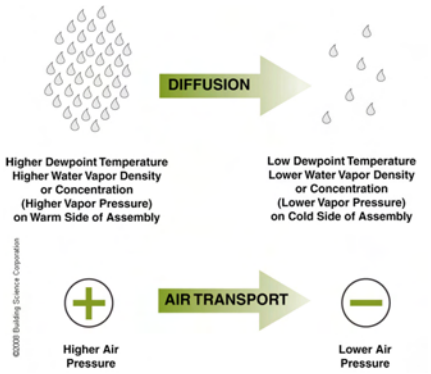
2007 Supplement to the International Residential Code

- R806.4 Unvented attic assemblies
- Table R806.4 Insulation for condensation control

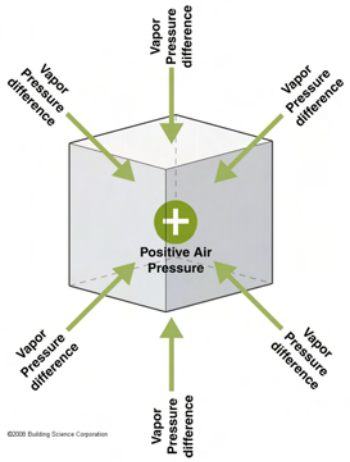
Builder's Guide to Structural Insulated Panels (SIPs)

WATER VAPOR CONTROL AND DRYING

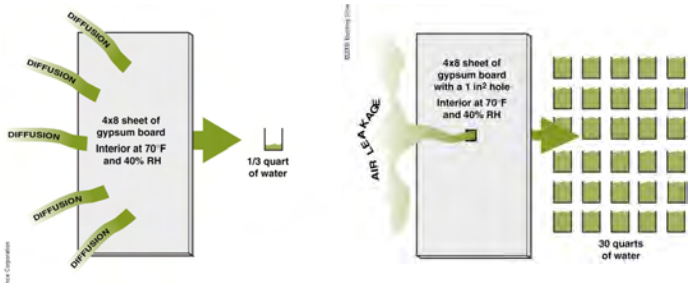
Theory: Diffusion vs. Air Leakage



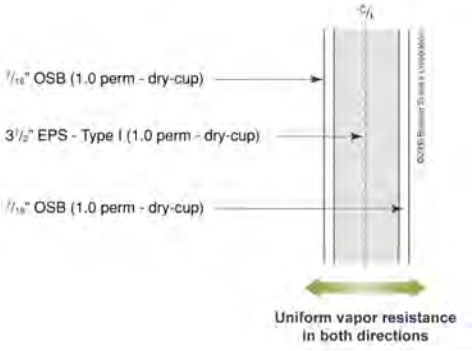
Air Pressure and Vapor Pressure



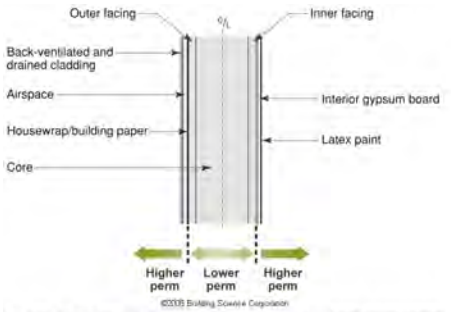
Diffusion vs. Air Leakage



SIPs - Bilateral Symmetry



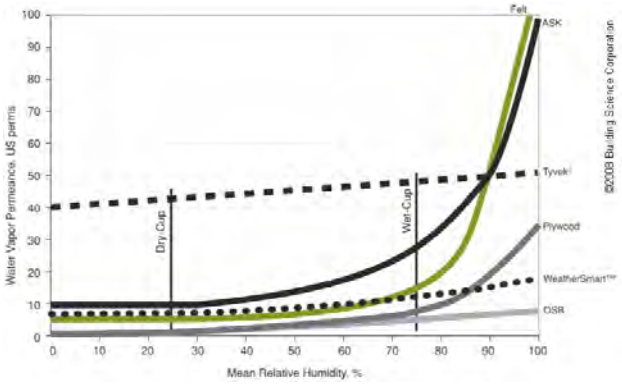
Design for Outward and Inward Drying



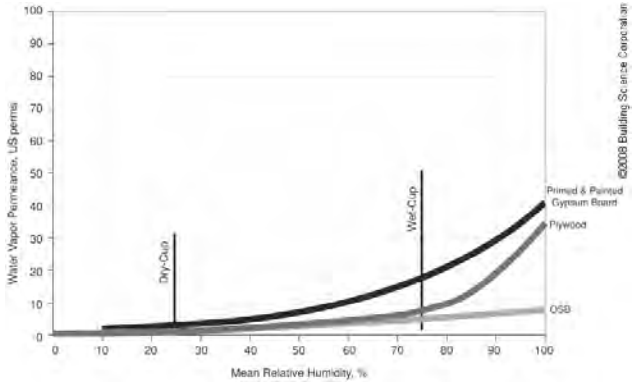
Outer Layer Towards Cladding
- Outer layer should be more vapor permeable than core
- Housewrap/building paper should be more permeable than outer layer
- Back-ventilating and draining exterior cladding makes exterior cladding more permeable than housewrap/building paper

Inner Layer Towards Interior Gypsum Board
- Inner layer should be more vapor permeable than core
- Painted interior gypsum board should be more vapor permeable than inner layer

Outward: Housewraps and Building Papers



Inward: Painted Gypsum Board



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

Builder's Guide to Structural Insulated Panels (SIPs)

HVAC FOR AIRTIGHT, ENERGY-EFFICIENT BUILDINGS

Combustion Safety

In an airtight SIPs house, all combustion sources must be considered:

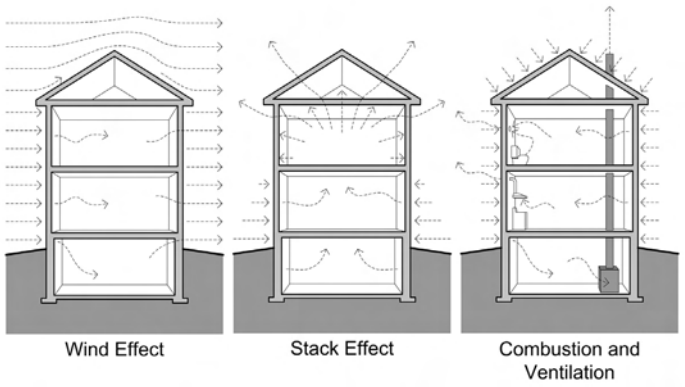
- Gas boiler, furnace or water heater
- Cooktop, oven or dryer
- Unvented gas fireplaces

Provide combustion air to each appliance and ensure that combustion gases do not interact with breathing space

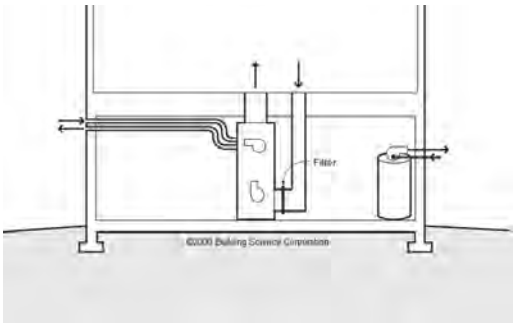
Use sealed combustion, direct or power-vented appliances

Do not use unvented gas or wood fireplaces

Air pressure driving forces



Use Sealed-Combustion, Power-Vented Equipment



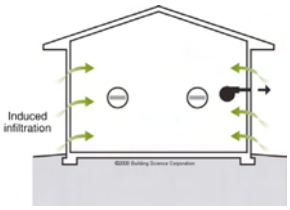
Provide mechanical ventilation

- SIP construction greatly reduces unintended infiltration and exfiltration
- Controlled mechanical ventilation is needed regardless of mechanical design

Our recommended approach:

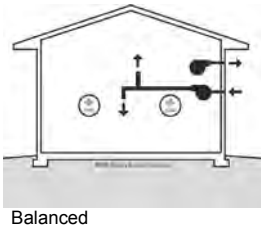
- Design system to meet ASHRAE 62.2 with controls to provide continuous ventilation at about half that rate.
- Many options

Mechanical Ventilation System Options



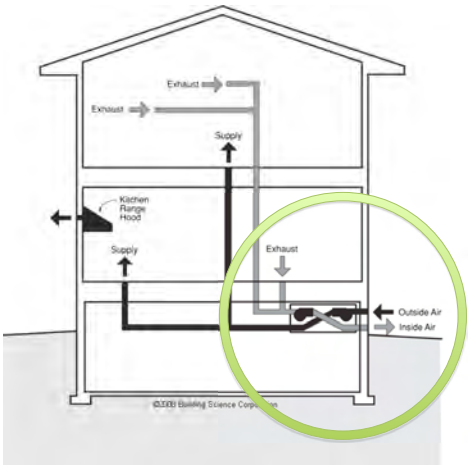
Exhaust

Supply, including CFIS



Balanced

Consider Heat Recovery in Cold Climates



Heat-loss Recovery Ventilator

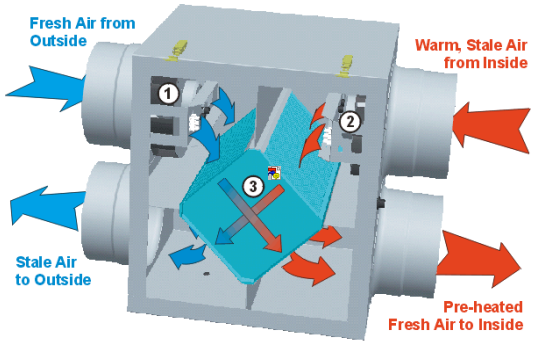


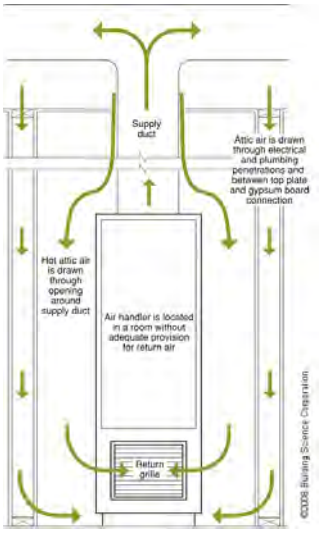
Image: Paul Malko, Foard Panel Inc.

Effective ventilation air distribution

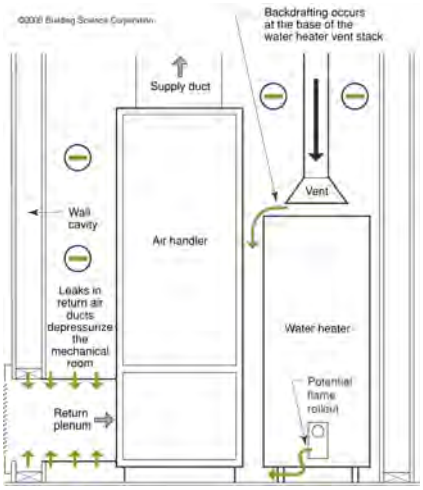
Unsealed ductwork can cause unintended air pressure interactions inside the building enclosure

- Seal ductwork with mastic (preferred) or tape, especially returns
- Provide continuous return pathways using transfer grilles and jump ducts
- Do not use interior wall or floor cavities as ducts

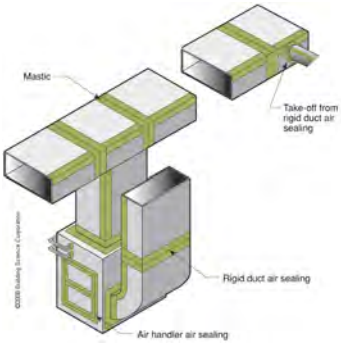
Air handler closet depressurization



Backdrafting in mechanical room



Effective Distribution and Return Pathways for the Whole House



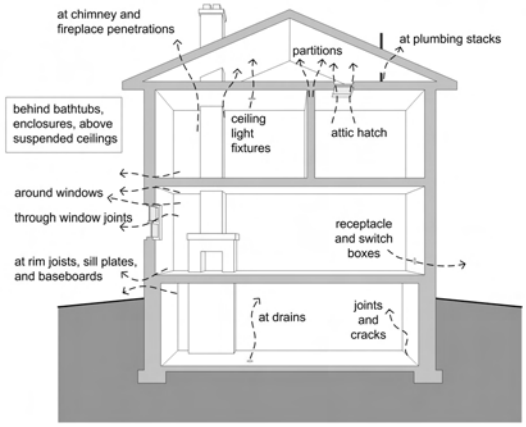
Builder's Guide to Structural Insulated Panels (SIPs)

TOP TEN LISTS

Top Ten Reasons Building Scientists Like SIPs

1. Panels are airtight and can be assembled into structures with little unintentional infiltration or exfiltration

Common Leakage Points



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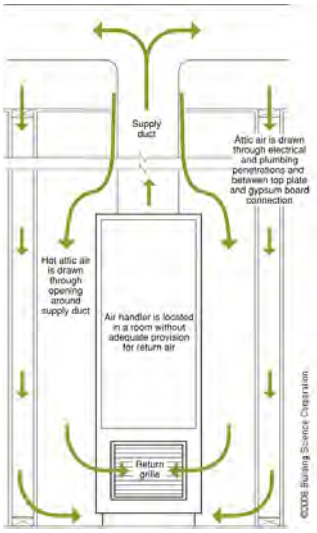
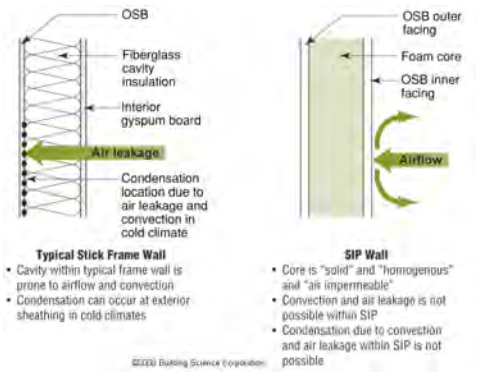
Air handler closet depressurization



Top Ten Reasons Building Scientists Like SIPs

1. Panels are airtight and can be assembled into structures with little unintentional infiltration or exfiltration
2. No wall cavities
3. Air impermeable, solid and homogenous insulation

Frame Wall vs. SIP Wall



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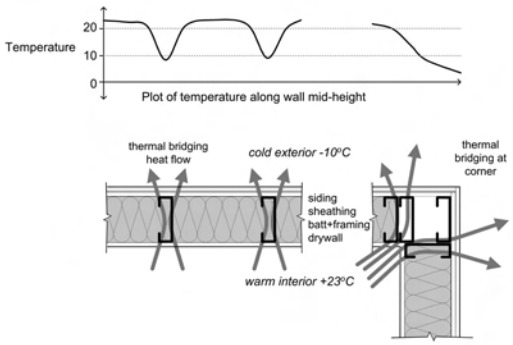
4. Far fewer thermal bridges

Thermal Bridging and Surface Temperature



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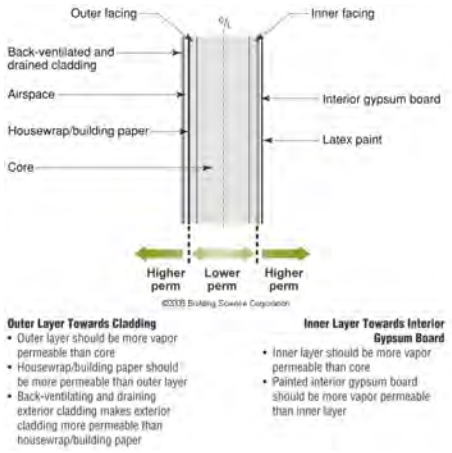
5. Panels are bilaterally symmetrical with respect to vapor permeance – appropriate for all climates

Design for Outward and Inward Drying



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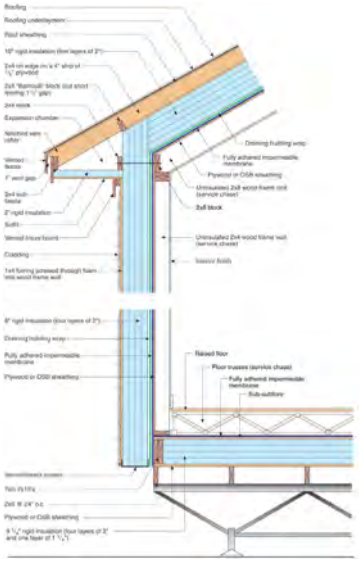
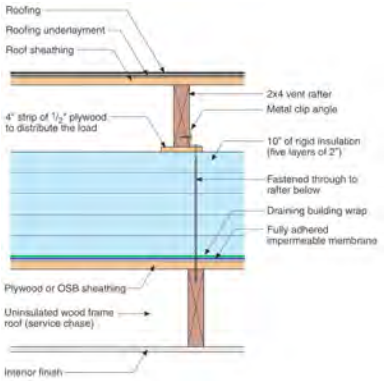
6. Easy to create conditioned attics (even with complex roof geometry)
7. Supports construction for extreme climate enclosures

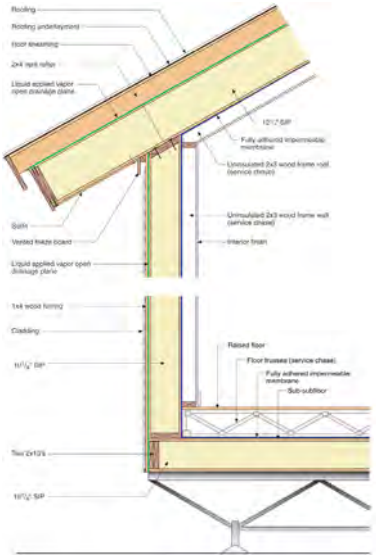
Extreme Cold Enclosure



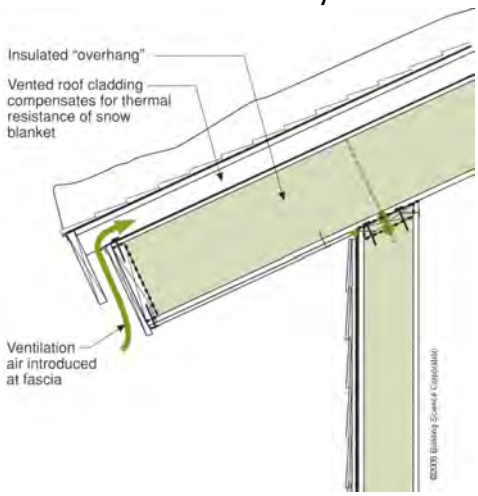
Extreme Cold Enclosure



Extreme Cold Enclosure



SIP Roof – Vented-Unvented Hybrid



Top Ten Reasons Building Scientists Like SIPs

1. Panels are airtight and can be assembled into structures with little unintentional infiltration or exfiltration
2. No wall cavities
3. Air impermeable, solid and homogenous insulation
4. Far fewer thermal bridges
5. Panels are bilaterally symmetrical with respect to vapor permeance – appropriate for all climates
6. Easy to create conditioned attics (even with complex roof geometry)
7. Supports construction for extreme climate enclosures
8. High snow load areas have insulated overhangs

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10. Control of heat and air is easily done leaving more time to get the water and water vapor control done right.

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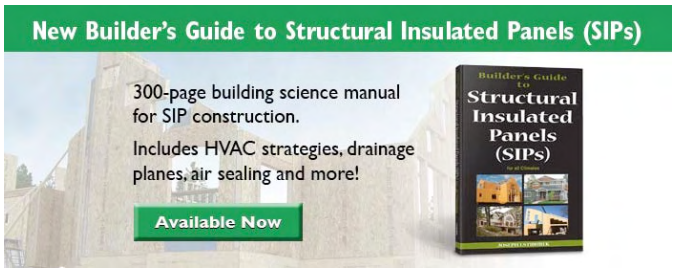
RESOURCES



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