Enclosing Timber Frames with Structural Insulated Panels

Frank Baker
Founder, Riverbend Timber Framing and Insulspan
Outline

• What are SIPs?
• Structural advantage of SIPs for timber frames
• Energy performance of SIPs
• Life cycle analysis
• Speed of installation
• Building science and durability
SIPA is a nonprofit association representing manufacturers, suppliers, dealer/distributors, design professionals, and builders committed to providing quality structural insulated panels for all segments of the construction industry.
Advantages of SIPs

- Energy savings
- Speed of installation
- Strength
- Sustainability
- Better indoor air quality
- Lifecycle cost savings
The fastest way to your energy-efficiency destination

- 2020 California Net Zero Energy
- 2012 IECC 30% Increase
- 2011 LEED for Homes 35% Increase
- 2030 Challenge Net Zero Energy Zero Carbon
- 2016 Building America 50% Increase
- 2012 ENERGY STAR v3 35% Increase
Structural Advantages

SIPs add considerable lateral load strength to timber frames

– Rob Erikson and Dick Schmidt, University of Wyoming

– Published in Timber Framing Journal 2002
Structural Advantages

• No such testing exists for stick frame

• Likely to have to sheath wall on both sides to equal strength of SIP

• Save on timber and labor
Energy Performance

Two factors effect the energy efficiency of the building envelope:

– Convective losses (air gaps in insulation,)

– Conductive losses (thermal bridging)
Air Infiltration

- Responsible for 30 – 50% of heating and cooling loss
- Blower door tests added to 2012 IECC
- Requirement for ENERGY STAR, Passive House, LEED for Homes
ORNL SIP Test Room

SIPs vs fiberglass insulation

Whole Room Air Infiltration

Cubic Feet Per Minute

SIPA
Structural Insulated Panel Association
ORNL Research Homes

5 homes built in Oak Ridge, TN
ORNL Research Homes

*Blower Door Test Results (ACH50)*

- ZEH1: 1.35
- ZEH2: 1.15
- ZEH3: 1.09
- ZEH4: 1.64
- Wood frame: 4
ZEBRAliance Research Homes

- Identical designs
- Built in 2009, 2009/10 was first heating season
- Houses controlled to simulate occupancy.
- Same windows, appliances, HVAC
Zebralliance Insulation Spec.

- Walls
  - 2x6 15% Framing Factor, Flash & batt – ½” spray foam + R-19 fiberglass batts
  - 6” SIP with EPS core
- Attic
  - R-35 Cathedral (SIPs 10-in)
  - R-50 Cathedral (aged phenolic) 2 X 12, 24in O.C.
ZEBRAAlliance Research Homes

Blower Door Test Results (ACH50)

- ZEBRA flash & batt: 1.23
- ZEBRA SIP: 0.74
Summary

- SIPS saved 21% more space heating energy than OVF
- SIPS scored a higher HERs Rating than OFV
  - SIPS attained 40% greater air tightness than OVF even though it was the Framing crews first SIP job.
  - Crew went to SIP school, then built same house with OVF.
- SIPS envelope went up in only 5 days compared to 15 for the OVF
Why the large difference in performance?

- Air leakage
- Thermal bridging
- FTC R-Value Myth, is it really R-19?
- ASTM Guarded Hot Box vs Whole Wall R-Value.
  - 75F test temp vs real world.
  - Tightly sealed box not a wall.
Benefits of Airtight Homes

- Better IAQ
- No cavity mold growth
- Smaller HVAC systems – cost savings
- Shorter duct runs
- Energy savings
Thermal Bridging

Stick

SIP
* Tests show that in the “worst case commonly found of procedures for installing batt insulation” the performance drops to R-11.
Building Science Corp. Wall Study

Software analysis of wall systems for cold climates

Available at www.buildingscience.com
ORNL Whole Wall R-Value Testing

4" SIP Wall

Nominal R-value: 14.4
Whole wall R-value: 14
## ORNL Whole Wall R-Value Testing

<table>
<thead>
<tr>
<th>Wall Type</th>
<th>Wall Cavity</th>
<th>R Value Face to Face</th>
<th>Insulation</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw Bale</td>
<td>19</td>
<td>10/75F</td>
<td>50/100F</td>
<td>26.97 Straw</td>
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<tr>
<td>SIP 6&quot;</td>
<td>5.675</td>
<td>22.26</td>
<td>21.72 EPS Core</td>
<td></td>
</tr>
<tr>
<td>Stud 2x6 Cellulose</td>
<td>5.5</td>
<td>13.52</td>
<td>14.59 EPS Core</td>
<td>Includes Drywall/OSB</td>
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<tr>
<td>SIP 4&quot;</td>
<td>3.675</td>
<td>15.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stud 2x6</td>
<td>5.5</td>
<td>14.4</td>
<td>FG Batt R 19, incl OSB/DW</td>
<td>Studies 16&quot; OC</td>
</tr>
<tr>
<td>Stud 2X6</td>
<td>5.5</td>
<td>13.74</td>
<td>Fiberglass Batt R 19</td>
<td></td>
</tr>
<tr>
<td>Stud 2x4 Cellulose</td>
<td>3.5</td>
<td>10.4</td>
<td>Includes Drywall/OSB</td>
<td></td>
</tr>
<tr>
<td>Stud 2x4</td>
<td>3.5</td>
<td>9.9</td>
<td>FG Batt R11, Incl OSB DW</td>
<td></td>
</tr>
<tr>
<td>Stud 2x4 25% FF</td>
<td>3.5</td>
<td>9.8</td>
<td>2&quot; Soy Foam/Cotton Batt</td>
<td></td>
</tr>
<tr>
<td>Stud 2x4 25% FF</td>
<td>3.5</td>
<td>9.65</td>
<td>1.59&quot; Soy Foam</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES**
None of the tests include air leakage in the heat loss.
Foam vs Fuzz

- Fiberglass and other types of fibrous insulation performance decreases as the Delta T increases.
- Foam insulation performance increases as the Delta T increases. EPS at 75F is 3.85, at 25 is 4.25. Over 10% increase.
- Yet the FTC labeling is fixed to the 75F standard.
Environmental Benefits

• Reduced energy use = less GHG emissions
• Reduced construction waste
• Fewer natural resources
• Indoor environmental quality
• Points in LEED, National Green Building Standard
Green Building

National Green Building Standard Certified.
Performance starts with the building envelope.

SIPA
Structural Insulated Panel Association
Green Building

LEED Platinum, EVHA Winner
0.86 ACH50
Life Cycle Analysis

EPS Molders Association
SIPs Work Group and Franklin Associates

**STRUCTURAL INSULATED PANELS**

**REDUCE GLOBAL WARMING**

**Life Cycle Benefits of SIPs**

The basic design concept for SIPs is elegant in its simplicity, and offers several advantages for constructing walls and roofs. There is general agreement that SIPs provide better overall air tightness and practical thermal performance than conventionally framed walls.

- NAHB Research Center

**SIPs Environmental Advantage**

By providing substantial energy savings and critical reductions in greenhouse gas emissions, the energy invested in the production and delivery of SIPs yields an exponential benefit to the environment, when compared to traditional stick framing.

The exceptional performance of SIPs as an insulator coupled with low air leakage for the built environment offers the construction industry the tools and technology needed to achieve superior thermal performance while making a significant and restorative contribution to the reduction of global warming.

This Environmental Profile summarizes a life cycle analysis conducted by Franklin Associates for the EPS Molders Association’s Work Group. The study was to quantify the energy savings and greenhouse gas reductions provided by SIPs vis-à-vis traditional stick construction.

Study results present a powerful case for the significant contributions SIPs provide in making homes more efficient, comfortable and environmentally sustainable.

A representative single-family home was the model used to illustrate the properties and performance of SIPs with EPS insulation compared to stick-framed construction. The total insulated wall area of the home modeled was 1,792 sq. ft.

The stick-framed home was constructed with 2x6 dimensionally lumber 24 in. on center, R-19 Insulfoam insulation,umen, and R-21 fiberglass batt insulation. The SIP home was constructed with 3-1/2” SIPs with an EPS core and dimensional lumber planking.

Both homes were clad with wood siding on the exterior and finished with 1/2” gypsum drywall on the interior. The study evaluated the environmental effects of using SIPs as an alternative to the stick-framed wall.

**Performance Model**

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Life Cycle Analysis

Technique to assess each and every impact associated with all the stages of a process from-cradle-to-grave

(i.e., from raw materials through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling)
Life Cycle Analysis

Goal and Scope:

– Model Structure - 1,791 sq. ft. wall area
– Walls SIPs vs 2x6 framing, R-19 fiberglass and vapor retarder
– Calculate Energy and GWP Impact
  • Whole wall R-Value
  • Heating/Cooling
  • Air Leakage
Life Cycle Analysis

- Additional energy investment recouped 10x over life of a home
- Energy payback in 5.1 years
- Global Warming Potential (GWP) payback in 3.8 years
BASF Eco Efficiency Analysis

Resource efficiency - LCA
Speed of Construction

- Independent R.S. Means study shows 55% labor savings over stick frame in residential construction
- 11% savings on electrical rough-in
Speed of construction

Labor savings – 8’ x 24’ panels
Speed of Construction

Labor savings – CNC fabrication

Structural Insulated Panel Association
Speed of Construction

Labor savings – dormers and preassembly
Cost Savings

- Trim installation
- Waste disposal
- Shortened duct runs
- Smaller HVAC
- Less skilled labor needed
- Overhead/construction loan
Economics of SIPs

What are you comparing it to?

– What will be required to reach low level of air infiltration?

– Eliminating thermal bridging?
Economics of SIPs

Material costs vs installed costs

Upfront costs vs lifecycle costs
  – Energy efficiency
  – Durability
  – Higher value for green buildings
Building Science

New Builder’s Guide to Structural Insulated Panels (SIPs)

300-page building science manual for SIP construction. Includes HVAC strategies, drainage planes, air sealing and more!

Available Now

By Joe Lstiburek, Building Science Corporation

SIPA
Structural Insulated Panel Association
Building Science – Airtight Homes

• Low levels of air infiltration demand mechanical ventilation

• Work with qualified HVAC professional

• Sealed combustion appliances
Building Science – Airtight Homes

• Ventilation options climate specific:
  – ERV/HRV
  – Fan cycler

• Exhaust moisture-laden air and supply fresh air
  – Filtered system removes allergens
  – Superior IAQ
Building Science – Air Sealing

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

©2008 Building Science Corporation
Moisture in improperly sealed joint
Building Science – Air Sealing

Follow manufacturer details
Building Science – Air Sealing

Air infiltration – sealing methods

Mastic

Expanding Foam
Building Science – Air Sealing

Air sealing – SIP tape

Draped over ridge beam
Building Science – Detailing

- Prevent vapor intrusion – sealing
- Protect from bulk water – WRB
- Create a way for assemblies to dry
  - Drainage plane in wet climates
  - Cool roof in wet climates
Wall Cladding

Siding should be back-ventilated in areas with annual rainfall greater than 20”
Wall Cladding

Drainage plane with ventilated cladding
Wall Cladding

Ventilated cladding with ¼” thick strips of foam sheathing
Wall Cladding

Ventilated cladding with drainage mat
Roofing should be ventilated (cool roof) in areas with annual rainfall greater than 20".
Roofing

Diagonal lath under metal roofing
Penetrations

- Prevent vapor intrusion:
  - Expanding foam
  - Caulking
- Protect from bulk water:
  - Flashing
Questions?