Technical Activities Committee Update

2017 SIPA Annual Meeting & Conference
Austin, TX

Technical Committee Chair: Tom Williamson, Timber Engineering, LLC
Call to Order and Welcome

Restraint of Trade Statement

Review and approval of minutes of last TAC meeting held jointly with Manufacturers Committee (July 21, 2016)
Technical Activities

- Joint FPL/SIPA creep testing project
- Joint FPL/APA/SIPA testing of SIP shear wall performance
- Joint FPL/SIPA aspect ratio and walls with openings testing
- NTA/SIPA Design Guide for SIPS
- ASTM D07.02.08 Standard on Structural Insulated Panels
- Update on SIP Research in Canada
- MSU Study on Lignin Based Polyurethane Cores for SIPS
- Timber Frame Engineering Council Symposium
- New Research Projects
- Next Meeting/Adjournment
Creep Testing – APA/FPL/SIPA Pilot Study

Results published as FPL Research Note FPL–RN–0332

No significant strength loss (Pmax) was observed after 90 days of creep loading and 30 days of unloading.
FPL Pilot Study Creep Testing Results

Specimens tested under both shear critical (APA) and moment critical loading (FPL) configurations using 3 load levels as shown:

- 11% of $P_{max}$
- 22% of $P_{max}$
- 33% of $P_{max}$

Recovered approximately 95% of the creep deflection after 30 days relaxation

Results led to Phase II test program
Short term bending testing of twenty-eight 12-1/4” deep specimens and twenty-eight 6-1/2” deep specimens completed to determine test loads for creep testing.
2015/2016 FPL Creep Testing of SIPs
Short Term Bending Tests

Typical Static Bending Failure (12-1/4”)

Typical Static Bending Failure (6-1/2”)

SIPA Structural Insulated Panel Association
<table>
<thead>
<tr>
<th>Pre-Creep  6-1/2”</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PMax (lbf)</strong></td>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td></td>
<td>1031.8</td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
<td>85.9</td>
</tr>
<tr>
<td>5% PE = mean - 1.645 * std. dev.</td>
<td>890.5</td>
</tr>
<tr>
<td>5% PTL with 75% confidence = mean – 1.878 * std. dev.</td>
<td>870.5</td>
</tr>
<tr>
<td><strong>Pre-Creep  12-1/4”</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Quantity  28</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>1013.6</td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
<td>68.2</td>
</tr>
<tr>
<td>5% PE = mean - 1.645 * std. dev.</td>
<td>901.5</td>
</tr>
<tr>
<td>5% PTL with 75% confidence = mean – 1.878 * std. dev.</td>
<td>885.6</td>
</tr>
</tbody>
</table>

**Creep Test Load = Pmax/3 ~ 350 lbs**
<table>
<thead>
<tr>
<th>Test #</th>
<th>Sample Depths</th>
<th>Sample Width(a)</th>
<th>Span(a)</th>
<th>Load Level</th>
<th># of Samples</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6-1/2 in.</td>
<td>12 in.</td>
<td>118.5”</td>
<td>To failure</td>
<td>28</td>
<td>1 min.</td>
</tr>
<tr>
<td>1a</td>
<td>6-1/2 in.</td>
<td>12 in.</td>
<td>118.5”</td>
<td>350 lbs.</td>
<td>28</td>
<td>90 days</td>
</tr>
<tr>
<td>2</td>
<td>12-1/4 in.</td>
<td>12 in.</td>
<td>226.5”</td>
<td>To failure</td>
<td>28</td>
<td>1 min.</td>
</tr>
<tr>
<td>2a</td>
<td>12-1/4 in.</td>
<td>12 in.</td>
<td>226.5”</td>
<td>350 lbs.</td>
<td>28</td>
<td>90 days</td>
</tr>
</tbody>
</table>
2015/2016 FPL Creep Testing of SIPs

90 day testing of twenty-eight 12-1/4” deep specimens and twenty-eight 6-1/2” deep specimens under creep load completed + 30 days with load removed
2015/2016 FPL Creep Testing of SIPs
Creep Deflection Curves

CREEP DEFLECTION OVER TIME,
12-1/4" DEEP SPECIMENS

DEFLECTION INCHES

TEST TIME, DAYS

12-1/4" Specimens
2015/2016 FPL Creep Testing of SIPs
Creep Deflection Curves

Creep Deflection Over Time, 6-1/2" Deep Specimens

6-1/2" Specimens
### 2015/2016 FPL Creep Testing of SIPs Results

<table>
<thead>
<tr>
<th></th>
<th>12-1/4&quot; Deep Specimens</th>
<th>6-1/2&quot; Deep Specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static failure load of control specimens, lbs</td>
<td>1013.6</td>
<td>1031.8</td>
</tr>
<tr>
<td>Deflection of control specimens at failure, in</td>
<td>1.251</td>
<td>1.031</td>
</tr>
<tr>
<td>Initial elastic deflection at start of creep test, in</td>
<td>0.452</td>
<td>0.400</td>
</tr>
<tr>
<td>Additional deflection due to creep behavior, in</td>
<td>0.189</td>
<td>0.116</td>
</tr>
<tr>
<td>Total deflection, in</td>
<td>0.641</td>
<td>0.516</td>
</tr>
<tr>
<td>Initial elastic recovery at removal of long-term load, in</td>
<td>-0.391</td>
<td>-0.397</td>
</tr>
<tr>
<td>Additional recovery due to creep behavior, in</td>
<td>-0.209</td>
<td>-0.077</td>
</tr>
<tr>
<td>Total deflection recovered, in</td>
<td>-0.600</td>
<td>-0.474</td>
</tr>
<tr>
<td>Static failure load of post creep-tested specimens, lbs</td>
<td>916.8</td>
<td>1043.3</td>
</tr>
<tr>
<td>Deflection of post creep-tested specimens at break, in</td>
<td>1.048</td>
<td>1.140</td>
</tr>
</tbody>
</table>
## 2015/2016 FPL Creep Testing of SIPs Results

<table>
<thead>
<tr>
<th></th>
<th>12-1/4&quot; Deep Specimens</th>
<th>6-1/2&quot; Deep Specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creep deflection, as a percentage of initial elastic deflection</td>
<td>42%</td>
<td>29%</td>
</tr>
<tr>
<td>Creep deflection, as a percentage of break deflection</td>
<td>15%</td>
<td>11%</td>
</tr>
<tr>
<td>Total deflection recovery, as a percentage of total creep test deflection</td>
<td>94%</td>
<td>92%</td>
</tr>
<tr>
<td>Static bending strength of post-creep tested specimens as a percentage of control specimen strength</td>
<td>90%</td>
<td>101%</td>
</tr>
</tbody>
</table>
SIPA/ FPL/APA test program on effects of boundary conditions on SIP shear wall performance

Project co-funded by:
- FPL ($40,000)
- APA ($8,000)
- SIPA ($5,000)

Cyclic testing of twenty-six 8x8 wall assemblies and monotonic testing of three 8x8 wall assemblies completed in July, 2016
SIPA/ FPL/APA test program on effects of boundary conditions on SIP shear wall performance

Test Variables

- Test protocol (monotonic and cyclic)
- Nail size for panel connection (8d Box vs. 8d Common)
- Nail spacing (6 inches, 4 inches, and 3 inches)
- Wall bearing type (wood vs. steel bearing)
- Spline type (block spline vs. 2-2x lumber spline)
- Number of panel joints (no joint, 1 joints, 2 joints, and 3 joints)
- SIP thickness (4-1/2 inches vs. 6-1/2 inches)
- Orientation of OSB facers (strength axis horizontal vs. vertical)
- Bottom plate washer geometry (square, large round, and small round)
SIPA/ FPL/APA test program on effects of boundary conditions on SIP shear wall performance

<table>
<thead>
<tr>
<th>Test Series</th>
<th>Purpose (Compared to Basic Wall)</th>
<th>Test Assembly Size</th>
<th>Test Protocol</th>
<th>Replicates</th>
<th>SIP Segment</th>
<th>Deviation from Basic Wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Effect of test protocol</td>
<td>8’ x 8’</td>
<td>ASTM E72</td>
<td>3</td>
<td>4’ x 8’</td>
<td>Monotonic test protocol</td>
</tr>
<tr>
<td>2</td>
<td>Basic wall</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td>Basic wall configuration</td>
</tr>
<tr>
<td>3</td>
<td>Effect of nail size</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>8d Common (0.131” X 2-1/2”)</td>
</tr>
<tr>
<td>4a</td>
<td>Effect of nail spacing</td>
<td></td>
<td></td>
<td>2</td>
<td>4” nail spacing</td>
<td>3” nail spacing</td>
</tr>
<tr>
<td>4b</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>4” nail spacing</td>
</tr>
<tr>
<td>5</td>
<td>Effect of spline nailing</td>
<td></td>
<td>ASTM E2126 (Method 3, CUREE)</td>
<td>2</td>
<td></td>
<td>Modified basic wall configuration (12” nail spacing at spline)</td>
</tr>
<tr>
<td>6</td>
<td>Effect of spline type</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>(2) 2x Lumber spline</td>
</tr>
<tr>
<td>7a</td>
<td>Effect of number of panel joints</td>
<td></td>
<td></td>
<td>2</td>
<td>8’ x 8’</td>
<td>1 SIP segment (no panel joints)</td>
</tr>
<tr>
<td>7b</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>32” x 8’</td>
<td>3 SIP segments (2 panel joints)</td>
</tr>
<tr>
<td>7c</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>24” x 8’</td>
<td>4 SIP segments (3 panel joints)</td>
</tr>
<tr>
<td>8</td>
<td>Effect of SIP thickness</td>
<td></td>
<td></td>
<td>2</td>
<td>4’ x 8’</td>
<td>6-1/2” SIP thickness</td>
</tr>
<tr>
<td>9</td>
<td>Effect of sheathing orientation</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>Modified basic wall configuration with horizontal sheathing</td>
</tr>
</tbody>
</table>

Total number of tests: 26

*Monotonic Test to be conducted using ASTM E72 and ASTM E564
Basic Wall Test Setup

Load Head
>10 x SDS Screws
evenly spaced

4x Block Spline
(provided)

6" o.c. nail spacing
(3/8" from edge)
Both Sides
8d box nails

2" x 6" Treated SPF (or equiv.)
Sill Plate (No.2 or Better)

3/4" Bolt
bore 1" deep hole in foam

6" o.c. nail spacing
(3/8" from edge)
Both Sides
8d Box nails

2" x 6" Untreated SPF Cap Plate
(No.2 or Better)

6" o.c. nail spacing
(3/8" from edge)
Both Sides
8d box nails

Two 2" x 4" end-post
12 x SDS Screws
~6.5" spacing
staggered in both directions

HDQ-8 Hold-down
12 x SDS Screws
evenly spaced

3/4" Bolt
Basic wall, 2 panels, 0.113-inch-diameter (8d box) nails spaced at 6 inches on center on wall perimeter.
Wall fabricated with four SIP pieces, 24 inches wide per piece. Perimeter nails of 0.113-inch-diameter nails spaced at 6 inches on center.
Example Cyclic Data

Backbone curves comparing 8d Box nails (Wall 2a) with 8d Common nails (Wall 3a).
Example Cyclic Data

Backbone curves comparing 8d Box nails spaced at 6 inches (Wall 2a), 3 inches (Wall 4a), and 4 inches (Wall 4b) on center.
Example Cyclic Data

Backbone curves comparing walls with 1 joint (Wall 2a), zero joints (Wall 7a), 2 joints (Wall 7b), and 3 joints (Wall 7c).
Test Results

- **Test protocol (monotonic and cyclic):** Testing based on ASTM E72 and ASTM E2126 resulted in similar ultimate loads. Testing based on ASTM E564 and ASTM E2126 resulted in similar deflection profiles, but the ultimate load from monotonic (ASTM E564) tests was approximately 12% lower than the cyclic (ASTM E2126) tests. There is not enough evidence to conclude that ASTM E564 will result in a significantly lower ultimate load than the other test methods.

- **Nail size for panel connection (8d Box and 8d Common):** Data showed that there was no practical difference in the ultimate load between SIP walls constructed with these two nail sizes.

- **Nail spacing (6 inches, 4 inches, and 3 inches):** Data showed that a decrease in nail spacing from 6 to 4 inches and from 6 to 3 inches on center resulted in an ultimate load increase of 27% and 58%, respectively.
SIPA/ FPL/APA test program on effects of boundary conditions on SIP shear wall performance

Test Results

• Wall bearing type (wood and rigid steel bearing): Data showed that when SIPs bear on steel, as compared to SPF bottom plates, the ultimate load was reduced by approximately 15%. However, the effect of bearingplate types on cyclic performance parameters was not significant.

• Spline type (Block spline and 2-2x lumber spline): Data showed that the difference in the ultimate load is insignificant (less than 5%).

• Number of panel joints (no joint, 1 joint, 2 joints, and 3 joints): Data showed that the number of panel joints and the aspect ratio of the individual SIP segments clearly had an effect on the cyclic performance. The more number of joints, the higher the ductility capacity of the SIP walls. As compared to 1 panel joint, zero joint resulted in an increase of around 10% in ultimate load, while 2 and 3 joints resulted in a reduction of ultimate load of 11% and 17% respectively.
Test Results

- **SIP thickness (4-1/2 inches and 6-1/2 inches):** Data showed that the ultimate load is similar between SIP wall thicknesses of 4-1/2 and 6-1/2 inches (less than 7%).

- **Orientation of OSB facers (strength axis horizontal and vertical):** Data showed that cross-oriented (horizontally oriented) facers resulted in a marginal (approximately 10%) reduction in the ultimate load, as compared to vertically oriented OSB facers.

- **Bottom plate washer geometry (square and round):** Data showed no difference between large and standard round washers. However, the squared washers showed a 13% higher ultimate load. However, since the failure modes were often associated with the top plate, but virtually never associated with the bottom plate, the difference in the ultimate load between squared and round washers is recommended to be further studied.
FPL/SIPA Aspect Ratio and Walls with Opening Testing

- Extension of HIRL Study in 2013: *SIP Shear Walls: Cyclic Performance of High Aspect Ratio Segments and Perforated Walls*

- HIRL study demonstrated that a SIP perforated shear wall performs like a traditional perforated shear wall but more testing needed.

- FPL staff and SIPA member representatives developed study plan to incorporate testing of 54 SIP wall assemblies

- Testing for aspect ratio testing (24 tests) completed in December 2016

- Testing for walls with openings initiated in January 2017
## Test plan

### Summary of Structural Insulated Panel Lateral Wall Tests

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>No of Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Aspect Ratio Tests With Anchor Bolts Only</strong></td>
<td></td>
</tr>
<tr>
<td>SP128A</td>
<td>2 by 8 SIP Panel Wall Test - Anchor Bolts Only</td>
<td>3</td>
</tr>
<tr>
<td>SP138A</td>
<td>2 ½ by 8 SIP Panel Wall Test - Anchor Bolts Only</td>
<td>3</td>
</tr>
<tr>
<td>SP148A</td>
<td>4 by 8 SIP Panel Wall Test - Anchor Bolts Only</td>
<td>3</td>
</tr>
<tr>
<td>SP188A</td>
<td>8 by 8 SIP Panel Wall Test - Anchor Bolts Only</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Aspect Ratio Tests With Hold Downs</strong></td>
<td></td>
</tr>
<tr>
<td>SP128H</td>
<td>2 by 8 SIP Panel Wall Test - Hold downs</td>
<td>3</td>
</tr>
<tr>
<td>SP138H</td>
<td>2 ½ by 8 SIP Panel Wall Test - Hold downs</td>
<td>3</td>
</tr>
<tr>
<td>SP148H</td>
<td>4 by 8 SIP Panel Wall Test - Hold downs</td>
<td>3</td>
</tr>
<tr>
<td>SP188H</td>
<td>8 by 8 SIP Panel Wall Test - Hold downs</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Multiple SIP Panel Wall Tests Without Openings</strong></td>
<td></td>
</tr>
<tr>
<td>SP248A</td>
<td>8 by 8 SIP Wall constructed with 2 - 4 by 8 Panels (Anchored)</td>
<td>3</td>
</tr>
<tr>
<td>SP348A</td>
<td>8 by 12 SIP Wall constructed with 3 - 4 by 8 Panels (Anchored)</td>
<td>3</td>
</tr>
<tr>
<td>SP548A</td>
<td>8 by 20 SIP Wall constructed with 2 - 4 by 8 Panels (Anchored)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Multiple SIP Panel Wall Tests With Various Openings Sizes</strong></td>
<td></td>
</tr>
<tr>
<td>SP5201</td>
<td>8 by 20 SIP Wall with openings - Configuration 1</td>
<td>3</td>
</tr>
<tr>
<td>SP5202</td>
<td>8 by 20 SIP Wall with openings - Configuration 2</td>
<td>3</td>
</tr>
<tr>
<td>SP5203</td>
<td>8 by 20 SIP Wall with openings - Configuration 2</td>
<td>3</td>
</tr>
<tr>
<td>SP5204</td>
<td>8 by 20 SIP Wall with openings - Configuration 4</td>
<td>3</td>
</tr>
<tr>
<td>SP5205</td>
<td>8 by 20 SIP Wall with openings - Configuration 5</td>
<td>3</td>
</tr>
<tr>
<td>SP5206</td>
<td>8 by 20 SIP Wall with openings - Configuration 6</td>
<td>3</td>
</tr>
<tr>
<td>SP5207</td>
<td>8 by 20 SIP Wall with openings - Configuration 7</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Maximum Number of Lateral Shear Wall Tests:</strong></td>
<td>54</td>
</tr>
</tbody>
</table>
FPL/SIPA Aspect Ratio Testing

General Notes:
- Wall Heights: 8'
- Wall Thickness: 6 1/2 in.
- 8d box nails (0.113-in by 2 1/2 in.)
- All framing No. 2 or better SPF
  - 2 - 2 by 6 End Studs
  - 2 by 6 Top and Bottom Plates
  - 2 by 8 Cap Plate (Trimmed)
  - 2 by 8 Sill Plate (Trimmed)
- 3/8" diameter anchor bolts with round washers attached only to sill plate
- 8d common nail (0.131-in by 2 1/2 in) fasten sill and bottom plate
- Simpson strong-tie hold downs sized for test

Detail of SIP Wall Test Fabrication
FPL/SIPA Aspect Ratio Testing

4 by 8 SIP Wall Test

8 by 8 SIP Wall Test

General Notes:
- Wall Heights: 8'
- Wall Thickness: 6 1/2 in
- #8 box nails (0.113-in by 2 1/2 in)
- All framing No. 2 or better SPF
  - 2 x 2 by 6 End Studs
  - 2 by 6 Top and Bottom Plates
  - 2 by 8 Cap Plate (Trimmed)
  - 2 by 8 Sill Plate (Trimmed)
- 7/8" diameter anchor bolts with round washers attached only to sill plate
- #8 common nail (0.131-in by 2 1/2 in) fasten sill and bottom plate
- Simpson strong-tie hold downs sized for test
FPL/SIPA Aspect Ratio Testing

8x8 wall test with hold downs

8x8 wall test with anchor bolts
FPL/SIPA Aspect Ratio Testing

Comparison of APA and FPL tests for 8x8 walls
Comparison of use of hold downs vs. anchor bolts only for 8x8 walls
FPL/SIPA Walls with Openings Testing

General Notes:
- Wall Heights: 8'
- Wall Thickness: 6.1 in
- 1d Box nails (0.33-in by 2 1/2 in)
- All framing No. 2 or better SPF
- 2 - 2 by 8 End Studs
- 2 by 6 Top and Bottom Plates
- 2 by 8 Cripple (Trimmed)
- 2 by 8 Sill Plate (Trimmed)
- 3/8" diameter anchor bolts with round washers attached only to sill plate
- 1d common nail (0.33-in by 2 1/2 in) fastens sill and bottom plate
- Simpson strong tie hold downs sized for test
- Box spline with 1d box nails at 6-in. oc

5 - 4 by 8 SIP Blocked Spline Wall Test

Detail of SIP Wall Test Fabrication

Detail of SIP Wall Block Spline
FPL/SIPA Walls with Openings Testing

8x20 wall with five 4x8 panels
FPL/SIPA Walls with Openings Testing

8x20 wall with single opening
FPL/SIPA Walls with Openings Testing

8x20 wall with two openings
Design Guide Development on schedule with NTA

4 year project which also includes developing software for the design of SIPs

TAC Task Group review of Design Guide drafts completed

Joint TAC and MFR Committee webinar on Design Guide presented by NTA staff

Members of SIPA invited to provide input to NTA
ASTM Standard for Establishing and Monitoring Structural Capacities of Structural Insulated Panels

The completed ASTM Standard on SIPs will provide a single test standard for which SIPs can be evaluated

Draft document in process at ASTM D07.02.08 Section Committee level. Numerous ballots completed.

After Section Committee level approval the standard will be balloted at the ASTM D07.02 Subcommittee level.

Once it passes the D07.02 Subcommittee it will be submitted to the main ASTM D07 committee for balloting.
Canadian (NRCAN) SIP Research

Emphasis is on the study of the durability/longevity of SIP construction.
Also conducting static load tests of various SIP facers and foam cores.
Canadian researchers agreeable to meeting with FPL staff and SIPA representatives to share research information.
Mississippi State University study on lignin-based polyurethane core material for SIPS.

Approved as a USDA research product for $250,000 under the 2016 Wood Innovations Funding Opportunity

“Green Building with Structural Insulated Panels Incorporating Lignin Based Polyurethane Foam Cores”

Total project costs are $385,000

SIPA is identified as a project cooperator

3 year project underway
May 18th & 19th, 2017
Madison WI

Recent Research to Expand the Engineering Knowledge Base for SIPs, Tom Williamson

Highlights of the New Structural Insulated Panel Design Manual, Eric Tompos
Possible New Research Projects

1. Determine allowable holes size/areas placement in SIP walls
2. Determine capacities for SIP roof diaphragms
3. Evaluate the performance of SIP roof cantilevers (including corners)
4. E119 fire tests of SIP roof and wall assemblies
5. Evaluate the transverse load resistance of SIPs with structural splines i.e. 2x, LVL, & TJI splines
6. Evaluate the effects of deteriorated facers on the performance of SIPs
7. Development of purchase specifications for SIP raw materials to minimize testing with supplier changes
8. Limitations of SIPs in the IRC
Administrative

Next Meeting

Adjournment