Sheathing Braced Design of Wall Studs
April 2009 Update

for
AISI Committee on Framing Standards, Design Methods Subcommittee
Wednesday, April 29, 2009, 9:00 AM – 11:00 AM
Radisson Hotel-Madison, 517 Grand Canyon Drive, Madison, Wisconsin 53719
Overview

• Work Plan Summary

• New work since last report
  – Fastener stiffness/strength testing
  – Single column with sheathing testing
  – 8’x8’ full wall testing (preliminary)

• Conclusions
Basic summary of work plan

• Literature summary
  – existing methods
  – existing predictive capabilities

• Computational modeling
  – to support testing
  – to support design method creation

• Phase 1 testing
  – 8’ wall, single stud type, different sheathing configurations, axial only
  – Fastener translational stiffness/strength tests
  – Single column with sheathing tests

• Phase 2 testing
  – Axial + bending tests, 8’ wall, final details TBD
  – Axial + bending single member tests, w/ sheathing

• Development of new design methods
  – identify limit states, potential design methodologies, calcs, examples

red = added to initial work plan
Basic summary of work products

• Literature summary
  – existing methods (summary report, corrections to Simaan and Peköz)
  – existing predictive capabilities (Mathcad form, currently being extended)

• Computational modeling
  – to support testing (CUFSM and preliminary ABAQUS)
  – to support design method creation (reliability study on 2a, fastener spacing studies, fastener demands in bending due to torsion not begun yet)

• Phase 1 testing
  – 8’ wall, single stud type, different sheathing configurations, axial only (initiated)
  – Fastener translational stiffness/strength tests (tests complete, report posted)
  – Single column with sheathing tests (tests nearly completed, report results here)
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• Conclusions
Recall earlier fastener stiffness tests

$k_x$, $k_y$, $k_\phi$, $k_{	heta}$

$k_\phi$ testing and design method
Component level fastener stiffness/strength test

focus on $k_x$, translational stiffness, a la Winter’s test method

a) Front view  
b) Lateral view  
c) Closer view of the connection cross-section and board
Typical P-Δ response

recall earlier discussion on difficulty in defining appropriate $k_x$

F-02-02-08-12-OSB-D.dat

kinitial = 20.16 kip/in
max P = 2.53 kip

screw shear failure (typical in OSB)

362S162-68 (50 ksi), OSB 7/16” (Rated 24/16, exposure 1), #8 Fasteners
Gyp board observed failure modes
Gyp board moisture sensitivity

<table>
<thead>
<tr>
<th>Test</th>
<th>Humidity</th>
<th>Initial stiffness (kip/in)</th>
<th>Maximum load (kip)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-03-02-08-06-GYP-H.dat</td>
<td>Humid</td>
<td>0.55</td>
<td>0.10</td>
</tr>
<tr>
<td>F-06-02-08-20-GYP-D.dat</td>
<td>Dry</td>
<td>0.83</td>
<td>0.14</td>
</tr>
<tr>
<td>F-17-06-24-12-GYP-N.dat</td>
<td>Normal</td>
<td>5.97</td>
<td>0.45</td>
</tr>
</tbody>
</table>

“normal” (7 days, 20C, 65%RH)

dry/baked (7 days, 103C)

humid/soaked (7 days, soaked)
OSB observed failure modes
OSB observed failure modes (overdriven)
## Summary P-Δ Response

<table>
<thead>
<tr>
<th></th>
<th>k initial</th>
<th>Pmax</th>
<th>δ @ Pmax</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean (kip/in)</td>
<td>coef. variation</td>
<td>mean (kip)</td>
</tr>
<tr>
<td><strong>Normal Conditions</strong></td>
<td>8.26</td>
<td>0.07</td>
<td>0.67</td>
</tr>
<tr>
<td><strong>Overdriven</strong></td>
<td>10.92</td>
<td>0.10</td>
<td>0.48</td>
</tr>
<tr>
<td><strong>Humid (saturated)</strong></td>
<td>7.38</td>
<td>0.10</td>
<td>0.31</td>
</tr>
<tr>
<td><strong>Normal Conditions</strong></td>
<td>2.84</td>
<td>0.02</td>
<td>0.10</td>
</tr>
<tr>
<td><strong>Overdriven</strong></td>
<td>4.08</td>
<td>0.14</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Humid (saturated)</strong></td>
<td>0.28</td>
<td>-</td>
<td>0.02</td>
</tr>
</tbody>
</table>

1 OSB board thickness=7/16”, Rated sheathing 24/16, exposure 1
2 Gypsum board thickness=½”, Brand Sheetrock
3 Normal conditions: w=24, s=4;12;20, e=6in, kept seven days at a temperature of 20C and 65% humidity
4 Overdriven: same as above, but screw is overdriven 1/8”
5 Humid: w=8, e=2, s=4;6;9;12;20, kept immersed for 7 days

**Diagram Notes:**
- **Front view**
- **Lateral view**
- **Detailed view**

**Diagrams:**
- Mean OSB Normal conditions
- Mean Gypsum Normal conditions
- Zoom in the connection
- Cut A-A
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Single column testing
single column testing (cont.)

Testing Details
• 2’, 4’, 6’ and 8’ (8’ still in progress)
• 362S162-68 (50 ksi) studs
• 362T125-68 (50 ksi) track
• OSB (7/16 in., rated 24/16, exposure 1)
  Simpson #8 x 1 15/16”
• Gypsum (½ in. Sheetrock).
  Simpson #6 x 1 5/8”
imperfection measurements
Stud response w/o sheathing

- 2-BARE-BARE-1S6L-6.dat
- 3-BARE-BARE-1S4L-4.dat
- 4-BARE-BARE-1S2L-2.dat
Stud response w/ sheathing (L= 6ft)

6 feet stud with different combination of restrictions

- 2-BARE-BARE-1S6L-6.dat
- 7-BARE-BARE-2S6LT-6-T.dat
- 9-OSB-OSB-4S6LTSP-6-T-S-P.dat
- 10-GYP-GYP-5S6LTSP-6-T-S-P.dat
- 12-OSB-BARE-6S6LTSP-6-T-S-P.dat
- 13-OSB-GYP-7S6LTSP-6-T-S-P.dat
L=6ft failure modes

OSB-OSB

OSB-GYP

GYP-GYP

OSB-BARE
Isolating composite action

Effect of bearing track on a plate, OSB-OSB

8-OSB-OSB-3S6LTS-6-T-S.dat
9-OSB-OSB-4S6LTSP-6-T-S-P.dat

19.83%
Isolating composite action (cont.)

Effect of bearing track on a plate, GYP-GYP

19.86% note percent drop
Summary results
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8’x8’ wall testing

- October 2008 testing rig disaster and COFS visit
- December 2008 retrofit of base completed initial shakedown test on OSB-Bare completed
- (January 2009 fastener stiffness testing)
- February 2009 new end plates, sensors and servovalve modifications completed and second shakedown test on OSB-Gyp completed
- (March 2009 single column testing)
- April 2009 full wall testing ready to initiate, compression testing to be completed in May, post-processing of all results in June, full speed ahead as they say.
results

![Graph showing force vs. displacement with a peak of 86 kips and 17.2 kips/stud.]

- 86 kips
- 17.2 kips/stud
OSB-Gyp Shakedown Test #2
OSB-Gyp Shakedown Test #2

mounted inside the wall
results

Displacement (in.) vs. Force (lbf)

110 kips

22 kips/stud
movies

setup

full engagement...

collapse
next steps

• 8’ single column tests

• 8’x8’ wall tests with plates in place to isolate direct loading of sheathing

• strength predictions and modeling

• preparations for beam-column testing
  – supplementary modeling for fastener forces
  – lateral load application rig
Conclusions

• Where we are at today
  – Basic model known (member braced at fastener locations)
  – Bracing knowledge becoming well developed
    • Translational and rotational stiffness tested
    • Fastener limit states tested
    • Imperfections (which lead to bracing demands) measured
    • Sensitivities quantified (at least initially)
      – moisture sensitivity, overdriven fasteners, missing fasteners (2a rule)
  – Sheathed column strength becoming well developed
    • Single column tests with dis-similar sheathing focusing methods
    • Full wall tests underway

• Axial + bending studies will soon be at hand
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