STATIC LOAD TEST FOR SHEAR RESISTANCE OF FRAMED WALLS FOR MANUFACTURED HOMES: SINGLE-SIDED WALL ASSEMBLIES SHEATHED WITH 5/16-IN. AMERICAN GYPSUM WALLBOARD

Tested/Prepared for:
Alpha Systems, Inc.
5120 Beck Drive
Elkhart, Indiana 46516
Web: www.alphasystemsinc.com

Test Report: ALP091907-23
Issued: January 4, 2008

Prepared By:
Brad Wear
Test Engineer

Reviewed By:
Douglas Berger P.E.
Test Engineer

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1. INTRODUCTION

1.1. GENERAL

This test measures the resistance of a framed wall assembly, sheathed with sheet materials, to a racking load such as would be imposed by winds blowing on a wall oriented at 90° to the wall assembly. The strength of such an assembly is often difficult to calculate based on engineering mechanics alone. For this reason, Section 3280.401(b) of the Federal Manufactured Home Construction and Safety Standards (FMHCSS)\(^1\) allows for ultimate load tests to establish the design strength of structural assemblies to be used in manufactured housing construction.

1.2. OBJECTIVE AND SCOPE

NTA Testing Laboratories, Inc. conducted racking load tests on wall assemblies at the NTA test facility in Nappanee, Indiana. The purpose of this evaluation is to assess the racking resistance of a typical section of sheathed wall framing in accordance with Section 3280.305 of the Federal Manufactured Home Construction and Safety Standards (FMHCSS)\(^1\). The tested assemblies were constructed as specified by the client.

2. TEST PROGRAM

2.1. DESCRIPTION OF TEST SPECIMENS

Each specimen consisted of a 96-in.x 96-in. wall assembly constructed as specified in Table 1 and as shown in Figure 1. Sheathing attachment was as specified in Table 2. The adhesive bead size was specified by the client. Accordingly, the adhesive was applied to the framing immediately followed by the placement of the sheathing panels. The panels were then promptly fastened as described in Table 2. Fasteners were driven perpendicular to the surface of the sheathing with the center of each fastener the specified distance from the edge. Furthermore, all fasteners were driven so that the head of the fastener contacts the surface of the sheathing but not so deep as to crush the surface. Following construction, each specimen was allowed to cure for a minimum of seven days prior to testing.

<table>
<thead>
<tr>
<th>Location</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studs</td>
<td>Single, 2x3 Stud Grade SPF, 16-in. oc</td>
</tr>
<tr>
<td>Top Plate</td>
<td>Single 1x3 Un-graded SPF</td>
</tr>
<tr>
<td>Bottom Plate</td>
<td>Single 1x3 Un-graded SPF</td>
</tr>
<tr>
<td>Sheathing Side A</td>
<td>5/16-in. x 48-in. x 96-in. American Gypsum Wallboard</td>
</tr>
<tr>
<td>Sheathing Side B</td>
<td>None</td>
</tr>
</tbody>
</table>
Table 2: Fastening Schedule

<table>
<thead>
<tr>
<th>Connection</th>
<th>Fastener</th>
<th>Quantity or Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top plate to Studs</td>
<td>7/16-in. x 1-3/4-in. x 15 Ga. Staple</td>
<td>2</td>
</tr>
<tr>
<td>Bottom Plate to Studs</td>
<td>7/16-in. x 1-3/4-in. x 15 Ga. Staple</td>
<td>2</td>
</tr>
<tr>
<td>Sheathing A to Framing (Mechanical)</td>
<td>3/16-in. x ¾-in. x 19 Ga. Staple</td>
<td>6/6-21&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sheathing A to Framing (Adhesive)</td>
<td>Pemco 5100</td>
<td>1/16-in. Average Bead Diameter</td>
</tr>
<tr>
<td>Sheathing B to Framing (Mechanical)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<sup>a</sup> Given as edge spacing/field spacing.

2.2. PREPARATIONS FOR TESTING

Prior to placement in the racking fixture (Figure 2 and Figure 3), a steel loading and reaction bar are attached to the top and bottom, respectively, of each assembly. With these bars in place, each specimen is positioned in the racking fixture.

A hydraulic cylinder is used to apply the racking force to the loading bar at the top of the specimen, as shown in Figure 2. The applied load is monitored using an in-line load cell. Digital deflection indicators, with a resolution of 0.001-in., are positioned at three corners of the specimen, as shown in Figure 2.

2.4. TEST PROCEDURE

Each test is conducted in accordance with 24 CFR §3280.401(b). Additional test procedures are based on ASTM E 72<sup>2</sup>, Standard Methods of Conducting Strength Tests of Panels for Building Construction. Accordingly, each specimen is loaded in 395 pound increments, at a uniform rate of 790 pounds in not less than two minutes. At each load increment, deflection readings are taken while maintaining the load. The applied load is then removed and the specimen was given time to recover. After which, residual deflection readings are taken. This cycle of loading and unloading is continued up to a load of 2360 lbs. Above this load, deflection readings are discontinued as the applied load is increased to ultimate.
3. TEST RESULTS

Overall, the three specimens behaved similarly. This similarity is seen in both the ultimate loads, provided in Table 3, and in the load-deflection plots, shown in Figure A4. Table 3 provides a summary of the ultimate and design shear loads, as well as the failure mode. Additional test data are provided in the Appendix.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Ultimate Load (lbs)</th>
<th>Design Shear Load(^a) (plf)</th>
<th>Failure Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>14055</td>
<td>5099</td>
<td>255</td>
<td>Gypsum paper shear failure along bottom plate, gypsum failure at bottom corner of load end</td>
</tr>
<tr>
<td>13009</td>
<td>4904</td>
<td>245</td>
<td>Gypsum paper shear failure along bottom plate, and gypsum failure at bottom corner of load end</td>
</tr>
<tr>
<td>13010</td>
<td>4532</td>
<td>227</td>
<td>Gypsum paper shear along bottom plate</td>
</tr>
<tr>
<td>Average Value</td>
<td>4845</td>
<td>242</td>
<td>--</td>
</tr>
</tbody>
</table>

\(^a\) Design shear load determined using the equation \( P_{\text{allowable}} = P_{\text{ultimate}} / (2.5 \times 8 \text{ ft}) \). A factor of safety of 2.5 is applied in accordance with 24 CFR §3280.401(b).
4. CONCLUSION

Three similar assemblies were tested and assessed in accordance with the ultimate load test procedures of the FMHCSS. The conditions of test and overall findings are summarized in Table 4, below. The specimens tested in this investigation were constructed to simulate those produced under typical manufacturing conditions; however, construction methods and quality can vary greatly, thereby effecting performance. Additionally, actual assembly performance may vary depending on tie-down and support conditions. Designs utilizing the findings in this report must be reviewed by a professional engineer to ensure proper construction and use.

Table 4: Conclusion

<table>
<thead>
<tr>
<th>Wall Construction</th>
<th>Allowable Shear Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/16-in. American Gypsum Wall Board, Adhered with Pemco 5100 by Alpha Systems Fastened and constructed as detailed herein</td>
<td>242 plf</td>
</tr>
</tbody>
</table>

It must be noted that NTA Testing Laboratories, Inc. did not oversee or verify the sampling procedure used by the client when selecting the sample material(s). Materials provided by NTA Testing Laboratories, Inc. were obtained through common suppliers and were inspected upon receipt to verify that the materials were of average quality. The data provided herein were obtained based on FMHCSS test procedures and assessed based on FMHCSS criteria and should not be used for other types of construction. For use in manufactured housing, these results are subject to DAPIA review and approval.

PREPARED BY: Brad Wear 1-4-08
Brad Wear
Test Engineer

REVIEWED BY: Douglas Berger, P.E. 1-4-08
Douglas Berger, P.E.
Test Engineer
REFERENCES


Figure 1: Specimen Construction

Figure 2: Racking Test Fixture
APPENDIX

Metal framing used to connect to top plate of wall framing

1-1/4" diameter x 4" steel rollers (2 places)

1/2" diameter tie-down (20 lbf tension at beginning of test)

Screws into top plate

Roller support frame

Hard rubber rollers

1/2" diameter steel rod

2x3 Wall sample

Figure 3: Racking Test Fixture Detail A-A

Figure 4: Failure Mode (Specimen # 14055)
APPENDIX

Racking Test for Wall Assemblies to be used in Manufactured Homes:
Specimen Construction

Client: Alpha Systems, Inc.
Job Number: ALP091907-23
Test Method: FMHCS, Section 3280.401(b), Ultimate Load
Test Procedure (based on ASTM E72)

Nominal Specimen Size: 96-in. x 96-in.

Framing Specifications:
Studs: (1) 2 x 3 Stud SPF @ 16-in. oc (Spec. #7155)
Top Plate: (1) 1 x 3 Un-Graded SPF (Spec. #12994)
Bottom Plate: (1) 1 x 3 Un-Graded SPF (Spec. #12994)

Panel Specifications:
Sheathing, Side A: 1 Layer(s) 5/16-in. 48 x 96-in. American Gypsum Board (Spec. #13345)
Sheathing, Side B: none

Mechanical Fastening Schedule:
Top plate-to-stud: (2) 1-3/4 x 15 Ga. Staple (Spec. #7365)
Bottom plate-to-stud: (2) 1-3/4 x 15 Ga. Staple (Spec. #7365)
Top plate-to-top plate (if double): n/a
Bottom plate-to-bottom plate (if double): n/a
Stud-to-stud (if double): n/a
Sheathing A: 3/16 x 3/4 19 ga. Staple @ 6/6-21-in. oc (edge/field) (Spec. #9063)
Sheathing B: n/a

Adhesive Application:
Sheathing, Side A
Adhesive: Pemco 5100 (Spec. #13015)
Application: 1/16-in.-in. dia. average bead size
Bead Qty: (1) Top-Plate, (1) Bottom-Plate, (2) Edge Stud, (2) Center Stud, (2) Interior Stud

Sheathing, Side B
Adhesive: none
Application: n/a
Bead Qty: n/a

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Racking Test for Wall Assemblies to be used in Manufactured Homes:

Specimen 1

Client: Alpha Systems, Inc.
Job Number: ALP091907-23
Test Method: FMHCS, Section 3280.401(b), Ultimate Load Test Procedure (Based on ASTM E72)

Performed By: Todd Ferguson
Witnessed By: Brad Wear
Test Location: NTA Testing Laboratories, Inc.
Nappanee, Indiana

General:
Specimen No.: 014055
Wood MC: 9.2%-11.8%
Received: 9/19/2007
Fabrication Date: 10/5/2007

Test Date: 12/6/2007

Ambient Conditions:
Ambient Temp.: 73 deg. F
Ambient R.H.: 51% RH

Sensor Asset No.: 00576

Apparatus:
Shearwall Rack: 00022
Indicator #1: 00057
Indicator #2: 00568
Indicator #3: 00055
Timing Device: 00813

Specimen 1 Test Deflection Data

<table>
<thead>
<tr>
<th>Load Stages (lbs)</th>
<th>Measured Deflections (in.)</th>
<th>Net Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>REF 0</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>790</td>
<td>0.071</td>
<td>0.010</td>
</tr>
<tr>
<td>0</td>
<td>0.017</td>
<td>0.005</td>
</tr>
<tr>
<td>1570</td>
<td>0.144</td>
<td>0.018</td>
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<tr>
<td>0</td>
<td>0.024</td>
<td>0.006</td>
</tr>
<tr>
<td>2360</td>
<td>0.214</td>
<td>0.023</td>
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<tr>
<td>0</td>
<td>0.035</td>
<td>0.007</td>
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<tr>
<td>3160</td>
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<td>3950</td>
<td>0.387</td>
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<tr>
<td>4740</td>
<td>0.518</td>
<td>0.035</td>
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<tr>
<td>5530</td>
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</tr>
<tr>
<td>6320</td>
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<td>--</td>
</tr>
<tr>
<td>7110</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Avg. Loading Rate: 396 lbs/min.
Ultimate Load: 5099 lbs

Failure Mode:
Paper shear failure along bottom plate, along with gypsum failure at bottom corner on load end.

Figure A1: Specimen 1 Failure Diagram

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Racking Test for Wall Assemblies to be used in Manufactured Homes:
Specimen 2

Client: Alpha Systems, Inc.
Job Number: ALP091907-23
Test Method: EMHCSS, Section 3280.401(b), Ultimate Load
Test Procedure (Based on ASTM E72)

General:
Specimen No.: 013009
Wood MC: 9.9%-11.4%
Received: 9/19/2007
Fabrication Date: 10/5/2007
Test Date: 10/12/2007

Ambient Conditions:
Ambient Temp.: 73.9 deg. F
Ambient R.H.: 48.6% RH
Sensor Asset No.: 00576

Apparatus:
Shearwall Rack: 00022
Indicator #1: 00057
Indicator #2: 00154
Indicator #3: 00055
Timing Device: 00813

Specimen 2 Test Deflection Data

<table>
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<tr>
<th>Load Stages (lbs)</th>
<th>Measured Deflections (in.)</th>
<th>Net Deflection</th>
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</thead>
<tbody>
<tr>
<td>REF 0</td>
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<td>0.000</td>
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<tr>
<td>790</td>
<td>0.080</td>
<td>0.020</td>
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<td>0.018</td>
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<td>0.157</td>
<td>0.043</td>
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<tr>
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<td>0.006</td>
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<td>0.231</td>
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<td>0.011</td>
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<td>0.091</td>
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<tr>
<td>3950</td>
<td>0.396</td>
<td>0.114</td>
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<tr>
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<tr>
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<td>6320</td>
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<td>--</td>
</tr>
<tr>
<td>7110</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Avg. Loading Rate: 399 lbs/min.
Ultimate Load: 4904 lbs

Failure Mode:
Wallboard paper shear across bottom plate and gypsum shear at bottom load end panel

Figure A2: Specimen 2 Failure Diagram

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Racking Test for Wall Assemblies to be used in Manufactured Homes:
Specimen 3

Client: Alpha Systems, Inc.
Job Number: ALP091907-23
Test Method: FMHC35, Section 3280.401(b), Ultimate Load
Test Procedure (Based on ASTM E72)

General:
Specimen No.: 013010
Wood MC: 9.1%-10.9%
Received: 9/19/2007
Fabrication Date: 10/5/2007
Test Date: 10/12/2007

Ambient Conditions:
Ambient Temp.: 73.5 deg. F
Sensor R.H.: 50.4% RH

Apparatus:
Shearwall Rack: 00022
Indicator #1: 00057
Indicator #2: 00154
Indicator #3: 00055
Timing Device: 00813

<table>
<thead>
<tr>
<th>Load Stages (lbs)</th>
<th>Measured Deflections (in.)</th>
<th>Net Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>790</td>
<td>0.057 0.013 0.022</td>
<td>0.050</td>
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<tr>
<td>0</td>
<td>0.025 0.008 0.008</td>
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</tr>
<tr>
<td>1570</td>
<td>0.169 0.022 0.047</td>
<td>0.100</td>
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<td>0.036 0.009 0.012</td>
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<tr>
<td>2360</td>
<td>0.255 0.028 0.071</td>
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<td>--</td>
</tr>
<tr>
<td>7110</td>
<td>-- -- --</td>
<td>--</td>
</tr>
</tbody>
</table>

Avg. Loading Rate: 596 lbs/min.
Ultimate Load: 4532 lbs

Failure Mode:
Wallboard paper shear across bottom plate

Figure A3: Specimen 3 Failure Diagram

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Client: Alpha Systems, Inc.
Job Number: ALP091907-23
Test Method: FMHCSS, Section 3280.401(b), Ultimate Load
Test Procedure (Based on ASTM E72)

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Ultimate Load (lbs)</th>
<th>Design Shear Load (plf)</th>
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</thead>
<tbody>
<tr>
<td>Specimen No.</td>
<td>14055</td>
<td>5099</td>
</tr>
<tr>
<td>2</td>
<td>13000</td>
<td>4904</td>
</tr>
<tr>
<td>3</td>
<td>13010</td>
<td>4532</td>
</tr>
</tbody>
</table>

Average Ultimate Load: 4845 lbs
Average Shear Strength*: 242 plf

* As required in FMHCSS, Section 3280.401(b), Ultimate Load Test Procedure, the average ultimate load is divided by a factor of safety of 2.5 to arrive at the allowable shear strength.

Figure A4: Load vs. Deflection Plot

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