TEST REPORT ON
CENTRAL STATES MANUFACTURING, INC.'S
PANEL-LOC PLUS PANELS
(29 GA., 80 KSI, 36" WIDE)
FASTENED TO WOOD SUPPORTS
AT 2' 0" & 3' 0" PANEL SPANS
IN ACCORDANCE WITH ASTM E455-11
AND AISI S907-08

TESTED FOR:
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TEST WITNESSED BY:
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TESTING DATE: January 16 & 18, 2013
REPORTING DATE: January 29, 2013
ENCON® Project C1877-1
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TEST SUMMARY

1.1 SUMMARY

Tests were conducted on Central States Manufacturing, Inc.’s 29 ga., 80 ksi Panel-Loc Plus panels at ENCON® Technology, Inc.’s Test Facility, Tulsa, Oklahoma. The purpose of the tests was to determine the diaphragm shear strength and shear stiffness of Panel-Loc Plus panel construction under simulated loading conditions. These tests meet the provisions of ASTM E455-11 and AISI S907-08. The tests are listed below according to date tested.

Test #1 & 2: Panel-Loc Plus panels at four equal spans of 2’ 0". The structural fastener spacing was 9" o.c. at the end and interior wood supports. Both tests were conducted on January 16, 2013.

Test #3: Panel-Loc Plus panels at three equal spans of 3’ 0". The structural fastener spacing was 9" o.c. at the end and interior wood supports. This test was conducted on January 18, 2013.

The sidelap fasteners spacing for all tests was 24” o.c. The above-defined tests were witnessed by Bala Sockalingam, Ph.D., P.E. of ENCON Technology, Inc.

1.2 PANEL SYSTEM DESCRIPTION

Central States Mfg.’s Panel-Loc Plus panels were 29 ga., 3/4" high and 36" wide through fastened panels. Each panel consisted of five major ribs spaced at 9" o.c. as shown on Page 2.

The panels were fastened to nominal 2" x 6" SPF wood supports with #10 x 1-1/2" long Kwikseal® II Wood Binder screws with washers. The screw spacing was 9" o.c. at the end and interior wood supports. Each panel spanned over four continuous spans of 2’ 0" or three continuous spans of 3’ 0" with 2" overhang. The sidelap fasteners were #12 x 3/4" long hex head stitch screws with washers and spaced at 24" o.c. The two sides of the panel assembly were not attached to the side post of the interior frame.

1.3 TEST RESULTS

Load was applied incrementally and deflections of the test construction were recorded for ‘no load’ condition and at each load increment. The failure mode in Test #1 & #2 was the panel slotting at fasteners near the roller and pinned corners. The average ultimate shear strength from the two test constructions was 291.7 lb/ft and average shear stiffness was 8383.5 lb/in.

The failure mode in Test #3 was the panel buckling near the loaded corner. The ultimate shear strength was 183.3 lb/ft and shear stiffness was 8145.2 lb/in.
### TEST SUMMARY

- **Panel Type:** 29 GA. PANEL-LOC PLUS PANEL
- **Supports:** End & Intermediate

### Test Series

<table>
<thead>
<tr>
<th>Test Series</th>
<th>Span A (ft)</th>
<th>Span B (ft)</th>
<th>Max. Load Pu (lb)</th>
<th>Shear Strength Su (lb/ft)</th>
<th>0.4Pu (lb)</th>
<th>Defl. 0.4Pu (in)</th>
<th>Shear Stiffness G' (lb/in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2-2-2-2</td>
<td>8.33</td>
<td>12.0</td>
<td>3500</td>
<td>291.7</td>
<td>1400</td>
<td>0.119</td>
</tr>
<tr>
<td>2</td>
<td>2-2-2-2</td>
<td>8.33</td>
<td>12.0</td>
<td>3500</td>
<td>291.7</td>
<td>1400</td>
<td>0.113</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>291.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3-3-3</td>
<td>9.33</td>
<td>12.0</td>
<td>2200</td>
<td>183.3</td>
<td>880</td>
<td>0.095</td>
</tr>
</tbody>
</table>

### Notes:

1. Panel thickness was 29 GA. and yield stress was 80 KSI (Nom.).
2. Panel to support fastener was #10 x 1.5" long wood screw.
3. Panel to panel fastener was #12 x 3/4" long stitch screw.
4. Panel to panel fastener spacing was 24" OC.
2.1 DESCRIPTION OF TEST

OBJECTIVES

Tests were conducted to determine shear strength and shear stiffness of the panels under simulated loading conditions. The test method consisted of the following:

1. assembling the test panel on an interior test frame to form a typical roof or wall construction;
2. loading the test frame incrementally; and
3. observing, measuring, and recording the deflections, deformations, and nature of any failures of principal or critical elements of the test construction.

The increments of load application were chosen such that a sufficient number of readings were obtained to determine the load deformation curve of the system.

TEST SETUP

The test setup consisted of an exterior reaction truss and interior panel support frame as shown in the applicable drawings in the appendix. The L-shaped reaction truss was constructed of two built-up tube sections with cross-braced angle sections to form a truss. The panel support frame was constructed of wood supports having equal or lower strength and stiffness than that intended for use in the typical constructions. All the connections in the interior frame were pinned.

Both the truss and frame lay in the same horizontal plane. The reaction frame was supported by short columns, which rested on the laboratory floor. Two corners of the interior frame were connected to the exterior frame with a hinge and roller. The side opposite to these corners was held up by columns with roller bases. The interior supports were attached to the side post with pinned connections.

LOADING DEVICE

Load was applied using a 10 kip capacity hydraulic ram and manual pump. The load was monitored with a calibrated 10 kip capacity load cell and associated instrumentation. The accuracy of the load cell was estimated to be ± 0.01 kips. The hydraulic ram was attached to the reaction truss and the load cell was attached to the interior frame. The load was applied parallel to and in close proximity to one of the points of contact between the diaphragm web and frame.

DEFLECTION MEASUREMENT

Deflection measurements were taken by means of dial indicators calibrated to 1/1000 of an inch. Deflections were measured at locations as shown on the drawings in the appendix. The deflection locations are based on AISI S907-08.
DESCRIPTION OF TEST

DIAPHRAGM SIZE

The overall dimension of each construction was in excess of 12’ x 8’ 4” or 9’ 4”. The panels covered four equal spans of 2’ 0” or three equal spans of 3’ 0”. The construction width contained four full panels. The panels were attached to the end and interior wood supports with self-drilling screws. The panels were not attached to the side member of the interior frame. The details of the methods of construction are depicted in the enclosed test drawings. All the material used in the construction represented a typical construction.

NUMBER OF TESTS

Minimum of two panel assemblies was tested for panel span of 2’ 0” to determine the shear strength and stiffness. As per Section 8.2 of ASTM E455, the duplicate test for panel span of 3’ 0” was waived due to testing span variability.

TEST PROCEDURE

Prior to the diaphragm construction, the interior frame was loaded to determine its bare frame stiffness. The bare frame stiffness was insignificant, deflecting 1” under a 10-lb load. The loading procedure on the completed diaphragm construction consisted of loads applied in increments. The diaphragm was loaded to 20% of the anticipated ultimate load and unloaded. Deflection measurements were recorded at ‘no load’ conditions. The diaphragm was loaded in 250-lb increments until failure for Test #1 & #2 and in 200-lb increments until failure for Test #3. Deflection measurements were recorded at every load increment.

TEST DURATION

The test was stopped when the test specimen was unable to carry additional load or visual failure of one or more components of the diaphragm occurred.

2.2 CALCULATIONS

The ultimate shear strength $S_u$ (lb/ft) of a given construction is where

$$S_u = \frac{P_u}{b}$$

$P_u$ = maximum applied load in the cantilever beam test (lb),

$b$ = depth of diaphragm (ft).

The net shear deflections ($\Delta$) at any load level in the cantilever beam test is

$$\Delta = \Delta_3 + \frac{P_u}{b} \left( \Delta_1 + \Delta_4 \right)$$

where $\Delta_1$, $\Delta_2$, $\Delta_3$ and $\Delta_4$ are measured deformations with appropriate signs at locations shown in the test drawings.
The apparent shear stiffness $G'$ (lb/in) of a given construction is

$$G' = \frac{P}{\Delta} \left( \frac{a}{b} \right)$$

where
- $P = 0.4P_u$ in the cantilever beam test (lb),
- $a =$ span of diaphragm (ft),
- $\Delta =$ Net shear deflection of diaphragm (in) at $0.4P_u$ load.

The shear stiffness calculation is based on AISI S907-08.
3.1 SPECIMEN IDENTIFICATION

Manufacturer: Central States Manufacturing, Inc

Model Type: Panel-Loc Plus Panel

Dimensions: 0.75" high, 36" wide coverage

Panel Thickness: 29 ga.

Base Metal Thickness: 0.0136"

Panel Yield Stress: 80 ksi (100 ksi tested)

Panel Fasteners: #10 x 1.5" long hex head wood screws with washers (Sealtite Building Fasteners Kwikseal® II Wood Binder)

Panel Fasteners Spacing: 9" o.c.

Support Thickness: Nom. 2" x 6" SPF

Sidelap Fasteners: #12 x 3/4" long hex head stitch screws with washers (Sealtite Building Fasteners)

Sidelap Fasteners Spacing: 24" o.c.

Note: All the test materials were supplied by or purchased for Central States Manufacturing and were not sampled by ENCON.
3.2 TEST #1: 29 GA. PANEL-LOC PLUS AT FOUR EQUAL SPAN OF 2' 0"

Test No: 1
Date: 1.16.13
Panel Type: Panel-Loc Plus
Gauge: 29 ga.
Thickness: 0.0136"
Panel Width: 36"
Support Spacing: 4 spans @ 24" o.c.
Type of Structural Fastener: #10 x 1.5" long Kwikseal II screw
Fastener Spacing at End Supports: 9" o.c.
Fastener Spacing at Interior Supports: 9" o.c.
Insulation None
Type of Sidelap Fastener: #12 x 3/4" long stitch screws
Sidelap Fastener Spacing 24" o.c
\[ a = \text{span length of diaphragm (ft)}: 8.33 \]
\[ b = \text{depth of diaphragm (ft)}: 12.00 \]

<table>
<thead>
<tr>
<th>Load (lb)</th>
<th>Dial Indicator Reading (in)</th>
<th>Shear Deformation ( \Delta ) (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>0.000</td>
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<tr>
<td>250</td>
<td>0.006</td>
<td>0.008</td>
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<tr>
<td>500</td>
<td>0.029</td>
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</tr>
<tr>
<td>750</td>
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<tr>
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<td>0.090</td>
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<td>1500</td>
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<tr>
<td>1750</td>
<td>0.107</td>
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<td>2000</td>
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<tr>
<td>2250</td>
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<tr>
<td>2500</td>
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<td>2750</td>
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<tr>
<td>3000</td>
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<tr>
<td>3250</td>
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<td>3500</td>
<td>0.318</td>
<td>0.185</td>
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</table>

Failure Mode: Panel slotting at the fastener near roller and pinned corners

Duration of test: > 10 minutes

Temperature (F) Relative Humidity (%)
At construction: 66 26
At testing 66.2 26
Load vs Deflection (Test #1)
### 3.3 TEST #2: 29 GA., 80 KSI PANEL-LOC PLUS AT FOUR EQUAL SPAN OF 2' 0"

Test No: 2  
Date: 1.16.13  
Panel Type: Panel-Loc Plus  
Gauge: 29 ga.  
Thickness: 0.0136"  
Panel Width: 36"  
Support Spacing: 4 spans @ 24" o.c.  
Type of Structural Fastener: #10 x 1.5" long Kwikseal II screw  
Fastener Spacing at End Supports: 9" o.c.  
Fastener Spacing at Interior Supports: 9" o.c.  
Insulation None  
Type of Sidelap Fastener: #12 x 3/4" long stitch screws  
Sidelap Fastener Spacing: 24" o.c  
*a = span length of diaphragm (ft): 8.33  
*b = depth of diaphragm (ft): 12.00*

<table>
<thead>
<tr>
<th>Load (lb)</th>
<th>Dial Indicator Reading (in)</th>
<th>Shear Deformation Δ (in)</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>1000</td>
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<td>1250</td>
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<td>2750</td>
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<td>3000</td>
<td>0.122</td>
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<tr>
<td>3250</td>
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</tr>
<tr>
<td>3500</td>
<td>0.142</td>
<td>0.152</td>
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</table>

**Failure Mode:** Panel slotting at the fastener near roller and pinned corners  
**Duration of test:** > 10 minutes  
**Temperature (F)** Relative Humidity (%)  
At construction: 66.2 26  
At testing 66.2 26
Load vs Deflection (Test #2)
TEST RESULTS

3.4 TEST #3: 29 GA., 80 KSI PANEL-LOC PLUS AT THREE EQUAL SPAN OF 3' 0"

Test No: 3
Date: 1.18.13
Panel Type: Panel-Loc Plus
Gauge: 29 ga.
Thickness: 0.0136"
Panel Width: 36"
Support Spacing: 3 spans @ 36" o.c.
Type of Structural Fastener: #10 x 1.5" long Kwikseal II screw.
Fastener Spacing at End Supports: 9" o.c.
Fastener Spacing at Interior Supports: 9" o.c.
Insulation None
Type of Sidelap Fastener: #12 x 3/4" long stitch screws
Sidelap Fastener Spacing 24" o.c
a = span length of diaphragm (ft): 9.33
b = depth of diaphragm (ft): 12.00

<table>
<thead>
<tr>
<th>Load (lb)</th>
<th>Dial Indicator Reading (in)</th>
<th>Shear Deformation Δ (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
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<td>0</td>
<td>0.000</td>
<td>0.000</td>
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<tr>
<td>200</td>
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<td>0.018</td>
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<td>0.134</td>
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<td>0.216</td>
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Failure Mode: Panel buckled near load corner
Duration of test: > 10 minutes

<table>
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<tr>
<th>Temperature (F)</th>
<th>Relative Humidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>At construction: 66</td>
<td>27</td>
</tr>
<tr>
<td>At testing       66.2</td>
<td>27</td>
</tr>
</tbody>
</table>
PHOTOGRAPHS

PHOTO 1  View of the structural and sidelap fasteners.
(DSCN0005)

PHOTO 2  View of the wood support layout for panel span of 2' 0".
(DSCN0009)
PHOTOGRAPHS

PHOTO 3  View of the panel fasteners at end and interior supports.  
(DSCN0011)

PHOTO 4  Overview of the diaphragm test setup of the Panel-Loc Plus at 2' 0" span. 
(DSCN0010)
PHOTO 5  View of panel slotting at fastener near the roller support in Test #1. 
(DSCN0015)

PHOTO 6  View of panel slotting at fastener near the pinned support in Test #2. 
(DSCN0021)
PHOTO 7  Overview of the diaphragm test setup of Panel-Loc Plus at 3' 0" span. (DSCN0027)

PHOTO 8  View of panel buckling near the loaded corner in Test #3. (DSCN0030)
TEST SETUP PLAN VIEW

NOTES:

1. DIAL INDICATOR LOCATION
PLAN VIEW OF TEST PANEL SETUP
NOTES:

1. DIAL INDICATOR LOCATION
PLAN VIEW OF TEST PANEL SETUP
DETAILS OF "STARTER RAKE" OF TEST ROOF

DETAILS OF "FINISHED RAKE" OF TEST ROOF
DETAILS OF "END SUPPORTS" OF TEST ROOF

24" O.C.  2" FOR 2' SPAN  8" FOR 3' SPAN
LABORATORY REPORT

Attn: Bala Sockalingam
ENCON Technology, Inc.
1216 N. Lansing Ave.
Suite C
Tulsa, OK 74106 United States

Material: Steel

Description: (1) Panel-Loc Plus 29 ga., Sample No.: 1

Room Temperature Tensile Testing ASTM E8/E8M-11, Parallel to Length of the Specimen, As Received

<table>
<thead>
<tr>
<th>Width, Initial, in</th>
<th>Thickness, Initial, in</th>
<th>Tensile Strength, psi</th>
<th>Yield (0.2% Offset), psi</th>
<th>Elongation (4W), %</th>
<th>Location of Fracture</th>
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</thead>
<tbody>
<tr>
<td>0.504</td>
<td>0.0136</td>
<td>106600</td>
<td>100000</td>
<td>2</td>
<td>Outside Middle Half of Gage</td>
</tr>
</tbody>
</table>

Approved by:

Tim Jones
Mechanical Testing Technician

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APPENDIX

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