

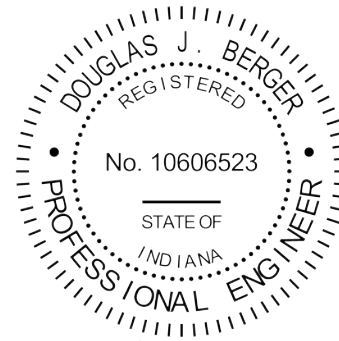
**NEGATIVE WIND PRESSURE TEST ON EXTERIOR SHEATHING
FOR MANUFACTURED HOUSING APPLICATIONS:
SINGLE 2x4 STUD GRADE SPF ON 16-IN. CENTERS SHEATHED ON THE EXTERIOR WITH
3/8-IN. APA SPAN RATED 24/0 OSB AND
CLIPSTONE LEDGESTONE BLACK RUNDER FLATS SIDING FOR
96-IN. TALL EXTERIOR WALLS WIND ZONE II, CORNER**

Prepared for:
Environmental StoneWorks
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Test Report: ESW071417-1
Issued: November 9, 2017

Prepared By:
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Test Engineer



Douglas J. Berger
11/9/17

Reviewed By:
Douglas Berger, P.E.
Test Engineer

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1. INTRODUCTION

Environmental StoneWorks retained NTA, Inc. to perform negative wind pressure load tests on wall assemblies constructed with their exterior siding. The purpose of this evaluation was to assess the suitability of sheathing wall assemblies for use in manufactured home construction when subjected to simulated negative wind pressure in accordance with Section 3280.401(b) of the *Federal Manufactured Home Construction and Safety Standards* (FMHCSS)¹. General test parameters and pass/fail criteria, in accordance with the FMHCSS, are summarized in Table 1, below. All tests were conducted at the NTA, Inc. test facility located in Nappanee, Indiana.

Table 1: Test Parameters

Parameter	Value
FMHCSS Wind Zone	II
Corner/Non-Corner	Corner
Design Pressure	48 psf
Deflection Limit	$L/180$
Clear Height, h	96-in.
Specimen Width, w	49.5-in.
Uniform Load Application	Material: Polyethylene Sheeting Thickness: 6 mil Location: Between wall framing and exterior sheathing

2. TEST PROGRAM

2.1. DEVIATIONS FROM TEST STANDARD

The testing detailed herein was performed with no modifications to the test standard.

2.2. DESCRIPTION OF TEST SPECIMENS

Three similar test assemblies were constructed from the sample siding material provided by the client. A diagram of the test assembly is provided in Figure 1. Additional photographs of materials and construction of specimens are provided in Figures 2 through 13.

NTA, Inc. randomly selected lumber for constructing specimens to represent average quality. NTA, Inc. provided commonly available construction materials and assembled each specimen to the client's specifications.

Representative material was sampled from inventory by Quality Control Consultants, LLC personnel on August 1, 2017 at the client's manufacturing facility located in North Branch, MN. As necessary, NTA, Inc. provided commonly available construction materials and assembled each specimen to the client's specifications.

Table 2: Materials

Location	Material
Studs	Single 2 x 4 Stud Grade SPF at 16-in. oc
Top Plate	Single 1 x 4 Ungraded SPF
Bottom Plate	Single 1 x 4 Ungraded SPF
Exterior Sheathing	3/8-in. APA Span Rated 24/0, Exposure 1 OSB (1) 96-in. x 48-in. Sheet Applied Vertically Strength Axis Parallel to Length
Exterior Siding	ClipStone LedgeStone Black Runder Flats, 4-in. tall x 1-1/2-in. Thick x Lengths of 15-1/2, 13-1/2, 11-3/4, 10-1/2, or 7-3/4-in. Model MN 160224 SKU CSM.11.010.30
Interior Sheathing	5/16-in. x 48-in. x 96-in. Square Edge USG Gypsum

Table 3: Fastening Schedule

Connection	Fastener	Quantity or Spacing
Top Plate-to-Studs	7/16-in. x 1-3/4-in. x 15 Ga. Senco Staple #Q19BRB	3
Bottom Plate-to-Studs	7/16-in. x 1-3/4-in. x 15 Ga. Senco Staple #Q19BRB	3
Exterior Sheathing-to-Studs (Mechanical)	7/16-in. x 1-1/2-in. x 16 Ga. Senco Staple #N17BRB	6/6 ^a (3/8-in. Edge Distances)
Exterior Siding (Mechanical)	#8 x 1-1/4-in. Buildex TekS Lath Screws, Part #21512, #2 Phillips Head	Through hole in the top of each of the (2) metal hangers the back of each ClipStone piece, except the bottom row of stone which had a fastener in each of the (2) metal hangers above the stone and a fastener in each of the (2) hangers below the stone, fasteners were driven into exterior sheathing only (NOT into studs)
Interior Sheathing-to-Framing (Adhesive)	Pemco 3100 by Alpha Systems, LLC Expiration: 12-16-17 Adhesive Manufacturer Stated Minimum Cure Time: 24 hours	Ø1/4-in. bead per framing member
Interior Sheathing-to-Framing (Mechanical)	3/16-in. x 3/4-in. x 19 Ga.	6/0 ^a (3/8-in. Edge Distances)

^a Given as edge spacing/field spacing

2.3. TEST PROCEDURE

The test procedure is based on ASTM E72², Section 11; however, the loading stages were modified to correspond with those required in the ultimate load test procedures found in Section 3280.401(b) of the Federal Manufactured Home Construction and Safety Standards. Accordingly, the test setup consists of a vacuum chamber with an open side slightly larger than the test assembly, as shown in Figure 3. A vacuum pump and

manometer connection provide a means to apply and monitor the applied pressure. The samples are placed with the exterior sheathing and siding facing into the vacuum chamber, thereby placing a negative force on the exterior sheathing. The polyethylene sheeting is pleated to accommodate the specimen deflection and then sealed to the chamber.

Instrumentation consists of a water manometer and dial indicators. The water manometer has a resolution of 0.1 inches of water for pressures up to ± 72.0 inches of water. Dial indicators, with a resolution of 0.001 in., are positioned along selected studs to take deflection readings at mid-span and at the supports. For specimens with studs spaced at 16 in. centers, the center two studs are gauged, using a total of six dial gauges. For studs spaced at 24 in. centers, only the middle stud is gauged, using a total of three gauges. Figure 9 provides an example of a test setup.

For testing, each specimen is loaded monotonically at approximate $\frac{1}{4}$ live load pressure increments. Upon reaching each loading stage, applied load is maintained for not less than 10 minutes prior to reading the dial indicators. Once the dial indicators have been read, the pressure is increased to the next loading stage. This procedure is followed through pressure corresponding to 1.25 times live load. After which, the dial gauges are removed and the pressure is increased to ultimate load. At ultimate load, the peak pressure and mode of failure are noted. Ultimate load is taken as the point where the specimen exhibits rupture, fracture, or excessive yielding. Any failure or observations at any point during the test are duly noted.

The applied pressure, in inches of water, is converted to pounds per square foot (psf) using the following conversion: 1 inch of water column = 5.2 psf.

3. TEST RESULTS

A total of three specimens were tested using the procedure outlined herein. The ultimate loads and service load deflections for each specimen are presented in Table 4, below. This table also provides average values, which are compared to the required pass/fail criteria

Table 4: Test Results

Specimen	Ultimate Pressure (psf)	Service Load Deflection (in.)	Failure Mode at Ultimate
94991	171	0.330	<i>Stud to plate fastener failure and exterior sheathing to framing fastener withdrawal</i>
94992	148	0.370	<i>Stud to plate fastener failure and exterior sheathing to framing fastener withdrawal</i>
94993	172	0.328	<i>Stud to plate fastener failure and exterior sheathing to framing fastener withdrawal</i>
Average	163	0.343	--
Evaluation Criteria ^a	120	0.533	--
Overall Result	<i>Pass</i>	<i>Pass</i>	--

^a As required by the FMHCSS¹, which requires a factor of safety of 2.5 against failure and L/180 deflection limit under service level loads.


4. CONCLUSION

Environmental StoneWorks retained NTA, Inc. to perform testing on negative wind assemblies in accordance with procedures in Section 3280.401(b) of the *Federal Manufactured Home Construction and Safety Standards* (FMHCSS)¹. Conclusions from this testing are provided in Table 5 below.

The data provided herein were obtained and assessed in accordance with FMHCSS test procedures and criteria and should not be used for other types of construction. For use in manufactured housing, these findings and results are subject to DAPIA review and approval.

Table 5: Conclusion

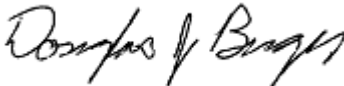
Specimen	Test Conditions	Overall Result
Single 2x4 Stud Grade SPF on 16-in. centers with 3/8-in. APA Span Rated 24/0, Exposure 1 OSB exterior sheathing and Clipstone Ledgerstone Black Rundle Flats 1-1/2-in. thick x 4-in. tall stone siding for 96-in. tall exterior walls, fastened and constructed as detailed herein.	Wind Zone II Corner	PASS

PREPARED BY: 

 Brad Wear
 Test Engineer

11-09-17

 Date

REVIEWED BY: 

 Douglas Berger, P.E.
 Test Engineer

11-09-17

 Date

REFERENCES



1. Department of Housing and Urban Development (HUD). *Manufactured Home Construction and Safety Standards & Interpretive Bulletins to the Standards. 24 Code of Federal Regulations Part 3280*. Office of Assistant Secretary for Housing, Federal Housing Commissioner, Department of Housing and Urban Development.

FIGURES

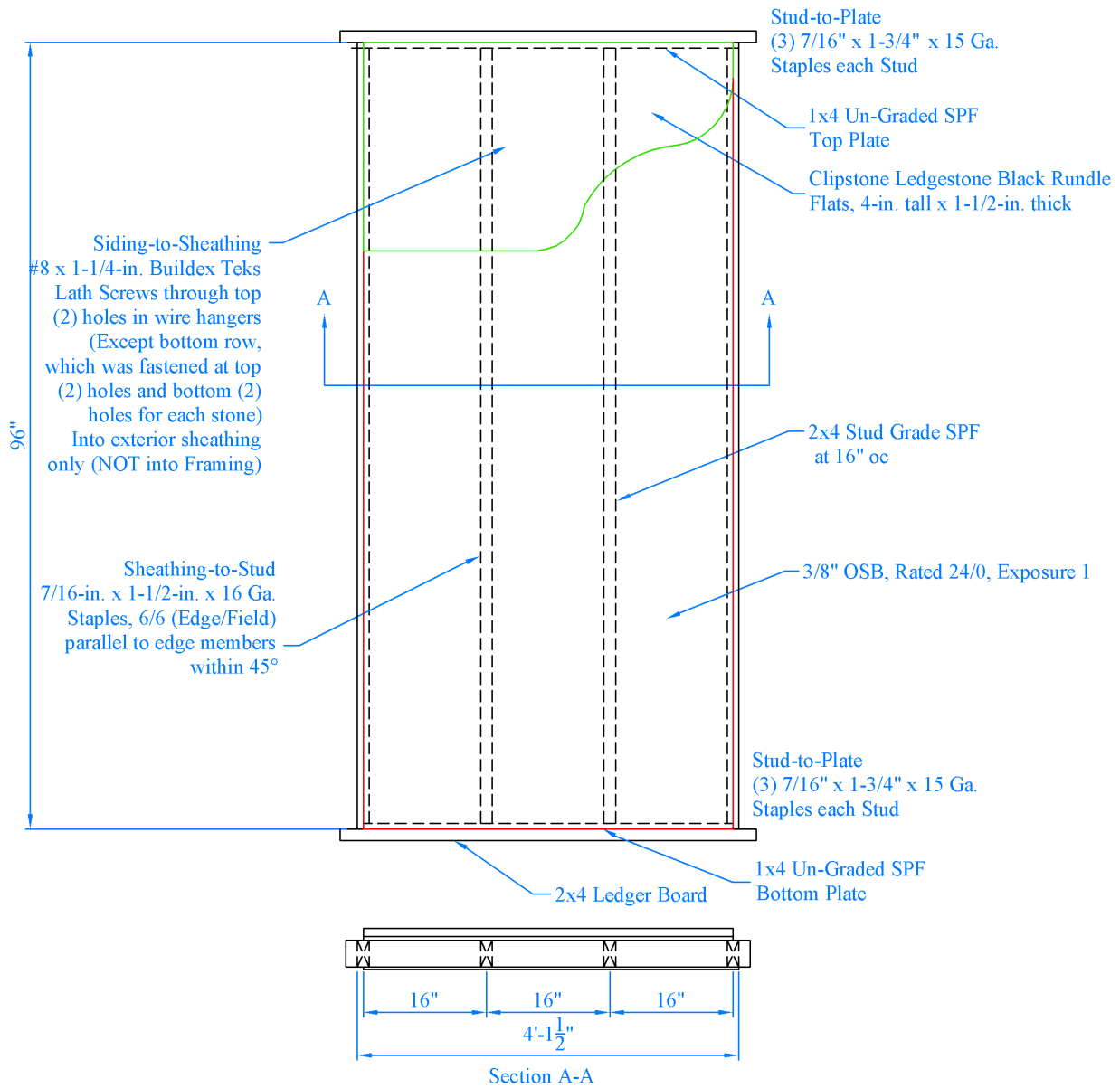


Figure 1: Specimen Diagram

FIGURES



Figure 2: Clipstone Received



Figure 3: Close-Up View of a Box of ClipStone

FIGURES



Figure 4: Close-Up Views of ClipStone

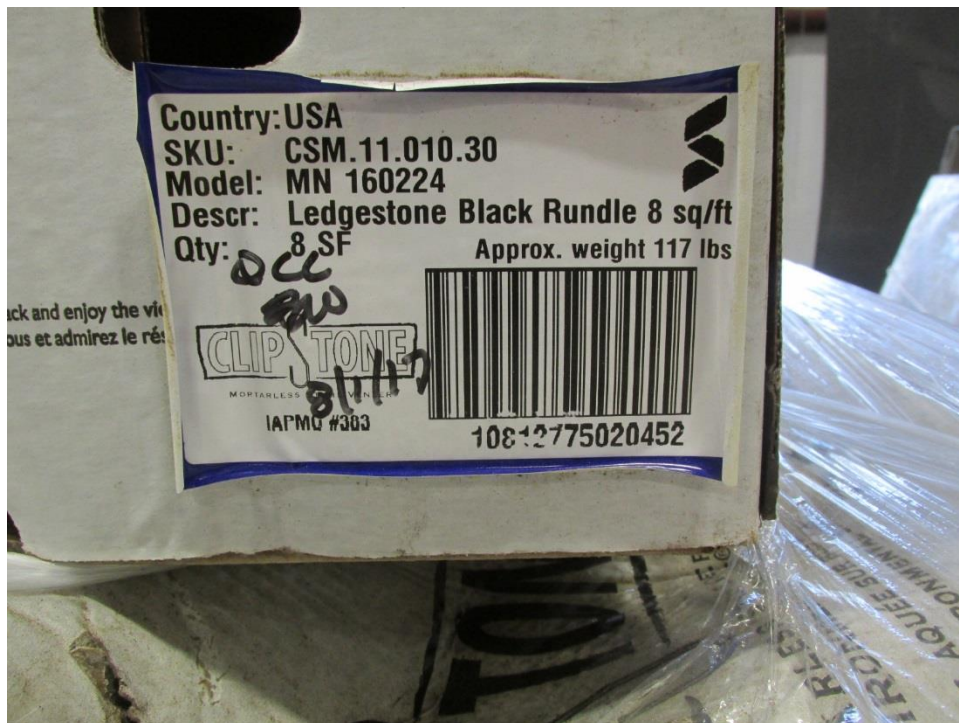


Figure 5: Information on a Box of ClipStone Received



Figure 6: Construction of Wood Framing

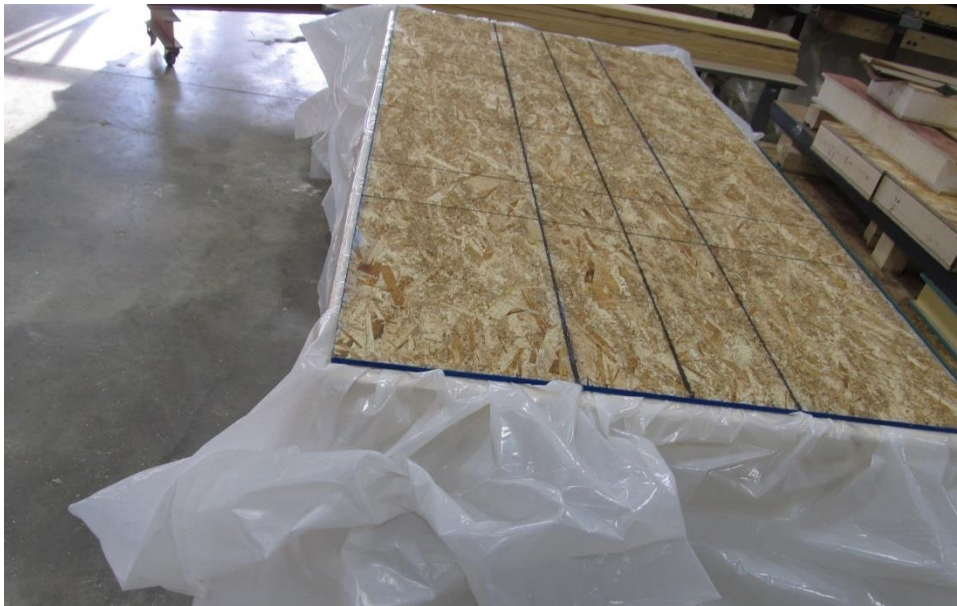


Figure 7: OSB Exterior Sheathing Attached to Framing



Figure 8: Attaching the First Row of ClipStone (Fastened both above and below the ClipStone)



Figure 9: Edge View of ClipStone Attachment



Figure 10: Continuing to Attach Rows of ClipStone (All rows above the first row were only fastened above the ClipStone)



Figure 11: A Specimen after Finish of ClipStone Attachment



Figure 12: Adhesive Application to Interior of Wood Framing



Figure 13: Interior Sheathing (Gypsum) Attachment

FIGURES

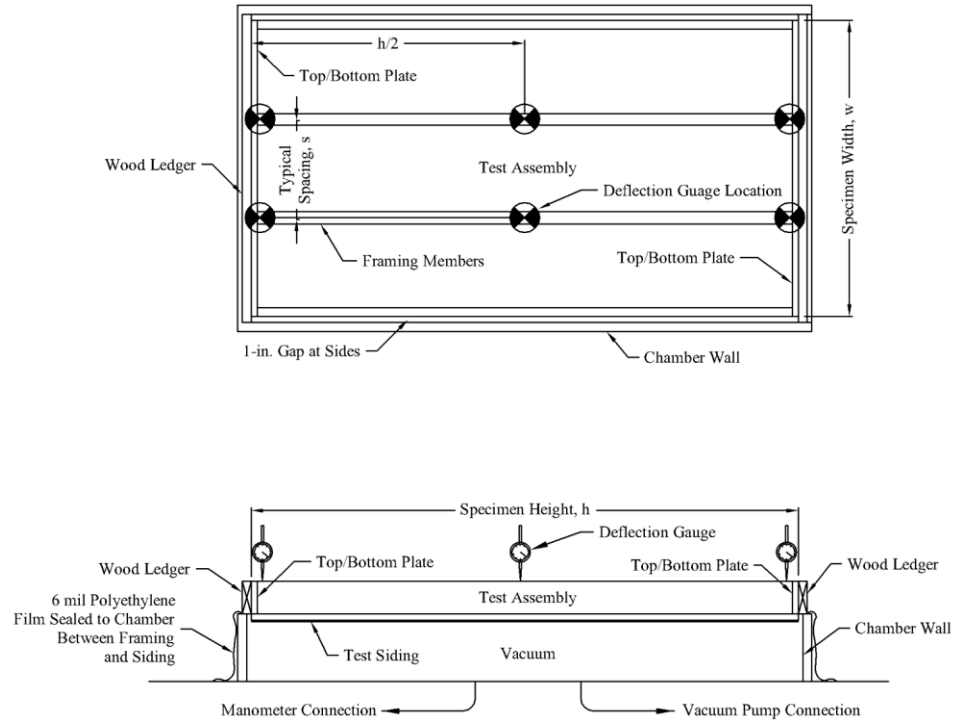


Figure 14: Test Setup



Figure 15: Photograph of a Test Setup



Figure 16: Specimen #94991 after Ultimate

APPENDIX



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NTA, Inc.

SUMMARY DATA
HUD 04-01

Negative Wind Test for Wall Assemblies to be used in Manufactured Homes:
Specimen 1

Client: Environmental Stone Works
Job Number: ESW071417-1
Test Method: FMHCSS, Section 3280.401(b), Ultimate Load Test Procedure

Performed By: Keith Hassell
Witnessed By: Bradley Wear

General:	Apparatus:	Asset No.	Ambient Test Conditions:
Received: 8/17/2017	Length Measure: 01384		Ambient Temp.: 75.2 deg. F
Fabrication Date: 9/28/2017	Vacuum Table: 00023		Ambient R.H.: 48.2%
Test Date: 10/11/2017	Manometer: 423, 337		Sensor Asset No.: 01355
Test Location: NTA, Inc. Nappanee, IN	Moisture Meter: 00830		
	Balance: 00468		

Specimen Description:	Loading Conditions:
Specimen No.: 94991	HUD Wind Zone: Zone II (Corner)
Clear Span: 96-in.	Design Pressure: 48 psf
Width: 49.5-in.	Deflection Limit (L/180): 0.533-in.
Dead Weight: 12.37 psf	Test Orientation: Vertical
Framing: (4) 2 x 4 Stud SPF 16-in. oc	
Ext. Sheathing: 3/8-in x 48-in x 96-in Georgia Pacific OSB Applied Vertically (vertical to length strength axis) 3/8-in. Exposure 1 16ga x 7/16 x 1 1/2-in. 6/6-in. oc edge/field	

Ext. Siding: Clipstone Ledgestone Black Rundle 1 1/2-in. Stone
#8 x 1 1/4-in. Buildex Tek's Lath Screws, Part #21512, #2 Phillips Head 2 per stone through sheathing only

Int. Sheathing: USG Gypsum 5/16-in. Gypsum, Fastening: 19 x 3/16 x 3/4-in. Senco, Galvanized Staple, (P#R11BAB) 6/0-in. oc edge/field
and Pemco 3100 Adhesive, expires 12/16/17
1/4 in. average bead Adhesive cure time was 13 days
Wood MC: 8.2% - 12.8%

Specimen 1 Ultimate Load Test Deflection Data

Load Stages	Applied Pressure (psf)	Left Stud Deflection (in.)			Right Stud Deflection (in.)		
		Top Support	Mid Span	Bottom Support	Top Support	Mid Span	Bottom Support
		01784	01941	00655	01785	01942	00657
0 (REF)	0.0	0.000	0.000	0.000	0.000	0.000	0.000
1/4LL	12.0	0.078	0.116	0.018	0.045	0.103	0.016
1/2LL	23.9	0.097	0.219	0.031	0.065	0.217	0.031
3/4LL	36.4	0.110	0.350	0.043	0.077	0.317	0.045
LL	47.8	0.123	0.404	0.052	0.090	0.416	0.056
5/4LL	60.3	0.137	0.527	0.064	0.104	0.548	0.069
5/2LL	119.6	--	--	--	--	--	--

Note: If testing was performed in a horizontal orientation the cladding weight was included in the 5/2LL stage above and the ultimate load below.

Net LL Deflection: 0.33-in. at 48 psf
Ultimate Uniform Load: 171 psf
Failure Mode: Stud to plate fastener failure. Sheathing to framing fastener withdraw.

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NTA, Inc.

**Negative Wind Test for Wall Assemblies to be used in Manufactured Homes:
Specimen 2**

Client: Environmental Stone Works
Job Number: ESW071417-1
Test Method: FMHCSS, Section 3280.401(b), Ultimate Load Test Procedure

Performed By: Keith Hassell
Witnessed By: Bradley Wear

General:	Apparatus:	Asset No.	Ambient Test Conditions:
Received: 8/17/2017	Length Measure: 01384		Ambient Temp.: 75.5 deg. F
Fabrication Date: 9/28/2017	Vacuum Table: 00023		Ambient R.H.: 48.8%
Test Date: 10/11/2017	Manometer: 423, 337		Sensor Asset No.: 01355
Test Location: NTA, Inc.	Moisture Meter: 00830		
Nappanee, IN	Balance: 00468		

Specimen Description:	Loading Conditions:
Specimen No.: 94992	HUD Wind Zone: Zone II (Corner)
Clear Span: 96-in.	Design Pressure: 48 psf
Width: 49.5-in.	Deflection Limit (L/180): 0.533-in.
Dead Weight: 11.99 psf	Test Orientation: Vertical
Framing: (4) 2 x 4 Stud SPF 16-in. oc	
Ext. Sheathing: 3/8-in x 48-in x 96-in Georgia Pacific OSB Applied Vertically (vertical to length strength axis) 3/8-in. Exposure 1	
16ga x 7/16 x 1 1/2-in. 6/6-in. oc edge/field	
Ext. Siding: Clipstone LedgeStone Black Rundle 1 1/2-in. Stone	
#8 x 1 1/4-in. Buildex Tek's Lath Screws, Part #21512, #2 Phillips Head 2 per stone through sheathing only	
Int. Sheathing: USG Gypsum 5/16-in. Gypsum, Fastening: 19 x 3/16 x 3/4-in. Senco, Galvanized Staple, (P#R11BAB) 6/0-in. oc edge/field	
and Pemco 3100 Adhesive, expires 12/16/17	
1/4 in. average bead	
Wood MC: 11% - 13%	

Specimen 2 Ultimate Load Test Deflection Data

Load Stages	Applied Pressure (psf)	Left Stud Deflection (in.)			Right Stud Deflection (in.)		
		Top Support	Mid Span	Bottom Support	Top Support	Mid Span	Bottom Support
		01784	01941	00655	01785	01942	00657
0 (REF)	0.0	0.000	0.000	0.000	0.000	0.000	0.000
1/4LL	12.2	0.017	0.109	0.022	0.014	0.105	0.028
1/2LL	24.6	0.036	0.238	0.046	0.033	0.225	0.058
3/4LL	36.4	0.051	0.348	0.068	0.047	0.324	0.082
LL	47.8	0.069	0.474	0.090	0.064	0.432	0.108
5/4LL	60.3	0.089	0.643	0.113	0.085	0.563	0.137
5/2LL	119.6	--	--	--	--	--	--

Note: If testing was performed in a horizontal orientation the cladding weight was included in the 5/2LL stage above and the ultimate load below.

Net LL Deflection: 0.37-in. at 48 psf
Ultimate Uniform Load: 148 psf
Failure Mode: Stud to plate fastener failure. Sheathing to framing fastener withdraw.

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**Negative Wind Test for Wall Assemblies to be used in Manufactured Homes:
Specimen 3**

Client: Environmental Stone Works
Job Number: ESW071417-1
Test Method: *FMHCSS, Section 3280.401(b), Ultimate Load Test Procedure*

Performed By: Keith Hassell
Witnessed By: Bradley Wear

General:	Apparatus:	Asset No.	Ambient Test Conditions:
Received: 8/17/2017	Length Measure: 01384		Ambient Temp.: 73.7 deg. F
Fabrication Date: 9/28/2017	Vacuum Table: 00023		Ambient R.H.: 50.3%
Test Date: 10/11/2017	Manometer: 423, 337		Sensor Asset No.: 01355
Test Location: NTA, Inc.	Moisture Meter: 00830		
Nappanee, IN	Balance: 00468		

Specimen Description:	Loading Conditions:
Specimen No.: 94993	HUD Wind Zone: Zone II (Corner)
Clear Span: 96-in.	Design Pressure: 48 psf
Width: 49.5-in.	Deflection Limit (L/180): 0.533-in.
Dead Weight: 12.98 psf	Test Orientation: Vertical
Framing: (4) 2 x 4 Stud SPF 16-in. oc	
Ext. Sheathing: 3/8-in x 48-in x 96-in Georgia Pacific OSB Applied Vertically (vertical to length strength axis) 3/8-in. Exposure 1 16ga x 7/16 x 1 1/2-in. 6/6-in. oc edge/field	
Ext. Siding: Clipstone LedgeStone Black Rundle 1 1/2-in. Stone #8 x 1 1/4-in. Buildex Tek's Lath Screws, Part #21512, #2 Phillips Head 2 per stone through sheathing only	
Int. Sheathing: USG Gypsum 5/16-in. Gypsum, Fastening: 19 x 3/16 x 3/4-in. Senco, Galvanized Staple, (P#R11BAB) 6/0-in. oc edge/field and Pemco 3100 Adhesive, expires 12/16/17 1/4 in. average bead	
Wood MC: 9.5% - 13%	

Specimen 3 Ultimate Load Test Deflection Data

Load Stages	Applied Pressure (psf)	Left Stud Deflection (in.)			Right Stud Deflection (in.)		
		Top Support	Mid Span	Bottom Support	Top Support	Mid Span	Bottom Support
		01784	01941	00655	01785	01942	00657
0 (REF)	0.0	0.000	0.000	0.000	0.000	0.000	0.000
1/4LL	11.9	0.038	0.108	0.033	0.035	0.110	0.026
1/2LL	23.8	0.067	0.215	0.063	0.059	0.221	0.051
3/4LL	36.4	0.087	0.307	0.085	0.074	0.325	0.067
LL	47.8	0.109	0.407	0.106	0.090	0.441	0.080
5/4LL	60.3	0.133	0.516	0.128	0.108	0.577	0.092
5/2LL	119.6	--	--	--	--	--	--

Note: If testing was performed in a horizontal orientation the cladding weight was included in the 5/2LL stage above and the ultimate load below.

Net LL Deflection: 0.328-in. at 48 psf
Ultimate Uniform Load: 172 psf
Failure Mode: Stud to plate fastener failure. Sheathing to framing fastener withdraw.

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NTA, Inc.

**Negative Wind Test for Wall Assemblies to be used in Manufactured Homes:
Results Summary**

Client: Environmental StoneWorks
Job Number: ESW071417-1
Test Method: FMHCSS, Section 3280.401(b), Ultimate Load Test Procedure

Performed By: Keith Hassell
Witnessed By: Bradley Wear

Specimen Description:

Clear Span: 96-in.
Width: 49.5-in.

Loading Conditions:

HUD Wind Zone: Zone II (Corner)
Design Pressure: 48 psf
Deflection Limit (L/180): 0.533-in.

Framing: (4) 2 x 4 Stud SPF 16-in. oc
Ext. Sheathing: 3/8-in x 48-in x 96-in Georgia Pacific OSB Applied Vertically (vertical to length strength axis) 3/8-in. Exposure 1
16ga x 7/16 x 1 1/2-in. 6/6-in. oc edge/field

Ext. Siding: Clipstone Ledgestone Black Rundle 1 1/2-in. Stone
#8 x 1 1/4-in. Buildex Tek's Lath Screws, Part #21512, #2 Phillips Head 2 per stone through sheathing only

Int. Sheathing: USG Gypsum 5/16-in. Gypsum, Fastening: 19 x 3/16 x 3/4-in. Senco, Galvanized Staple, (P#R11BAB) 6/0-in. oc edge/field
and Pemco 3100 Adhesive, expires 12/16/17
1/4 in. average bead

Wood MC: 8.2% - 13%

Construction Description: Single 2x4 studs at 16 in. oc with 3/8-in x 48-in x 96-in OSB, Exposure 1, Rated 24/0 exterior sheathing applied vertically, fastened at 6/6 with a 3/8-in Edge distance using 7/16-in x 1-1/2-in x 16 gauge staple, Clipstone Ledgestone Black Rundle Flats, fastened with Buildex Tek's Lath Screws into exterior sheathing only (NOT into studs) for Wind Zone II-Corner. Product samples by Quality Control Consultants, LLC who was contracted by Environmental Stoneworks, LLC to witness (3) pallets (38 boxes, 304 sq. ft.) of Clipstone Ledgestone Black Rundle Flats, for HUD testing. Sampled on 8/1/17, samples taken randomly from inventory and are individual pieces witnessed by Brett Wrigley.

Test Variable: Negative Wind Test, Wind Zone II-Corner, specimens tested in a vertical orientation

Procedures Modification: None

Overall Test Results

Specimen	Specimen No.	Ultimate Pressure (psf)	Service Deflection (in.)
1	94991	171	0.330
2	94992	148	0.370
3	94993	172	0.328

Average Ultimate Pressure^b: 163 psf, Pass (48 psf x 2.5 - Specimen Dead Load = Min. Ultimate Pressure)

Average Mid-Span Deflection^a: 0.343-in., Pass (L/180 = 0.533-in.)

amid-span deflection less the average of the support deflections.

^bIf the orientation of specimen during testing is horizontal, the specimen dead load may be subtracted from the design pressure to obtain the required minimum ultimate pressure.

Note: Each individual specimen must pass the criteria above in order for the whole test to be considered passing.

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