PRODUCT APPROVAL SUPPORTING CALCULATIONS

F-2500 Folding Wall (non-Impact)

REPORT TO:

JELD-WEN WINDOWS & DOORS
3737 LAKEPORT BLVD
KLAMATH FALLS, OREGON

REPORT NUMBER: NCTL-110-23777-1
REPORT DATE: 10/20/20
Revision 1: 12/09/20

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FL PE 58920
FL REG 33474

Scope

National Certified Testing Laboratories was contracted by Jeld-Wen Windows & Doors to evaluate alternate installation methods for their F-2500 Folding Wall (XX). The evaluation is based on physical testing and product certifications. Reference standards utilized in this project include:

Florida Building Code, Building. International Code Council.

ANSI/AWC *National Design Specification (NDS) for Wood Construction*. American Wood Council.

AISI S100 *North American Specification for the Design of Cold-Formed Steel Structural Members*. American Iron and Steel Institute.

Aluminum Design Manual. The Aluminum Association, Inc.

ICC-ES Report ESR-1976 *ITW Buildex TEKS Self-Drilling Fasteners*. ICC Evaluation Service.

NOA 16-1222.06 *Tapcon Concrete and Masonry Anchors with Advanced Threadform Technology*. Miami-Dade County Product Control Section.

The anchorage analyses presented herein do not address the water resistance, water penetration or air infiltration performance of the installation method or the installed product. In addition, the analyses rely on the assumption that the building substrate is capable of withstanding incurred loads.

Certification of Independence

In accordance with Rule 61G20-3 Florida Administrative Code, National Certified Testing Laboratories hereby certifies the following:

- National Certified Testing Laboratories does not have, nor does it intend to acquire or will it acquire, a financial interest in any company manufacturing or distributing products tested or labeled by the agency.

- National Certified Testing Laboratories is not owned, operated or controlled by any company manufacturing or distributing products it tests or labels.

- Joseph A. Reed, P.E. does not have nor will acquire, a financial interest in any company manufacturing or distributing products for which the reports are being issued.

- Joseph A. Reed, P.E does not have, nor will acquire, a financial interest in any other entity involved in the approval process of the product.

Analyses

Summary of Test Results

The following table summarizes the various F-2500 Folding Wall (XX) products and their corresponding performance levels which have been established by testing or product certification.

Table 1 Summary of Test Results

Series/Model	Test Report Number	Size (W x H)	Performance
F-2500 Folding Wall (XX) (Frame Install)	L1622.01-301-47 (Rev. 1, 09/28/20)	72" x 80"	+50/-55 psf
F-2500 Folding Wall (XX) (Frame Install)	L1341.01-301-47 (Rev. 3, 11/19/20)	71-1/4" x 79-5/16"	+50/-55 psf

Testing documented in Table 1 was conducted by the Intertek laboratory in Fresno, California (Florida Department of Business & Professional Regulation Test Lab No. TST2609, IAS Certification TL-264).

As-Tested Installation Analysis

For air/water/structural testing the test specimen was secured to a 2x Spruce-Pine-Fir buck. The as-tested installation methods are evaluated on page 3 to page 8. These capacities will be used to prove acceptable alternate anchors and substrates for the product.

Alternate Anchorages

Calculations on page 9 through page 18 determine the design capacity of alternate installation anchorages for the product.

Anchorage Requirements

As-tested spacing must be maintained. It must be determined the anchorages are not overloaded for the approved product size and design pressures. Calculations presented on page 19 show the anchor spacing requirements for the established limiting anchor capacities.

Anchorage requirements established by this report are accurately presented in Drawing D015284.

Attachments

Appendix A – Revision Log (1 page)

As-Tested Installation – Through Frame to Wood (Head/Sill)

#8 Flat Head Screw; 1-1/2" penetration to wood

0.062" thick Aluminum Frame (6063-T5)

1/4" Maximum Shim Space

Spruce-Pine-Fir 2x Wood Substrate Minimum (G=0.42)

Allowable Shear of #8 Flat Head Screw

Z' = 119 lb   (See Following 2 Pages)

Bending of #8 Flat Head Screw

L = 1/4" (maximum shim space)
$S = \pi d^3/32 = \pi(0.131)^3/32 = 0.000221 \text{ in}^3$
$F_b = (1.3)(0.6F_y) = (1.3)(0.6)(90,000 \text{ psi}) = 70,200 \text{ psi}$ (1.3 weak axis factor)
$F_b = M/S = (VL/2)/S$ (L/2 for guided bending)
$V = 2SF_b/L = (2)(0.000221 \text{ in})(70,200 \text{ psi})/0.25" = 124 \text{ lb.}$

Capacity of Connection is 119 lb

As-Tested Installation – Through Frame to Wood (Head/Sill) (Continued)

Lateral Design Strength of Wood Connections

Data

Fastener

Fastener	=	#8 Wood Screw	
Shank Dia	=	0.164	in.
Root Dia.	=	0.131	in.
F_{yb}	=	90,000	psi
Fastener length	=	2.000	in.

Main Member

Material	=	SPF	
G	=	0.42	
θ	=	90	<= (Angle of load to grain $0^o \le \theta \le 90^o$)
F_e	=	3,350	psi
Thickness	=	1.500	in.

Side Member

Material	=	6063 T5 Aluminum	
G	=	N/A	
θ	=	90	<= (Angle of load to grain $0^o \le \theta \le 90^o$)
F_{es}	=	27,500	psi
Thickness	=	0.062	in.

Calculations

Lateral Bearing Factors

D	=	0.131	in.
ℓ_m	=	1.500	in.
K_θ	=	1.25	
K_D	=	2.20	
R_e	=	0.122	
R_t	=	24.19	
k_1	=	1.1803	
k_2	=	0.5536	
k_3	=	12.71	

As-Tested Installation – Through Frame to Wood (Head/Sill) (Continued)

Yield Mode	R_d
I_m, I_s	2.20
II	2.20
III_m, III_s, IV	2.20

Lateral Design Values, Z

Mode I_m	=	299	lbf	
Mode I_s	=	102	lbf	
Mode II	=	120	lbf	
Mode III_m	=	133	lbf	
Mode III_s	=	74	lbf	<====== Minimum Value
Mode IV	=	104	lbf	
C_D	=	1.6		
Wet Service Factor				
Fabrication/In-Service		Dry/Dry		
C_M	=	1.0		
In service temperature		T≤100˚F		
C_t	=	1.0		
C_g	=	1.0		
C_Δ	=	1.0		
Is fastener installed in end grain?		No		
C_{eg}	=	1.00		
Is fastener part of a diaphragm?		No		
C_{di}	=	1.0		
Is fastener toe-nailed?		No		
C_{tn}	=	1.00		
Z'	=	**119**	lbf	

As-Tested Installation – Through Frame to Wood (Jambs)

#8 Flat Head Screw; 1-1/2" penetration to wood

3/4" thick Wood Frame (G = 0.42)

1/4" Maximum Shim Space

Spruce-Pine-Fir 2x Wood Substrate Minimum (G=0.42)

Allowable Shear of #8 Flat Head Screw

      Z' = 110 lb   (See Following 2 Pages)

Bending of #8 Flat Head Screw

      L = 1/4" (maximum shim space)
      $S = \pi d^3/32 = \pi(0.131)^3/32 = 0.000221 \text{ in}^3$
      $F_b = (1.3)(0.6F_y) = (1.3)(0.6)(90{,}000 \text{ psi}) = 70{,}200 \text{ psi}$ (1.3 weak axis factor)
      $F_b = M/S = (VL/2)/S$ (L/2 for guided bending)
      $V = 2SF_b/L = (2)(0.000221 \text{ in})(70{,}200 \text{ psi})/0.25" = 124 \text{ lb.}$

Capacity of Connection is 110 lb

As-Tested Installation – Through Frame to Wood (Jambs) (Continued)

Lateral Design Strength of Wood Connections

Data

Fastener

Fastener	=	#8 Wood Screw	
Shank Dia	=	0.164	in.
Root Dia.	=	0.131	in.
F_{yb}	=	90,000	psi
Fastener length	=	2.000	in.

Main Member

Material	=	SPF	
G	=	0.42	
θ	=	90	<= (Angle of load to grain $0^o \le \theta \le 90^o$)
F_e	=	3,350	psi
Thickness	=	1.500	in.

Side Member

Material	=	SPF	
G	=	0.42	
θ	=	90	<= (Angle of load to grain $0^o \le \theta \le 90^o$)
F_{es}	=	3,350	psi
Thickness	=	0.750	in.

Calculations

Lateral Bearing Factors

D	=	0.131	in.
ℓ_m	=	0.922	in.
K_θ	=	1.25	
K_D	=	2.20	
R_e	=	1.000	
R_t	=	1.23	
k_1	=	0.4659	
k_2	=	1.2549	
k_3	=	1.37	

As-Tested Installation – Through Frame to Wood (Jambs) (Continued)

Yield Mode	R_d
I_m, I_s	2.20
II	2.20
III_m, III_s, IV	2.20

Lateral Design Values, Z

Mode I_m	=	184	lbf
Mode I_s	=	150	lbf
Mode II	=	70	lbf
Mode III_m	=	77	lbf
Mode III_s	=	69	lbf <====== Minimum Value
Mode IV	=	78	lbf
C_D	=	1.6	
	Wet Service Factor		
Fabrication/In-Service	Dry/Dry		
C_M	=	1.0	
In service temperature		T≤100°F	
C_t	=	1.0	
C_g	=	1.0	
C_Δ	=	1.0	
Is fastener installed in end grain?	No		
C_{eg}	=	1.00	
Is fastener part of a diaphragm?	No		
C_{di}	=	1.0	
Is fastener toe-nailed?	No		
C_{tn}	=	1.00	
Z'	**=**	**110**	**lbf**

Alternate Installation – Through Frame to Concrete

3/16" Tapcon Anchor

2-1/2" Minimum Edge Distance, 1-1/4" Minimum Embedment

1/4" Maximum Shim Space

Minimum f'_c = 3,000 psi Concrete

Allowable Shear of 3/16" Tapcon Anchor

P_{ss}/Ω = 181 lb   (NOA-No. 16-1222.06)

Bearing of 3/16" Tapcon Anchor on Frame (Head/Sill)

$V_a = 2DtF_{tu}/3.0 = 2(0.170")(0.062")(22,000 \text{ psi})/3.0 = 155$ lb.

Bearing of 3/16" Tapcon Anchor on Frame (Jambs)

$V_a = F_eDt/K_D = (3,350 \text{ psi})(0.170")(0.75")/(10(0.170)+0.5) = 194$ lb

Bending of 3/16" Tapcon Anchor

L = 1/4" (Maximum Shim Space)
$S = \pi d^3/32 = \pi(0.170")^3/32 = 0.000482 \text{ in}^3$
$F_b = (1.3)(0.6F_y) = (1.3)(0.6)(137,000 \text{ psi}) = 106,860 \text{ psi}$ (1.3 weak axis factor)
$F_b = M/S = (VL/2)/S$ (L/2 for guided bending)
$V = 2SF_b/L = (2)(0.000482 \text{ in}^3)(106,860 \text{ psi})/0.25" = 412$ lb.

Capacity of Connection is 155 lb

Alternate Installation – Through Frame to CMU

3/16" Tapcon Anchor

2-1/2" Minimum Edge Distance, 1-1/4" Minimum Embedment

1/4" Maximum Shim Space

Minimum ASTM C90 Concrete Masonry Unit

Allowable Shear of 3/16" Tapcon Anchor

P_{ss}/Ω = 135 lb   (NOA-No. 16-1222.06)

Bearing of 3/16" Tapcon Anchor on Frame (Head/Sill)

$V_a = 2DtF_{tu}/3.0 = 2(0.170")(0.062")(22,000\ psi)/3.0 = 155\ lb.$

Bearing of 3/16" Tapcon Anchor on Frame (Jambs)

$V_a = F_eDt/K_D = (3,350\ psi)(0.170")(0.75")/(10(0.170)+0.5) = 194\ lb$

Bending of 3/16" Tapcon Anchor

L = 1/4" (Maximum Shim Space)
$S = \pi d^3/32 = \pi(0.170")^3/32 = 0.000482\ in^3$
$F_b = (1.3)(0.6F_y) = (1.3)(0.6)(137,000\ psi) = 106,860\ psi$ (1.3 for weak axis bending)
$F_b = M/S = (VL/2)/S$ (L/2 for guided bending)
$V = 2SF_b/L = (2)(0.000482\ in^3)(106,860\ psi)/0.25" = 412\ lb.$

Capacity of Connection is 135 lb

Alternate Installation – Strap Anchor to Wood

Two #8 x 1-1/2" Flat Head Screws securing strap to substrate

Spruce-Pine-Fir 2x Wood Substrate Minimum (G=0.42)

Two #8 Screws securing strap to frame

0.062" thick Aluminum Frame (Head/Sill)

3/4" thick Wood Frame (Jambs)

20 gauge (0.033" thick) 33 KSI Steel Strap Anchor

1/4" Maximum Shim Space

Allowable Shear of #8 x 1-1/2" Flat Head Screw

   $Z' = 122$ lb   (See Following 2 Pages)

Bending of #8 x 1-1/2" Flat Head Screw

   $L = 1/4"$ (maximum shim space)
   $S = \pi d^3/32 = \pi(0.131)^3/32 = 0.000221 \text{ in}^3$
   $F_b = (1.3)(0.6F_y) = (1.3)(0.6)(90,000 \text{ psi}) = 70,200 \text{ psi}$ (1.3 weak axis factor)
   $F_b = M/S = (VL/2)/S$ (L/2 for guided bending)
   $V = 2SF_b/L = (2)(0.000221 \text{ in})(70,200 \text{ psi})/0.25" = 124$ lb.

Bearing of #8 Screw on Frame (Head/Sill)

   $V_a = 2DtF_{tu}/3.0 = 2(0.164")(0.062")(22,000 \text{ psi})/3.0 = 149$ lb.

Bearing of #8 Screw on Frame (Jambs)

   $V_a = F_eDt/K_D = (3,350 \text{ psi})(0.164")(0.75")/(10(0.164)+0.5) = 193$ lb

Bearing of #8 Screw on Strap Anchor

   $V_a = 2.7DtF_{tu}/3.0$
   $V_a = 2.7(0.164")(0.033")(45,000 \text{ psi})/3.0$
   $V_a = 219$ lb.

Capacity of Connection is 122 lb

Capacity for Two Screws is 244 lb

Alternate Installation – Strap Anchor to Wood (Continued)

Lateral Design Strength of Wood Connections

Data

Fastener

Fastener	=	#8 Wood Screw
Shank Dia	=	0.164 in.
Root Dia.	=	0.131 in.
F_{yb}	=	90,000 psi
Fastener length	=	2.500 in.

Main Member

Material	=	SPF
G	=	0.42
θ	=	90 <= (Angle of load to grain $0^o \le \theta \le 90^o$)
F_e	=	3,350 psi
Thickness	=	1.500 in.

Side Member

Material	=	ASTM A 653, Grade 33 Steel
G	=	N/A
θ	=	90 <= (Angle of load to grain $0^o \le \theta \le 90^o$)
F_{es}	=	61,850 psi
Thickness	=	0.033 in.

Calculations

Lateral Bearing Factors

D	=	0.131 in.
ℓ_m	=	1.500 in.
K_θ	=	1.25
K_D	=	2.20
R_e	=	0.054
R_t	=	45.45
k_1	=	1.0041
k_2	=	0.5032
k_3	=	23.87

Yield Mode	R_d
I_m, I_s	2.20
II	2.20
III_m, III_s, IV	2.20

<u>Alternate Installation – Strap Anchor to Wood</u> (Continued)

Lateral Design Values, Z

Mode I_m	=	299	lbf
Mode I_s	=	122	lbf
Mode II	=	122	lbf
Mode III_m	=	136	lbf
Mode III_s	=	77	lbf	<====== Minimum Value
Mode IV	=	108	lbf
C_D	=	1.6	

Wet Service Factor

Fabrication/In-Service		Dry/Dry	
C_M	=	1.0	
In service temperature		T≤100°F	
C_t	=	1.0	
C_g	=	1.0	
C_Δ	=	1.0	
Is fastener installed in end grain?		No	
C_{eg}	=	1.00	
Is fastener part of a diaphragm?		No	
C_{di}	=	1.0	
Is fastener toe-nailed?		No	
C_{tn}	=	1.00	
Z'	**=**	**<u>122</u>**	**lbf**

Alternate Installation – Strap Anchor to Concrete

3/16" Tapcon Anchor; 2-1/2" Minimum Edge Distance, 1-1/4" Minimum Embedment

#8 Screws Connecting Strap to Frame

0.062" thick Aluminum Frame (Head/Sill)

3/4" thick Wood Frame (Jambs)

20 gauge (0.033" thick) 33 KSI Steel Strap Anchor

1/4" Maximum Shim Space

Minimum f'_c = 3,000 psi Concrete

Allowable Shear of 3/16" Tapcon Anchor

P_{ss}/Ω = 181 lb   (NOA-No. 16-1222.06)

Bearing of 3/16" Tapcon Anchor on Strap Anchor

$V_a = 2.7DtF_{tu}/3.0$
$V_a = 2.7(0.170")(0.033")(45,000 \text{ psi})/3.0$
V_a = 227 lb.

Bending of 3/16" Tapcon Anchor

L = 1/4" (Maximum Shim Space)
$S = \pi d^3/32 = \pi(0.170")^3/32 = 0.000482 \text{ in}^3$
$F_b = (1.3)(0.6F_y) = (1.3)(0.6)(137,000 \text{ psi}) = 106,860 \text{ psi}$ (1.3 weak axis factor)
$F_b = M/S = (VL/2)/S$ (L/2 for guided bending)
$V = 2SF_b/L = (2)(0.000482 \text{ in}^3)(106,860 \text{ psi})/0.25" = 412$ lb.

Bearing of #8 Screw on Strap Anchor

$V_a = 2.7DtF_{tu}/3.0$
$V_a = 2.7(0.164")(0.033")(45,000 \text{ psi})/3.0$
V_a = 219 lb.

Alternate Installation – Strap Anchor to Concrete (Continued)

Bearing of #8 Screw on Frame (Head/Sill)

$$V_a = 2DtF_{tu}/3.0 = 2(0.164")(0.062")(22,000 \text{ psi})/3.0 = 149 \text{ lb.}$$

Bearing of #8 Screw on Frame (Jambs)

$$V_a = F_eDt/K_D = (3,350 \text{ psi})(0.164")(0.75")/(10(0.164)+0.5) = 193 \text{ lb}$$

Capacity of Connection is 181 lb (only one concrete screw per strap)

Alternate Installation – Strap Anchor to CMU

3/16" Tapcon Anchor; 2-1/2" Minimum Edge Distance, 1-1/4" Minimum Embedment

#8 Screws Connecting Strap to Frame

0.062" thick Aluminum Frame (Head/Sill)

3/4" thick Wood Frame (Jambs)

20 gauge (0.033" thick) 33 KSI Steel Strap Anchor

1/4" Maximum Shim Space

Minimum ASTM C90 Concrete Masonry Unit

Allowable Shear of 3/16" Tapcon Anchor

P_{ss}/Ω = 135 lb   (NOA-No. 16-1222.06)

Bearing of 3/16" Tapcon Anchor on Strap Anchor

V_a = 2.7DtF_{tu}/3.0
V_a = 2.7(0.170")(0.033")(45,000 psi)/3.0
V_a = 227 lb.

Bending of 3/16" Tapcon Anchor

L = 1/4" (Maximum Shim Space)
S = πd^3/32 = π(0.170")^3/32 = 0.000482 in^3
F_b = (1.3)(0.6F_y) = (1.3)(0.6)(137,000 psi) = 106,860 psi (1.3 for weak axis bending)
F_b = M/S = (VL/2)/S (L/2 for guided bending)
V = 2SF_b/L = (2)(0.000482 in^3)(106,860 psi)/0.25" = 412 lb.

Bearing of #8 Screw on Strap Anchor

V_a = 2.7DtF_{tu}/3.0
V_a = 2.7(0.164")(0.033")(45,000 psi)/3.0
V_a = 219 lb.

Alternate Installation – Strap Anchor to CMU (Continued)

<u>Bearing of #8 Screw on Frame (Head/Sill)</u>

$V_a = 2DtF_{tu}/3.0 = 2(0.164")(0.062")(22,000 \text{ psi})/3.0 = 149$ lb.

<u>Bearing of #8 Screw on Frame (Jambs)</u>

$V_a = F_eDt/K_D = (3,350 \text{ psi})(0.164")(0.75")/(10(0.164)+0.5) = 193$ lb

Capacity of Connection is 135 lb (only one concrete screw per strap)

Alternate Installation – Strap Anchor to Wood – Cap Installation

Two #8 x 1-1/2" Flat Head Screws securing strap to substrate

Spruce-Pine-Fir 2x Wood Substrate Minimum (G=0.42)

Two #8 Screws securing strap to frame

0.062" thick Aluminum Frame (Head/Sill)

3/4" thick Wood Frame (Jambs)

20 gauge (0.033" thick) 33 KSI Steel Strap Anchor

1/4" Maximum Shim Space

Allowable Withdrawal of #8 x 1-1/2" Flat Head Screw

$$W' = 1.6(82 \text{ lb/inch})(1.5") = 197 \text{ lb}$$

Allowable Pull-over of #8 x 1-1/2" Flat Head Screw

$$P_{nov}/\Omega = 1.5td_wF_u/\Omega = 1.5(0.033")(0.332")(45,000 \text{ psi})/3.0 = 247 \text{ lb}$$

Bearing of #8 Screw on Frame (Head/Sill)

$$V_a = 2DtF_{tu}/3.0 = 2(0.164")(0.062")(22,000 \text{ psi})/3.0 = 149 \text{ lb.}$$

Bearing of #8 Screw on Frame (Jambs)

$$V_a = F_eDt/K_D = (3,350 \text{ psi})(0.164")(0.75")/(10(0.164)+0.5) = 193 \text{ lb}$$

Bearing of #8 Screw on Strap Anchor

$$V_a = 2.7DtF_{tu}/3.0$$
$$V_a = 2.7(0.164")(0.033")(45,000 \text{ psi})/3.0$$
$$V_a = 219 \text{ lb.}$$

Capacity of Connection is 149 lb

Capacity for Two Screws is 298 lb

72x80 +50/-55 psf

Anchorage Requirements

Product Overall Size: 72" x 80"

Product Overall Area: (72")(80")/144 = 40 ft^2

Product Overall Wind Load: (55 psf)(40 ft^2) = 2,200 lb

Installed Anchor Spacing: 8-1/2" head/sill; 14-1/2" jambs

Installed Anchors: 8 head + 8 sill + 2(6) jambs = 28 installed anchors

Minimum Anchor Capacity: 110 lb/anchor

Total Anchor Capacity: (28 anchors)(110 lb/anchor) = 3,080 lb > 2,200 lb **OK**

Appendix A

Revision Log

Identification	Date	Page & Revision
Original Issue	10/20/20	Not Applicable
Revision 1	12/09/20	2
		Added test report L1341.01-301-47