

Micah Swartz, P.E.	Project Number:	MS24-06009
	Project Name:	ID 176 - Endurance Twin Single Hung
	Date:	7/27/2025

**Product Approval Supporting Calculations
Alternative Anchorage Analysis & Design - R1 General Update**

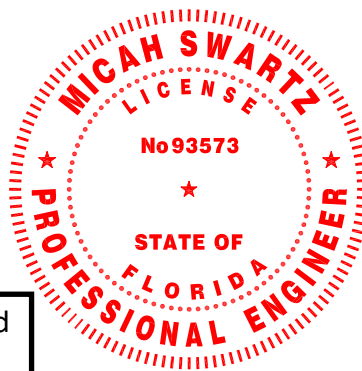
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Drawing Number: 176-1

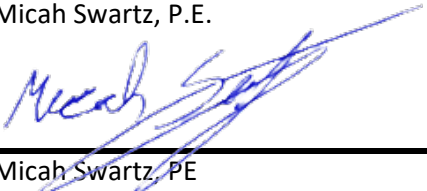
Reference Test Report: I2449.01-901-44 R0

Product Name: ID 176 - Endurance Twin Single Hung 88x96

Prepared for:
VPI Quality Windows
3420 E. Ferry Avenue
Spokane, WA 99202



Prepared by:
Micah Swartz, P.E.



Micah Swartz, PE
Florida License No. PE 93573

This item has been digitally signed and sealed by Micah Swartz, P.E. on the date adjacent to the seal.

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07/27/25

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Scope:

Micah Swartz, P.E. is contracted by Jeld-Wen Windows & Doors to evaluate alternative anchorage for the product: ID 176 - Endurance Twin Single Hung 88x96. This evaluation is based on testing performed by Intertek Building and Construction in Kent WA, test report no.: I2449.01-901-44 R0 and dated 9/25/18.

This evaluation does not include the air infiltration, water resistance or water penetration of the installation method or the installed product. In addition, the design of the building substrate to resist the superimposed loads is by others.

Reference Standards:

Current edition of the Florida Building Code, Building

ANSI/AWC NDS - National Design Specification (NDS) for Wood Construction

AISI S100 North American Specification for the Design of Cold-Formed Steel Structural Members

ICC-ES Report ESR-1976 ITW Buildex TEKS Self-Drilling Fasteners

ICC-ES Report ESR-2196 Hilti Self Drilling Screws to connect cold-formed steel

NOA 24-0102.06 Tapcon Concrete and Masonry Anchors with Advanced Threadform Technology

Certification of Independence:

In accordance with Rule 61G20-3 Florida Administrative Code, Micah Swartz, P.E. hereby certifies the following:

(1) Micah Swartz, P.E. 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.

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(4) Micah Swartz, P.E. does not have, nor will acquire, a financial interest in any other entity involved in the approval process of the product.

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Design Summary:

The table below summarizes the product: ID 176 - Endurance Twin Single Hung 88x96 and their corresponding performance levels as established by testing.

Table 1: Summary of Test Results

Series/Model	Test Report Number	Size (W x H)	Performance
ID 176 - Endurance Twin Single Hung 88x96	I2449.01-901-44 R0 (9/25/18)	88" x 96"	+45 psf / -45 psf

As Tested Design:

Geometry - Through Nail Flange

Screw Information:

Screw Size: 8 Screw Embed: 1 in Edge Distance: 3/4 in (minimum)
 qty: 1 Spacing: 4 in O.C.

Wood Screw Withdrawal: 131 lbs Per ft. Capacity: 394 plf

Geometry - Fender Washer over Nail Flange @ Header

See Intertek Report No. N2543.01-904-44 issued 3/15/22

Performance of Unit: -45 psf Load Applied to Header (Tributary Method): 135 plf

Load resisted by one (1) #8 screw w/ 1-1/8" embedment @ 12" o.c.

Screw Size: 8 Screw Embed: 1.125 in Edge Distance: 3/4 in (minimum)
 qty: 1 Spacing: 12 in O.C.

Wood Screw Withdrawal: 148 lbs Per ft. Capacity: 148 plf

Performance of Unit: 45 psf Load Applied to Header (Tributary Method): 160 plf

Load is resisted by #8 screws w/ 1" embedment @ 4" O.C. with a capacity of 394 plf as shown above.

Geometry - Masonry Straps

Performance of Unit: 45 psf Load Applied to Header (Tributary Method): 160 plf

Load resisted by masonry strap @ 12" o.c. Load resisted by each strap: 160 lbs

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Alternative Fasteners Cont. - See following sheets for detailed fastener analysis

Geometry - Through Nail Flange

TEK Screw Information:

Screw Size: 10-16

qty: 1

Spacing: 4 in O.C.

TEK Withdrawal: 145 lbs

Per ft. Capacity: 435 plf Unity: 0.90

Alternative Fasteners Cont. - See following sheets for detailed fastener analysis

Geometry - Masonry Strap

Screw Information:

Screw Size: 8

Screw Embed: 1 in

Edge Distance: 3/4 in (minimum)

qty: 2

Spacing: 12 in O.C.

Wood Screw Lateral: 106 lbs

Per ft. Capacity: 211 plf Unity: 0.76

TEK Screw Information:

Screw Size: 10-16

qty: 2

Spacing: 12 in O.C.

TEK Lateral: 147 lbs

Per ft. Capacity: 294 plf Unity: 0.54

Tapcon Information:

Tapcon Size: 1/4

Embedment: 1-1/4 in (minimum)

Edge Distance: 2-1/2 in (minimum)

qty: 1

Spacing: 12 in O.C.

Tapcon Lateral (Concrete): 237 lbs

Per ft. Capacity: 237 plf Unity: 0.67

Tapcon Lateral (CMU): 161 lbs

Per ft. Capacity: 161 plf Unity: 0.99

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Alternative Fasteners Cont. - See following sheets for detailed fastener analysis

Geometry - Sill Angle (See TEK screw withdrawal and Tapcon Capacities above)

TEK Screw Information: Note: Fastener into sill does NOT span shim gap.

Screw Size: 10-16
qty: 1 Spacing: 4 in O.C.

TEK Lateral: 147 lbs Per ft. Capacity: 441 plf Unity: 0.89

Tapcon Information:

Tapcon Size: 3/16 Embedment: 1-1/4 in (minimum) Edge Distance: 2-1/2 in (minimum)
qty: 1 Spacing: 4 in O.C.

Tapcon Lateral (Concrete): 181 lbs Per ft. Capacity: 543 plf Unity: 0.72
Tapcon Lateral (CMU): 135 lbs Per ft. Capacity: 405 plf Unity: 0.97

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Subject: As Tested - Wood Screw Withdrawal (Fender Washer)

Input:	
Calculation:	

Screw Information:

Screw Size:	8	Root Diameter:	0.131	in
Screw Embed:	1.125			

Main Member Type:	S-P-F	G:	0.42	F _{em} :	3,350	psi
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$W' = W * C_D * C_M^2 * C_t$ – As per table 11.3.1 NDS

C _D :	1.6	Load Duration Factor - Table 2.3.2 (NDS)
C _M :	1.0	Wet Service Factor - Table 11.3.3 (NDS)
C _t :	1.0	Temperature Factor - Table 11.3.4 (NDS)

W:	82	lbs/in - Table 12.2B (NDS)
W:	92	lbs

W':	148	lbs
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Subject: Wood Screw Lateral Design - Single Shear

Input:

Calculation:

Screw Information:

Screw Size: 8

Root Diameter: 0.131 in

Screw Embed: 1 in

Main Member Type: S-P-F G: 0.42 F_{em}: 3,350 psi thickness (t_m): 1.5 in

Side Member Type: PVC G: N/A F_{es}: 13,750 psi thickness (t_s): 0.063 in

Lateral Design Factors - Table 12.3.1A (NDS)

D:	0.131	in	Diameter
F _{yb} :	100	ksi	Dowel Bending Yield Strength
F _{em} :	3,350	psi	Main Member dowel bearing strength
F _{es} :	13,750	psi	Side Member dowel bearing strength
l _m :	1	in	Main Member dowel bearing length
l _s :	0.063	in	Side Member dowel bearing length
R _d :	2.2		Reduction term - Table 12.3.1B (NDS)
R _e :	0.2436		= F _{em} /F _{es}
R _t :	15.9		= l _m /l _s
k ₁ :	1.506		See Table
k ₂ :	0.731		See Table

Reference Lateral Design Values - Table 12.3.1A (NDS)

Z_{I_m}: 199 lbs $Z_{Im} = \frac{Dl_mF_{em}}{R_d}$ (EQ 12.3 – 1)

Z_{II}: 78 lbs $Z_{II} = \frac{k_1Dl_sF_{es}}{R_d}$ (EQ 12.3 – 3)

Z_{III_m}: 98 lbs $Z_{III_m} = \frac{k_2Dl_mF_{em}}{(1 + 2R_e)R_d}$ (EQ 12.3 – 4)

Z_{IV}: 105 lbs $Z_{IV} = \frac{D^2}{R_d} \sqrt{\frac{2F_{em}F_{yb}}{3(1 + R_e)}}$ (EQ 12.3 – 6)

Z_{MIN}: 78 lbs

Note: Side member is part of the Jeld-Wen assembly and verified during testing. Modes Z_{Is} and Z_{III_s} are not applicable to the calculation.

Subject: Wood Screw Lateral Design - Single Shear Cont.**Adjusted Lateral Design Values**

$$Z' = Z * C_D * C_M * C_t * C_g * C_{\Delta} - \text{As per table 11.3.1 NDS}$$

C_D :	1.6	Load Duration Factor - Table 2.3.2 (NDS)
C_M :	1.0	Wet Service Factor - Table 11.3.3 (NDS)
C_t :	1.0	Temperature Factor - Table 11.3.4 (NDS)
C_g :	1.0	Group Action Factor - Section 11.3.6 (NDS)
C_{Δ} :	1.0	Geometry Factor - Section 12.5.1.1 (NDS)

$$Z': \boxed{124} \text{ lbs}$$

Fastener Bending Across Shim Space

Ω :	1.67	
L:	0.25	in Maximum Shim Gap
D:	0.131	in Diameter
F_{yb} :	100	ksi Dowel Bending Yield Strength

$$\frac{F_{yb}}{\Omega} = \frac{M}{S} = \frac{16ZL}{\pi D^3} \Leftrightarrow Z = \frac{F_{yb} \pi D^3}{16 \Omega L}$$

$$\text{Where } M = \frac{ZL}{2} \text{ (Guided Bending)}$$

$$Z_n/\Omega: \boxed{106} \text{ lbs}$$

Bearing on Masonry Strap

Ω :	3.00	
F_u :	33	ksi Tensile Strength of strap
t:	20	GA
t:	0.036	in thickness of strap
D:	0.131	in

$$\frac{P_{nv}}{\Omega} = 2.7 * t * D * F_u - (EQ. J4.3.1 - 4, AISI S100)$$

$$P_{nv}/\Omega: \boxed{140} \text{ lbs}$$

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Subject:

Input:
Calculation:

Tensile Strength of Fastener - ESR 1976

Screw Size:

P_{nv}/Ω : lbs See ESR-1976

Tensile Pullout - ESR 1976

Screw Size:

F_u :	45	ksi	Tensile Strength of material NOT in contact with screw head
t:	16	GA	
t:	0.0598	in	

P_{nv}/Ω : lbs See ESR-1976

Tensile Pullover

Note: The tensile pullover analysis checks the material IN contact with the screw head. This material is part of the Jeld-Wen assembly and has been verified by testing. Below is a check to ensure the head size of the TEK screw is equal to or larger than the head of the tested fastener, ensuring compliance.

Tested Fastener Head Size:

Screw Size:	8	Tested fastener is a
Head Size:	0.312 in	

TEK Screw Head Size:

Screw Size:	10-16
Head Size:	0.365 in

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Subject:

TEK Lateral Design

Input:
Calculation:

Shear Strength of Fastener - ESR 1976

Screw Size:

10-16

P_{nv}/Ω :

573

 lbs See ESR-1976

Bearing Strength of Material NOT in Contact with Screw Head - AISI S100

Screw Size:

10-16

 Ω :

3.00

D: 0.138	in	Root Diameter of TEK Screw
F_u : 45	ksi	Tensile Strength of material NOT in contact with screw head
t: 18	GA	
t: 0.0478	in	Thickness of material NOT in contact with screw head

$$\frac{P_{nv1}}{\Omega} = 2.7 * t * D * F_u - (EQ.J4.3.1 - 3, AISI S100)$$

$$\frac{P_{nv2}}{\Omega} = 4.2\sqrt{t^3 * D} * F_u - (EQ.J4.3.1 - 1, AISI S100)$$

P_{nv1}/Ω :

267

 lbs
 P_{nv2}/Ω :

245

 lbs

P_{nv}/Ω :

245

 lbs $\frac{P_{nv}}{\Omega} = \text{smallest of } \frac{P_{nv1}}{\Omega} \text{ and } \frac{P_{nv2}}{\Omega}$

Bearing Strength of Material IN in Contact with Screw Head

Note: Material IN contact with the screw head is part of the Jeld-Wen assembly and has been verified by testing.

Fastener Bending Across Shim Space

L: 0.25	in	Maximum Shim Gap	Ω : 3.00
D: 0.138	in	Root Diameter of TEK Screw	
F_{yb} : 100	ksi	Yield Strength of TEK Screw	

$$\frac{F_{yb}}{\Omega} = \frac{M}{S} = \frac{16P_nL}{\pi D^3} \Leftrightarrow P_n = \frac{F_{yb}\pi D^3}{16\Omega L}$$
 Where $M = \frac{P_nL}{2}$ (Guided Bending)

P_n/Ω :

206

 lbs

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Bearing Strength of Masonry Straps - AISI S100

Screw Size:	10-16	TEK Screw	Ω:	3.00
D:	0.138	in	Root Diameter of TEK Screw	
F _u :	33	ksi	Tensile Strength of Masonry Strap	
t:	20	GA		
t:	0.0359	in	Thickness of Masonry Strap	

$$\frac{P_{nv}}{\Omega} = 2.7 * t * D * F_u - (EQ.J4.3.1 - 3, AISI S100)$$

P_{nv}/Ω: 147 lbs

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Subject: Tapcon Lateral Design

Input:

Calculation:

Tapcon Size:

Size: 1/4

D: 0.25 in Nominal Diameter

D_{sh}: 0.19 in Shank Diameter**Fastener Shear Capacity - 3,000 psi Concrete**P_{nv}/Ω: 237 lbs See Table 1B of NOA 24-0102.06**Fastener Shear Capacity - Medium-Weight CMU**P_{nv}/Ω: 161 lbs See Table 3 of NOA 24-0102.06**Note:**

- Critical anchor spacing is 16D
- Minimum Anchor Embedment is 1-1/4"
- Minimum Edge Distance is 2-1/4"

Fastener Bending Across Shim Space

L: 0.25 in Maximum Shim Gap

D_{sh}: 0.19 in Shank Diameter of TapconF_{yb}: 100 ksi Yield Strength of Tapcon

Ω: 3.00

$$\frac{F_{yb}}{\Omega} = \frac{M}{S} = \frac{16P_n L}{\pi D^3} \Leftrightarrow P_n = \frac{F_{yb} \pi D^3}{16 \Omega L}$$

Where $M = \frac{P_n L}{2}$ (Guided Bending)P_n/Ω: 539 lbs**Bearing Strength of Masonry Straps - AISI S100**

Size: 1/4 Tapcon Size

D_{sh}: 0.19 in Shank Diameter of Tapcon ScrewF_u: 33 ksi Tensile Strength of Masonry Strap

t: 16 GA

t: 0.0598 in Thickness of Masonry Strap

Ω: 3.00

$$\frac{P_{nv}}{\Omega} = 2.7 * t * D * F_u - (EQ. J4.3.1 - 3, AISI S100)$$

P_{nv}/Ω: 337 lbs

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Subject: Tapcon Lateral Design

Input:

Calculation:

Tapcon Size:

Size: 3/16

D: 0.1875 in Nominal Diameter

D_{sh}: 0.145 in Shank Diameter**Fastener Shear Capacity - 3,000 psi Concrete**P_{nv}/Ω: 181 lbs See Table 1B of NOA 24-0102.06**Fastener Shear Capacity - Medium-Weight CMU**P_{nv}/Ω: 135 lbs See Table 3 of NOA 24-0102.06**Note:**

- Critical anchor spacing is 16D
- Minimum Anchor Embedment is 1-1/4"
- Minimum Edge Distance is 2-1/4"

Fastener Bending Across Shim Space

L: 0.25 in Maximum Shim Gap

D_{sh}: 0.145 in Shank Diameter of TapconF_{yb}: 100 ksi Yield Strength of Tapcon

Ω: 3.00

$$\frac{F_{yb}}{\Omega} = \frac{M}{S} = \frac{16P_n L}{\pi D^3} \Leftrightarrow P_n = \frac{F_{yb} \pi D^3}{16 \Omega L}$$

Where $M = \frac{P_n L}{2}$ (Guided Bending)P_n/Ω: 239 lbs**Bearing Strength of Masonry Straps - AISI S100**

Size: 3/16 Tapcon Size

D_{sh}: 0.145 in Shank Diameter of Tapcon ScrewF_u: 33 ksi Tensile Strength of Masonry Strap

t: 16 GA

t: 0.0598 in Thickness of Masonry Strap

Ω: 3.00

$$\frac{P_{nv}}{\Omega} = 2.7 * t * D * F_u - (EQ. J4.3.1 - 3, AISI S100)$$

P_{nv}/Ω: 258 lbs

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Subject: Sill Angle Design

Input:

Calculation:

Plate Bending - Steel: AISI S100-16

Bending Condition: Cantilever

Moment Equation: $M_u = P \cdot l$

Applied Load (P): 0.033 kips

Length (l): 0.75 in

Applied Moment (Mu): 0.025 kip-in

Thickness (t): 0.063 in

Width (b): 1.000 in

Yield Strength (F_y): 45 ksi

Modulus of Elasticity (E): 29,000 ksi

Moment of Inertia (I_x): 0.000020 in⁴

Section Modulus (S_{fy}): 0.000977 in³

Ω: 1.67

Moment Capacity (Mn): 0.044 kip-in

Mn/Ω: 0.026 kip-in

$M_n = M_y = S_{fy} * F_y$ (Eq. F2.1 – 2)

Unity: 0.93

Deflection (Δ): 0.0078177 in