# PRODUCT APPROVAL SUPPORTING CALCULATIONS

**Series/Model 1650I PVC Double Hung (Non-Impact)**

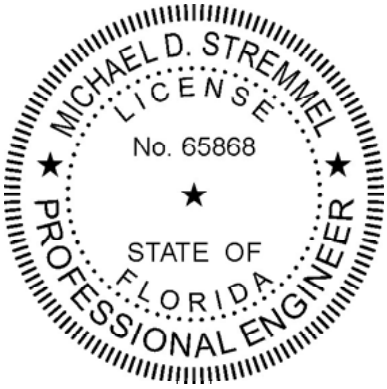
REPORT NO.: 27250.01-107-16

RENDERED TO: MI Windows and Doors
702 West Market Street
Gratz, Pennsylvania 17030

PREPARED BY: Michael D. Stremmel, P.E.

Molimo, LLC
1410 Eden Road
York, Pennsylvania 17402

REVISION 2 DATE: 3/22/2024

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Michael D. Stremmel, P.E.
Senior Project Engineer
FL PE 65868
FL REG 37122

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**SCOPE**:
Molimo, LLC was contracted by MI Windows and Doors to evaluate alternate installation methods for their 1650I PVC Double Hung window. The evaluation is based on physical testing and product certifications.

Reference standards utilized in this project include:

*Florida Building Code, Building, 8th Edition (2023)*. International Code Council, 2023.

ANSI/AWC NDS-2018 *National Design Specification (NDS) for Wood Construction*. American Wood Council, 2018.

AISI S100-16 *North American Specification for the Design of Cold-Formed Steel Structural Members, 2016*. American Iron and Steel Institute, 2016.

ADM1-2020 *2020 Aluminum Design Manual*. The Aluminum Association, Inc. 2020.

ICC-ES Report ESR-1976 ITW Buildex TEKS Self-Drilling Fasteners. ICC Evaluation Service. 07/2016.

NOA 21-0201.06 *Tapcon Concrete and Masonry Anchors with Advanced Threadform Technology*. Miami-Dade County Product Control Section. 05/06/2021.

The anchorage analysis 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 the incurred loads.

Certification of Independence

In accordance with Rule 61G20-3 Florida Administrative Code, Molimo, LLC hereby certifies the following:

- Molimo, LLC 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.
- Molimo LLC s is not owned, operated or controlled by any company manufacturing or distributing products it tests or labels.
- Michael D. Stremmel, 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.
- Michael D. Stremmel, 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**

Table 1 summarizes the various 1650I PVC Double Hung Window products and their corresponding performance levels which have been established by testing of product certification.

The products considered in this report satisfy the requirements of the *Florida Building Code, Building 8th Edition (2023)* for the overall sizes and design pressures of the following product certifications and their installation methods presented in this report.

**Table 1**: Summary of Product Certifications and Limitations of Use

| Series/Model | Test Report Number | Product Certification | Size (W x H) | Performance |
|---|---|---|---|---|
| 1650I (Non-Impact) | 12558.02-106-12 (Rev. 1, 8/3/2023) | CPD 21205 | 52" x 75" | ±50 psf |

Testing documented in Table 1 was conducted by Molimo, LLC of York, Pennsylvania (Florida Department of Business & Professional Regulation Test Lab No. TST11282, IAS Certificate of Accreditation TL-678).

**ANALYSES**: (Continued)

**As-Tested Installation Analysis**

For air/water/structural testing, the test specimen was secured to a pine wood test buck with #8 x 1-5/8" screws at the jambs. A structural test specimen with #8 x 2" screws through the integral PVC nail fin was also tested. The as tested installation methods are evaluated on Pages 8 through 10 and the established design capacities are summarized in Table 2.

**Table 2**: As-tested Anchorage Design Capacities

| Test Specimen Installation Method | Connection Details | Capacity |
|---|---|---|
| 1650I DH<br>Through-Frame Install | Jambs Only<br>#8 x 2" wood screws<br>Located 4" from each corner and spaced 18" on center (4 per jamb) | 112 lb |
| 1650I DH<br>Mounting Fin Install | #8 x 1-5/8" wood screws<br>Located 4" from each corner and spaced 8" on center | 49 lb |

The capacities presented in Table 2 will be used to prove acceptable alternate anchors and substrates for the windows.

**ANALYSES**: (Continued)

**Alternate Anchorages**

Calculations on Page 11 determine the design capacity of alternate mounting fin installation anchorages for the window. The alternate anchorage capacities are summarized in Table 3.

**Table 3**: Alternate Anchorage Capacities for Mounting Fin Installations

| Substrate | Anchor | Capacity | Comments |
|---|---|---|---|
| 18 Ga. Steel Stud | #10-16 TEKS Screw | 104 lb | 1. 33 KSI yield strength stud<br>2. Full penetration +3 threads<br>3. Limited by pullout capacity |

Calculations on Pages 12 through 14 determine the design capacity of alternate through-frame installation anchorages for the window. The alternate anchorage capacities are summarized in Table 4.

**Table 4**: Alternate Anchorage Capacities for Through-frame Installations

| Substrate | Anchor | Capacity | Comments |
|---|---|---|---|
| 18 Ga. Steel Stud | #10-16 TEKS Screw | 152 lb | 1. 33 KSI yield strength stud<br>2. Full penetration +3 threads<br>3. Limited by bending capacity |
| Concrete | 3/16" Tapcon | 170 lb | 1. Minimum $f'_c$ = 3,000 psi<br>2. 1-1/2" min. embedment<br>3. 2" min. edge distance<br>4. Limited by frame bearing capacity<br>5. Maximum 1x buck strip |
| CMU Block | 3/16" Tapcon | 135 lb | 1. Minimum ASTM C90 CMU Block<br>2. 1-1/2" min. embedment<br>3. 2" min. edge distance<br>4. Limited by anchor shear capacity<br>5. Maximum 1x buck strip |

***Note**: Maximum available length of a 3/16" Tapcon anchor is 3-1/4". Use 1/4" x 4" Tapcon anchors for through-frame installations with 1x buck strip.*

**ANALYSES**: (Continued)

**Anchorages Requirements**

It must be determined the anchorages are not overloaded for the approved window size and design pressures. Calculations presented on Page 15 shows the following:

1. Mounting Fin Installation Method: The as-tested spacing is adequate for the minimum anchor capacity reported in this report when the windows are subjected to the maximum design pressures of the products at their approved maximum sizes.
2. Through-Frame Installation Method: The as-tested spacing is overstressed using the minimum anchor capacity reported in this report when the windows are subjected to the maximum design pressure of the products at their approved maximum sizes. The calculations on Page 15 show the updated maximum spacing for this installation method.

Based on the calculations, Table 5 shows the maximum anchor spacing for each installation method. The anchor spacings shown in the following table apply to all substrates and anchor types.

**Table 5**: Anchorage Spacing Requirements

| Installation Method | Maximum Anchor Spacing |
|---|---|
| Mounting Fin | 4" from each corner, and spaced a maximum of 8" on center, through the mounting fin into the building substrate |
| Through-Frame (Jambs only) | Within 6" of each end and spaced a maximum of 13-1/4" on center, through the frame into the building substrate |

**As-Tested Installation – Nail Fin to Wood**

Anchor: #8 x 1-5/8" Wood Screw

Details: Through the PVC Nail Fin

Substrate: SPF wood test buck (G = 0.42 min.)

Wood Screw Capacity (Tension)

W = 1.6(1.625" – 0.062")(82 lb/in) (NDS, Table 12.2B)

W = 205 lb

Pull-over of Wood Screw

Pull-over of the wood screw is validated by the test

| | |
|---|---|
| As-tested spacing: | 8" on center |
| As-tested Anchor head size: | 0.330" |
| Anchor Placement: | 4" from corner; 8" on center |
| Anchor Quantities: | |
| Jambs: | 8 |
| Head: | 6 |
| Sill: | 6 |
| Total: | 28 |
| Load to Anchors: | (52")(75")(50 psf / 144) = 1,354 lb |
| Individual Anchor Load: | (1,354 lb) / (28 anchors) = 49 lb (< withdrawal capacity) |

**Design Capacity of the Connection = 49 lb**

**As-Tested Installation – Through-Frame to Wood**

Anchor: #8 x 2" Wood Screw

Details: Through the PVC Frame
- Two 0.050" thick frames at anchor location
- 1/4" max shim space

Substrate: SPF wood test buck (G = 0.42 min.)

Wood Screw Capacity (Shear)

Z' = 112 lb (Reference the following page)

Bearing Capacity (of PVC frame)

$P_b$ = D t Ftu = (0.164")(0.100")(10,000 psi)

$P_b$ = 164 lb

Bending Capacity (of Wood Screw)

L = 1/4" (maximum shim space)

$S = \pi d^3 / 32 = \pi (0.131")^3 / 32 = 0.000221 \text{ in}^3$

$F_b = (1.3)(0.6 F_y) = (1.3)(0.6)(90{,}000 \text{ psi}) = 70{,}200 \text{ psi}$ (1.3 for weak axis bending)

$F_b = M / S = (V) (L/2) / S$ (L/2 for guided bending)

$V = 2 S F_b / L = (2)(0.000221 \text{ in3})(70{,}200 \text{ psi}) / 1/4"$

V = 124 lb

**Design Capacity of the Connection = 112 lb**

# Lateral Design Strength of Wood Connections (ANSI / AF&PA NDS-2018)

**Project:** 1650I
**Comment:** As-Tested Installation - Thru-Frame

| | | | |
|---|---|---|---|
| **Fastener:** | #8 Wood Screw | | <= Choose Fastener |
| **Shank Dia.:** | 0.164 | inch | |
| **Root Dia.:** | 0.131 | inch | |
| **Bending Yield Stress:** | 90,000 | psi | |
| **Fastener length:** | 2.000 | inch | <= Choose Fastener Length |
| **Main Member:** | SPF 2x | | <= Choose Member being fastened to |
| **G:** | 0.42 | | |
| **Dowel Bearing Strength:** | 3,350 | psi | |
| **Thickness:** | 1.500 | inch | |
| **Side Member:** | Vinyl (PVC) | | <= Choose Member being fastened |
| **Allowable Bearing Stress:** | 13,750 | psi | |
| **Thickness:** | 0.100 | inch | |
| **Threads in Shear Plane?:** | 1 | (0=NO, 1=YES) | |
| **θ:** | 90 | <= (Angle of load to grain $0^o \leq \theta \leq 90^o$) | |
| **D:** | 0.131 | inch | |
| **Lm:** | 1.900 | | |
| **$K_\theta$:** | 1.25 | | |
| **$K_D$:** | 2.2 | | |
| **K1:** | 1.807091309 | | |
| **K2:** | 0.61675648 | | |
| **K3:** | 7.897731756 | | |
| **$R_e$:** | 0.244 | | |
| **$R_t$:** | 19.000 | | |
| **k:** | 6.870 | | |
| **$C_d$:** | 1.000 | | |

**Lateral Design Values, Z**

| | | | |
|---|---|---|---|
| **Mode Im** | 379 | lbf | |
| **Mode Is** | N/A | lbf | |
| **Mode II** | 148 | lbf | |
| **Mode IIIm** | 157 | lbf | |
| **Mode IIIs** | 70 | lbf | <====== Minimum Value |
| **Mode IV** | 99 | lbf | |

**Notes:** Mode Is is bearing of side member and may not be increased by $C_D$ if side member is a metal plate.
$C_D$ = 1.6 for short duration loads.

Allowable Load for Wind Resistance: 70 x 1.6 = 112 lbs

**Alternate Installation – Nail Fin to Steel Stud**

Anchor: #10-16 TEKS Screw

Details: Through the PVC Nail Fin

Substrate: 18 ga steel stud (33 ksi, 0.043" thick)

Wood Screw Capacity (Tension)

$P_{ss} / \Omega$ = 885 lb (ESR-1976)

Pull-over of #10-16 TEKS Screw

Anchor head size = 0.365" > 0.330" (maintain as tested spacing)

Pull-out of #10-16 TEKS Screw

$P_{not} = 0.85\ t_c\ d\ F_{tu} = 0.85(0.043")(0.190")(45{,}000\ psi) = 312\ lb$

$P_{allow} = 312\ lb / 3.0 =$ 104 lb

**Design Capacity of the Connection = 104 lb**

**Alternate Installation – Through-Frame to Steel Stud**

Anchor: #10-16 TEKS Screw

Details: Through the PVC Frame
- Two 0.050" thick frames at anchor location
- 1/4" max shim space

Substrate: 18 ga steel stud (33 ksi, 0.043" thick)

Anchor Capacity (Shear of #10-16 TEKS)

$P_{ss} / \Omega$ = 573 lb (ESR-1976)

Bearing Capacity (of PVC frame)

$P_b = D\ t\ Ftu = (0.190")(0.100")(10{,}000\ psi)$

$P_b$ = 190 lb

Bearing/Tilting Capacity (of steel stud)

$P_b = 2.7\ D\ t\ F_{tu} = 2.7(0.190")(0.043")(45{,}000\ psi) = 992\ lb$

$P_b = 4.2\ (D\ t^3)^{1/2}\ F_{tu} = 2.7\{(0.190")(0.043")^3]^{1/2}(45{,}000\ psi) = 743\ lb$

$P_{allow}$ = 743 lb / 3.0 = 243 lb

Bending Capacity (of Wood Screw)

L = 1/4" (maximum shim space)

$S = \pi\ d^3 / 32 = \pi\ (0.139")^3 / 32 = 0.000264\ in^3$

$F_b = (1.3)(0.6\ F_y) = (1.3)(0.6)(92{,}000\ psi) = 71{,}760\ psi$ (1.3 for weak axis bending)

$F_b = M / S = (V)\ (L/2) / S$ (L/2 for guided bending)

$V = 2\ S\ F_b / L = (2)(0.000264\ in3)(71{,}760\ psi) / 1/4"$

V = 152 lb

**Design Capacity of the Connection = 152 lb**

**Alternate Installation – Through-Frame to Concrete**

Anchor: 3/16" Tapcon Anchor
- 1-1/2" min embedment
- 2" min edge distance
- 3" min anchor spacing

Details: Through the PVC Frame
- Two 0.050" thick frames at anchor location
- 1/4" max shim space

Substrate: 3,000 psi Concrete

Anchor Capacity (Shear of 3/16" Tapcon)

$P_{ss} / \Omega$ = 186 lb (NOA-No. 16-1222.06)

Bearing Capacity (of PVC frame)

$P_b$ = D t Ftu = (0.170")(0.100")(10,000 psi)

$P_b$ = 170 lb

Bending Capacity (of 3/16" Tapcon)

L = 1/4" (maximum shim space)

$S = \pi d^3 / 32 = \pi (0.170")^3 / 32 = 0.000482 \text{ in}^3$

$F_b = (1.3)(0.6 F_y) = (1.3)(0.6)(137{,}000 \text{ psi}) = 106{,}860 \text{ psi}$ (1.3 for weak axis bending)

$F_b = M / S = (V) (L/2) / S$ (L/2 for guided bending)

$V = 2 S F_b / L = (2)(0.000482 \text{ in3})(106{,}860 \text{ psi}) / 1/4"$

V = 412 lb

**Design Capacity of the Connection = 170 lb**

**Qualifies 1/4" Tapcon if longer length anchor is required to achieve minimum embedment**

**Alternate Installation – Through-Frame to CMU Block**

Anchor: 3/16" Tapcon Anchor
- 1-1/2" min embedment
- 2" min edge distance
- 3" min anchor spacing

Details: Through the PVC Frame
- Two 0.050" thick frames at anchor location
- 1/4" max shim space

Substrate: CMU Block (ASTM C90)

Anchor Capacity (Shear of 3/16" Tapcon)

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

Bearing Capacity (of PVC frame)

$P_b$ = D t Ftu = (0.170")(0.100")(10,000 psi)

$P_b$ = 170 lb

Bending Capacity (of 3/16" Tapcon)

L = 1/4" (maximum shim space)

$S = \pi d^3 / 32 = \pi (0.170")^3 / 32 = 0.000482 \text{ in}^3$

$F_b = (1.3)(0.6 F_y) = (1.3)(0.6)(137{,}000 \text{ psi}) = 106{,}860 \text{ psi}$ (1.3 for weak axis bending)

$F_b = M / S = (V) (L/2) / S$ (L/2 for guided bending)

$V = 2 S F_b / L = (2)(0.000482 \text{ in3})(106{,}860 \text{ psi}) / 1/4"$

V = 412 lb

**Design Capacity of the Connection = 135 lb**

**Qualifies 1/4" Tapcon if longer length anchor is required to achieve minimum embedment**

**Alternate Requirements**

Series/Model: 1650I

Test Unit Size: 52" x 75"

Design Pressure: ±50 psf

Mounting Fin Installation Method

Anchor Placement: 4" from corners and 8" on center

Anchor Quantities: Head / Sill = 6 per
Jambs = 8 per
Total = 28

Load to the Anchors = (52")(75")(50 psf / 144) = 1,354 lb

Individual Anchor Load = 1,354 lb / 28 anchors = 49 lb

Least Anchor Capacity = 104 lb (Steel Stud) > 49 lb **Tested Anchor Spacing Governs**

Through-Frame Installation Method

Perimeter Load at Jambs

Jamb Load Area: (52"/2)(75") / 144 = 13.54 $ft^2$

Anchor Quantity: n = 4

Load to the Anchors = (13.54 $ft^2$)(50 psf) = 677 lb

Individual Anchor Load = 677 lb / 4 anchors = 169 lb

Least Anchor Capacity = 112 lb (Wood) < 169 lb **Tested Anchor Spacing is Overstressed**

** Add two additional Anchor to each jamb

Max Anchor Spacing = 13-1/4" on center (6 anchors per jamb)

Anchor Load = 677 lb / 6 anchors = 112.8 lb < 1% **13-1/4" On Center Spacing OK**

## Revision Log

| Rev. # | Date | Page(s) | Revision(s) |
|---|---|---|---|
| 0 | 9/29/2023 | All | Original Report Issue |
| 1 | 11/3/2023 | Page 2 | Corrected the reference standards section |
| 2 | 3/22/2024 | Page 4 | Updated FBC Reference from the 7th Edition (2020) to the 8th Edition (2023) |