# PRODUCT APPROVAL SUPPORTING CALCULATIONS

# 3540 Single Hung Window – non-Impact

REPORT TO:

**MI WINDOWS AND DOORS, LLC**
**702 WEST MARKET ST**
**GRATZ, PENNSYLVANIA 17030**

REPORT NUMBER: 27488.08-107-16
REPORT DATE: 12/11/23

MICHAEL D. STREMMEL
LICENSE
No. 65868
STATE OF
FLORIDA
PROFESSIONAL ENGINEER

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This item has been digitally signed and sealed by Michael D. Stremmel, PE on the date adjacent to the seal.

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Michael D. Stremmel, PE
FL PE 58920
FL REG 33474

## Scope

Molimo, LLC was contracted by MI Windows and Doors, LLC to evaluate alternate installation methods for their Series 3540 Single Hung Window. The evaluation is based on physical testing and product certifications.

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 the installation methods presented in this report.

| Series/Model | Product Certification | Overall Size (W x H) | Performance |
|---|---|---|---|
| 3540 SH | CPD 20272 | 44" x 84" | +/- 30 psf |

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.

ICC-ES Report ESR-1976 *ITW Buildex TEKS Self-Drilling Fasteners*. ICC Evaluation Service. 04/2021.

NOA 21-0201.06 *Tapcon Concrete and Masonry Anchors with Advanced Threadform Technology*. Miami-Dade County Product Control Section. 02/06/2021.

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, 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 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

The following table summarizes the various 3540 Single Hung Window 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 | Product Certification | Size (W x H) | Performance |
|---|---|---|---|---|
| 3540 SH (Fin Install) | 11398.07-106-12 (Rev. 1, 08/03/22) | CPD 20272 | 44" x 84" | +/- 30 psf |
| 3540 SH (Finless Install) | 11398.07-106-12 (Rev. 1, 08/03/22) | CPD 20272 | 44" x 84" | +/- 30 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).

**As-Tested Installation Analysis**

For air/water/structural testing, the test specimens were secured to a pine buck with #8 x 1-5/8" wood screws through the integral PVC nail fin. A test specimen with #8 x 2" screws through the frame to the wood buck was also tested. The as-tested installation methods are evaluated on page 7 to page 10 and the established design capacities are summarized in Table 2.

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

| Test | Connection | Capacity |
|---|---|---|
| 3540 SH Air/Water/Structural Test Fin Install | #8 x 1-5/8" screws.<br>Placed 3" from each corner and 8" on center. | 26 lb |
| 3540 SH Air/Water/Structural Test Finless Install | #8 x 2-1/2" screws<br>Placed at jambs 4" from corners and midspan (3 each jamb) | 112 lb |

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

**Alternate Anchorages**

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

**Table 3** Alternate Anchorage Capacities for Nail Fin Installations

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

Calculations on page 12 through page 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 Installation

| Substrate | Anchor | Capacity | Comments |
|---|---|---|---|
| 18 Gauge 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 of anchor<br>4. 1/4" maximum shim space. |
| Concrete | 3/16" Tapcon | 186 lb | 1. Minimum $f'_c$ = 3,000 psi<br>2. 1-1/2" Minimum Embedment<br>3. 2" Min. Edge Distance<br>4. Limited by shear capacity<br>5. Maximum 1x buck strip<br>6. 1/4" maximum shim space. |
| CMU | 3/16" Tapcon | 135 lb | 1. Minimum ASTM C90 CMU<br>2. 1-1/2" Minimum Embedment<br>3. 2" Min. Edge Distance<br>4. Limited by shear capacity.<br>5. Maximum 1x buck strip<br>6. 1/4" maximum shim space |

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

2. Through-frame qualifies finless and flange installations.

**Anchorage Requirements**

It must be determined the anchorages are not overloaded for the approved window size and design pressures. Calculations presented on page 15 show the as-tested spacings are 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.

## Attachments

Appendix A – Revision Log (1 page)

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

#8 x 1-5/8" Wood Screw

PVC Nailing Fin

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

Allowable Tension of #8 x 1-5/8" Wood Screw

W = 1.6(1.625"-0.070")(82 lb/in)  (NDS, Table 12.2B)
W = 204 lb

Pull-Over of #8 x 1-5/8" Wood Screw

Validated by Testing

Must maintain anchor spacing and anchor head size

| | |
|---|---|
| As-tested spacing: | 8" on center |
| As-tested anchor head size: | 0.332" |

44 x 84 SH – Fin Install

| | |
|---|---|
| Anchor Placement: | 3" from corner; 8" on center |
| Anchor Quantities: | 10 each jamb; 5 head; 5 sill; 30 total |
| Load to Anchors: | (44")(84")(30 psf/144) = 770 lb |
| Individual Anchor Load: | (770 lb)/(30 anchors) = 26 lb < withdrawal capacity |

**Design Capacity of Connection is 26 lb**

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

#8 x 2-1/2" Wood Screw

PVC Frame; 2x0.050" thick = 0.100" thickness at fastener location

1/4" Maximum Shim Space

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

1-1/4" penetration to wood

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

Z' = 112 lb (Limited by Mode $III_s$, See Following 2 Pages)

Bending of #8 x 2-1/2" Wood Screw

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

**Capacity of Connection is 112 lb**

## As-Tested Installation – Through-Frame 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 | = | 1.625 | in. |

**Main Member**

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

**Side Member**

| | | | |
|---|---|---|---|
| Material | = | Vinyl (PVC) | |
| G | = | N/A | |
| $\theta$ | = | 90 | <= (Angle of load to grain $0^o \leq \theta \leq 90^o$) |
| $F_{es}$ | = | 13,750 | psi |
| Thickness | = | 0.100 | in. |

## Calculations

**Lateral Bearing Factors**

| | | | |
|---|---|---|---|
| D | = | 0.131 | in. |
| $\ell_m$ | = | 1.197 | in. |
| $K_\theta$ | = | 1.25 | |
| $K_D$ | = | 2.20 | |
| $R_e$ | = | 0.244 | |
| $R_t$ | = | 11.97 | |
| $k_1$ | = | 1.1321 | |
| $k_2$ | = | 0.6752 | |
| $k_3$ | = | 7.90 | |

## As-Tested Installation – Through-Frame to Wood (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 $I_m$ | = | 239 | lbf | |
| Mode $I_s$ | = | 82 | lbf | |
| Mode II | = | 93 | lbf | |
| Mode $III_m$ | = | 108 | lbf | |
| Mode $III_s$ | = | 70 | lbf | <====== Minimum Value |
| Mode IV | = | 99 | 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 | | |
| $C_\Delta$ | = | 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'** | **=** | **112** | **lbf** | |

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

#10-16 TEKS Screw

PVC Nailing Fin

Minimum 18 gauge 33 KSI Steel Stud

Allowable Tension of #10-16 TEKS Screw

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

Pull-Over of #10-16 TEKS Screw

Anchor head size: 0.365" > 0.332" Maintain as-tested spacing.

Pull-Out of #10-16 TEKS Screw

$P_{not} = 0.85 t_c d F_{u2}/\Omega$
$P_{not}$ = 0.85(0.0428")(0.190")(45,000 psi)/3.0
$P_{not}$ = 104 lb

**Capacity of Connection is 104 lb**

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

#10-16 TEKS Screw

PVC Frame; 2x0.050" thick = 0.100" thickness at fastener location

1/4" Maximum Shim Space

Minimum 18 gauge 33 KSI Steel Stud

Allowable Shear of #10-16 TEKS Screw

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

Bearing of #10-16 TEKS Screw on Frame

$V_a = DtF_p$
$V_a$ = (0.190")(0.100")(10,000 psi)
$V_a$ = 190 lb

Bearing of #10-16 TEKS Screw on Steel Stud

$V_a = 2.7DtF_{tu}/\Omega$
$V_a$ = 2.7(0.190")(0.0428")(45,000 psi)/3.0
$V_a$ = 329 lb.

Tilting of #10-16 TEKS Screw in Steel Stud

$V_a = 4.2(t_2^3D)^{1/2}F_{tu2}/n_s$
$V_a = 4.2(0.0428''^3 \times 0.190'')^{1/2}(45{,}000\ psi)/3.0$
$V_a$ = 243 lb.

Bending of #10-16 TEKS Screw

L = 1/4" (Maximum Shim Space)
$S = \pi d^3/32 = \pi(0.139'')^3/32 = 0.000264\ in^3$
$F_b = (1.3)(0.6F_y) = (1.3)(0.6)(92{,}000\ psi) = 71{,}760\ psi$ (1.3 for weak axis bending)
$F_b = M/S = (VL/2)/S$ (L/2 for guided bending)
$V = 2SF_b/L = (2)(0.000264\ in^3)(71{,}760\ psi)/0.25'' = 152$ lb.

**Capacity of Connection is 152 lb.**

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

3/16" Tapcon Anchor

1-1/2" Minimum Embedment; 2" Minimum Edge Distance

1/4" Maximum Shim Space

PVC Frame; 2x0.050" thick = 0.100" thickness at fastener location

Minimum $f'_c$ = 3,000 psi Concrete

Allowable Shear of 3/16" Tapcon Anchor

$P_{ss}/\Omega$ = 186 lb (NOA 21-0201.06)

Bearing of 3/16" Tapcon Anchor on Frame

$V_a = DtF_p$
$V_a$ = (0.188")(0.100")(10,000 psi)
$V_a$ = 188 lb

Bending of 3/16" Tapcon Anchor

L = 1/4" (Maximum Shim Space)
$S = \pi d^3/32 = \pi(0.145")^3/32 = 0.000299\ in^3$
$F_b = (1.3)(0.6F_y) = (1.3)(0.6)(137{,}000\ psi) = 106{,}860\ psi$ (1.3 for weak axis bending)
$F_b = M/S = (VL/2)/S$ (L/2 for guided bending)
$V = 2SF_b/L = (2)(0.000299\ in^3)(106{,}860\ psi)/0.25" = 256\ lb.$

**Capacity of Connection is 186 lb**

**Alternate Installation – Through Frame to CMU**

3/16" Tapcon Anchor

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

1/4" Maximum Shim Space

PVC Frame; 2x0.050" thick = 0.100" thickness at fastener location

Minimum ASTM C90 Concrete Masonry Unit

Allowable Shear of 3/16" Tapcon Anchor

$P_{ss}/\Omega$ = 135 lb (NOA 21-0201.06)

Bearing of 3/16" Tapcon Anchor on Frame

$V_a = DtF_p$
$V_a$ = (0.188")(0.100")(10,000 psi)
$V_a$ = 188 lb

Bending of 3/16" Tapcon Anchor

L = 1/4" (Maximum Shim Space)
$S = \pi d^3/32 = \pi(0.145")^3/32 = 0.000299\ in^3$
$F_b = (1.3)(0.6F_y)$ = (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)
$V = 2SF_b/L = (2)(0.000299\ in^3)(106{,}860\ psi)/0.25" = 256$ lb.

**Capacity of Connection is 135 lb**

**Anchorage Requirements**

44 x 84 SH – Fin Install

| | |
|---|---|
| Anchor Placement: | 3" from corner; 8" on center |
| Anchor Quantities: | 10 each jamb; 5 head; 5 sill; 30 total |
| Load to Anchors: | (44")(84")(30 psf/144) = 770 lb |
| Individual Anchor Load: | (770 lb)/(30 anchors) = 26 lb |
| Least Anchor Capacity: | 104 lb > 26 lb **OK** |

44 x 84 SH – Through-Frame Install

| | | |
|---|---|---|
| Jamb Load Area: | (44"/2)(84")/144 = 12.8 $ft^2$ | |
| Jamb Load: | (30 psf)(12.8 $ft^2$) = 384 lb | |
| Least Anchor Capacity: | 112 lb | |
| Number of Anchors: | (384 lb)/(112 lb) = 3.4 | **Specify n = 4 each jamb** |

## Appendix A

## Revision Log

| Identification | Date | Page & Revision |
|---|---|---|
| Original Issue | 12/11/23 | Not Applicable |