

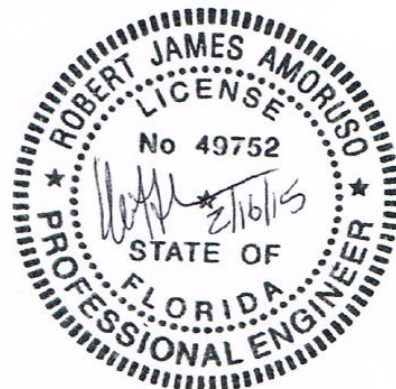


## Product Evaluation Report

|                       |                                                                                                                                                                                                                                                                                        |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Date:                 | February 16, 2015                                                                                                                                                                                                                                                                      |
| Report #:             | 1799                                                                                                                                                                                                                                                                                   |
| Report Revision No.:  | 2                                                                                                                                                                                                                                                                                      |
| Project #:            | 414-1104                                                                                                                                                                                                                                                                               |
| Product Mfg.:         | Pella Corporation<br>102 Main Street<br>Pella, IA 50219                                                                                                                                                                                                                                |
| Product Description:  | Series 350 Vinyl Window Mulling System: ½" Light Duty, ½" Standard, ½" Standard w/reinforcement, 1" Structural and 1" Structural w/reinforcement Aluminum Mullion with Fin Frame, Block Frame and Flange Frame Mullion End Clips, Non-Impact and Impact (Wind Zone 3, Missile Level D) |
| Product Category:     | Windows                                                                                                                                                                                                                                                                                |
| Product Sub-Category: | Mullion                                                                                                                                                                                                                                                                                |
| Compliance Method:    | Product Approval Rule 61G20-3.005(1)(d) – Evaluation Report by a Licensed Florida Professional Engineer                                                                                                                                                                                |
| Prepared By:          | Robert J. Amoruso, P.E.<br>Florida P.E. No. 49752<br>PTC Product Design Group, LLC, PO Box 520775, Longwood, FL 32752-0775<br>Florida C of A No. 25935                                                                                                                                 |

### CERTIFICATED OF INDEPENDENCE

PTC Product Design Group, LLC and Robert J. Amoruso, P.E. do not have, nor will acquire, any financial interest in the company manufacturing or distributing product(s) covered by the aforementioned Product Evaluation Report. PTC Product Design Group, LLC and Robert J. Amoruso, P.E. do not have, nor will acquire any financial interest in any other entity involved in the approval process or testing of the product(s) covered by the aforementioned Product Evaluation Report.



Evaluated by:  
Robert J. Amoruso, P.E.  
Florida P.E. License Number 49752



## OBJECTIVE

The objective of this report is to demonstrate code compliance to the current edition of the Florida Building Code and AAMA A450-06, Option 3.

PTC Product Design Group, LLC was contracted by Pella Corporation to perform engineering evaluations of various mulled window combinations.

These mulled window assemblies were tested for the following:

- Air Infiltration and Water Penetration Resistance of the mulled assembly consistent with the following:
  - Mulled Assembly
    - AAMA 450-06,
    - ASTM E330-02,
    - ASTM E283-04 and
    - ASTM E547-00.

These mulled window assemblies were engineered to the following in conformance with AAMA 450-06, Option 3 and the current edition of the Florida Building Code, Building and Residential Volumes – Sections related to Window Mullions:

- Strength analysis of mullion including fiber stresses and deflection.
- Strength analysis of mullion end clips.
- Strength analysis of mullion end clip anchorage to structural substrate.

This report is based on using the properties of the aluminum reinforcing mull with and w/o reinforcement only and does not include the section properties of the window head, sill or jambs. Therefore product grouping is not required as full loading is assumed reacted by the reinforcing mullion.



## SCOPE

The scope of this report includes the following components shown below used in various mulled window assemblies.

The Pella Series 350 4 ½" Wide Frame Size Vinyl Window System includes vinyl extrusion profiles with a removable fin and snap-in flange allowing the same profile to be used in the following configurations.

- Fin Frame – uses integral nailing fin for attachment to wood substrates.
- J-Channel Frame – used snap-in J-Channel Cover on fin frame with integral nailing fin for attachment to wood substrates.
- Flange Frame – uses snap-in flange for through frame or installation clip attachment to concrete/masonry, wood and metal substrates in the same manner as the Block Frame (below).
- Block Frame - through frame or installation clip attachment to concrete/masonry, wood and metal substrates.

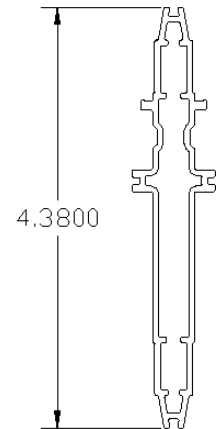
The following table shows which clip and mullion is used with the frame types. A steel reinforcement plate can be placed inside the ½" standard and 1" structural mullions. The reinforcement is continuous the full length of the mullion except for 3" on each end (6" total) to account for insertion of clip end into mullion.

| Clip                                                                    | Frame                                                              | Mullion |        |               | Reinforcement Used |               |
|-------------------------------------------------------------------------|--------------------------------------------------------------------|---------|--------|---------------|--------------------|---------------|
|                                                                         |                                                                    | ½" LD   | ½" STD | 1" Structural | ½" STD             | 1" Structural |
| 4 ½" Nailing Fin Frame Clip                                             | 4 ½" Nailing Fin Frame                                             | x       | x      | x             | x                  | x             |
| 4 ½" Flange Frame (Block Frame with snap-in 5/8" or 2 1/4" Flange) Clip | 4 ½" Flange Frame (Block Frame with snap-in 5/8" or 2 1/4" Flange) | n/a     | n/a    | x             | n/a                | x             |
| 4 ½" Block Frame Clip                                                   | 4 ½" Block Frame                                                   | x       | x      | x             | x                  | x             |

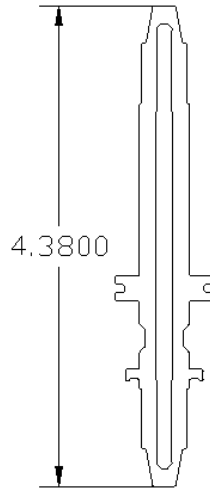
See the following sections for sketches of the above components. The reinforcement bar (not shown) is a Stainless Steel plate, 3.969" wide x 0.077" thick x mull length – 6" as required.

## MULLION PROFILES

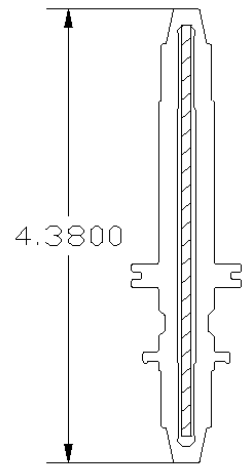
1/2" Light Duty Aluminum Mullion



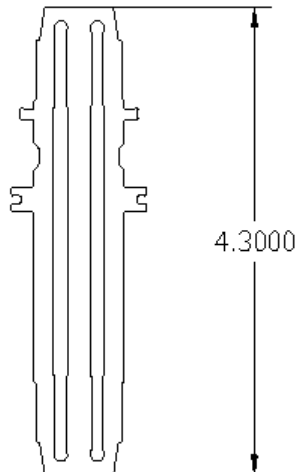
1/2" Standard Aluminum Mullion



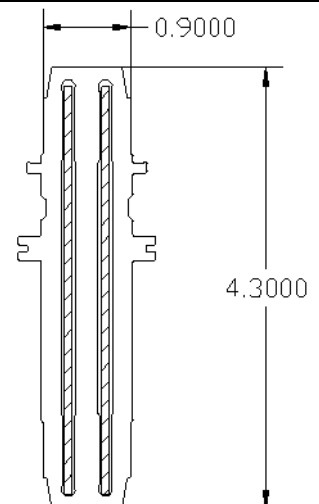
1/2" Standard Aluminum Mullion W/Stainless Steel Reinforcement Plate



1" Structural Aluminum Mullion

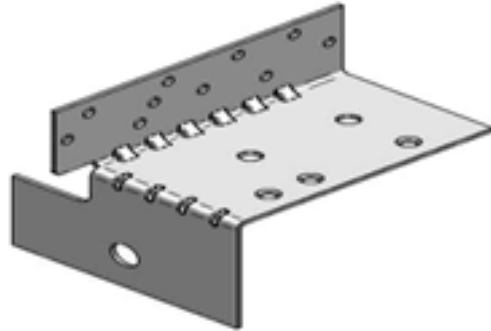


1" Structural Aluminum Mullion W/Stainless Steel Reinforcement Plates

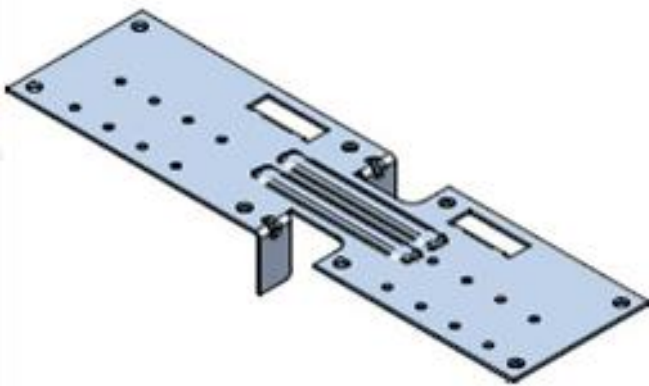


## MULLION END CLIPS

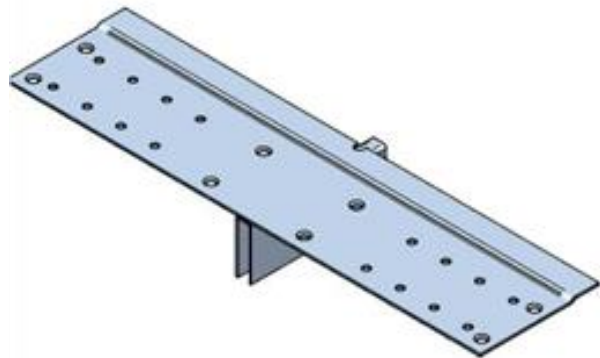
4 1/2" Nailing Fin Frame Mullion End Clip



4 1/2" Block Frame Mullion End Clip



4 1/2" Flange Frame (Block Frame with snap-in 5/8" or 2 1/4" Flange) Mullion End Clip





Fenestration Products applicable to and for use with this mulling system include the following Series 350 Vinyl Window product line.

- Single Hung Window
- Double Hung Window
- Fixed (Picture) Window (including shapes)
- Sliding (Horizontal) Window
- Casement Window
- Awning Window

Frame configurations applicable to the Series 350 Vinyl Window product line include the following.

- 4 ½" Nailing Fin Frame,
- 4 ½" Block Frame, and
- 4 ½" Flange Frame (Block Frame with snap-in 5/8" or 2 1/4" Flange).
- 4 ½" J-Channel Frame (Nail Fin Frame with snap-in J-Channel Cover).

## LIMITATIONS AND CONDITIONS OF USE

The Series 350 Mulling System shall be limited to the following.

1. This product has been evaluated and designed to comply with the current edition of the Florida Building and Residential Codes - Sections related to Window Mullions and AAMA 450-06 and is acceptable for use with non-impact and impact rated fenestration products in Wind Zone 3 and below as defined in ASTM E1996 and modified by the current edition of the FBC.
2. Windborne Debris Region Opening Protection
  - a. This Product Evaluation Document can be used for non-impact rated Pella Series 350 Vinyl Windows in windborne debris regions if an impact protective system complying with the FBC requirements for windborne debris regions is used with the product(s) described herein.
  - b. This Product Evaluation Document can be used for impact rated Pella Series 350 Vinyl Windows in windborne debris regions without an impact protective system with the product(s) described herein.
3. This Product Evaluation Document is NOT for use in the High Velocity Hurricane Zone (HVHZ).
4. Based on the Load Width and Mullion Span of the mulled assembly, the overall Design Pressure Rating of the mulled assembly shall be based on the lower of the following:
  - a. the individual fenestration elements design pressure rating,
  - b. the individual fenestration elements installation limitations of use,
  - c. the individual fenestration elements ASTM E1300 glass load resistance, or
  - d. the mullion design pressure ratings documented in the Reference 1 reports.



5. The Pella Series 350 Mullion System Mull Clip Anchorage to structural substrate will be as required by the Reference 1 reports.
6. Limitations of Use as specified on the individual fenestration elements product evaluation documents.

## QUALITY ASSURANCE

This product is manufactured under a quality assurance program audited by an approved Quality Assurance Entity **Window and Door Manufacturers Association (WDMA)**. See FBC Organization No. QUA2515 for approval under Rule 61G20-3.

## APPLICATIONS/INSTALLATIONS OUTSIDE THE LIMITATIONS AND CONDITIONS OF USE

Rule 61G20-3.005(1)(e) states “Rational engineering analysis cannot be used in lieu of a standard test required by the Code for approval of products within the scope of the standard, except that project specific approval by the local authorities having jurisdiction in accordance with alternate methods and materials authorized in the Code.”

Any modification to this product as evaluated in this report and approved by the Florida Building Commission is outside the scope of this evaluation and will be the responsibility of others. As allowed in Rule 61G20-3.005(1)(e), a project specific approval by the local authorities having jurisdiction may be used given an appropriate rational analysis is conducted and deemed acceptable to the local authorities having jurisdiction.

## INSTALLTION REQUIRMENTS

Installation Specifics are summarized for the following in the Reference 1 reports.

- 4 ½” Nailing Fin and J-Channel Frame, Installation Specifics
- 4 ½” Block and Flange Frame, Installation Specifics

## DESIGN PRESSURE CAPACITY RESULTS

Result summaries include Design Pressure Capacities for Load Width vs. Mullion Span tables in various combinations of widths and spans for the following assemblies. See Reference 1 for results summaries.

Table 1 – Vertical Mullion in 2-Way, Side-by-Side window assembly

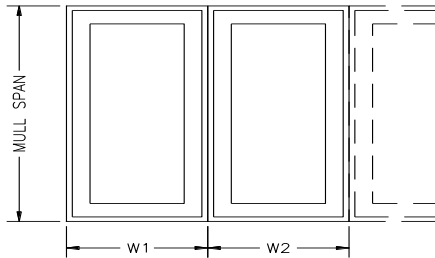


Table 2 – Horizontal Mullion in 2-Way, One-over-One window assembly

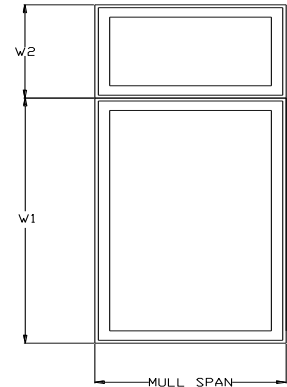


Table 3.1 – Vertical Mullion in 3-Way, Transom/Side-by-Side window assembly

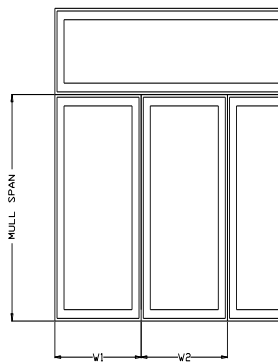


Table 3.2 – Horizontal Mullion in 3-Way, Transom/Side-by-Side window assembly

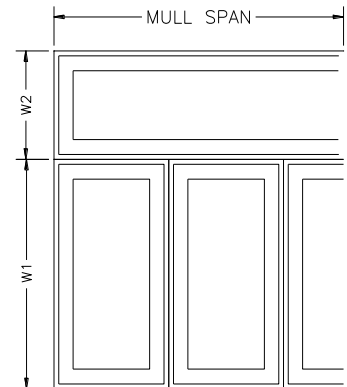


Table 4.1 – Vertical Mullion in 4-Way, Side-by-Side/Side-by-Side window assembly

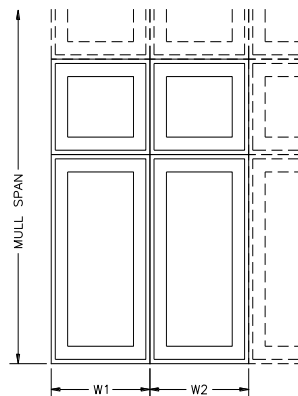
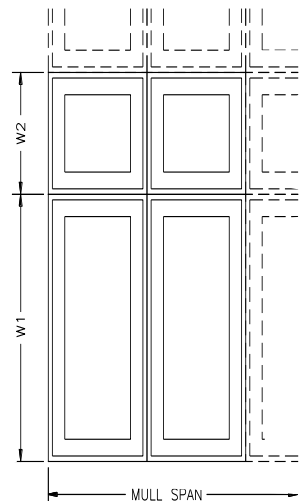


Table 4.2 – Horizontal Mullion in 4-Way, Side-by-Side/Side-by-Side window assembly





## AAMA 450-06 and FBC Code Compliance

The table below summarizes conformance to AAMA 450-06, Option No. 3 Design Pressure rating. The analysis performed to Option No. 3 of AAMA 450 also demonstrates compliance to the current edition of the Florida Building and Residential Codes.

Comparison to AAMA 450-06 shown below.

| Rating Options                                                                                       | Option 1<br>Test Total<br>Assembly<br>Configuration | Option 2<br>Testing Mullion<br>Elements as<br>Individual<br>Components | Option 3<br>Structural<br>Calculations by<br>P.E. |
|------------------------------------------------------------------------------------------------------|-----------------------------------------------------|------------------------------------------------------------------------|---------------------------------------------------|
| Air and Water Test Required?                                                                         | Yes                                                 | Yes                                                                    | Yes                                               |
| Deflection Limit of L/175 During<br>Application of Design Pressure Load?                             | See 8.1.1                                           | Yes                                                                    | Yes                                               |
| Permanent Set Limit of 0.4% of Span After<br>Application and Removal of Structural Test<br>Pressure? | See 8.1.1                                           | Yes                                                                    | No                                                |
| Professional Engineer to Sign and Seal?                                                              | No                                                  | Yes                                                                    | Yes                                               |
| Separate Anchorage Calculations Required?                                                            | No                                                  | Yes                                                                    | Yes                                               |
| Product Grouping Permitted?                                                                          | Yes                                                 | Yes                                                                    | Yes                                               |

| AAMA 450-06, Rating Options                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Conformance Discussion                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>8.1</b> The overall design pressure rating assigned to the mulled fenestration assembly shall be the lower design pressure achieved by either the individual product or by the assembly, as determined by one of the following three options. Calculations based on any of the three options can be used to determine structural performance of mullions in different combination assembly sizes.</p> <ul style="list-style-type: none"><li>Option 1: Testing Total Assembly Configuration</li><li>Option 2: Testing Mullion Elements as Individual Components</li><li>Option 3: Structural Calculations by P.E.</li></ul> | <p>Option 3 is chosen to demonstrated code compliance. Reference 3 documents Air Infiltration Testing and Water Penetration Resistance Testing to 15 psf and 11.25 psf (100 psf and 75 psf Design Pressure respectively). Reference 2 documents mullion strength analysis and deflection evaluation (capped at 75 psf Design Pressure). Reference 1 summarizes Overall Design Pressure Limitations for Various Mullion Spans and Load Widths (capped at 75 psf Design Pressure).</p> |
| <p><b>8.1.1</b> Mullion deflections and permanent set requirements must match individual product class deflection/permanent set requirements. See the appropriate edition of 101/I.S.2 for additional information as some classes differ. The required air and water test for options 2 and 3 is intended to qualify the mullion seal to adjacent units and at mullion ends. If these seals are similar for different product types, only the product type(s) selected by the</p>                                                                                                                                                | <p>As required by AAMA 450-06, Section 8.5.2 for Option 3 compliance, deflection is limited to L/175. Permanent set was tested and documented in Reference 3 test reports in accordance with ASTM E330. Additionally, Reference 2 engineering analysis limited aluminum mullions to the design stresses promulgated by ADM 2005. Reference 3 documents Air Infiltration Testing and Water Penetration Resistance Testing to 15 psf and 11.25 psf (100 psf and</p>                    |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>P.E. need be tested. The required air and water test for options 2 and 3 may be performed on a combination assembly smaller than what will be structurally qualified, at the discretion of the P.E.; members (sash, frame, mullion stiffener) with reduced strength and stiffness may be substituted to simulate the rotations and displacements expected on the largest combination assembly size. At the discretion of the P.E., multiple tests of different sizes and components may be used to demonstrate maximum values of all relevant test derived-design-parameters. Mullion anchor(s) must be qualified, either by test or by calculations.</p>                                                                                                                                                                                                                                                                                                                                                     | <p>75 psf Design Pressure respectively). Fixed windows were used in testing. The vinyl extrusion profile is the same or similar for all products within the scope of this evaluation such that seals on the exterior and interior of the products will be the same as that used in testing. The fixed window profile is used as it represents the least stiff section. As the window frame extrusions are comprised of vinyl (PVC) material, they do not offer significant rotational restraint. As such, various combination assemblies with an overall size for 120" x 120" utilizing the ½" light duty mullion (least stiff) and the 1" structural mullion with and without reinforcement (most stiff) were used to simulate expected rotational characteristics to the mulled assemblies. As the mullion themselves offer the greater resistance to rotation, testing the lightest duty mullion (least stiff) and the heaviest duty mullion (most stiff) at the largest mullion span (120") envelopes all proposed configurations in Reference 1.</p> |
| <p><b>8.2</b> In all of the design pressure rating options listed above the air infiltration and water penetration resistance performance for the mulled fenestration assembly shall be demonstrated by testing.</p> <p><b>8.2.1 Air Infiltration Test</b> Test specimen shall be subjected to an air infiltration test in accordance with ASTM E 283. The performance shall be documented as a pass or fail when tested per AAMA/NWWDA 101/I.S. 2-97.</p> <p><b>8.2.2 Water Penetration Resistance Test</b> The test specimen shall be subjected to a water penetration resistance test in accordance with ASTM E 547 and, if required, ASTM E 331. The ASTM E 547 test shall consist of four cycles, each cycle shall consist of five minutes with pressure applied and one minute with the pressure released; the water shall be continuously applied. The water test pressure may be increased in increments described in AAMA/NWWDA 101/I.S. 2-97 until a maximum pressure is achieved without failure.</p> | <p>Reference 3 documents the following: Air Infiltration testing to 1.57 psf and 6.24 psf per ASTM E283. Air infiltration met stated requirements. Water Penetration Resistance Testing to 15 psf and 11.25 psf (100 psf and 75 psf Design Pressure respectively) per ASTM E547.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

| AAMA 450-06, Option 3 Requirements                                                                                                                                                                                                                                                                                                                                         | Conformance Discussion                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>8.5 Design Pressure Rating Option #3 (Rating the Mullion Element by Structural Calculation - mullion element containing reinforcement that is not continuous shall not be qualified by this method)</b>                                                                                                                                                                 | Conformance demonstrated by engineering analysis using sound practices documented in Reference 2 analysis and Reference 3 testing.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| The minimum performance levels, as outlined in the Gateway Performance Requirements in Section 2.0 of AAMA/NWWDA 101/I.S. 2-97, must be met by each fenestration product being mulled to acquire a rating. Optional performance levels for the design pressure shall be obtained using Table 3.1 as shown in Section 4.0 of AAMA/NWWDA 101/I.S. 2-97.                      | Deflections reported but are not limited by 101/I.S. 2-97, 101/I.S.2/A440-05 or 101/I.S.2/A440-08 for products covered by this report. Conformance demonstrated by testing documented in Reference 3 test reports for the products covered in this report. The Overall Mulled Assembly Design Pressure is the lower of the following: the individual fenestration elements design pressure rating, the individual fenestration elements installation limitations of use, the individual fenestration elements ASTM E1300 glass load resistance, or the mullion design pressure ratings documented in the Reference 1 report. |
| Bending moments and deflections shall be determined by the methods listed utilizing the design rules in Appendix 2, or by accepted rational analysis. Structural calculations of the mullion element as defined in Section 5.0 shall be signed and sealed by a P.E. licensed in a state within the United States. The structural calculations shall include the following: | See Reference 2 for signed and sealed engineering analysis meeting this requirement.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 8.5.1 Moment of inertia and section modulus of the mullion element being considered shall be documented in the calculations forming a portion of the report.                                                                                                                                                                                                               | See Reference 2 for signed and sealed engineering analysis meeting this requirement.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 8.5.2 Deflection of the mullion element as defined in Section 5.0 shall not exceed $L/175$ at the given design pressure ( $L$ representing the mullion span).                                                                                                                                                                                                              | See Reference 2 for signed and sealed engineering analysis meeting this requirement.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 8.5.3 Extreme fiber stress shall be structurally calculated using accepted engineering rational analysis. Stress on individual mullion elements of mulled fenestration assemblies having components of different materials shall be determined based upon the shared portion of the maximum bending moment under the specified load (based on desired DP). This            | Extreme fiber bending stresses, horizontal shearing stresses and deflection limitations on the mullion only are considered in developing the load span design pressures. Credit for the fenestration framing components is not considered.                                                                                                                                                                                                                                                                                                                                                                                   |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                             |
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| shall be shown not to exceed the allowable fiber stress for that material in the section being evaluated. Horizontal shear stress and effective composite action shall be considered when appropriate for multi-component mullions. Calculations can utilize design-parameters for materials with design specifications recognized by the International Building Code (IBC) or other approved building code.                                                             |                                                                                                                                                             |
| Calculations for materials not covered by the above referenced codes can use test-derived-design parameters obtained from tests described in this standard. Several tests may be required to assign maximum limits for all applicable design parameters.                                                                                                                                                                                                                 | Not applicable. No testing conducted.                                                                                                                       |
| Anchorage of the mullion element or mulled fenestration assembly as defined in Section 5.6 shall be documented and the adequacy of the anchorage under specified design pressure load reported, supported by engineering calculations, signed and sealed by a P.E. licensed in a state within the United States. The calculations shall demonstrate the transfer of the design pressure load applied by the mulled fenestration assembly to the rough opening substrate. | Reference 2 documents anchorage analysis of the mullion to the substrate only. See Reference 1 for results summary and anchorage installation requirements. |



## FBC Code Compliance – Impact Rating

In accordance with the current edition of the Florida Building Code, Section – Protection of Openings and the current edition of the Florida Residential Code, Section – Protection of Openings, impact testing of the mullion system is not intrinsically required by ASTM E1996-09 when limited to Wind Zone 3 as discussed below. References below pertain to ASTM E1996-09.

**Structural Analysis of Mullions:** Florida Building & Residential Code Sections address methods of qualification of mullions which includes structural calculation as provided for by a Professional Engineer. These sections do not intrinsically address impact requirements.

### From current edition of FBC for Protection of Openings:

*Building Volume - Protection of openings. Glazed openings in buildings located in wind-borne debris regions shall be protected from wind-borne debris. Glazed opening protection for wind-borne debris shall meet the requirements of SSTD 12, ASTM E 1886 and ASTM E 1996, ANSI/DASMA 115 (for garage doors and rolling doors) or TAS 201, 202 and 203 or AAMA 506 referenced therein.*

*Residential Volume - Protection of openings. Windows in buildings located in wind-borne debris regions shall have glazed openings protected from wind-borne debris. Glazed opening protection for wind-borne debris shall meet the requirements of the Large Missile Test of ASTM E 1996, ASTM E 1886, SSTD 12, or TAS 201, 202 and 203 or AAMA 506 referenced therein. Garage door glazed opening protection for wind-borne debris shall meet the requirements of an approved impact resisting standard of ANSI/DASMA 115.*

These sections of the FBC state that ASTM E1996 can be used for impact protection testing. They do not give any specific requirements as to how. You must refer to ASTM E1996 for specific requirements.

### ASTM E1996-09

*4.5 Fenestration assemblies and impact protective systems intended to be mulled together shall be tested separately or tested by combining three specimens into one mounting frame separated only by the mullions.*

This section indicates that the windows can be tested as a mulled assembly or with each product separately. No requirement exists to impact the mullion.

*5.3.3.6 In Wind Zone 4, impact the integral mullion and other intermediate members such as a meeting rail, check rail, or meeting stile mid-span in lieu of the impact specified in 5.3.2.3 if applicable.*

*5.3.3.7 In Wind Zone 4, for each type of mullion impact one vertical or horizontal combination mullion with the longest span at mid span in addition to impacts specified in 5.3.*

This indicates that the mullion (whether integral or acting as reinforcement) MUST be impacted for Wind Zone 4 only. This evaluation report limits the mullion system to Wind Zone 3. Therefore the mullion does not have to be



impacted and the assemblies can be qualified per Section 4.5 above. As the Pella windows are certified in both non-impact and impact rated configurations individually tested, Section 4.5 is met.

**Current edition of the FBC, Mullions occurring between individual window and glass door assemblies.**

**Mullions.** Mullions or mullioned fenestration assemblies shall be tested by an approved testing laboratory in accordance with either AAMA 450, ASTM E 330, or TAS 202 (HVHZ shall comply with TAS 202), or shall be engineered in accordance with AAMA 450 using accepted engineering practice.

Mullions tested as stand-alone units or qualified by engineering shall use performance criteria cited in Sections below.

Mullions qualified by an actual test of an entire assembly shall comply with Section 1715.5.5.4, except that mullions in assemblies requiring a deflection limitation, as defined in AAMA/WDMA/CSA 101/I.S.2/A440, shall meet the criteria below.

Products not included within the scope of Section 1715.5.5.1 shall comply with Sections below.

**Load transfer.** Mullions shall be designed to transfer the design pressure loads applied by the window and door assemblies to the rough opening substrate.

**Deflection.** Mullions shall be capable of resisting the design pressure loads applied by the window and door assemblies to be supported without deflecting more than  $L/175$ , where  $L$  is the span of the mullion in inches.

**Structural safety factor.** Mullions that are tested by an approved testing laboratory shall be capable of resisting a load of 1.5 times the design pressure loads applied by the window and door assemblies to be supported. The design pressures, as determined from ASCE 7, are permitted to be multiplied by 0.6. The 1.5 times the design pressure load shall be sustained for 10 seconds, and the permanent deformation shall not exceed 0.2 percent of the mullion span for assemblies requiring deflection limitations, as defined in AAMA/WDMA/CSA 101/I.S.2/A440 and 0.4 percent of the mullion span for all other assemblies after the 1.5 times design pressure load is removed. Mullions that are qualified by engineering shall be capable of resisting the design pressure loads applied by the window and door assemblies to be supported without exceeding the allowable stress of the mullion elements.

**Current edition of the FRC, Mullions**

**Mullions.** Mullions, other than mullions which are an integral part of a window or glass door assembly tested and labeled in accordance with Section R612.6, shall be tested by an approved testing laboratory in accordance with AAMA 450 or be engineered in accordance with accepted engineering practice and shall meet the following criteria:

**Engineered mullions.** Mullions qualified by accepted engineering practice shall comply with the performance criteria in Sections below.



**Mullions tested as stand-alone units.** Mullions tested as stand-alone units in accordance with AAMA 450 shall comply with the performance criteria in Sections below.

**Mullions tested in an assembly.** Mullions qualified by a test of an entire assembly in accordance with AAMA 450 shall comply with Sections on Load Transfer and Safety Factor below.

**Load transfer.** Mullions shall be designed to transfer the design pressure loads applied by the window and door assemblies to the rough opening substrate.

**Deflection.** Mullions shall be capable of resisting the design pressure loads applied by the window and door assemblies to be supported without deflecting more than  $L/175$ , where L is the span of the mullion in inches.

**Structural safety factor.** Mullions shall be capable of resisting a load of 1.5 times the design pressure loads applied by the window and door assemblies to be supported without exceeding the appropriate material stress levels. If tested by an approved laboratory, the 1.5 times the design pressure load shall be sustained for 10 seconds, and the permanent deformation shall not exceed 0.4 percent of the mullion span after the 1.5 times design pressure load is removed.



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## ANALYSIS METHODOLOGY

The following methodology was used to develop the Load Width/Span Tables presented in Reference 1.

1. Determine the tributary loading area of the proposed configurations.
  - a. The basis of the analysis is comparison of the loading in the proposed configurations limited by
    - i. Mullion bending stress,
    - ii. Mullion horizontal shearing stress,
    - iii. Mullion deflection,
    - iv. Anchor clip shear stress, and
    - v. Anchor allowable in shear for concrete/masonry and wood substrates.
  - b. Load width/span tables based on trapezoidal loading considering the requirements of AAMA 450 and AAMA 203 with regard to equivalent concentrated and uniform loading on the mullion.
2. Loading analysis based on the following:
  - a. Shear Stress =  $P/A$  (psi) for end of mullion clip.
  - b. Horizontal Shear Stress =  $VQ/It$  for mullion.
  - c. Bending Stress =  $Mc/I = M/Z$  (psi)
    - i.  $M$  is bending moment and is equal to  $M/K_f$
    - ii.  $K_f$  is moment coefficient based on rectangular distribution (Ref. 5).
  - d. Deflection =  $WL^2 / KdEI$ 
    - i.  $K_d$  is deflection coefficient based on rectangular distribution (Ref. 5).
    - ii.  $W$  is load on mullion in lbs =  $wL$  where  $w$  is distributed load in lbs/in and  $L$  in mullion span in inches.
  - e. Mullion End Load Reactions
    - i. Based on trapezoidal loading on mullion resolved into total load distributed to each end of mullion equally considering an equivalent concentrated load using AAMA 450 as guidance were applicable.
3. Mullion Section Properties are shown in Appendix 1.



## REFERENCES

1. PTC Engineering Reports – Summary of Design Pressure Capacities for various Load Widths vs. Mull Spans
  - a. No. 1786, Rev. 2, *Engineering Report: Evaluation of Series 350 Vinyl Window Mulling System: 1/2" Light Duty Aluminum Mullion with Fin Frame and Block Frame Mullion End Clips*, signed and sealed by Robert J. Amoruso, P.E. dated 2/16/15.
  - b. No. 1789, Rev. 2, *Engineering Report: Evaluation of Series 350 Vinyl Window Mulling System: 1/2" Standard Aluminum Mullion with Fin Frame and Block Frame Mullion End Clips*, signed and sealed by Robert J. Amoruso, P.E. dated 2/16/15.
  - c. No. 1792, Rev. 2, *Engineering Report: Evaluation of Series 350 Vinyl Window Mulling System: 1/2" Standard Aluminum Mullion w/Stainless Steel Reinforcement with Fin Frame and Block Frame Mullion End Clips*, signed and sealed by Robert J. Amoruso, P.E. dated 2/16/15.
  - d. No. 1795, Rev. 2, *Engineering Report: Evaluation of Series 350 Vinyl Window Mulling System: 1" Aluminum Mullion with Fin Frame, Block Frame and Flange Frame Mullion End Clips*, signed and sealed by Robert J. Amoruso, P.E. dated 2/16/15.
  - e. No. 1798, Rev. 2, *Engineering Report: Evaluation of Series 350 Vinyl Window Mulling System: 1" Aluminum Mullion w/Stainless Steel Reinforcement with Fin Frame, Block Frame and Flange Frame Mullion End Clips*, signed and sealed by Robert J. Amoruso, P.E. dated 2/16/15.
2. PTC Engineering Evaluation Reports – Anchorage End Reaction Engineering and Mullion Stress Analysis
  - a. No. 1785, *Anchorage Engineering and Mullion Stress Analysis of Series 350 Vinyl Window Mulling System: 1/2" Light Duty Aluminum Mullion with Fin Frame and Block Frame Mullion End Clips*, signed and sealed by Robert J. Amoruso, P.E. dated 6/17/11.
  - b. No. 1788, *Anchorage Engineering and Mullion Stress Analysis of Series 350 Vinyl Window Mulling System: 1/2" Standard Aluminum Mullion with Fin Frame and Block Frame Mullion End Clips*, signed and sealed by Robert J. Amoruso, P.E. dated 6/17/11.
  - c. No. 1791, *Anchorage Engineering and Mullion Stress Analysis of Series 350 Vinyl Window Mulling System: 1/2" Standard Aluminum Mullion w/Stainless Steel Reinforcement with Fin Frame and Block Frame Mullion End Clips*, signed and sealed by Robert J. Amoruso, P.E. dated 6/17/11.
  - d. No. 1794, *Anchorage Engineering and Mullion Stress Analysis of Series 350 Vinyl Window Mulling System: 1" Aluminum Mullion with Fin Frame, Block Frame and Flange Frame Mullion End Clips*, signed and sealed by Robert J. Amoruso, P.E. dated 6/17/11.
  - e. No. 1797, *Anchorage Engineering and Mullion Stress Analysis of Series 350 Vinyl Window Mulling System: 1" Aluminum Mullion w/Stainless Steel Reinforcement with Fin Frame, Block Frame and Flange Frame Mullion End Clips*, signed and sealed by Robert J. Amoruso, P.E. dated 6/17/11.



3. Stork Twin City Testing Corporation, 3922 Delaware Ave., Des Moines, IA 50313 Test Reports listed below:

| Stork Report No. | Stork Report Date | Frame                           | Config | Overall Width (in) | Overall Height (in) | Mull        | Clip   | Air Infiltration (ASTM E283) | Water Penetration Resistance (ASTM E547) |
|------------------|-------------------|---------------------------------|--------|--------------------|---------------------|-------------|--------|------------------------------|------------------------------------------|
| TCT006132P.1     | 4/3/2011          | 4.50" Block Frame W/ 5/8" Flng. | 4-way  | 120                | 120                 | 1" w/reinf. | Flange | 1.57 psf and 6.24 psf        | 15 psf                                   |
| TCT006132P.2     | 4/3/2011          | 4.5" NF with End Clip           | 3-way  | 120                | 120                 | 1"          | Fin    | 1.57 psf and 6.24 psf        | 11.29 psf                                |
| TCT006132P.3     | 4/3/2011          | 4.50" Block Frame               | 3-way  | 120                | 120                 | 1/2" LD     | Block  | 1.57 psf and 6.24 psf        | 15 psf                                   |
| TCT006132P.4     | 4/3/2011          | 4.5" NF with End Clip           | 4-way  | 120                | 120                 | 1"          | Fin    | 1.57 psf and 6.24 psf        | 15 psf                                   |
| TCT006132P.5     | 4/3/2011          | 4.50" Block Frame               | 4-way  | 120                | 120                 | 1"          | Block  | 1.57 psf and 6.24 psf        | 15 psf                                   |
| TCT006132P.6     | 4/3/2011          | 4.50" Block Frame               | 4-way  | 120                | 120                 | 1/2" LD     | Block  | 1.57 psf and 6.24 psf        | 15 psf                                   |
| TCT006132P.7     | 4/3/2011          | 4.5" NF with End Clip           | 4-way  | 120                | 120                 | 1/2" LD     | Fin    | 1.57 psf and 6.24 psf        | 15 psf                                   |

4. AAMA 450-06, Voluntary Performance Rating Method for Muller Fenestration Assemblies.
5. AAMA 203-98, Procedural Guide – WINS
6. Current Edition of the Florida Building Code – Building and Residential Volumes
7. ASTM E1996-09, Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes.



## **APPENDIX 1**

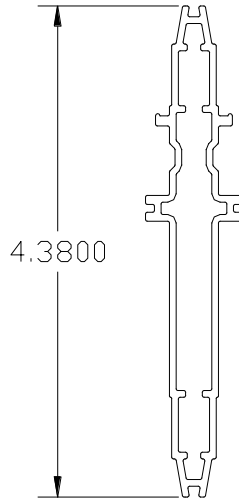
### **Mullion Section Properties**

## Steel Reinforcement Bar

Stainless Steel Plate, 3.969" wide x 0.077" thick x mullion length – 6"

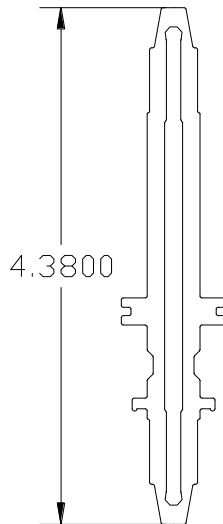
Section properties are combined with those of the Aluminum Mullion by considering the Modulus of Elasticity and Moment of Inertia and developing equivalent section properties in terms of aluminum which can be added to those of the mullion.

1/2" Light Duty Aluminum Mullion



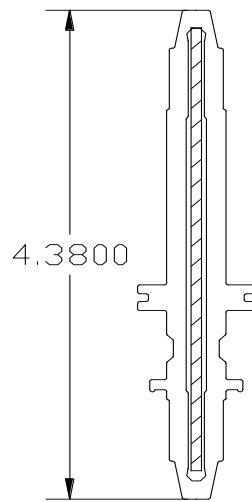
$$\begin{aligned} I &= 1.046 \text{ in}^4 \\ S &= 0.461 \text{ in}^3 \\ A &= 0.663 \text{ in}^2 \end{aligned}$$

1/2" Standard Aluminum Mullion



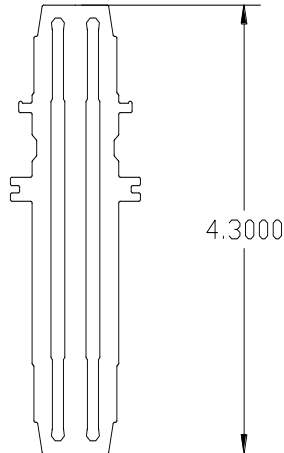
$$\begin{aligned} I &= 1.786 \text{ in}^4 \\ S &= 0.803 \text{ in}^3 \\ A &= 1.292 \text{ in}^2 \end{aligned}$$

1/2" Standard Aluminum  
Mullion with Stainless Steel  
Reinforcement Plate



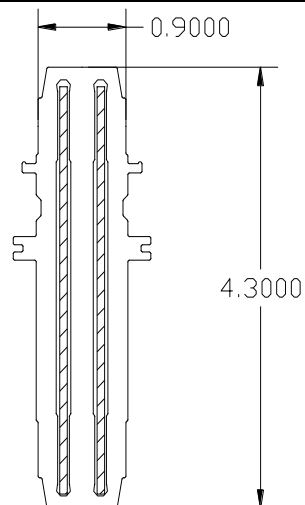
$$\begin{aligned} I &= 2.949 \text{ in}^4 \\ S &= 1.347 \text{ in}^3 \\ A &= 2.178 \text{ in}^2 \end{aligned}$$

1" Structural Aluminum  
Mullion



$$\begin{aligned} I &= 4.315 \text{ in}^4 \\ S &= 1.999 \text{ in}^3 \\ A &= 2.872 \text{ in}^2 \end{aligned}$$

1" Structural Aluminum  
Mullion with Stainless  
Steel Reinforcement  
Plates



$$\begin{aligned} I &= 6.642 \text{ in}^4 \\ S &= 3.089 \text{ in}^3 \\ A &= 4.644 \text{ in}^2 \end{aligned}$$