

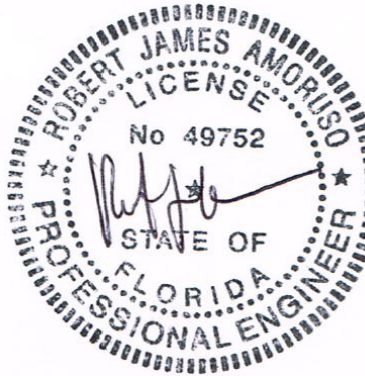
Pella Corporation

102 Main Street
Pella, Iowa 50219

PROJECT:
MULLION CALCULATIONS
FOR VERTICAL AND HORIZONTAL MULLION

SERIES: Joining Mull for Doors with
Transoms and/or Sidelights (Tight Mulls)

PROJECT NO.: 423-1101
REPORT NO.: 0506-6
DATE: 2/4/2024



Digitally signed
by Robert J
Amoruso
Date:
2024.02.06
16:21:17 -05'00'

Prepared by:

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SCOPE PTC, PRODUCT DESIGN GROUP was contracted by Pella Corporation to perform engineering evaluations of various mulled door and window combinations. This report will be based on joining the properties of the weakest wood frame (Inswing Door) jambs as demonstrated in the section property section of this report, by evaluation of possible groupings of mullions based on section property comparisons in accordance with the AAMA 450-06/09/10. Structural analysis of the mullions is based on the current edition of the Florida Building Code – Building and Residential Volumes, Chapter 17 and Chapter 6 respectively using the product grouping method and tributary loading of AAMA 450.

PRODUCT APPLICABILITY: This report is applicable to the following Pella Corporation product lines and types only.

1. Product Lines

- a. Reserve Series, exterior clad and wood.
- b. Lifestyle Series with HGP, exterior clad
- c. Lifestyle Series without HGP, exterior clad
- d. Direct Set Aluminum Clad Wood Fixed Windows
- e. Pella Entry Systems, exterior clad and wood

2. Product Types

- a. Casement
- b. Awning
- c. Picture
- d. Direct Set Geometric and Radius
- e. Sliding Patio Door
- f. In-swing Patio Door
- g. Out-swing Patio Door
- h. In-swing Entry Door
- i. Out-swing Entry Door

3. Product Materials

- a. Extruded aluminum for aluminum portions of door and windows.
- b. Pine for wood portions of door and window frames.

The tributary areas are identified and calculated. These results are used to calculate the maximum pressure that the product can withstand without exceeding the allowable stresses or deflection. The minimum of these results is selected and defined as the design pressure for the product. Mullion stress and deflection is calculated using the AAMA 450 load distribution method.

For each mullion configuration, spreadsheet programs are used to calculate the apparent EI and equivalent I, a design pressure verification using equivalent I, and alternate spans from the design pressure calculation.



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ANALYSIS METHODOLOGY:

The following methodology was used to develop the Load width span tables presented in this report.

1. Determine the allowable design pressure (D.P.) based on the actual shear stress, bending stress, deflection and mullion reactions as compared to their respect design allowables choosing the worst case.
- 2.. Worst case section properties determined by a comparison of the individual component sections of the applicable products, the cross sections exhibiting the lowest Moment of Inertia (I) and section Modulus (Z) will be used. Area as it is related to shear stress does not govern design so it is not a deciding factor of the worst case section.
3. Using a ratio of the wood window jambs Modulus of Elasticity (E) compute the overall apparent section properties of the worst case cross section.
4. Use the properties determined above in determining the load width/span tables.
5. Analysis based on:
 - a. Horizontal Shear Stress = P/A (psi)
 - b. Bending Stress = $M/I = M/Z$ (psi)
 - i. M = bending moment and is equal to M/Kf
 - ii. Kf is moment coefficient based on trapezoidal load distribution.
 - c. Deflection = $WL^3 / KdEI$
 - i. Kd is deflection coefficient based on trapezoidal distribution.
 - ii. W is load on mullion in Lbs. = wL where w is distributed load in Lbs/in and L in mullion span inches.
 - d. Mullion End Load Reactions
 - i. Based on trapezoidal load on mullion resolved into total load distributed to each end of mullion equally.
6. Load Width/Span Tables based on:
 - a. Solving for the allowable design pressure (D.P.) considering various window sizes and mullion spans.



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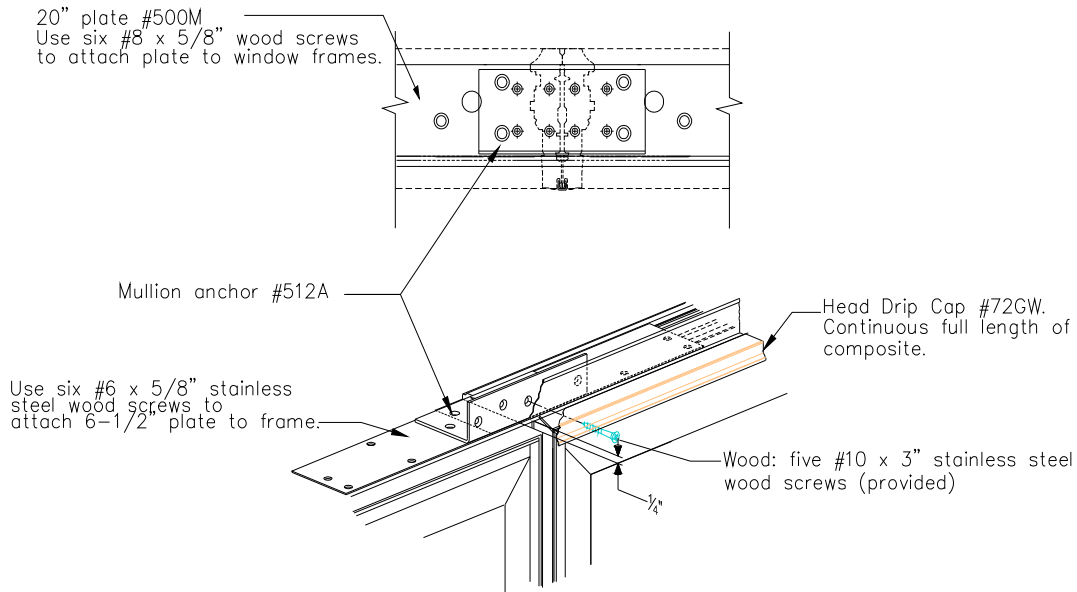
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MULLION END ANCHORAGE:

1. Calculated performance is based on the following:
Mullions anchor plates
 - a. 512-A Wood mullion anchor clip. (316 stainless steel)
 - b. 5071 installation type clip (A-653 Hot dipped Galvanized steel)
 - c. 500 P steel plate and through frame alternate end anchorage.

MULLION ATTACHEMENT:

2. a. **Mullion End Clip 512-A (Fin mull anchor clip)**
 - i. The end clip is secured to each end of window jambs using eight #10 x 5/8" wood screws below, and requires a minimum of 1-1/2" wood buck thickness (See Detail A).
 - ii. For 20" plate attachment to both window frames use six (6) #6 x 5/8" stainless steel screws.
 - iii. For clip attachment to wood frame substrates use five (5) #10 x 2" long or longer wood screws per clip leg into the installation bucking or frame with a minimum of 1 1/2" embedment into substrate and maintaining at least 3/4" minimum edge distance is required based on the analysis used in this report for development of the load width and span.



Mullion End Clip 512-A (Fin mull anchor clip)
Detail A



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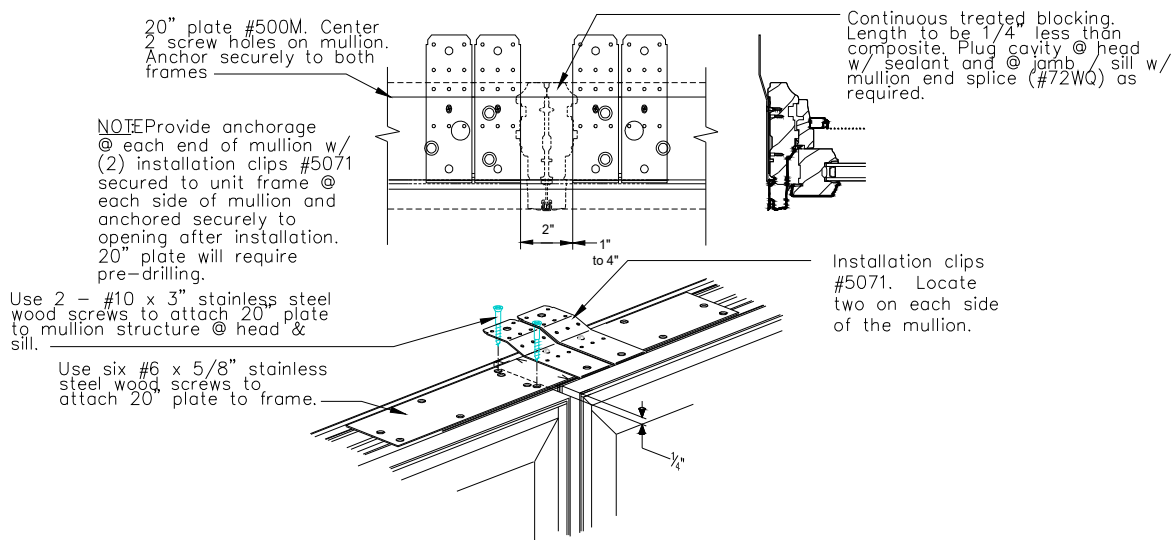
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f. Mullion End Clip 5071

- i. The end clips are secured to each end of joined widow frames using a 6-1/2" steel plate #500M installed directly over both frames, then install two (2) 5071 mull clips two at each side of the joined window frames, (See Detail B)
- ii. For 6-1/2" plate attachment to both window frames use six (6) #6 x 5/8" stainless steel screws.
- iii. For clip attachment to wood frame substrates use a total of four (4) #10 x 2" long or longer wood screws one per each clip leg into the installation bucking or frame with a minimum of 1 1/2" embedment into substrate and maintaining at least 3/4" minimum edge distance, for clip attachment to window frames through plate use two (2) #5/8" stainless steel screws per each clip is required based on the analysis used in this report for development of the load width span.
- iv. For clip attachment to CMU or concrete substrates use a total of four (4) 3/16" dia. masonry anchors one (1) per each clip leg into the installation bucking or frame with a minimum of 1 1/4" embedment into substrate and maintaining at least 2 5/8" minimum edge distance each clip anchor hole spacing must be located at least on 2 1/4" spacing between anchors, for clip attachment to window frames through plate use two (2) #10 x 5/8" stainless steel screws per each individual clip is required based on the analysis of this report for development of the load width span.



Detail B
Mullion End Clip 5071



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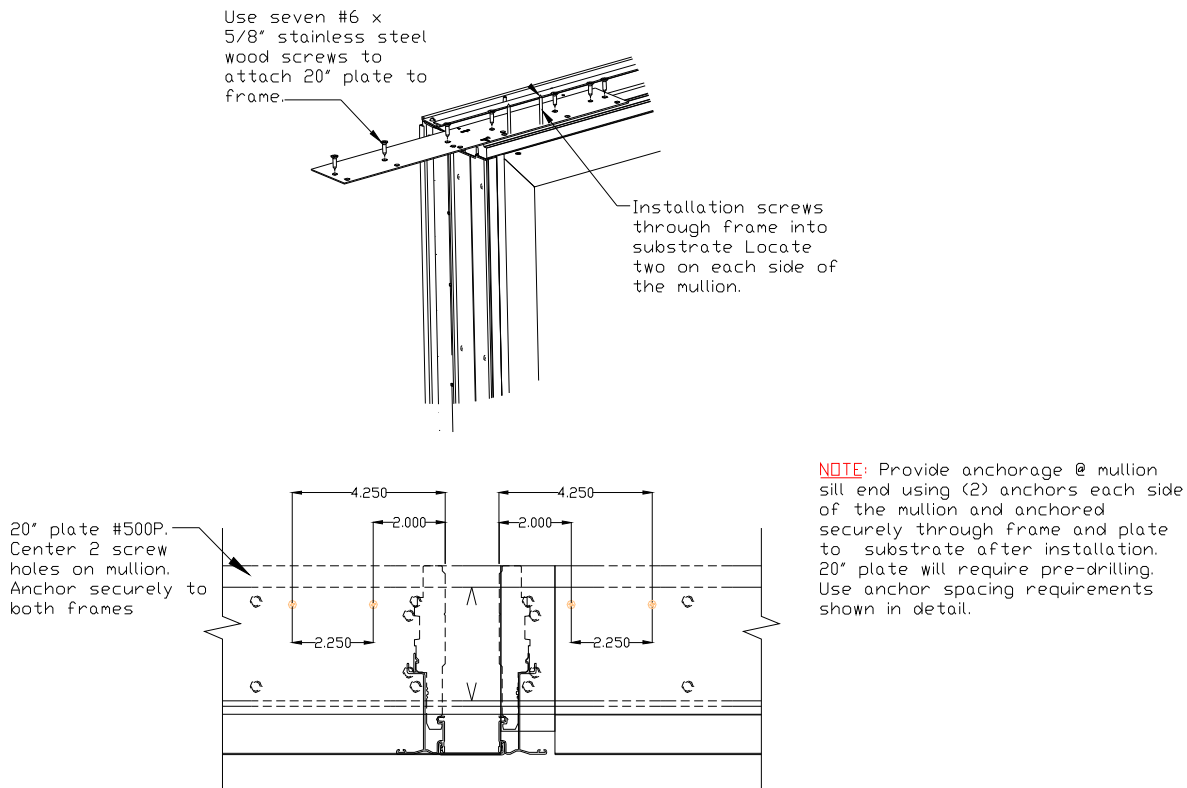
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g. Alternate, Through 500 P steel plate and main frame at mullion sill end.

- i. For 20" plate attachment to both main frame members use seven (7) #6 x 5/8" stainless steel wood screws and two (2) #10 x 3" stainless steel wood screws to attach the 500 P plate directly to mullion structure at sill end (See detail C).
- ii. For anchor attachment to wood frame substrates use a total of four (4) #10 x 2" long or longer wood screws located 2" and 4-1/4" from each mullion end into the installation bucking or frame with a minimum embedment of 1-1/2" and maintaining at least 3/4" minimum edge distances is required based on the analysis used on this report for the development of the load width and span tables.
- iii. For anchor attachment to cmu or concrete substrates use a total of four (4) 3/16" diam. Masonry anchors located 2" and 4-1/4" from each mullion end into the installation bucking or frame with a minimum embedment of 1-1/4" and maintaining at least 2-5/8" minimum edge distances is required based on the analysis used on this report for the development of the load width and span tables.

Detail C

Through Plate and Frame anchorage





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REFERENCED DOCUMENTS:

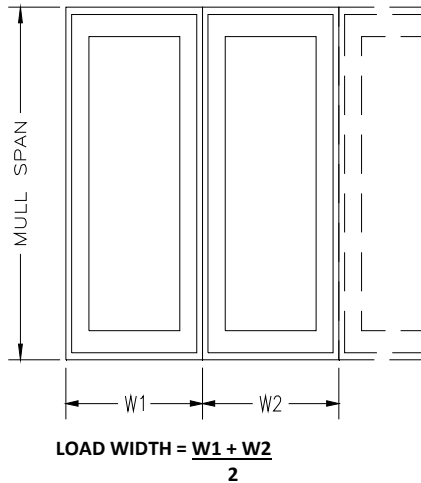
1. AAMA 450-06/09/10
2. Florida Building Code
 - a. Current Edition of the Florida Building Code (FBC), Building Volume
 - i. Chapter 17 - Mullions
 - b. Current Edition of the Florida Building Code (FBC), Residential volume
 - i. Chapter 6 - Mullions



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THIS CHART APPLIES TO MULTIPLE WIDE 1 HIGH, VERTICALLY.

LOAD WIDTH MUST BE CALCULATED USING LARGEST ADJACENT (SIDE BY SIDE) DOOR HEIGHTS OR WIDTHS.

MULL SPANS ARE RESTRICTED BY THE LONGEST SPAN, (ALL TABLES).

WINDOWS MAY BE INTERMIXED COMBINATIONS OF CASEMENT, AWNING, PICTURE, IN-SASH AND DIRECT SET GEOMETRIC OR RADIUS, (ALL TABLES).

ALLOWABLE PRESSURES ON THE MULLED ASSEMBLY SHALL BE CONTROLLED BY THE LESSER OF MULLION OR THE INDIVIDULE WINDOW UNIT.

MULLION TABLE 1							
DOOR TO DOOR OR DOOR TO WINDOW (VERTICAL SPAN—JOINING Mull)							
MULL SPAN	LOAD WIDTH	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)	MULL SPAN	LOAD WIDTH	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)
60	30	82	82	96	30	30	30
	36	71	71		36	26	26
	42	64	64		42	22	22
	48	60	60		48	20	20
66	30	67	67	102	30	26	26
	36	58	58		36	22	22
	42	51	51		42	19	19
	48	47	47		48	17	17
72	30	56	56	108	30	22	22
	36	48	48		36	19	19
	42	42	42		42	16	16
	48	38	38		48	14	14
78	30	47	47	114	30	19	19
	36	40	40		36	16	16
	42	35	35		42	14	14
	48	32	32		48	12	12
84	30	40	40	120	30	16	16
	36	34	34		36	13	13
	42	30	30		42	12	12
	48	27	27		48	10	10
90	30	35	35				
	36	29	29				
	42	26	26				
	48	23	23				

* Use this table for intermediate 2-way vertical mullions.

* For anchor clip attachment to substrates, see notes on sheets 4 & 5 on this report.

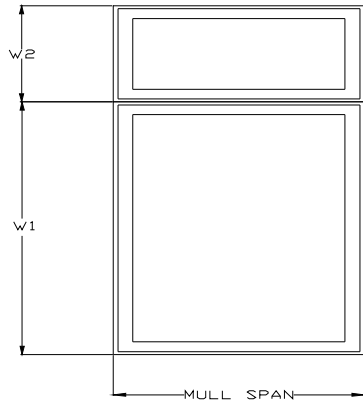
* where installation applications do not permit the use of clip type 5071 an alternate through frame mullion anchorage may be substituted see detail "C" on sheet 6 of this report.



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$$\text{LOAD WIDTH} = \frac{W1 + W2}{2}$$

THIS CHART APPLIES TO 1 WIDE 1 HIGH, HORIZONTALLY.

LOAD WIDTH MUST BE CALCULATED USING LARGEST ADJACENT (SIDE BY SIDE) DOOR AND WINDOW HEIGHTS OR WIDTHS.

MULL SPANS ARE RESTRICTED BY THE LONGEST SPAN, (ALL TABLES).

WINDOWS MAY BE INTERMIXED COMBINATIONS OF CASEMENT, AWNING, PICTURE, IN-SASH AND DIRECT SET GEOMETRIC OR RADIUS, (ALL TABLES).

ALLOWABLE PRESSURES ON THE MULLED ASSEMBLY SHALL BE CONTROLLED BY THE LESSER OF MULLION OR THE INDIVIDUAL DOOR UNIT.

* Use this table for intermediate 2-way horizontal mullions.

* For anchor clip attachment to substrates, see notes on sheets 4 & 5 on this report.

* Where installation applications do not permit the use of clip type 5071 an alternate through frame mullion anchorage may be substituted, see detail "C" on sheet 6 on this report.

MULLION TABLE 2											
DOOR TO WINDOW											
(HORIZONTAL SPAN—JOINING MULLION FOR DOOR TO WINDOW UNITS)											
MULL SPAN	LOAD WIDTH	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)	MULL SPAN	LOAD WIDTH	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)	MULL SPAN	LOAD WIDTH	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)
30	30	85	85	66	30	85	85	96	30	31	31
	36	85	85		36	77	77		36	27	27
	42	85	85		42	69	69		42	23	23
	48	85	85		48	63	63		48	21	21
	54	85	85		54	59	59		54	19	19
	60	85	85		60	57	57		60	18	18
	66	85	85		66	57	57		66	17	17
36	72	85	85	68	72	57	57	102	72	16	16
	30	85	85		30	84	84		30	26	26
	36	85	85		36	72	72		36	22	22
	42	85	85		42	64	64		42	19	19
	48	85	85		48	59	59		48	17	17
	54	85	85		54	55	55		54	16	16
	60	85	85		60	53	53		60	15	15
42	66	85	85	72	66	52	52	108	66	14	14
	72	85	85		72	52	52		72	13	13
	30	85	85		30	74	74		30	22	22
	36	85	85		36	63	63		36	19	19
	42	85	85		42	56	56		42	16	16
	48	85	85		48	51	51		48	14	14
	54	85	85		54	48	48		54	13	13
48	60	85	85	78	60	45	45	114	60	12	12
	66	85	85		66	44	44		66	11	11
	72	85	85		72	44	44		72	11	11
	30	85	85		30	60	60		30	19	19
	36	85	85		36	51	51		36	16	16
	42	85	85		42	45	45		42	14	14
	48	85	85		48	41	41		48	12	12
54	54	85	85	84	54	38	38	120	54	11	11
	60	85	85		60	36	36		60	10	10
	66	85	85		66	35	35		66	9	9
	72	85	85		72	34	34		72	9	9
	30	85	85		30	48	48		30	16	16
	36	85	85		36	41	41		36	13	13
	42	85	85		42	36	36		42	12	12
60	48	85	85	90	48	32	32		48	10	10
	54	85	85		54	30	30		54	9	9
	60	85	85		60	28	28		60	9	9
	66	85	85		66	27	27		66	8	8
	72	85	85		72	26	26		72	7	7
	30	85	85		30	38	38				
	36	85	85		36	33	33				
	42	85	85		42	29	29				
	48	80	80		48	26	26				
	54	76	76		54	24	24				
	60	75	75		60	22	22				
	66	75	75		66	21	21				
	72	75	75		72	20	20				



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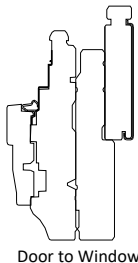
Product Grouping:

1. Reserve and Lifestyle Series Clad combination assemblies with Joining mullion in intermixed configurations of casement, Awning, Picture, In-sash or Direct set Geometric or Radius.
2. Product type grouping: operable vs. fixed window load distribution was considered in the determination of the theoretical stress and deflection analysis due to mullion bending load and how concentrated loads produce higher bending stresses and deflections.

Section Property Grouping:

1. The casement and inswing door type frame jambs combined produce the lowest overall section properties as joined section properties. The wood jambs joined mechanically with anchors act as one member.
2. The illustration below shows the individual component section properties for the casement and inswing door jamb.
3. The intermixed combinations of Casement, Awning, Picture, In-Sash, and Direct Set geometric or Radius were examined, the combined section properties calculated using AutoCad (independent of material stiffnesses), and based on comparison of these section properties the combination of units that produce the weakest section determined. This section, combined was used in the analysis.

JOINED COMPOSITE SECTION PROPERTIES



In-swing door jamb with casement jamb used in door to window or door to door mull analysis is shown at left. Only the wood jambs, wood side stops are considered in the calculation of section properties.
The wood covers are not considered.

The combined section properties for the above, considering the material differences were found to be the following.

I =	10.579 in ⁴
S =	4.904 in ³
A =	9.114 in ²

(In terms of wood)

The individual wood jambs, wood side stops section properties used to determine the combined section properties are given on the following page.



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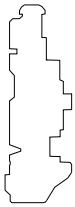
Joining Mull, 2-Way (VT or HZ)

Wood Side Stop (VT or HZ)



----- REGIONS -----
Area: 0.9721
Perimeter: 5.6195
Bounding box: X: -0.3265 -- 0.3715
Y: -1.0161 -- 0.9037
Centroid: X: 0.0000
Y: 0.0000
Moments of inertia: X: 0.2751
Y: 0.0293
Product of inertia: XY: 0.0319
Radii of gyration: X: 0.5320
Y: 0.1735
Principal moments and X-Y directions about centroid:
I: 0.0252 along [0.1265 0.9920]
J: 0.2792 along [-0.9920 0.1265]

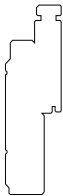
wood Jamb (VT or HZ)



----- REGIONS -----
Area: 3.3695
Perimeter: 11.4918
Bounding box: X: -0.5527 -- 0.6973
Y: -1.8257 -- 2.1593
Centroid: X: 0.0000
Y: 0.0000
Moments of inertia: X: 3.8249
Y: 0.2682
Product of inertia: XY: -0.0773
Radii of gyration: X: 1.0654
Y: 0.2821
Principal moments and X-Y directions about centroid:
I: 0.2665 along [0.0217 -0.9998]
J: 3.8266 along [0.9998 0.0217]

Wood Door Jamb and Stop (VT or HZ)

Composite Properties



----- REGIONS -----
Area: 4.7731
Perimeter: 12.3995
Bounding box: X: -0.6823 -- 0.7537
Y: -2.1853 -- 2.2637
Centroid: X: 0.0000
Y: 0.0000
Moments of inertia: X: 6.4792
Y: 0.7146
Product of inertia: XY: 0.9018
Radii of gyration: X: 1.1651
Y: 0.3869
Principal moments and X-Y directions about centroid:
I: 0.5768 along [0.1510 0.9885]
J: 6.6170 along [-0.9885 0.1510]

IXX = 6.4792
SXX = 2.862
A = 4.773



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SECTION PROPERTY COMPARISON CHART (VT. & HZ.)

Minimum of Compared Section Properties				
Brand	Product	Section	Exterior	MOI_Wood
Minimum of Compared Section Properties	Window Mullion Charts	All	Clad	4.1239
	Door Mullion Charts	All	Clad	6.4792
Reserve and Lifestyle Series	Clad Frame (Direct Set)	All	Clad	4.3409
Reserve Series	Casement	All	Wood	5.8819
	In-swing Patio Door	All	Wood	10.5581
	Out-swing Patio Door	All	Wood	8.7762
	Casement	All	Clad	4.1239
	In-swing Patio Door	All	Clad	6.4792
	Out-swing Patio Door	All	Clad	9.2629
	Sliding Patio Door	Jamb	Clad	6.5248
	Sliding Patio Door	Head	Clad	6.5248
Lifestyle Series with HGP	Casement	All	Clad	4.1239
	In-swing Patio Door	All	Clad	6.4792
	Sliding Patio Door	Jamb	Clad	6.5248
	Sliding Patio Door	Head	Clad	6.5248
Lifestyle Series w/o HGP	Casement	All	Clad	4.1239
	In-swing Patio Door	All	Clad	8.0055
	Sliding Patio Door	Jamb	Clad	7.5874
	Sliding Patio Door	Head	Clad	6.6263
Pella	In-swing Entry Door	All	Clad	6.7557
	Out-swing Entry Door	All	Clad	9.2338
	In-swing Entry Door	All	Wood	6.7557

MOE_Wood
(x10^6 psi)

Discussion:

- 1). Frame Section Properties above provided by Pella Corporation.
- 2). Ixx is moment of Inertia about axis of bending of the mulled configuration , Ymax is the maximum distance from "X" axis to outer fibers of the section in the "y" direction. Zx is section modulus = Ixx / y max. A is area.
- 3). The configuration with the lowest I and Z will envelope all other configurations. A is relatively the same for all, except the DS radius, therefore will not be deciding factor.
- 4). Based on the above comparison of sections the casement jamb is the worst case.
- 5). Comparison above based on section properties of the combined jamb sections only.



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THE FOLLOWING CONFIGURATIONS ARE EXAMPLES IN THIS REPORT

2-Way

