

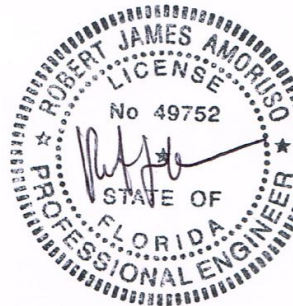
Pella Corporation

102 Main Street
Pella, Iowa 50219

PROJECT:
***MULLION CALCULATIONS
FOR VERTICAL AND HORIZONTAL MULLION***

SERIES: 4.0" Wood Spread Mull for Windows
4.0" x 4-3/8" Wood Mullion

PROJECT NO.: 423-1101
REPORT NO.: 0505-3
DATE: 2/4/2024



Digitally
signed by
Robert J
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SCOPE PTC, PRODUCT DESIGN GROUP was contracted by Pella Corporation to perform engineering evaluations of various mulled window combinations. This report will be based on using the combined properties of the 4.0" x 4-3/8" wood spread mull and the weakest wood frame (Casement Window) 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. Double Hung

3. Product Materials

- a. Extruded aluminum for aluminum portions of window.
- b. Pine for wood portions of mullion member 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 mull and 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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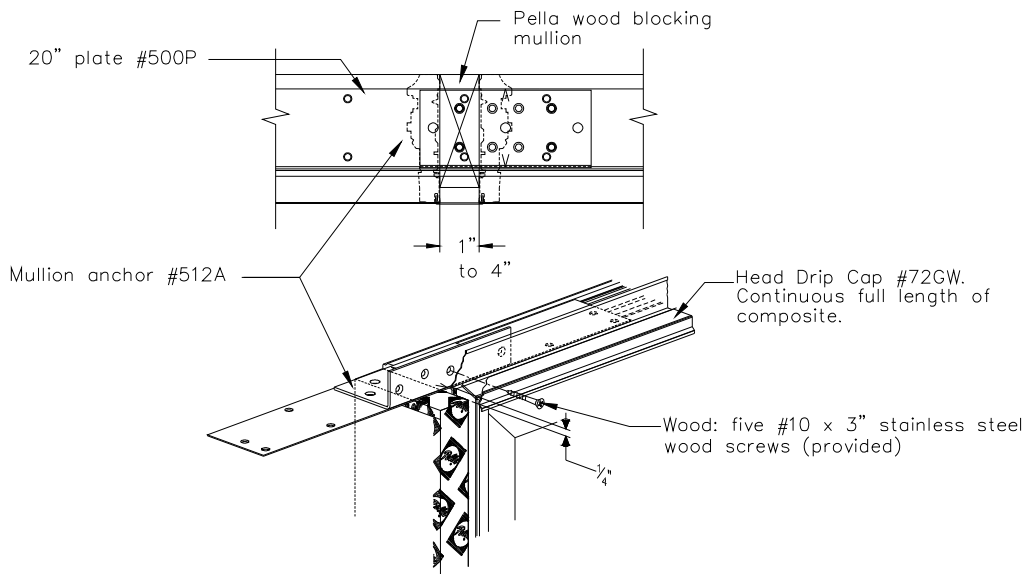
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MULLION END ANCHORAGE:

1. Calculated performance is based on the following:
Mullions anchor plates
 - a. 512-A Wood mullion anchor clip. (316 stainless steel)
 - e. 5071 installation type clip (A-653 Hot dipped Galvanized steel)

MULLION ATTACHEMENT:

2. a. **Mullion End Clip 512-A (Fin mull anchor clip)**
 - i. The end clip is secured to each end of wood spread mullion 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 ten (10) #8 x 5/8" stainless steel screws.
 - ii. 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



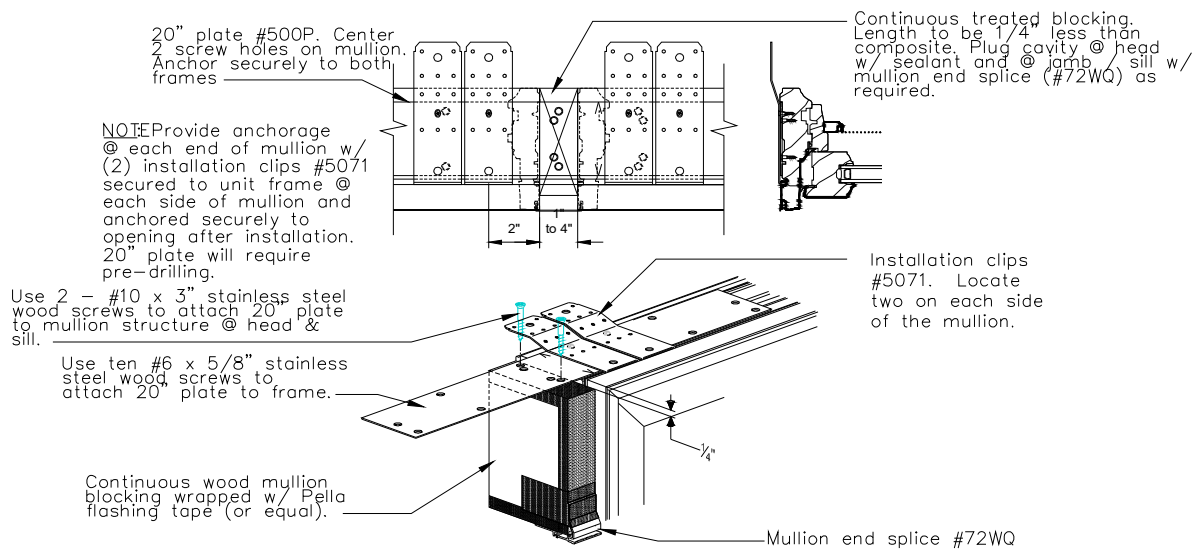
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f. Mullion End Clip 5071

- i. The end clips are secured to each end of wood mullion using a 20" steel plate #500P installed directly over mullion to secure both frames then install two (2) 5071 mull clips two at each side of the mullion, (See Detail B)
- ii. For 20" plate attachment to both window frames use ten (10) #8 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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REFERENCED DOCUMENTS:

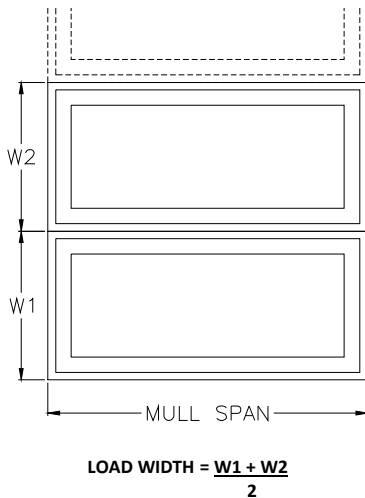
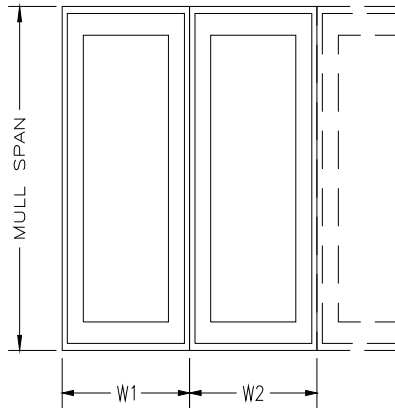
1. AAMA 450-06/09/10
2. Florida Building Code
 - a. Current Edition of the Florida Building Code (FBC), Building Volume
 - i. Chapter 17 - Mullions
 - b. Current Edition of the Florida Building Code (FBC), Residential volume
 - i. Chapter 6 - Mullions



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THIS CHART APPLIES TO MULTIPLE WIDE 1 HIGH, VERTICALLY OR HORIZONTALLY.

LOAD WIDTH MUST BE CALCULATED USING LARGEST ADJACENT (SIDE BY SIDE) 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 AND DOUBLE HUNG, (ALL TABLES).

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

MULLION TABLE 1											
(VERTICAL OR HORIZONTAL SPAN—4.0" WOOD SPREAD MULLION FOR WINDOW UNITS)											
MULL SPAN (in.)	LOAD WIDTH (in.)	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)	MULL SPAN (in.)	LOAD WIDTH (in.)	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)	MULL SPAN (in.)	LOAD WIDTH (in.)	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)
36	24	85	85	66	24	85	85	96	24	85	85
	30	85	85		30	85	85		30	85	85
	36	85	85		36	85	85		36	78	81
	42	85	85		42	85	85		42	69	72
	48	85	85		48	85	85		48	63	66
	54	85	85		54	85	85		54	59	61
	60	85	85		60	85	85		60	55	57
	66	85	85		66	85	85		66	53	55
42	24	85	85	72	24	85	85	102	24	85	85
	30	85	85		30	85	85		30	84	85
	36	85	85		36	85	85		36	72	75
	42	85	85		42	85	85		42	64	66
	48	85	85		48	85	85		48	58	59
	54	85	85		54	84	85		54	54	54
	60	85	85		60	85	85		60	50	50
	66	85	85		66	85	85		66	47	47
48	24	85	85	78	24	85	85	108	24	85	85
	30	85	85		30	85	85		30	75	75
	36	85	85		36	85	85		36	63	63
	42	85	85		42	85	85		42	55	55
	48	85	85		48	84	85		48	49	49
	54	85	85		54	79	82		54	45	45
	60	85	85		60	76	79		60	41	41
	66	85	85		66	74	76		66	38	38
54	24	85	85	84	24	85	85				
	30	85	85		30	85	85				
	36	85	85		36	85	85				
	42	85	85		42	83	85				
	48	85	85		48	76	79				
	54	85	85		54	71	74				
	60	85	85		60	68	70				
	66	85	85		66	65	67				
60	24	85	85	90	24	85	85				
	30	85	85		30	85	85				
	36	85	85		36	84	85				
	42	85	85		42	76	78				
	48	85	85		48	69	72				
	54	85	85		54	64	67				
	60	85	85		60	61	63				
	66	85	85		66	58	60				

* Use this table for intermediate 2-way mullions.

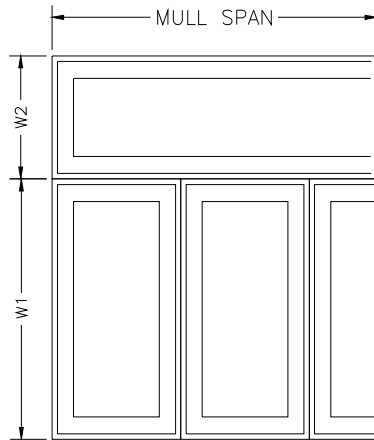
* For anchor clip attachment to substrates, see notes on sheets 4 & 5 on this report.



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

THIS CHART APPLIES TO ("T") 3-WAY MULLS.

LOAD WIDTH MUST BE CALCULATED USING LARGEST ADJACENT (SIDE BY SIDE) 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 AND DOUBLE HUNG, (ALL TABLES).

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

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

*Table 2A is to be used for the horizontal mullion that goes through the 3-way frame intersection, which is the structural through-mull, use table 1 for the remaining, intermediate 2-way mullions.

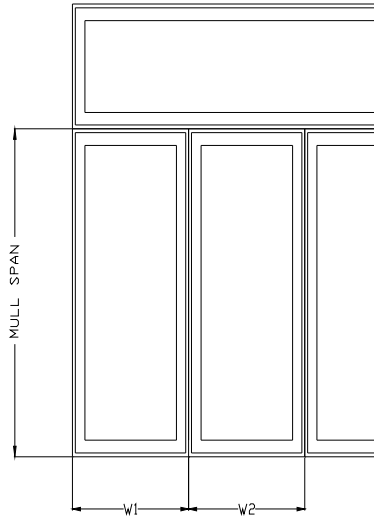
MULLION TABLE 2A (HORIZONTAL SPAN—4.0" WOOD SPREAD MULLION FOR WINDOW)							
MULL SPAN (in.)	LOAD WIDTH (in.)	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)	MULL SPAN (in.)	LOAD WIDTH (in.)	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)
30	30	85	85	66	30	85	85
	36	85	85		36	85	85
	42	85	85		42	85	85
	48	85	85		48	85	85
	54	85	85		54	85	85
	60	85	85		60	85	85
	66	85	85		66	85	85
	72	85	85		72	85	85
36	30	85	85	72	30	85	85
	36	85	85		36	85	85
	42	85	85		42	85	85
	48	85	85		48	85	85
	54	85	85		54	85	85
	60	85	85		60	82	85
	66	85	85		66	78	81
	72	85	85		72	75	78
42	30	85	85	78	30	85	85
	36	85	85		36	84	85
	42	85	85		42	85	85
	48	85	85		48	84	85
	54	85	85		54	78	81
	60	85	85		60	73	76
	66	85	85		66	69	72
	72	85	85		72	66	69
48	30	85	85	84	30	78	81
	36	85	85		36	74	77
	42	85	85		42	83	85
	48	85	85		48	76	79
	54	85	85		54	70	73
	60	85	85		60	66	68
	66	85	85		66	62	65
	72	85	85		72	59	62
54	30	85	85	90	30	69	72
	36	85	85		36	66	68
	42	85	85		42	63	65
	48	85	85		48	69	72
	54	85	85		54	64	66
	60	85	85		60	60	62
	66	85	85		66	57	59
	72	85	85		72	54	56
60	30	85	85	96	30	62	64
	36	85	85		36	59	61
	42	85	85		42	56	59
	48	85	85		48	63	66
	54	85	85		54	59	61
	60	85	85		60	55	57
	66	85	85		66	52	54
	72	85	85		72	49	51



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

THIS CHART APPLIES TO ("T") 3-WAY MULLS.

LOAD WIDTH MUST BE CALCULATED USING LARGEST ADJACENT (SIDE BY SIDE) 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 AND DOUBLE HUNG, (ALL TABLES).

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

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

*Table 2B is to be used for the mullion that frames into the 3-way frame intersection, at the horizontal which is the structural through mull.

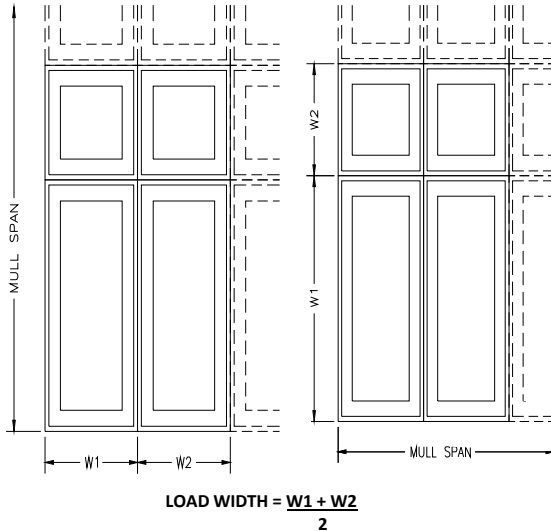
MULLION TABLE 2B							
(VERTICAL SPAN—4.0" WOOD SPREAD MULLION FOR WINDOW)							
MULL SPAN (in.)	LOAD WIDTH (in.)	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)	MULL SPAN (in.)	LOAD WIDTH (in.)	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)
36	15	85	85	60	15	85	85
	18	85	85		18	85	85
	21	85	85		21	85	85
	24	85	85		24	85	85
	27	85	85		27	85	85
	30	85	85		30	85	85
	33	85	85		33	85	85
	36	85	85		36	85	85
	39	85	85		39	85	85
	42	85	85		42	85	85
	45	85	85		45	85	85
	48	85	85		48	85	85
42	15	85	85	66	15	85	85
	18	85	85		18	85	85
	21	85	85		21	85	85
	24	85	85		24	85	85
	27	85	85		27	85	85
	30	85	85		30	85	85
	33	85	85		33	85	85
	36	85	85		36	85	85
	39	85	85		39	85	85
	42	85	85		42	85	85
	45	85	85		45	85	85
	48	85	85		48	85	85
48	15	85	85	72	15	85	85
	18	85	85		18	85	85
	21	85	85		21	85	85
	24	85	85		24	85	85
	27	85	85		27	85	85
	30	85	85		30	85	85
	33	85	85		33	85	85
	36	85	85		36	85	85
	39	85	85		39	85	85
	42	85	85		42	85	85
	45	85	85		45	85	85
	48	85	85		48	85	85
54	15	85	85	78	15	85	85
	18	85	85		18	85	85
	21	85	85		21	85	85
	24	85	85		24	85	85
	27	85	85		27	85	85
	30	85	85		30	85	85
	33	85	85		33	85	85
	36	85	85		36	85	85
	39	85	85		39	85	85
	42	85	85		42	85	85
	45	85	85		45	85	85
	48	85	85		48	84	85



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THIS CHART APPLIES TO 4-WAY INTERSECTING HORIZONTAL OR VERTICAL WHERE THE VERTICAL MULLION RUNS THROUGH FULL LENGTH.

LOAD WIDTH MUST BE CALCULATED USING LARGEST ADJACENT (SIDE BY SIDE) 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 AND DOUBLE HUNG, (ALL TABLES).

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

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

*Table 3 is to be used for the mullion that goes through the 4-way frame intersection, which is the structural thru-mull. Use Table 1 for the remaining, intermediate 2-way mullions.

MULLION TABLE 3											
(VERTICAL OR HORIZONTAL 4-WAY SPAN—4.0" WOOD SPREAD MULLION)											
MULL SPAN (in.)	LOAD WIDTH (in.)	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)	MULL SPAN (in.)	LOAD WIDTH (in.)	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)	MULL SPAN (in.)	LOAD WIDTH (in.)	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)
36	24	85	85	66	24	85	85	96	24	66	76
	30	85	85		30	85	85		30	60	60
	36	85	85		36	85	85		36	49	49
	42	85	85		42	85	85		42	42	42
	48	85	85		48	85	85		48	36	36
	54	85	85		54	85	85		54	31	31
	60	85	85		60	84	84		60	28	28
	66	85	85		66	76	76		66	25	25
42	24	85	85	72	24	85	85	102	24	59	63
	30	85	85		30	85	85		30	50	50
	36	85	85		36	85	85		36	41	41
	42	85	85		42	85	85		42	35	35
	48	85	85		48	83	83		48	30	30
	54	85	85		54	73	73		54	26	26
	60	85	85		60	65	65		60	24	24
	66	85	85		66	59	59		66	21	21
48	24	85	85	78	24	85	85	108	24	54	54
	30	85	85		30	85	85		30	42	42
	36	85	85		36	84	85		36	35	35
	42	85	85		42	76	76		42	29	29
	48	85	85		48	65	65		48	25	25
	54	85	85		54	58	58		54	22	22
	60	85	85		60	51	51		60	20	20
	66	85	85		66	46	46		66	18	18
54	24	85	85	84	24	83	85				
	30	85	85		30	78	85				
	36	85	85		36	72	72				
	42	85	85		42	61	61				
	48	85	85		48	53	53				
	54	85	85		54	46	46				
	60	85	85		60	41	41				
	66	85	85		66	37	37				
60	24	85	85	90	24	74	85				
	30	85	85		30	69	72				
	36	85	85		36	59	59				
	42	85	85		42	50	50				
	48	85	85		48	43	43				
	54	85	85		54	38	38				
	60	85	85		60	34	34				
	66	85	85		66	31	31				



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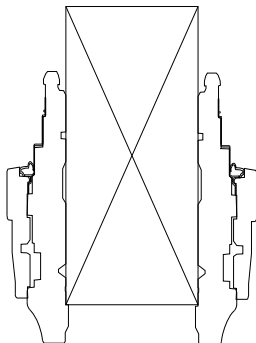
Product Grouping:

1. Reserve and Lifestyle Series Clad combination assemblies with 4.0" wood spread mullion in intermixed configurations of casement, Awning, Picture, In-sash or Direct set Geometric or Radius.
2. Window 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 type frame components combined with the 4.0" wood spread mullion produce the lowest overall combined composite section properties. The wood jamb, stop and wood mullion act as one member.
2. The illustration below shows the individule component section properties for the casement window.
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 with the wood mullion was used in the analysis.

MULLIONS COMPOSITE SECTION PROPERTIES



Casement with 4.0" wood spread Mullion used in analysis is shown at left. Only the wood jamb, wood side stop combined with the 4.0" wood spread mullion is used in the calculation of section properties. The wood mull covers are not considered.

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

I =	36.113 in ⁴	(In terms of wood)
S =	16.844 in ³	
A =	26.182 in ²	

The individule wood jamb, wood side stop and 4.0" wood spread mullion section properties used to determine the combined section properties are given on the following page.



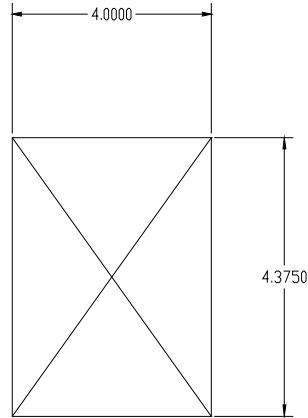
PTC PRODUCT DESIGN GROUP, LLC

P.O. Box 520775, Suite C25
Longwood, Florida 32752

Client: Pella Corporation
Project #: 423-1101
Report #: 0505-3
Prepared by: RJA
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4.0" wood spread Mull (VT or HZ)

----- REGIONS -----
Area: 17.5000
Perimeter: 16.7500
Bounding box: X: -2.0000 -- 2.0000
Y: -2.1875 -- 2.1875
Centroid: X: 0.0000
Y: 0.0000
Moments of inertia: X: 27.9134
Y: 23.3333
Product of inertia: XY: 0.0000
Radii of gyration: X: 1.2630
Y: 1.1547
Principal moments and X-Y directions about centroid:
I: 23.3333 along [0.0000 1.0000]
J: 27.9134 along [-1.0000 0.0000]



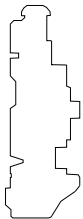
Ixx = 27.913
Sxx = 12.760
A= 17.500

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]



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SECTION PROPERTY COMPARISON CHART (VT. & HZ.)

Minimum of Compared Section Properties					<u>MOE Wood</u> <u>(x10⁶ psi)</u>
Brand	Product	Section	Exterior	MOI_Wood	
Minimum of Compared Section Properties	Window Mullion Charts	All	Clad	4.1239	
Reserve and Lifestyle Series	Clad Frame (Direct Set)	All	Clad	4.3409	
Reserve Series	Casement	All	Wood	5.8819	
	Model 4 DH	Jamb	Wood	10.9364	
	Model 4 DH	Head	Wood	6.9324	
	Model 3 DH	Jamb	Wood	7.7429	
	Model 3 DH	Head	Wood	5.1873	
	Casement	All	Clad	4.1239	
	Model 3 DH	Jamb	Clad	4.7736	
	Model 3 DH	Head	Clad	4.6296	
	Model 4 DH	Jamb	Clad	6.7893	
	Model 4 DH	Head	Clad	5.1533	
Lifestyle Series with HGP	Casement	All	Clad	4.1239	
Lifestyle Series w/o HGP	Casement	All	Clad	4.1239	
	Double Hung	Jamb	Clad	4.9908	
	Double Hung	Head	Clad	4.9565	

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 sections without the wood mullion. Adding the wood mullion has the same affect on each combination. So the weakest combination without wood mullion will still be the weakest combination with reinforcement.



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THE FOLLOWING CONFIGURATIONS ARE EXAMPLES IN THIS REPORT

