

Pella Corporation

102 Main Street
Pella, Iowa 50219

PROJECT:

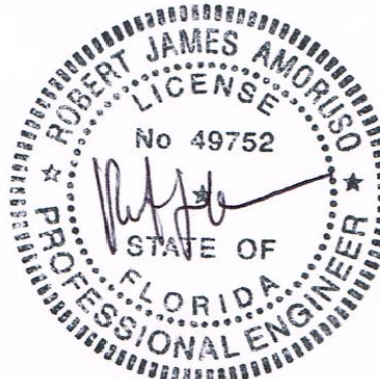
***MULLION CALCULATIONS
FOR VERTICAL AND HORIZONTAL MULLION***

SERIES: 1.5" Wood Spread Mull for Windows
1-1/2" x 4-3/8" Wood Mullion

PROJECT NO.: 423-1101

REPORT NO.: 0502-2

DATE: 2/4/2024



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by Robert J
Amoruso

Date:
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Prepared by:

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PTC PRODUCT DESIGN GROUP, LLC

P.O. Box 520775
Longwood, Florida 32752

Client: Pella Corporation
Project #: 423-1101
Report #: 0502-2
Prepared by: RJA
Date: 2/4/2024
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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 1-1/2" 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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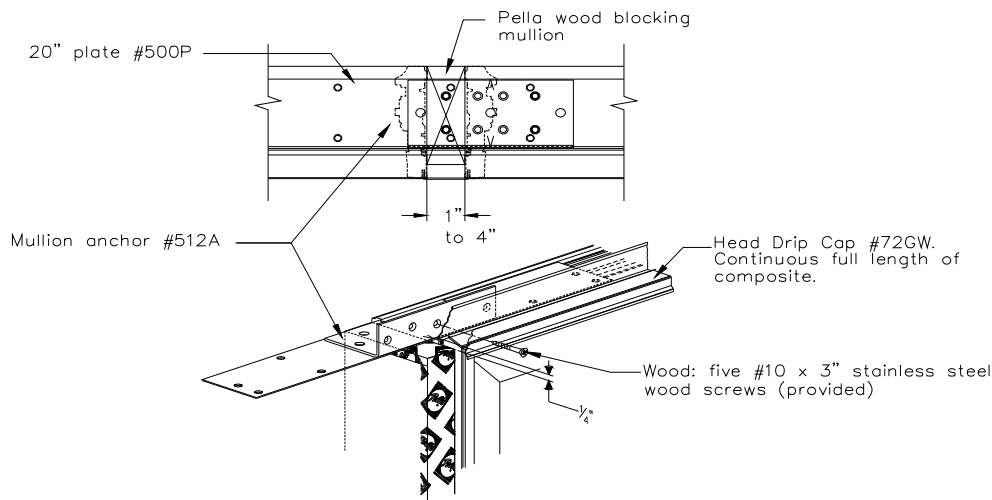
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MULLION END ANCHORAGE:

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.
 - 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



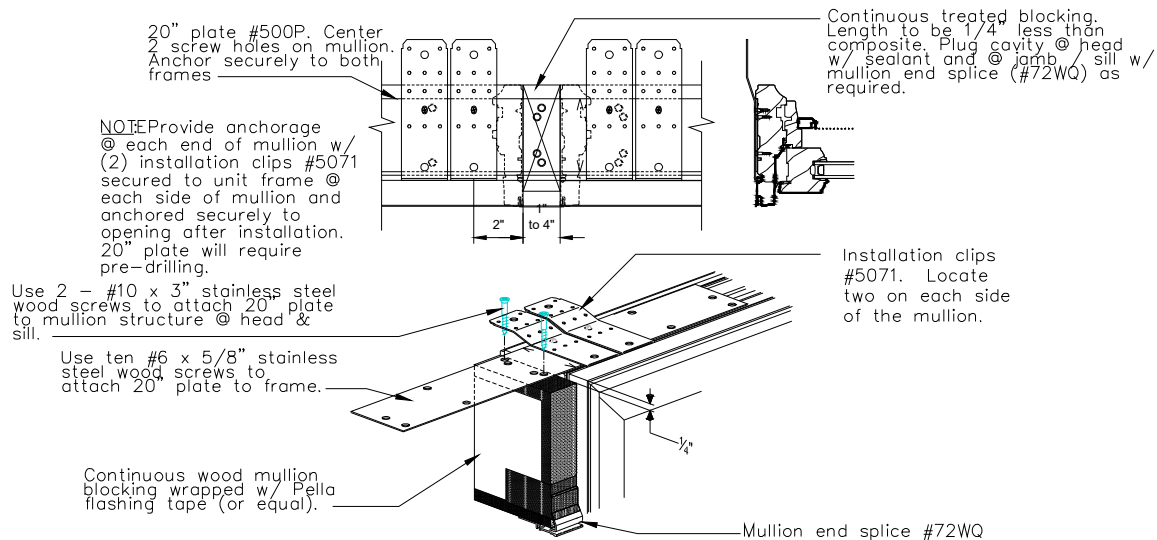
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f. Mullion End Clip 5071

- 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:

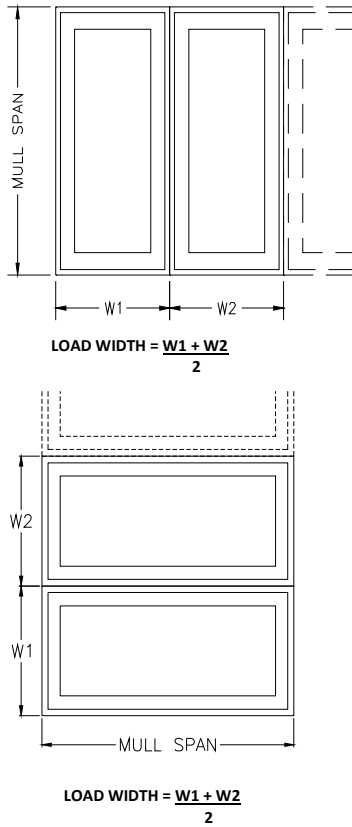
1. AAMA 450-06/09/10
2. Florida Building Code
 - a. Current Edition of the Florida Building Code (FBC), Building Volume
 - i. Chapter 17 - Mullions
 - b. Current Edition of the Florida Building Code (FBC), Residential volume
 - i. Chapter 6 - Mullions



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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).

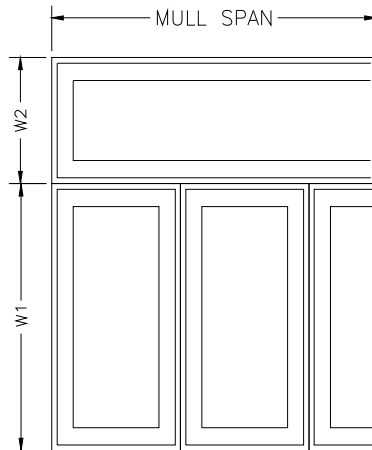
WINDOWS MAY BE INTERMIXED COMBINATIONS OF CASEMENT, AWNING, PICTURE, IN-SASH AND DIRECT SET GEOMETRIC OR RADIUS AND DOUBLE HUNG, (ALL TABLES).

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—1.5" 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	68	68
	30	85	85		30	85	85		30	55	55
	36	85	85		36	85	85		36	47	47
	42	85	85		42	85	85		42	41	41
	48	85	85		48	85	85		48	36	36
	54	85	85		54	81	81		54	33	33
	60	85	85		60	78	78		60	31	31
	66	85	85		66	77	77		66	29	29
42	24	85	85	72	24	85	85	102	24	57	57
	30	85	85		30	85	85		30	46	46
	36	85	85		36	85	85		36	39	39
	42	85	85		42	76	76		42	34	34
	48	85	85		48	65	65		48	30	30
	54	85	85		54	58	58		54	28	28
	60	85	85		60	62	62		60	26	26
	66	85	85		66	60	60		66	24	24
48	24	85	85	78	24	85	85	108	24	48	48
	30	85	85		30	85	85		30	39	39
	36	85	85		36	72	72		36	33	33
	42	85	85		42	64	64		42	28	28
	48	85	85		48	58	58		48	25	25
	54	85	85		54	53	53		54	23	23
	60	85	85		60	50	50		60	21	21
	66	85	85		66	48	48		66	20	20
54	24	85	85	84	24	85	85				
	30	85	85		30	73	73				
	36	85	85		36	62	62				
	42	85	85		42	54	54				
	48	85	85		48	49	49				
	54	85	85		54	45	45				
	60	85	85		60	42	42				
	66	85	85		66	40	40				
60	24	85	85	90	24	78	78				
	30	85	85		30	63	63				
	36	85	85		36	53	53				
	42	85	85		42	47	47				
	48	85	85		48	42	42				
	54	85	85		54	38	38				
	60	85	85		60	36	36				
	66	85	85		66	34	34				

* Use this table for intermediate 2-way mullions.

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



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

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).

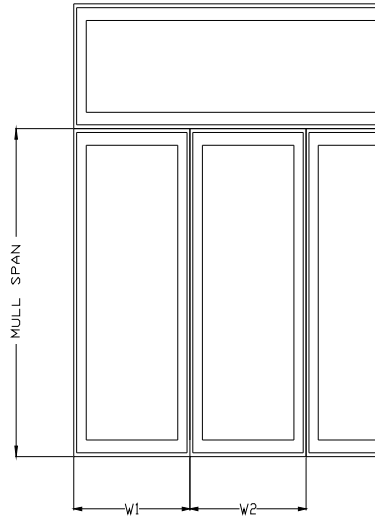
WINDOWS MAY BE INTERMIXED COMBINATIONS OF CASEMENT, AWNING, PICTURE, IN-SASH AND DIRECT SET GEOMETRIC OR RADIUS AND DOUBLE HUNG, (ALL TABLES).

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—1.5" 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	79	79
	60	85	85		60	73	73
	66	85	85		66	68	68
	72	85	85		72	64	64
36	30	85	85	72	30	85	85
	36	85	85		36	85	85
	42	85	85		42	79	79
	48	85	85		48	71	71
	54	85	85		54	65	65
	60	85	85		60	60	60
	66	85	85		66	56	56
	72	85	85		72	53	53
42	30	85	85	78	30	85	85
	36	85	85		36	76	76
	42	85	85		42	67	67
	48	85	85		48	60	60
	54	85	85		54	54	54
	60	85	85		60	50	50
	66	85	85		66	46	46
	72	85	85		72	44	44
48	30	85	85	84	30	76	76
	36	85	85		36	65	65
	42	85	85		42	57	57
	48	85	85		48	51	51
	54	85	85		54	46	46
	60	85	85		60	42	42
	66	85	85		66	39	39
	72	85	85		72	37	37
54	30	85	85	90	30	66	66
	36	85	85		36	56	56
	42	85	85		42	49	49
	48	85	85		48	44	44
	54	85	85		54	40	40
	60	85	85		60	36	36
	66	85	85		66	34	34
	72	85	85		72	32	32
60	30	85	85	96	30	58	58
	36	85	85		36	49	49
	42	85	85		42	43	43
	48	85	85		48	38	38
	54	85	85		54	34	34
	60	85	85		60	32	32
	66	85	85		66	29	29
	72	81	81		72	27	27



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

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 INDIVIDULE 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.

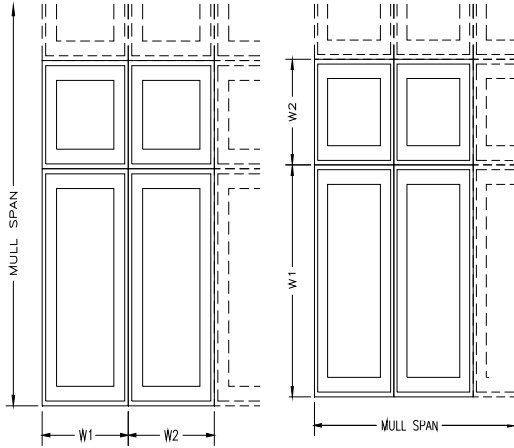
MULLION TABLE 2B							
(VERTICAL SPAN—1.5" WOOD SPREAD MULLION FOR WINDOW							
MULL SPAN (in.)	LOAD WIDTH (in.)	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)	MULL SPAN (in.)	LOAD WIDTH (in.)	CLIP TYPE 512A (PSF)	CLIP TYPE 5071 (PSF)
36	15	85	85	60	15	85	85
	18	85	85		18	85	85
	21	85	85		21	85	85
	24	85	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
42	45	85	85	66	45	85	85
	48	85	85		48	85	85
	15	85	85		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
48	39	85	85	72	39	85	85
	42	85	85		42	85	85
	45	85	85		45	85	85
	48	85	85		48	85	85
	15	85	85		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
54	33	85	85	78	33	85	85
	36	85	85		36	85	85
	39	85	85		39	81	81
	42	85	85		42	76	76
	45	85	85		45	73	73
	48	85	85		48	69	69
	15	85	85		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	78	78
	36	85	85		36	72	72
	39	85	85		39	68	68
	42	85	85		42	64	64
	45	85	85		45	60	60
	48	85	85		48	58	58



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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—1.5" 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	39	39
	30	85	85		30	85	85		30	31	31
	36	85	85		36	75	75		36	25	25
	42	85	85		42	64	64		42	21	21
	48	85	85		48	55	55		48	19	19
	54	85	85		54	49	49		54	16	16
	60	85	85		60	43	43		60	14	14
42	66	85	85	72	66	39	39	102	66	13	13
	24	85	85		24	85	85		24	33	33
	30	85	85		30	72	72		30	26	26
	36	85	85		36	59	59		36	21	21
	42	85	85		42	49	49		42	18	18
	48	85	85		48	43	43		48	16	16
	54	85	85		54	38	38		54	14	14
48	60	85	85	78	60	34	34	108	60	12	12
	66	85	85		66	30	30		66	11	11
	24	85	85		24	72	72		24	28	28
	30	85	85		30	57	57		30	22	22
	36	85	85		36	46	46		36	18	18
	42	85	85		42	39	39		42	15	15
	48	85	85		48	34	34		48	13	13
54	54	85	85	84	54	30	30		54	12	12
	60	85	85		60	27	27		60	10	10
	66	80	80		66	24	24		66	9	9
	24	85	85		24	58	58				
	30	85	85		30	46	46				
	36	85	85		36	37	37				
	42	85	85		42	32	32				
60	48	85	85	90	48	27	27				
	54	79	79		54	24	24				
	60	70	70		60	21	21				
	66	64	64		66	19	19				
	24	85	85		24	47	47				
	30	85	85		30	37	37				
	36	85	85		36	31	31				
	42	84	84		42	26	26				
	48	73	73		48	22	22				
	54	64	64		54	20	20				
	60	57	57		60	17	17				
	66	52	52		66	16	16				



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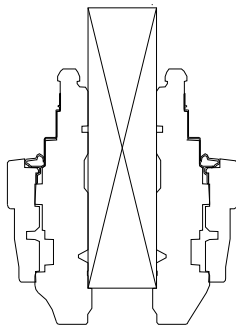
Product Grouping:

1. Reserve and Lifestyle Series Clad combination assemblies with 1.5" 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 1.5" 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 individual 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 1.5" wood spread Mullion used in analysis is shown at left. Only the wood jamb, wood side stop combined with the 1.5" 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 =	18.666 in4	(In terms of wood)
S =	8.868 in3	
A =	15.245 in2	

The individual wood jamb, wood side stop and 1.5" wood spread mullion section properties used to determine the combined section properties are given on the following page.

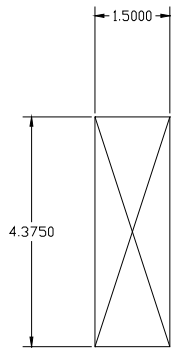


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1.5" wood spread Mull (VT or HZ)



Ixx = 10.466
Sxx = 4.784
A= 6.563

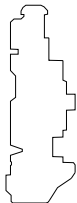
----- REGIONS -----
Area: 6.5625
Perimeter: 11.7500
Bounding box: X: -0.7500 -- 0.7500
Y: -2.1875 -- 2.1875
Centroid: X: 0.0000
Y: 0.0000
Moments of inertia: X: 10.4675
Y: 1.2305
Product of inertia: XY: 0.0000
Radii of gyration: X: 1.2630
Y: 0.4330
Principal moments and X-Y directions about centroid:
I: 1.2305 along [0.0000 -1.0000]
J: 10.4675 along [1.0000 0.0000]

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 w/o HGP	Casement	All	Clad	4.1239	
	Double Hung	Jamb	Clad	4.9908	
	Double Hung	Head	Clad	4.9565	
Lifestyle Series with HGP	Casement	All	Clad	4.1239	

Discussion:

- 1). Frame Section Properties above provided by Pella Corporation.
- 2). I_{xx} is moment of Inertia about axis of bending of the mulled configuration, Y_{max} is the maximum distance from "X" axis to outer fibers of the section in the "y" direction. Z_x is section modulus = I_{xx} / 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

