Installation Analysis

Harbor Terrace Apartments
Portland, Maine

Report F8229.01-122-34

Rendered to:

S&L SPECIALTY CONTRACTING, INC.
315 South Franklin Street
Syracuse, New York 13202

Prepared by:

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May 19, 2016

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
JOSEPH A. REED
ENGINEER No. PE-044401-E

Digitally Signed by: Joseph A. Reed

Joseph A. Reed, P.E.
Director – Engineering

2016.05.20 16:56:12 -04'00'

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Daniel C. Culbert

Scope

Architectural Testing, Inc., an Intertek company, was contracted by S&L Specialty Contracting, Inc. to perform installation analysis for the windows to be installed at the Harbor Terrace Apartments project in Portland, Maine. Graham Architectural Products 1200 series fixed windows, 6600 series casement windows and 2000 series single hung windows are evaluated as shown in the project shop drawings (see Referenced Drawings).

The analyses performed satisfy the methods and requirements of the following:

2009 International Building Code. International Code Council, 2008.

ASCE 7-05 *Minimum Design Loads for Building and Other Structures*. American Society of Civil Engineers, 2005.

Aluminum Design Manual 2005, The Aluminum Association, Inc., 2005.

AAMA TIR-A9-14 *Design Guide for Metal Cladding Fasteners*. American Architectural Manufacturers Association, 2014.

ESR-1976 *ITW Buildex TEKS Self-Drilling Fasteners*. ICC Evaluation Service, LLC. July 1, 2015.

The calculations presented herein are for the integrity of the window installations based on wind load. The weather tightness of the installation is not addressed by this report. The air/water/structural performance of the individual products is not proven by this report. The building substrate is assumed to have the integrity to resist the anchor loads developed by the products. Furthermore, the results of the analyses present a solution that satisfies the scope of the project, but other feasible solutions may exist.

Analyses

Design Wind Pressure Analysis

Design wind pressures are determined using the methods of ASCE 7-05 and based on the following conditions:

Building Location:	Portland, Maine
Mean Roof Height:	80 ft
Roof Slope:	0°
Building Risk Category:	II
Exposure:	C
Basic Wind Speed:	100 MPH

The building is considered "enclosed" for the purpose of calculating design wind pressures for components and cladding. Calculations presented on page 10 show that the worst-case design pressure for the windows is +33.0/-33.4 psf for windows in Zone 4 (mid-wall) and +33.0/-61.2 psf for windows in Zone 5 (corners). For all glazing analyses, a conservative design pressure of +/-61.2 psf will be used. For member and anchorage analyses, the Zone 4 pressure or Zone 5 pressure appropriate for the window location on the building will be used.

Glazing Analysis

The glazing load resistance is calculated using ASTM E1300. Glazing type 1 is insulating glass with 1/8" annealed glass to the exterior and interior. Glazing type 2 is insulating glass with 1/4" annealed glass to the exterior and interior. Representative ASTM E1300 analyses are presented on page 11 through page 13 and all analyses summarized in Table 1.

Table 1 Results of Glazing Analyses

Elevation	Location	Glazing Type	Glazing DLO (width x height)	Glazing Resistance
A/WE-01	Single Hung	1	24" x 27-1/2"	141 psf
NB/WE-01 RNB/WE-01	Fixed	2	57-7/8" x 53-3/8"	89.5 psf
	Single Hung	1	26-1/4" x 24-3/4"	144 psf
NC/WE-01 NRC/WE-02	Fixed	2	39-3/4" x 53-3/8"	112 psf
	Single Hung	1	24-3/8" x 24-3/4"	152 psf
D/WE-02	Fixed	2	14" x 57-3/8"	>209 psf
E/WE-02	Casement	1	22-1/4" x 24-3/8"	163 psf
	Fixed	2	57-7/8" x 27-3/8"	132 psf
F/WE-02	Casement	1	17-1/2" x 24-3/8"	183 psf
	Fixed	2	20-1/2" x 27-3/8"	>209 psf
NG/WE-03 RNG/WE-03	Fixed	2	63-1/4" x 53-3/8"	83.3 psf
	Single Hung	1	28-7/8" x 24-3/4"	134 psf
BAY1/WE-04	Fixed	2	54-3/8" x 65"	80.4 psf
	Casement	1	23" x 62"	53.7 psf
BAY2/WE-05	Fixed	2	48-3/4" x 65"	85.0 psf
	Casement	1	20-1/2" x 62"	59.4 psf
BAY3/WE-06	Fixed	2	48" x 65"	85.4 psf
	Casement	1	18-1/4" x 62"	70.2 psf
BAY4/WE-07	Fixed	2	48" x 65"	85.4 psf
	Casement	1	20" x 62"	61.5 psf
BAY5/WE-08	Fixed	2	47-3/4" x 65"	85.6 psf
	Casement	1	20-5/8" x 62"	58.8 psf
BAY6/WE-09	Fixed	2	46-3/8" x 65"	86.5 psf
	Casement	1	19" x 62"	66.2 psf

For the evaluated glazed panels, the glazing capacity exceeds the worst-case design wind pressure of 61.2 psf thereby validating the glazing with the following exception:

The casement windows at elevations BAY1, BAY2 and BAY 5. However, these elevations are located in zone 4 (mid-wall) and the calculated glazing resistances exceed the worst-case zone 4 design pressure of 33.4 psf.

Mullion Stress and Deflection

Stress and deflection analyses were conducted for the free-spanning mullions and intermediate members. The members were analyzed as a simply supported beam. The proposed window geometry and design loads are used to verify that the deflections are less than $\ell/175$ and that stresses are below allowable stress design (ASD) values. The mullions are 6063-T6 aluminum unless noted otherwise. Geometric properties of the mullions are calculated on page 14 through page 21 and summarized in Table 2.

Table 2 Member Geometric Properties

Detail	Section	Part	Material	I_x (in^4)	c_{max} (in)
2/WD-01	2000 Single Hung Meeting Rail	E200051	6063-T6	0.1434	0.9320
		E200061	6063-T6	0.1838	0.8073
5/WD-02 7/WD-02	2000 Single Hung M-F Mullion	E200030	6063-T6	0.8098	1.8571
		E203031	6063-T6	0.9210	1.8347
11/WD-04 13/WD-04	2000 Single Hung-1200 Fixed M-F Mullion	E203031	6063-T6	0.9210	1.8347
		E120010	6063-T6	0.6367	1.7613
26/WD-08 33/WD-11	1200 Fixed-6600 Casement M-F Mullion	E120032	6063-T6	0.7117	1.8135
		E120010	6063-T6	0.6367	1.7613
		E660002	6063-T6	0.3123	1.3317
27/WD-09 34/WD-11	3-Piece Jamb	E120010	6063-T6	0.6367	1.7613
		E200203	6063-T6	1.1218	2.1977
28/WD-09 29/WD-09 30/WD-10 31/WD-10	Ribbon Window Head and Sill	E120010	6063-T6	0.6367	1.7613
32/WD-11	3-Piece Mullion	E120010	6063-T6	0.6367	1.7613
		E200203	6063-T6	1.1218	2.1977
		E120010	6063-T6	0.6367	1.7613

Calculations on page 22 through page 28 confirm that the mullions shown on the project drawings satisfy the stress and deflection requirements for the established wind pressures.

Anchor Capacities

The modes of failure considered include fastener shear and tension, bearing failure of the member and substrate, pull-out, and pull-over. The pertinent physical and mechanical properties assumed for the anchor components are summarized in Table 3.

Table 3 Component Properties

Substrate	Description/Specification	Properties
Window Frames	6063-T6 Aluminum	F_y = 25,000 psi F_u = 30,000 psi
Window Accessories	6063-T5 Aluminum	F_y = 16,000 psi F_u = 22,000 psi
Structural Steel	ASTM A36	F_y = 36,000 psi F_u = 58,000 psi
Masonry	ASTM C62 Clay Brick	f'_m = 1,500 psi
Wood Blocking	Southern Yellow Pine (S-Y-P)	G = 0.88

Capacities of the various anchorage details are calculated as shown on page 29 through page 35. These capacities are compared to member reactions and will be used to establish the anchorage requirements. The calculated anchorage capacities are summarized in Table 4.

Table 4 Anchor Capacities

Detail	Connection	Capacity	Comments
1/WD-01, 3/WD-01, 8/WD-03 9/WD-03, 10/WD-04, 12/WD-04 14/WD-05, 15/WD-05, 16/WD-05 21/WD-07, 22/WD-07, 23/WD-08 24/WD-08	#12 Wood screw connecting trim clip to wood blocking	186 lb	1. Limited by Yield IIIs 2. 1-1/2" min penetration
4/WD-02, 6/WD-02, 17/WD-06 19/WD-06, 20/WD-07, 25/WD-08	1/4" Powers Tapper+ connecting trim clip to clay brick	270 lb	1. Limited by shear capacity 2. 1-1/2" min embedment 3. 1-3/4" min edge distance 4. See Note
18/WD-06	#12-14 TEKS connecting trim clip to structural steel	307 lb	1. Limited by bearing at trim clip 2. Full penetration +1/2"
All Details Trim Clip Connection	#10-16 TEKS screw connecting trim clip to window frame	97 lb	1. Limited by pull-over 2. Full penetration +1/2"

Note: Installation to existing clay brick assumes the clay brick substrate has been evaluated for and approved to resist anchorage loads.

Perimeter Anchorage Requirements

Anchorage requirements are established by comparing the calculated anchorage capacities to the perimeter reactions caused by the design loads. Perimeter anchor spacing requirements are calculated on page 36 through page 37 and summarized in Table 5 for zone 4 mid-wall anchorage and in Table 6 (page 8) for zone 5 corner anchorage.

Table 5 Perimeter Anchor Spacing for Zone 4 (Mid-Wall)

Elevation	Location	Clip to Substrate		Clip to Frame	
		Fastener	Max Spacing	Fastener	Max Spacing
A/WE-01	Head	#12 Wood Screw	18"	#10 TEKS	18"
	Sill	#12 Wood Screw	18"	#10 TEKS	18"
	Jamb	1/4" Tapper+	18"	#10 TEKS	17"
NB/WE-01 RNB/WE-01	Head	#12 Wood Screw	18"	#10 TEKS	15"
	Sill	#12 Wood Screw	18"	#10 TEKS	15"
	Jamb	#12 Wood Screw	18"	#10 TEKS	18"
NC/WE-01 NRC/WE-02	Head	#12 Wood Screw	18"	#10 TEKS	16"
	Sill	#12 Wood Screw	18"	#10 TEKS	16"
	Jamb	#12 Wood Screw	18"	#10 TEKS	18"
D/WE-02	Head	#12-14 TEKS	18"	#10 TEKS	18"
	Sill	1/4" Tapper+	18"	#10 TEKS	18"
	Jamb	1/4" Tapper+	18"	#10 TEKS	18"
E/WE-02	Head	#12 Wood Screw	18"	#10 TEKS	18"
	Sill	#12 Wood Screw	18"	#10 TEKS	18"
	Jamb	1/4" Tapper+	18"	#10 TEKS	18"
F/WE-02	Head	#12 Wood Screw	18"	#10 TEKS	18"
	Sill	#12 Wood Screw	18"	#10 TEKS	18"
	Jamb	1/4" Tapper+	18"	#10 TEKS	18"
NG/WE-03 RNG/WE-03	Head	#12 Wood Screw	18"	#10 TEKS	15"
	Sill	#12 Wood Screw	18"	#10 TEKS	15"
	Jamb	#12 Wood Screw	18"	#10 TEKS	18"

Notes:

1. Start anchor placement approximately 3" from corners, then per spacing in table.
2. Place a minimum of 2 anchors on each side of a window.
3. Anchor spacing calculated greater than 18" specified as 18" per project specification.

Table 6 Perimeter Anchor Spacing for Zone 5 (Corners)

Elevation	Location	Clip to Substrate		Clip to Frame	
		Fastener	Max Spacing	Fastener	Max Spacing
A/WE-01	Head	#12 Wood Screw	17"	#10 TEKS	9"
	Sill	#12 Wood Screw	17"	#10 TEKS	9"
	Jamb	1/4" Tapper+	18"	#10 TEKS	8"
NB/WE-01 RNB/WE-01	Head	#12 Wood Screw	14"	#10 TEKS	7"
	Sill	#12 Wood Screw	14"	#10 TEKS	7"
	Jamb	#12 Wood Screw	17"	#10 TEKS	9"
NC/WE-01 NRC/WE-02	Head	#12 Wood Screw	15"	#10 TEKS	8"
	Sill	#12 Wood Screw	15"	#10 TEKS	8"
	Jamb	#12 Wood Screw	17"	#10 TEKS	9"
D/WE-02	Head	#12-14 TEKS	18"	#10 TEKS	18"
	Sill	1/4" Tapper+	18"	#10 TEKS	18"
	Jamb	1/4" Tapper+	18"	#10 TEKS	18"
E/WE-02	Head	#12 Wood Screw	18"	#10 TEKS	14"
	Sill	#12 Wood Screw	18"	#10 TEKS	14"
	Jamb	1/4" Tapper+	18"	#10 TEKS	17"
F/WE-02	Head	#12 Wood Screw	18"	#10 TEKS	14"
	Sill	#12 Wood Screw	18"	#10 TEKS	14"
	Jamb	1/4" Tapper+	18"	#10 TEKS	17"
NG/WE-03 RNG/WE-03	Head	#12 Wood Screw	14"	#10 TEKS	7"
	Sill	#12 Wood Screw	14"	#10 TEKS	7"
	Jamb	#12 Wood Screw	17"	#10 TEKS	9"

Notes:

1. Start anchor placement approximately 3" from corners, then per spacing in table.
2. Place a minimum of 2 anchors on each side of a window.
3. Anchor spacing calculated greater than 18" specified as 18" per project specification.

3-Piece Mullion Anchorage

Anchorage is required at the ends of the 3-piece mullions located at elevations BAY1 through BAY6. The anchorage is required at both the jamb mullion and the intermediate vertical mullions. The calculations are presented on page 38 through page 44. The anchorage requirements are as follows:

At the Jambs - One (1) angle per mullion end is required. Each angle is connected to the mullion with two (2) #12-14 TEKS screws spaced at 1" on center. At the sill, the angle is connected to the wood blocking substrate with two (2) #12 wood screws, spaced 1" on center. At the head, the angle is connected to the steel substrate with two (2) #12-14 TEKS screws, spaced 1" on center.

At the Intermediate Vertical Mullions - Two (2) angles per mullion end are required. Each angle is connected to the mullion with two (2) #12-14 TEKS screws spaced at 1" on center. At the sill, each angle is connected to the wood blocking substrate with one (1) #12 wood screw. At the head, each angle is connected to the steel substrate with one (1) #12-14 TEKS screw.

Referenced Drawings

Harbor Terrace Apartments C-01, BE-01 to BE-04, WE-01 to WE-09, WD-01 to WD-11. Specialty Contracting, Inc. Revision -, 04/21/2016. (25 pages)

Design Wind Pressures for Components and Cladding

ASCE 7-05

For Buildings > 60 ft tall

Project: Harbor Terrace Apartments

Location: Portland, Maine

Building Category	II	K_h	1.21	
Importance	1.00	K_{zt}	1.00	
Basic Wind Speed	100 MPH	K_d	1.00	
Exposure Category	C	GC_{pi}	0.18	(0.18 Enclosed, 0.55 Partially Enclosed)
Building Roof Height	80 ft			
Building Roof Slope	0.0 degrees	q_h	30.9 psf	

Mark	Width (inch)	Height (inch)	Elevation (ft)	Area (ft^2)	GC_p Zone 4 & 5	GC_p Zone 4	GC_p Zone 5	K_z	q_z (psf)	Design Wind Pressures (psf) Zone 4 & 5	Zone 4	Zone 5
A/WE-01	54.0	60.9	75.0	22.8	0.89	-0.89	-1.77	1.19	30.5	32.6	-33.1	-60.2
NB/WE-01, RNB/WE-01	89.0	55.4	75.0	34.2	0.85	-0.87	-1.67	1.19	30.5	31.5	-32.4	-57.1
NC/WE-01, NRC/WE-02	69.0	55.4	75.0	26.5	0.87	-0.88	-1.73	1.19	30.5	32.2	-32.8	-59.0
D/WE-02	16.0	59.4	75.0	6.6	0.90	-0.90	-1.80	1.19	30.5	33.0	-33.4	-61.2
E/WE-02	89.0	29.4	75.0	18.2	0.90	-0.90	-1.80	1.19	30.5	33.0	-33.4	-61.2
F/WE-02	45.0	29.4	75.0	9.2	0.90	-0.90	-1.80	1.19	30.5	33.0	-33.4	-61.2
NG/WE-03, RNG/WE-03	97.0	55.4	75.0	37.3	0.84	-0.86	-1.65	1.19	30.5	31.2	-32.2	-56.4
BAY1/WE-04 thru BAY5/WE-08	254.8	67.0	10.0	118.5	0.73	-0.79	-1.36	0.78	20.0	20.2	-30.0	-47.5
BAY6/WE-09	195.9	67.0	10.0	91.1	0.76	-0.81	-1.42	0.78	20.0	20.7	-30.5	-49.6

Architectural Testing

DATE: May 19, 2016

BY: JAR/DCC

PROJECT NO. F8229.01-122-34 SHEET 10 OF 45

PROJECT NAME: Harbor Terrace Apartments

Glass Load Resistance Report -- Harbor Terrace Apts

Glazing Information

Edge Supports: 4 Sides
Glazing Angle: 90°
Lite Dimensions:
Width: 24.0 in.
Height: 27.5 in.

Project Details

Project Name: Harbor Terrace Apts
Location: Portland, Maine
Comments: F8229.01-122-34

Glass Construction (Rectangular)

Double Glazed Insulating Unit

Air Space: 0.5 in.

	Outboard Lite	Inboard Lite
Glass Type:	Annealed	Annealed
Nominal Thickness:	1/8 in.	1/8 in.

Short Load Duration, Resistance, and Deflection Data

Load (~ 3 sec.):	61.2 psf
Load Resistance:	141 psf
Approximate center of glass deflection:	0.18 in.

Conclusion

Based on your design information, the load resistance is greater than or equal to the specified loading.

Statement of Compliance

Procedures followed in determining the resistance of this window glass are in accordance with ASTM E1300-09.

Disclaimer:

This software can be used to determine the load resistance of specified glass types exposed to uniform lateral loads of short or long duration subject to the following conditions:

- The glass is free of edge and surface damage and has been properly glazed in the opening in conformance with the manufacturer's recommendations.
- Procedures exist to determine load resistance for rectangular glass assemblies that are:
  a. Continuously supported along all four edges,
  b. Continuously supported along three edges,
  c. Continuously supported along two parallel edges, and
  d. Continuously supported along one edge.
- The software user has the responsibility of selecting the correct procedures for the required application from the software.
- The stiffness of members supporting any glass edge shall be sufficient that under design load, edge deflections shall not exceed L/175, where L denotes that length of the supported edge.
- The manufacturer states that the Safety Plus II 0.090 Polyurethane Large Missile Resistant interlayer is comparable to the PVB interlayer.

For other limiting conditions that may apply, refer to Section 5 of ASTM E1300 and local building codes.

Prepared by: _____ on 5/19/2016
DCC

Glass Load Resistance Report -- Harbor Terrace Apts

Glazing Information

Edge Supports: 4 Sides
Glazing Angle: 90°
Lite Dimensions:
Width: 57.9 in.
Height: 53.4 in.

Project Details

Project Name: Harbor Terrace Apts
Location: Portland, Maine
Comments: F8229.01-122-34

Glass Construction (Rectangular)

Double Glazed Insulating Unit

Air Space: 0.5 in.

	Outboard Lite	Inboard Lite
Glass Type:	Annealed	Annealed
Nominal Thickness:	1/4 in.	1/4 in.

Short Load Duration, Resistance, and Deflection Data

Load (~ 3 sec.):	61.2 psf
Load Resistance:	89.5 psf
Approximate center of glass deflection:	0.48 in.

Conclusion

Based on your design information, the load resistance is greater than or equal to the specified loading.

Statement of Compliance

Procedures followed in determining the resistance of this window glass are in accordance with ASTM E1300-09.

Disclaimer:

This software can be used to determine the load resistance of specified glass types exposed to uniform lateral loads of short or long duration subject to the following conditions:

- The glass is free of edge and surface damage and has been properly glazed in the opening in conformance with the manufacturer's recommendations.
- Procedures exist to determine load resistance for rectangular glass assemblies that are:
  a. Continuously supported along all four edges,
  b. Continuously supported along three edges,
  c. Continuously supported along two parallel edges, and
  d. Continuously supported along one edge.
- The software user has the responsibility of selecting the correct procedures for the required application from the software.
- The stiffness of members supporting any glass edge shall be sufficient that under design load, edge deflections shall not exceed L/175, where L denotes that length of the supported edge.
- The manufacturer states that the Safety Plus II 0.090 Polyurethane Large Missile Resistant interlayer is comparable to the PVB interlayer.

For other limiting conditions that may apply, refer to Section 5 of ASTM E1300 and local building codes.

Prepared by: _____ on 5/19/2016
DCC

Glass Load Resistance Report -- Harbor Terrace Apts

Glazing Information

Edge Supports: 4 Sides
Glazing Angle: 90°
Lite Dimensions:
Width: 20.6 in.
Height: 62.0 in.

Project Details

Project Name: Harbor Terrace Apts
Location: Portland, Maine
Comments: F8229.01-122-34

Glass Construction (Rectangular)

Double Glazed Insulating Unit

Air Space: 0.5 in.

	Outboard Lite	Inboard Lite
Glass Type:	Annealed	Annealed
Nominal Thickness:	1/8 in.	1/8 in.

Short Load Duration, Resistance, and Deflection Data

Load (~ 3 sec.):	61.2 psf
Load Resistance:	58.8 psf
Approximate center of glass deflection:	0.29 in.

Conclusion

Based on your design information, the load resistance is less than specified loading.

Statement of Compliance

Procedures followed in determining the resistance of this window glass are in accordance with ASTM E1300-09.

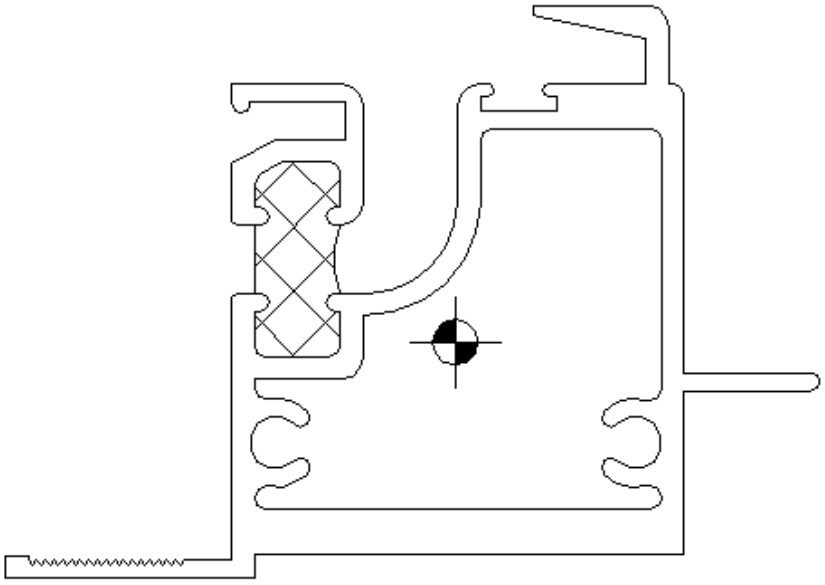
Disclaimer:

This software can be used to determine the load resistance of specified glass types exposed to uniform lateral loads of short or long duration subject to the following conditions:

- The glass is free of edge and surface damage and has been properly glazed in the opening in conformance with the manufacturer's recommendations.
- Procedures exist to determine load resistance for rectangular glass assemblies that are:
  a. Continuously supported along all four edges,
  b. Continuously supported along three edges,
  c. Continuously supported along two parallel edges, and
  d. Continuously supported along one edge.
- The software user has the responsibility of selecting the correct procedures for the required application from the software.
- The stiffness of members supporting any glass edge shall be sufficient that under design load, edge deflections shall not exceed L/175, where L denotes that length of the supported edge.
- The manufacturer states that the Safety Plus II 0.090 Polyurethane Large Missile Resistant interlayer is comparable to the PVB interlayer.

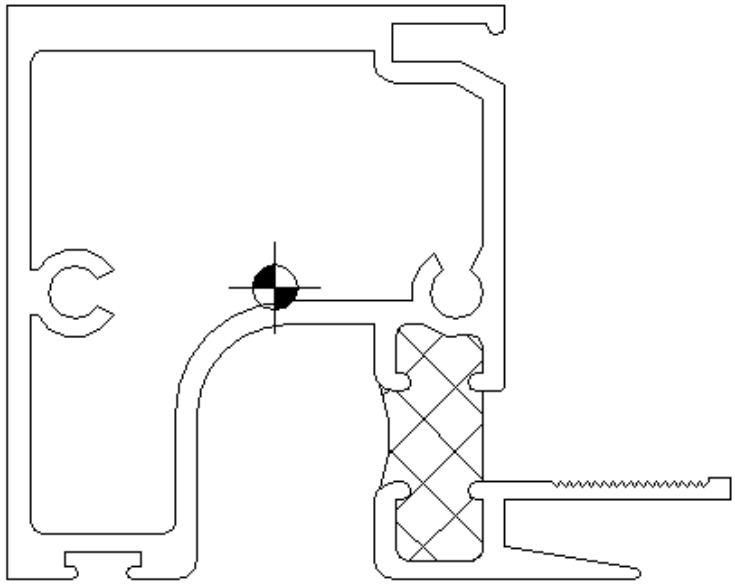
For other limiting conditions that may apply, refer to Section 5 of ASTM E1300 and local building codes.

Prepared by: _____ on 5/19/2016
DCC



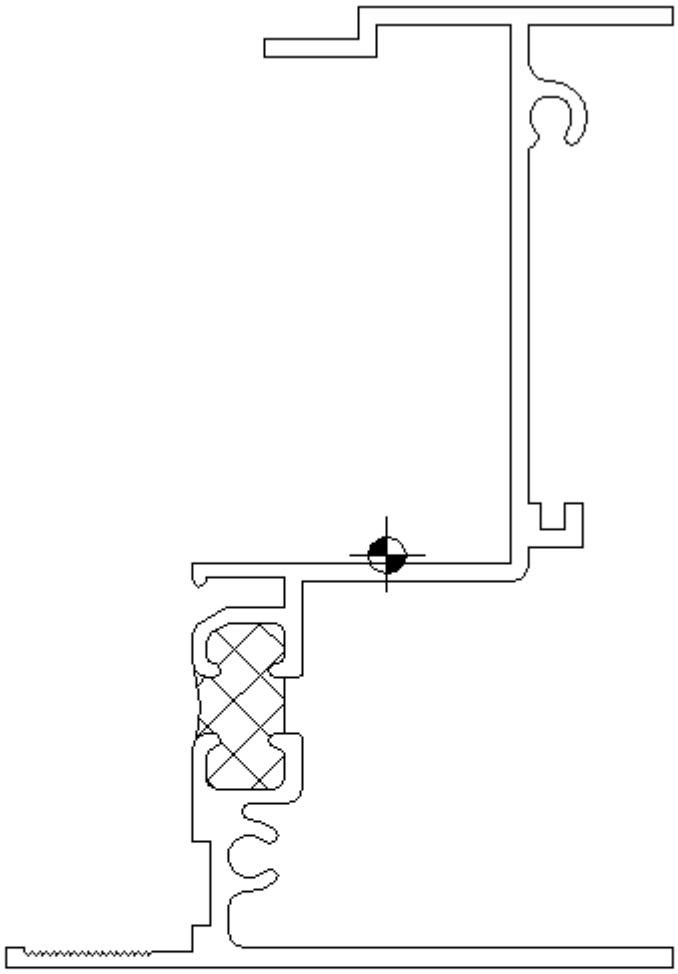
---------- REGIONS ----------

Area:	0.5831		
Bounding box:	X: −1.2427	--	1.0073
	Y: −0.6530	--	0.9320
Moments of inertia:	X: 0.1434		
	Y: 0.1416		
Radii of gyration:	X: 0.4959		
	Y: 0.4928		



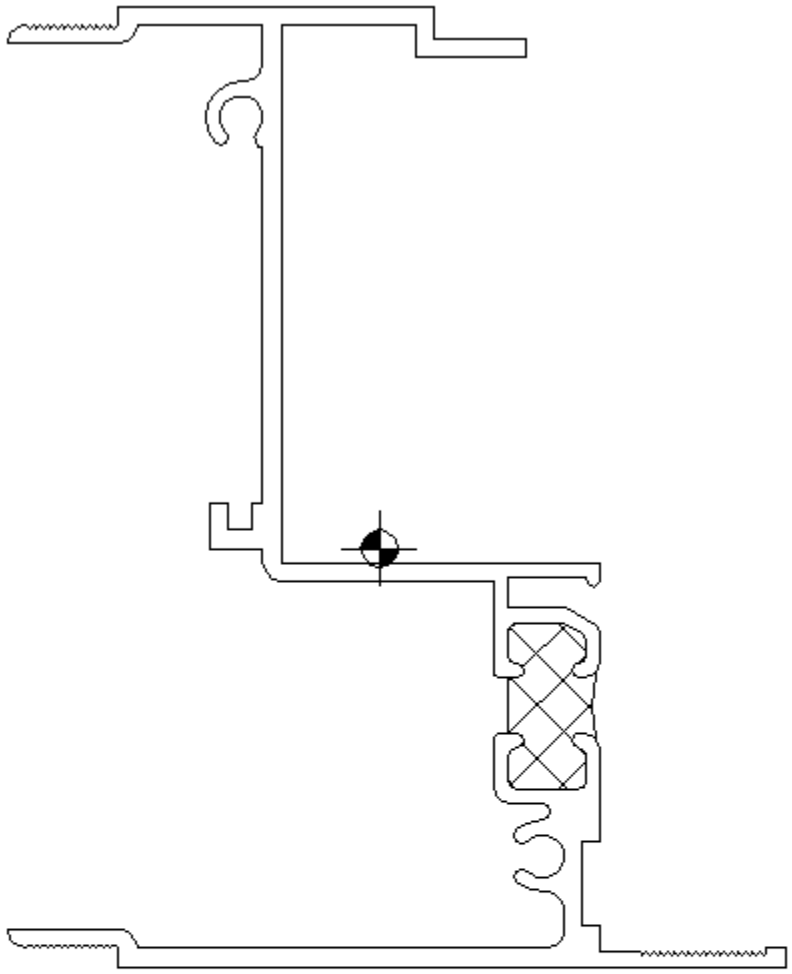
---------- REGIONS ----------

Area:	0.5879	
Bounding box:	X: −0.7391	-- 1.2609
	Y: −0.8073	-- 0.7787
Moments of inertia:	X: 0.1838	
	Y: 0.1719	
Radii of gyration:	X: 0.5591	
	Y: 0.5407	



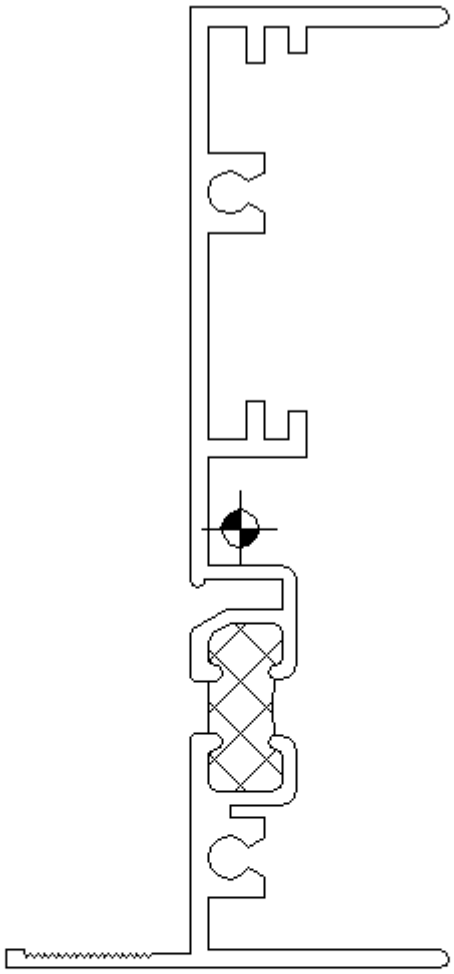
---------- REGIONS ----------

Area:	0.6008		
Bounding box:	X: −1.2879	--	0.9681
	Y: −1.3929	--	1.8571
Moments of inertia:	X: 0.8098		
	Y: 0.1589		
Radii of gyration:	X: 1.1610		
	Y: 0.5143		



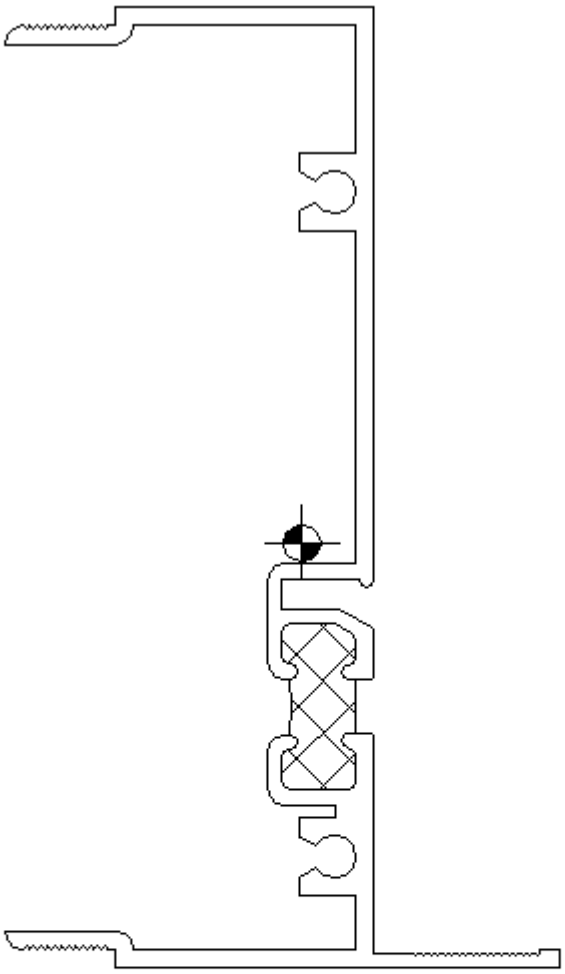
---------- REGIONS ----------

Area:	0.6412		
Bounding box:	X: −1.2567	--	1.3743
	Y: −1.4153	--	1.8347
Moments of inertia:	X: 0.9210		
	Y: 0.2142		
Radii of gyration:	X: 1.1985		
	Y: 0.5779		



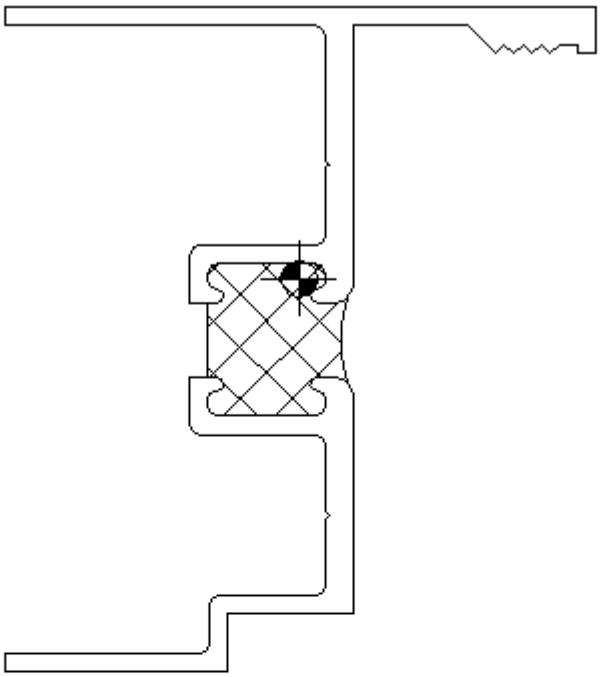
---------- REGIONS ----------

Area:	0.4961		
Bounding box:	X: −0.7922	--	0.7078
	Y: −1.4887	--	1.7613
Moments of inertia:	X: 0.6367		
	Y: 0.0277		
Radii of gyration:	X: 1.1328		
	Y: 0.2365		



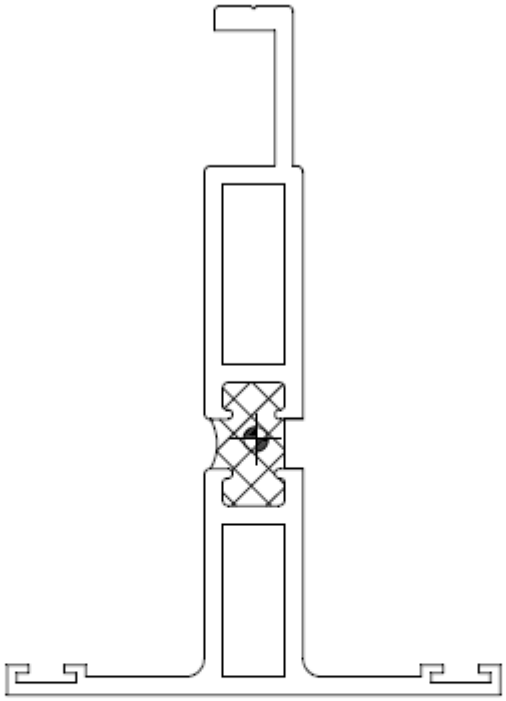
---------- REGIONS ----------

Area:	0.4978		
Bounding box:	X: −1.0064	--	0.8686
	Y: −1.4365	--	1.8135
Moments of inertia:	X: 0.7117		
	Y: 0.0612		
Radii of gyration:	X: 1.1957		
	Y: 0.3508		



---------- REGIONS ----------

Area:	0.4785		
Bounding box:	X: −0.9928	--	1.0072
	Y: −1.3317	--	0.9183
Moments of inertia:	X: 0.3123		
	Y: 0.0908		
Radii of gyration:	X: 0.8079		
	Y: 0.4357		



---------- REGIONS ----------

Area:	0.8843		
Bounding box:	X: −1.2612	--	1.2388
	Y: −1.2973	--	2.1977
Moments of inertia:	X: 1.1218		
	Y: 0.1461		
Radii of gyration:	X: 1.1263		
	Y: 0.4065		

Mullion Design Pressure Calculator

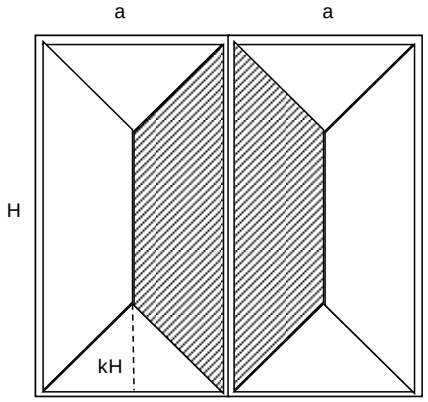
Standard Vertical or Horizontal Mullion

Manufacturer Graham Architectural Products
Project Harbor Terrace Apartments
Product Single Hung Meeting Rail
Size NG/WE-03
Cladding N/A
Reinforcement N/A
Wind DP 61.2 psf

	Frame Parts				Cladding Parts		Reinforcement
Material	6063-T6 Aluminum						
E (psi)	10,000,000						
Fb (psi)	15,152						
	Member 1	Member 2	Member 3	Member 4	Member 5	Member 6	Member 7
Part ID	E200051	E200061					
Max c (in)	0.9320	0.8073	0.0000	0.0000	0.0000	0.0000	0.0000
I_{xx} (in^4)	0.1434	0.1838	0.0000	0.0000	0.0000	0.0000	0.0000

I_{tot} 0.327 in^4

	Window 1	Window 2
Frame Width, a	2.307 ft	2.307 ft
Frame Height, H	2.651 ft	2.651 ft
K	0.435	0.435
B	6.050	6.050
Load Area	1.727 ft^2	1.727 ft^2
M	0.757 ft-lb	0.757 ft-lb
Total M	1.514 ft-lb	
Mullion length	2.651 ft	
DP Member 1	292.8 PSF	
DP Member 2	338.1 PSF	
DP Member 3	PSF	
DP Member 4	PSF	
DP Member 5	PSF	
DP Member 6	PSF	
DP Member 7	PSF	
Governing DP	292.8 PSF	
C	60.17	60.17
Deflection at DP	0.165 in	
Deflection Limit	0.182 in	L/175
Stress Governs, DP =	292.8 PSF	OK, > 61.2 psf
End Reactions at DP	505.8 lbs	
Scale Reaction to 61 psf	105.7 lbs	



$M = \frac{WH}{B}$ $\Delta = \frac{WH^3}{DEI}$

Notes: Mullion is analyzed as a simple supported beam with uniform load.
Reinforcement and members behave non-compositely.

Mullion Design Pressure Calculator

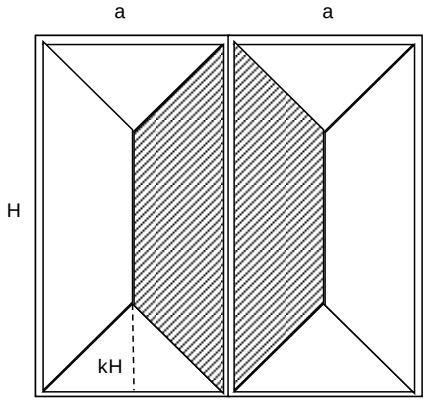
Standard Vertical or Horizontal Mullion

Manufacturer Graham Architectural Products
Project Harbor Terrace Apartments
Product Single Hung-Single Hung M-F Mullion
Size A/WE-01
Cladding N/A
Reinforcement N/A
Wind DP 61.2 psf

	Frame Parts				Cladding Parts		Reinforcement
Material	6063-T6 Aluminum						
E (psi)	10,000,000						
Fb (psi)	15,152						
	Member 1	Member 2	Member 3	Member 4	Member 5	Member 6	Member 7
Part ID	E200030	E203031					
Max c (in)	1.8571	1.8347	0.0000	0.0000	0.0000	0.0000	0.0000
I_{xx} (in^4)	0.8098	0.9210	0.0000	0.0000	0.0000	0.0000	0.0000

I_{tot} 1.731 in^4

	Window 1	Window 2
Frame Width, a	2.250 ft	2.250 ft
Frame Height, H	5.073 ft	5.073 ft
K	0.222	0.222
B	6.658	6.658
Load Area	4.441 ft^2	4.441 ft^2
M	3.384 ft-lb	3.384 ft-lb
Total M	6.768 ft-lb	
Mullion length	5.073 ft	
DP Member 1	173.9 PSF	
DP Member 2	176.0 PSF	
DP Member 3	PSF	
DP Member 4	PSF	
DP Member 5	PSF	
DP Member 6	PSF	
DP Member 7	PSF	
Governing DP	173.9 PSF	
C	64.78	64.78
Deflection at DP	0.311 in	
Deflection Limit	0.348 in	L/175
Stress Governs, DP =	173.9 PSF	OK, > 61.2 psf
End Reactions at DP	772.2 lbs	
Scale Reaction to 61 psf	271.8 lbs	



$M = \frac{WH}{B}$ $\Delta = \frac{WH^3}{DEI}$

Notes: Mullion is analyzed as a simple supported beam with uniform load.
Reinforcement and members behave non-compositely.

Mullion Design Pressure Calculator

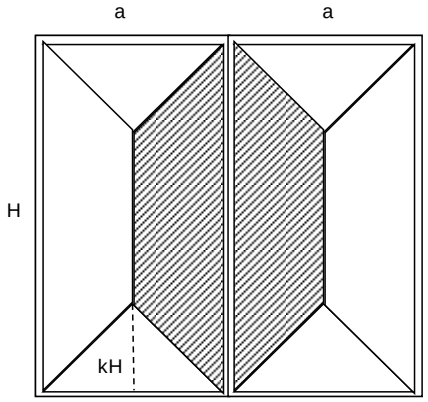
Standard Vertical or Horizontal Mullion

Manufacturer Graham Architectural Products
Project Harbor Terrace Apartments
Product Single Hung-Fixed M-F Mullion
Size NG/WE-03
Cladding N/A
Reinforcement N/A
Wind DP 61.2 psf

	Frame Parts				Cladding Parts		Reinforcement
Material	6063-T6 Aluminum						
E (psi)	10,000,000						
Fb (psi)	15,152						
	Member 1	Member 2	Member 3	Member 4	Member 5	Member 6	Member 7
Part ID	E203031	E120010					
Max c (in)	1.8347	1.7613	0.0000	0.0000	0.0000	0.0000	0.0000
I_{xx} (in^4)	0.9210	0.6367	0.0000	0.0000	0.0000	0.0000	0.0000

I_{tot} 1.558 in^4

	Window 1	Window 2
Frame Width, a	2.651 ft	5.432 ft
Frame Height, H	4.615 ft	4.615 ft
K	0.287	0.589
B	6.400	6.000
Load Area	4.360 ft^2	5.324 ft^2
M	3.143 ft-lb	4.094 ft-lb
Total M	7.238 ft-lb	
Mullion length	4.615 ft	
DP Member 1	148.1 PSF	
DP Member 2	154.3 PSF	
DP Member 3	PSF	
DP Member 4	PSF	
DP Member 5	PSF	
DP Member 6	PSF	
DP Member 7	PSF	
Governing DP	148.1 PSF	
C	62.65	60.00
Deflection at DP	0.256 in	
Deflection Limit	0.316 in	L/175
Stress Governs, DP =	148.1 PSF	OK, > 61.2 psf
End Reactions at DP	717.1 lbs	
Scale Reaction to 61 psf	296.3 lbs	



$M = \frac{WH}{B}$ $\Delta = \frac{WH^3}{DEI}$

Notes: Mullion is analyzed as a simple supported beam with uniform load.
Reinforcement and members behave non-compositely.

Mullion Design Pressure Calculator

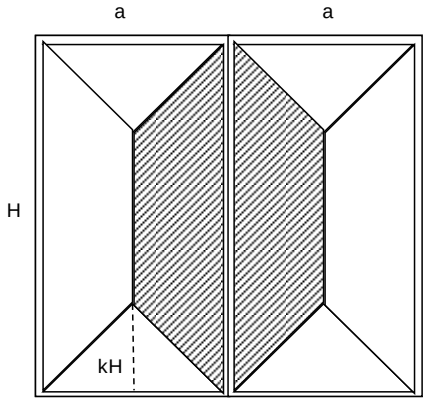
Standard Vertical or Horizontal Mullion

Manufacturer Graham Architectural Products
Project Harbor Terrace Apartments
Product Fixed-Casement M-F Mullion
Size BAY1/WE-04
Cladding N/A
Reinforcement N/A
Wind DP 61.2 psf

	Frame Parts				Cladding Parts		Reinforcement
Material	6063-T6 Aluminum						
E (psi)	10,000,000						
Fb (psi)	15,152						
	Member 1	Member 2	Member 3	Member 4	Member 5	Member 6	Member 7
Part ID	E120032	E120010	E660002				
Max c (in)	1.8135	1.7613	1.3317	0.0000	0.0000	0.0000	0.0000
I_{xx} (in^4)	0.7117	0.6367	0.3123	0.0000	0.0000	0.0000	0.0000

I_{tot} 1.661 in^4

	Window 1	Window 2
Frame Width, a	2.328 ft	2.328 ft
Frame Height, H	5.583 ft	5.583 ft
K	0.208	0.208
B	6.717	6.717
Load Area	5.144 ft^2	5.144 ft^2
M	4.276 ft-lb	4.276 ft-lb
Total M	8.552 ft-lb	
Mullion length	5.583 ft	
DP Member 1	135.2 PSF	
DP Member 2	139.2 PSF	
DP Member 3	184.1 PSF	
DP Member 4	PSF	
DP Member 5	PSF	
DP Member 6	PSF	
DP Member 7	PSF	
Governing DP	135.2 PSF	
C	65.29	65.29
Deflection at DP	0.386 in	
Deflection Limit	0.383 in	L/175
Deflection Governs, DP =	134.1 PSF	OK, > 61.2 psf
End Reactions at DP	690.1 lbs	
Scale Reaction to 61 psf	314.8 lbs	



$M = \frac{WH}{B}$ $\Delta = \frac{WH^3}{DEI}$

Notes: Mullion is analyzed as a simple supported beam with uniform load.
Reinforcement and members behave non-compositely.

Mullion Design Pressure Calculator

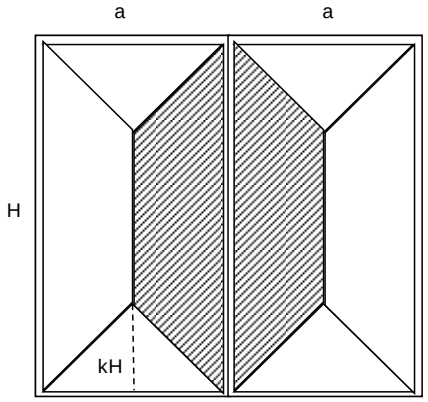
Standard Vertical or Horizontal Mullion

Manufacturer Graham Architectural Products
Project Harbor Terrace Apartments
Product 3 Piece Jamb
Size BAY1/WE-04
Cladding N/A
Reinforcement N/A
Wind DP 61.2 psf

	Frame Parts				Cladding Parts		Reinforcement
Material	6063-T6 Aluminum						
E (psi)	10,000,000						
Fb (psi)	15,152						
	Member 1	Member 2	Member 3	Member 4	Member 5	Member 6	Member 7
Part ID	E120010	E200203					
Max c (in)	1.7613	2.1977	0.0000	0.0000	0.0000	0.0000	0.0000
I_{xx} (in^4)	0.6367	1.1218	0.0000	0.0000	0.0000	0.0000	0.0000

I_{tot} 1.759 in^4

	Window 1	Window 2
Frame Width, a	4.698 ft	0.000 ft
Frame Height, H	5.583 ft	5.583 ft
K	0.421	0.000
B	6.070	7.999
Load Area	7.597 ft^2	0.000 ft^2
M	6.988 ft-lb	0.000 ft-lb
Total M	6.988 ft-lb	
Mullion length	5.583 ft	
DP Member 1	180.4 PSF	
DP Member 2	144.6 PSF	
DP Member 3	PSF	
DP Member 4	PSF	
DP Member 5	PSF	
DP Member 6	PSF	
DP Member 7	PSF	
Governing DP	144.6 PSF	
C	60.27	76.67
Deflection at DP	0.312 in	
Deflection Limit	0.383 in	L/175
Stress Governs, DP =	144.6 PSF	OK, > 61.2 psf
End Reactions at DP	549.2 lbs	
Scale Reaction to 61 psf	232.5 lbs	



$M = \frac{WH}{B}$ $\Delta = \frac{WH^3}{DEI}$

Notes: Mullion is analyzed as a simple supported beam with uniform load.
Reinforcement and members behave non-compositely.

Mullion Design Pressure Calculator

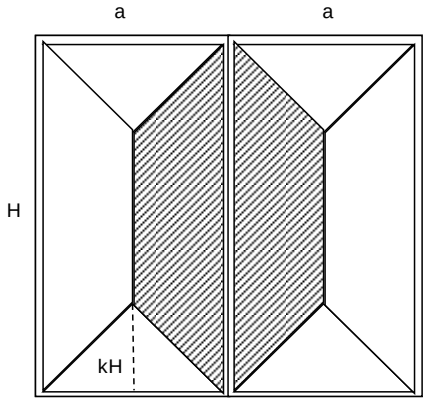
Standard Vertical or Horizontal Mullion

Manufacturer Graham Architectural Products
Project Harbor Terrace Apartments
Product Ribbon Window Head/Sill
Size BAY1/WE-04
Cladding N/A
Reinforcement N/A
Wind DP 61.2 psf

	Frame Parts				Cladding Parts		Reinforcement
Material	6063-T6 Aluminum						
E (psi)	10,000,000						
Fb (psi)	15,152						
	Member 1	Member 2	Member 3	Member 4	Member 5	Member 6	Member 7
Part ID	E120010						
Max c (in)	1.7613	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
I_{xx} (in^4)	0.6367	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

I_{tot} 0.637 in^4

	Window 1	Window 2
Frame Width, a	5.583 ft	0.000 ft
Frame Height, H	4.698 ft	4.698 ft
K	0.594	0.000
B	6.000	7.999
Load Area	5.518 ft^2	0.000 ft^2
M	4.320 ft-lb	0.000 ft-lb
Total M	4.320 ft-lb	
Mullion length	4.698 ft	
DP Member 1	105.7 PSF	
DP Member 2	PSF	
DP Member 3	PSF	
DP Member 4	PSF	
DP Member 5	PSF	
DP Member 6	PSF	
DP Member 7	PSF	
Governing DP	105.7 PSF	
C	60.00	76.67
Deflection at DP	0.273 in	
Deflection Limit	0.322 in	L/175
Stress Governs, DP =	105.7 PSF	OK, > 61.2 psf
End Reactions at DP	291.5 lbs	
Scale Reaction to 61 psf	168.8 lbs	



$M = \frac{WH}{B}$ $\Delta = \frac{WH^3}{DEI}$

Notes: Mullion is analyzed as a simple supported beam with uniform load.
Reinforcement and members behave non-compositely.

Mullion Design Pressure Calculator

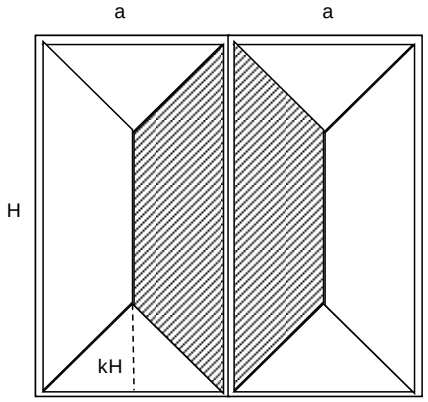
Standard Vertical or Horizontal Mullion

Manufacturer Graham Architectural Products
Project Harbor Terrace Apartments
Product 3 Piece Mullion
Size BAY1/WE-04
Cladding N/A
Reinforcement N/A
Wind DP 61.2 psf

	Frame Parts				Cladding Parts		Reinforcement
Material	6063-T6 Aluminum						
E (psi)	10,000,000						
Fb (psi)	15,152						
	Member 1	Member 2	Member 3	Member 4	Member 5	Member 6	Member 7
Part ID	E120010	E200203	E120010				
Max c (in)	1.7613	2.1977	1.7613	0.0000	0.0000	0.0000	0.0000
I_{xx} (in^4)	0.6367	1.1218	0.6367	0.0000	0.0000	0.0000	0.0000

I_{tot} 2.395 in^4

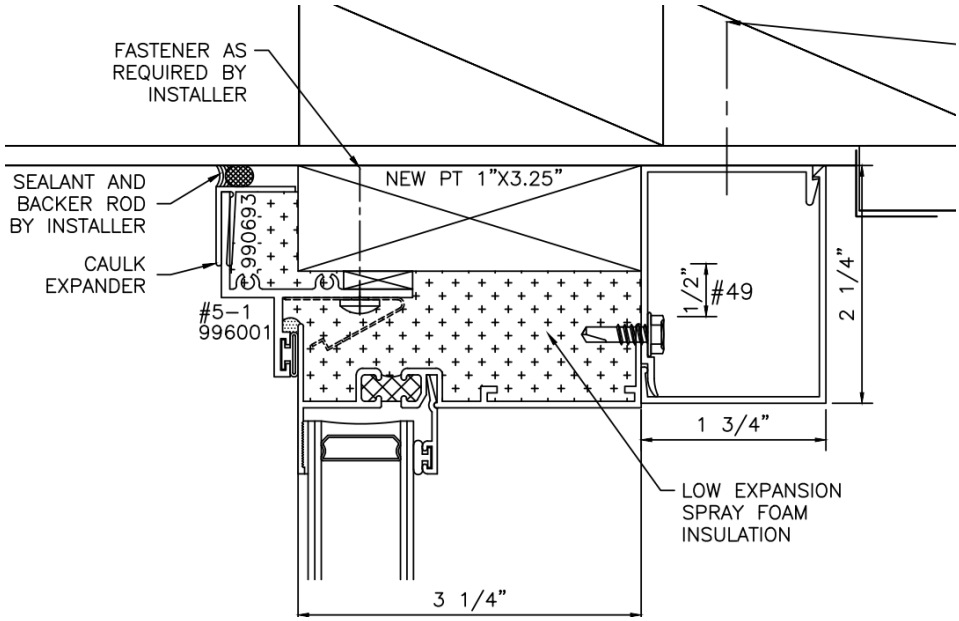
	Window 1	Window 2
Frame Width, a	4.698 ft	4.510 ft
Frame Height, H	5.583 ft	5.583 ft
K	0.421	0.404
B	6.070	6.097
Load Area	7.597 ft^2	7.506 ft^2
M	6.988 ft-lb	6.873 ft-lb
Total M	13.861 ft-lb	
Mullion length	5.583 ft	
DP Member 1	123.9 PSF	
DP Member 2	99.3 PSF	
DP Member 3	123.9 PSF	
DP Member 4	PSF	
DP Member 5	PSF	
DP Member 6	PSF	
DP Member 7	PSF	
Governing DP	99.3 PSF	
C	60.27	60.43
Deflection at DP	0.312 in	
Deflection Limit	0.383 in	L/175
Stress Governs, DP =	99.3 PSF	OK, > 61.2 psf
End Reactions at DP	749.7 lbs	
Scale Reaction to 61 psf	462.2 lbs	



$M = \frac{WH}{B}$ $\Delta = \frac{WH^3}{DEI}$

Notes: Mullion is analyzed as a simple supported beam with uniform load.
Reinforcement and members behave non-compositely.

1/WD-01



#12 Wood Screw

1-1/2" Minimum Penetration

1/16" thick 6063-T5 Trim Clip

Southern Yellow Pine (S-Y-P) Wood Blocking

Allowable Shear of #12 Wood Screw

Z' = 186 lb (Limited by Yield Mode IIIs, see following 2 pages)

Bearing of #12 Wood Screw on Trim Clip

$V_a = 2DtF_u/n_u$
$V_a = 2(0.216")(0.063")(22{,}000\ psi)/1.95$
$V_a = 307$ lb.

Capacity of Connection is 186 lb

Also Qualifies 3/WD-01, 8/WD-03, 9/WD-03, 10/WD-04, 1, 2/WD-04, 14/WD-05 15/WD-05, 16/WD-05, 21/WD-07, 22/WD-07, 23/WD-08, 24/WD-08

1/WD-01 (Continued)

Lateral Design Strength of Wood Connections

ANSI / AF&PA NDS-2005

Data

Fastener

Fastener	=	#10 Wood Screw	
Shank Dia	=	0.190	in.
Root Dia.	=	0.152	in.
F_{yb}	=	80,000	psi
Fastener length	=	2.500	in.

Main Member

Material	=	SYP		
G	=	0.55		
θ	=	90	<= (Angle of load to grain $0^o \le \theta \le 90^o$)	
F_e	=	5,550	psi	Table 11.3.2
Thickness	=	1.500	in.	

Side Member

Material	=	Aluminum 6063-T5		
G	=	N/A		
θ	=	0	<= (Angle of load to grain $0^o \le \theta \le 90^o$)	
F_{es}	=	27,500	psi	Aluminum Design Manual 2005
Thickness	=	0.063	in.	

Calculations

Lateral Bearing Factors

D	=	0.152	in.	
ℓ_m	=	1.500	in.	
K_θ	=	1.25		Table 11.3.1B
K_D	=	2.20		Table 11.3.1B
R_e	=	0.202		Table 11.3.1A
R_t	=	23.81		Table 11.3.1A
k_1	=	1.8950		Table 11.3.1A
k_2	=	0.5944		Table 11.3.1A
k_3	=	10.62		Table 11.3.1A

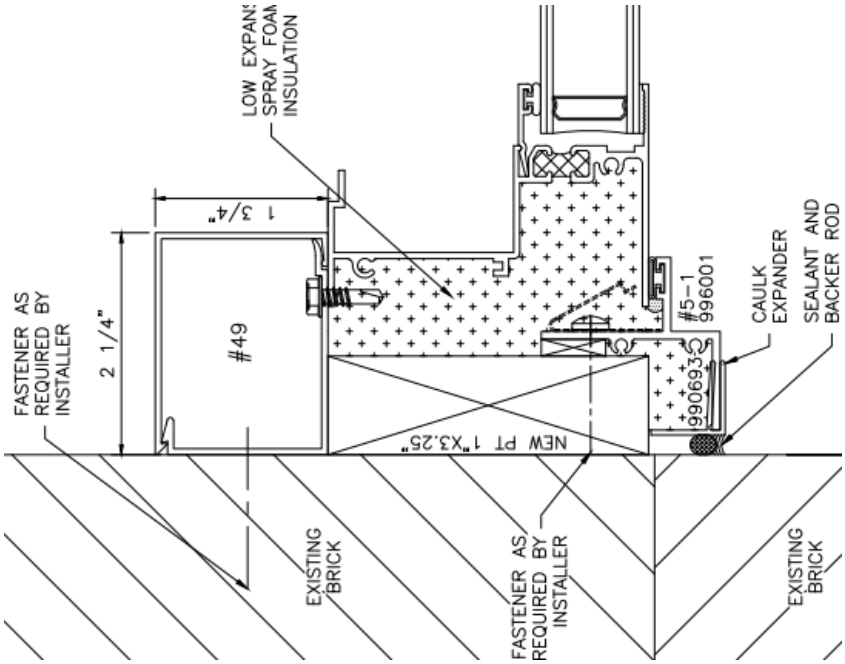
1/WD-01 (Continued)

Yield Mode	R_d		
I_m, I_s	2.20		Table 11.3.1B
II	2.20		Table 11.3.1B
III_m, III_s, IV	2.20		Table 11.3.1B

Lateral Design Values, Z

Mode I_m	=	575	lbf		Eq 11.3-1
Mode I_s	=	120	lbf		Eq 11.3-2
Mode II	=	227	lbf		Eq 11.3-3
Mode III_m	=	244	lbf		Eq 11.3-4
Mode III_s	=	117	lbf	<====== Minimum Value	Eq 11.3-5
Mode IV	=	165	lbf		Eq 11.3-6
C_D	=	1.6			B.2
Wet Service Factor					
Fabrication/In-Service		Dry/Dry			
C_M	=	1.0			Table 10.3.3
In service temperature		T≤100˚F			
C_t	=	1.0			Table 10.3.4
C_g	=	1.0			10.3.6
C_Δ	=	1.0			11.5.1
Is fastener installed in end grain?		No			
C_{eg}	=	1.00			11.5.2
Is fastener part of a diaphragm?		No			
C_{di}	=	1.0			11.5.3
Is fastener toe-nailed?		No			
C_{tn}	=	1.00			11.5.4
Z'	**=**	**186**	**lbf**		Table 10.3.1

4/WD-02



1/4" Powers Tapper+ Screw Anchor

1-1/2" Minimum Embedment, 1-3/4" Minimum Edge Distance

1/16" thick 6063-T5 Trim Clip

f'_m = 1,500 psi ASTM C62 Clay Brick Masonry

Allowable Shear of 1/4" Tapper+

V_a = 270 lb (Powers Technical Data)

Bearing of 1/4" Tapper+ on Trim Clip

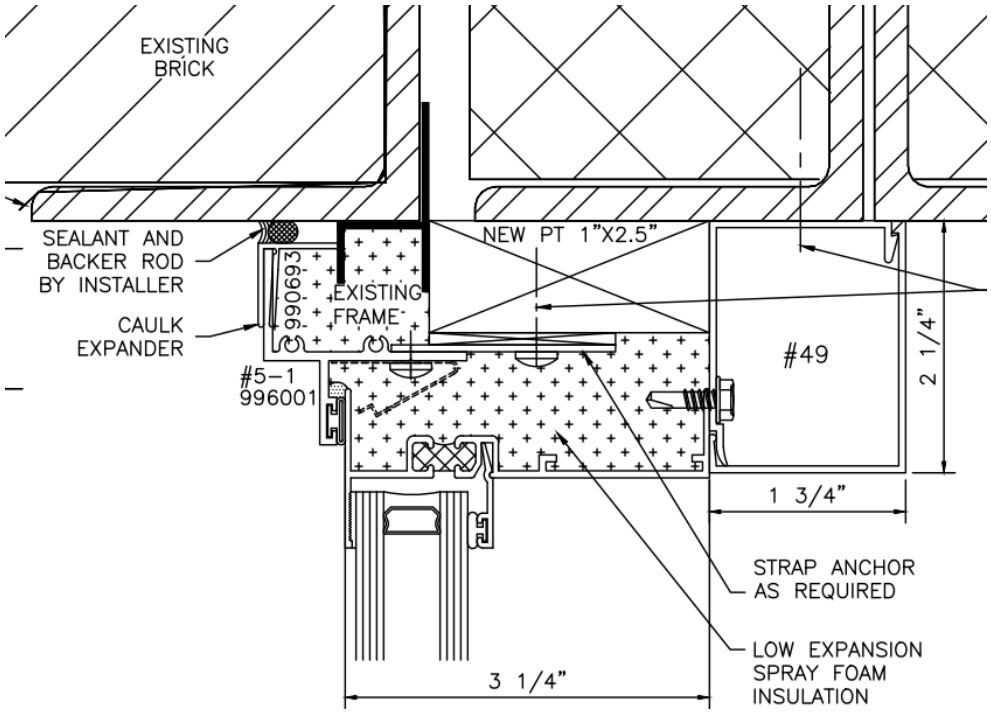
$V_a = 2DtF_u/n_u$
$V_a = 2(0.25")(0.063")(22{,}000\ psi)/1.95$
V_a = 355 lb.

Capacity of Connection is 270 lb

Also Qualifies 6/WD-02, 17/WD-06, 19/WD-06, 20/WD-07, 25/WD-08

Installation to existing clay brick assumes the clay brick substrate has been evaluated for and approved to resist anchorage loads.

18/WD-06



#12-14 TEKS Screw

1/16" thick 6063-T5 Trim Clip

1/8" thick ASTM A36 Steel Lintel

Allowable Shear of #12-14 TEKS Screw

$P_{ss}/\Omega = 724$ lb (ESR-1976)

Bearing of #12-14 TEKS Screw on Trim Clip

$V_a = 2DtF_u/n_u$
$V_a = 2(0.216")(0.063")(22{,}000 \text{ psi})/1.95$
$V_a = 307$ lb.

18/WD-06 (Continued)

Bearing of #12-14 TEKS Screw on Lintel

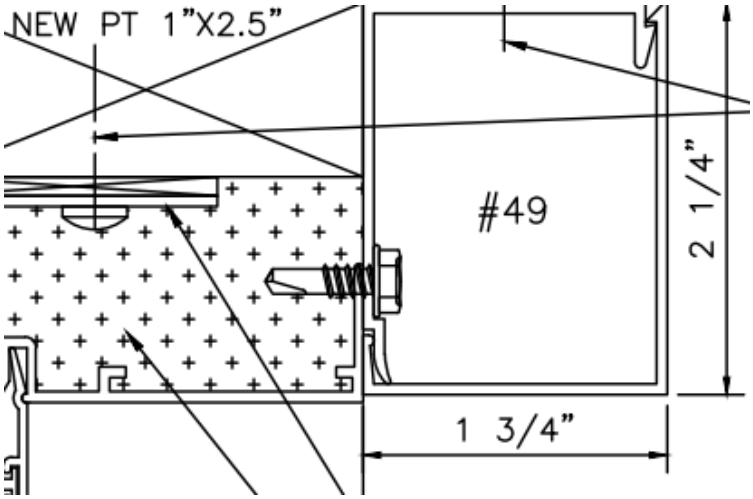
$V_a = 2.7DtF_{tu}/3.0$
$V_a = 2.7(0.216")(0.125")(58{,}000\ psi)/3.0$
$V_a = 1{,}409$ lb.

Tilting of #12-14 TEKS Screw

$V_a = 4.2(t_2^3D)^{1/2}F_{tu2}/n_s$
$V_a = 4.2(0.125"^3 \times 0.216")^{1/2}(58{,}000\ psi)/3.0$
$V_a = 1{,}668$ lb.

Capacity of Connection is 307 lb

All Details Trim Clip Connection



#10-16 TEKS Screw

1/16" thick 6063-T5 Trim Clip

1/16" thick 6063-T6 Window Frame

Allowable Tension of #10-16 TEKS Screw

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

Pull-Over of #10-16 TEKS Screw

$P_{nov} = C_{pov}t_1F_{tu1}(D_{ws}-D_h)/3.0$
$P_{nov} = 1.0(0.063")(22{,}000 \text{ psi})(0.400" - 0.190")/3.0$
$P_{nov} = 97$ lb

Pull-Out of #10-16 TEKS Screw

$P_{not} = K_sDL_eF_{ty2}/3.0$
$P_{not} = 1.01\ (0.190")(0.063")(25{,}000 \text{ psi})/3.0$
$P_{not} = 101$ lb

Capacity of Connection is 97 lb

Anchorage Requirements

Zone 4 Mid-Wall Spacing

Punched Opening Anchor Reactions

Roark's Formulas for Stress & Strain (Sixth Ed.) Table 26-1a

Elevation	Design Pressure	Location	Fastener	Anchor Capacity	Width, w (inch)	Height, h (inch)	w/h	gamma	R (lb/inch)	Anchor Spacing	Specified Spacing
A/WE-01	33.4 psf	Head	#12 Wood Screw	186 lb	54.00	54.00	1.00	0.420	5.26	35.4''	18''
		Sill	#12 Wood Screw	186 lb	54.00	54.00	1.00	0.420	5.26	35.4''	18''
		Jamb	1/4" Tapper+	270 lb	54.00	60.88	1.13	0.444	5.56	48.5''	18''
NB/WE-01 RNB/WE-01	33.4 psf	Head	#12 Wood Screw	186 lb	89.00	55.38	1.61	0.492	6.31	29.5''	18''
		Sill	#12 Wood Screw	186 lb	89.00	55.38	1.61	0.492	6.31	29.5''	18''
		Jamb	#12 Wood Screw	186 lb	55.38	55.38	1.00	0.420	5.39	34.5''	18''
NC/WE-01 NRC/WE-02	33.4 psf	Head	#12 Wood Screw	186 lb	69.00	55.38	1.25	0.461	5.93	31.4''	18''
		Sill	#12 Wood Screw	186 lb	69.00	55.38	1.25	0.461	5.93	31.4''	18''
		Jamb	#12 Wood Screw	186 lb	55.38	55.38	1.00	0.420	5.39	34.5''	18''
D/WE-02	33.4 psf	Head	#12-14 TEKS Screw	307 lb	16.00	16.00	1.00	0.420	1.56	197.0''	18''
		Sill	1/4" Tapper+	270 lb	16.00	16.00	1.00	0.420	1.56	173.2''	18''
		Jamb	1/4" Tapper+	270 lb	16.00	59.38	3.71	0.503	1.87	144.6''	18''
E/WE-02	33.4 psf	Head	#12 Wood Screw	186 lb	89.00	29.38	3.03	0.505	3.44	54.1''	18''
		Sill	#12 Wood Screw	186 lb	89.00	29.38	3.03	0.505	3.44	54.1''	18''
		Jamb	1/4" Tapper+	270 lb	29.38	29.38	1.00	0.420	2.86	94.4''	18''
F/WE-02	33.4 psf	Head	#12 Wood Screw	186 lb	45.00	29.38	1.53	0.487	3.32	56.0''	18''
		Sill	#12 Wood Screw	186 lb	45.00	29.38	1.53	0.487	3.32	56.0''	18''
		Jamb	1/4" Tapper+	270 lb	29.38	29.38	1.00	0.420	2.86	94.4''	18''
NG/WE-03 RNG/WE-03	33.4 psf	Head	#12 Wood Screw	186 lb	97.00	55.38	1.75	0.498	6.39	29.1''	18''
		Sill	#12 Wood Screw	186 lb	97.00	55.38	1.75	0.498	6.39	29.1''	18''
		Jamb	#12 Wood Screw	186 lb	55.38	55.38	1.00	0.420	5.39	34.5''	18''

Design Pressure 33.4 psf
Anchor Capacity 97 lb #10 TEKS Screw

Elevation	Location	Width, w (inch)	Height, h (inch)	w/h	gamma	R (lb/inch)	Anchor Spacing	Specified Spacing
A/WE-01	Head	54.00	54.00	1.00	0.420	5.26	18.4''	18''
	Sill	54.00	54.00	1.00	0.420	5.26	18.4''	18''
	Jambs	54.00	60.88	1.13	0.444	5.56	17.4''	17''
NB/WE-01 RNB/WE-01	Head	89.00	55.38	1.61	0.492	6.31	15.4''	15''
	Sill	89.00	55.38	1.61	0.492	6.31	15.4''	15''
	Jambs	55.38	55.38	1.00	0.420	5.39	18.0''	18''
NC/WE-01 NRC/WE-02	Head	69.00	55.38	1.25	0.461	5.93	16.4''	16''
	Sill	69.00	55.38	1.25	0.461	5.93	16.4''	16''
	Jambs	55.38	55.38	1.00	0.420	5.39	18.0''	18''
D/WE-02	Head	16.00	16.00	1.00	0.420	1.56	62.2''	18''
	Sill	16.00	16.00	1.00	0.420	1.56	62.2''	18''
	Jambs	16.00	59.38	3.71	0.503	1.87	51.9''	18''
E/WE-02	Head	89.00	29.38	3.03	0.505	3.44	28.2''	18''
	Sill	89.00	29.38	3.03	0.505	3.44	28.2''	18''
	Jambs	29.38	29.38	1.00	0.420	2.86	33.9''	18''
F/WE-02	Head	45.00	29.38	1.53	0.487	3.32	29.2''	18''
	Sill	45.00	29.38	1.53	0.487	3.32	29.2''	18''
	Jambs	29.38	29.38	1.00	0.420	2.86	33.9''	18''
NG/WE-03 RNG/WE-03	Head	97.00	55.38	1.75	0.498	6.39	15.2''	15''
	Sill	97.00	55.38	1.75	0.498	6.39	15.2''	15''
	Jambs	55.38	55.38	1.00	0.420	5.39	18.0''	18''

Anchorage Requirements (Continued)

Zone 5 Corner Spacing

Punched Opening Anchor Reactions

Roark's Formulas for Stress & Strain (Sixth Ed.) Table 26-1a

Elevation	Design Pressure	Location	Fastener	Anchor Capacity	Width, w (inch)	Height, h (inch)	w/h	gamma	R (lb/inch)	Anchor Spacing	Specified Spacing
A/WE-01	66.2 psf	Head	#12 Wood Screw	186 lb	54.00	54.00	1.00	0.420	10.43	17.8''	17''
		Sill	#12 Wood Screw	186 lb	54.00	54.00	1.00	0.420	10.43	17.8''	17''
		Jamb	1/4" Tapper+	270 lb	54.00	60.88	1.13	0.444	11.03	24.5''	18''
NB/WE-01 RNB/WE-01	66.2 psf	Head	#12 Wood Screw	186 lb	89.00	55.38	1.61	0.492	12.52	14.9''	14''
		Sill	#12 Wood Screw	186 lb	89.00	55.38	1.61	0.492	12.52	14.9''	14''
		Jamb	#12 Wood Screw	186 lb	55.38	55.38	1.00	0.420	10.69	17.4''	17''
NC/WE-01 NRC/WE-02	66.2 psf	Head	#12 Wood Screw	186 lb	69.00	55.38	1.25	0.461	11.74	15.8''	15''
		Sill	#12 Wood Screw	186 lb	69.00	55.38	1.25	0.461	11.74	15.8''	15''
		Jamb	#12 Wood Screw	186 lb	55.38	55.38	1.00	0.420	10.69	17.4''	17''
D/WE-02	66.2 psf	Head	#12-14 TEKS Screw	307 lb	16.00	16.00	1.00	0.420	3.09	99.4''	18''
		Sill	1/4" Tapper+	270 lb	16.00	16.00	1.00	0.420	3.09	87.4''	18''
		Jamb	1/4" Tapper+	270 lb	16.00	59.38	3.71	0.503	3.70	72.9''	18''
E/WE-02	66.2 psf	Head	#12 Wood Screw	186 lb	89.00	29.38	3.03	0.505	6.82	27.3''	18''
		Sill	#12 Wood Screw	186 lb	89.00	29.38	3.03	0.505	6.82	27.3''	18''
		Jamb	1/4" Tapper+	270 lb	29.38	29.38	1.00	0.420	5.67	47.6''	18''
F/WE-02	66.2 psf	Head	#12 Wood Screw	186 lb	45.00	29.38	1.53	0.487	6.58	28.3''	18''
		Sill	#12 Wood Screw	186 lb	45.00	29.38	1.53	0.487	6.58	28.3''	18''
		Jamb	1/4" Tapper+	270 lb	29.38	29.38	1.00	0.420	5.67	47.6''	18''
NG/WE-03 RNG/WE-03	66.2 psf	Head	#12 Wood Screw	186 lb	97.00	55.38	1.75	0.498	12.67	14.7''	14''
		Sill	#12 Wood Screw	186 lb	97.00	55.38	1.75	0.498	12.67	14.7''	14''
		Jamb	#12 Wood Screw	186 lb	55.38	55.38	1.00	0.420	10.69	17.4''	17''

Design Pressure 66.2 psf
Anchor Capacity 97 lb #10 TEKS Screw

Elevation	Location	Width, w (inch)	Height, h (inch)	w/h	gamma	R (lb/inch)	Anchor Spacing	Specified Spacing
A/WE-01	Head	54.00	54.00	1.00	0.420	10.43	9.3''	9''
	Sill	54.00	54.00	1.00	0.420	10.43	9.3''	9''
	Jambs	54.00	60.88	1.13	0.444	11.03	8.8''	8''
NB/WE-01 RNB/WE-01	Head	89.00	55.38	1.61	0.492	12.52	7.8''	7''
	Sill	89.00	55.38	1.61	0.492	12.52	7.8''	7''
	Jambs	55.38	55.38	1.00	0.420	10.69	9.1''	9''
NC/WE-01 NRC/WE-02	Head	69.00	55.38	1.25	0.461	11.74	8.3''	8''
	Sill	69.00	55.38	1.25	0.461	11.74	8.3''	8''
	Jambs	55.38	55.38	1.00	0.420	10.69	9.1''	9''
D/WE-02	Head	16.00	16.00	1.00	0.420	3.09	31.4''	18''
	Sill	16.00	16.00	1.00	0.420	3.09	31.4''	18''
	Jambs	16.00	59.38	3.71	0.503	3.70	26.2''	18''
E/WE-02	Head	89.00	29.38	3.03	0.505	6.82	14.2''	14''
	Sill	89.00	29.38	3.03	0.505	6.82	14.2''	14''
	Jambs	29.38	29.38	1.00	0.420	5.67	17.1''	17''
F/WE-02	Head	45.00	29.38	1.53	0.487	6.58	14.7''	14''
	Sill	45.00	29.38	1.53	0.487	6.58	14.7''	14''
	Jambs	29.38	29.38	1.00	0.420	5.67	17.1''	17''
NG/WE-03 RNG/WE-03	Head	97.00	55.38	1.75	0.498	12.67	7.7''	7''
	Sill	97.00	55.38	1.75	0.498	12.67	7.7''	7''
	Jambs	55.38	55.38	1.00	0.420	10.69	9.1''	9''

3-Piece Mullion Anchorage

All BAY elevations are in Zone 4

Jamb R_{max} = (232.5 lb)(33.4 psf)/(61.2 psf) = 127 lb

Vertical Intermediate R_{max} = (462.2 lb)(33.4 psf)/(61.2 psf) = 252 lb

One (1) Angle per mullion end 3 Piece Mullion at Jambs

Two (2) Angles per mullion end 3 Piece Mullion at Vertical Intermediates

Angle to Mullion Connection

Two (2) #12-14 TEKS Screws, Spaced 1" On Center

1/8" Thick 6063-T5 Angle

0.093" thick 6063-T6 Mullion Wall

Allowable Shear of #12-14 TEKS Screw

P_{ss}/Ω = 724 lb (ESR-1976)

Bearing of #12-14 TEKS Screw on Angle

$V_a = 2DtF_u/n_u$
$V_a = 2(0.216")(0.125")(22{,}000 \text{ psi})/1.95$
V_a = 609 lb.

Bearing of #12-14 TEKS Screw on Mullion

$V_a = 2DtF_u/n_u$
$V_a = 2(0.216")(0.093")(30{,}000 \text{ psi})/1.95$
V_a = 618 lb.

Tilting of #12-14 TEKS Screw

$V_a = 4.2(t_2^3D)^{1/2}F_{tu2}/n_s$
$V_a = 4.2(0.093"^3 \times 0.216")^{1/2}(30{,}000 \text{ psi})/3.0$
V_a = 554 lb.

Capacity of Connection is (2)(554 lb) = 1,108 lb > 252 lb, OK

3-Piece Mullion Anchorage (Continued)

Angle to Steel Lintel at Head

Two (2) #12-14 TEKS Screws per Angle at Jamb Spaced 1" OC

One (1) #12-14 TEKS Screw per Angle at Intermediate Vertical

1/8" Thick 6063-T5 Angle

1/8" thick ASTM A36 Steel Lintel

Allowable Shear of #12-14 TEKS Screw

$P_{ss}/\Omega = 724$ lb (ESR-1976)

Bearing of #12-14 TEKS Screw on Angle

$V_a = 2DtF_u/n_u$
$V_a = 2(0.216")(0.125")(22{,}000 \text{ psi})/1.95$
$V_a = 609$ lb.

Bearing of #12-14 TEKS Screw on Lintel

$V_a = 2.7DtF_{tu}/3.0$
$V_a = 2.7(0.216")(0.125")(58{,}000 \text{ psi})/3.0$
$V_a = 1{,}409$ lb.

Tilting of #12-14 TEKS Screw

$V_a = 4.2(t_2^3D)^{1/2}F_{tu2}/n_s$
$V_a = 4.2(0.125"^3 \times 0.216")^{1/2}(58{,}000 \text{ psi})/3.0$
$V_a = 1{,}668$ lb.

Capacity of Fastener is 609 lb

Capacity of Jamb Connection is 405 lb > 127 lb, OK (See Following Page)

Capacity of Intermediate Vertical Connection is (2)(609 lb) = 1,218 lb > 252 lb, OK

3-Piece Mullion Anchorage (Continued)

BOLT GROUP ANALYSIS

Using the Elastic Method for up to 25 Total Bolts

Job Name:	Harbor Terrace Apartments	Subject:	Mullion Steel Anchorage		
Job Number:	F8229.01-122-34	Originator:	DCC	Checker:	

Input Data:

Number of Bolts, Nb = 2

Bolt Coordinates:

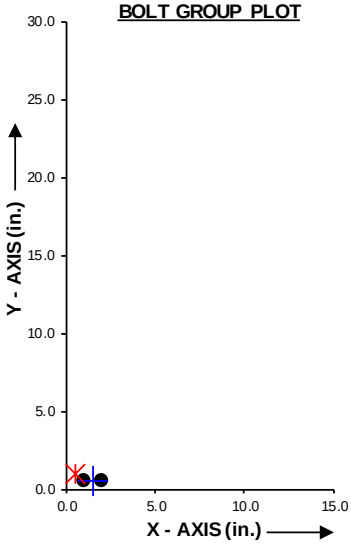
	Xo (in.)	Yo (in.)
#1:	1.000	0.500
#2:	2.000	0.500

Results:

Bolt Reactions (k)

	Axial Rz	Shear Rh
#1:	0.00	609.00
#2:	0.00	203.00

BOLT GROUP PLOT



Bolt Group Properties:

Xc =	1.500	in.
Yc =	0.500	in.
Ix =	0.00	in.^2
Iy =	0.50	in.^2
J =	0.50	in.^2
Ixy =	0.00	in.^2
θ =	0.000	deg.

No. of Load Points, N = 1

Load Point Data: Point #1

X-Coordinate (in.) =	0.500			
Y-Coordinate (in.) =	1.000			
Z-Coordinate (in.) =	0.000			
Axial Load, Pz (k) =	0.00			
Shear Load, Px (k) =	0.00			
Shear Load, Py (k) =	406.00			
Moment, Mx (in-k) =	0.00			
Moment, My (in-k) =	0.00			
Moment, Mz (in-k) =	0.00			

Σ Loads @ C.G. of Bolt Group:

Σ Pz =	0.00	kips
Σ Px =	0.00	kips
Σ Py =	406.00	kips
Σ Mx =	0.00	in-k
Σ My =	0.00	in-k
Σ Mz =	-406.00	in-k

Bolt Reaction Summary:

Rz(max) =	0.00	kips
Rz(min) =	0.00	kips
Rh(max) =	609.00	kips

3-Piece Mullion Anchorage (Continued)

Clip to Wood Blocking at Sill

Two (2) #12-14 TEKS Screws per Angle at Jamb Spaced 1" OC

One (1) #12-14 TEKS Screw per Angle at Intermediate Vertical

1-1/2" Minimum Penetration

1/8" thick 6063-T5 Angle

Southern Yellow Pine (S-Y-P) Wood Blocking

Allowable Shear of #12 Wood Screw

Z' = 194 lb (Limited by Yield IIIs, see following 2 pages)

Bearing of #12 Wood Screw on Angle

$V_a = 2DtF_u/n_u$
$V_a = 2(0.216")(0.125")(22{,}000 \text{ psi})/1.95$
$V_a = 609$ lb.

Capacity of Fastener is 194 lb

Capacity of Jamb Connection is 129 lb > 127 lb, OK (See Following Page)

Capacity of Intermediate Vertical Connection is (2)(194 lb) = 338 lb > 252 lb, OK

3-Piece Mullion Anchorage (Continued)

BOLT GROUP ANALYSIS
Using the Elastic Method for up to 25 Total Bolts

Job Name:	Harbor Terrace Apartments	Subject:	Mullion Wood Anchorage		
Job Number:	F8229.01-122-34	Originator:	DCC	Checker:	

Input Data:

Number of Bolts, Nb = 2

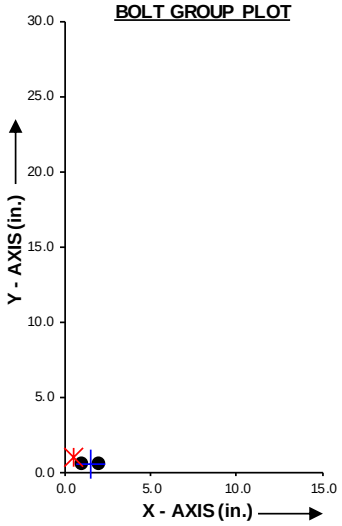
Bolt Coordinates:

	Xo (in.)	Yo (in.)
#1:	1.000	0.500
#2:	2.000	0.500

Results:

	Bolt Reactions (k)	
	Axial Rz	Shear Rh
#1:	0.00	193.50
#2:	0.00	64.50

BOLT GROUP PLOT



Bolt Group Properties:

Xc =	1.500	in.
Yc =	0.500	in.
Ix =	0.00	in.^2
Iy =	0.50	in.^2
J =	0.50	in.^2
Ixy =	0.00	in.^2
θ =	0.000	deg.

No. of Load Points, N = 1

Load Point Data: Point #1

X-Coordinate (in.) =	0.500			
Y-Coordinate (in.) =	1.000			
Z-Coordinate (in.) =	0.000			
Axial Load, Pz (k) =	0.00			
Shear Load, Px (k) =	0.00			
Shear Load, Py (k) =	129.00			
Moment, Mx (in-k) =	0.00			
Moment, My (in-k) =	0.00			
Moment, Mz (in-k) =	0.00			

Σ Loads @ C.G. of Bolt Group:

Σ Pz =	0.00	kips
Σ Px =	0.00	kips
Σ Py =	129.00	kips
Σ Mx =	0.00	in-k
Σ My =	0.00	in-k
Σ Mz =	-129.00	in-k

Bolt Reaction Summary:

Rz(max) =	0.00	kips
Rz(min) =	0.00	kips
Rh(max) =	193.50	kips

3-Piece Mullion Anchorage (Continued)

Lateral Design Strength of Wood Connections

ANSI / AF&PA NDS-2005

Data

Fastener

Fastener	=	#10 Wood Screw	
Shank Dia	=	0.190	in.
Root Dia.	=	0.152	in.
F_{yb}	=	80,000	psi
Fastener length	=	2.500	in.

Main Member

Material	=	SYP		
G	=	0.55		
θ	=	90	<= (Angle of load to grain $0^o \le \theta \le 90^o$)	
F_e	=	5,550	psi	Table 11.3.2
Thickness	=	1.500	in.	

Side Member

Material	=	Aluminum 6063-T5		
G	=	N/A		
θ	=	0	<= (Angle of load to grain $0^o \le \theta \le 90^o$)	
F_{es}	=	27,500	psi	Aluminum Design Manual 2005
Thickness	=	0.125	in.	

Calculations

Lateral Bearing Factors

D	=	0.152	in.	
ℓ_m	=	1.500	in.	
K_θ	=	1.25		Table 11.3.1B
K_D	=	2.20		Table 11.3.1B
R_e	=	0.202		Table 11.3.1A
R_t	=	12.00		Table 11.3.1A
k_1	=	0.9497		Table 11.3.1A
k_2	=	0.5944		Table 11.3.1A
k_3	=	5.57		Table 11.3.1A

Yield Mode	R_d	
I_m, I_s	2.20	Table 11.3.1B
II	2.20	Table 11.3.1B
III_m, III_s, IV	2.20	Table 11.3.1B

3-Piece Mullion Anchorage (Continued)

Lateral Design Values, Z					
Mode I_m	=	575	lbf		Eq 11.3-1
Mode I_s	=	238	lbf		Eq 11.3-2
Mode II	=	226	lbf		Eq 11.3-3
Mode III_m	=	244	lbf		Eq 11.3-4
Mode III_s	=	121	lbf	<====== Minimum Value	Eq 11.3-5
Mode IV	=	165	lbf		Eq 11.3-6
C_D	=	1.6			B.2
Wet Service Factor					
Fabrication/In-Service		Dry/Dry			
C_M	=	1.0			Table 10.3.3
In service temperature		T≤100˚F			
C_t	=	1.0			Table 10.3.4
C_g	=	1.0			10.3.6
C_Δ	=	1.0			11.5.1
Is fastener installed in end grain?		No			
C_{eg}	=	1.00			11.5.2
Is fastener part of a diaphragm?		No			
C_{di}	=	1.0			11.5.3
Is fastener toe-nailed?		No			
C_{tn}	=	1.00			11.5.4
Z'	**=**	**194**	**lbf**		Table 10.3.1

Revision Log

Rev. #	Date	Page(s)	Revision(s)
0	05/19/16	N/A	Original report issue