Structural Calculations – PHENOLIC COMPOSITE and TEMPERED GLASS Panels
FACE MOUNTING SYSTEM with Connection Elements & Fasteners Analysis
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JN 3716-PG

FACE MOUNTED SYSTEM – PHENOLIC DECORATIVE INTERIOR WALL PANELS from WPS, Inc.

The wall panel system analyzed herein is comprised of colored and textured panels of homogenous phenolic composite panels or tempered glass panels mounted, with proprietary hardware and commercially available fasteners or adhesives to structural and non-structural building wall partitions (wall backing or backing). Panels are fabricated to various modular dimensions to fit interior wall height and length constraints. Extruded Aluminum alloy clips, rails, and Extruded ABS (Acrylonitrile Butadiene Styrene) clips, designed and manufactured by Wall Panel Systems Inc. (WPS) are exclusive to this panel system.

Extruded Aluminum alloy clips and rails are mounted to interior wall partitions (backing). ABS Extruded Clips are mounted to phenolic panels with steel machine screws. ABS Extruded Clips are mounted to tempered glass panels with epoxy adhesive. These panel assemblies are hung on aluminum extrusions mounted to the backing. All fasteners include commercially available steel self-tapping screws, wood screws, machine screws and concrete screws, or epoxy adhesive as appropriate, for the materials and backing being fastened. Panel assemblies are fastened to interior non-bearing partition walls of either cold formed steel stud framing or wood framing. Partition framing is sheathed in gypsum wall board (drywall). Panel assemblies may also be mounted on reinforced Concrete Masonry Unit (CMU) walls or reinforced concrete (PCC) walls.

The panel wall elements, anchorage, and assemblies are evaluated for vertical and lateral load resistance under the California Building Code (CBC) and International Building Code (IBC) as non-structural architectural finish components. The following is an analysis of the design seismic and gravity forces affecting typical wall panel assembly connections between the respective panel materials and the supporting partition walls.

Panel System:

The decorative wall panel assembly is mounted on interior wall partitions. Panels are grouped in modular patterns and assembled with the edges fastened to extruded aluminum edge rails, mid-panel rails, corner rails and clips. The panels and ABS components are collectively fastened to the aluminum extrusions mounted on partition wall backing.

Connections between the decorative phenolic panels, aluminum extrusions, ABS connectors, and partition backing are made using various screw fasteners. Tempered glass connection to ABS panel clips is made with epoxy adhesive. Fasteners consist of galvanized steel self-drilling tapping screws, zinc-coated steel machine screws, wood screws, or sheet metal screws, as appropriate. Attachment of panel assemblies to CMU or PCC backing is accomplished by use of concrete and masonry screws set in holes drilled in CMU or PCC partitions.

Panel Connection Spacing:

Typical wall connection spacing for phenolic panels is given to occur at 24 inch o.c. maximum horizontally. This is the typical maximum horizontal spacing for partition wall studs in commercial applications. Vertical connections are analyzed for a 34 inch o.c. maximum spacing. (This is h/3 for an 8

foot wall height & h/4 for a 12 foot wall height). Tempered glass panel connection spacing is more frequent as the allowable loads for epoxy adhesive in tension is limiting the connection spacing. Horizontal clip spacing will occur at 16 inch o.c. maximum. Vertical spacing for rails and panel clips will occur at 17 inch o.c. maximum.

Panel edge connections to wall panel assemblies occur at the tops, bottoms and all vertical panel edges of partition walls. Panel material properties are referenced elsewhere in this document. Modular panel sizes vary according to the interior dimensions of the surface being faced. For the purposes of connection analysis we will base our calculations on panel dimensions that will result in a typical maximum area tributary to an individual panel to backing connection based upon dimensions of the supporting backing partitions.

5.67 sq. ft. = Typical maximum tributary area per phenolic connection = (24 in)(34 in)/ (12 in/ft)^2.
1.88 sq. ft. = Typical maximum tributary area per tempered glass connection = (16 in)(17 in)/ (12 in/ft)^2.

Panel System Unit Dead Loads (DL) per square foot (psf) are listed below. Each system is comprised of decorative panels, alloy components, and fasteners that collectively comprise each panel assembly.

4.0 psf DL = Phenolic Composite, 1/2 in thick.
3.0 psf DL = Phenolic Composite, 3/8 in thick.
2.5 psf DL = Phenolic Composite, 5/16 in thick.
4.76 psf DL = Tempered Glass, 3/8 in thick.

Tributary Dead Loads per connection for various Panel Assemblies:

22.7 lbs = 1/2 in. Phenolic Composite = (5.67 sq.ft)(4.0 psf)
17.0 lbs = 3/8 in. Phenolic Composite = (5.67 sq.ft)(3.0 psf)
14.2 lbs = 5/16 in. Phenolic Composite = (5.67 sq.ft)(2.5 psf)
27.0 lbs = 3/8 in. Tempered Glass = (5.67 sq.ft)(4.76 psf)
9.0 lbs = 3/8 in. Tempered Glass = (1.88 sq.ft)(4.76 psf)

Therefore for system consistency we will analyze various connections based upon the maximum tributary Dead Load (DL) values each connection will likely support utilizing similarly sized fasteners for the various panel materials:

Use 22.7 lbs / connection for design of machine screw connections to panel clip.
Use 9.0 lbs / connection for design of Glass Panel to panel clip connections (1.88 sq.ft).
Use 27.0 lbs / connection for design of Glass Panel to panel clip connections (5.67 sq.ft).

Inverted Sloping Panel applications: Panel connections have been analyzed for inverted sloping wall applications, including ceiling applications.

Each panel assembly consists of: Modular Phenolic or Tempered Glass Panels, ABS Extruded Panel Clips, Extruded aluminum alloy clips or rails fastened to each panel at its vertical edges, top panel edges, bottom panel edges, and at mid-wall horizontal rails spaced as noted above. Extruded aluminum components are connected to partition wall backing with galvanized steel self-drilling tapping screws conforming to AISI Standard for cold formed steel framing. Alternative backing may include reinforced concrete masonry unit walls (CMU) or concrete walls (PCC). In this case, aluminum alloy rails are fastened to the CMU or PCC backing with hardened steel concrete screws set in drilled holes. ABS panel clips and mid wall clips are connected to phenolic wall panels with zinc-coated steel machine screws or epoxy adhesive for tempered glass.

Rails, edges, and trim pieces are connected to each other with fitted joints. ABS panel clips and mid wall clips are connected to phenolic wall panels with four panel fasteners (machine screws) per clip.

CLIPS, RAILS, AND TRIM FOR PHENOLIC PANEL SYSTEMS ARE AS FOLLOWS:

ABS Extruded Clips:

Panel Clip 022 (U)

Aluminum Alloy:

Edge Mounting Rail FM-602 (U)

Mid-Wall Clip, GEN-014 (U)

Wainscot Cap, WCS-161 (U)

Wainscot Clip, WCS-160 (U)

Edge Trim, SHA-101 (U)

Inside Corner, SHA-140 (U)

Horizontal Mounting Rail, FM-621 (U)

Outside Corner Radius, SHA-130 (U)

Outside Corner Mitered, SHA-139 (U)

Outside Corner Square, SHA-131 (U)

Vertical Joint, SHA-612 (U)

IBC 2015/CBC 2016 - Allowable Stress Design (ASD), out of plane seismic force for vertical wall panel assembly attached to steel framing, per ASCE 7-10, Sec 13.3.1:

Lateral loads for out of plane seismic forces are evaluated as normal to the wall panel face, and for the vertical seismic force component in addition to gravity. Lateral analysis will be done under allowable stress design for non-structural components per IBC 2015/CBC 2016.

a_p = 1.0 per Table 13.5-1 S_{DS} = 1.373 most severe locale W_p = 22.7 lb Tributary DL (1/2 in. Phenolic)
I_p = 1.0 per Sec.13.1.3, ASCE R_p = 2.5 per 13.5-1 ASCE Z_{max} = 12 ft h_{max} = 12 ft

For PHENOLIC PANELS:

Eq. 13.3-1 $$F_p = 15.0 \text{ lbs} = \frac{(0.4)(a_p)(S_{DS})(W_p)}{(R_p / I_p)}[1 + (2)(Z/h)] = \frac{(12.5)}{(2.5)}[3]$$

Eq. 13.3-2 $\max. F_p = 49.9 \text{ lbs} = (1.6)(S_{DS})(W_p)(I_p)$

Eq. 13.3-2 $\min. F_p = 9.4 \text{ lbs} = (0.3)(S_{DS})(W_p)(I_p)$

Therefore, F_p = 49.9 lbs = PHENOLIC Maximum Horizontal Out of Plane Seismic force / connection, perpendicular to panel face, from any direction, in the most severe locale.

Vertical Concurrent force = (DL) +/- [(0.2)(S_{DS})(W_p)] = (22.7 lb) +/- [6.2 lb per connection]
PHENOLIC - Vertical Concurrent (gravity + seismic) forces = 28.9 lb max, or 16.5 lb min.

IBC 2015/CBC 2016 - Allowable Stress Design (ASD), out of plane seismic force for vertical wall panel assembly of Tempered Glass attached to steel framing, per ASCE 7-10, Sec 13.3.1:

Lateral loads for out of plane seismic forces are evaluated as normal to the wall panel face, and for the vertical seismic force component in addition to gravity. Lateral analysis will be done under allowable stress design for non-structural components per IBC 2015/CBC 2016.

a_p = 1.0 per Table 13.5-1 S_{DS} = 1.373 most severe locale W_p = 28.4 lb Tributary DL (3/8 in.Glass)
I_p = 1.0 per Sec.13.1.3, ASCE R_p = 2.5 per 13.5-1 ASCE Z_{max} = 12 ft h_{max} = 12 ft

For 3/8 in TEMPERED GLASS PANELS:

Eq. 13.3-1 $$F_p = 18.7 \text{ lbs} = \frac{(0.4)(a_p)(S_{DS})(W_p)}{(R_p / I_p)}[1 + (2)(Z/h)] = \frac{(15.6)}{(2.5)}[3]$$

Eq. 13.3-2 $\max. F_p = 62.4 \text{ lbs} = (1.6)(S_{DS})(W_p)(I_p)$

Eq. 13.3-2 $\min. F_p = 11.7 \text{ lbs} = (0.3)(S_{DS})(W_p)(I_p)$

Therefore, F_p = 62.4 lbs = 3/8 in TEMPERED GLASS panels - Maximum Horizontal Out of Plane Seismic force / connection, perpendicular to panel face, from any direction, in the most severe locale.

Vertical Concurrent force = (DL) +/- [(0.2)(S_{DS})(W_p)] = (28.4 lb) +/- [7.8 lb per connection]
3/8 in TEMPERED - Vertical Concurrent (gravity + seismic) forces = 36.2 lb max, or 20.6 lb min.

Sloping PHENOLIC ½" Thick Wall Panel Assemblies – APPLIED LOAD ANALYSIS
Applied Loads per fastener, Dead Loads and Seismic (values in pounds).

		#8 Self Tapping Screw		(2)#8 Machine screws	
Wall Angle	**Load Type**	**Shear**	**Tension**	**Shear**	**Tension**
Degrees from level					
90 (Vert. Wall)	Normal	**22.7**	0	**11.4**	0
	Seismic	28.9	49.9	14.5	25.0
70	Normal	21.3	7.8	10.7	3.9
	Seismic	44.2	56.3	22.1	28.2
60	Normal	19.7	11.4	9.9	5.7
	Seismic	50.1	**57.7**	25.1	**28.9**
45	Normal	16.1	16.1	8.0	8.0
	Seismic	55.8	55.8	27.9	27.9
30	Normal	11.4	19.7	5.7	9.9
	Seismic	**57.7**	50.1	**28.9**	25.1
0 (flat - Horiz.)	Normal	0	**22.7**	0	**11.4**
	Seismic	49.9	28.9	25.0	14.5

Load Summary: IBC 2015/CBC 2016

Sloping PHENOLIC ½" Thick Wall Panel Assemblies
Dead Loads and Seismic for all sloping configurations. (values in pounds).

MAXIMUM APPLIED LOADS PER FASTENER

		#8 Self Tapping Screw		# 8 Wood Screw		#8 Machine screw	
	Load Type	**Shear**	**Tension**	**Shear**	**Tension**	**Shear**	**Tension**
Use for							
Design of	**Normal**	**22.7**	**22.7**	**11.4**	**11.4**	**11.4**	**11.4**
Connections	**Seismic**	**57.7**	**57.7**	**28.9**	**28.9**	**28.9**	**28.9**

Sloping TEMPERED GLASS 3/8" Thick Panels – APPLIED LOAD ANALYSIS AT 2 CONDITIONS
TRIBUTARY DEAD LOAD = 28.4 lb / connection. (5.67 sq. ft. tributary panel /connection)
Applied Loads per connection, Dead Loads and Seismic (values in pounds).
One #10 Self Tapping Screw / connection for edge rails. Epoxy loads on panel clip to panel.
W_p= 28.4 lb DL (A_t=5.76 sf), Wp+E_V = 36.2lb maximum, E = 62.4 lb

		#10 Self Tapping Screw		Epoxy on Panel Clip	
Wall Angle	**Load Type**	**Shear**	**Tension**	**Shear**	**Tension**
Degrees from level					
90 (Vert. Wall)	Normal	**28.4**	0	**28.4**	0
	Seismic	36.2	62.4	36.2	62.4
70	Normal	26.6	9.8	26.6	9.8
	Seismic	55.1	70.6	55.1	70.6
60	Normal	24.6	14.2	24.6	14.2
	Seismic	62.6	**72.2**	62.6	**72.2**
45	Normal	20.2	20.2	20.2	20.2
	Seismic	69.7	69.7	69.7	69.7
30	Normal	14.2	24.6	14.2	24.6
	Seismic	**72.2**	62.6	**72.2**	62.6
0 (flat - Horiz.)	Normal	0	**28.4**	0	**28.4**
	Seismic	62.4	36.2	62.4	36.2

Load Summary: IBC 2015/CBC 2016

Sloping TEMPERED GLASS PANELS 3/8" Thick Wall Panel Assemblies
Dead Loads and Seismic for all sloping configurations. (values in pounds).

MAXIMUM APPLIED LOADS PER FASTENER/CONNECTION

		#10 Self Tapping Screw		Epoxy on Panel Clip	
	Load Type	**Shear**	**Tension**	**Shear**	**Tension**
Use for					
Design of	**Normal**	**28.4**	**28.4**	**28.4**	**28.4**
Connections	**Seismic**	**72.2**	**72.2**	**72.2**	**72.2**

INTERACTION ANALYSIS – COMBINED SHEAR / TENSION

Seismic force acts perpendicular (out-of-plane) in tension on fastener – panel connection.
Gravity + vertical component of seismic force acts in shear.
Combined forces interaction for the limiting connection: Phenolic Panel to Panel Fastener.

V_a = 258 lbs = Allowable Seismic Shear / panel backing screw connection = (194)(1.33).
P_a = 113 lbs = Allowable Tension Wall Panel to Panel Fastener connection = (85)(1.33).
P_s = 57.7 lbs = Maximum Applied Seismic out of plane tension per connection.
V_{G+S} = 28.9 lbs = Applied gravity + vertical seismic component per connection.

$$\frac{V_{G+S}}{V_a} + \frac{P_s}{P_a} = \frac{28.9}{258} + \frac{57.7}{113} = 0.11 + 0.51 = 0.62 < 1.0, \text{ OK}$$

Interaction Analysis indicates weakest connection link is adequate for most severe load condition (2015 IBC / 2016 CBC).

INTERACTION ANALYSIS – COMBINED SHEAR / TENSION (TEMPERED GLASS, $A_P \leq 5.67$ S.F.)

Seismic force acts perpendicular (out-of-plane) in tension on fastener – panel connection. Gravity + vertical component of seismic force acts in shear. Combined forces interaction for the limiting connection: Phenolic Panel to Self-Drilling Panel Fastener in steel stud/GWB backing.

V_a = 258 lbs = Allowable Seismic Shear / panel backing screw connection = (193)(1.33).
P_a = 113 lbs = Allowable Tension Wall Panel to Panel Fastener connection = (85)(1.33).
P_s = 72.2 lbs = Maximum Applied Seismic out of plane tension per connection.
V_{G+S} = 36.2 lbs = Applied gravity + vertical seismic component per connection.

$$\frac{V_{G+S}}{V_a} + \frac{P_s}{P_a} = \frac{36.2}{258} + \frac{72.2}{113} = 0.14 + 0.64 = 0.78 < 1.0, \text{ OK}$$

Interaction Analysis indicates weakest connection link is adequate for most severe load condition (2015 IBC / 2016 CBC).

ANALYSIS OF SEISMIC LOAD APPLIED causing PRYING ACTION ON HORIZONTAL MOUNTING RAIL FASTENERS and EDGE RAIL FASTENERS – Vertical Wall condition.
Refer to typical connection drawing details "B" & "E" of Typical Connection Diagrams for Extruded Aluminum Rails and Clips.

Horizontal (Out of plane) force To wall fastener (self drilling tapping screws) at steel stud, Base Edge Trim Rail, maximum of 29.0 lbs. per screw connection.

$$\frac{(57.7/2 \text{ lb})(1.15 \text{ in})}{(0.53 \text{ in})} = 62.6 \text{ lb tension in wall fasteners} < 113 \text{ lb allowable seismic tension at backing}$$

Apply horiz. force to Wall fasteners at steel studs Horiz.Mounting Rail

$$\frac{(57.7 \text{ lb})(2.2 \text{ in})}{(0.58 + 0.58 \text{ in})} = 109.4 \text{ lb} < 226 \text{ lb allowable seismic tension at backing fasteners}$$

Vertical component of seismic force plus gravity per screw connection at Base Edge Rail horiz to backing fastener

$$\frac{(28.9 \text{ lb})(0.563 \text{ in})}{(0.58 \text{ in})} = 28.1 \text{ lb} < 113 \text{ lb Allowable seismic in backing fastener}$$

Vertical component of seismic force plus gravity per screw connection at Horizontal Mounting Rail at backing fastener

$$\frac{(28.9 \text{ lb})(0.563 \text{ in})}{(0.58 \text{ in})} = 28.1 \text{ lb} < 113 \text{ lb Allowable seismic in backing fastener}$$

ANALYSIS OF SEISMIC LOAD APPLIED causing PRYING ACTION ON MIDWALL HORIZONTAL JOINT MOUNTING RAIL FASTENERS and EDGE RAIL FASTENERS – Horizontal (Ceiling or soffit) Installation.
Refer to typical connection drawing details "B" & "E", rotated 90 degrees, of Typical Connection Diagrams for Extruded Aluminum and ABS Rails and Clips

Vertical (Out of plane force) For Horizontal Joint Receiver Rail

$$\frac{(28.9 \text{ lb})(2.2 \text{ in})}{(1.20 \text{ in})} = 53.0 \text{ lb tension in wall fastener} < 113 \text{ lb allowable seismic tension at backing}$$

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Apply vertical force to Wall fastener screw at backing.	(28.9 lb)(1.15 in) / (0.58 in)	= 57.3 lb tension in wall fastener at backing	< 113 lb allowable seismic tension
Vertical component of seismic force plus gravity per 2 screw connection at edge rail backing.	(28.9 lb)(0.58 in) / (0.62 in)	= 27.0 lb tension	< 113 lb Allowable seismic in backing fastener
Vertical component of seismic force plus gravity per screw connection at horiz. joint rail.	(57.7 lb)(1.2 in) / (1.2 in)	= 57.7 lb tension	< 113 lb Allowable seismic in backing fastener

CONNECTION SUMMARY		**Calculated Load Capacity Between Elements**		
Typical Panel Assembly ELEMENT		**PULLOUT (lbs)**	**SHEAR (lbs)**	**CLIP SHEAR (lbs)**
1/2“ Phenolic Composite				
	Normal	**450**	**247**	
	Seismic	**598**	**329**	
Panel fasteners – (4) #8 x 1/2 in machine screws				
	Normal	450	247	
	Seismic	598	329	
Panel Clip 022 (U)				
3/8” Phenolic Composite				
	Normal	**225**	**166**	
	Seismic	**299**	**221**	
Panel fastener – (4) #8 x 3/8 in machine screws				
	Normal	225	166	
	Seismic	598	221	
Panel Clip 022 (U)				
5/16” Phenolic Composite				
	Normal	**225**	**166**	
	Seismic	**299**	**221**	
Panel fastener – (4) #8 x 3/8 in machine screws				
	Normal	225	166	
	Seismic	598	221	
Panel Clip 022 (U)				

CONNECTION SUMMARY

ELEMENT	**Calculated Load Capacity Between Elements** PULLOUT (lbs)	SHEAR (lbs)	CLIP SHEAR (lbs)
Panel Clip 022 (U)			320 Normal 425 Seismic
Horizontal Mounting Rails FM-621 (U)			164 Normal (2) #8 218 Seismic(2) #8 190 Normal (2) #10 252 Seismic (2) #10
Midwall Clip GEN-014 (U)			82 Normal 109 Seismic 95 Normal #10 126 Seismic #10
Edge Trim Rails : FM-602 (U), WCS-161 (U), WCS-160 (U) Edge Trim, SHA-101 (U),Vertical Joint, SHA-612 (U)			82 Normal 109 Seismic
Corner Rails SHA-140 (U), SHA-130 (U), SHA-139 (U), SHA-131 (U)			164 Normal 218 Seismic

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Edge Trim Rails , Midwall Clips	**Normal**	**85**	**194**
	Seismic	**113**	**258**

Backing – 20 ga (39 mil) Cold Formed Steel Stud Wall // Fasteners - #10 self-drilling screw

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Horizontal Joint Rails, Corner Rails	Normal	170	388
	Seismic	226	516

Backing – 20 ga (39 mil) Cold Formed Steel Stud Wall // Fasteners – (2) # 10 x self-drilling screws

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Edge Trim Rails , Midwall Clips	Normal	150	250
	Seismic	200	332

Backing – Reinforced Concrete Masonry (CMU) // Fasteners – 1/4 x 1-1/2 in TITEN TTN CMU Screw

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Horizontal Joint Rails, Corner Rails	Normal	300	500
	Seismic	400	664

Backing – Reinforced Concrete Masonry (CMU) // Fasteners – (2) 1/4 x 1-1/2 in TITEN TTN CMU Screw

MATERIAL PROPERTIES: Material property allowable stresses that follow are for normal duration of load. For Seismic Loads; these values are increased by 1/3 (1.33), except for Modulus of Elasticity "E".

ALUMINUM ALLOY FOR EXTRUDED MIDWALL CLIP RAILS, HORIZONTAL EDGE RAILS, VERTICAL EDGE RAILS, AND CORNER EDGE RAILS

Values are for extruded Aluminum alloy 6063-T5, no welds or welded joints, as per the Aluminum Association, Inc, datasheet available on www.matweb.com

SG = 2.7	Specific Gravity	DD = 168.5 pcf	Dry Density

Design Working Stress (normal loading conditions)

F_v = 17 ksi	Horizontal Shear stress	F_b = 12 ksi	Bending Stress
F_y = 21 ksi	Tensile (yield) strength	F_p = 8 ksi	Bearing stress
E = 10×10^3 ksi	Modulus of Elasticity		

ABS – ACRYLONITRILE BUTADIENE STYRENE for EXTRUDED PANEL CLIPS

Values are for extruded ABS, datasheet available on www.matweb.com

SG = 1.2	Specific Gravity
DD = 74.8 pcf	Dry Density

Design Working Stress (normal loading conditions)

F_v = 17 ksi	Horizontal Shear stress
F_y = 6 ksi	Tensile (yield) strength
F_b = 9.3 ksi	Bending Stress
F_p = 6.8 ksi	Bearing stress: estimated (0.6)(F_v)
E = 0.3×10^3 ksi	Modulus of Elasticity

3M Scotch Weld EPOXY ADHESIVE – DP 420 Black (3 -5 mil thick, 0.003-0.005 in on prep. surface)

FS = Factor of Safety, per ICC / CBC.

F_v = 112 psi	Horizontal Shear stress (overlap shear = 450 psi on ABS, FS = 4)
Fp = 15 PIW	Peel Strength (Pounds Per Inch of Width = 60 lbs, FS = 4)

COLD FORMED GALVANIZED STEEL WALL FRAMING (Wall partitions; sill plate, wall studs & top plates)

Values per AISI Specification – Prescriptive Method – 2004 Commentary

Galvanized cold formed steel framing – 20 gauge (39 mil) = 0.396 in thick
22 gauge (33 mil) = 0.336 in thick

SG = 7.9	Specific Gravity	DD = 490 pcf	Dry Density

Design Working Stress (normal loading conditions)

F_y = 33 ksi	Yield Strength	E = 29×10^3 ksi	Modulus of Elasticity

SOLID PHENOLIC COMPOSITE WALL PANELS -- 5/16 in, 3/8 in, & 1/2 in thicknesses.
Values for allowable stresses as per Material Property Data Sheets available online for phenolic wall panels fabricated for interior applications comprised of 5/16 in or 3/8 in thicknesses.

SG = 1.42 Specific Gravity DD = 88.3 pcf Dry Density

Design Working Stresses (for normal loading conditions)

F_b =	12.0 ksi	Bending (Flexural) Stress
F_c =	6.0 ksi	Compression stress [estimated @ (0.6)(F_t)]
F_v =	4.06 ksi	Horizontal Shear stress [estimated @ (0.4)(F_t)]
F_t =	10.1 ksi	Tensile strength
E =	1.3 x 10^3 ksi	Modulus of Elasticity
	450 lbs	Pullout strength/screw [(2000 N / 4.448 lb per N) @ 0.24 in depth]

Unit Dead Load (DL) Weights of Panel Materials:
5/16 in thick Phenolic = 2.30 PSF = [88.3 pcf x (0.3125 in / 12 in per ft)].
3/8 in thick Phenolic = 2.76 PSF = [88.3 pcf x (0.375 in / 12 in per ft)].
1/2 in thick Phenolic = 3.68 PSF = [88.3 pcf x (0.50 in / 12 in per ft)].
3/8 in thick Tempered Glass = 4.76 psf = [152.3 pcf x (0.375 in / 12 in per ft)].

ABS - ACRYLONITRILE BUTADIENE STYRENE for EXTRUDED PANEL CLIPS:
Material data are average values as reported in datasheet available on www.matweb.com
Calculated Shear assumes #8 fastener transfers load to Clips and Rails.

PANEL CLIP (022 (U)
Shear Allowable, normal, per fastener, **Panel clips**
94 lbs = (0.164 in) (0.125)(4.6 ksi)(1000 lbs/k)
Shear Allowable, normal, per connection, Panel clips (4 fasteners / connection)
377 lbs = (4)(0.164 in) (0.125)(4.6 ksi)(1000 lbs/k)
Seismic Shear Allowable load/connection on Panel clip
501 lbs = (377)(1.33) lbs,

PANEL CLIP (022 (U)
Shear Allowable from epoxy adhesive, normal, per clip,
Shear - Normal Loads - Panel clips
470 lbs = (1.4 in) (3 in)(112 psi)
Seismic Shear Allowable load/connection on Panel clip
625 lbs = (470)(1.33) lbs,

Peeling Strength (Tension on adhesive) , normal per connection per clip
Normal Allowable Tension = 21.6 lbs = (1.44 in)(15 PIW).
Seismic Allowable Tension = 28.7 lbs = (1.44)(15 PIW)(1.33).

Maximum applied loads for wall (vertical) applications:
28.4 lbs vertical DL, 62.4 lbs seismic horizontal for 5.67 sq.ft. of tributary area. Horizontal rails are spaced at 34 in oc vertical maximum and 24 in oc horizontally. Due to limitations on epoxy adhesive for peel strength, in order to not exceed allowable loads per connection, we need to adjust panel clip spacing for tempered glass systems to reduce the applied load per connection.
To accomplish this, panel fasteners for tempered glass panels will require additional horizontal rails between the 34 in oc spacing. Use 17 in oc vertical spacing and space panel clips 16 in oc.
New tributary area = 1.88 sq.ft.

For vertical wall conditions:

$$\text{Applied normal tension} = 9.4 \text{ lbs} = \frac{1.88}{5.67}(28.4 \text{ lbs}) < 21.6 \text{ lbs allowable at new connection spacing.}$$

$$\text{Applied seismic tension} = 20.7 \text{ lbs} = \frac{1.88}{5.67}(62.4 \text{lbs}) < 28.7 \text{ lbs allowable at new connection spacing.}$$

For sloping conditions:

$$\text{Allowable normal} = \frac{1.88}{5.67}(36.2 \text{ lbs}) = 12.0 \text{ lbs} < 21.6 \text{ lbs at new connection spacing for glass panels.}$$

$$\text{Allowable seismic} = \frac{1.88}{5.67}(72.2 \text{lbs}) = 23.9 \text{ lbs} < 28.7 \text{ lbs at new connection spacing for glass panels.}$$

ALLOWABLE SHEAR - ALUMINUM ALLOY EXTRUDED CLIPS AND RAILS SUBJECT TO LOADS:
Extruded Aluminum Alloy clip & rail material: Alloy 6063-T5, no welds or welded joints, as per the Aluminum Association, Inc, datasheet available on www.matweb.com

EDGE TRIM RAILS
Edge Mounting Rail FM-602 (U)
Wainscot Cap, WCS-161 (U)
Wainscot Clip, WCS-160 (U)
Edge Trim, SHA-101 (U)
Vertical Joint, SHA-612 (U)

Shear Allowable, normal, Edge Trim Rails per connection
82 lbs = (0.164 in)(0.0625)(8 ksi)(1000 lbs/k)
Seismic allowable shear load/connection on Edge rails
109 lbs = (1.33)(82 lbs).

CORNER RAILS:
Inside Corner, SHA-140 (U)
Outside Corner Radius, SHA-130 (U)
Outside Corner Mitered, SHA-139 (U)
Outside Corner Square, SHA-131 (U)

Shear, normal allowable, Corner Rails (2 fasteners per connection)
164 lbs = (2) (0.164 in)(0.0625)(8 ksi)(1000 lbs/k)
Shear, seismic allowable shear load/connection on Edge Trim & /Corner rails
218 lbs = (1.33)(164 lbs).

HORIZONTAL JOINT RAILS Horizontal Mounting Rail, FM-621 (U)

Shear, normal allowable, per connection, Horizontal Joint Rails (2 fasteners / connection)
164 lbs = (2)(0.164 in)(0.0625)(8 ksi)(1000 lbs/k)
Shear, seismic allowable per connection, Horizontal Mounting Rails
218 lbs = (2)(1.33)(0.164 in)(0.0625)(8 ksi)(1000 lbs/k)

MID-WALL CLIP (GEN-014)
82 lbs = Shear Allowable, normal, per connection, Mid-wall Clip = (0.164 in)(0.0625)(8 ksi)(1000 lbs/k)
109 lbs = Seismic Shear, per connection, Mid-wall Clip = (1.33)(0.164 in) (0.0625)(8 ksi)(1000 lbs/k)

FASTENERS - ALLOWABLE TENSION & SHEAR : CONCRETE MASONRY UNIT (CMU) SCREWS
1/4 in dia. Simpson TITEN Concrete &Masonry Screws (TTN). Material: Heat Treated Carbon Steel
Florida FL 2355.1 Report: Allowable tension / screw = 740 lbs. Allowable Shear / screw = 1242 lbs.
Using Factor of safety of 5.0 for installations under IBC.
Normal load tension / screw = 150 lbs. Seismic allowable tension / screw = 200 lbs = (150)(1.33) lbs.
Normal load shear / screw = 250 lbs Seismic allowable shear / screw = 332 lbs = (150)(1.33)lbs.
Using one 1/4 in dia, 1-1/2 in long screw / connection of clip rails or edging to wall backing (1-1/4 in embedment in CMU :
150 lbs = Tension, Normal Allowable load (pullout) / connection
200 lbs = Tension, Seismic Allowable load (pullout) / connection
250 lbs = Shear, Normal Allowable load / connection
332 lbs = Shear, Seismic Allowable load / connection

FASTENERS – SELF DRILLING TAPPING SCREWS – SCREW CAPACITY IN 20 GA STEEL WALL FRAMING.
AISI STANDARD "Commentary on the Standard for Cold-Formed Steel Framing -Prescriptive Method ", 2001 Edition, with2004 Supplement. Given below is Table C-B1, from Section B, "CONNECTIONS",

Table C-B1
Minimum Allowable Fastener Capacity for Steel-to-Steel Connections
[Safety factor = 3.0]

Screw Size	Minimum Shank Diameter (inch)	Minimum Head Diameter (inch)	Minimum Capacity (lbs)			
			Shear Capacity		Pullout Capacity	
			43 mils[1]	33 mils[1]	43 mils[1]	33 mils[1]
#8	0.164	0.322	244	164	94	72
#10	0.190	0.384	263	177	109	84

For SI: 1 inch = 25.4 mm, 1 lb = 4.448 N.
[1] The value represents the smaller thickness of two pieces of steel being connected.
From the values given in Table C-B1 above:

ALLOWABLE LOADS PER SCREW:
One #8 screw, set in 22 ga (33 mil) steel stud framing has:
Allowable normal load tension (pullout) of 72 lbs. Allowable seismic tension =97.8 lbs = (1.33) (72 lbs).
Allowable normal load shear of 164 lbs. Allowable seismic shear = 218.1 lbs = (1.33) (164 lbs)
Similarly, one #8 screw set in 20 ga (39 mil) steel stud framing, interpolating for thickness, we get:
Tension, normal allowable load (pullout) of 85.1 lbs = (39 mil / 33 mil) (72 lbs).
Tension, seismic allowable = 113.2 lbs = (1.33) (85.3 lbs).
Shear, normal allowable load of 193.8 lbs = (39 mil / 33 mil)(164 lbs),
Shear, seismic allowable = 257.8 lbs = (1.33) (193.8 lbs),
Similarly, one #10 screw set in 20 ga (39 mil) steel stud framing, interpolating for thickness, we get:
Tension, normal allowable load (pullout) of 99.3 lbs = (39 mil / 33 mil) (84 lbs).
Tension, seismic allowable = 132 lbs = (1.33) (99.3 lbs).
Shear, normal allowable load of 209.2 lbs = (39 mil / 33 mil)(177 lbs),
Shear, seismic allowable = 278 lbs = (1.33) (209.2 lbs),

ALLOWABLE LOADS - ONE #8 SCREW PER CONNECTION (20 ga):
Tension, normal allowable load (pullout)/connection = 85.1 lbs.
Tension, seismic allowable / connection = 113.2 lbs.
Shear, normal allowable load / connection = 193.8 lbs,
Shear, seismic allowable / connection = 257.7 lbs,

ALLOWABLE LOADS - ONE #10 SCREW PER CONNECTION (20 ga):
Tension, normal allowable load (pullout) / connection = 99.3 lbs.
Tension, seismic allowable /per connection = 132 lbs.
Shear, normal allowable load /connection = 209.2 lbs,
Shear, seismic, allowable /connection = 278 lbs,

FASTENER ALLOWABLE TENSION & SHEAR OF FASTENERS : MACHINE SCREWS
ALLOWABLE TENSION & SHEAR – WORKING STRENGTH & SHANK DIAMETER:
#8x32 machine screws for this connection are per the requirements of ANSI & ASME Standards.
Use FS = 4 for working strength of screws in material and for capacity based upon fastener strength.
Machine screws based upon ASME B 1.1, with tensile strength of 60 ksi, #8-32 has a capacity of 850 lbs.
Allowable screw tension based upon screw tensile strength = 212.5 lb working strength.

Tensile Strength of screws = 60 ksi. Shank diameter = 0.164 in.
Tension allowable / screw = 850 lbs. Using Factor of safety of 4.0.
Tension, normal working load per screw = 212.5 lbs = 850/4.
Tension, Seismic load allowable per screw = 282.6 lbs = (212.5)(1.33) lbs.
Shear, normal working load per screw = 127.0 lbs = (212.5)(0.6) lbs
Shear, seismic load allowable per screw = 169.5 lbs = (282.6)(0.6)lbs.

When we use four #8 x 32 screws, per connection :
Tension, normal allowable load (pullout)/connection = 850 lbs = (212.5 lbs) (4)
Tension, seismic allowable/connection = 1130.4 lbs = (282.6 lbs) (4)
Shear, normal allowable load / connection = 508 lbs = (127 lbs) (4)
Shear, seismic allowable load / connection = 676 lbs = (169 lbs) (4)

TENSION CAPACITY (PULLOUT) OF MACHINE SCREWS IN PHENOLIC COMPOSITE PANELS:
Screw pullout capacity in phenolic panels is based upon Material Property Data Sheets.
Pan head machine #8 -32 screw @ 450 lb pullout capacity for 0.236 in depth. [2000 N / 4.448 lb per N)]
Allowable screw tension based upon phenolic panel material = 112.5 lb working strength.

Effective thread length in screw = (thread length) – (thickness of Midwall Clip GEN-002).
Effective thread length in screw for tension = 0.375 in = (0.50 in) – (0.125 in). 0.375 in > 0.236 in, OK.
Therefore, Allowable machine screw tension = 112.5 lb.

Normal Loads: Allowable tension per screw = 112.5 lbs
Allowable tension per connection = 450 lbs = (112.5 lbs / screw)(4 screws / connection).

Seismic Loads: Allowable tension per screw = 149.6 lbs = (1.33)(112.5 lbs),
Allowable tension per connection = 598.4 lbs = (4)(149.6 lbs)

SHEAR (Bearing)CAPACITY OF MACHINE SCREWS IN PHENOLIC COMPOSITE PANELS:
1/2 inch machine screw. Effective screw bearing length in 1/2 in Phenolic panel = 0.378 in
= (0.50 in) – (0.125 in) = (Panel thickness) – (Clip thickness).
Effective bearing area on Phenolic panel = 0.061 sq in = (0.164 in)(0.375 in).
Normal Loads: Allowable Bearing/screw on Phenolic panel = 61.9 lbs = (4060 psi/4) (0.061 sq in),
Seismic Loads: Allowable Bearing/screw on Phenolic panel = 82.3 lbs = (1.33)(61.9 lbs).

3/8 inch machine screw. Effective screw bearing length in 3/8 in Phenolic panel = 0.250 in
= (0.375 in) – (0.125 in) = (Screw length) – (Clip thickness).
3/8 inch machine screw. Effective screw bearing length in 5/16 in Phenolic panel = 0.250 in
= (0.375 in) – (0.125 in) = (Screw length) – (Clip thickness).

Effective bearing area on Phenolic panel = 0.041 sq in = (0.164 in)(0.250 in).
Normal Loads: Allowable Bearing/screw on Phenolic panel = 41.6 lbs = (4060 psi/4) (0.041 sq in),
Seismic Loads: Allowable Bearing/screw on Phenolic panel = 55.3 lbs = (1.33)(41.6 lbs).

ABS Panel Clip 022 (U) SHEAR (Bearing) CAPACITY OF MACHINE SCREWS) :
Using 1/2 inch or 3/8 inch long machine screws with the same diameter = 0.164 in.
Effective screw bearing length in 0.125 thick ABS panel clip = 0.125 in
Effective bearing area on ABS panel clip = 0.0205 sq in = (0.164 in)(0.125 in).
Normal Loads: Allowable Bearing/screw on panel clip = 34.9 lbs = (6800 psi/4) (0.0205 sq in),
Seismic Loads: Allowable Bearing/screw on panel clip = 46.3 lbs = (1.33)(34.9 lbs).

Using 4 screws / connection:
Shear, Normal allowable lateral load /connection = 139.6 lbs = (4) (34.9 lbs)
Shear, Seismic allowable lateral load /connection = 185.2 lbs = (4) (46.3 lbs).

ABS Panel Clip 022 (U) SHEAR CAPACITY OF EPOXY ADHESIVE ON PANEL CLIP :
Effective panel clip area loaded in shear = 0.125 in
Effective bearing area on ABS panel clip = 0.0205 sq in = (0.164 in)(0.125 in).
Normal Loads: Allowable Bearing/screw on panel clip = 34.9 lbs = (6800 psi/4) (0.0205 sq in),
Seismic Loads: Allowable Bearing/screw on panel clip = 46.3 lbs = (1.33)(34.9 lbs).

ABS Panel Clip 022 (U) TENSION (PULLOUT) CAPACITY OF EPOXY ADHESIVE ON PANEL CLIP :
Shear strength of Epoxy adhesive is (6.8 ksi.
0.11 sq. in = (0.29 in)(pi) (0.125 in) = Area in shear for screw heads to pull out of the clip.
Pullout capacity per screw of ABS clip = 126 lb = (4.6 ksi)(0.11 sq. in)(1000 psi/ksi)/4.
Pullout capacity per screw based upon phenolic panel allowable tension = 112.5 lbs.
Use tension capacity for screws based upon allowable tension of phenolic panel.

ABS Panel Clip 022 (U) TENSION (PULLOUT) CAPACITY OF CLIP MATERIAL :
Shear strength of ABS (6.8 ksi) is greater than the shear strength of Phenolic (4.06 ksi).
0.11 sq. in = (0.29 in)(pi) (0.125 in) = Area in shear for screw heads to pull out of the clip.
Pullout capacity per screw of ABS clip = 126 lb = (4.6 ksi)(0.11 sq. in)(1000 psi/ksi)/4.
Pullout capacity per screw based upon phenolic panel allowable tension = 112.5 lbs.
Use tension capacity for screws based upon allowable tension of phenolic panel.

SUMMARY: SHEAR CONNECTION CAPACITY OF MACHINE SCREWS IN PANELS, VARIOUS MATERIALS
The governing values for this connection will be the lowest values of the conditions given above.
Use for design the following allowable fastener / material shear loads for the machine screw connection:

Shear, Normal allowable lateral load /screw = 41.6 lbs,
Shear, Seismic allowable lateral load /screw = 55.3 lbs = (1.33)(41.6 lbs).

3/8 in or 5/16 in Phenolic Panel, Using (4) 3/8 in screws / connection:

Shear, Normal allowable lateral load /connection = 166.4 lbs,
Shear, Seismic allowable lateral load /connection = 221.3 lbs = (1.33)(166.4 lbs).

1/2 in Phenolic Panel, Using (4) 1/2 in screws / connection:

Shear, Normal allowable lateral load /connection = 247.6 lbs,
Shear, Seismic allowable lateral load /connection = 329.3 lbs = (1.33)(247.6 lbs).

ABBREVIATIONS / ACRONYMS

Abbreviation	MEANING
AF&PA	American Forest and Paper Association
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
ASD	Allowable Stress Design
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
AWC	American Wood Council
CBC	California Building Code
CONN	Connection
DIA	Diameter
DL	Dead Load
E	Modulus of Elasticity
ESR	Evaluation Service Report
FT	Foot or Feet
FS	Factor of Safety
GA	Gauge
IBC	International Building Code
ICC-ES	International Code Council – Evaluation Service, Inc.
IN	Inch or Inches
K	Kip or Kips (1000 pounds per kip)
KSI	Kips per Square Inch
LB	Pound or Pounds (weight or force)
LL	Live Load
LVL	Laminated Veneer Lumber
MDF	Medium Density Fiberboard
MIL	Mils or 1/1000 of an inch
MM	Millimeters
MPa	MegaPascals
N	Newtons
NDS-2005	National Design Specification for Wood Construction, 2005 edition
SG	Specific Gravity
PCF	Pounds per Cubic Foot
PSI	Pounds per Square Inch
PSF	Pounds per Square Foot
SG	Specific Gravity (relative to water where SG of water = 1.00)
SQ FT	Square Feet
SQ IN	Square Inches
STD	Standard Number
UBC	Uniform Building Code
WPS	Wall Panel Systems, Inc .

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