NOTES ON ANALYSIS, DESIGN METHOD, BUILDING CODE REFERENCES, AND ASSUMPTIONS.

The exterior phenolic panel siding system is classified under the International Building Code as a Non-Structural components and cladding assembly mounted upon weather-proofed structural building walls. Where applicable, analysis is performed for Allowable Stress Design methods under ASCE 7-10.

Cladding assemblies may be mounted on vertical or sloping walls, including horizontal soffits. Panel systems are evaluated for cladding on Risk Category I or II building structures, enclosed, for 115 mph ultimate wind (gust) wind speeds, for topography up to exposure C. Panel systems have been evaluated for wind zones 4 and 5 on building walls. Panel systems have not been evaluated for use on roofs. Panel systems may be applied to walls for buildings up to 60 feet in height, and for the most severe seismic locales, given that panel connections are evaluated with S_{DS} = 1.373.

Panel systems, if applications are being considered for use on Risk Category III or IV buildings, or for locales with more severe wind speeds or exposure categories, will require a separate engineering analysis to determine connection type, fastener spacing and other requirements to ensure proper and safe use of Wall Panel Systems products.

As such, the panel fastenings for systems analyzed in this document are limited to assemblies utilizing phenolic panel dimensions of up to 24 inches in width, and for panel lengths as needed by wall dimensions. Wall Panel Systems Flush Mounted phenolic composite panel siding is available and analyzed for the following thicknesses: 1/2 inch, 3/8 inch, & 5/16 inch. The Lapped Mounted Siding system is evaluated for 5/16 inch thickness panels only. Consult Wall Panel Systems for specialized analysis, connection type, fastener type and spacing for other widths, thicknesses, and configurations.

Aluminum extrusions connect panel horizontal edges at a maximum of 16 inches on center (o.c.), the nominal framing spacing for cold formed steel framed walls and for wood framed walls. These connections consist of an aluminum extrusion clip or rail that fastens to the wall substrate with a minimum of one fastening screw, as described later, depending upon the wall substrate material. The use of two screws per connection is for the 24 inch wide panel systems which require the use of two (2) screws at 16 inches o.c. to resist suction and prying action of screws from wind loads. Extrusion clips will need to be positioned over the underlying stud to ensure two screws fasten to each framing stud.

Panel horizontal edges are held in place with extruded aluminum clips and rails by tongue and groove connections. The vertical edges of panel assemblies are held in place by vertical edge extrusions fastened to the wall substrate. Extrusions are fastened to wall substrates of sheathed cold formed steel framing, structural wood framing, concrete (PCC) walls, or grouted concrete masonry unit (CMU) walls.

Extruded clips and rails use various fasteners to attach panel assemblies to structural wall substrates.

Self Drilling Self Tapping Steel (STSD) screws fasten aluminum extrusions to sheathed wall framing of cold formed structural steel.

Structural Wood Screws attach extrusions to sheathed wood wall framing.

Concrete or Masonry Screws of hardened steel are set in drilled holes to attach extrusions to concrete or masonry walls, respectively.

DECORATIVE EXTERIOR SYSTEM OF WALL SIDING from WALL PANEL SYSTEMS, INC. (WPS)
The exterior siding system analyzed herein is comprised of fabricated, textured, and colored siding of phenolic composites of varying thicknesses. Siding pieces are fabricated to dimensions to fit exterior wall length constraints as specified by the Architect of Record. Fabricated edges allow for lapped joints. Vertical siding edges may be constrained by edge rails at wall edges or with butted joints at board edges.

Extruded Aluminum alloy clips, brackets, and rails manufactured by Wall Panel Systems Inc. (WPS) are mounted on exterior wall substrates of wood framed structural walls, steel framed structural walls, concrete walls, masonry walls, non-structural exterior wall framing, and façade panels. Fasteners typically include commercially available stainless steel self-drilling self-tapping (STSD) screws for wood or steel framing, as appropriate. For masonry and concrete wall substrates fasteners include commercially available masonry and concrete screws. All connection fasteners evaluated are suggested fasteners that must meet minimum physical material specifications for strength, tension, shear, material type, and other physical characteristics as noted in the referenced ASTM standards.

Alternative fasteners proposed by others for use with WPS Systems must have appropriate and applicable ICC Evaluation Reports proving they are made of the appropriate corrosion resistant materials, are capable of withstanding the working stresses stated in the connection analyses herein, and meet the latest specified code requirements for exterior non-structural components and cladding. Material properties for WPS panels, extrusions, and suggested fasteners are referenced elsewhere in this document.

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 wind, seismic and gravity forces affecting typical wall panel assembly connections between the respective panel materials and the supporting partition walls or exterior curtain walls.

Siding System:
The decorative sheathing wall systems are not intended to provide structural support to the building being clad. They may be mounted on various exterior wall substrate materials. The architect of record or their consultant structural engineer is expected to account for and provide adequate design load capacity for all expected dead and live loads that may be experienced by structural elements and cladding of buildings providing support to WPS siding assemblies. WPS Panel Systems are expected to be fastened to the structural wall substrate at nominal 16 in oc stud spacing for steel or wood framed walls. Connection spacing to concrete or masonry walls may vary, but tributary loads are calculated on a 16 in oc horizontal spacing. Panel edges are also fastened to structural wall vertical and horizontal edges. The architect and engineer of record must provide adequate structural support to resist the imposed dead and lateral loads from cladding. These calculations are intended to demonstrate the panel assemblies are fastened and connected to the building wall elements in accordance with current building codes as non-structural decorative wall cladding.

Exterior wall backing may be of cold formed steel framing, together with other various wall sheathing materials that form a weather / moisture barrier. Sheathing may be laminated gypsum wall board, laminated treated wood sheathing, plywood with an exterior moisture membrane, or other sheathing manufactured with the intent to provide structural stiffness, create a moisture barrier, reduce thermal conductivity, and enhance energy conservation.

Panel assemblies may also be mounted on exterior solid grouted, reinforced concrete masonry unit (CMU) walls or upon exterior concrete curtain walls. Exterior walls and building façades are regarded as part of the building structure that supports the exterior siding. They are collectively known as backing or wall substrate. Decorative siding pieces are grouped in modular patterns, are assembled and fastened to a framework of extruded aluminum edge rails, mid-panel rails, mounting brackets, corner rails and clips. The panels and aluminum alloy framework is collectively fastened as an assembly to the partition wall backing.

Wall backing connections have been evaluated for vertical walls, and for sloping wall conditions for various slope angles, including horizontal soffit applications. For the analysis given, angles vary from 90^o (vertical or plumb walls) to 0^o (flat or horizontal soffits).

Connections between the siding pieces, aluminum components, and backing are made using various types of screw fasteners that may differ, depending upon the connection materials being fastened. Fasteners consist of stainless steel self-tapping screws, or structural wood screws, as appropriate. Attachment of panel assemblies to CMU and concrete wall backing is accomplished by use of concrete screws set in drilled holes. Attachment to backing with cold formed steel framing is done by self-drilling self-tapping screws. Fastening of aluminum components to each other and to WPS panels may also be done by other screw fasteners as noted or as mentioned elsewhere in this document.

Panel Connection Spacing:

Typical panel connection spacing to wall backing is given to occur at 16 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 24 inch o.c. maximum spacing for exterior wall sections more than 48 in (4ft) from edges and roof of building. Due to wind forces expected on exterior walls, horizontal fastener to backing connections are evaluated at 16 in oc maximum. Panel edge connections to wall panel occur at board edges, wall tops, bottoms and all vertical panel edges of partition walls.

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. Building Zones noted below refer to those wall and roof elements as given in the latest editions of the IBC and CBC.

2.67 sq.ft.= (Zone 5 or 4) Typical maximum tributary area edge/corner/conn.= $(24\text{ in})(16\text{ in})/(12\text{ in/ft})^2$.

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.

Phenolic Composite Panels - Dry Density = DD = 88.3 pcf

4.0 psf DL = 3.7 + 0.3 for 1/2 in thick, Nominal DL for wall panel assembly.
3.1 psf DL = 2.8 + 0.3 for 3/8 in thick, Nominal DL for wall panel assembly.
2.6 psf DL = 2.3 + 0.3 for 5/16 in thick, Nominal DL for wall panel assembly.

The above reflects an estimated 0.3 psf for aluminum alloy rails, clips, and fasteners for each system.

Therefore for system consistency we will analyze various connections based upon Panel Tributary DL. We will also analyze various connections using the maximum values each connection will likely support utilizing similarly sized fasteners for the various panel materials:

Tributary Dead Loads per panel connection to backing :

Using 2.67 sq. ft. maximum panel tributary areas per connection:
10.7 lbs = 1/2 in. Panel 16" oc horiz. conn. = (2.67 sq.ft)(4.0 psf)
8.3 lbs = 3/8 in. Panel 16" oc horiz. conn. = (2.67 sq.ft)(3.1 psf)
6.9 lbs = 5/16 in. Panel 16" oc horiz. conn. = (2.67 sq.ft)(2.6 psf)

24 inch wide panels of varying thickness, flush siding system, panel DL per connection to backing.

For a more universal application of these systems, we will evaluate fastener analysis per connection based upon 16 in oc horizontal connection spacing, and for both the 12 inch width and 24 inch width of phenolic panels.

10.7 lbs DL ; 1/2 in thick Panel.
8.3 lbs DL ; 3/8 in thick Panel.
6.9 lbs DL ; 5/16 in thick Panel.

24 inch wide panels, 5/16 in thickness, lapped siding system, panel DL per connection to backing.

6.9 lbs DL ; 5/16 in thick Panel.

Each panel assembly consists of Pre-fabricated siding boards supported on extruded aluminum alloy components forming a framework assembly, fastened to a wall substrate backing. The aluminum extrusions consist of panel clips, edge rails, and joint rails fastened to each board at its top panel edges, bottom panel edges, and at mid-panel with panel clips spaced at 16 inches o.c. In exterior applications where exterior cladding panels must contain air space due to fire requirements, ventilation, backing texture, shape, or another architectural need, the framework system of aluminum alloy clips and rails may include shims as needed to provide the minimum air space. Their effect is evaluated herein.

Extruded aluminum alloy components are connected to steel framed wall backing with self-drilling self-tapping screws conforming to AISI Standard 200 for connections to cold formed steel framing. Extrusions connected to wood framed wall backing are done with self-drilling wood screws conforming to National Design Specification for Wood Construction, 2005 edition (NDS-2005).

Alternative backing may include reinforced concrete masonry unit walls (CMU) or concrete walls or panels. In this case, extrusions are fastened to the CMU backing with hardened steel concrete screws set in drilled holes to the CMU or concrete wall backing. Fastener spacing evaluated and specified is intended to match that of the steel framed backing.

Aluminum alloy panel clips are connected to the modular panels with a tongue and groove slot configuration. The extrusion provides the tongue at the bottom rail. The panel boards provide the slots along panel horizontal joints and at the top of a wall panel array. The panel boards are slotted along the bottom edge and have a tongue at the top edge.

WPS Extruded Clips, Edge Rails, or Trim Rails on the Panel Flush Siding and Lap Siding Systems consist of:

Bottom Edge Rail	(LFS-901),
Horizontal Clip	(LFS-920),
Edge Trim Rail	(LFS-931),
Trim Cleat	(LPS-320),
Top Cap	(LFS-905).

WIND ANALYSIS per ASCE 7-10, Chapters 26, 27, 28, & 30; together with CBC Sec. 1609

Alternative All Heights Method to calculate design wind pressures

Lateral loads for out of plane wind forces are evaluated as normal to the wall panel face. Lateral analysis will be done under allowable stress design for non-structural components per CBC 2013.

Design Wind Load per ASCE 7-10 Sec 28.6.3, Simplified Design of Wind Pressures for simple Diaphragm Low-Rise Buildings.
Building Height (H) less than or equal to 60 ft,
Exposure C,
Basic Wind Speed = 115 mph.
Building Risk Category : Categories II, III & IV (Essential Facilities Hospitals, fire, police, emergency response facilities), or Category III (Assembly Buildings, Schools, non-essential utility buildings, jails, or detention facilities), or Category II (all other buildings not Category I, III, or IV). Category I buildings are light duty buildings.

Using CBC Eq. 16-35 (ASCE 7-10, Eq 30.3-1) for components and cladding :

p_{net} = (0.00256) (V^2)(K_z) (K_d) (C_{net})(K_{zt}), where

$+p_{net-5}$ = 32.5 psf = Positive wind pressure, zone 5 (positive pressure on corners & edges)

$-p_{net-5}$ = - 43.6 psf = Negative wind pressure, zone 5 (leeward or suction on corners & edges)

$+p_{net-4}$ = 32.5 psf = Positive wind pressure , zone 4 (wall interiors)

$-p_{net-4}$ = - 35.4 psf = Negative wind pressure, zone 4 (wall interiors)

V = 115 mph = Basic wind speed V_{ult}
K_z = 1.13
K_d = 0.85
K_{zt} = 1.0
$+C_{net-5}$ = + 1.00 positive pressure;
$-C_{net-5}$ = - 1.34 negative; Zone 5, (within 4 ft of building corners)
$+C_{net-4}$ = + 1.00 positive pressure;
$-C_{net-4}$ = - 1.09 negative; for Zone 4, (wall interior).

The above mentioned values govern over the minimum wind pressure referenced in the Code.
16 psf = Minimum design wind pressure for components & cladding per ASCE Sec. 30.2.2.

A_{ta} = 2.67 sq.ft. = 16 in x 24 in / $(12)^2$ sq. in. / sq. ft Zone 4 - Tributary area / connection, main wall.

A_{tc} = 2.67 sq.ft. = 16 in x 24 in / $(12)^2$ sq. in. / sq. ft Zone 5 - Area / connection, exterior wall, edges or corners.

Wind Design Load – Summary of Loads on components and cladding

Load Direction normal – out of plane loads - perpendicular to panel assembly, Wind positive or negative pressure.
Components and Cladding connections - panels to clips / rails to backing.

Wall Design Wind = (p_{net})(A_{tc})= Load on panel assembly & fasteners / connection at edges & corners of building.
Wall Design Wind = (p_{net})(A_{ta})= Load on panel assembly & fasteners / connection located mid wall of building.

86.8 lbs = Positive wind pressure – Zone 5 connection = (32.5)(2.67) Wind, 32.5 psf = Zone 5.

- 116.4 lbs = Negative wind pressure –Zone 5 connection = (-43.6)(2.67) Wind, - 43.6 psf = Zone 5.

86.8 lbs = Positive wind pressure – Zone 4 connection = (32.5)(2.67) Wind, 32.5 psf = Zone 4.

- 125.8 lbs = Negative wind pressure –Zone 4 connection = (-35.4)(2.67) Wind, - 35.4 psf = Zone 4.

Summary – 12 in wide panels (1.33) sq ft. tributary WIND - Tributary Loads per connection (lbs).
Out of Plane force, perpendicular to panel face.

Panel Thickness (in)	Zone 5 (lbs) Positive pressure Edge/Corners	Zone 5 (lbs) Negative pressure Edge/Corners	Zone 4 (lbs) Positive pressure Wall Interior	Zone 4 (lbs) Negative pressure Wall Interior
1/2	**43.2**	**-58.0**	**43.2**	**- 47.1**
3/8	**43.2**	**-58.0**	**43.2**	**- 47.1**
5/16	**43.2**	**-58.0**	**43.2**	**- 47.1**

Summary – 24 in wide panels (2.66) sq ft. tributary WIND - Tributary Loads per connection (lbs).
Out of Plane force, perpendicular to panel face.

Panel Thickness (in)	Zone 5 (lbs) Positive pressure Edge/Corners	Zone 5 (lbs) Negative pressure Edge/Corners	Zone 4 (lbs) Positive pressure Wall Interior	Zone 4 (lbs) Negative pressure Wall Interior
1/2	**86.8**	**-116.4**	**86.8**	**- 94.5**
3/8	**86.8**	**-116.4**	**86.8**	**- 94.5**
5/16	**86.8**	**- 116.4**	**86.8**	**- 94.5**

These values, when combined with dead loads for plumb and variable sloping wall conditions will exceed the values for a single fastener to resist the applied loads at 16 in oc. Therefore we will evaluate a connection for the 24 inch wide panels using a connection design to allow resistance to dead plus wind loads for 24 inch wide panels.

IBC 2012/CBC 2013 - OUT OF PLANE SEISMIC FORCE -Allowable Stress Design (ASD),
for vertical wall panel assembly attached to steel framed backing, 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 exterior wall elements and connections per ASCE 7-10 Sec. 13.5.3; & CBC 2013.

For 1/2 in. thick , 24 in. wide panels, evaluated for Siding Panel Connections per ASCE 7-10 Table 13.5-1:

a_p = 1.0 per Table 13.5-1 S_{DS} = 1.373 most severe locale W_p = 10.7 lb, Tributary DL (1/2 in. Panel)
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

Eq. 13.3-1 $F_p = 7.1 \text{ lbs} = \left[\dfrac{(0.4)(a_p)(S_{DS})(W_p)}{(R_p / I_p)}\right] [1 + (2)(Z/h)] = \dfrac{(5.9)}{(2.5)} [3]$

Eq. 13.3-2 **max. F_p = 23.5 lbs** = $(1.6)(S_{DS})(W_p)(I_p)$

Eq. 13.3-2 min. F_p = 4.4 lbs = $(0.3)(S_{DS})(W_p)(I_p)$

Therefore, F_p = 23.5 lbs = Panel Maximum Horizontal Out of Plane Seismic force / connection, perpendicular to panel face, from any direction.

Vertical Concurrent force = (DL) +/- [$(0.2)(S_{DS})(W_p)$] = (10.7 lb) +/- [2.9 lb per connection]

1/2 in. Panel - Vertical Concurrent (gravity + seismic) forces = 13.6 lb max, or 7.8 lb min.

1/2 in. thick panels, 24 inch wide panels, evaluated for Fastener Connections to steel framed backing per ASCE 7-10 Table 13.5-1:

Lateral loads for out of plane seismic forces are evaluated as normal to the wall panel face, and will be done under allowable stress design.

a_p = 1.25 per Table 13.5-1 S_{DS} = 1.373 most severe locale W_p = 10.7 lb, Tributary DL (1/2 in. Panel)
I_p = 1.0 per Sec.13.1.3, ASCE R_p = 1.0 per 13.5-1 ASCE Z_{max} = 12 ft h_{max} = 12 ft

Eq. 13.3-1 $F_p = 22.0 \text{ lbs} = \left[\dfrac{(0.4)(a_p)(S_{DS})(W_p)}{(R_p / I_p)}\right] [1 + (2)(Z/h)] = \dfrac{(7.3)}{(1.0)} [3]$

Eq. 13.3-2 **max. F_p = 23.5 lbs** = $(1.6)(S_{DS})(W_p)(I_p)$

Eq. 13.3-2 min. F_p = 4.4 lbs = $(0.3)(S_{DS})(W_p)(I_p)$

F_p = 10.9 lbs = This is the Fastener Maximum Horizontal Out of Plane Seismic force / connection, perpendicular to panel face, from any direction.

Vertical Concurrent force = (DL) +/- [$(0.2)(S_{DS})(W_p)$] = (10.7 lb) +/- [2.9 lb per connection]

1/2 in. Panel - Vertical Concurrent (gravity + seismic) forces = 13.6 lb max, or 7.8 lb min.

SEISMIC ANALYSIS, Continued:

1/2 in. thick panels, evaluated for Fastener Connections to CMU or concrete backing per ASCE 7-10 Table 13.5-1:
Lateral loads for out of plane seismic forces are evaluated as normal to the wall panel face, and will be done under allowable stress design. **We now will modify Equations 13.3-1, 13.3-2 , & 13.3-3 to include the effect of the over-strength factor (omega) upon various load combinations for fasteners anchored to CMU or concrete as per ASCE 7-10 Sec. 12.4.3.2.**

Modification being considered is to determine the most severe loading condition from load combinations 5, 6, & 8 of Sec. 2.4.1, ASCE 7-10.

5. (1+0.14 S_{DS})DL + 0.7(omega)(E) + H + F
6. (1+0.105 S_{DS})DL + 0.525(omega)(E) + H + F + 0.75L + 0.75 (L_r or S or R)
8. (0.6 - 0.14 S_{DS})DL + 0.7(omega)(E) + H .

In these equations, H, F, L_r, S, and R are zero. From Table 13.5-1, Omega = 1.5. Our equations then become:

5. (1+0.14 S_{DS}) DL + 0.7 (omega)(E)
6. (1+0.105 S_{DS}) DL + 0.525 (omega)(E)
8. (0.6 - 0.14 S_{DS}) DL + 0.7 (omega)(E).

Substituting:

5. [(1+ (0.14)(1.373)]D+0.7(1.5)(E) = **1.19 DL+1.05 E = 37.4 lbs** = (1.19)(10.7)+(1.05)(23.5)
6. [(1+ (0.105)(1.373)]DL+0.525(1.5)(E) = 1.14DL+0.79E = 30.7 lbs = (1.14)(10.7)+(0.79)(23.5)
8. [(0.6 – (0.14)(1.373)]DL + 0.7(1.5)(E) = 0.41 DL + 1.05 E = 29.1 lbs = (0.41)(10.7)+ (1.05)(23.5)

Load Combination 5 is the most severe condition, so substituting for W_P at the appropriate values:

W_p = **37.4 lbs = (1.19)(**10.7)(**1.05)(23.5)**

We now re-calculate Equations 13.3-1, 13.3-2 , & 13.3-3 to include the effect of the over-strength factor (omega).
a_p = 1.25 per Table 13.5-1 S_{DS} = 1.373 most severe locale **W_p = 37.4 lb, modified tributary DL (1/2 in. Panel)**
I_p = 1.0 per Sec.13.1.3, ASCE **R_p = 1.0 per Table 13.5-1 ASCE 7-10** Z_{max} = 12 ft h_{max} = 12 ft

Eq. 13.3-1 $$F_p = 77.0 \text{ lbs} = \left[\frac{(0.4)(a_p)(S_{DS})(W_p)}{(R_p / I_p)} \right] [1 + (2)(Z/h)] = \frac{(25.7)}{(1.0)} [3]$$

Eq. 13.3-2 **max. F_p = 82.2 lbs** = $(1.6)(S_{DS})(W_p)(I_p)$

Eq. 13.3-2 min. F_p = 15.4 lbs = $(0.3)(S_{DS})(W_p)(I_p)$

F_p = 82.2 lbs = The revised Fastener Maximum Horizontal Out of Plane Seismic force / connection, perpendicular to panel face, from any direction (masonry & concrete).

Vertical Concurrent force = (DL) +/- [$(0.2)(S_{DS})(W_p)$] = **(37.4 lb) +/- [10.3 lb per connection]**

1/2 in. Panel - Vertical Concurrent (gravity + seismic) forces = 47.7 lb max, or 27.1 lb min.

SUMMARY: 1/2 IN. PHENOLIC PANEL
Seismic Loads for panel connections in plumb (vertical) walls :
DL = 10.7 lbs, W_p = 23.5 lb, Vert. concurrent force = F_V = 13.6 lb max, or 7.8 lb min.

Seismic loads for fastener connections in masonry or concrete for plumb (vertical) walls :
Adj DL W_p = (37.4 lb), Horiz. max, F_p = 82.2 lbs., (37.4 lb) +/- [10.3 lb per connection]

SEISMIC ANALYSIS, Continued:
For 3/8 INCH THICK PANELS, evaluated for Siding Panel Connections per Table 13.5-1:

a_p = 1.0 per Table 13.5-1 S_{DS} = 1.373 most severe locale W_p = 8.3 lb, Tributary DL (3/8 in. Panel)
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

Eq. 13.3-1 F_p = 5.5 lbs $= \left[\dfrac{(0.4)(a_p)(S_{DS})(W_p)}{(R_p / I_p)} \right] [1 + (2)(Z/h)] = \dfrac{(4.6)}{(2.5)} [3]$

Eq. 13.3-2 **max. F_p = 18.2 lbs** $= (1.6)(S_{DS})(W_p)(I_p)$

Eq. 13.3-2 min. F_p = 3.4 lbs $= (0.3)(S_{DS})(W_p)(I_p)$

Therefore, F_p = 18.2 lbs = Panel 3/8 In Max. Horiz. Out of Plane Seismic Force / connection, perpendicular to panel face, from any direction.

Vertical Concurrent force = (DL) +/- [$(0.2)(S_{DS})(W_p)$] = W_p = 8.3 lb, +/- [2.3 lb per connection]
3/8 in Panel - Vertical Concurrent (gravity + seismic) forces = 10.6 lb max, or 6.0 lb min.

3/8 IN THICK PANELS, evaluated for Fastener Connections to steel framed backing per ASCE 7-10 Table 13.5-1:

a_p = 1.25 per Table 13.5-1 S_{DS} = 1.373 most severe locale W_p = 8.3 lb, Tributary DL (3/8 in. Panel)
I_p = 1.0 per Sec.13.1.3, ASCE R_p = 1.0 per 13.5-1 ASCE Z_{max} = 12 ft h_{max} = 12 ft

Eq. 13.3-1 F_p = 17.1 lbs $= \left[\dfrac{(0.4)(a_p)(S_{DS})(W_p)}{(R_p / I_p)} \right] [1 + (2)(Z/h)] = \dfrac{(5.7)}{(1.0)} [3]$

Eq. 13.3-2 **max. F_p = 18.2 lbs** $= (1.6)(S_{DS})(W_p)(I_p)$

Eq. 13.3-2 min. F_p = 3.4 lbs $= (0.3)(S_{DS})(W_p)(I_p)$

Therefore, F_p = 18.2 lbs = Panel 3/8 In Max. Horiz. Out of Plane Seismic Force / connection, perpendicular to panel face, from any direction.

Vertical Concurrent force = (DL) +/- [$(0.2)(S_{DS})(W_p)$] = W_p = 8.3 lb, +/- [2.3 lb per connection]
3/8 in Panel - Vertical Concurrent (gravity + seismic) forces = 10.6 lb max, or 6.0 lb min.

SEISMIC ANALYSIS, Continued:

Modifying Equations 13.3-1, 13.3-2, & 13.3-3 to include the effect of the over-strength factor (omega) upon various load combinations for fasteners anchored to CMU or concrete as per ASCE 7-10 Sec. 12.4.3.2.
In a similar analysis we evaluate 3/8 in panel assembly fasteners to steel framed backing, and
3/8 in. thick panel assembly fasteners to CMU or concrete backing per ASCE 7-10 Table 13.5-1:
Note that 3/8 in panels use steel framing backing fasteners (#10 x length varies SD-ST Stainless Steel Screws).

In a similar analysis evaluating 3/8 in thick panels, evaluated for Fastener Connections to CMU or concrete backing per ASCE 7-10 Table 13.5-1:

W_p = 29.0 lbs = (1.19)(8.3)+(1.05)(18.2)

a_p = 1.25 per Table 13.5-1 S_{DS} = 1.373 most severe locale **W_p = 29.0 lbs** , Tributary DL (3/8 in. Panel)
I_p = 1.0 per Sec.13.1.3, ASCE R_p = 1.0 per 13.5-1 ASCE Z_{max} = 12 ft h_{max} = 12 ft

Eq. 13.3-1 F_p = 59.7 lbs = $\left[\dfrac{(0.4)(a_p)(S_{DS})(W_p)}{(R_p / I_p)}\right][1 + (2)(Z/h)] = \dfrac{(19.9)}{(1.0)}[3]$

Eq. 13.3-2 max. F_p = 63.7 lbs = $(1.6)(S_{DS})(W_p)(I_p)$

Eq. 13.3-2 min. F_p = 11.9lbs = $(0.3)(S_{DS})(W_p)(I_p)$

F_p = 63.7 lbs = The revised Fastener Maximum Horizontal Out of Plane Seismic force / connection, perpendicular to panel face, from any direction (masonry & concrete).

Vertical Concurrent force = (DL) +/- [$(0.2)(S_{DS})(W_p)$] = **(29.0 lbs) +/- [8.0 lb per connection]**
3/8 in. Panel - Vertical Concurrent (gravity + seismic) forces = 37.0 lb max, or 21.0 lb min.

SUMMARY: 3/8 IN. PHENOLIC PANEL
Seismic Loads for panel connections in plumb (vertical) walls :
DL = 8.3 lbs, max. F_p = 18.2 lbs, Vert. concurrent force = 10.6 lb max, or 6.0 lb min.

Seismic loads for fastener connections in masonry or concrete for plumb (vertical) walls :
Adj DL W_p = 29.0 lbs , Horiz. max, F_p = 63.7 lbs., Vert. concurrent force = 37.0 lb max, or 21.0 lb min.

SEISMIC ANALYSIS, Continued:

BACKING FASTENER LOAD ANALYSIS – 5/16 inch thick composite panels :
FOR 5/16 INCH THICK panels, evaluated for Siding Panel Connections per Table 13.5-1:

a_p = 1.0 per Table 13.5-1 S_{DS} = 1.373 most severe locale W_p = 6.9 lb, Tributary DL (5/16 in. Panel)
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

Eq. 13.3-1 F_p = 4.5 lbs = $\left[\frac{(0.4)(a_p)(S_{DS})(W_p)}{(R_p / I_p)}\right][1+(2)(Z/h)] = \frac{(3.9)}{(2.5)}[3]$

Eq. 13.3-2 **max. F_p = 15.2 lbs** = $(1.6)(S_{DS})(W_p)(I_p)$

Eq. 13.3-2 min. F_p = 2.8 lbs = $(0.3)(S_{DS})(W_p)(I_p)$

Therefore, F_p = 15.2 lbs = Panel 3/8 In Max. Horiz. Out of Plane Seismic Force / connection, perpendicular to panel face, from any direction.

Vertical Concurrent force = (DL) +/- [(0.2)(S_{DS})(W_p)] = (6.9 lb) +/- [1.9 lb per connection]
5/16 in Panel - Vertical Concurrent (gravity + seismic) forces = 8.8 lb max, or 5.0 lb min.

5/16 IN THICK PANELS evaluated for Fastener Connections to steel framed backing per ASCE 7-10 Table 13.5-1:

a_p = 1.25 per Table 13.5-1 S_{DS} = 1.373 most severe locale W_p = 6.9 lb, Tributary DL (5/16 in. Panel)
I_p = 1.0 per Sec.13.1.3, ASCE R_p = 1.0 per 13.5-1 ASCE Z_{max} = 12 ft h_{max} = 12 ft

Eq. 13.3-1 F_p = 14.2 lbs = $\left[\frac{(0.4)(a_p)(S_{DS})(W_p)}{(R_p / I_p)}\right][1+(2)(Z/h)] = \frac{(4.7)}{(1.0)}[3]$

Eq. 13.3-2 **max. F_p = 15.2 lbs** = $(1.6)(S_{DS})(W_p)(I_p)$

Eq. 13.3-2 min. F_p = 2.8 lbs = $(0.3)(S_{DS})(W_p)(I_p)$

Therefore, F_p = 15.2 lbs = Panel 3/8 In Max. Horiz. Out of Plane Seismic Force / connection, perpendicular to panel face, from any direction.

Vertical Concurrent force = (DL) +/- [(0.2)(S_{DS})(W_p)] = (6.9 lb) +/- [1.9 lb per connection]
5/16 in Panel - Vertical Concurrent (gravity + seismic) forces = 8.8 lb max, or 5.0 lb min.

SEISMIC ANALYSIS, Continued:
Modifying Equations 13.3-1, 13.3-2, & 13.3-3 to include the effect of the over-strength factor (omega) upon various load combinations for fasteners anchored to CMU or concrete as per ASCE 7-10 Sec. 12.4.3.2.
In a similar analysis we evaluate 5/16 in panel assembly fasteners to steel framed backing, and
5/16 in. thick panel assembly fasteners to CMU or concrete backing per ASCE 7-10 Table 13.5-1:
Note that 5/16 in panels use steel framing backing fasteners (#10 x length varies SD-ST Stainless Steel Screws).

In a similar analysis evaluating 5/16 inch panel assembly fasteners to steel framed backing:
W_p = 24.2 lbs = (1.19)(6.9)+(1.05)(15.2 lb) = 1.19 DL+1.05 E

a_p = 1.25 per Table 13.5-1 S_{DS} = 1.373 most severe locale **W_p = 24.2 lbs**, Tributary DL (5/16 in. Panel)
I_p = 1.0 per Sec.13.1.3, ASCE R_p = 1.0 per 13.5-1 ASCE Z_{max} = 12 ft h_{max} = 12 ft

Eq. 13.3-1 $F_p = 49.8 \text{ lbs} = \left[\frac{(0.4)(a_p)(S_{DS})(W_p)}{(R_p / I_p)}\right][1 + (2)(Z/h)] = \frac{(16.6)}{(1.0)}[3]$

Eq. 13.3-2 **max. F_p = 53.2 lbs** = $(1.6)(S_{DS})(W_p)(I_p)$

Eq. 13.3-2 min. F_p = 10.0 lbs = $(0.3)(S_{DS})(W_p)(I_p)$

Vertical Concurrent force = (DL) +/- [$(0.2)(S_{DS})(W_p)$] = **(24.2 lbs) +/- [6.6 lb per connection]**
5/16 in. Panel - Vertical Concurrent (gravity + seismic) forces = 30.8 lb max, or 17.6 lb min.

SUMMARY: 5/16 in. Phenolic panel

Seismic Loads for panel connections in plumb (vertical) walls :
DL = 6.9 lbs, max. F_p = 15.2 lbs, Vert. concurrent force = 8.8 lb max, or 5.0 lb min.

Seismic loads for fastener connections in masonry or concrete for plumb (vertical) walls :
Adj DL W_p = 24.2 lbs, Horiz. max, F_p = 53.2 lbs., Vert. concurrent force = 30.8 lb max, or 17.6 lb min.

LATERAL FORCE SUMMARY –– WIND and SEISMIC –– 24 inch wide Panels

Out of Plane Loads (lbs) per connection

Loads calculated perpendicular to panel face on Vertical Panel Cladding and Components, unless noted otherwise.

WIND LOADS (max.)			SEISMIC LOADS Horizontal (F_P)			SEISMIC – Concurrent – Gravity+ Vertical (E_V)			
Panel thickness (in)	Zone 5 Edges Corners	Zone 4 Wall Interior	Panel steel Backing	Fastener steel Backing	Fastener CMU/Conc Backing	Steel Framing Backing Fasteners Maximum	Minimum	CMU - Concrete Backing Fasteners Maximum	Minimum
1/2	116.4*	94.5	23.5	23.5	82.2	13.6	7.8	47.7	27.1
3/8	116.4*	94.5	18.2	18.2	63.7	10.6	6.0	37.0	21.0
5/16	116.4*	94.5	15.2	15.2	53.2	8.8	5.0	30.8	17.6

* Wind zone 5 on building (within 4 ft of edges or corners) the horizontal connection spacing is at 12 in oc max. vertically along building height. Horizontal connections in the field are to be located at 16 in oc (stud spacing).

LATERAL FORCE SUMMARY –– WIND and SEISMIC –– 12 inch wide Panels

Out of Plane Loads (lbs) per connection

Loads calculated perpendicular to panel face on Vertical Panel Cladding and Components, unless noted otherwise.

WIND LOADS (max.)			SEISMIC LOADS Horizontal (F_P)			SEISMIC – Concurrent – Gravity+ Vertical (E_V)			
Panel thickness (in)	Zone 5 Edges Corners	Zone 4 Wall Interior	Panel steel Backing	Fastener steel Backing	Fastener CMU/Conc Backing	Steel Framing Backing Fasteners Maximum	Minimum	CMU - Concrete Backing Fasteners Maximum	Minimum
1/2	58.0*	47.1	11.6	11.6	40.6	6.8	3.8	23.6	13.4
3/8	58.0*	47.1	9.0	9.0	31.4	5.2	3.0	18.2	10.4
5/16	58.0*	47.1	7.7	7.7	27.0	4.5	2.5	15.7	8.9

* Wind zone 5 on building (within 4 ft of edges or corners) the horizontal connection spacing is at 12 in oc max. vertically along building height. Horizontal connections in the field are to be located at 16 in oc (stud spacing).

1/2 inch thick, **24 inch wide SLOPING PHENOLIC PANEL SIDING - APPLIED LOAD ANALYSIS**
Applied Loads per fastener, Dead Loads, DL + Seismic (Seismic), & DL + Wind (Wind)
Wind values are absolute values for the maximum wind for zones 4 & 5 (values in pounds).
Zone 5+, edges= 86.8 psf; **Zone 5 -, edges= - 116.4.** Zone 4+, field=86.8; **Zone 4 -, field= - 94.5**

		#10 Self Tapping Self Drilling Screw		**#12 Self Tapping Self Drilling Screw**		**# 10 Self drilling Wood Screw**		**1/4 in. dia. x 1-1/4 in Concrete/Masonry Screw**	
Wall Angle	**Load**	**Shear**	**Tension**	**Shear**	**Tension**	**Shear**	**Tension**	**Shear**	**Tension**
Degrees from level									
90	Normal	**10.7**	0	**10.7**	0	**10.7**	0	37.4	0
(Vert. Wall)	Seismic	13.6	23.5	13.6	23.5	13.6	23.5	47.7	82.2
	Wind, Z-4	10.7	94.5	10.7	94.5	10.7	94.5	37.4	94.5
	Wind, Z-5	10.7	116.4	10.7	116.4	10.7	116.4	37.4	116.4
70	Normal	10.0	3.7	10.0	3.7	10.0	3.7	35.1	12.8
	Seismic	20.8	30.1	20.8	30.1	20.8	30.1	72.9	93.6
	Wind, Z-4	10.1	98.2	10.1	98.2	5.0	48.9	35.1	107.3
	Wind, Z-5	10.1	120.1	10.1	120.1	10.1	120.1	35.1	129.2
60	Normal	9.3	5.4	9.3	5.4	9.3	5.4	32.4	18.7
	Seismic	23.5	**27.3**	23.5	**27.3**	23.5	**27.3**	82.4	95.0
	Wind, Z-4	9.3	99.5	9.3	99.5	9.3	99.5	32.4	113.2
	Wind, Z-5	9.3	121.8	9.3	121.8	9.3	121.8	32.4	135.1
45	Normal	7.6	7.6	7.6	7.6	7.6	7.6	26.4	26.4
	Seismic	26.2	26.2	26.2	26.2	26.2	26.2	91.9	91.9
	Wind, Z-4	7.6	95.1	7.6	95.1	7.6	95.1	26.4	120.9
	Wind, Z-5	7.6	124.0	7.6	124.0	7.6	124.0	26.4	142.8
30	Normal	5.4	10.1	5.4	10.1	5.4	10.1	18.7	32.4
	Seismic	**27.2**	23.5	**27.2**	23.5	**27.2**	23.5	**95.0**	82.4
	Wind, Z-4	5.4	103.8	5.4	103.8	5.4	103.8	18.7	126.9
	Wind, Z-5	5.4	125.7	5.4	125.7	5.4	125.7	18.7	148.8
0	Normal	0	10.7	0	10.7	0	10.7	0	37.4
(flat - Horiz.)	Seismic	23.5	13.6	23.5	13.6	23.5	13.6	82.2	47.7
	Wind, Z-4	0	**105.2**	0	**105.2**	0	**105.2**	0	**131.9**
	Wind, Z-5	0	**127.1**	0	**127.1**	0	**127.1**	0	**153.8**

1/2 inch thick, **12 inch wide SLOPING PHENOLIC PANEL SIDING - APPLIED LOAD ANALYSIS**
Applied Loads per fastener, Dead Loads, DL + Seismic (Seismic), & DL + Wind (Wind)
Wind values are absolute values for the maximum wind for zones 4 & 5 (values in pounds).
Zone 5+, edges=43.2 psf; **Zone 5-, edges= -58.0.** Zone 4+, field=43.2; **Zone 4-, field= -47.1**

		#10 Self Tapping Self Drilling Screw		#12 Self Tapping Self Drilling Screw		# 10 Self drilling Wood Screw		1/4 in. dia. x 1-1/4 in Concrete/Masonry Screw	
Wall Angle Degrees from level	**Load**	**Shear**	**Tension**	**Shear**	**Tension**	**Shear**	**Tension**	**Shear**	**Tension**
90	Normal	**5.3**	0	**5.3**	0	**5.3**	0	18.5	0
(Vert. Wall)	Seismic	6.8	11.6	6.8	11.6	6.8	11.6	23.6	40.6
	Wind, Z-4	5.3	47.1	5.3	47.1	5.3	47.1	18.5	47.1
	Wind, Z-5	5.3	58.0	5.3	58.0	5.3	58.0	18.5	58.0
70	Normal	5.0	1.8	5.0	1.8	5.0	1.8	17.4	6.3
	Seismic	8.9	12.7	8.9	12.7	8.9	12.7	36.1	46.2
	Wind, Z-4	5.0	48.9	5.0	48.9	5.0	48.9	17.4	53.4
	Wind, Z-5	5.0	59.8	5.0	59.8	5.0	59.8	17.4	64.3
60	Normal	4.6	2.7	4.6	2.7	4.6	2.7	16.0	9.3
	Seismic	10.4	**12.7**	10.4	**12.7**	10.4	**12.7**	40.7	47.0
	Wind, Z-4	4.6	49.8	4.6	49.8	4.6	49.8	16.0	56.4
	Wind, Z-5	4.6	60.7	4.6	60.7	4.6	60.7	16.0	67.3
45	Normal	3.7	3.7	3.7	3.7	3.7	3.7	13.1	13.1
	Seismic	12.0	12.0	12.0	12.0	12.0	12.0	45.4	45.4
	Wind, Z-4	3.7	50.8	3.7	50.8	3.7	50.8	13.1	60.2
	Wind, Z-5	3.7	61.7	3.7	61.7	3.7	61.7	13.1	71.1
30	Normal	2.7	4.6	2.7	4.6	2.7	4.6	9.3	16.0
	Seismic	**12.7**	10.4	**12.7**	10.4	**12.7**	10.4	**47.0**	40.7
	Wind, Z-4	2.7	51.7	2.7	51.7	2.7	51.7	9.3	63.1
	Wind, Z-5	2.7	62.6	2.7	62.6	2.7	62.6	9.3	74.0
0	Normal	0	5.3	0	5.3	0	5.3	0	18.5
(flat - Horiz.)	Seismic	11.6	6.8	11.6	6.8	11.6	6.8	40.6	23.6
	Wind, Z-4	0	**52.4**	0	**52.4**	0	**52.4**	0	**65.6**
	Wind, Z-5	0	**63.3**	0	**63.3**	0	**63.3**	0	**76.5**

INTERACTION ANALYSIS

1/2 inch, thick, 12 inch wide composite panels - Combined shear / tension.

Panel fasteners to backing connection is weakest connection by use of self-drilling, self tapping screws in cold formed steel backing.

Wind force acts perpendicular (out-of-plane) in tension on fastener – backing connection.

Gravity + vertical component of seismic force governs in shear. Wind governs tension.
Combined forces interaction for the limiting connection: Panel Fastener to backing.

#10 screw in steel 20 ga. backing. **Seismic shear = 278 lbs** = (1.33) (209.0 lbs),
Wind tension = 158 lbs = (1.6) (99 lbs).

#12 screw in steel 20 ga. backing. **Seismic shear = 298.6 lbs** = (1.33) (224.5 lbs),
Wind tension = 180 lbs = (1.6) (113 lbs).

#10 Screw:

V_a = 278 lbs = Allowable Maximum Seismic Shear / panel backing screw connection.
P_a = 158 lbs = Allowable Tension Wall Panel to Panel Fastener connection.
P_s = 76.5 lbs = Maximum Applied Wind out of plane tension per connection.
V_{G+S} = 23.6 lbs = Applied gravity + vertical seismic component per connection.

$$\frac{V_{G+S}}{V_a} + \frac{P_s}{P_a} = \frac{23.6}{278} + \frac{76.5}{158} = 0.08 + 0.48 = 0.57$$ **< 1.0, OK for #10 Screw**

#12 Screw:

V_a = 298 lbs = Allowable Maximum Seismic Shear / panel backing screw connection.
P_a = 180 lbs = Allowable Tension Wall Panel to Panel Fastener connection.
P_s = 76.5 lbs = Maximum Applied Wind out of plane tension per connection.
V_{G+S} = 23.6 lbs = Applied gravity + vertical seismic component per connection.

$$\frac{V_{G+S}}{V_a} + \frac{P_s}{P_a} = \frac{23.6}{298} + \frac{76.5}{180} = 0.08 + 0.43 = 0.50$$ **0.50 < 1.0, OK for #12 Screw**

Interaction Analysis indicates weakest connection link is adequate for most severe load condition (2012 IBC / 2013 CBC). This result also involves wind acting together with seismic, which is possible, but rare.

1/2 in thick, 12 inch wide COMPOSITE PANEL ANALYSIS OF WIND LOAD APPLIED causing prying action on fasteners joining panel clips to steel backing, Vertical Wall condition. Refer to connection drawing detail "F", Flush Siding System and Detail "E", Lapped Siding System.

½ inch panel, Flush Siding Condition, LFS-901 & LFS-920;

Horizontal joint detail and Edge bottom, Edge Detail, Horiz. (Out of plane) max. Force to wall fastener (1) self-drilling Self-tapping screw at steel stud, Zone 5, connection at backing

(76.5 lb)(1.125 in) / (0.677) = 127 lb tension in wall fastener < 134 lb wind allowable wind tension #10 SD ST Screw, O.K.

< 152 lb wind allowable #12 SD ST Screw, OK.

< 182 lb wind allowable for masonry screws, OK.

½ inch panel, Lap Siding Condition LFS-920 with ¼ inch shim ;

Horizontal joint detail and Edge bottom, Edge Detail, Horiz. (Out of plane) Max. Force to wall fastener (1) self-drilling Self-tapping screw at steel stud, Zone 5,

(76.5 lb)(1.43 in) / (0.677) = 161.5 lb tension in wall fasteners > 134 lb (#10), 152lb (#12) **N.G.** (1) #10 or (1)#12 Screw

< 268 lb wind allowable (2) #10 SDST Screws,O.K.

< 182 lb allowable for (1) masonry screw, OK.

12 inch Panels: For Zone 4 field connections or Zone 5 within 4 feet of building corner connections, prying action tension = 161.5 lbs > 268 lbs allowable, Use (2) #10 or (2) #12 SDST.

For CMU or concrete walls, use (2) ¼ in dia. x 1-1/4 in long Titen TTN Masonry Screws / connection.

INTERACTION ANALYSIS

1/2 inch, thick, 24 inch wide composite panels - Combined shear / tension.

Panel fasteners to backing connection is weakest connection by use of self-drilling, self tapping screws in cold formed steel backing.
Wind force acts perpendicular (out-of-plane) in tension on fastener – backing connection.
Gravity + vertical component of seismic force governs in shear. Wind governs tension.
Combined forces interaction for the limiting connection: Panel Fastener to backing.

#12 screw in steel 20 ga. backing. Seismic shear = 298.6 lbs = (1.33) (224.5 lbs),
Wind tension = 180 lbs = (1.6) (113 lbs).

#10 Screw:

V_a = 278 lbs = Allowable Maximum Seismic Shear / panel backing screw connection.
P_a = 158 lbs = Allowable Tension Wall Panel to Panel Fastener connection.
P_s = 153.8 lbs = Maximum Applied Wind out of plane tension per connection.
V_{G+S} = 47.7 lbs = Applied gravity + vertical seismic component per connection.

$$\frac{V_{G+S}}{V_a} + \frac{P_s}{P_a} = \frac{47.7}{278} + \frac{153.8}{158} = 0.17 + 0.97 = \mathbf{1.14} > \mathbf{1.0}$$
NG, Try #12 Screw

#12 Screw:

V_a = 298 lbs = Allowable Maximum Seismic Shear / panel backing screw connection.
P_a = 180 lbs = Allowable Tension Wall Panel to Panel Fastener connection.
P_s = 153.8 lbs = Maximum Applied Wind out of plane tension per connection.
V_{G+S} = 47.7 lbs = Applied gravity + vertical seismic component per connection.

$$\frac{V_{G+S}}{V_a} + \frac{P_s}{P_a} = \frac{47.7}{298} + \frac{153.8}{180} = 0.16 + 0.85 = \mathbf{1.01} > \mathbf{1.0}$$
NG, Try (2) #12 Screws

(2) #12 Screws:

V_a = 596 lbs = Allowable Maximum Seismic Shear / panel backing screw connection.
P_a = 360 lbs = Allowable Tension Wall Panel to Panel Fastener connection.
P_s = 153.8 lbs = Maximum Applied Wind out of plane tension per connection.
V_{G+S} = 47.7 lbs = Applied gravity + vertical seismic component per connection.

$$\frac{V_{G+S}}{V_a} + \frac{P_s}{P_a} = \frac{47.7}{596} + \frac{153.8}{360} = 0.08 + 0.43 = \mathbf{0.51} < \mathbf{1.0}$$
OK for (2) #12 Screws

Check (2) #10 Screws:

V_a = 556 lbs = Allowable Maximum Seismic Shear / panel backing screw connection.
P_a = 316 lbs = Allowable Tension Wall Panel to Panel Fastener connection.
P_s = 153.8 lbs = Maximum Applied Wind out of plane tension per connection.
V_{G+S} = 47.7 lbs = Applied gravity + vertical seismic component per connection.

$$\frac{V_{G+S}}{V_a} + \frac{P_s}{P_a} = \frac{47.7}{556} + \frac{153.8}{316} = 0.09 + 0.49 = 0.58 < 1.0$$ **OK for (2) #10 Screws**

Interaction Analysis indicates weakest connection link is adequate for most severe load condition (2012 IBC / 2013 CBC). This result also involves wind acting together with seismic, which is possible, but rare.

1/2 in thick, <u>24 inch wide</u> COMPOSITE PANEL ANALYSIS OF WIND LOAD APPLIED For Zone 5, corner & field connections, prying action causing prying action on fasteners joining panel clips to steel backing, Vertical Wall condition.
Refer to connection drawing detail "F", Flush Siding System and Detail "E", Lapped Siding System.

½ inch panel, Flush Siding Condition, LFS-901 & LFS-920;
Horizontal joint detail and Edge bottom, Edge Detail, Horiz. (Out of plane) max. Force to wall fastener (2) self-drilling Self-tapping screws at steel stud, Zone 5, connection at backing

$$\frac{(153.8 \text{ lb})(1.125 \text{ in})}{(0.677)} = 255.6 \text{ lb tension in wall fastener}$$

< 268 lb wind allowable wind tension (2) #10 SD ST Screws, O.K.
< 360 lb wind allowable (2) #12 SD ST Screws, OK.
< 364 lb wind allowable for masonry screws, OK.

½ inch panel, Lap Siding Condition LFS-920 with ¼ inch shim ;
Horizontal joint detail and Edge bottom, Edge Detail, Horiz. (Out of plane) Max. Force to wall fastener (1) self-drilling Self-tapping screw at steel stud, Zone 5,

$$\frac{(153.8 \text{ lb})(1.43 \text{ in})}{(0.677)} = 324.9 \text{ lb tension in wall fasteners}$$

> 268 lb (2) #10 SDST, **NG**
< 360 lb wind allowable (2) #12 SDST Screws, OK.

< 364 lb allowable for (2) masonry screws, OK.

For 24 inch wide panels Zone 4, field connections, or Zone 5 within 4 feet of building corner connections, prying action tension = 324 lbs < 360 lbs allowable, Use (2) #12 SDST

For CMU or concrete walls, use (2) ¼ in dia x 1-1/4 in long Titen TTN Masonry Screws / connection.

CONNECTION SUMMARY **Calculated Load Capacity Between Elements**

ELEMENT		TENSION (pullout) (lbs)	SHEAR (lbs)
Horizontal & Bottom Rails,			
	Normal	99	209
	Seismic	112	278
	Wind	158	n/a

Fastener: ONE #10, self-drilling screw in Backing – 20 ga (39 mil) Cold Formed Steel Stud Wall

ELEMENT		TENSION (pullout) (lbs)	SHEAR (lbs)
Horizontal & Bottom Rails,			
	Normal	198	418
	Seismic	224	556
	Wind	316	n/a

Fastener- TWO #10, self-drilling screws in Backing – 20 ga (39 mil) Cold Formed Steel Stud Wall

ELEMENT		TENSION (pullout) (lbs)	SHEAR (lbs)
Horizontal & Bottom Rails,			
	Normal	113	224
	Seismic	151	298
	Wind	180	n/a

Fastener: ONE #12, self-drilling screw in Backing – 20 ga (39 mil) Cold Formed Steel Stud Wall

ELEMENT		TENSION (pullout) (lbs)	SHEAR (lbs)
Horizontal & Bottom Rails,			
	Normal	226	448
	Seismic	302	596
	Wind	360	n/a

Fasteners: TWO #12, self-drilling screws in Backing–20 ga (39 mil) Cold Formed Steel Stud Wall

CONNECTION SUMMARY (Continued) **Calculated Load Capacity Between Elements**

ELEMENT		TENSION (pullout) (lbs)	SHEAR (lbs)
Horizontal & Bottom Rails,			
	Normal	137	124
	Wind/Seismic	182	165

Fasteners – ONE ¼ inch diameter x 1-1/4 inch long TITEN TTN STAINLESS STEEL CMU Screw to Backing of Reinforced Concrete or Solid Grouted Masonry (CMU).

ELEMENT		TENSION (pullout) (lbs)	SHEAR (lbs)
Horizontal & Bottom Rails,			
	Normal	274	248
	Wind/Seismic	364	330

Fasteners – TWO ¼ inch diameter x 1-1/4 inch long TITEN TTN STAINLESS STEEL CMU Screws to Backing of Reinforced Concrete or Solid Grouted Masonry (CMU).

ELEMENT		TENSION (pullout) (lbs)	SHEAR (lbs)
Horizontal & Bottom Rails,			
One SD10 x 2-1/2 in DF backing	Normal	173	215
	Wind/Seismic	230	286
One SDWH 0.195 x 3 in DF backing	Normal	265	285
	Wind/Seismic	362	379
(2) SD10 x 2-1/2 in DF backing	Normal	346	430
	Wind/Seismic	460	572
(2) SDWH 0.195 x 3 in DF backing	Normal	530	570
	Wind/Seismic	724	758

Fasteners:
Cold Formed, Heat Treated, Galvanized Steel Self-Drilling Screws manufactured by Simpson Strong-Tie Company.
Backing: sheathing covered structural wood studs of Douglas Fir (DF) / Southern Pine (SP).
Wood backing structural framing consists of solid sawn lumber or engineered lumber (LVL, PSL, or LSL), and weather protected structural panels of plywood, OSB or other weatherproof coated sheathing.

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 PANEL CLIPS, 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_y = 21 ksi — Tensile (yield) strength
F_b = 12 ksi — Bending Stress
F_p = 8 ksi — Bearing stress
E = 10 x 10^3 ksi — Modulus of Elasticity

COLD FORMED GALVANIZED STEEL WALL FRAMING (Wall partitions; sill plate, wall studs & top plates)
Values per AISI Standard for Cold Formed Steel Framing – Prescriptive Method – 2015 Edition, a revision of AISI S230-07 with supplements 2 and 3 (Reaffirmed 2012), with 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 x 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 1/4 in, 5/16 in, 3/8 in, or 1/2 in thicknesses.

SG = 1.42 — Specific Gravity
DD = 88.3 pcf — Dry Density

Design Working Stresses (for normal loading conditions)E

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 = 10.15 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]

5/16 in thick Panel Dead Load (DL) = 2.30 PSF = [88.3 pcf x (0.3125 in / 12 in per ft)].
3/8 in thick Panel Dead Load (DL) = 2.76 PSF = [88.3 pcf x (0.375 in / 12 in per ft)].
1/2 in thick Panel Dead Load (DL) = 3.68 PSF = [88.3 pcf x (0.50 in / 12 in per ft)].

ASTM A510, AISI GRADE 1018 CARBON STEEL, MATERIAL OF SIMPSON SD & SDWH STRUCTURAL WOOD SCREWS

SG = 7.87 Specific Gravity
DD = 490 pcf Dry Density
Design Working Stress (normal loading conditions)
F_v = 17 ksi Horizontal Shear stress
F_y = 46 ksi Tensile (yield) strength
F_b = 27 ksi Bending Stress
F_p = 9.2 ksi Bearing stress
E = 29×10^3 ksi Modulus of Elasticity
Datasheet available on www.matweb.com

FASTENERS: ALLOWABLE TENSION & SHEAR :

BACKING FASTENERS TO EXTRUSIONS
MASONRY SCREWS, HARDENED CARBON STEEL, FASTENING TO CONCRETE MASONRY AND CONCRETE
SELF-DRILLING TAPPING SCREWS, CONFORMING TO AISI S200, FASTENING TO STEEL FRAMED BACKING
SIMPSON STRONG TIE STRUCTURAL WOOD SCREWS, PER NDS-2005, ICC ESR-3046, AND IAPMO ER 0192

ALUMINUM ALLOY EXTRUDED CLIPS AND RAILS ALLOWABLE SHEAR:

Bottom Edge Rail (LFS-901),
Horizontal Clip (LFS-920),
Edge Trim Rail (LFS-931),
Trim Cleat (LPS-320),
Top Cap (LFS-905).

Clip and rail material: Extruded Aluminum alloy 6063-T5, no welds or welded joints, as per the Aluminum Association, Inc, datasheet available on www.matweb.com

FASTENERS - ALLOWABLE TENSION & SHEAR : CONCRETE MASONRY UNIT (CMU) SCREWS
1/4 in dia. X 1-1/4 In long Simpson TITEN Concrete & Masonry Screws (TTN). Material: Heat Treated Grade 410 Stainless Steel
Florida FL 2355.1 Report: Ultimate tension / screw = 548 lbs. Ultimate Shear / screw = 496 lbs. Using Factor of safety of 4.0 for installations under IBC.

Normal load tension / screw = 137 lbs. Seismic / Wind allowable tension / screw = 182 lbs = (137)(1.33) lbs.
Normal load shear / screw = 124 lbs Seismic / Wind allowable shear / screw = 165 lbs = (124)(1.33)lbs.
Use one 1/4 in dia, 1-1/4 in long screw / connection of clip rails or edging to backing (1 in embedment in CMU :
137 lbs = Tension, Normal Allowable load (pullout) / connection
182 lbs = Tension, Seismic / Wind Allowable load (pullout) / connection
124 lbs = Shear, Normal Allowable load / connection
165 lbs = Shear, Seismic / Wind Allowable load / connection

FASTENERS – SELF DRILLING, SELF TAPPING SCREWS – SCREW CAPACITY IN 20 GA STEEL WALL FRAMING.
AISI STANDARD S100 – 2007-S2-10 Supplement No. 2 to the North American Specification for Design of Cold Formed Steel Structural Members, Feb. 2010 edition."

Fu_2 = 45 ksi = tensile strength and Fy = 33 ksi per ASTM A-653 SS, Gr 33. Omega = 3.0

Allowable Fu_2 = 33.75 ksi = (0.75) (45 ksi) **Allowable Tension $T_S = (A_g)(R)$**

Area of section = A_{g10} = thickness x diameter = 0.036 x 0.19 = 0.0068 in^2 for #10 screw.

A_{g12} = thickness x diameter = 0.039 x 0.216 = 0.0078 in^2 for #12 screw.

Per Section 4.1.1, **T_S / omega = R = Allowable Tension in screw (lbs).**

Allowable Tension #10 = T_{S10} = 83 lb = (0.0074)(33.75)(1000 lb/kip) / 3

Allowable Tension #12 = T_{S10} = 95 lb = (0.0084)(33.75)(1000 lb/kip) / 3

Comparing the tension / screw below:

From "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**
#12	0.215	*0.446*	*282*	*190*	*124*	***96***

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.
Values in italics are extrapolated values from those of #8 & #10 fasteners.
Standard Steel Studs: 22 ga (0.033), **20 ga (0.039)**, 18 ga(.048)

From the values given in Table C-B1 above:

ALLOWABLE LOADS PER SCREW:
One #10 screw set in 20 ga (39 mil) steel stud framing,
Normal tension (pullout) 99 lbs = (39 mil / 33 mil)(84) lbs.
Seismic tension = 112 lbs = (1.33) (84 lbs).
Normal load shear of 209.2 lbs = (39 mil / 33 mil)(177 lbs),
Seismic shear = 278 lbs = (1.33) (209.2 lbs),
Wind tension = 158 lbs = (1.6) (99 lbs).

Similarly, one #12 screw set in 20 ga (39 mil) steel stud framing,
Normal load tension (pullout) of 113 lbs = (39/33)(96) lbs.
Seismic tension = 150.9 lbs = (1.33) (113.5 lbs).
Normal load shear of 224.5 lbs = (39 mil / 33 mil)(190 lbs),
Seismic shear = 298.6 lbs = (1.33) (224.5 lbs),
Wind tension = 180 lbs = (1.6) (113 lbs).

STRUCTURAL WOOD SCREWS: FASTENER ALLOWABLE TENSION and SHEAR– Loads per fastener.
SD Screw Data per ICC ESR-3046 for Cold Formed, Heat Treated, Galvanized Steel Self-Drilling Screws as manufactured by Simpson Strong-Tie. Material conforming to ASTM A510, AISI Grade 1018 Steel.
SDWH Screw Data per IAPMO Evaluation Report ER-0192 (Jan 2014) for Cold Formed, Heat Treated, Dowel Threaded, Carbon Steel Self-Drilling Screws as manufactured by Simpson Strong-Tie. Material conforming to ASTM A510, AISI Grade 1018 Steel.

Wood Backing Structural Framing to consist of solid sawn lumber or engineered lumber (LVL, PSL, or LSL), and structural panels of plywood or OSB, in accordance with ANSI/AWC National Design Specification for Wood Construction (NDS – 2005, or later edition) and with the Plywood Design Specification, PS-1, 1997, as per the American Plywood Association (APA).

Fastener	Backing: Spruce-Pine-Fir (SPF) / Hem Fir (HF)				Backing: Douglas Fir (DF) / Southern Pine (SP)			
	SHEAR		TENSION (Pullout)		SHEAR		TENSION (Pullout)	
	Normal	Seismic/Wind	Normal	Seismic/Wind	Normal	Seismic/Wind	Normal	Seismic/Wind
SD 9 x 2-1/2	**112**	**149**	**122**	**162**	**200**	**266**	**173**	**230**
SD10 x 2-1/2	**165**	**219**	**122**	**162**	**215**	**286**	**173**	**230**
SDWH 0.195 x 3	**230**	**306**	**180**	**239**	**285**	**379**	**265**	**362**
SDWH 0.195 x 4	**330**	**439**	**350**	**465**	**370**	**492**	**455**	**605**

ABBREVIATIONS / ACRONYMS

Abbreviation	MEANING
AF&PA	American Forest and Paper Association
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
APA	American Plywood Association
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
IAPMO	International Association of Plumbing and Mechanical Officials
IBC	International Building Code
ICC-ES	International Code Council – Evaluation Service, Inc.
IN	Inch or Inches
K	Kip or Kips (1000 pounds per kip)
KM	Kilometers
KSI	Kips per Square Inch
LB	Pound or Pounds (weight or force)
LL	Live Load
LVL	Laminated Veneer Lumber
M	Meters
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
SEC	Section Number
SG	Specific Gravity (relative to water where SG of water = 1.00)
SQ IN	Square Inches
STD	Standard Number
UBC	Uniform Building Code
USD	Ultimate Stress Design
WPS	Wall Panel Systems, Inc .

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American Iron and Steel Institute (AISI)–S 202-11, Standard Practice for Cold Formed Steel Framing (CFSF), 2011
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American Plywood Association (APA) – Plywood Design Specification, PS-1, 1997
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American Forest & Paper Association/ American Wood Council, (AFPA/AWC) 2005 National Design Specification for Wood Construction- (NDS)
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ICC Evaluation Service Inc. ICC-ESR-2196, Hilti Kwik Pro Self Drilling Screws
ICC - ES Inc. ICC-ESR-3046, Simpson SD Cold Formed Heat Treated, Galvanized Structural Wood Screws
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