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TECHNICAL NOTE

On Cold-Formed Steel Construction

CFSEI COLD-FORMED STEEL ENGINEERS INSTITUTE

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DIAPHRAGM DESIGN WITH PNEUMATICALLY DRIVEN PINS

This Technical Note updates and replaces LGSEA Technical Note 561c

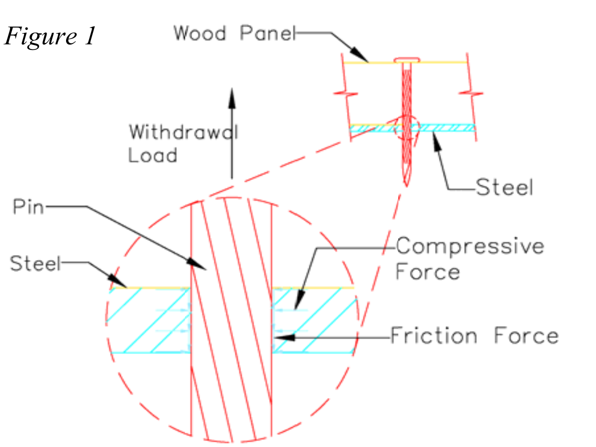
Summary: Wood based panels for shear walls and horizontal diaphragms have traditionally been attached to cold formed steel framing using self-drilling, tapping screws. With the introduction of pneumatic nailing systems, wood based panels can now be fastened to steel in a manner similar to which panels have been nailed to wood framing in the past. Information on specifications, selection, and field inspection of pneumatic drive pins is contained in Technical Note F300-09. This Technical Note contains procedures for the design of floor and roof diaphragms over cold-formed steel (CFS) framing using pneumatically driven pins.

INTRODUCTION

The use of air driven fasteners, called pins, for fastening into relatively thick steel, 68 mil to 3/8", has been common in commercial construction for over 20 years. The predecessor of the International Code Council (ICC), the International Conference of Building Officials (ICBO), first recognized the use of such pins in horizontal diaphragms and shear walls constructed with minimum 68 mil steel supports in 1986. Pins currently being used for CFS framing are smaller in diameter than pins used for thicker steel. These pins are installed using hand held pneumatic tools, similar to the air nailers that are used in traditional wood framed construction.

A typical pin fastener installation detail for cold formed steel is shown in Figure 1. Please refer to Technical Note F300-09 (*Pneumatically Driven Pins for Wood Based Panel Attachment*) for a more thorough discussion of pin selection, installation and inspection.

Figure 1



Pneumatically driven pins are proprietary products that have unique characteristics and performance capabilities that vary by manufacturer. Variations can be found in head sizes, shank characteristics, and the length, diameter, and point of the pin. For this reason, the designer should consult individual pin manufacturers for design values for their specific products. Pin manufacturers publish design values for their own products, typically in a format similar to nailing schedules.

DESIGN EXAMPLE

To illustrate the use of pneumatically driven pins in the design of diaphragms, a simple one-story building with wind shear loads is discussed below.

The example illustrates the procedure for determining horizontal plywood diaphragm attachment to CFS roof joists or CFS roof trusses using pneumatic drive pins. Although the example is based on the design data of one company's product, similar data from other pin manufacturers (as referenced in this document) may also be used. The reader is advised that the tables in this Technical Note are excerpted from the referenced International Code Council Evaluation Service (ICC-ES) reports and may not contain all the information necessary for proper design. Individual reports contain tables for other design conditions. Complete Evaluation Reports should be obtained for the manufacturer's pin to be specified. Contact ICC-ES at (562) 699-0543 or www.icc-es.org for the specific reports referenced in this Technical Note.

HORIZONTAL DIAPHRAGM ATTACHMENT

Diaphragm dimensions: 48 ft x 24 ft
Loads: wind load of 200 plf (25 psf x 16' tall wall x 1/2)
Support members: 33 mil steel, 1-5/8" flanges, 3-1/2" web, minimum yield strength 33ksi, spacing 24" o.c.
Panels: 1/2" thick, Structural I plywood
k value for fastener slip: 310 $lbs/in^{1/3}$ for 33 mil steel, per manufacturer

Determine: 1. Pin fastening pattern
2. Diaphragm deflection

At the time of this note's publication, all pin manufacturers' reports for horizontal diaphragm design are Legacy Reports based on the 1997 Uniform Building Code (UBC) and allowable strength design (ASD). ASD will be used for the design example.

From Table 2, use the first line for Structural I panels, minimum 3/8" thick and 1-1/2" frame width, blocked diaphragm, fasteners spaced 4" o.c. at diaphragm boundaries, 6" o.c. at other plywood edges, and 12" o.c. along intermediate framing members. The allowable shear load is 225 plf which exceeds the design shear load of 200 plf. The fastener spacing and diaphragm configuration is shown in Figure 2. Use 33 mil strapping, minimum 1-1/2" wide for shear transfer, as required by the manufacturers' evaluation report.

Calculate diaphragm deflection , Δ, using International Building Code (IBC) equation 23-1:

$$\Delta = \frac{5VL^3}{8EAb} + \frac{VL}{4Gt} + 0.188Le_n + \frac{\Sigma(\Delta_c X)}{2b}$$

- $\frac{5VL^3}{8EAb}$ — bending deflection
- $\frac{VL}{4Gt}$ — shear deflection
- $0.188Le_n$ — deflection due to pin slip
- $\frac{\Sigma(\Delta_c X)}{2b}$ — deflection due to chord splice slip

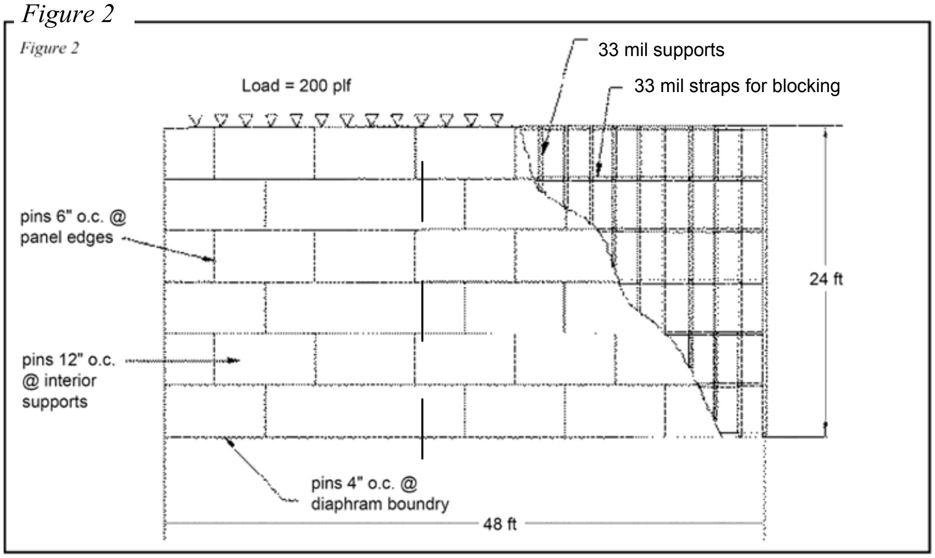


Figure 2

where V = shear = 200 plf
L = diaphragm length = 48 ft
b = diaphragm width = 24 ft
A = area of chord cross section = 0.2049 in^2 (net area from AISI S100-07)
E = elastic modulus of chords = 29,500,000 psi
G = shear modulus of webs = 90,000 psi (plywood)
t = effective plywood thickness = 0.535 in (UBC Standard 23-2, Tables 23-2-H and 23-2-I)
e_n= pin deformation, (inches) at load per pin on perimeter of interior panel

$$e_n = \left[\frac{\text{load per fastener}}{k}\right]^3$$

$$= \left[\frac{200\text{plf} \div 2\ \text{pins/ft}}{310\ \text{lbs/in}^{1/3}}\right]^3$$

$$= 0.0336\ \text{in}$$

$\Sigma(\Delta_c x)$ =sum of individual chord splice slip values on both sides of the diaphragm, each multiplied by its distance (ft) to the nearest support. Assume negligible for spliced steel studs.

$$\Delta = \frac{(5)(200)(48)^3}{(8)(29500000)(0.2049)(24)} + \frac{(200)(48)}{(4)(90000)(.535)} +$$

$$0.188(48)(0.0336) + 0 = 0.4483\text{in.}$$

This deflection value can be used to check diaphragm rigidity, and to model the stiffness of building systems when pin-fastened plywood diaphragms are used. Although section 1613.6.1 of the IBC and section 12.3.1.1 of ASCE 7 permit many wood-sheathed diaphragms to be idealized as flexible, many lateral force resisting systems require a more detailed analysis of the load distribution to the shearwalls. This deflection value may be used to check diaphragm stiffness in accordance with ASCE 7 section 12.3. It must be noted that AISI has published deflection equation D2.1-1 in AISI S213 for use with horizontal diaphragms with cold formed steel supports. This equation is based on performance of #8 screws. In order to use the AISI equation with pins, manufacturers of propriety pin fasteners must develop a similar equation with terms appropriate for their specific products.

Table 1

ALLOWABLE SHEAR FOR WIND OR SEISMIC FORCES (plf) FOR HORIZONTAL PLYWOOD DIAPHRAGMS WITH STEEL FRAMING AND 0.100" DIAMETER PINS [1,2,8]

PLYWOOD GRADE	MINIMUM UNCOATED STEEL THICKNESS (inches) [3,4,5]	MINIMUM PANEL THICKNESS (inches)	BLOCKED DIAPHRAGM PIN SPACING (inches) [6,7]				UNBLOCKED DAPHRAGM PIN SPACING (inches) [6,7]	
			Pin spacing at diaphragm boundaries (all cases), at continuous panel edges parallel to load (cases 3 and 4) and at all panel edges (cases 5 and 6)				Pins spaced 6 inches maximum at supported edges.	
			6	4	2 ½	2	Case 1 (no unblocked edges or continuous joints parallel to load)	All other configura-tions (cases 2, 3, 4, 5. and 6)
			Pin spacing at other panel edges					
			6	6	4	3		
Structural I	0.0359 0.0598	7/16 15/32	185 205	280 305	420 460	475 520	185 205	140 150
Grades other than Structural I	0.0359 0.0598	7/16 15/32	165 185	250 275	380 415	430 470	165 185	125 140

For SI: 1 inch = 25.5mm, 1 pound/linear foot = 14.6 N/m

1. These values are for short-time loads imposed by wind and must be reduced 25% for normal loading.
2. The pin shall be long enough to penetrate through the thickness of the steel a minimum of 1/4 inch.
3. The minimum width of framing is 1-1/2 inches.
4. Base metal thickness of steel (without coatings) is from research on material that may not match currently available framing thicknesses. Tabulated values are minimums; thicker steel may be used.
1. These shear values also apply to framing made of thicker steel.
2. Spacing of fasteners along intermediate framing members is 12 inches on center.
3. The minimum panel edge distance is 3/8 inch.
4. Please refer to ICC Evaluation Report ER-5667, re-issued December 1, 2002 for additional information.

Table 2

ALLOWABLE SHEAR VALUES (plf) FOR HORIZONTAL PLYWOOD DIAPHRAGMS WITH MIMIMUM 33 mil or 27 mil STEEL FRAMING AND 0.100" DIAMETER PINS [1,2,3,7,8]

PANEL	MINIMUM PANEL THICK-NESS (inch)	FRAMING		BLOCKED DIAPHRAGM FASTENER SPACING [4,5]				UNBLOCKED[4]	UNBLOCKED[4]
		Thickness (inches)[6]	Minimum Flange Width (inches)	Pin spacing at diaphragm boundaries (all cases), at continuous panel edges parallel to load (cases 3 and 4) and at all panel edges (cases 5-6)					
				6	4	2 ½	2		
				Pin spacing at other panel edges					
				6	6	4	3	Case 1	Cases 2-6
Structural I	3/8	0.0275	1 ½ 2 ½	165 190	225 250	335 375	445 500	150 165	110 125
		0.0333	1 ½ 2 ½	200 225	270 300	400 450	535 600	180 200	135 150
SHEATHING, other grades covered in doc PS1 or PS2	3/8	0.0275	1 ½ 2 ½	150 170	200 225	300 340	400 450	135 150	100 115
		0.0333	1 ½ 2 ½	180 205	240 270	360 405	480 540	160 180	120 135

For SI: 1 inch = 25.5mm, 1 pound/linear foot = 14.6 N/m

1. Values are for loads imposed by wind or earthquake and must be reduced 25% for normal loading
2. The pin must be long enough to penetrate through the metal framing a minimum of 1/4 inch.
3. The minimum panel edge distance is 3/8 inch.
4. For fastener spacing and case descriptions, see 1997 UBC Table 23-II-H
5. Spacing of fasteners along intermediate framing members is 12 inches on center.
6. Base metal thickness of steel (without coatings) is from research on material that may not match currently available framing thicknesses. Tabulated values are minimums; thicker steel may be used.
7. Shear capacities in this table are limited by steel thickness; use of thicker wood panels does not increase the allowable shear values.
8. Please refer to ICC ES evaluation report ER-4144, reissued June 1, 2008, for additional information and design values for thicker steel supports.

Table 3

ALLOWABLE SHEAR FOR WIND OR SEISMIC FORCES (plf) FOR STRUCTURAL PLYWOOD HORIZONTAL DIAPHRAGMS SUPPORTED BY STEEL FRAMING WITH PLYWOOD FASTENERS[1,7]

SHEATHING PANEL	MINIMUM PANEL THICKNESS (inch)	SUPPORTING STEEL MEMBER FLANGE DIMENSIONS		BLOCKED DIAPHRAGMS				UNBLOCKED DIAPHRAGMS	
		Width (inches)	Minimum Thickness (Inches)[6]	Fastener Spacing at Diaphragm Boundaries (all cases), at Continuous Panel Edges Parallel to Load (Cases 3 and 4) and at All Panel Edges (Cases 5 and 6)[2,3,4,5]				Nails Spaced 6 Inches Maximum at Supported Edges	
				6	4	2 ½	2	Case 1 (no unblocked edges or continuous joints to load)	All Other Cases (Cases 2 through 6)
				Fastener Spacing at Other Panel Edges					
				6	6	4	3		
Structural I or Rated sheathing	3/8	1.5	0.0299	202	270	405	459	180	135
	3/8	2.5		227	303	455	515	202	152
	15/32	1.5		191	255	382	433	170	127
	15/32	2.5		215	286	430	487	191	143
	3/8	1.5	0.0359	202	270	405	459	180	135
	3/8	2.5		227	303	455	515	202	152
	15/32	1.5		234	313	469	531	208	156
	15/32	2.5		263	351	527	597	234	176

1. These values are for short-time loads due to wind or earthquake and must be reduced 25% for normal loading.
2. The pin must be long enough to penetrate through the metal framing a minimum of 1/4 inch.
3. Fasteners are spaced a maximum of 12 inches on center along intermediate framing members.
4. Tabulated values allow for a maximum of 20 percent of the fasteners to be overdriven more than 1/16 inch.
5. Framing is permitted to be oriented in either direction for diaphragms, provided sheathing is design for vertical loads.
6. Base metal thickness of steel (without coatings) is from research on material that may not match currently available framing thicknesses. Tabulated values are minimums; thicker steel may be used.
7. Please refer to ICC ES evaluation report ER-5380, reissued July 1, 2008, for additional information and design values for thicker steel supports.

References

1. AISI (2007). *North American Specification for the Design of Cold Formed Steel Structural Members*, 2007 Edition. (AISI S100-07). American Iron and Steel Institute (AISI), Washington, DC.
2. ASCE (2009). *Minimum Design Loads for Buildings and Other Structures*. ASCE 7-10. American Society of Civil Engineers. Reston, VA.
3. ICBO (1997) *Uniform Building Code* (UBC), 1997 edition. International Council of Building Officials (ICBO), Whittier, CA.
4. ICC (2009). *International Building Code* (IBC), 2009 edition. International Code Council, Washington, DC.

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