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TECHNICAL NOTE
On Light Gauge Steel Construction

LGSEA

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DIAPHRAGM DESIGN WITH PNEUMATICALLY DRIVEN PINS

Summary: Wood based panels for shear wall and horizontal diaphragms have traditionally been attached to light gauge 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* 561b. This *Technical Note* contains procedures for the design of connections using pneumatically driven pins.

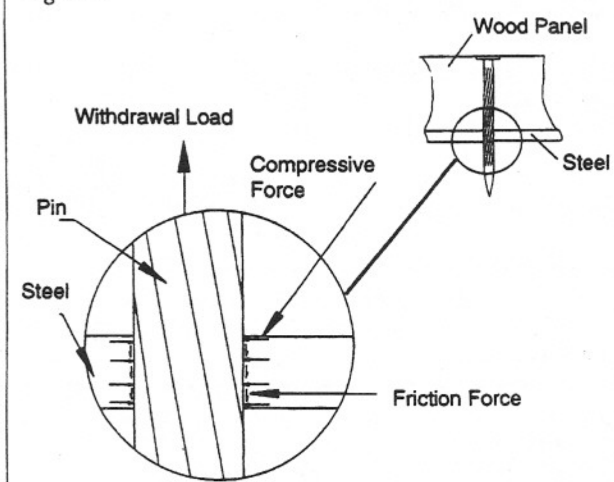
Introduction

The use of air driven fasteners, called pins, for fastening into relatively thick steel, 68 mils (14 ga.) to 3/8" has been common in commercial construction for about 15 years. ICBO ES first recognized the use of such pins in horizontal diaphragms and shear walls constructed with minimum 68 mils steel supports in 1986. Pins currently being used for cold formed steel framing are smaller in diameter to 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 Tech Note 561b (*"Pneumatically Driven Pins for Wood Based Panel Attachment"*) for a more thorough discussion of pin selection, installation and inspection.

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.

Figure 1



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 steel studs using pneumatic drive pins. This is similar to the design procedure for shear wall calculations.

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 Tech Note are excerpted from the referenced ICBO ES and NER reports, and may not contain all the information necessary for proper design. Complete Evaluation reports should be obtained for the manufacturer's pin to be specified. Contact ICBO ES at (562) 699-0543 (or www.icbo.org) for the specific reports referenced in this Technical Note. As of this writing, copies of National Evaluation Service reports can be obtained by calling (205) 599-9800.

HORIZONTAL DIAPHRAGM ATTACHMENT

Diaphragm dimensions: 48 ft x 24 ft
Loads: wind shear load of 200 plf

Support members: 33 mil (20 ga.) 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 for 33 mil steel, per manufacturer

Determine: 1. Pin fastening pattern
2. Diaphragm deflection

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 (20 gauge) strapping, minimum 1-1/2" wide for shear transfer, as required by the manufacturers research report.

Calculate diaphragm deflection , Δ =

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

- $\frac{5VL^3}{8EAb}$ — 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

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 Prescriptive Method)
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, 1994, Table 23-2-1)
e_n = pin deformation, in. at load per pin on perimeter of interior panel

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

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

$$= 0.0336 \text{ in}$$

$\Sigma(\Delta_c x)$ = 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.

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

$$0.188(48)(0.0336) + 0$$

Therefore, the calculated diaphragm deflection for this design example is: $\Delta = 0.4483$in.

Figure 2

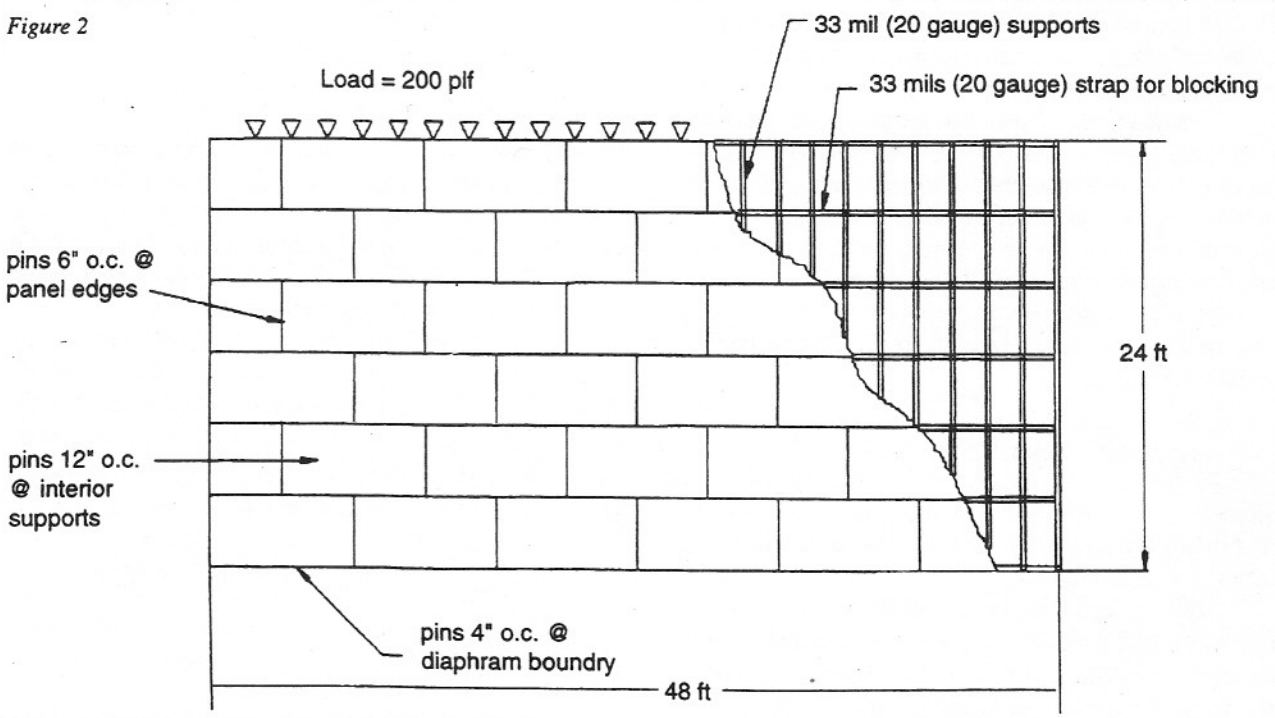


Table 1 ALLOWABLE SHEAR VALUES (plf) FOR HORIZONTAL PLYWOOD DIAPHRAGMS WITH STEEL FRAMING AND 0.100" DIAMETER PINS [1,2,3,6,7,8]								
			BLOCKED DIAPHRAGM PIN SPACING [6,7]				UNBLOCKED DIAPHRAGMS [6,7]	
			Pin Spacing at Diaphragm Boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4) and at all panel edges (Cases 5 & 6)				Pins spaced 6 inches max. at supported edges	
			6	4	2-1/2	2	CASE 1 (no unblocked edges or continuous joints parallel to load)	ALL OTHER (Cases 2-6)
			Pin Spacing at Other Panel Edges					
PLYWOOD GRADE	MINIMUM STEEL THICKNESS [3,4,5]	MINIMUM PANEL THICKNESS (IN)	6	6	4	3		
STRUCTURAL I	36 mil / 20 ga.	7/16	185	280	420	475	185	140
GRADES OTHER THAN STRUCTURAL 1	36 mil / 20 ga.	7/16	165	250	380	430	165	125

1 Values are for short-time loads imposed by wind 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 width of framing is 1-1/2 inches.
4 Base metal thickness of steel measured without coatings shall comply with minimum thickness as specified in Section 3.1 of NER-407.
5 Shear values also apply to framing made of thicker steel.
6 Spacing of fasteners along intermediate framing members is 12 inches on center.
7 The minimum panel edge distance is 3/8 inch.
8 Please refer to NES evaluation report NER-407, re-issued December 1, 1997, for additional information.

Table 2 ALLOWABLE SHEAR VALUES (plf) FOR HORIZONTAL PLYWOOD DIAPHRAGMS WITH MINIMUM 33 mil (20 Ga.) STEEL FRAMING AND 0.100" DIAMETER PINS [1,2,3,6,7]								
			BLOCKED DIAPHRAGM FASTENER SPACING [4,5]				UNBLOCKED DIAPHRAGMS [4,5]	
			DIAPHRAGM BOUNDRIES					
			6	4	2-1/2	2		
			OTHER PLYWOOD EDGES					
PANEL	MINIMUM PANEL THICKNESS (IN)	FRAMING WIDTH (IN)	6	6	4	3	CASE 1	CASE 2-6
STRUCTURAL I	3/8	1-1/2 2-1/2	170 190	225 250	335 380	450 505	150 170	110 125
RATED SHEATHING	3/8	1-1/2 2-1/2	150 170	200 225	305 340	405 455	135 150	100 115
	7/16	1-1/2 2-1/2	170 190	225 250	335 380	450 505	150 170	110 125

1 Values are for loads imposed by wind 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 1994 UBC Table 23-I-J-1 (page 3-
5 Spacing of fasteners along intermediate framing members is 12 inches on center.
6 Shear capacities in this table are limited by steel thickness. Use of thicker timber panels does not increase the allowable shear values unless the framing elements have been increased.
7 Please refer to ICBO ES evaluation report ER-4144, re-issued December 1, 1995, for additional information.

Table 3

ALLOWABLE SHEAR VALUES (plf) FOR HORIZONTAL PLYWOOD DIAPHRAGMS WITH STEEL FRAMING AND 0.120" DIAMETER[1] PINS

SHEATHING PANEL	MINIMUM PANEL THICKNESS (in.)	SUPPORTING STEEL MEMBER FLANGE DIMENSIONS[6,7]		BLOCKED DIAPHRAGM PIN SPACING				UNBLOCKED DIAPHRAGMS[6,7]	
				Pin Spacing at Diaphragm Boundaries (all cases), at continuous panel edges parallel to load (Cases 3 & 4) and at all panel edges (Cases 5 & 6)[2,3,4,5,7]				Pins spaced 6 inches max. at supported edges	
				6	4	2-1/2	2	CASE 1 (no unblocked edges or continuous joints parallel to load)	ALL OTHER (Cases 2-6)
		Width (in.)	Minimum Thickness	Pin Spacing at Other Panel Edges					
				6	6	4	3		
STRUCTURAL I or RATED SHEATHING	3/8	1.5	36 mil (20 ga.)	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 Values are for short-time loads imposed by wind 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 Spacing of fasteners along intermediate framing members is 12 inches on center.
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 measured without coatings shall comply with minimum thickness as specified in Section 2.2.3 of ICBO ES ER-5380.
7 Please refer to ICBO ES evaluation report ER-5380, issued November 1, 1997, for additional information.

References

1. International Conference of Building Officials, "*1997 Uniform Building Code*".
2. American Plywood Association, "Plywood Diaphragms, Publication No. 138", John R. Tissell, P.E. and James R. Elliott, P.E., 1993.
3. *"Prescriptive Method for Residential Cold-Formed Steel Framing,"* Second Edition, American Iron & Steel Institute, 1997.

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