Design and Use Guide For Precast Concrete Skirt Board
by Perma-Column

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400 Carol Ann Lane
Ossian, IN 46777
PH: 800-622-7190
www.permacolumn.com

By:

Dimitry A. Reznik, P.E.
Timber Tech Engineering, Inc.
www.timbertecheng.com
email: tte@timbertecheng.com

East
22 Denver Road, Suite B
Denver, PA 17517
717.335.2750
Fax: 717.335.2753

West
406 S. Main St, P.O. Box 509
Kouts, IN 46347
219.766.2499
Fax: 219.766.2394

Southeast
172 Luyben Hills Road
Kingston Springs, TN 37082
615.378.1535
Fax: 615.378.1587

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1. Design Overview

This guide is intended for post-frame building engineers and designers. Perma-Column Skirt Board consists of a #1 SYP treated wood board stacked on top of a non-structural precast concrete board reinforced with composite fiber rebar. The wood board is designed in accordance with *2018 Edition of The National Design Specification for Wood Construction (NDS)* by the American Wood Council (AWC) to resist axial compression, axial tension, out of plane shear and out of plane bending forces. Structural analysis is based on load and resistance factor (LRFD) and the allowable strength design (ASD) methodologies in accordance with 2018 International Building Code (IBC).

2. Skirt Board Description

The concrete bottom of the Perma-Column skirt board assembly is manufactured with 8,000 psi precast concrete and two (2) composite fiber rebar. The concrete board is attached to a 1.5"x3" #1 SYP wood board with 11ga x 2.5" Type 304 or 316 stainless steel shear studs spaced at 6 inches on centers. The top edge of the wood plate is finished with a tongue and grove (T&G) edge for stacking additional wood boards with T&G joints above the skirt board (Figure 2).

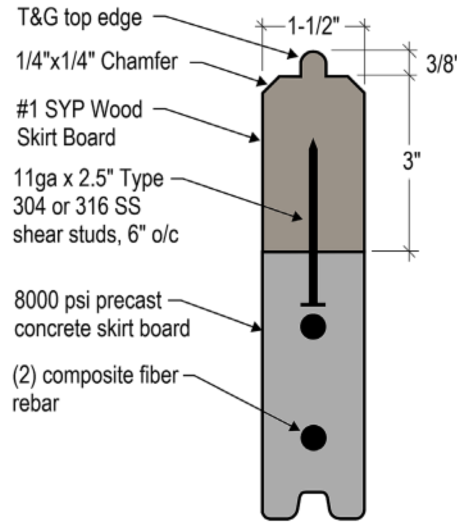


Figure 2: Skirt Board Cross Section

3. Skirt Board Loads

In post-frame construction, a skirt board is both a primary and a secondary structural member. It is part of the lateral force resisting system (LFRS) responsible for transferring shear loads from wall panels to columns. This is its primary structural function. In areas where lateral design is controlled by seismic loads, a skirt board is part of the seismic force resisting system (SFRS) and may be subject to additional seismic code requirements. A skirt board is also part of a building's wall cladding system where it functions as the lowest wall girt responsible for transferring out-of-plane pressures from wall panels to columns. This is the secondary structural function of a skirt board. Both load conditions are shown in Figure 3.1. A skirt board may also be used as a boundary for concrete floor slab. For this application, to prevent excessive out-of-plane deformation during construction, installation of temporary intermediate stakes may be required.

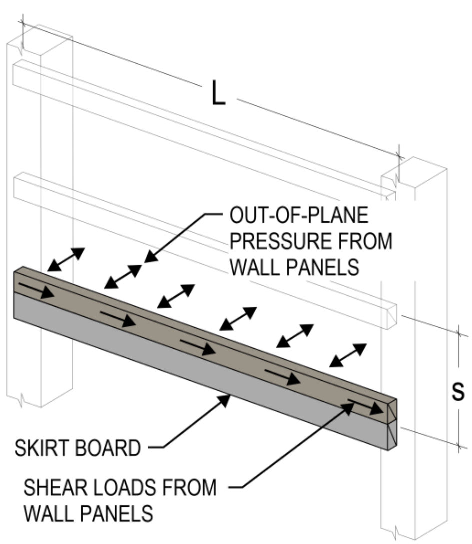


Figure 3.1: Loads on Skirt Board

Loads on a building should be calculated in accordance with the governing version of the *International Building Code* (IBC) and ASCE/SEI 7 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. Internal in-plane shear load in wall panels should be determined by rational analysis or in accordance with the most current version of ASABE EP484, and applied to a skirt board uniformly, subjecting the skirt board to axial tension and axial compression forces. If columns on both ends of a skirt board can resist shear loads, the skirt board will be subjected to an axial tension force at one end and an axial compression force at the opposite end simultaneously (Figure 3.2). This is the most common load condition. In all other cases, a skirt board will be subjected to an axial tension force, or an axial compression force applied separately in accordance with standard engineering mechanics.

Out-of-plane wind pressures on wall panels should be calculated using Component and Cladding (C&C) pressures in accordance with ASCE/SEI 7 Chapter 30. Tables A1.1 through A1.9 in Appendix A provide C&C design pressures for wall zones 4 and 5 as defined in ASCE/SEI 7 and Table 3.1. On most buildings, the width of Zone 5 (dimension "a") is likely to be less than the length of the skirt board. In such cases, loads from zone 5 and zone 4 should be applied to the skirt board. On larger buildings zone 5 may be as wide or wider than the length of the skirt board and loads from zone 4 need not be considered.

Wind loads on a skirt board may be calculated by multiplying C&C wind pressures by half of the distance from the center of the skirt board to the center of the first wall girt:

$$w = p\,s/2 \qquad \text{(Eq. 3)}$$

w = uniform load on the skirt board (lb/ft)
p = positive or negative wall pressure (C&C)
s = distance from the center of the skirt board to the center of the nearest wall girt (Figure 3.1)

For example, if the distance between the center of the skirt board and the center of the first wall girt is 1.5 ft, dimension "a" is 5 ft, and C&C wall pressures are 28 psf and 35 psf for zones 4 and 5, respectively, the load on the skirt board is calculated as:

Zone 4: 28 psf x (1/2) x 1.5 ft = 21.0 lb/ft
Zone 5: 35 psf x (1/2) x 1.5 ft = 26.3 lb/ft

In this example, if the length of the skirt board is 8 ft, the load from zone 5 would be applied to the first or last 5 ft of the board's length, and the balance of the length would be loaded with the load from zone 4.

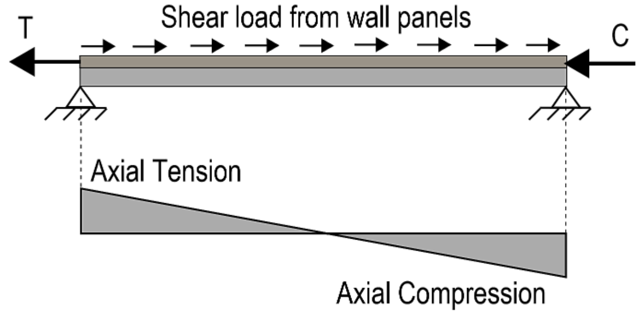
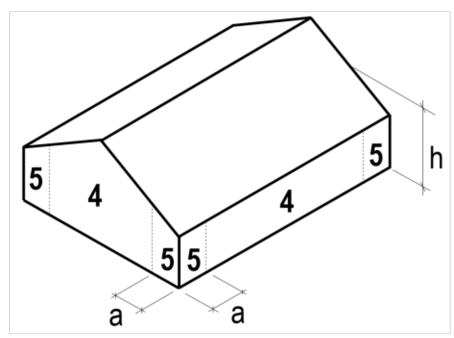


Figure 3.2: A diagram of internal axial compression and tension load in a skirt board where columns on both ends can resist lateral loads (reaction T at the left end and reaction C at the right end)

TABLE 3.1: Dimension "a" as defined in ASCE 7 (ft)

W_{min} (ft)	Roof Mid-Height, h (ft)				
	16	18	22	26	32
30	3.0	3.0	3.0	3.0	3.0
40	4.0	4.0	4.0	4.0	4.0
50	5.0	5.0	5.0	5.0	5.0
60	6.0	6.0	6.0	6.0	6.0
70	6.4	7.0	7.0	7.0	7.0
80	6.4	7.2	8.0	8.0	8.0
100	6.4	7.2	8.8	10.0	10.0
120	6.4	7.2	8.8	10.4	12.0

W_{min} = the least horizontal dimension of the building (either length or width of the building)



In most buildings, vertical loads do not need to be applied to a skirt board. The in-plane shear stiffness of metal or wood wall panels is significantly greater than the flexural stiffness of a skirt board. This disparity in stiffness prevents vertical wall loads from being transferred into the skirt board.

4. Skirt Board Design

Bending tests have shown that the concrete portion of the Perma-Column Skirt Board can flex with the wood skirt board until the wood board fails (breaks). The load-resisting contribution of the concrete portion of the skirt board is ignored. The design of the Perma-Column Skirt Board is governed by the NDS *National Design Specification for Wood Construction*. Table 4.1 provides unadjusted reference design values as well as ASD and LRFD adjustment factors for #1 SYP 1.5"x3" lumber. The design values should be modified by all applicable adjustment factors. If the wood or concrete portion of the skirt board is anticipated to be partially unprotected and/or in contact with the ground, it is reasonable to assume that moisture content in the wood will exceed 19%. The wet-use factors in such applications should be as specified in NDS or Table 4.1.

TABLE 4.1: Unadjusted Reference Design Values for 1.5"x3" #1 SYP (NDS Supplement)								
	F_b (psi)	F_t (psi)	F_v (psi)	$F_{c\perp}$ (psi)	F_c (psi)	E (psi)	E_{min} (psi)	G
	1,500	1,000	175	565	1,650	1,600,000	580,000	0.55
ASD and LRFD Adjustment Factors for 10-Minute (Wind) Load Duration								
C_M	0.85	1.0	0.97	0.67	0.8	0.9	0.9	-
C_D	1.6	1.6	1.6	-	1.6	-	-	-
C_t	*NDS Table 2.3.3*							
C_L	1.0	-	-	-	-	-	-	-
C_F	-	-	-	-	-	-	-	-
C_{fu}	1.0	-	-	-	-	-	-	-
C_r	1.15	-	-	-	-	-	-	-
C_P	-	-	-	-	calculate	-	-	-
LRFD (only) Adjustment Factors for 10-Minute (Wind) Load Duration								
K_F	2.54	2.70	2.88	1.67	2.40	-	1.67	
Φ	0.85	0.80	0.75	0.90	0.90	-	0.85	
λ	1.0	1.0	1.0	-	1.0	-	-	-

The C&C out-of-plane bending load and the axial compression load from the Main Wind Force Resisting System (MWFRS) are not expected to occur simultaneously at the maximum calculated load value. The combined axial compression and bending loading need not be considered. It is acceptable to evaluate these load conditions separately.

The design of a skirt board should also satisfy deflection limits specified in IBC Table 1604.3 or Table 4.2. When calculating skirt board deflections, C&C wind pressure should be reduced by a factor of 0.42 without further reductions found in ASD load combination (0.6 ASD wind multiplier should not be used in conjunction with the 0.42 C&C multiplier). The "L" in Table 4.2 represents the length of the skirt board between supports.

TABLE 4.2: SKIRT BOARD WIND LOAD DEFLECTION LIMITS	
Exterior walls with plaster or stucco finishes	L / 360
Exterior walls with other brittle finishes	L / 240
Exterior walls with flexible finishes	L / 120
Exterior walls with corrugated metal siding	L / 90
Farm buildings	No limit
Greenhouses	No limit

5. Design of Skirt Board Connections

The wood skirt board is fastened to a concrete Perma-Column base with 3/16"x2-1/2" Perma-Grip concrete fasteners (nails), with a minimum 1-inch penetration into the concrete. A 3/16"x1-1/4" hole must be predrilled to receive concrete fasteners in accordance with Perma-Grip literature. Only the fasteners through the wood girt should be considered; load-resisting contribution of the fasteners through the concrete skirt board should be ignored. The connection should be designed to resist shear and tension forces (Figure 5) determined by structural analysis (Section 4). The shear and pull-through strength of fasteners in the wood girt should be determined by a designer in accordance with the National Design Specifications for Wood Construction or Table 5.1. The allowable shear and pullout strength of concrete fasteners in concrete may not exceed the respective ultimate strength capacities provided by Perma-Grip divided by the factor of safety of 5 (Table 5.2).

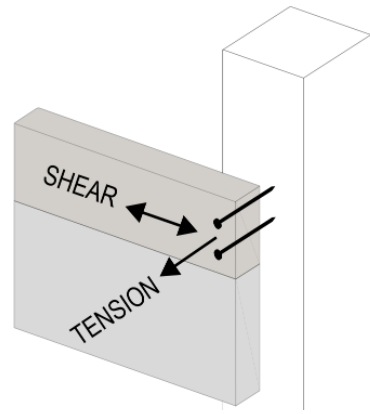


Figure 5: Loads on Connections

Installation of Perma-Grip Concrete fasteners should comply with Perma-Grip literature.

TABLE 5.1: Shear and Pull-Through Strength of One Perma-Grip Fastener in #1 SYP 2x Wood Skirt Board

	Unadjusted Allowable Capacity (lbs)	Allowable Capacity C_D = 1.6 & C_M=1.0 (lbs)	Allowable Capacity C_D = 1.6 & C_M=0.7 (lbs)
Shear Strength of one fastener	180	290	200
Pull-Through Strength of one fastener	130	210	150

TABLE 5.2: Shear and Pullout Strength of One Perma-Grip Fastener, 1-inch Penetration Into Concrete

	Ultimate Strength (lbs)	Factor of Safety	Allowable Strength (lbs)
Shear Strength of one fastener	2994	5	600
Concrete Pullout of one fastener	1016	5	200

APPENDIX A

Component and Cladding Wind Pressures on a Wall

ASCE 7-16
Low-rise buildings (h ≤ 60 ft)

Partially Enclosed, Enclosed, and Partially Open Building Envelope
Wind Exposure C
Wind Directionality Factor 0.85
Topographic Factor 1.0

TABLE A.1.1: Maximum C&C Design Pressures for Basic Wind Speed of 105 mph

Building Envelope	Zone	GC_{pi}	GC_p	Roof Mid-Height, h (ft) 16	18	22	26	32
				Velocity Pressure (psf) 20.6	21.2	22.1	22.9	23.9
Enclosed or Partially Open	4 Positive	-0.18	0.97	24	24	25	26	27
	5 Positive	-0.18	0.97	24	24	25	26	27
	4 Negative	0.18	-1.06	-26	-26	-27	-28	-30
	5 Negative	0.18	-1.34	-31	-32	-34	-35	-36
Partially Enclosed	4 Positive	-0.55	0.97	31	32	34	35	36
	5 Positive	-0.55	0.97	31	32	34	35	36
	4 Negative	0.55	-1.06	-33	-34	-36	-37	-38
	5 Negative	0.55	-1.34	-39	-40	-42	-43	-45

TABLE A.1.2: Maximum C&C Design Pressures for Basic Wind Speed of 115 mph

Building Envelope	Zone	GC_{pi}	GC_p	Roof Mid-Height, h (ft) 16	18	22	26	32
				Velocity Pressure (psf) 24.8	25.4	26.5	27.4	28.7
Enclosed or Partially Open	4 Positive	-0.18	0.97	28	29	30	32	33
	5 Positive	-0.18	0.97	28	29	30	32	33
	4 Negative	0.18	-1.06	-31	-31	-33	-34	-36
	5 Negative	0.18	-1.34	-38	-39	-40	-42	-44
Partially Enclosed	4 Positive	-0.55	0.97	38	39	40	42	44
	5 Positive	-0.55	0.97	38	39	40	42	44
	4 Negative	0.55	-1.06	-40	-41	-43	-44	-46
	5 Negative	0.55	-1.34	-47	-48	-50	-52	-54

TABLE A.1.3: Maximum C&C Design Pressures for Basic Wind Speed of 125 mph

Building Envelope	Zone	GC_{pi}	GC_p	Roof Mid-Height, h (ft) 16	18	22	26	32
				Velocity Pressure (psf) 29.3	30.0	31.3	32.4	33.9
Enclosed or Partially Open	4 Positive	-0.18	0.97	34	34	36	37	39
	5 Positive	-0.18	0.97	34	34	36	37	39
	4 Negative	0.18	-1.06	-36	-37	-39	-40	-42
	5 Negative	0.18	-1.34	-44	-46	-48	-49	-51
Partially Enclosed	4 Positive	-0.55	0.97	44	46	48	49	51
	5 Positive	-0.55	0.97	44	46	48	49	51
	4 Negative	0.55	-1.06	-47	-48	-50	-52	-55
	5 Negative	0.55	-1.34	-55	-57	-59	-61	-64

TABLE A.1.4: Maximum C&C Design Pressures for Basic Wind Speed of 135 mph

Building Envelope	Zone	GC_{pi}	GC_p	Roof Mid-Height, h (ft)				
				16	18	22	26	32
				Velocity Pressure (psf)				
				34.1	35.0	36.5	37.8	39.5
Enclosed or Partially Open	4 Positive	-0.18	0.97	39	40	42	43	45
	5 Positive	-0.18	0.97	39	40	42	43	45
	4 Negative	0.18	-1.06	-42	-43	-45	-47	-49
	5 Negative	0.18	-1.34	-52	-53	-55	-57	-60
Partially Enclosed	4 Positive	-0.55	0.97	52	53	55	57	60
	5 Positive	-0.55	0.97	52	53	55	57	60
	4 Negative	0.55	-1.06	-55	-56	-59	-61	-64
	5 Negative	0.55	-1.34	-64	-66	-69	-71	-75

TABLE A.1.5: Maximum C&C Design Pressures for Basic Wind Speed of 145 mph

Building Envelope	Zone	GC_{pi}	GC_p	Roof Mid-Height, h (ft)				
				16	18	22	26	32
				Velocity Pressure (psf)				
				39.4	40.4	42.1	43.6	45.6
Enclosed or Partially Open	4 Positive	-0.18	0.97	45	46	48	50	52
	5 Positive	-0.18	0.97	45	46	48	50	52
	4 Negative	0.18	-1.06	-49	-50	-52	-54	-56
	5 Negative	0.18	-1.34	-60	-61	-64	-66	-69
Partially Enclosed	4 Positive	-0.55	0.97	60	61	64	66	69
	5 Positive	-0.55	0.97	60	61	64	66	69
	4 Negative	0.55	-1.06	-63	-65	-68	-70	-73
	5 Negative	0.55	-1.34	-74	-76	-80	-82	-86

TABLE A.1.6: Maximum C&C Design Pressures for Basic Wind Speed of 155 mph

Building Envelope	Zone	GC_{pi}	GC_p	Roof Mid-Height, h (ft)				
				16	18	22	26	32
				Velocity Pressure (psf)				
				45.0	46.1	48.1	49.8	52.1
Enclosed or Partially Open	4 Positive	-0.18	0.97	52	53	55	57	60
	5 Positive	-0.18	0.97	52	53	55	57	60
	4 Negative	0.18	-1.06	-56	-57	-60	-62	-65
	5 Negative	0.18	-1.34	-68	-70	-73	-76	-79
Partially Enclosed	4 Positive	-0.55	0.97	68	70	73	76	79
	5 Positive	-0.55	0.97	68	70	73	76	79
	4 Negative	0.55	-1.06	-72	-74	-77	-80	-84
	5 Negative	0.55	-1.34	-85	-87	-91	-94	-98

TABLE A.1.7: Maximum C&C Design Pressures for Basic Wind Speed of 165 mph

Building Envelope	Zone	GC_{pi}	GC_p	Roof Mid-Height, h (ft) 16	18	22	26	32
				Velocity Pressure (psf) 51.0	52.3	54.5	56.5	59.0
Enclosed or Partially Open	4 Positive	-0.18	0.97	59	60	63	65	68
	5 Positive	-0.18	0.97	59	60	63	65	68
	4 Negative	0.18	-1.06	-63	-65	-68	-70	-73
	5 Negative	0.18	-1.34	-77	-79	-83	-86	-90
Partially Enclosed	4 Positive	-0.55	0.97	77	79	83	86	90
	5 Positive	-0.55	0.97	77	79	83	86	90
	4 Negative	0.55	-1.06	-82	-84	-88	-91	-95
	5 Negative	0.55	-1.34	-96	-99	-103	-107	-111

Footnotes: ASCE 7-16, Envelope procedure, Wind Exposure Category C, Wind Directionality Factor 0.85, Topographic Factor 1.0

TABLE A.1.8: Maximum C&C Design Pressures for Basic Wind Speed of 175 mph

Building Envelope	Zone	GC_{pi}	GC_p	Roof Mid-Height, h (ft) 16	18	22	26	32
				Velocity Pressure (psf) 57.3	58.8	61.3	63.5	66.4
Enclosed or Partially Open	4 Positive	-0.18	0.97	66	68	71	73	76
	5 Positive	-0.18	0.97	66	68	71	73	76
	4 Negative	0.18	-1.06	-71	-73	-76	-79	-82
	5 Negative	0.18	-1.34	-87	-89	-93	-97	-101
Partially Enclosed	4 Positive	-0.55	0.97	87	89	93	97	101
	5 Positive	-0.55	0.97	87	89	93	97	101
	4 Negative	0.55	-1.06	-92	-95	-99	-102	-107
	5 Negative	0.55	-1.34	-108	-111	-116	-120	-125

TABLE A.1.9: Maximum C&C Design Pressures for Basic Wind Speed of 180 mph

Building Envelope	Zone	GC_{pi}	GC_p	Roof Mid-Height, h (ft) 16	18	22	26	32
				Velocity Pressure (psf) 60.7	62.2	64.9	67.2	70.2
Enclosed or Partially Open	4 Positive	-0.18	0.97	70	72	75	77	81
	5 Positive	-0.18	0.97	70	72	75	77	81
	4 Negative	0.18	-1.06	-75	-77	-80	-83	-87
	5 Negative	0.18	-1.34	-92	-95	-99	-102	-107
Partially Enclosed	4 Positive	-0.55	0.97	92	95	99	102	107
	5 Positive	-0.55	0.97	92	95	99	102	107
	4 Negative	0.55	-1.06	-98	-100	-104	-108	-113
	5 Negative	0.55	-1.34	-115	-118	-123	-127	-133