

SIMPLIFIED WALL BRACING USING WOOD: STRUCTURAL PANEL CONTINUOUS SHEATHING

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1 INTRODUCTION

Before the introduction to the inaugural version of the International Residential Code (IRC) in 2000, code conforming wall bracing was poorly understood with marginal code compliance in some areas of the United States. The first version of the IRC provided a comprehensive methodology for providing prescriptive wall bracing, including expanding the methods of bracing, and expanding the applicability of the prescriptive provisions. With each triannual update of the IRC, the prescriptive bracing provisions have continued to evolve into very complicated solutions to prescriptively brace walls for wind and seismic loads.

The IRC provisions have raised the awareness to code officials; thus strict compliance to the building code is now being required by jurisdictions throughout the United States. However, the complexity of the residential code makes it difficult for designers and builders to navigate the various options of the IRC. The IRC attempted to address this issue by introducing a simplified wall bracing method in 2012, though this simplified method was still fairly complicated.

Based on a multi-year research and testing initiative carried out by APA, the APA Simplified Wall Bracing Method expands on the IRC Simplified Bracing Method to provide an approach to bracing that is even more valuable to builders and building officials by, in many cases, decreasing the amount of required wall bracing and the minimum length of braced wall panels. In addition, the APA Simplified Wall Bracing Method increases the applicability of the IRC simplified wall

bracing provisions to as much as 4 times as many house plans, including those with multiple window and door openings on the front and rear elevations.

The Simplified Wall Bracing Method described in this paper is based on APA System Report SR-102 (2015). This methodology provides building officials, builders and designers with an approach and the supporting technical information to meet the requirements of the 2015 IRC Wall Bracing (Section R602.10). The IRC Simplified Wall Bracing has been modified to increase its applicability to a greater percentage of home designs. To achieve broad applicability and acceptance, the system uses the most common type of wall sheathing, wood structural panels, based on their superior structural performance. To provide the user with the greatest possible architectural latitude, SR-102 only covers continuously sheathed wood structural panel bracing (IRC Method CS-WSP) with an increased sheathing thickness (called "Performance Category" in product standards) and a closer nailing schedule on the first story of a two-story structure. This approach increases the performance of the bracing panels on the first story due to the additional restraint provided by the mass and stiffness of the structure above, through strength from increased fastening and with the use of thicker wood structural panel continuous sheathing. This enhanced performance on the bottom story of multi-story structures leads to reduced length of required bracing in these areas, allowing for the method to be used on homes with abundant window and door openings typically found on the front and back elevations. These decreases in the required

bracing of multi-story structures are reflected in Table 3.

Design simplification and flexibility are achieved through the enhanced sheathing thickness and nailing described in this paper. Intermittent wood structural panel (Method WSP) and other bracing methods, except as discussed in Section 2.1 of this paper, are outside the scope. Like the IRC simplified bracing method, the APA Simplified Wall Bracing Method may be used for houses located in areas of low to moderate wind and seismicity. To increase the usability of the method, SR-102 includes additional details to augment IRC simplified bracing provisions. Also included are references to specific areas of the IRC and other publications when additional information is required.

Buildings meeting the requirements of SR-102 meet all of the bracing requirements of the 2015 Section R602.10 Wall Bracing with the enhancements discussed in Section 2 of this paper.

2 METHODOLOGY

2.1 Applicability

Residential structures must meet all of the following conditions when using this method:

1. The entire building should be continuously sheathed with wood structural panels in accordance with the requirements specified in this section.
2. Other bracing provisions of the 2015 IRC Section R602.10, except as specified herein, are outside the scope of this method.
3. The foundation or basement walls are concrete or masonry, or concrete slab; and the structure above should be 3 stories or less. Permanent wood foundations are beyond the scope of this methodology.
4. Floor cantilevers are not more than 0.61 m (24 inches) beyond the foundation or bearing wall below.
5. Stud wall height is 3.0 m (10 feet) or less when using the minimum required bracing lengths specified in Table 3 of this paper unless adjustments are made for other wall heights up to 3.7 m (12 feet) in accordance with Footnote c to Table 3 in this paper.
6. Roof eave-to-ridge height is 4.6 m (15 feet) or less.

7. Interior finish of exterior walls consist of minimum 12 mm (1/2-inch) gypsum boards installed on the interior side fastened in accordance with IRC Table R702.3.5. Interior gypsum finish is not required on continuously sheathed wood structural panels adjacent to garage openings (Method CS-G) and continuously sheathed portal frame (Method CS-PF) bracing panels (see Section 2.5 of this paper).
8. Design wind speed is 58 m/s (130 mph, Ultimate Design Wind Speed in the 2015 IRC) or less and the Wind Exposure Category is either B or C.
9. Seismic Design Category is either A, B or C for detached one- and two-family dwellings or Seismic Design Category A or B for townhouses.
10. Cripple walls, if present, is considered as the first story of the structure when using this method unless they are designed in accordance with 2015 Section R301.1.2. When the foundation has been engineered/ designed to support all of the loads from the structure above, the method described in this paper is appropriate. Such foundation systems may include cripple walls, daylight and pile foundations, and permanent-wood and insulated-concrete-form foundations.
11. Horizontal joint blocking of the bracing panels may be omitted if the amount of bracing on a given wall is 2 times or more than the minimum required amount of bracing derived from Table 3 of this paper after adjustment by the relevant footnotes.

2.2 Circumscribed Rectangle

Traditional wall bracing following the IRC must consider many wall lines, wall line spacing, off-sets in wall lines, lengths of each wall line, and many various multipliers and bracing methods. Figure 1a demonstrates the plan view of a traditional home in North America with the initial layout for resolving the lateral loads. Figure 1b demonstrates the methodology described in this paper using a circumscribed rectangle. The rectangle surrounds all enclosed offsets and projections, such as sunrooms and attached garages, unless an attached garage or portion of the building is to be designed as a separate structure in accordance with IRC Section R301.1.3 or a separate element. SR-102 shows a detailed design example for designing a home in parts of circumscribed rectangles. Open structures, such as attached carports and decks, may be excluded from the rectangle. The rectangle should

have no side longer than 18 m (60 feet) and the ratio between the long side and the short side should not exceed 3:1.

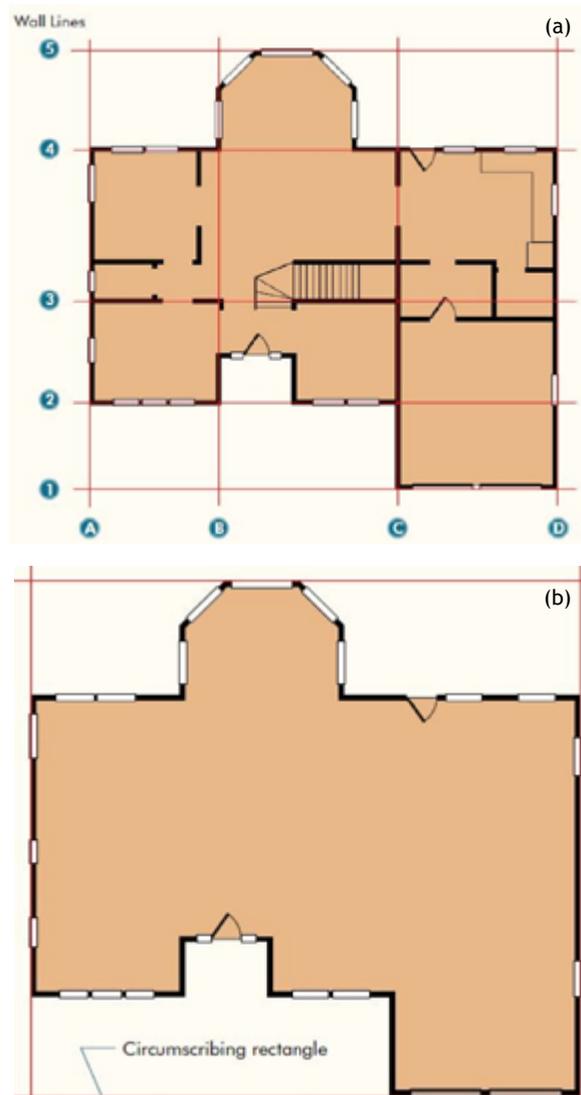


Figure 1: (a) Traditional wall bracing, (b) simplified wall bracing.

2.3 Wood Structural Panel Materials

The wood structural panel sheathing is either Rated Sheathing or siding with a minimum 11 mm (7/16 Performance Category), meeting the requirements of DOC PS1 or PS2.

2.4 Wood Structural Panel Attachment

The wood structural panel sheathing is attached to framing in accordance with the following requirements:

1. The wood structural panels should be installed with minimum 8d common nails, 3.3 x 65 mm (0.131 x 2-1/2 inches), spaced at 100 mm (4 inches) on center at panel edges and at 300 mm

(12 inches) on center over intermediate supports. For single-story or the top story of two- or three-story buildings, the panels may be installed with 8d common nails spaced at 150 mm (6 inches) on center at panel edges and 300 mm (12 inches) at intermediate supports.

2. The wood structural panels are applied continuously over all areas of the exterior walls except windows and doors, and including gable ends; and may be installed either vertically or horizontally.
3. All horizontal panel joints should occur over and be nailed to common framing or blocking with an appropriate panel edge-nailing schedule in accordance with IRC Section R602.10.10.
4. Each end of a continuously sheathed braced wall line should have a 0.61 m (24-inch) return corner as defined in IRC Section R602.10.7 or a 3.6-kN (800-lbf) hold-down attached to the end stud of the braced wall panel closest to the corner.
 - If a continuously sheathed braced wall line contains an opening greater than 6 m (20 feet), each end of each resulting braced wall line segment/section should have one of the conditions described above.
 - If a continuously sheathed braced wall line contains two or more offset braced wall line segments/sections as permitted in Section R602.10.1.2, each end of each braced wall line segment/section should have one of the conditions described above.

5. Gypsum wallboard is installed on the opposite side of wall bracing panels. Gypsum wallboard is a minimum of 12 mm (1/2-inch) thick and is fastened with nails or screws in accordance with IRC Table R702.3.5. Exception: Gypsum wallboard may be omitted if the amount of bracing on a given wall is equal to or greater than 1.4 times the minimum required amount of bracing derived from Table 3 of this paper after adjustment by the relevant footnotes.

2.5 “Qualified” Bracing Panel

A single “qualified” bracing panel consist of a full-height portion of an exterior wall continuously sheathed with wood structural panels with a minimum length as shown in Tables 1 and 2 of this paper. The bracing panel should have no openings, except that

small drilled holes in the wall sheathing and not penetrating the wall framing up to 38 mm (1-1/2 inches) for the passage of wiring and utilities. When using narrow wall bracing methods, CS-G and CS-PF, the minimum permissible lengths and contributing lengths for computing available bracing is shown in

Table 1 of this paper. When using Method CS-WSP, Table 1 provides the minimum permissible lengths and contributing lengths based on both the wall height and the adjacent clear opening height. If an 2.4- or 2.7- m (8-, or 9-foot) tall wall line is present, Method CS-WSP braced wall segments less than the

Table 1: Minimum length of braced wall lines (excerpt from 2015 IRC Table R602.10.5, modified in accordance with R602.12.3).

Method	Adjacent clear opening height (m)	Minimum length(m)			Contributing length (m)
		Wall height			
		2.4m	2.7m	3.1m	
CS-G	--	0.61	0.69	0.76	actual length ^(a)
CS-PF ^(c)	--	0.41 ^(b)	0.46 ^(b)	0.51 ^(b)	1.5 x actual length ^(a)
CS-WSP	≤1.63	0.61	0.69	0.76	actual length ^(a)
	1.73	0.66	0.69	0.76	
	1.83	0.69	0.69	0.76	
	1.93	0.76	0.74	0.76	
	2.03	0.81	0.76	0.76	
	2.13	0.89	0.81	0.81	
	2.24	0.91	0.89	0.84	
	2.34	0.91	0.91	0.89	
	2.44	0.91	0.91	0.91	
	2.54 - 2.74	--	0.91	0.91	
2.84 - 3.05	--	--	0.91		

(39.4 in. = 1 m)

(a) Use the actual length when it is greater than or equal to the minimum length

(b) The wall height for CS-PF is based on the height of the portal frame, as documented in Keith (2014). The height of the portal frame is measured from the bottom plate to the top of the portal frame header.

(c) See IRC Figure R602.10.6.4.

Table 1 minimum length may be used but with a corresponding reduction in contributing lengths for computing available bracing in accordance with Table 2 of this paper.

2.5.1 Partial Credit for CS-WSP Panels

CS-WSP panels in 2.4- or 2.7-m (8- or 9-foot) tall walls between 0.51 and 0.61 m (20 and 24 inches) in length that do not meet the minimum length requirements of Table 1 may be used as bracing units at a full or reduced contributing length (depending on the adjacent opening height), as shown in Table 2 of this paper based on the latest APA research results, as documented in Keith (2012a and 2012b).

2.6 Computing “Qualified” Wall Bracing Length

Within an exterior wall, only those full-height wall panels with a length greater than or equal to the lengths specified in Tables 1 and 2 of this paper is

deemed to contribute to resisting lateral load, and counted toward the required bracing length. The total bracing length contributing to the side of a rectangle is equal to the sum of the contributing lengths of each “qualified” wall panel. Any length of a “qualified” bracing panel over the minimum bracing length required in Table 1 of this paper may be used toward the total bracing length required for that side of the rectangle. Thus, if the minimum requirement for a specific method is 0.61 m (24 inches) in accordance with Table 1 of this paper and two such panels with lengths of 0.66 and 0.86 m (26 and 34 inches) are present, (0.66 + 0.86 =) 1.5m (60 inches) of bracing are present and should be used in determining the total bracing length for that wall.

For Methods CS-G and CS-PF, the bracing length on either side of the opening is considered a “qualified” bracing panel and contributes to bracing lengths for

Table 2: Partial credit for CS-WSP less than full length with 2.4- or 2.7-m (8- or 9-foot) tall walls^(a).

Wall height (m)	Length of full height Method CS-WSP Panel (m)	Adjacent to a clear opening height (m) or less	Contributing length of braced wall panels (m)
2.4 or 2.7	0.61	≤1.55	0.61
		1.63	0.56
		1.73	0.51
		1.83	0.46
		1.93	0.41
	0.51	2.03	0.36
		≤1.55	0.51
		1.63	0.46
		1.73	0.41
		1.83	0.38
		1.93	0.33
		2.03	0.28

(39.4 in. = 1 m)

(a) Linear interpolation may be used

meeting the minimum length requirements of Table 1 of this paper. Examples of utilizing this simplified approach are demonstrated in the Appendix to SR-102 (APA, 2015).

2.7 Length of Bracing Required

Determining the minimum bracing length required is relatively straightforward:

1. Circumscribe the building with a rectangle. The rectangle encloses the maximum building length and width dimensions as described in Section 2.2.
2. Ensure that the long side of the rectangle is not greater than 3 times the short side of the rectangle or greater than 18 m (60 feet). If it is greater, consider using the multiple rectangle method covered in Appendix A of SR-102. The alternatives are to:
 - Use the “legacy” bracing provisions of IRC Section R602.10,
 - Use the multiple rectangle method in conjunction with the APA Simplified Wall Bracing Method (see Appendix A or SR-102), or
 - Have the structure designed in accordance with IRC Section R301.1.3 and the International Building Code (IBC).
3. With the dimensions of this circumscribed rectangle, use Table 3 of this paper to

determine the bracing length that is required on each rectangle side perpendicular to the side used to enter the table. Note that interpolation may be used. Either value, the rounded or interpolated value, is multiplied by a wall height adjustment factor in accordance with Footnotes (c) and (d) to Table 3 of this paper, as applicable.

4. Parallel wall lines within 1.2 m (4-feet) of each other are considered the same wall line when following the Distribution Rules of Section 2.8 of this paper.

2.8 “Distribution Rules” for Bracing Panels

Once the required minimum bracing length has been determined for each side of the circumscribed rectangle using Table 3 of this paper, this bracing length is distributed along the actual exterior walls of the structure. In distributing these bracing panels, all of the following “Distribution Rules” should be met:

1. The first “qualified” bracing panel on each side of the rectangle begins within 3.7 m (12 feet) of the wall corner. The 3.7 m is measured between the wall corner and closest edge of the first full-height “qualified” bracing panel.
2. The distance between the closest edges of adjacent full-height “qualified” bracing panels is 6.1 m (20 feet) or less.
3. Any exterior wall with a length of 2.4 m (8

feet) or greater, when used as bracing, should have a minimum of 0.91 m (3 feet) of bracing.

In some cases, a greater bracing length is required to meet the Distribution Rules than is required by Table 3. In this case, the greater bracing length required by the Distribution Rules governs. In any cases, the bracing length required by Table 3 or the Distribution Rules, whichever is greater, should be met.

If the upper and lower stories share common exterior wall lines and the amount of bracing on the second floor equals or exceeds the amount of bracing located on the story immediately below, and the distribution rules of Section 2.8 for all such stories are met, only the bracing in the bottom story must be checked. If the bottom story checks out, the upper stories will be acceptable as well.

Table 3: Minimum required bracing length on each side of the circumscribed rectangle for wind exposure B ^{(a)(b)(c)(d)}. (Table provides required bracing amount for walls perpendicular to the maximum bracing length used to enter the table.)

Wind Speed	Story Level	Eave-to-Ridge Height (m)	Minimum required bracing length on each long/short side (m)					
			Length of short/long side (m)					
			3.0	6.1	9.1	12.2	15.2	18.3
51 m/s (115 mph) ultimate based on 2015 IRC			0.61	1.07	1.52	1.83	2.29	2.74
		3.0	0.88	1.65	2.26	3.02	3.66	4.27
			1.25	2.41	3.41	4.42	5.43	6.40
		4.6	0.79	1.40	1.98	2.38	2.99	3.57
			1.01	1.89	2.59	3.47	4.21	4.91
			1.37	2.65	3.75	4.88	5.97	7.04
58 m/s (130 mph) ultimate based on 2015 IRC			0.76	1.22	1.83	2.29	2.90	3.35
		3.0	1.13	2.01	2.77	3.66	4.54	5.33
			1.52	2.90	4.15	5.43	6.68	7.80
		4.6	1.01	1.58	2.38	2.99	3.78	4.36
			1.31	2.32	3.20	4.21	5.21	6.13
			1.68	3.20	4.57	5.97	7.35	8.60

(39.4 in. = 1 m)

(a) Based on IRC Table R602.10.3(1) and modified in accordance with Keith (2011).

(b) Interpolation may be used.

(c) The Wall Height Adjustment Factor, as shown below, is used to multiply the minimum bracing lengths listed in the table above to accommodate wall heights from 2.4 to 3.7 m (8 to 12) feet based on IRC Table R602.10.3(2). Interpolation may be used.

	Wall Height (m)	Weight Adjustment factor
Any Story	2.4	0.90
	2.7	0.95
	3.0	1.00
	3.4	1.05
	3.7	1.10

(d) For Wind Exposure Category C, multiply length required from table above by 1.2 for single-story buildings, 1.3 for two-story buildings and 1.4 for three-story structures.

(e) The first story of two stories and the first and second of three stories should be continuously sheathed with wood structural panels attached with 8d common nails, 3.3 x 65 mm, (0.131 x 2-1/2 inches) spaced 100 mm (4 inches) on center around the panel perimeter and at 300 mm (12 inches) on center over intermediate supports.

3 LATERAL SUPPORT

For bracing panels in exterior walls located along eaves where the distance between the top of the top plates to the underside of the roof sheathing is 0.23 m (9-1/4 inch-es) or less, blocking between the rafters or trusses is not required. When the distance between the top of the top plates to the underside of the roof sheathing above braced walls is greater than 0.24 m (9-1/4 inches) and less than 0.39 m (15-1/4 inch-es), attachment should be in accordance with IRC Section R602.10.8.2, item 1. These details are not duplicated here because they vary slightly between different editions of the IRC and because the 0.39 m (15-1/4 inches) limitation is not commonly exceeded.

If the vertical distance between the underside of the roof sheathing and the top of the top plate is greater than 0.39 m (15-1/4 inches), or if the user wants to use the wall sheathing to block raised-heel trusses to meet the wind uplift and lateral load requirements of IRC sections R602.3.5 and R602.10.2.1, see APA System Report SR-103, for more information.

4 LIMITATIONS

Recommendations provided in this paper are subject to the following conditions:

1. The exterior walls of the structure is continuously sheathed with a minimum 11 mm (7/16 Performance Category) wood structural panel sheathing or siding meeting the requirements of DOC PS1 or PS2 and is attached to framing with 8d common nails, 3.3 x 65 mm, (0.131 x 2-1/2 inches) at 100 mm (4 inches) on center around the panel perimeter and at 300 mm (12 inches) on center over intermediate supports. For exterior walls in single story structures or in the top story of multi-story structures the 8d common nails are spaced at 150 mm (6 inches) on center around the panel perimeter and at 300 mm (12 inches) on center over intermediate supports.
2. The APA Simplified Wall Bracing Method is applicable to buildings of no more than three stories, subject to the applicability listed in

Section 2.1 of this paper.

3. When placed over masonry or concrete stem walls, wall bracing panels used in the APA Simplified Wall Bracing Method must meet the requirements of IRC Section R602.10.9.
4. While the APA Simplified Wall Bracing Method is not part of the code, it is based on the code and other modifications permitted by IRC Sections R301.1.3 Engineering Design. Further modifications to the APA Simplified Wall Bracing Method by the user of this paper are beyond the scope of this paper.
5. The basis for this paper, APA System Report SR-102 is subject to periodic re-view. The latest copy of SR-102, in imperial units, is available for download at www.apawood.org/resource-library.

REFERENCES

- [1] APA. 2015. APA simplified wall bracing method using wood structural panel continuous sheathing, APA System Report - SR-102C, APA - The Engineered Wood Association, Tacoma, WA
- [2] APA. 2014. Use of wood structural panels for energy-heel trusses, APA System Report - SR-103A, APA - The Engineered Wood Association, Tacoma, WA
- [3] AWC. 2015. Wood frame construction manual for one and two family dwellings (WFCM), American Wood Council, Leesburg, VA.
- [4] ICC. 2015a. International building code (IBC), International Code Council, Falls Church, VA.
- [5] ICC. 2015b. International residential code (IRC), International Code Council, Falls Church, VA.
- [6] Keith, E. L. 2011. Wall bracing capacity enhanced due to partial restraint, APA Report T2011L-33, APA - The Engineered Wood Association, Tacoma, WA
- [7] Keith, E. L. 2012a. Narrow wall bracing. APA Report T2012L-16, APA - The Engineered Wood Association, Tacoma, WA
- [8] Keith, E. L. 2012b. Narrow wall bracing -

eight-foot tall walls, APA Report T2012L-16,
APA - The Engineered Wood Association,
Tacoma, WA

[9] Keith, E. L. 2014. Portal frame aspect ratio,
APA Report T2014L-39, APA - The Engineered
Wood Association, Tacoma, WA
