

# 2005 Special Design Provisions for Wind and Seismic (SDPWS)

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## Introduction

AF&PA's 2005 *Special Design Provisions for Wind and Seismic (SDPWS)* is a dual format, allowable stress design (ASD) / load and resistance factor design (LRFD) specification, developed as an ANSI consensus standard by AF&PA's Wood Design Standards Committee. In the 2006 *International Building Code (IBC)*, provisions of SDPWS are permitted as an alternative to provisions in IBC Section 2305 (see "Seismic Requirements for Wood Building Design – Recent Changes to ASCE 7 and IBC" in this issue of *Wood Design Focus*). SDPWS provisions are generally consistent with design provisions of the IBC Section 2305; however, refinement of SDPWS provisions occurred over its three-year development cycle. As SDPWS continues to develop, it is expected that future editions of the IBC will either match provisions contained in SDPWS or be replaced by reference to SDPWS.

## Design Value Format

In SDPWS, nominal design values are tabulated for shear wall and diaphragm shear capacities. For ASD, nominal design values are divided by an ASD reduction factor to establish an allowable design value. For LRFD, nominal design values are multiplied by the resistance factor,  $\phi$ , to establish a LRFD factored resistance value.

## Nominal, ASD, and LRFD Unit Shear Capacities for Shear Walls and Diaphragms

The tabulated nominal unit shear capacity for wind, ( $v_w$ ), equals the IBC allowable stress design value times a factor of 2.8. A factor of 2.8, based on minimum performance requirements of *Performance Standard for Wood-Based Structural Use Panels, PS-2*, has commonly been considered the minimum safety factor associated with allowable unit shear values for wood structural panel shear walls and diaphragms. A reduced value equal to 1/1.4 times the nominal unit shear capacity for wind is assigned as the nominal unit shear capacity for seismic, ( $v_s$ ), maintaining the current ratio of wind and seismic design capacities for wood structural panel shear walls and diaphragms in the IBC.

For ASD, nominal unit shear capacities for shear walls and diaphragms are divided by an ASD reduction factor of 2.0. Resulting allowable unit shear capacities for wood

structural panel shear walls and diaphragms are identical to those provided in the IBC. For LRFD, nominal unit shear capacities for shear walls and diaphragms are multiplied by  $\phi = 0.80$ . This value,  $\phi = 0.80$ , provides exact calibration to ASD for wind design. For seismic design, application of  $\phi = 0.80$  coupled with reduced nominal unit shear values results in an effective  $\phi = 0.57$  (e.g.  $0.80/1.4 = 0.57$ ). When compared to ASD, LRFD will have up to a 12 percent benefit for seismic design for shear when using the following IBC load factors: (for LRFD: 1.0E or 1.6W; for ASD: 0.7E or 1.0W). This benefit is reduced where drift limits govern in design.

## Shear Wall and Diaphragm Deflection Equations

The same tables that specify nominal unit shear capacities also contain values of apparent shear stiffness, ( $G_a$ ). Re-formatted deflection equations make use of these tabulated values of apparent shear stiffness to simplify deflection calculations and to extend deflection calculations to a variety of sheathing materials and unblocked wood structural panel diaphragms. The SDPWS three-term deflection equations are an algebraic simplification of the four-term equations in the IBC; however, SDPWS provides an option to calculate deflections using other methods such as the four-term equations. In SDPWS, total diaphragm deflection,  $\delta_{dia}$ , is calculated in accordance with Equation [1]:

$$\delta_{dia} = \frac{5vL^3}{8EAW} + \frac{0.25vL}{1000G_a} + \frac{\sum(x\Delta_c)}{2W} \quad [1]$$

where:

$5vL^3/(8EAW)$  = deflection due to bending;

$0.25vL/(1000G_a)$  = deflection due to shear deformation (from panel shear and nail slip); and

$\Sigma(x\Delta_c)/(2W)$  = deflection due to chord splice slip.

Total shear wall deflection,  $\delta_{SW}$ , is calculated as shown in Equation [2]:

$$\delta_{SW} = \frac{8vh^3}{EAb} + \frac{vh}{1000G_a} + \frac{h\Delta_a}{b} \quad [2]$$

where:

- $8vh^3/(EAb)$  = deflection due to bending;
- $vh/(1000G_a)$  = deflection due to shear deformation (from panel shear and nail slip); and
- $h\Delta_a/b$  = deflection due to tie-down slip.

### Apparent Shear Stiffness, $G_a$

Tabulated  $G_a$  values, used to calculate the component of deflection due to shear deformation, replace the need for intermediate calculations that separately account for nail slip and panel shear stiffness. Equation [3] relates  $G_a$  to nail slip and panel shear stiffness:

$$G_a = \frac{v}{\frac{v}{G_v t_v} + 0.75e_n} \quad [3]$$

where:

- $G_v t_v$  = panel shear stiffness, lb/inch of panel depth;
- $e_n$  = nail slip, inches; and
- $v$  = 1.4 times the ASD unit shear value of the shear wall or diaphragm, plf.

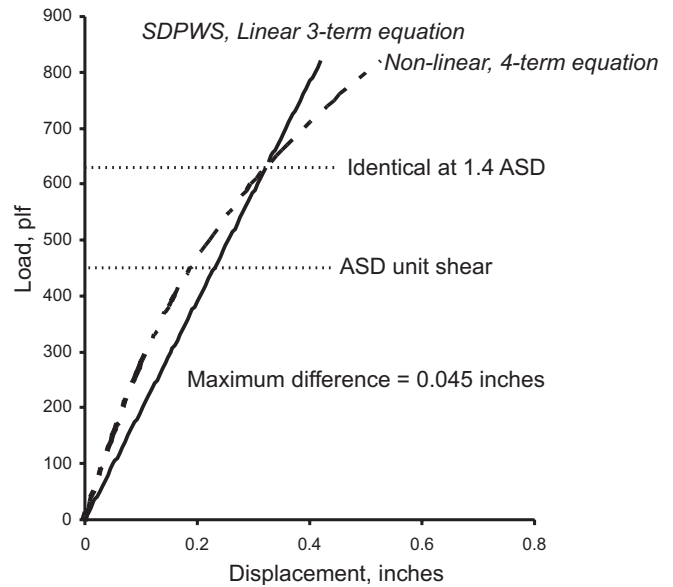
Identical values of calculated deflection are given by the three-term and four-term deflection equations at 1.4 times the ASD unit shear value (or, strength level force), as shown in **Figure 1**, for a wood structural panel shear wall. For the case shown, the maximum difference in calculated deflection is 0.045 inch. This small difference is not a significant factor in design; however, users should be aware that calculated deflection values will be different except at 1.4 times the ASD unit shear value.

### Perforated Shear Wall

Limits on shear capacity are given in terms of nominal unit strength for single-sided and double-sided perforated shear walls. For single-sided walls, the nominal unit shear capacity shall not exceed 980 plf for seismic or 1370 plf for wind. For double-sided walls, the nominal unit shear capacity shall not exceed two times 980 plf or 1960 plf for seismic or 2000 plf for wind. The double-sided limit on nominal unit shear capacity for wind is not two times the single-sided value (e.g.,  $2 \times 1370$  plf = 2740 plf) because test data for double-sided walls was limited to 2000 plf (*APA 157*). Nominal unit shear values must be divided by an ASD reduction factor or multiplied by the LRFD factor  $\phi$  to arrive at an appropriate design value.

### Adhesive Attachment of Shear Wall Sheathing

*SDPWS* wording clarifies that adhesive attachment of shear wall sheathing shall not be used regardless of presence of mechanical fasteners except in SDC A, B, or C. Approved adhesive attachment systems are permitted in SDC A, B, and C for wind and seismic design; however, seismic design coefficients  $R$  and  $\Omega_o$  are limited to low values ( $R = 1.5$  and  $\Omega_o = 2.5$ ) unless other values are approved. This tightens conditions under which adhesives are permitted compared to *2003 IBC* where adhesive attachment is per-



**Figure 1.**—Comparison of shear wall deflection (8 ft by 8 ft, 7/16-inch OSB sheathing, 8d common nails, 3 inches o.c. at edges).

**Table 1.**—Adhesive attachment of shear wall sheathing.

Seismic design category	Seismic design coefficient	
	<i>SDPWS</i>	<i>IBC 2006</i>
A, B, and C	$R = 1.5, \Omega_o = 2.5$	--
D	Not permitted	Not permitted

mitted in SDC A, B, or C without assignment of special seismic design coefficients (**Table 1**).

### Panel Widths for Shear Walls

For wood-framed shear walls, which are required to have all panel edges nailed to blocking or framing, a minimum panel width dimension is not specified in *SDPWS*:

“4.3.7.1 ...Panels shall not be less than 4 feet  $\times$  8 feet, except at boundaries and changes in framing. Framing members or blocking shall be provided at the edges of all panels.”

*SDPWS* language provides construction flexibility by permitting use of other than full size panels in shear wall construction such as may occur in a wall that is 8 feet-6 inches tall or 4 feet-6 inches wide. Cyclic tests (*APA T2005-08*) of shear walls constructed with panel widths of 6 inches and 24 inches showed no significant differences in performance.

### Wood Structural Panel Over Lumber Planking or Laminated Decking

Expanded provisions, compared to *IBC* Section 2305, are provided for minimum fastener penetration, aspect ratio, and requirements to maintain load path where wood structural panels are applied over solid lumber planking or laminated decking:

“4.2.7.1...Wood structural panel sheathing in a diaphragm is permitted to be fastened over solid lumber planking or laminated decking provided the following requirements are met:

- a) panel edges do not coincide with joints in the lumber planking or laminated decking;
- b) adjacent panel edges parallel to the planks or decking are fastened to a common member;
- c) the planking or decking shall be of sufficient thickness to satisfy minimum fastener penetration in framing requirements as given in *SDPWS* Table 4.2A;
- d) diaphragm aspect ratio (L/W) does not exceed that for a blocked wood structural panel diaphragm (4:1);
- e) diaphragm forces are transferred to diaphragm boundary elements through planking or decking by other methods.”

#### **Forces Contributed by Concrete and Masonry Walls**

*SDPWS* Section 4.1.5 limitations on use of wood systems to resist forces contributed by concrete or masonry walls are similar to requirements in *2006 IBC*; however, editorial revision clarifies requirements:

“4.1.5 Wood Members and Systems Resisting Seismic Forces Contributed by Masonry and Concrete Walls: Wood shear walls, diaphragms, trusses, and other wood members and systems shall not be used to resist seismic forces contributed by masonry or concrete walls in structures over one story in height.

Exceptions:

1. Wood floor and roof members shall be permitted to be used in diaphragms and horizontal trusses to resist horizontal seismic forces contributed by masonry or concrete walls provided such forces do not result in torsional force distribution through the truss or diaphragm.
2. Vertical wood structural panel sheathed shear walls shall be permitted to be used to provide resistance to seismic forces in two-story structures of masonry or concrete walls, provided the following requirements are met...”

Since only forces contributed by concrete or masonry walls are addressed in 4.1.5, *SDPWS* Section 4.1.6 clarifies that wood members and systems must be designed when resisting forces from other structural and non-structural concrete or masonry construction:

“4.1.6 Wood Members and Systems Resisting Seismic Forces from Other Concrete or Masonry Construction: Wood members and systems shall be designed to resist seismic forces from other concrete or masonry components, including but not limited to: chimneys, fireplaces, concrete or masonry veneers, and concrete floors.”

Language “including but not limited to” is provided to avoid an exhaustive list of other concrete or masonry components or cement-based products such as roof tile and siding, which might be present in wood-frame construction.

#### **Summing Shear Capacities**

Provisions for summing shear capacities expand upon the current rule of thumb approach in *IBC* Section 2305. For similar materials and construction on opposite sides of a wall, nominal unit shear capacity is based on relative stiffness (and associated strength) of each side - consistent with general principles of analysis in *ASCE 7* and *IBC* Chapter 16. The approach given in *SDPWS* Section 4.3.3.2 results in consistent treatment of strength and stiffness contribution whether a given panel is located on one side of a two-sided wall or whether the same panel is part of a one-sided wall segment located elsewhere in the wall line. For seismic design of walls sheathed on opposite sides with dissimilar materials, the strength-based rule of thumb is applied:

“4.3.3.2 Summing Shear Capacities...For shear walls sheathed with dissimilar materials on opposite sides, the combined nominal unit shear capacity, ( $v_{sc}$ ) or ( $v_{wc}$ ), shall be either two times the smaller nominal unit shear capacity or the larger nominal unit shear capacity, whichever is greater.”

Where design is based on the combined capacity of dissimilar materials on opposite sides as part of a wood-frame bearing wall system, the corresponding R factor equals 2 and the system is limited to SDC A-D (walls utilizing fiber-board capacity are limited to SDC A, B, and C).

#### **Conclusion**

New aspects of the *2005 SDPWS* include simplified equations for determining shear wall and diaphragm deflection and the use of nominal design values to derive ASD and LRFD capacities for shear walls and diaphragms. It also includes stiffness properties for construction types other than wood structural panel shear walls and blocked diaphragms to assist designers and regulators attempting to ensure compliance with existing seismic criteria.

#### **References**

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