Changes to the *2018 Wood Frame Construction Manual*

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Introduction

The 2018 Edition of the *Wood Frame Construction Manual (WFCM) for One- and Two-Family Dwellings,* designated *ANSI/AWC WFCM-2018,* is approved as an ANSI American National Standard (Figure 1). The *2018 WFCM* was developed by the American Wood Council's (AWC) Wood Design Standards Committee (WDSC) and is referenced in the *2018 International Residential Code (IRC)* and *2018 International Building Code (IBC)*.

Tabulated engineered and prescriptive design provisions in WFCM Chapters 2 and 3, respectively are based on the following loads from *ASCE/SEI 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures*:

- 0-70 psf ground snow loads
- 90-195 mph 3-second gust basic wind speeds for risk category II buildings
- Seismic Design Categories A-D

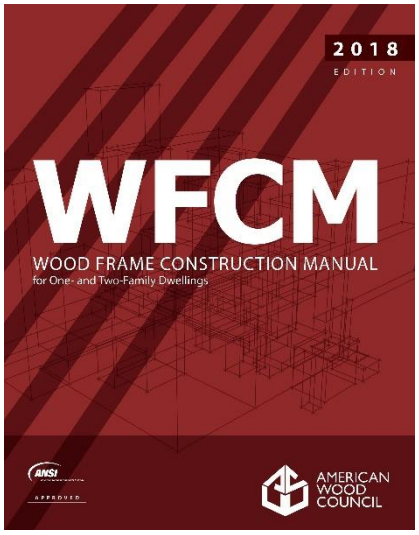


Figure 1. The* 2018 WFCM *is referenced in the* 2018 IRC *and* 2018 IBC*.

The *WFCM* includes design and construction provisions for connections, wall systems, floor systems, and roof systems. A range of structural elements are covered, including sawn lumber, structural glued laminated timber, wood structural panel sheathing, I-joists, and trusses.

Primary changes to the *2018 WFCM* are listed here and major topics are subsequently covered in more detail:

- Updated wind loads from *ASCE/SEI 7-10* to *ASCE/SEI 7-16*
- Inclusion of lower wind speed categories (e.g. 90, 95, 100, and 105 mph) to coordinate with ASCE/SEI 7-16
- Updated fastener criteria to coordinate with *2018 National Design Specification® (NDS®) for Wood Construction* including provisions for roof sheathing ring shank (RSRS) nails and fastener head pull through design values
- Revised provisions for roof rake overhangs at gable ends
- Revised shear wall assembly allowable unit shear capacities, maximum shear wall segment aspect ratios, and sheathing type adjustments incorporate updated aspect ratio adjustments to be consistent with the *2015 Special Design Provisions for Wind and Seismic (SDPWS)*

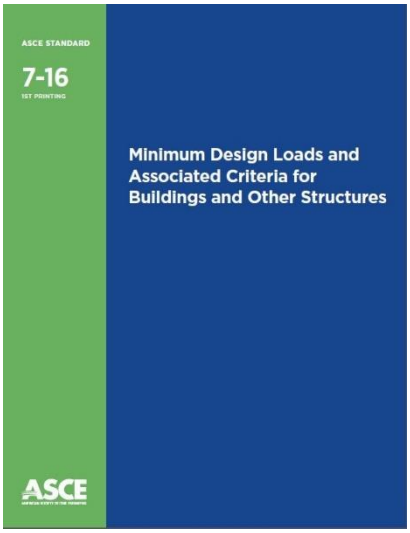


Figure 2. The majority of changes to the* 2018 WFCM *reflect increased C&C wind pressures in* ASCE/SEI 7-16*.

ASCE/SEI 7-16 Revised Wind Loads

The majority of changes to the *2018 WFCM* were developed to address increased component and cladding (C&C) wind pressures in *ASCE/SEI 7-16*. Lower wind speed categories (e.g. 90, 95, 100, and 105 mph) were also added consistent with *ASCE/SEI 7-16*. For a summary of ASCE 7-16 wind provisions, see the 2017 NCSEA Webinar titled "*ASCE 7-16* Wind Provisions – How they affect the Practicing Engineer" by Don Scott, Chair of both the *ASCE 7-16* Wind Load Subcommittee and NCSEA Wind Engineering Committee.

Wind pressure changes for roof design can be summarized as follows:

- New C&C roof pressure coefficients increase localized pressures on roofs
- New C&C roof pressure zones have been added
- Interior C&C roof pressures have the largest increase on a percentage basis

Table 1a provides a comparison of *ASCE/SEI 7-16* to *ASCE/SEI 7-10* C&C roof coefficients and Table 1b provides the same comparison for the larger roof overhang coefficients. Figure 3 provides an overview of the various roof zones as defined in *ASCE/SEI 7-16* for a gable roof with roof slopes between 7 and 45 degrees. Tables 1a and 1b also show the roof coefficients as implemented for *2018 WFCM* chapters 2 and 3. *WFCM* Chapter 2 uses the maximum magnitude suction loads for roof slopes between 7 and 45 degrees in Roof Zones 1, 2, and 3. *WFCM* Chapter 3 further simplifies the roof loading requirements by combining Roof Zones 2 and 3 into an end zone and reducing the magnitude of Zone 3 loads by limiting rake overhangs. As a result of these simplifications, the effective uplift pressures on critical roof edge and overhang zones is limited to an 11% increase in WFCM Chapter 3 requirements as shown in Tables 1a and 1b (e.g. -4.1 coefficient under *ASCE 7-16* versus -3.7 coefficient under *ASCE 7-10*). This results in a smaller increase in uplift load requirements between editions of the WFCM than the actual percent increase in design pressures between *ASCE/SEI 7-10* and *ASCE/SEI 7-16*.

Table 1a. Comparison of C&C Roof Coefficients [a] (suction)

	ASCE 7-16						ASCE 7-10					
	Roof GC_p - GC_{pi}						Roof GC_p - GC_{pi}					
	3r	**3e**	**2n**	**2r**	**2e**	**1**	**3r**	**3e**	**2r**	**2n**	**2e**	**1**
7 < Θ ≤ 20	-3.8	-3.2	-3.2	-3.2	-2.2	-2.2	-2.8	-2.8	-1.9	-1.9	-1.9	-1.1
20 < Θ ≤ 27	-3.8	-2.7	-2.7	-2.7	-1.7	-1.7	-2.8	-2.8	-1.9	-1.9	-1.9	-1.1
27 < Θ ≤ 45	-2.2	-3.4	-2.2	-2.0	-2.0	-2.0	-1.4	-1.4	-1.4	-1.4	-1.4	-1.2
Maximum (suction)	**-3.8**	**-3.4**	**-3.2**	**-3.2**	**-2.2**	**-2.2**	**-2.8**	**-2.8**	**-1.9**	**-1.9**	**-1.9**	**-1.2**
WFCM Ch. 2 Simplified	**-3.8**		**-3.2**			**-2.2**	**-2.8**		**-1.9**			**-1.2**
WFCM Ch. 3 Simplified	**-4.1 [b]**					**-2.2**	**-3.7**					**-1.2**

Table 1b. Comparison of C&C Roof Overhang Coefficients (suction)

	ASCE 7-16						ASCE 7-10					
	Roof Overhang GC_p						Roof Overhang GC_p					
	3r	**3e**	**2r**	**2n**	**2e**	**1**	**3r**	**3e**	**2r**	**2n**	**2e**	**1**
7 < Θ ≤ 20	-4.7	-4.1	-3.5	-3.5	-2.5	-2.5	-3.7	-3.7	-2.2	-2.2	-2.2	-
20 < Θ ≤ 27	-4.7	-3.6	-3.0	-3.0	-2.0	-2.0	-3.7	-3.7	-2.2	-2.2	-2.2	-
27 < Θ ≤ 45	-2.8	-4.0	-2.8	-2.6	-2.6	-2.6	-2.0	-2.0	-2.0	-2.0	-2.0	-
Maximum (suction)	**-4.7**	**-4.1**	**-3.5**	**-3.5**	**-2.6**	**-2.6**	**-3.7**	**-3.7**	**-2.2**	**-2.2**	**-2.2**	**-**
WFCM Ch. 2 Simplified	**-4.7**		**-3.5**			**- [c]**	**-3.7**		**-2.2**			**-**
WFCM Ch. 3 Simplified	**-4.1 [b]**					**- [c]**	**-3.7**					**-**

a. C&C roof coefficients include external and internal pressures assuming an enclosed structure.

b. In *2018 WFCM* Chapter 3, the maximum length of rake overhangs (without outlookers) has been limited to 9", so the effective GC_p value in overhang zone 3r is less than non-overhang zone 3r or overhang zone 3e.

c. In *2018 WFCM* Chapter 3, the maximum length of eave and rake overhangs has been limited to 2', so a Zone 1 Overhang would never exist since the edge dimension "a" is always greater than 2'.

Changes to Fastener Design

Wind uplift related changes include new fastener withdrawal and new fastener head pull-through design provisions.

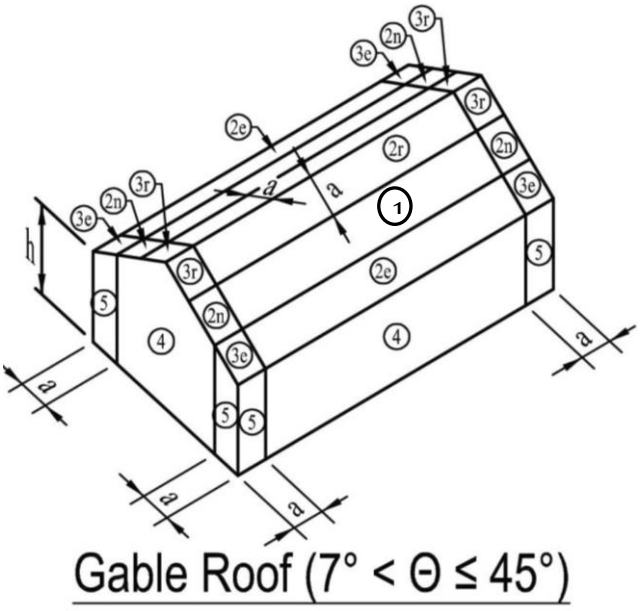


***Figure 3. Overview of various gable roof zones as defined in* ASCE/SEI 7-16.**

Roof Sheathing Ring Shank Nails

Roof Sheathing Ring Shank (RSRS) nails were recently added to *ASTM F 1667 Standard Specification for Driven Fasteners: Nails, Spikes, and Staples*. Design provisions for RSRS nails have been added to the *2018 NDS* and *2018 WFCM*. RSRS nails, which have larger withdrawal design values than smooth shank nails of equal length and diameter, provide additional options for efficient attachment of wood structural panel roof sheathing. In many cases, specification of RSRS nails will produce a reduced roof sheathing attachment schedule than permissible by use of smooth shank nails and enable use of a single minimum fastener schedule for roof perimeter edge zones and interior zones. Recognition of higher withdrawal strength is based on presence of 1-1/2" length of standardized ring deformations on the nail.

Fastener Head Pull-through Provisions

Fastener head pull-through design in accordance with NDS 2018 is incorporated in to sheathing attachment requirements for resistance to wind uplift/suction forces. For design of roof sheathing fastening to resist wind uplift, the lesser of the head pull-through design value or the fastener withdrawal design value from wood is used to establish the "fastener uplift capacity" as shown in Figure 4 which is excerpted from *2018 WFCM* Table 3.10.

Figure 4. Excerpt from* 2018 WFCM *Table 3.10 showing fastener uplift capacity controlled either by nail withdrawal capacity or head pull-through.

	Fastener Uplift Capacity [2, 3] (lbs)									
Sheathing Thickness (in.)	3/8		7/16		15/32		19/32		23/32	
Framing Member SG	0.42	0.49	0.42	0.49	0.42	0.49	0.42	0.49	0.42	0.49
8d common [4]	70	91	68	100	67	98	63	92	58	86
10d box [4]	84	101	82	118	81	120	77	114	73	108
RSRS-03 [5]	91	91	99	106	99	114	99	135	99	135

2 Minimum capacity of withdrawal and fastener head pull-through is tabulated.

3 Tabulated values include a load duration factor adjustment, C_D=1.6.

4 Tabulated values for 8d common nails and 10d box nails are applicable to carbon steel nails (bright or galvanized).

5 Tabulated values for RSRS-03 nails are applicable to carbon steel (bright or galvanized) or stainless steel nails.

Example
Compare fastener uplift capacity of 8d Common and RSRS-03 nails as shown in Figure 4. Fastener uplift capacity is the lesser of withdrawal and head pull through.

Assume 180 mph Exposure B wind loads, 19/32" WSP sheathing, framing specific gravity (G) = 0.49 or higher, and rafter spacing = 24". Using 2018 WFCM Table 3.10, the required nailing pattern (i.e. panel edge/panel field) at roof perimeter zones and interior zones is shown in Table 2.

Table 2. Comparison of RSRS-03 to 8d Common Nailing Patterns for High Wind.[a]

Nail Type[b]	**Roof Perimeter Zone Nail Spacing** (o.c. WSP edge/interior, inches)	**Roof Interior Zone Nail Spacing** (o.c. WSP edge/interior, inches)
RSRS-03 (L=2.5", TL=1.5", D=0.131", H=0.281")	6/6	6/12
8d Common (L=2.5", D=0.131", H=0.281")	4/4	6/6

a. Assume 180 mph Exposure B wind loads, 19/32" WSP sheathing, framing specific gravity (G) = 0.49 or higher, and rafter spacing = 24".
b. TL=thread length, D=diameter, H=head diameter, L=length.

In this case, the RSRS nail provides nailing pattern options that reduce required nailing when compared to 8d common smooth shank nails.

Roof Rake Overhangs

Rake overhang provisions were revised to clarify terminology and limit rake overhang lookout blocks to 9 inches (previously limited to 12 inches) based on increased wind pressures (see Figure 5a). Rake overhang outlooker provisions were expanded to tabulate requirements for overhang spans of 12", 16" and 19.2" in addition to 24" previously tabulated (see Figure 5b). The smaller span cases were added to address increased wind pressures and remove conservatism associated with tabulated requirements based only on assumed 24" overhang span.

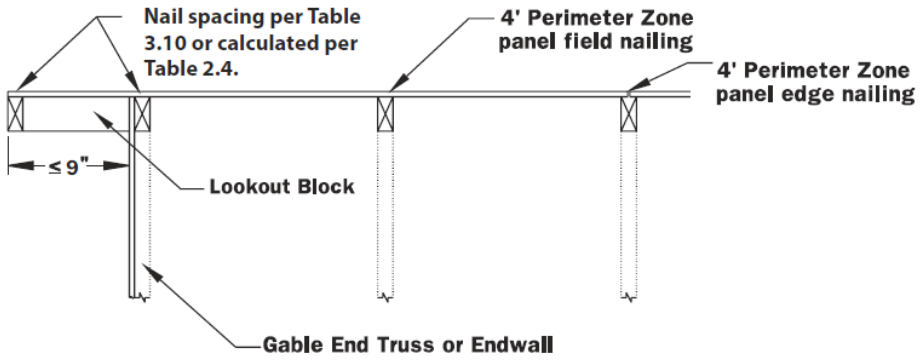
Shear Wall Assemblies

Shear wall aspect ratio adjustments were revised to be consistent with the *2015 Special Design Provisions for Wind and Seismic (SDPWS).* Shear walls using gypsum wallboard are subject to the following limits (underlines show clarifying text added to *2018 WFCM*):

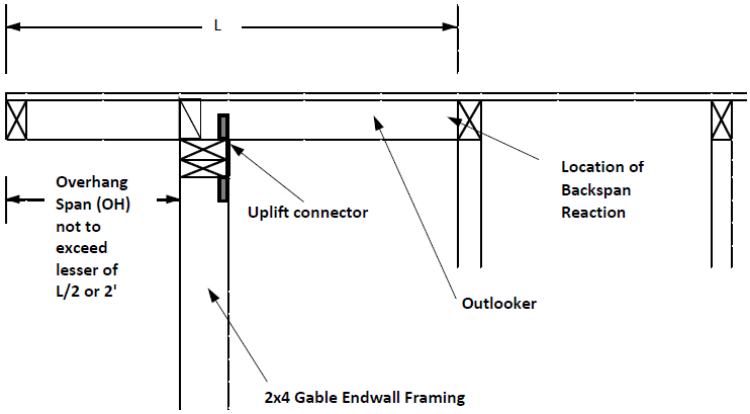
> Gypsum wallboard walls having aspect ratios exceeding 1.5:1 shall be blocked. Where shear walls are gypsum wallboard only, the maximum aspect ratio shall not exceed 2:1 in accordance with *AWC/ANSI Special Design Provisions for Wind and Seismic (SDPWS)* Table 4.3.4.

Shear walls with blocked wood structural panel sheathing now show a maximum shear wall segment aspect ratio for wind of 2:1 (previously 3.5:1). However, the *2018 WFCM* still allows aspect ratio increases up to 3.5:1 for walls with blocked WSP sheathing or structural fiberboard sheathing provided the unit shear capacity and sheathing type adjustment factor are adjusted in accordance with *2015 SDPWS* Section 4.3.3.4.1 Exception 1 for wood structural panel shear walls or Exception 2 for structural fiberboard shear walls.

Figure 5. Rake Overhang Outlooker and Lookout Block Details (excerpted from* 2018 WFCM*).



a. Lookout Block Detail



b. Outlooker Detail

Applicability to Non-Residential Structures

IBC 2309 allows for use of the *WFCM* for non-residential structures within its scoping limitations:

> **(IBC) 2309.1 Wood Frame Construction Manual.** Structural design in accordance with the AWC WFCM shall be permitted for buildings assigned to Risk Category I or II subject to the limitations of Section 1.1.3 of the AWC WFCM and the load assumptions contained therein. Structural elements beyond these limitations shall be designed in accordance with accepted engineering practice.

While *WFCM* provisions are intended primarily for detached one-and two-family dwellings due to the floor live load assumption associated with those occupancies, many of the *WFCM* provisions for specific geographic wind, seismic, and snow loads may be applicable for other buildings. For example, wind provisions for sizing of roof sheathing, wall sheathing, fastening schedules, uplift straps, shear anchorage, shear wall lengths, and wall studs for out of plane wind loads are included in the *WFCM* and are applicable for other use groups within the load limitations of the *WFCM* tables. Similarly, roof rafter size and spacing for heavy snow, and shear wall lengths and anchorage for seismic are applicable within the load limitations of the *WFCM* tables. Examples of non-residential applications include single-story wood structures or top stories in mixed use structures in Risk Categories I or II.

Applications outside the scope of the *WFCM* tabulated requirements, such as floor joist design for floor live loads greater than 40 psf and design of supporting gravity elements for the additional floor live load is beyond the applicability of the *WFCM* and must be designed in accordance with accepted

engineering practice. This parallels the approach taken in *IRC* Section R301.1.3, which permits unconventional elements of one and two-family dwellings to be designed per the *IBC*.

More Details
A section by section list of changes to the *WFCM* is available in the Appendix to this paper.

Availability
The *2018 WFCM* is currently available in electronic format (PDF) only. Once the *WFCM Commentary* is updated, printed copies will be available for purchase. Check the AWC website (www.awc.org) for status updates on the *2018 WFCM*.

Conclusion
The *2018 WFCM* represents the state-of-the-art for design of wood members and connections. The *2018 WFCM* updates pre-engineered design provisions based on loads from ASCE 7-16 and design requirements from the 2018 NDS and 2015 SDPWS. Both the *2018 IRC* and *2018 IBC* reference the 2018 *WFCM* for design of wood structures.

Authors
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Appendix: Summary of Changes
2018 Wood Frame Construction Manual (WFCM) for One- and Two-Family Dwellings

Section	Description of Change
Chapter 1 General Information	1) Updated design load reference from *ASCE 7-10* to *ASCE 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. 2) Revised Figure 1.1 Basic Wind Speeds for One- and Two-Family Dwellings Based on 3-second Gust Basic Wind Speeds for Risk Category II Buildings to coordinate with updated reference to *ASCE 7-16*. 3) Added requirements for identification and description of wood structural panels to recognize "Performance Category" consistent with the *International Building Code*. *WFCM* reference to wood structural panel (WSP) thickness appears in several forms. Reference to WSP thickness were revised throughout the standard to consistently describe wood structural panels and more accurately describe thickness as a nominal value to coordinate with the change to Section 1.2.1.8. For example: 15/32" Wood Structural Panel becomes Nominal 15/32" Wood Structural Panel; 7/16" becomes Nominal 7/16"; Minimum Panel Thickness (in.) becomes Minimum Nominal Panel Thickness (in.).
Chapter 2 Engineered Design	1) Revisions to coordinate with *ASCE 7-16* wind pressures and lower wind speed categories (e.g. 90, 95, 100, and 105 mph) include the following: Section 2.1.3.1 Adjustments for Wind Exposure and Mean Roof Height Table 2.1.3.1 Adjustment for Wind Exposure and Mean Roof Height Table 2.1 Lateral Framing Connection Loads from Wind Table 2.2A Uplift Connection Loads from Wind Table 2.2B Ridge Connection Loads from Wind Table 2.2C Rake Overhang Outlooker Uplift Connection Loads Table 2.4 Roof and Wall Sheathing Suction Loads Table 2.5A Lateral Diaphragm Loads from Wind – Perpendicular to Ridge Table 2.5B Lateral Diaphragm Loads from Wind – Parallel to Ridge Table 2.5C Lateral Diaphragm Loads from Wind – Parallel to Ridge (For Attic Floor or Ceiling Diaphragm When Bracing Gable Endwall) Table 2.9A Exterior Wall Stud Bending Stresses from Wind Loads Table 2.10 Exterior Wall Stud Wind Loads (Normal to the Wall Surface). This wind pressure table replaces previously tabulated "induced moments" to facilitate checking deflection per building code deflection criteria. Table 2.14A Rafter Spans for 20 psf Live Load. Revisions remove footnote for wind design based on addition of new Table 2.16 and new Table 3.26M. Table 2.15A Roof Framing Capacity Requirements for 20 psf Roof Live Load. Revisions remove footnote for wind design based on addition of new Table 2.16. Table 2.16 Roof Framing Wind Loads (Normal to the Roof Surface). This new table provides wind pressures for rafter design for wind. Coordinating change to charging text is in 2.5.1.1 Rafters. Existing Table 2.16 and Table 2.17 are re-numbered Table 2.17 and Table 2.18, respectively. 2) Revised Section 2.1.5.6 Fasteners incorporates fastener criteria from the *2018 National Design Specification (NDS) for Wood Construction* including provisions for roof sheathing ring shank (RSRS) nails and fastener head pull through design values.

	3) Revised Section 2.5.1.1.3 Rake Overhangs clarifies terminology and limits rake overhang lookout blocks to 9 inches based on increased wind pressures as follows: Revised Figure 2.1h to reflect the 9 inch limit. Revised Figure 2.1g Rake Overhang limits – Outlookers clarifies call-outs for the rake overhang detail. 4) Revised Figure 2.3 title and figure labels clarify applicability of the detail to floor and roof construction.
Chapter 3 Prescriptive Design	1) Revisions to coordinate with *ASCE 7-16* wind pressures and lower wind speed categories (e.g. 90, 95, 100, and 105 mph) include the following list of tables: Table 3.2 Sill or Bottom Plate to Foundation Requirements for Wind Table 3.2A Sill Plate to Foundation Connections Resisting Shear Loads from Wind Table 3.2C Sill or Bottom Plate to Foundation Connections (Anchor Bolts) Resisting Uplift from Wind Table 3.4 Rafter/Truss Framing to Wall Connection Requirements for Wind Loads Table 3.4A Rafter and/or Ceiling Joist to Top Plate Lateral and Shear Connection Requirements Table 3.4B Shear Walls Resisting Uplift and Shear Table 3.4C Rake Overhang Outlooker Uplift Connection Requirements. Revisions include new prescribed connection and framing requirements to enable sheathing to span with strong axis across support provided by blocking and fly rafter. Table 3.5 Top and Bottom Plate to Stud Lateral Connection Requirements for Wind Loads Table 3.5A Top and Bottom Plate to Stud Lateral Connections for Wind Loads Revisions also remove Footnote 2 since it is a carryover from Footnote 1 in Table 3.5 (Unit Framing Loads) where the footnote is more applicable. There is also never a case in Table 2.5A where footnote 2 would reduce the number of nails required. Table 3.6 Ridge Connection Requirements for Wind Table 3.7 Header Connection Requirements for Wind Table 3.8 Window Sill Plate Connection Requirements for Wind Table 3.10 Roof Sheathing Attachment Requirements for Wind Loads. Table 3.10 is a replacement of the former table and includes both requirements for uplift load per nail and fastener uplift capacity. Fastener uplift capacity is in accordance with NDS and based on nail type, sheathing thickness, and framing specific gravity (G). Table 3.10A Roof Sheathing Attachment Requirements for Wind Loads (Prescriptive Alternative to Table 3.10). Table 3.10A is similar to former Table 3.10 and provides prescriptive nailing at panel edges and in the panel field for assumed 7/16 nominal panel thickness and framing G=0.50. Table 3.11 Wall Sheathing and Cladding Attachment Requirements for Wind Loads Table 3.12A Roof Sheathing Requirements for Wind Loads. Revisions for WSP sheathing address recommended inclusion of panel span rating, associated with sheathing grades, to potentially avoid misapplications based on specifying nominal thickness only. Table 3.13A Wall Sheathing Requirements for Wind Loads. Revisions for WSP sheathing with strength axis parallel to supports are in accordance with revised panel capacities in *SDPWS 2015* and address recommended inclusion of panel span rating to potentially avoid misapplications based on specifying nominal thickness only. Potentially smaller required span ratings and nominal thickness for Structural I Sheathing with greater cross-bending properties is addressed by footnote 5. Table 3.13B Wall Cladding Requirements for Wind Loads

	Table 3.15 Minimum Attic Floor/Ceiling Lengths When Bracing Gable Endwall for Wind Loads Table 3.16A1-A4 Roof Diaphragm Limits for Wind Table 3.16B Floor Diaphragm Limits for Wind Table 3.17A Segmented Shear Wall Sheathing Requirements for Wind Table 3.20 A1-A6 Maximum Exterior Loadbearing and Non-Loadbearing Stud Lengths Resisting Interior Zone Wind Loads Table 3.20 B1-B6 Maximum Exterior Loadbearing and Non-Loadbearing Stud Lengths Resisting Interior Zone Wind Loads Table 3.23A Laterally Unsupported (Dropped) Header Spans for Exterior Loadbearing Walls Resisting Wind Loads Table 3.23B Laterally Unsupported (Dropped) Header Spans for Exterior Non-Loadbearing Walls and Window Sill Plate Spans Resisting Wind Loads Table 3.26M Rafter Spans for Wind Loads. New span tables for roof rafters based on wind pressures. Table 3.26M replaces footnote 3 of Table 3.26A which is removed. 2) Revised Section 3.1.3.4c and Section 3.5.1.1.3 Rake Overhangs – clarify terminology used for rake overhangs and limit rake overhang lookout blocks to 9 inches. 3) Revised Table 3.17D to incorporate updated shear wall aspect ratio adjustments consistent with *SDPWS 2015*.
Appendix	1) Revisions to coordinate with *ASCE 7-16* lower wind speed categories (i.e. 90, 95, 100, and 105 mph) include the following: Table A-3.4 Uplift Strap Connection Requirements (Roof-to-Wall, Wall-to-Wall, and Wall-to-Foundation) Table A-3.6 Ridge Tension Strap Connection Requirements for Wind 2) Revised Table A-3.4 and A-3.6 incorporates a check of strap capacity and removes cases where strap load exceeds the tension capacity of the strap based on calculations in accordance with *AISI S100 North American Specification for the Design of Cold-Formed Steel Structural Members*.