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An Overview of Structural Changes in the 2021 IBC

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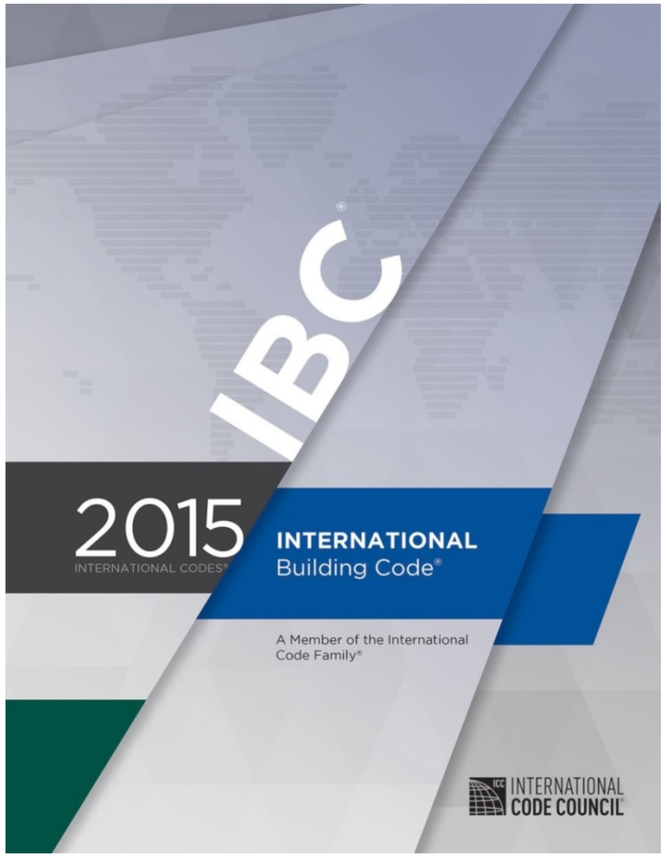
Dr. Ghosh has influenced seismic design provisions in the United States for many years. In addition to authoring many publications in the area of structural design, Dr. Ghosh has investigated and reported on structural performance in most recent earthquakes. He is currently leading a World Bank project on building code enforcement in Dhaka, Bangladesh.

Dr. Ghosh is an Honorary Member of ACI, and is a Fellow of ASCE, SEI, and PCI. He is a member of ACI Committee 318, Standard Building Code, the ASCE 7 Standard Committee (Minimum Design Loads for Buildings and Other Structures), and the Board of Governors of ASCE's Structural Engineering Institute.

2015, 2018 International Building Codes



Adopted ASCE 7-10 with Supplement No. 1

Adopted ASCE 7-16

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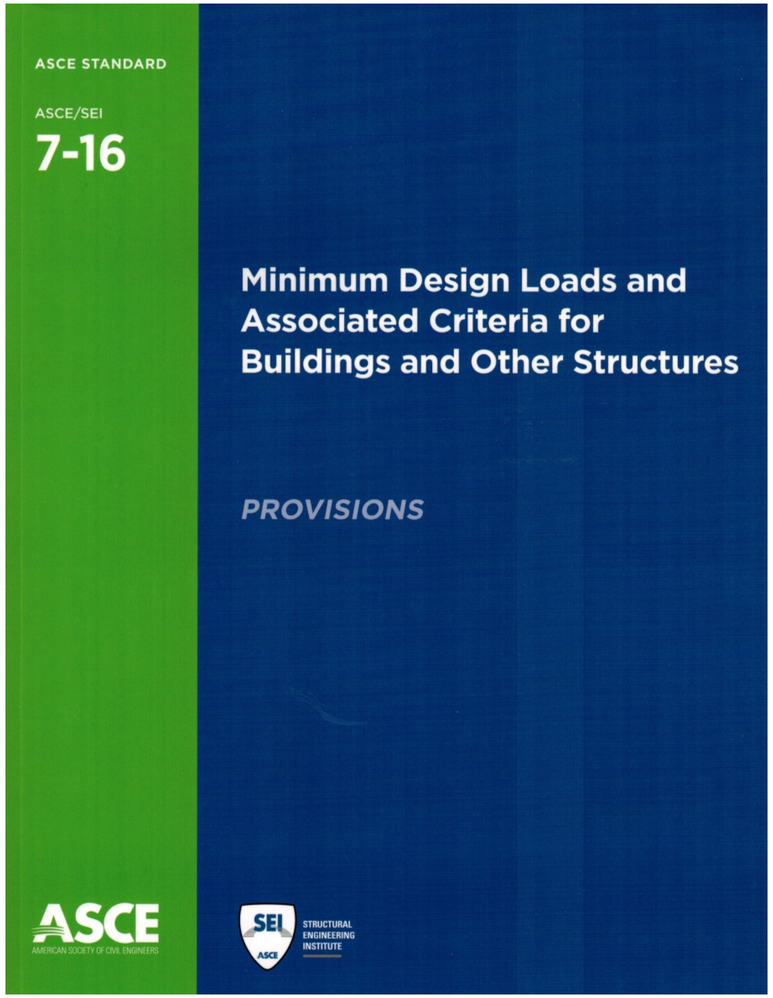
ASCE 7-16


ASCE STANDARD
ASCE/SEI
7-16
Minimum Design Loads and Associated Criteria for Buildings and Other Structures
PROVISIONS
ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS
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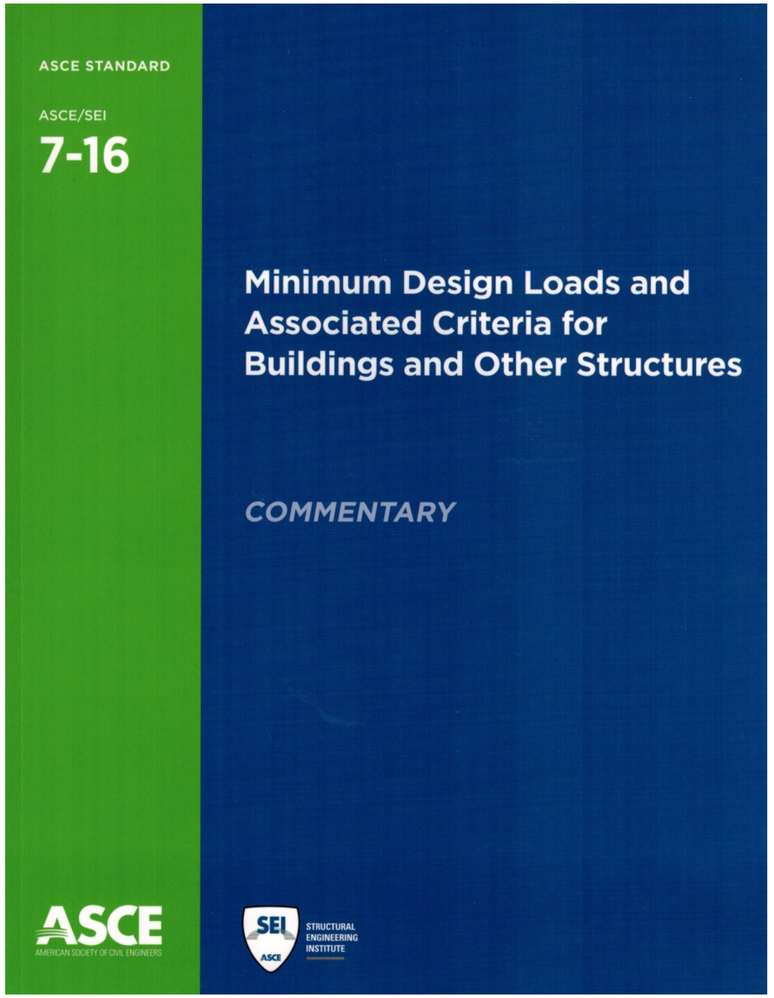
ASCE STANDARD
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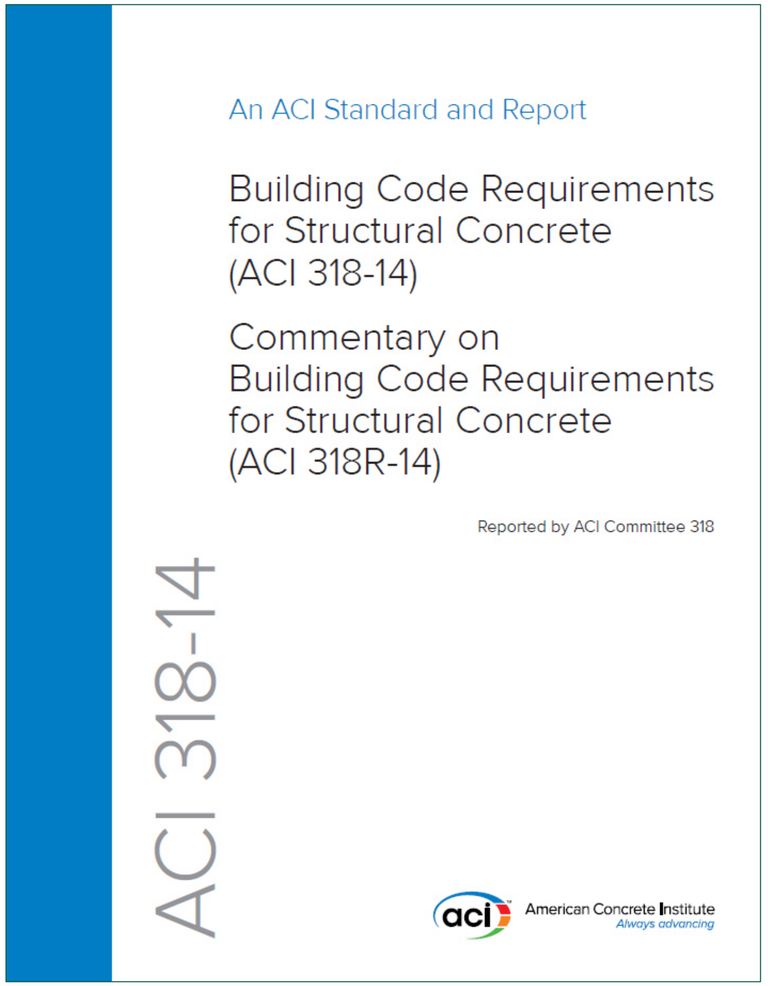
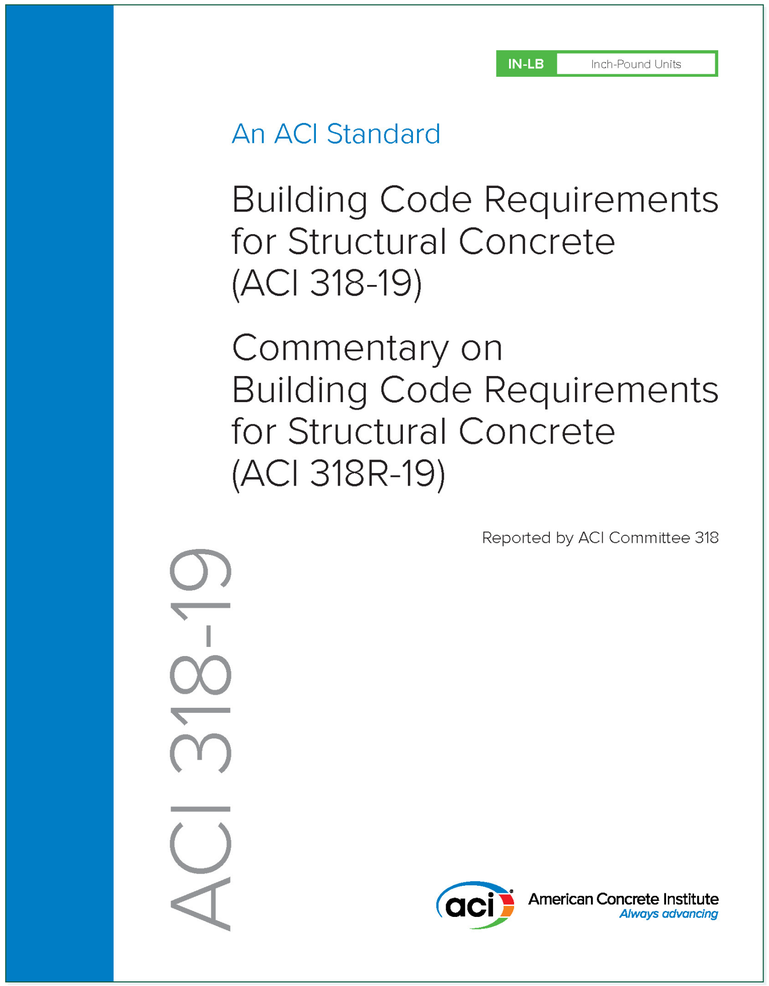
2021 IBC

Adopts ASCE 7-16 with Supplement No. 1

ACI 318-14 and -19



2018 IBC



2021 IBC

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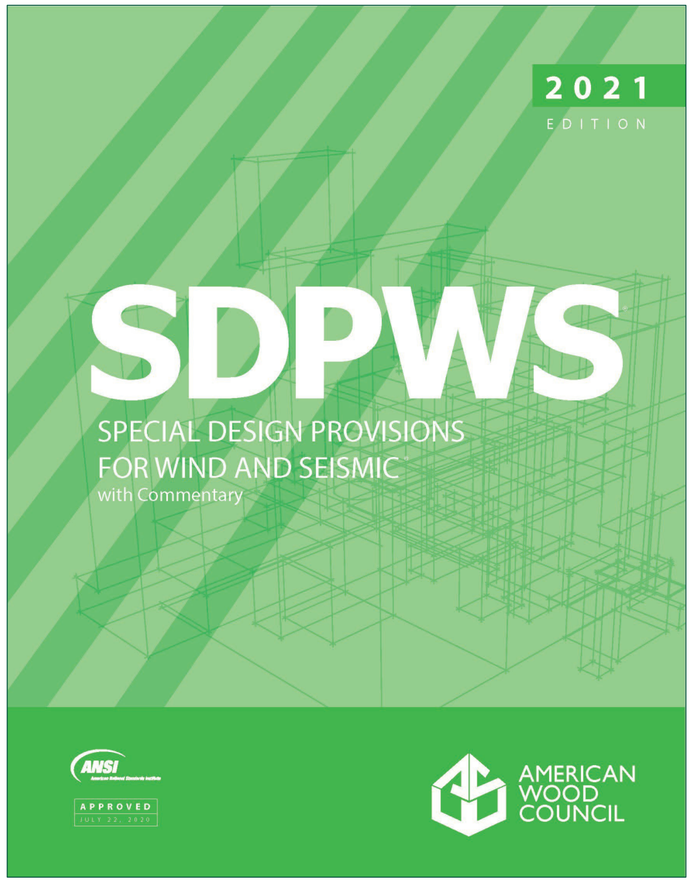
SDPWS-2015 and -2021

2018 IBC



2021 IBC

202 Live Load, Roof

LIVE LOAD, ROOF. A load on a roof produced:

1. During maintenance by workers, equipment and materials; or

2. During the life of the structure by movable objects such as planters or other similar small decorative appurtenances that are not occupancy related.~~; or~~

~~3. By the use and occupancy of the roof such as for roof gardens or assembly areas.~~

202 Live Load, Roof

SECTION 1602 NOTATIONS

L = ~~Roof live load greater than 20 psf (0.96 kN/m) and floor live~~ Live load.

L_r = Roof live load ~~of 20 psf (0.96 kN/m) or less~~.

ASCE 7-16 Separation of Seismic Load Combinations

Load combinations involving seismic loads are placed separately in new Sections 2.3.6 (strength design) and 2.4.5 (ASD)

Seismic load E is expressed in terms of E_h and E_v

ASCE 7-16 Separation of Seismic Load Combinations

2.3.~~2~~1 Basic Combinations. Structures, components, and foundations shall be designed so that their design strength equals or exceeds the effects of the factored loads in the following combinations:

1. 1.4*D*
2. 1.2*D* + 1.6*L* + 0.5(*Lr* or *S* or *R*)
3. 1.2*D* + 1.6(*Lr* or *S* or *R*) + (*L* or 0.5*W*)
4. 1.2*D* + 1.0*W* + *L* + 0.5(*Lr* or *S* or *R*)
5. ~~1.2*D* + 1.0*E* + *L* + 0.2*S*~~
6. ~~6~~5. 0.9*D* + 1.0*W*
7. ~~0.9*D* + 1.0*E*~~

ASCE 7-16 Separation of Seismic Load Combinations

2.3.6 Basic Combinations with Seismic Load Effects. When a structure is subject to seismic load effects, the following load combinations shall be considered in addition to the basic combinations in Section 2.3.1. The most unfavorable effects from seismic loads shall be investigated, where appropriate, but they need not be considered to act simultaneously with wind loads.

Where the prescribed seismic load effect, $E = f(E_v, E_h)$ (defined in Section 12.4.2 or 12.14.3.1) is combined with the effects of other loads, the following seismic load combinations shall be used:

6. $1.2D + E_v + E_h + L + 0.2S$
7. $0.9D - E_v + E_h$

ASCE 7-16 Separation of Seismic Load Combinations

Section 2.3.6 continued…..

Where the seismic load effect with overstrength, $E_m = f(E_v, E_{mh})$, defined in Section 12.4.3, is combined with the effects of other loads, the following seismic load combination for structures shall be used:

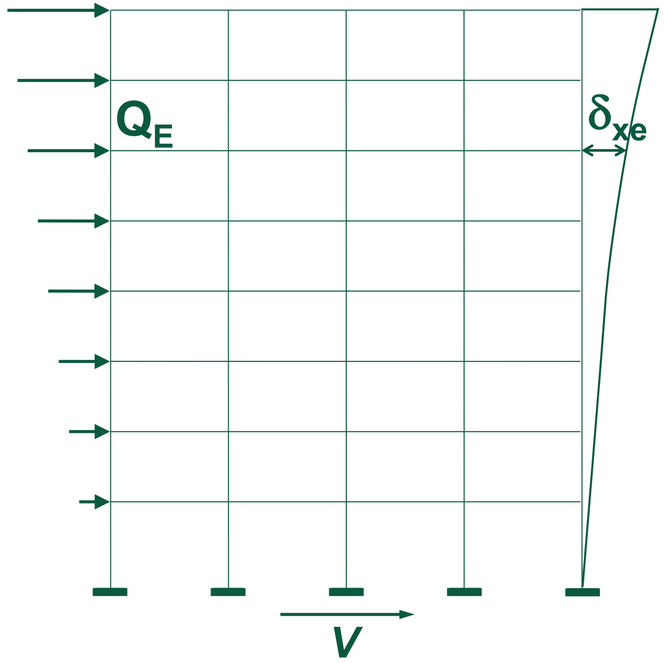
6. $1.2D + E_v + E_{mh} + L + 0.2S$

7. $0.9D - E_v + E_{mh}$

$E_h = \rho Q_E$

$E_v = 0.2 S_{DS} D$

$E_{mh} = \Omega_o Q_E$



ASCE 7-16 Separation of Seismic Load Combinations

2.4.1 Basic Combinations.

1. D

2. $D + L$

3. $D +$ (L_r or S or R)

4. $D + 0.75L + 0.75$(L_r or S or R)

~~5. $D +$ ($0.6W$ or $0.7E$)~~

6a. $D + 0.75L + 0.75(0.6W) + 0.75$($L_r$ or S or R)

~~6b. $D + 0.75L + 0.75(0.7E) + 0.75S$~~

7. $0.6D + 0.6W$

~~8. $0.6D + 0.7E$~~

ASCE 7-16 Separation of Seismic Load Combinations

2.4.5 Basic Combinations with Seismic Load Effects. When a structure is subject to seismic load effects, the following load combinations shall be considered in addition to the basic combinations in Section 2.4.1.

Where the prescribed seismic load effect, $E = f(E_v, E_h)$ (defined in Section 12.4.2) is combined with the effects of other loads, the following seismic load combinations shall be used:

8. $1.0D + 0.7E_v + 0.7E_h$

9. $1.0D + 0.525E_v + 0.525E_h + 0.75L + 0.75S$

10. $0.6D - 0.7E_v + 0.7E_h$

ASCE 7-16 Separation of Seismic Load Combinations

Section 2.4.5 Continued …..

Where the seismic load effect with overstrength, $E_m = f(E_v, E_{mh})$, defined in Section 12.4.3, is combined with the effects of other loads, the following seismic load combination for structures not subject to flood or atmospheric ice loads shall be used:

8. $1.0D + 0.7E_v + 0.7E_{mh}$

9. $1.0D + 0.525E_v + 0.525E_{mh} + 0.75L + 0.75S$

10. $0.6D - 0.7E_v + 0.7E_{mh}$

1605.1 General

ASCE 7-16 changes not implemented in the **2018 IBC**.

2021 IBC: Buildings and other structures and portions thereof shall be designed to resist the Strength Load Combinations specified in ASCE 7 Section 2.3, the Allowable Stress Design Load Combinations specified in ASCE 7 Section 2.4, or the Alternative Allowable Stress Design Load Combinations of Section 1605.2.

1605.3 Load Combinations using ASD

1605.3.2 Alternative basic load combinations (cont.)

- $D + L + (L_r \text{ or } S \text{ or } R)$ (Equation 16-1~~17~~)
- $D + L + 0.6\omega W$ (Equation 16-2~~18~~)
- $D + L + 0.6\omega W + S/2$ (Equation 16-3~~19~~)
- $D + L + S + 0.6\omega W/2$ (Equation 16-4~~20~~)
- $D + L + S + E/1.4$ (Equation 16-5~~21~~)
- $0.9D + E/1.4$ (Equation 16-6~~22~~)

1605.3 Load Combinations using ASD

Reason: The material chapters have been revised since the omega factor was introduced in the code to account for some of the material chapters allowing a one-third stress increase on the allowable stresses. This one-third stress increase has been eliminated from the material chapters. Thus, the omega factor is not longer necessary.

ASCE 7-16 Photovoltaic Panel (PV) Systems

New! **3.1.5 Photovoltaic Panel (PV) Systems**

The weight of photovoltaic panels, their support system, and ballast shall be considered as dead load.

*Now **2021 IBC** Section 1606.3.*

ASCE 7-16 Vegetative and Landscaped Roofs

3.1.4 Vegetative and Landscaped Roofs

The weight of all landscaping and hardscaping materials shall be considered as dead load. The weight shall be computed considering both fully saturated soil and drainage layer materials and fully dry soil and drainage layer materials to determine the most severe load effects on the structure.

*Now **2021 IBC** Section 1606.4.*

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1607.13.3.1 Vegetative and Landscaped Roofs

1607.13.3.1 Vegetative and landscaped roofs. ~~The weight of all landscaping materials shall be considered as dead load and shall be computed on the basis of saturation of the soil as determined in accordance with Section 3.1.4 of ASCE 7.~~ The uniform design live load in unoccupied landscaped areas on roofs shall be 20 psf (0.958 kN/m). The uniform design live load for occupied landscaped areas on roofs shall be determined in accordance with Table 1607.1.

Table 1607.1 Design Live Loads

Table 1607.1 Minimum Uniformly Distributed Live Loads, L_0, and Minimum Concentrated Loads.

Made consistent with ASCE 7-16 Table 4.3-1. All 15 footnotes removed. The substance of each footnote is incorporated in text where it belongs.

1607.13.5 Photovoltaic Panel Systems.

1607.13.5.1 Roof live load.

1607.13.5.2 Photovoltaic panels or modules.

1607.13.5.~~2.1~~ 3 Photovoltaic panels installed on open grid roof structures.

1607.13.5.~~3~~4 ~~Photovoltaic panels or modules installed as an independent structure.~~ Ground-mounted photovoltaic (PV) panel systems.

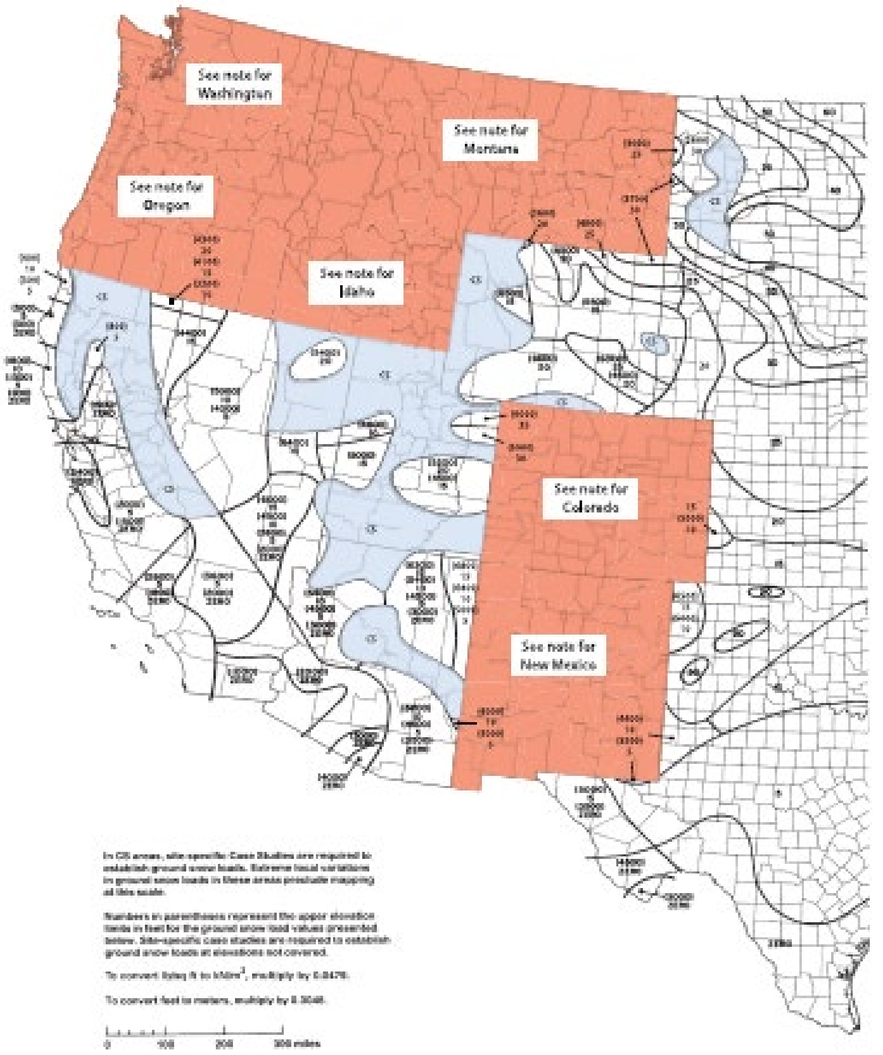
1607.13.5.4 Ballasted photovoltaic panel systems.

1607.13.5.4 Ground-mounted Photovoltaic (PV) Panel Systems

1607.13.5.~~3~~4 ~~Photovoltaic panels or modules installed as an independent structure.~~ Ground-mounted photovoltaic (PV) panel systems. ~~Solar photovoltaic panels or modules~~ Ground-mounted photovoltaic (PV) panel systems that are independent structures and do not have accessible/occupied space underneath are not required to accommodate a roof photovoltaic live load~~, provided that the area under the structure is restricted to keep the public away~~. Other loads and combinations in accordance with Section 1605 shall be accommodated. [*Remaining text in this section is deleted*]

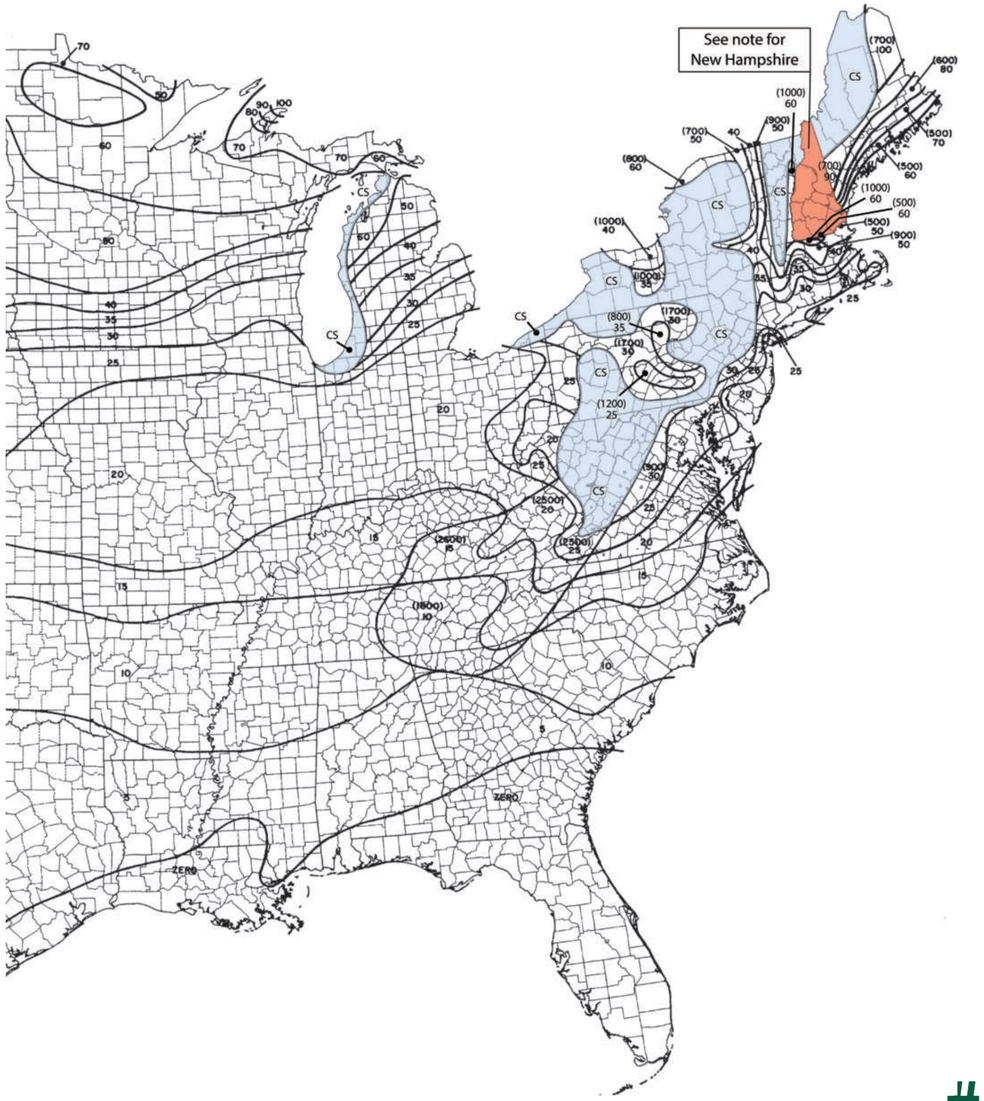
ASCE 7-16 Sec. 7.2 - Ground Snow Load

Replaces IBC Figure 1608.2



ASCE 7-16 Sec. 7.2 - Ground Snow Load

Replaces IBC Figure 1608.2



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1610 Soil Lateral Loads

1610.2 Uplift loads on floor and foundations. Basement floors, slabs on ground, foundations, and similar approximately horizontal elements below grade shall be designed to resist uplift loads where applicable. The upward pressure of water shall be taken as the full hydrostatic pressure applied over the entire area. The hydrostatic load shall be measured from the underside of the element being evaluated. The design for upward loads caused by expansive soils shall comply with Section 1808.6.

1611 Rain Loads

1611.1 Design rain loads. Each portion of a roof shall be designed to sustain the load of rainwater ~~that will accumulate on it if the primary drainage system for that portion is blocked plus the uniform load caused by water that rises above the inlet of the secondary drainage system at its design flow. as per the requirements of Chapter 8 of ASCE 7~~. The design rainfall shall be based on the 100-year ~~hourly rainfall rate indicated in Figure 1611.1~~ 15-minute duration event, or on other rainfall rates determined from approved local weather data.

1611 Rain Loads

1611.1 Design rain loads. (Contd.)

Alternatively, a design rainfall of twice the 100-year hourly rainfall rate indicated in Figure 1611.1 shall be permitted.

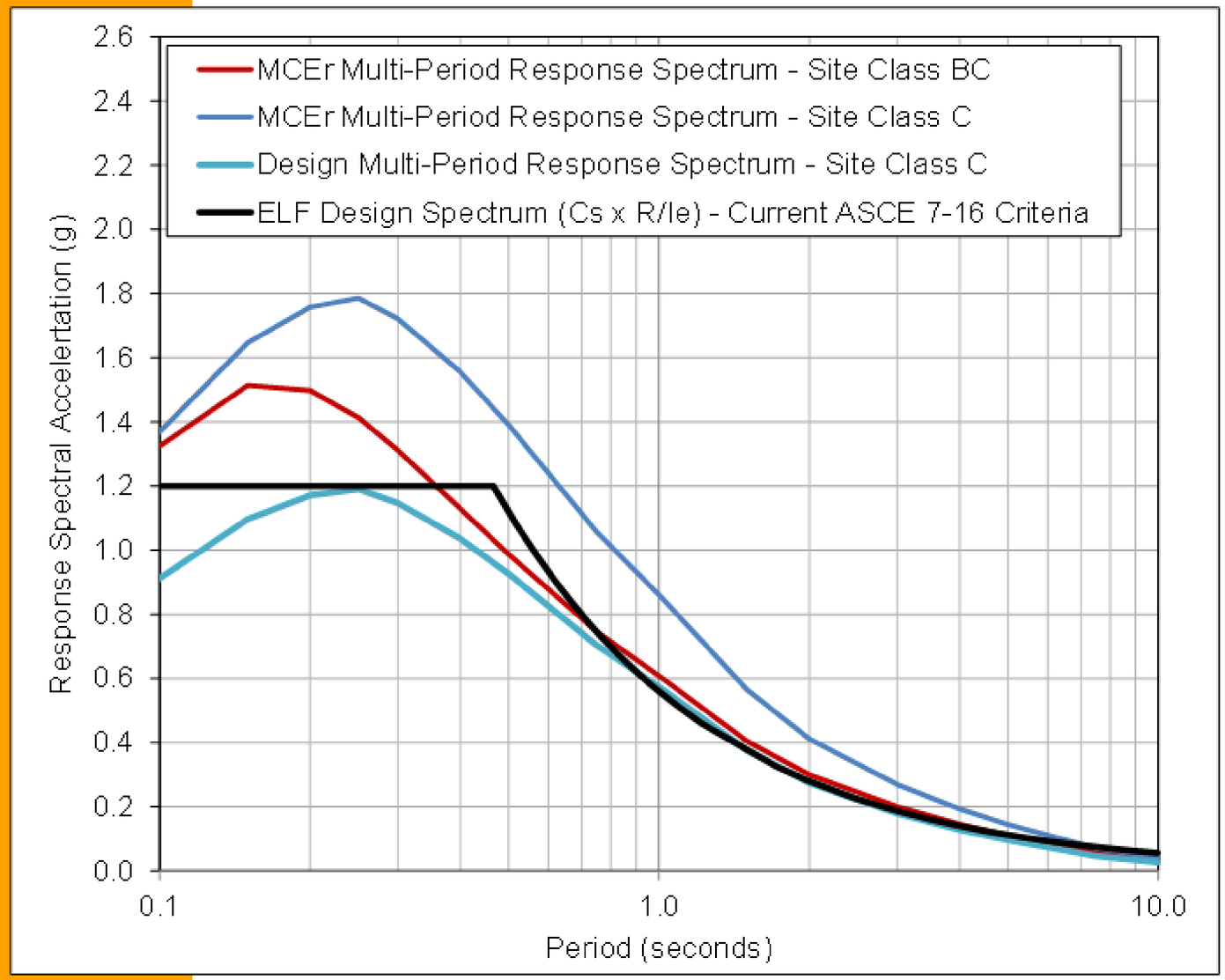
Supplement 1 to ASCE 7-16

https://ascelibrary.org/doi/10.1061/9780784414248.sup1

Supplement 1 for Standard 7-16, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*

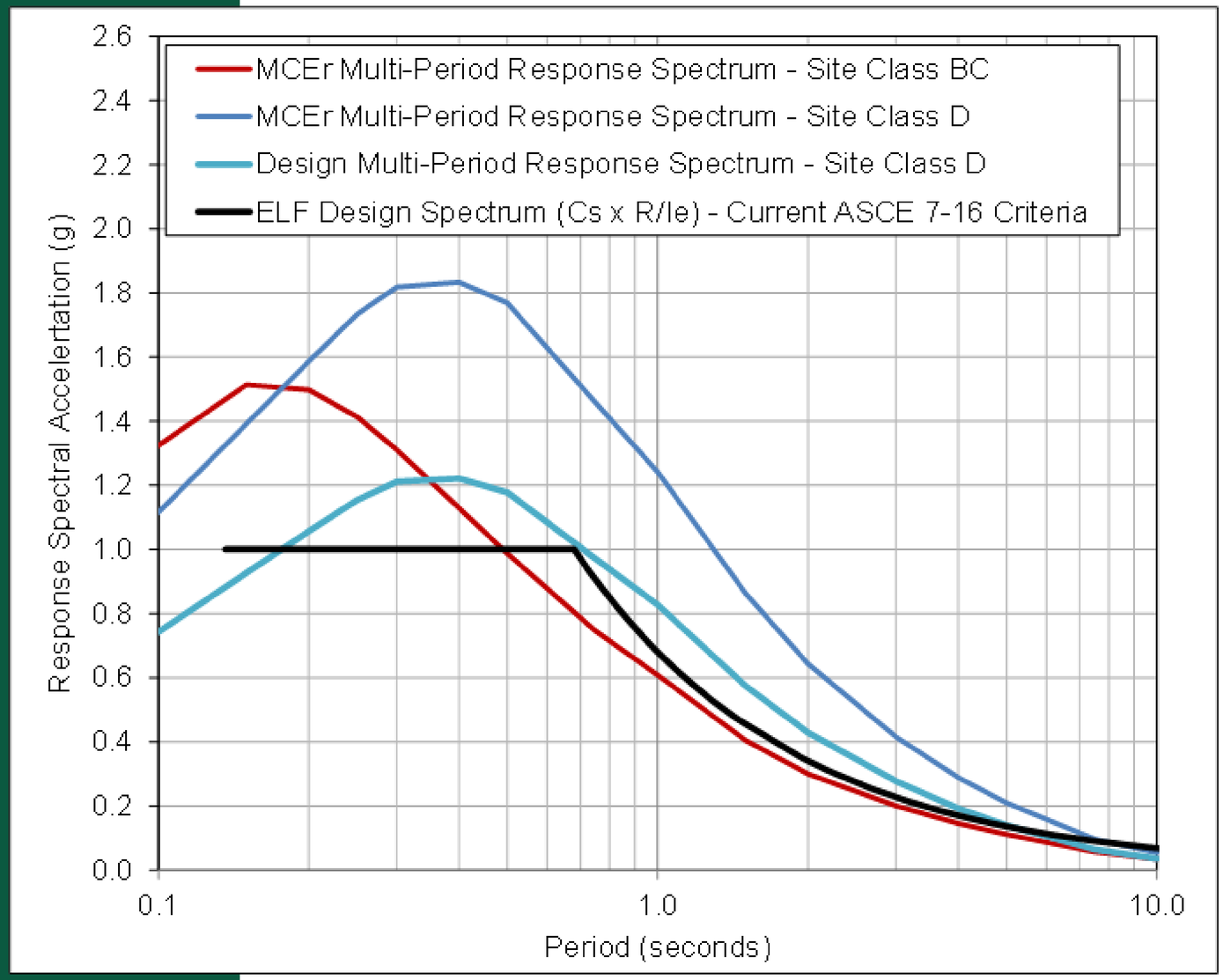
Effective: December 12, 2018

Multi-Period Spectrum



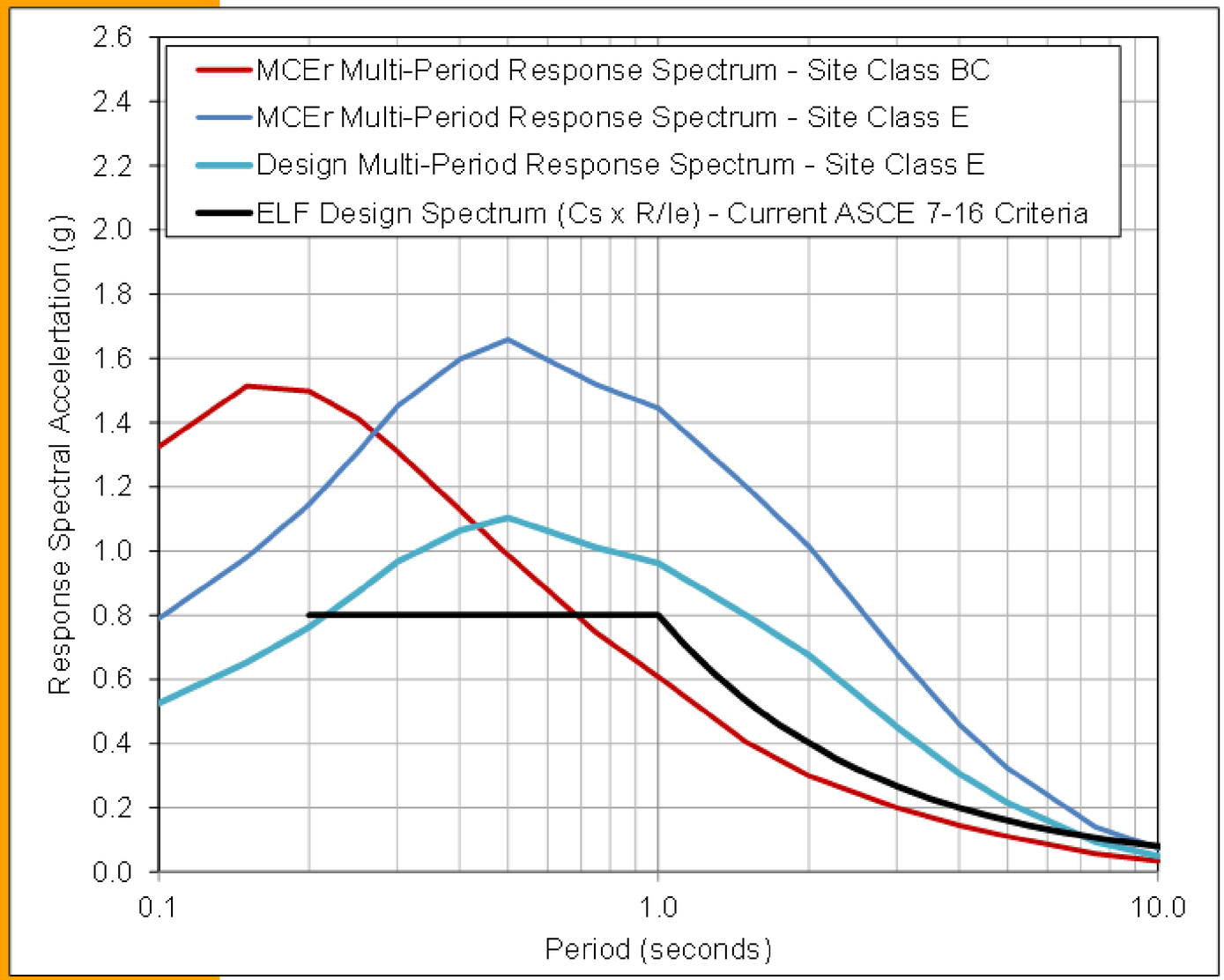
Comparison of ELF and Multi-Period Design Spectra – Site Class **C** Ground Motions ($v_{s,30}$ = 1600 ft/s) – Current ASCE7-16 Criteria

Multi-Period Spectrum



Comparison of ELF and Multi-Period Design Spectra – Site Class **D** Ground Motions ($v_{s,30}$ = 870 ft/s) – Current ASCE 7-16 Criteria

Multi-Period Spectrum



Comparison of ELF and Multi-Period Design Spectra – Site Class **E** Ground Motions ($v_{s,30}$ = 510 ft/s) – Current ASCE 7-16 Criteria

Site-Specific Hazard Analysis

Site-Specific Hazard Analysis

Required for the following site conditions:

- Structures on Site Class E sites with $S_s \geq 1.0$
- Structures on Site Class D & E sites with $S_1 \geq 0.2$

Exceptions to the above, intertwined with Site Coefficients F_a and F_v, are the subject of the most significant item in Supplement 1 to ASCE 7-16. See SKGA blogs [*next slide*].

Links to Detailed Discussion

https://www.skghoshassociates.com/blog/a-few-things-you-need-to-know-about-the-new-site-coefficients-in-asce-7-16/

https://www.skghoshassociates.com/blog/new-site-coefficients-in-asce-7-16-2/

1704.6 Structural Observation

1704.6.1 Structural observations for structures. Structural observations shall be provided for those structures where one or more of the following conditions exist:

1. The structure is classified as Risk Category III or IV.
2. The structure is a high-rise building.
3. The structure is assigned to Seismic Design Category E, and is greater than two stories above the grade plane.

1704.6 Structural Observation

1704.6.1 Structural observations for structures. (Contd.)

~~3.~~4. Such observation is required by the registered design professional responsible for the structural design.

~~4.~~5. Such observation is specifically required by the building official.

1704.6.2 Structural observations for seismic resistance and 1704.6.3 Structural observations for wind resistance *are deleted.*

1705.6 Required Special Inspections and Tests of Soils

TABLE 1705.6
REQUIRED SPECIAL INSPECTIONS AND TESTS OF SOILS

TYPE	CONTINUOUS SPECIAL INSPECTION	PERIODIC SPECIAL INSPECTION
1.Verify materials below shallow foundations are adequate to achieve the design bearing capacity.	—	X
2.Verify excavations are extended to proper depth and have reached proper material.	—	X
3.Perform classification and testing of compacted fill materials.	—	X
4.During fill placement, verify use of proper materials and procedures in accordance with the provisions of the *approved* geotechnical report. Verify densities and lift thicknesses during placement and com-paction of compacted fill.	X	—
5.Prior to placement of compacted fill, inspect subgrade and verify that site has been pre-pared properly.	—	X

1705.8 Required Special Inspections and Tests of Driven Deep Foundation Elements

TABLE 1705.7
REQUIRED SPECIAL INSPECTIONS AND TESTS OF DRIVEN DEEP FOUNDATION ELEMENTS

TYPE	CONTINUOUS SPECIAL INSPECTION	PERIODIC SPECIAL INSPECTION
1.Verify element materials, sizes and lengths comply with the requirements.	X	—
2.Determine capacities of test elements and conduct additional load tests, as required.	X	—
3.Inspect driving operations and maintain complete and accurate records for each element.	X	—
4.Verify placement locations and plumbness, confirm type and size of hammer, record number of blows per foot of penetration, determine required penetrations to achieve design capacity, record tip and butt elevations and document any damage to foundation element.	X	—
5.For steel elements, perform additional special inspections in accordance with Section 1705.2.	In accordance with 1705.2	
6.For concrete elements and concrete-filled elements, perform tests and additional special inspections in accordance with Section 1705.3.	In accordance with 1705.3	
7.For specialty elements, perform additional inspections as defined in the statement of special inspections.	In accordance with Statement of Special Inspections	

1705.8 Required Special Inspections and Tests of CIP Deep Foundation Elements

TABLE 1705.8
REQUIRED SPECIAL INSPECTIONS AND TESTS OF CAST-IN-PLACE DEEP FOUNDATION ELEMENTS

TYPE	CONTINUOUS SPECIAL INSPECTION	PERIODIC SPECIAL INSPECTION
1.Inspect drilling operations and maintain complete and accurate records for each element.	X	—
2.Verify placement locations and plumbness, confirm element diameters, bell diameters (if applicable), lengths, embedment into bedrock (if applicable) and adequate end-bearing strata capacity. Record concrete or grout volumes.	X	—
3.For concrete elements, perform tests and additional special inspections in accordance with Section 1705.3.	In accordance with 1705.3	

1810.3.2.6 Deep Foundation Elements – Allowable Stresses

TABLE 1810.3.2.6
ALLOWABLE STRESSES FOR MATERIALS USED IN DEEP FOUNDATION ELEMENTS

Portions of table not shown remain unchanged.

MATERIAL TYPE AND CONDITION	MAXIMUM ALLOWABLE STRESS[a]
1. Concrete or grout in compression[b]	
Cast-in-place with a permanent casing in accordance with Section 1810.3.2.7 or Section 1810.3.5.3.4	$0.4 f'_c$
Cast-in-place in ~~a pipe, tube,~~ other permanent casing or rock	$0.33 f'_c$
Cast-in-place without a permanent casing	$0.3f'_c$
Precast nonprestressed	$0.33f'_c$
Precast prestressed	$0.33f'_c - 0.27 f_{pc}$

1810.3.2.6 Deep Foundation Elements – Allowable Stresses

TABLE 1810.3.2.6
ALLOWABLE STRESSES FOR MATERIALS USED IN DEEP FOUNDATION ELEMENTS

Portions of table not shown remain unchanged.

MATERIAL TYPE AND CONDITION	MAXIMUM ALLOWABLE STRESS[a]
3. Steel in compression	
Cores within concrete-filled pipes or tubes	0.5 $F_y \leq$ 32,000 psi
Pipes, tubes or H-piles, where justified in accordance with Section 1810.3.2.8	0.5 $F_y \leq$ 32,000 psi
Pipes or tubes for micropiles	0.4 $F_y \leq$ 32,000 psi
Other pipes, tubes or H-piles	0.35 $F_y \leq$ ~~16,000~~ 24,000 psi
Helical piles	0.6 $F_y \leq$ 0.5 F_u
5. Steel in tension	
Pipes, tubes or H-piles, where justified in accordance with Section 1810.3.2.8	0.5$F_y \leq$ 32,000 psi
Other pipes, tubes or H-piles	0.35 $F_y \leq$ ~~16,000~~ 24,000 psi
Helical piles	0.6 $F_y \leq$ 0.5 F_u

1810.3.2.6 Deep Foundation Elements – Allowable Stresses

TABLE 1810.3.2.6
ALLOWABLE STRESSES FOR MATERIALS USED IN DEEP FOUNDATION ELEMENTS

Portions of table not shown remain unchanged.

MATERIAL TYPE AND CONDITION	MAXIMUM ALLOWABLE STRESS[a]
4. Nonprestressed reinforcement in tension	
Within micropiles	$0.6 f_y$
Other conditions	
For load combinations that do not include wind or seismic loads	$0.5 f_y \leq$ ~~24,000~~ 30,000 psi
For load combinations that include wind or seismic loads	$0.5 f_y \leq 40{,}000$ psi

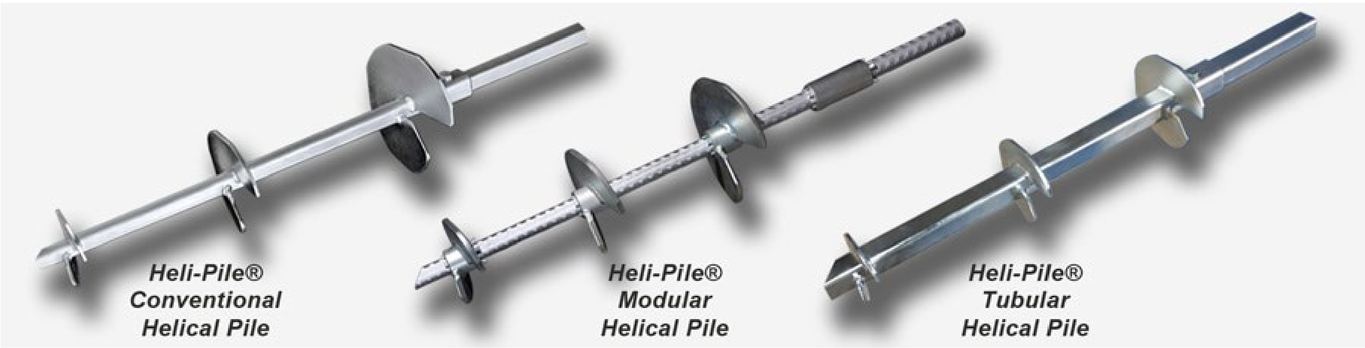
1810.3.2.6 Deep Foundation Elements – Allowable Stresses

TABLE 1810.3.2.6

ALLOWABLE STRESSES FOR MATERIALS USED IN DEEP FOUNDATION ELEMENTS

Footnote b. The stresses specified apply to the gross cross-sectional area ~~within~~ of the concrete ~~surface~~ for precast prestressed piles and to the net cross-sectional area for all other piles. Where a temporary or permanent casing is used, the inside face of the casing shall be considered ~~to be~~ the outer edge of the concrete ~~surface~~ cross-section.

1810.3.3.1.9 Helical Piles



1810.3.3.1.9 Helical Piles

$P_a = 0.5P_u$

where P_u is the least value of:

1. Base capacity plus shaft resistance of the helical pile. The base capacity is equal to the s~~S~~um of the areas of the helical bearing plates times the ultimate bearing capacity of the soil or rock comprising the bearing stratum. The shaft resistance is equal to ~~only~~ the area of the shaft above the uppermost helical bearing plate times the ultimate skin resistance ~~shall be considered~~.

1810.3.8 Precast Concrete Piles

1810.3.8 Precast concrete piles. Precast concrete piles shall be designed and detailed in accordance with ~~Sections 1810.3.8.1 through 1810.3.8.3~~ ACI 318.

1810.3.8 Precast Concrete Piles

1810.3.8 Precast concrete piles. (Contd.)

Exceptions:

1. For precast prestressed piles in Seismic Design Category C, the minimum volumetric ratio of spirals or circular hoops required by Section 18.13.5.10.4 of ACI 318 shall not apply in cases where the design includes full consideration of load combinations specified in ASCE 7, Section 2.3.6 or Section 2.4.5 and the applicable overstrength factor, Ω_o . In such cases, minimum transverse reinforcement index shall be as specified in Section 13.4.5.6 of ACI 318.

1810.3.8 Precast Concrete Piles

1810.3.8 Precast concrete piles. (Contd.)

Exceptions:

2. For precast prestressed piles in Seismic Design Categories D through F, the minimum volumetric ratio of spirals or circular hoops required by Section 18.13.5.10.5(c) of ACI 318 shall not apply in cases where the design includes full consideration of load combinations specified in ASCE 7, Section 2.3.6 or Section 2.4.5 and the applicable overstrength factor, Ω_o . In such cases, minimum transverse reinforcement shall be as specified in Section 13.4.5.6 of ACI 318.

1810.3.11 Pile Caps

1810.3.11.1 Seismic Design Categories C through F. For structures assigned to Seismic Design Category C, D, E or F, concrete deep foundation elements shall be connected to the pile cap ~~by embedding the element reinforcement or field-placed dowels anchored in the element into the pile cap for a distance equal to their development length~~ in accordance with ACI 318. [*Rest of paragraph is deleted*].

[*Second paragraph is unchanged*]

1810.3.12 Grade beams

1810.3.12 Grade beams. ~~For structures assigned to Seismic Design Category D, E or F, grade~~ Grade beams shall comply with the provisions ~~in Section 18.13.3~~ of ACI 318~~ for grade beams, except where they are~~.

Exception: Grade beams designed to resist the seismic load effects including overstrength factor in accordance with Section 2.3.6 or 2.4.5 of ASCE 7.

1810.3.12 Grade beams

1810.3.13 Seismic ties.

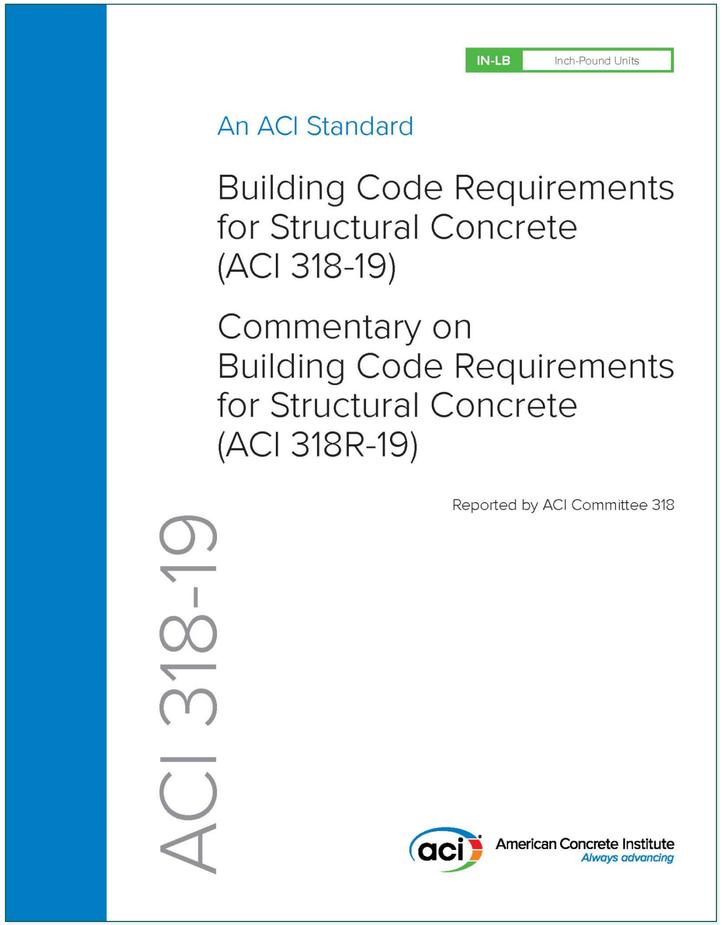
[2018 IBC text is deleted]

Seismic ties shall comply with the provisions of ACI 318.

1810.4.1.2 Shafts in unstable soils

1810.4.1.2 ~~Casing.~~ Shafts in unstable soils. Where cast-in-place deep foundation elements are formed through unstable soils ~~and concrete is placed in an open-drilled hole, a casing shall be inserted in the hole~~ , the open hole shall be stabilized by a casing, slurry, or other approved method prior to placing the concrete. Where the casing is withdrawn during concreting, the level of concrete shall be maintained above the bottom of the casing at a sufficient height to offset any hydrostatic or lateral soil pressure. Driven casings shall be mandrel driven their full length in contact with the surrounding soil.

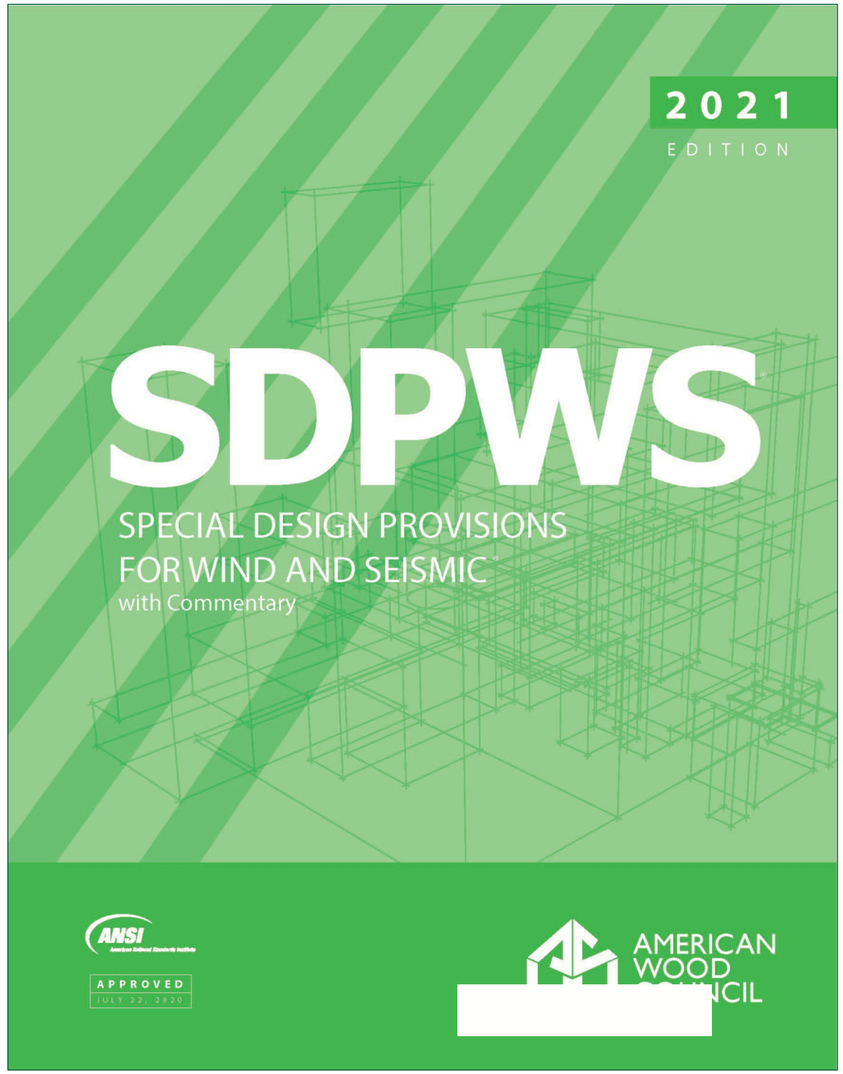
ACI 318-19



ACI 318-19

- A large number of substantive changes of far-reaching consequence
- Will require significant learning and adjustment on the part of the practitioner

2021 SDPWS


2021
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SPECIAL DESIGN PROVISIONS
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Questions?

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Thank you for participating!

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