Building Seismic Safety Council | BSSC

AN OVERVIEW OF THE NEHRP RECOMMENDED SEISMIC PROVISIONS

David Bonneville – Chair, Provisions Update Committee

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What are the NEHRP Provisions

- Purpose
- Relationship to ASCE 7 Seismic

What's New in the 2020 Provisions

- Provisions and Commentary
- Resource Papers

Overview Topics to be Covered Today

- Selected Technical Topics
- Future Topics and Research Needs

The NEHRP Recommended Seismic Provisions

- A set of recommendations written in building code language that serves as the starting point for the U.S. seismic standards development process

  - Major technical changes to ASCE/SEI 7 seismic design maps, and analysis and design concepts originate in the Provisions

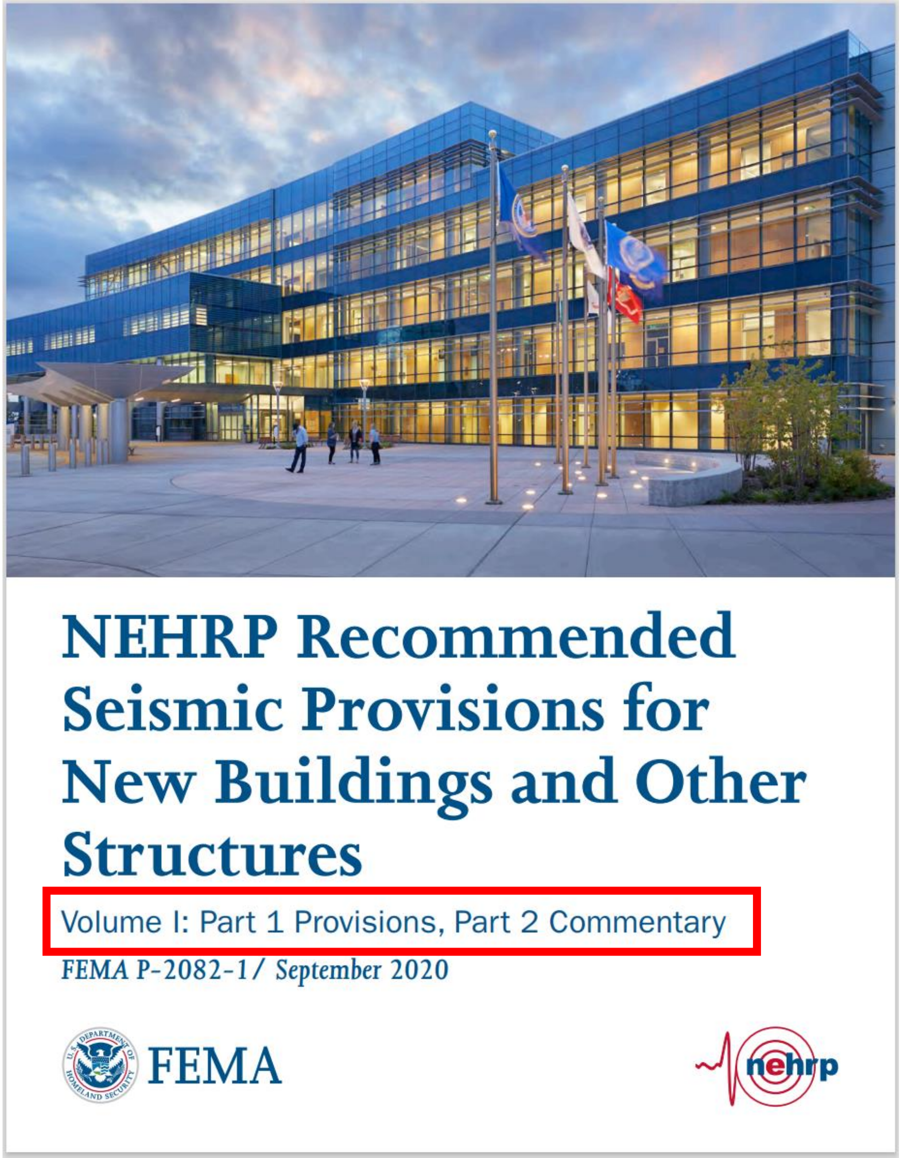
- Resistance to ground shaking is computed using spectral response acceleration parameters that reference a set of national seismic design values maps.
- The maps are produced by USGS working with BSSC
- The BSSC Provisions Update Committee defines the rules by which the maps are developed (e.g., the probabilistic ground motion, risk target, deterministic cap)

2020 NEHRP Provisions Update Committee (PUC)

Chair	David Bonneville	Degenkolb Engineers
Voting Member	Peter Carrato	Bechtel Power Corporation
Voting Member	Kelly Cobeen	Wiss, Janney, Elstner Associates
Voting Member	C.B. Crouse	AECOM
Voting Member	Dan Dolan	Washington State University
Voting Member	Anindya Dutta	Simpson Gumpertz & Heger
Voting Member	S.K. Ghosh	S.K. Ghosh Associates
Voting Member	John Gillengerten	SE, Retired OSHPD
Voting Member	Ron Hamburger	Simpson Gumpertz & Heger
Voting Member	Jim Harris	James Harris & Associates
Voting Member	William Holmes	Rutherford + Chekene
Voting Member	John Hooper	Magnusson Klemencic Associates
Voting Member	Gyimah Kasali	Rutherford + Chekene
Voting Member	Charles Kircher	Charles Kircher & Associates
Voting Member	Philip Line	American Wood Council
Voting Member	Bret Lizundia	Rutherford + Chekene
Voting Member	James Malley	Degenkolb Engineers
Voting Member	Bonnie Manley	American Iron and Steel Institute
Voting Member	Robert Pekelnicky	Degenkolb Engineers
Voting Member	Rafael Sabelli	Walter P. Moore
Voting Member	John Silva	Hilti
Voting Member	J. G. (Greg) Soules	CB&I Storage Tank Solutions
Voting Member	Jonathan Stewart	University of California, Los Angeles
FEMA technical advisor and representative	Robert Hanson	University of Michigan (Professor Emeritus)
FEMA representative	Mai Tong	Federal Emergency Management Agency
USGS representative	Nicolas Luco	U.S. Geological Survey
USGS representative	Sanaz Rezaeian	U.S. Geological Survey
NIST representative	Steven McCabe	National Institute of Standards and Technology
NIST representative	Matthew Speicher	National Institute of Standards and Technology
NIBS Staff	Jiqiu (JQ) Yuan	National Institute of Building Sciences

Provisions Update Committee – Issue Teams

- IT 1 - Seismic Performance Objectives
- IT 2 - Seismic Resisting Systems and Design Coefficients
- IT 3 - Modal Response Spectrum Analysis
- IT 4 - Shear Wall Design
- IT 5 - Nonstructural Components
- IT 6 - Nonbuilding Structures
- IT 7 - Soil Foundation Interaction
- IT 8 - Base Isolation and Energy Dissipation
- IT 9 - Diaphragm Issues
- IT 10 - Seismic Design Maps and Multi-Period Response Spectrum


NEHRP Recommended Seismic Provisions for New Buildings and Other Structures
Volume I: Part 1 Provisions, Part 2 Commentary
FEMA P-2082-1/ September 2020
FEMA
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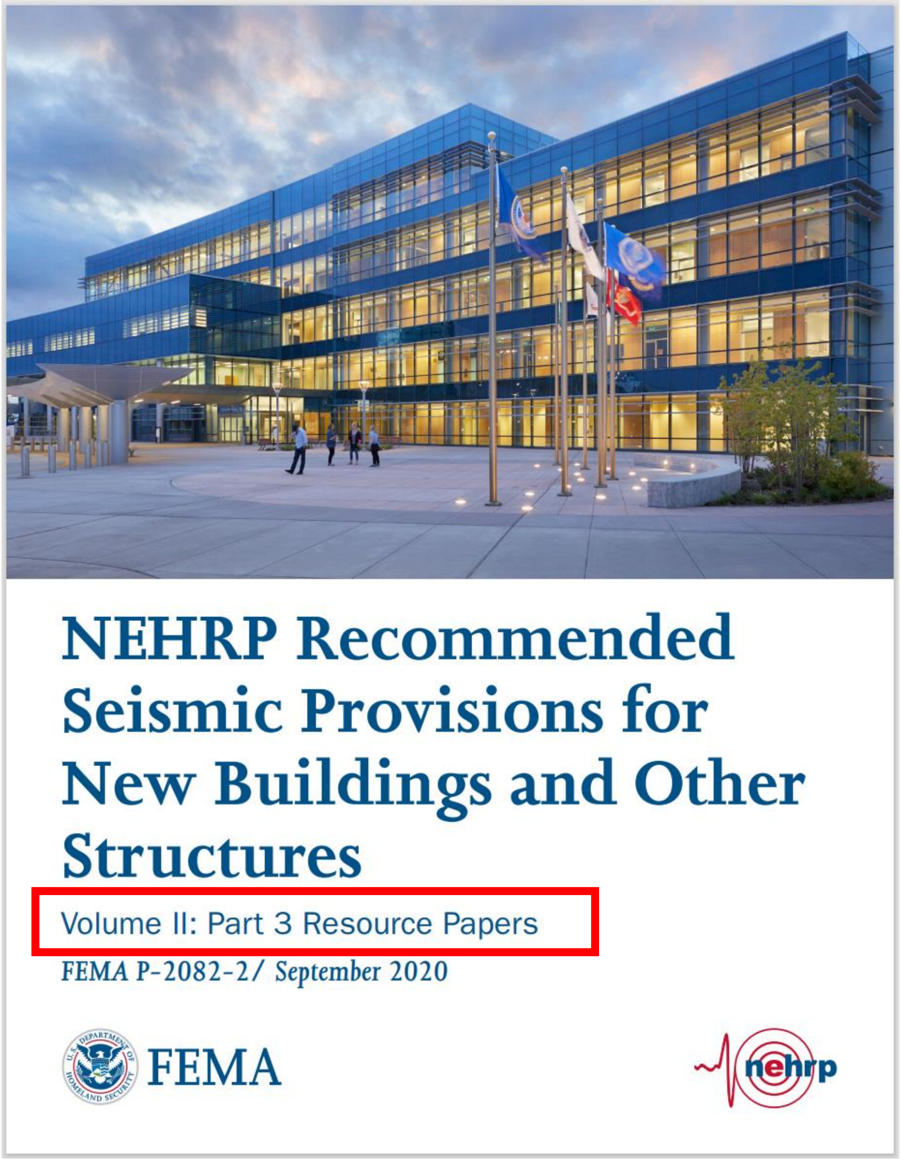
NEHRP Recommended Seismic Provisions for New Buildings and Other Structures
Volume II: Part 3 Resource Papers
FEMA P-2082-2/ September 2020
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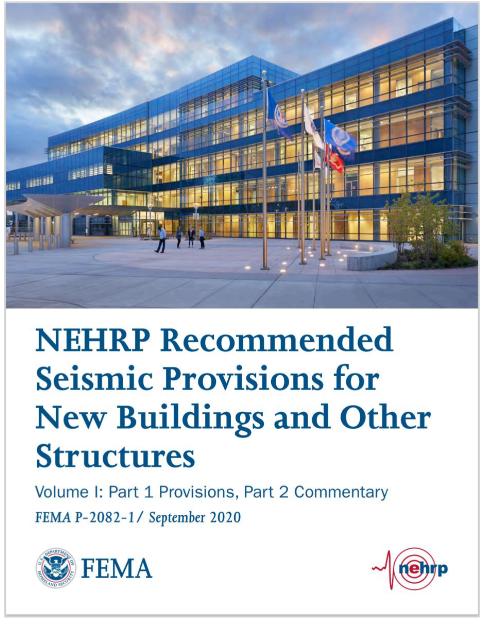
Intent - Section 1.1

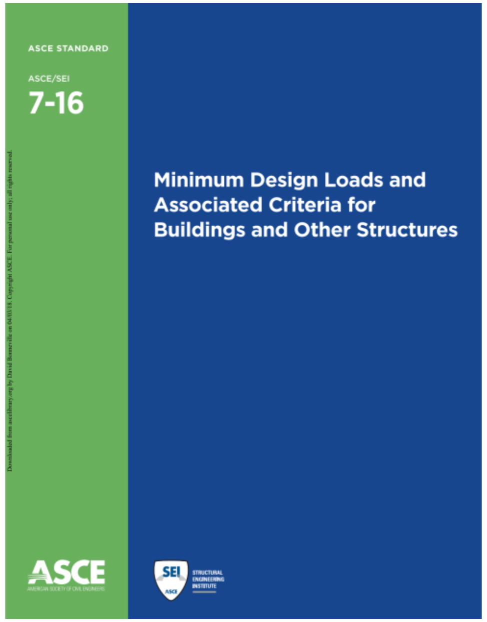
1. Avoid serious injury and loss of life due to:
   a. Structure Collapse
   b. Failure of nonstructural components and systems
   c. Release of hazardous materials
2. Preserve means of egress
3. Avoid loss of function in critical facilities, and
4. Reduce structural and nonstructural repair costs where practicable

The Path from NEHRP Provisions to Building Code

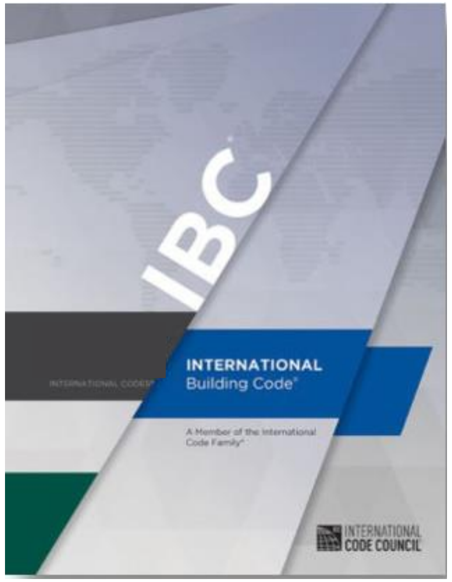


2020 NEHRP Provisions

<u>2016 – 2020</u>



ASCE/SEI 7-22



2024 & 2027 IBC

2025 & 2028 CBC

<u>Jan 2026 – Dec 2031</u>

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Summary of What's New in the Provisions

Summary Tables In Intro

Topic of Change Proposals	Brief Summary of the Changes	Related or New Sections of ASCE/SEI 7-16	Related Commentary in ASCE/SEI 7-16
Exemption for System Height Limitations	Provides an exemption that allows buildings with lateral force-resisting systems otherwise conforming to the design parameters defined in ASCE/SEI 7-16 Table 12.2-1 to exceed the height limits prescribed in the table when the building is designed in accordance with the requirements of Chapter 16.	Section 12.2.1	C12.2.1
Reinforced Concrete Ductile Coupled Walls	Introduces reinforced concrete ductile coupled walls into Table 12.2-1.	Table 12.2-1, Section 12.2.5.4	C12.2
Coupled Composite Plate Shear Walls – Concrete Filled	Introduces steel and concrete coupled composite plate shear walls into Table 12.2-1 and adds a new Section 14.3.5 to provide specific provisions for the definition and application.	Table 12.2-1, Sections 12.2.5.4, 14.3.3 and 14.3.5	C12.2 and C14.3.5
Cross-Laminated Timber Shear Walls	Introduces cross-laminated timber (CLT) shear walls into Table 12.2-1 and Table 12.14-1 and adds a new section 14.5.2 for requirements of CLT shear walls.	Tables 12.2-1 and 12.14-1, Section 14.5.2	C12.2 and C14.5.2
Elimination of Mass Irregularity	Eliminates the mass irregularity from *Vertical Structural Irregularities* in Table 12.3-2.	Table 12.3-2	C12.3.2.2
Accidental Torsion Modification	Removes some of the unnecessary conservatism from the current code provisions, while adding requirements for building configurations not adequately addressed by the current code provisions.	Table 12.3-1 and Sections 12.3.3.1, 12.3.4.2, 12.5.3.1	C12.3.4.2, C12.5.3, C12.5.4, C12.6 and C12.8.4.3
Application of Equivalent Lateral Force Analysis Procedure	Eliminates Table 12.6-1 *Permitted Analytical Procedures* and replaces it with a sentence stating that each Chapter 12 analysis procedure is permitted for each seismic design category.	Table 12.6-1	C12.6

Summary of What's New in the Provisions

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	Eliminates the *Irregularities* in …		
	Removes some o… code provisions… configurations n… provisions.		
Application of Equivalent Lateral Force Analysis Procedure	Eliminates Table… replaces it with a sentence stating that each Chapter 12 analysis procedure is permitted for each seismic design category.		

References to ASCE 7 sections

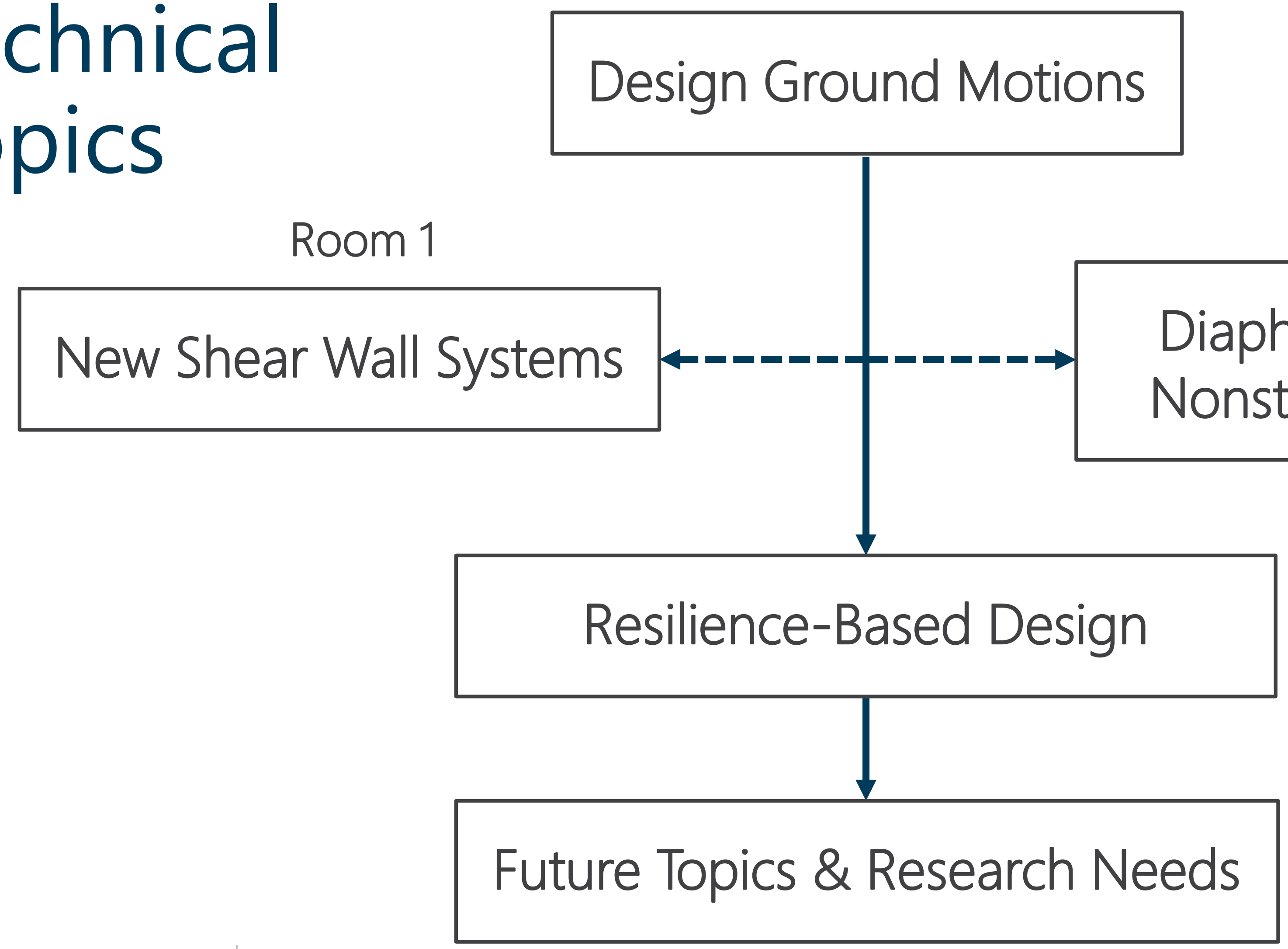
Coupled Composite Plate Shear Walls - Concrete Filled

Introduces steel and concrete coupled composite plate shear walls into Table 12.2-1 and adds a new Section 14.3.5 to provide specific provisions for the definition and application

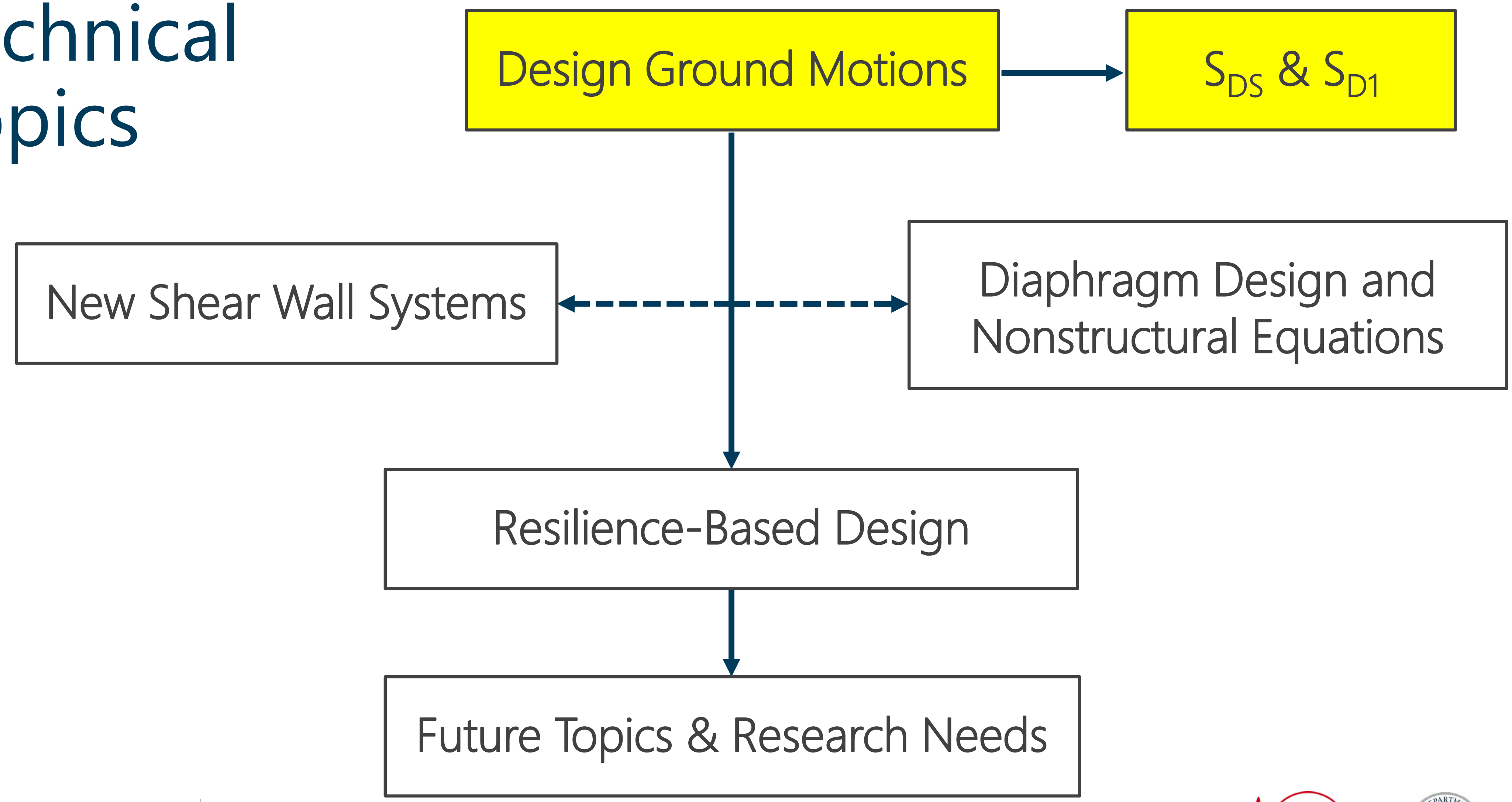
Part 3 Resource Papers

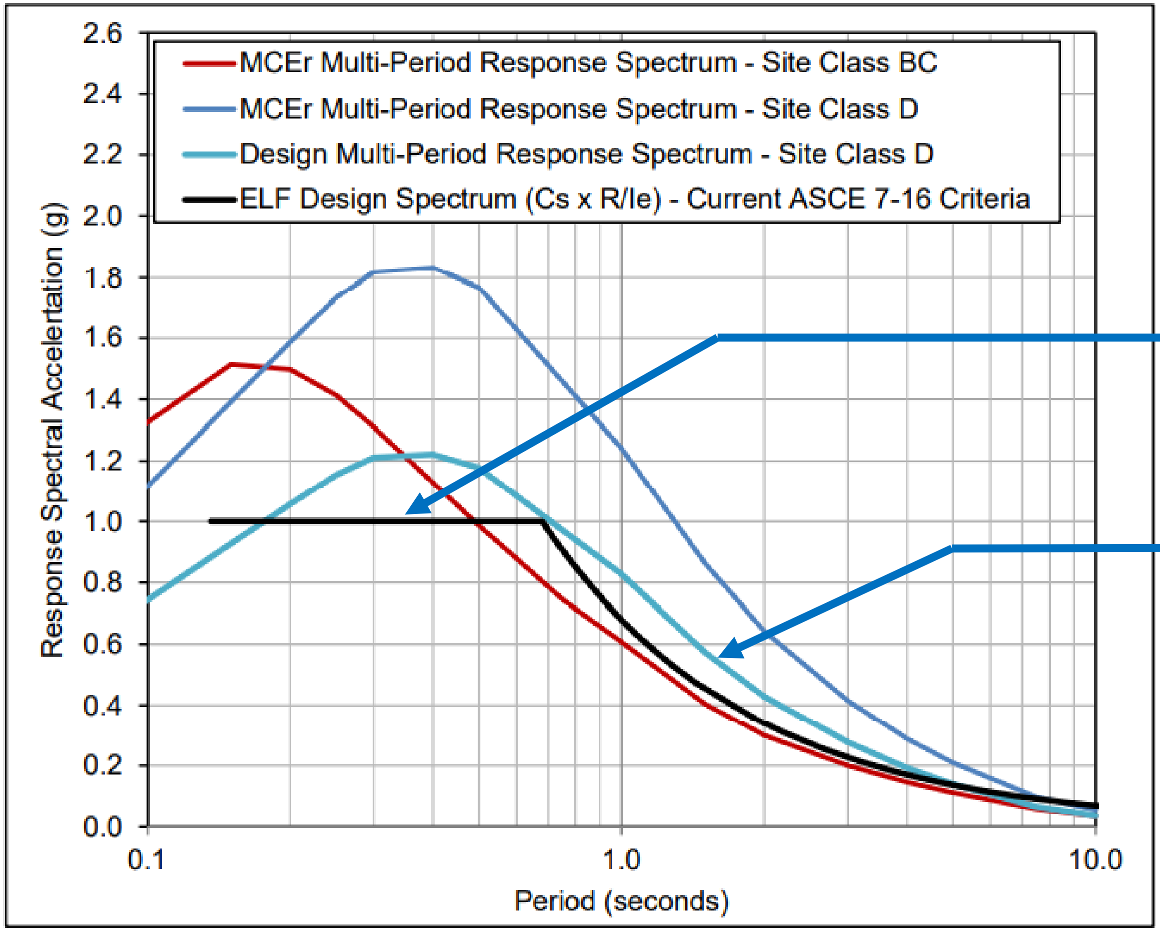
- Resilience-Based Design and the NEHRP Provisions
- Risk-Based Alternatives to Deterministic Ground Motion Caps
- Design of Isolated and Coupled Shear Walls of Concrete, Masonry, Structural Steel, Cold-Formed Steel and Wood
- Seismic Lateral Earth Pressures
- Seismic Design Story Drift Provisions – Needed Studies
- Diaphragm Design Factor R_S for Concrete on Metal Deck
- Development of Diaphragm Design R_S Factors
- Calculation of Diaphragm Deflections Under Seismic Loading
- Modal Response Spectrum Analysis Methods

Symposium Technical Topics



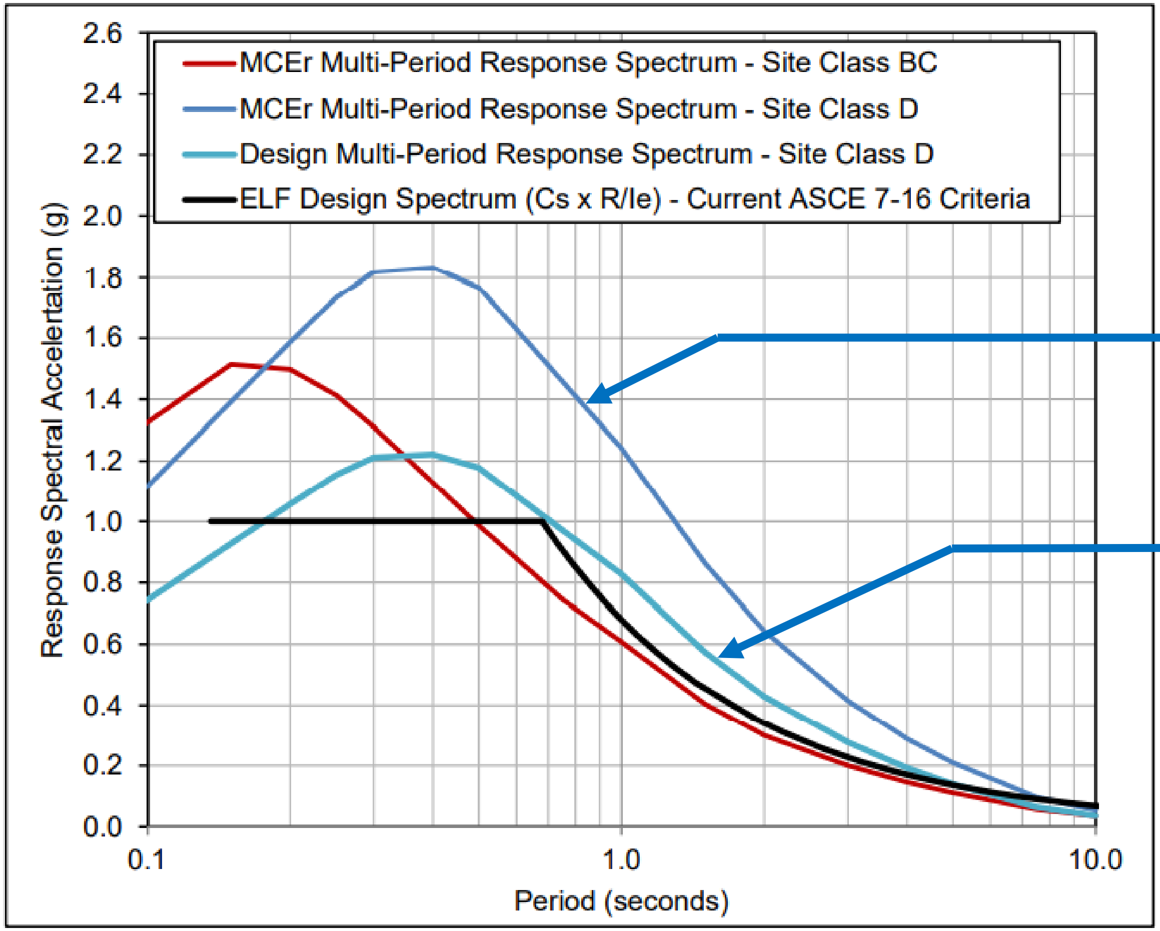
Symposium Technical Topics





Traditional two-domain Design Spectrum

Site-Specific Spectrum (Design level)



MCF_R MPRS (USGS) defining S_{MS} and S_{M1}

Design MPRS provides S_{DS} and S_{D1}

Site-specific – incorporates site class, location

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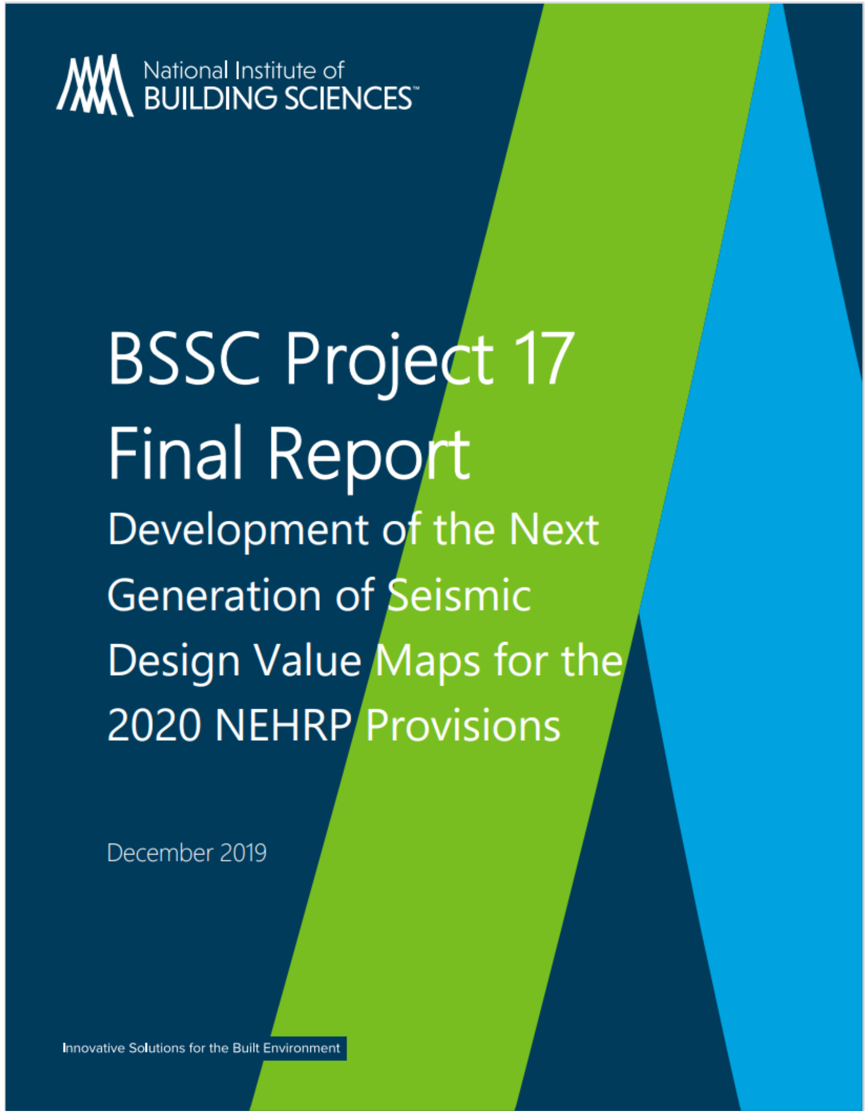
Developing Design Spectra for the U.S.

- Multi-Period and Design Ground Motions – Charles Kircher
  Why the MPRS and how to construct it

- Update to the USGS National Seismic Hazard Model – Sanaz Rezaeian
  The scientific modeling for the updated maps

- Example Changes to Design Ground Motion Values – Nico Luco
  The resulting changes to design ground motion values


National Institute of BUILDING SCIENCES

BSSC Project 17

Final Report

Development of the Next Generation of Seismic Design Value Maps for the 2020 NEHRP Provisions

December 2019

Innovative Solutions for the Built Environment

Project 17

A joint committee of USGS and BSSC

Purpose: To formulate recommendations for the rules by which next-generation seismic design value maps derived from the USGS NSHM will be developed for adoption by the 2020 NEHRP Provisions, ASCE/SEI 7-22 and 2024 IBC.

Symposium Technical Program – This Afternoon

Room 1

- New Concrete and Steel Plate Shear Wall Provisions – Ghosh
- New Cross Laminated Timber Shear Wall Provisions - Line

Room 2

- New Nonstructural Force Equations – Gillengerten
- New Diaphragm Design Provisions – Cobeen

- Resilience Based Design and the NEHRP Provisions - Bonowitz

- Future Topics and Research Needs – Cobeen and Ghosh

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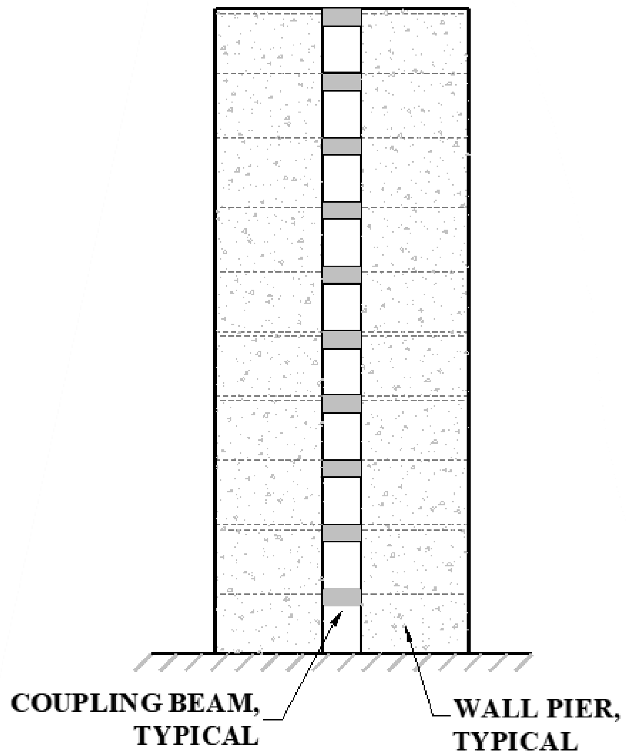
New Shear Wall Systems

- Ductile Coupled Reinforced Concrete
  S.K. Ghosh
- Coupled Composite Steel Plate
  S.K. Ghosh
- Cross Laminated Timber
  Phil Line



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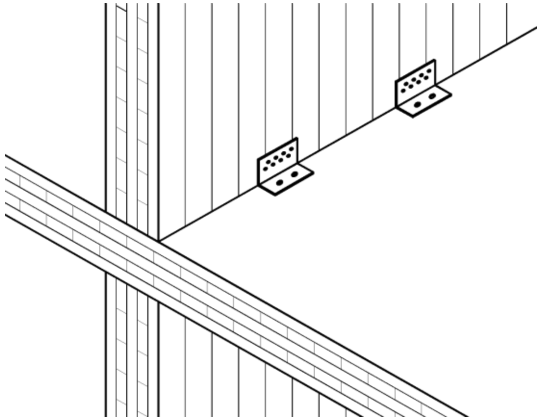

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New Nonstructural Force Equations

John Gillengerten

$$F_p = \frac{0.4 a_p S_{DS} W_p}{\left(\frac{R_p}{I_p}\right)}\left(1 + 2\frac{z}{h}\right)$$

Old

$$F_p = 0.4 S_{DS} I_p W_p \left[\frac{H_f}{R_\mu}\right]\left[\frac{C_{AR}}{R_{po}}\right]$$

New

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New Diaphragm Design Provisions

Kelly Cobeen

- New Provisions for RWFD Buildings
- Provisions for Bare Metal Deck
- Enhanced Commentary and Diaphragm Resource Paper

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Symposium Technical Program – This Afternoon

- New Concrete and Steel Plate Shear Wall Provisions – Ghosh
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Resilience-Based Design and the NEHRP Provisions

David Bonowitz

Adopting the current code-and-standard model to resilience-based design with consideration of functional recovery.

Symposium Technical Program – This Afternoon

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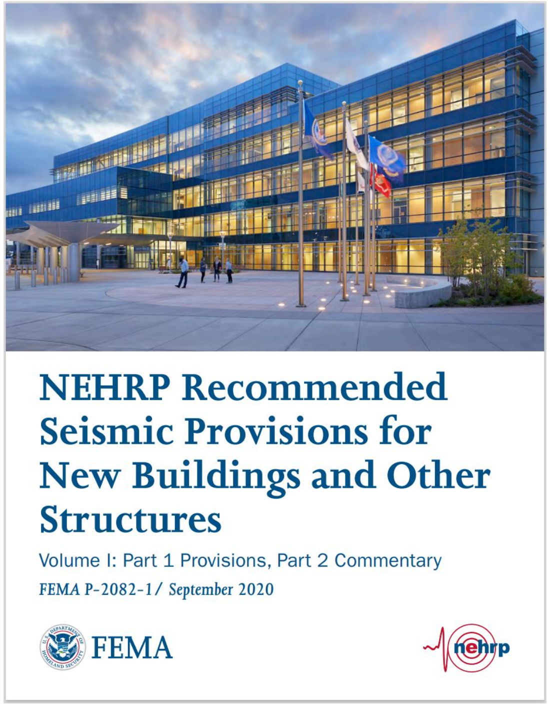
Future Topics and Research Needs


NEHRP Recommended Seismic Provisions for New Buildings and Other Structures

Volume I: Part 1 Provisions, Part 2 Commentary

FEMA P-2082-1/ September 2020

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Presentation and Discussion
led by Kelly Cobeen and S.K. Ghosh

Purpose:

- Recap 2020 PUC and BSSC Member Organization input received to date
- Outreach to you - the engineering community - related to future direction

Thank You!

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NEW MULTI-PERIOD RESPONSE SPECTRA AND GROUND MOTION REQUIREMENTS AND NEW SITE CLASSES

Charles A. Kircher, Ph.D., P.E., NAE
Principal Kircher & Associates

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Presentation Topics

- Overview of Multi-Period Response Spectra (MPRS) Code Requirements
  - Changes to Chapters 11, 20, 21 and 22 of the *2020 NEHRP Provisions* (and *ASCE 7-22)*
- Background Material
  - Design response spectrum (Figure 11.4-1 of *ASCE 7-16*) and multi-period design spectra
- The Problem (with *ASCE 7-10*) – Need for MPRS
- Interim Solution (*2015 NEHRP Provisions* and *ASCE 7-16*)
  - Revised site-specific requirements of ASCE 7-16 Code (in lieu of MPRS)
- Long-Term MPRS Solution (*2020 NEHRP Provisions* and *ASCE 7-22*)
  - Definition, calculation and example comparisons with *ASCE 7-16* (and *ASCE 7-10*)
  - USGS Science – USGS updating of MCE_R ground motions (now defined by MPRS)
  - MPRS Study – FEMA-funded ATC-136-1 study of MPRS methods for OCONUS sites (e.g., Alaska and Hawaii, etc.) – FEMA P-2078 (August 2020)

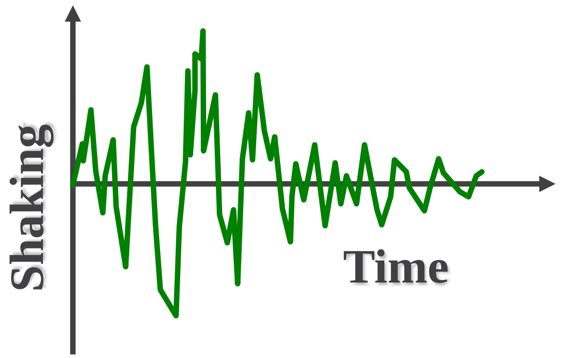
Multi-Period Response Spectra (MPRS)

Multi-Period Response Spectra of the *2020 NEHRP Provisions*:

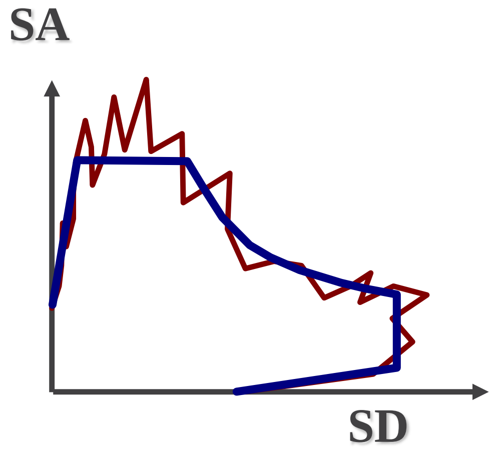
- Collectively improve the accuracy of the frequency content of earthquake design ground motions
- Enhance the reliability of the seismic design parameters derived from these ground motions
- Make better use of the available earth science (including the 2018 update of the USGS NSHM) which has, in general, sufficiently advanced to accurately define spectral response for different site conditions over a broad range of periods
- Eliminate the need for site-specific hazard analysis required by *ASCE 7-16 (2015 NEHRP Provisions)* for certain (soft soil) sites where the site coefficients are either undefined or inadequate
- Do no change the ELF (MRSA) design procedures commonly used by most design engineers and projects

Earthquake Ground Motion Characterization

- Ground Motion Records (Time Histories)
  - Acceleration (including PGA)
  - Velocity (including PGV)
  - Displacement (including (PGD)



- Elastic Response Spectra (e.g., MPRS)
  - – Peak response of a collection of linear single-degree-of-freedom systems with 5% viscous damping
  - – “Smooth” spectra used for design (to represent many different possible ground motion time histories)



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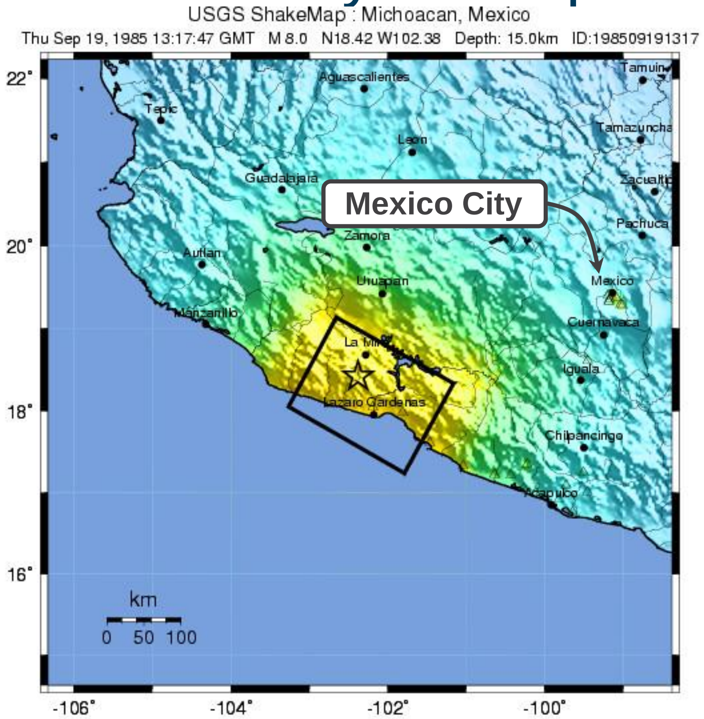
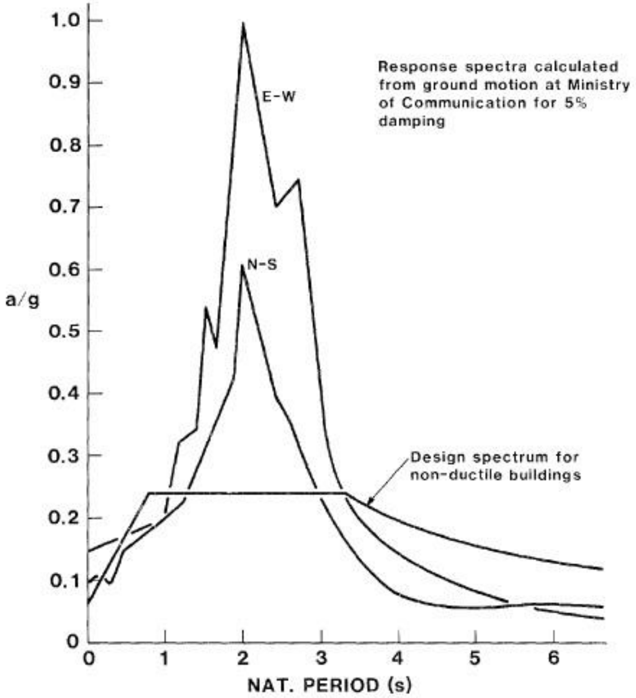
Earthquake Damage - What Matters?

- Ground Motions Characteristics:
  - Intensity - Strength of Shaking
  - Frequency Content of Shaking (site conditions)
  - *Duration of (Strong) Shaking*
- Building Properties:
  - Configuration (height, irregularity, etc.)
  - Structural system (ductility, durability, etc.)
  - Strength of building (relative to strength of shaking)
  - Dynamic response properties (relative to frequency content of ground motions)

1985 Mexico City Earthquake – Collapse of 6 – 15-Story Buildings





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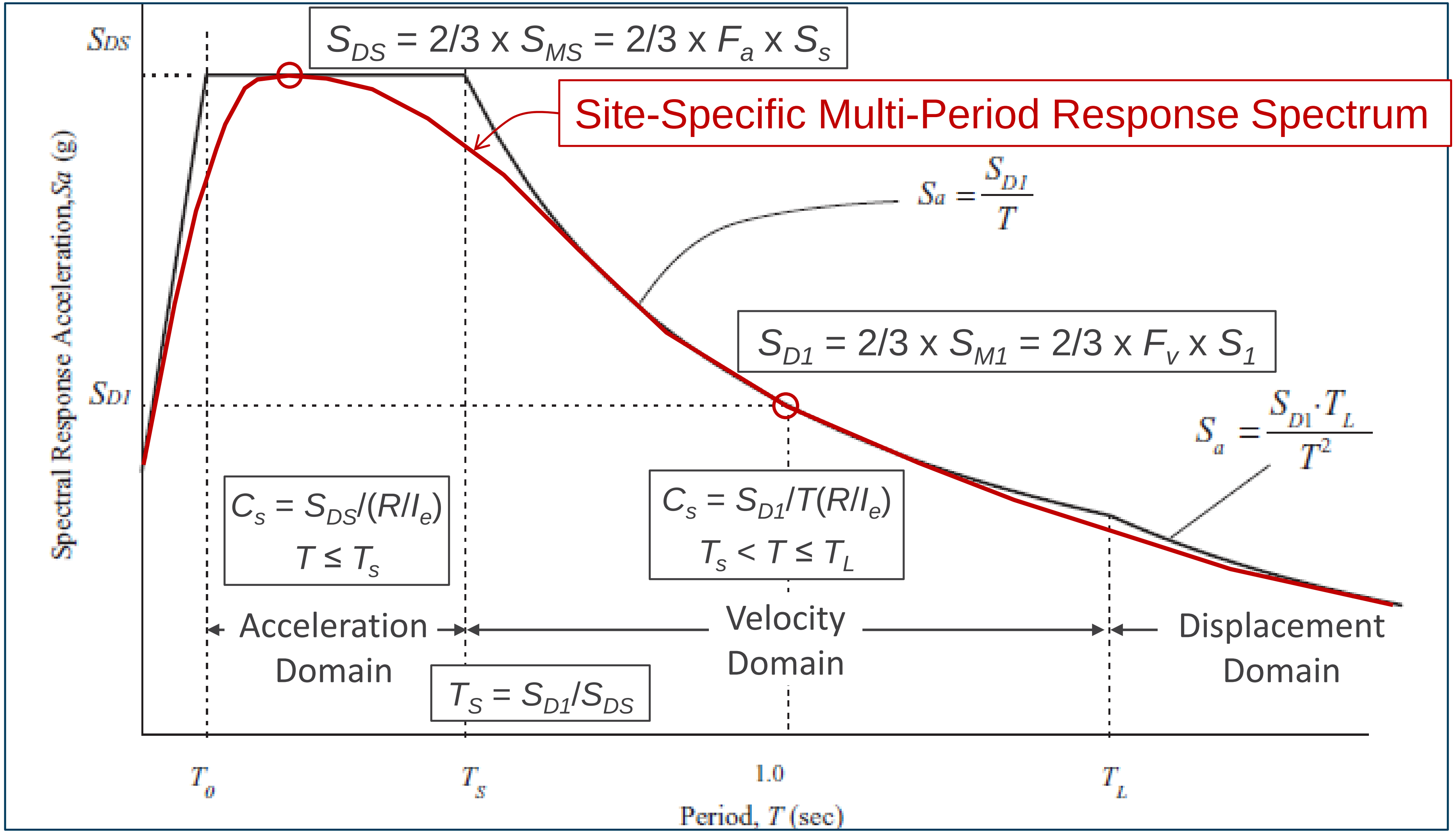
Summary of MPRS and Related Changes (to *ASCE 7-16*)

- Chapter 11 – Seismic Ground Motion Values
  - Added new "site-specific" multi-period design spectra and related values of seismic design parameters (e.g., S_{MS}, S_{M1} and PGA_M) of the "USGS Seismic Design Geodatabase", available online from a USGS web service for user-defined site location and site conditions (i.e., site class)
  - Deleted site coefficient tables (i.e., site factors are no longer required)
  - Removed the site-specific (interim solution) ground motion procedures of *ASCE 7-16*
- Chapter 20 – Site Classification Procedure for Seismic Design
  - Added three new site classes (Site Classes BC, CD and DE) to Table 20.3-1
  - *Added new site class shear wave velocity-based requirements*
- Chapter 21 – Site-specific Ground Motion Procedures for Seismic Design
  - Added new deterministic MCE_R "scenario" earthquake requirements (based on de-aggregation)
  - Revised determination of S_{D1} from site-specific design spectrum (Section 21.4)
- Chapter 22 – Seismic Ground Motion and Long-Period Period Maps
  - Incorporated USGS update of MCE_R ground motions based on 2018 update of the USGS NSHM
  - Updated to provide new maps of S_{MS} and S_{M1} (and PGA_M) for "default" site conditions

Two-Period Design Response Spectrum (Multi-Period Design Spectrum)

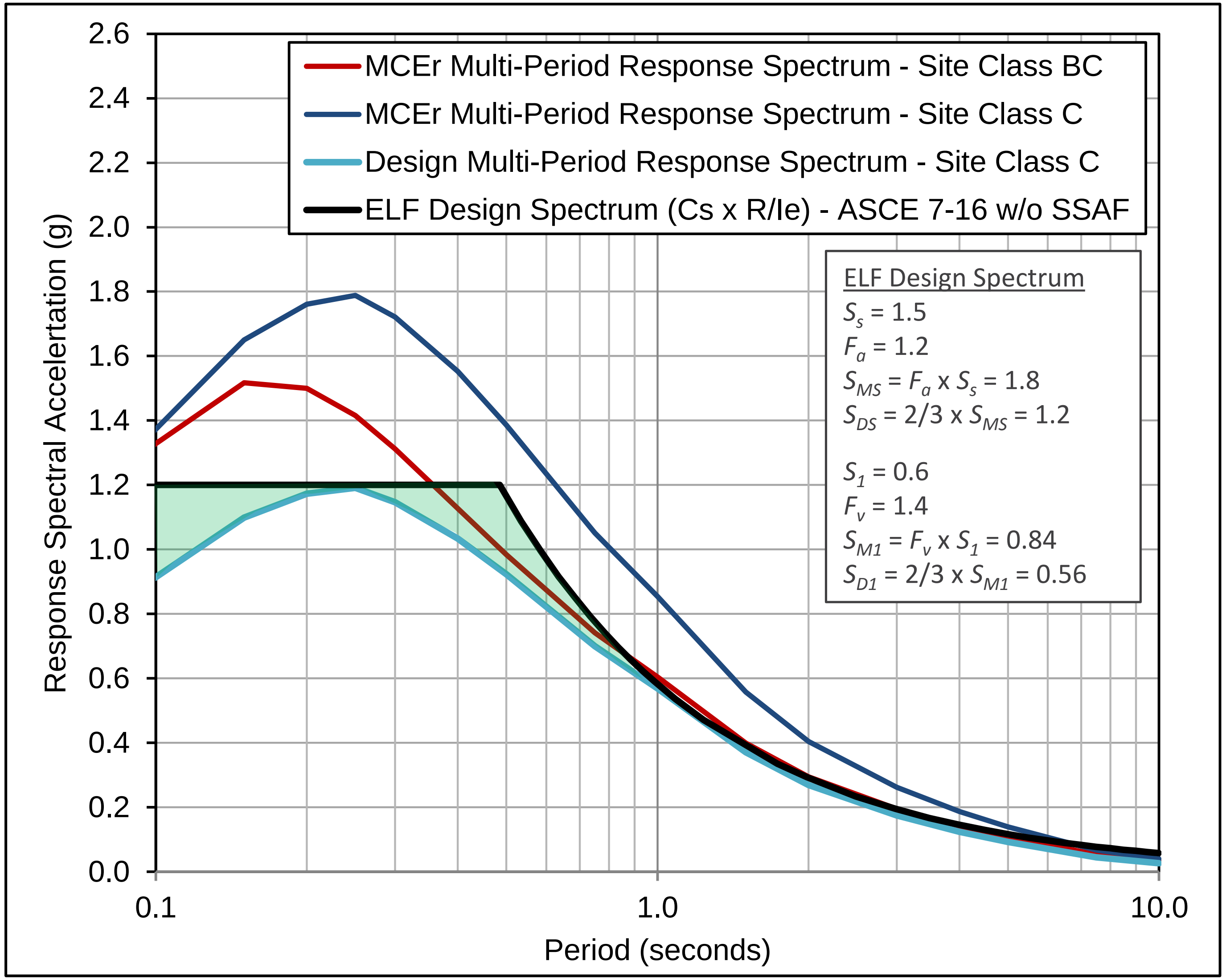
(Figure 11.4-1, *ASCE 7-05, ASCE 7-10 and ASCE 7-16* with annotation)



The “Problem” with ASCE 7-10

- For softer sites, in particular those where seismic hazard is governed by large magnitude earthquakes:
  - Frequency content of ground motions (spectrum shape) is not accurately characterized by of the two-period design response spectrum and site coefficients
  - Design ground motions are significantly underestimated (e.g., by as much as a factor of 2 at longer response periods)

Comparison of *ASCE 7-16* Two-Period (ELF) Design Spectrum w/o Spectrum Shape Adjustment and Multi-Period Response Spectra based on M7.0 earthquake ground motions at R_X = 6.8 km) – Site Class C



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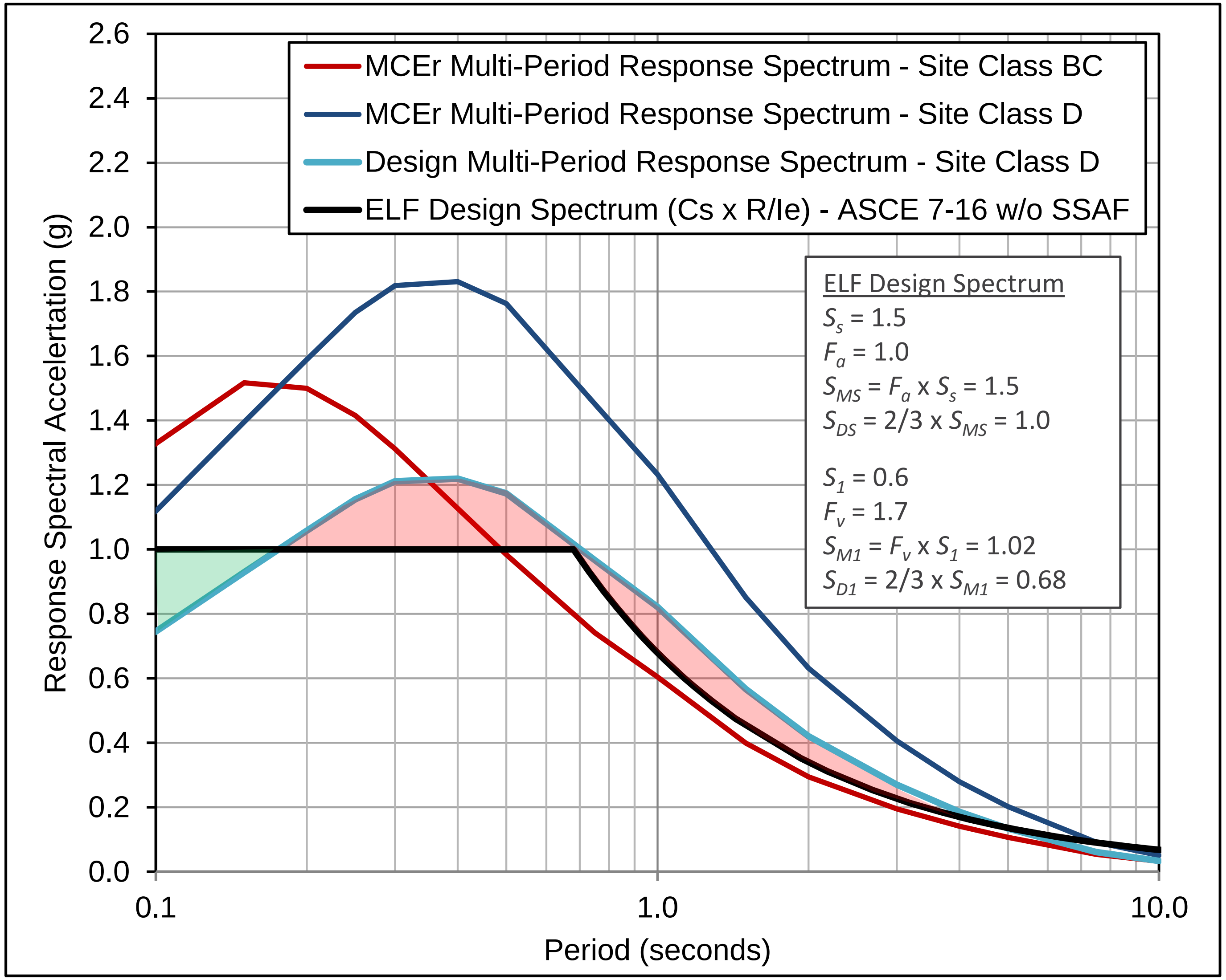
Comparison of *ASCE 7-16* Two-Period (ELF) Design Spectrum w/o Spectrum Shape Adjustment and Multi-Period Response Spectra based on M7.0 earthquake ground motions at R_X = 6.8 km) – Site Class D



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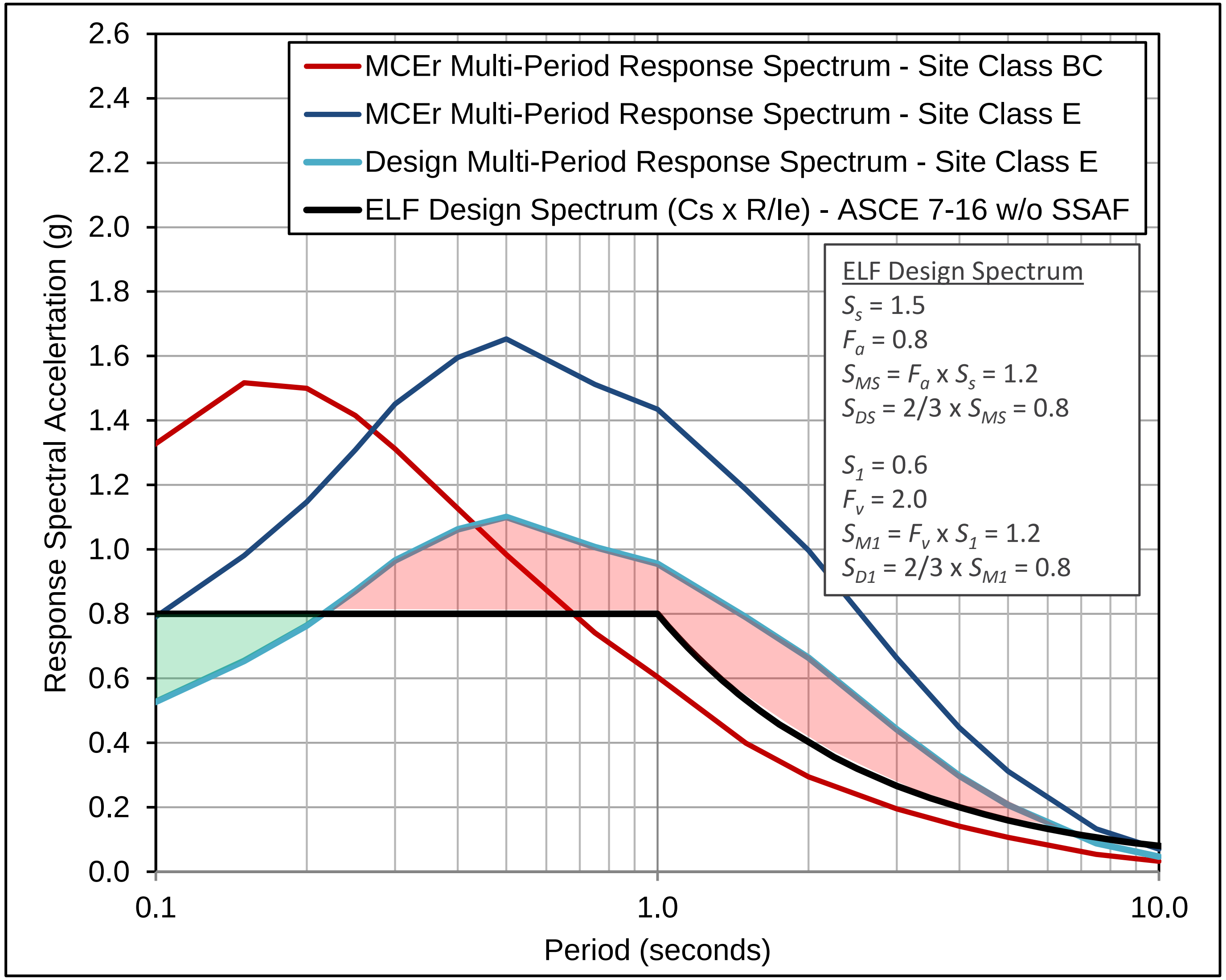
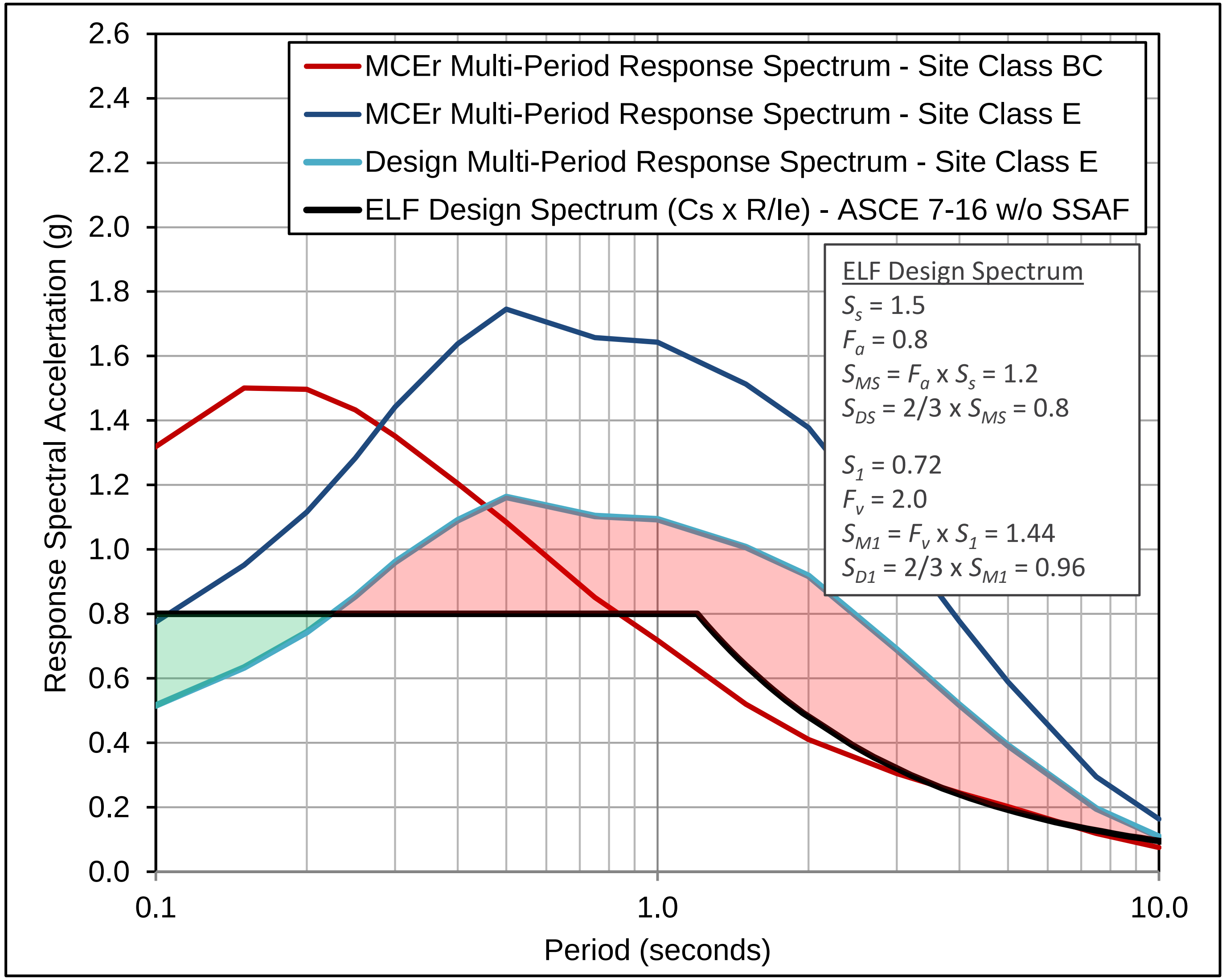
Comparison of *ASCE 7-16* Two-Period (ELF) Design Spectrum w/o Spectrum Shape Adjustment and Multi-Period Response Spectra based on M7.0 earthquake ground motions at R_X = 6.8 km) – Site Class E



Comparison of *ASCE 7-16* Two-Period (ELF) Design Spectrum w/o Spectrum Shape Adjustment and Multi-Period Response Spectra based on M8.0 earthquake ground motions at R_X = 9.9 km) – Site Class E



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Interim Solution of *ASCE 7-16* *(2015 NEHRP Provisions)*

- Require site-specific analysis to determine design ground motions for softer sites, but
- Provide exceptions to permit design using "conservative" values seismic design parameters

Site-Specific Requirements of Section 11.4.7 of *ASCE 7-16 (2015 NEHRP Provisions)*

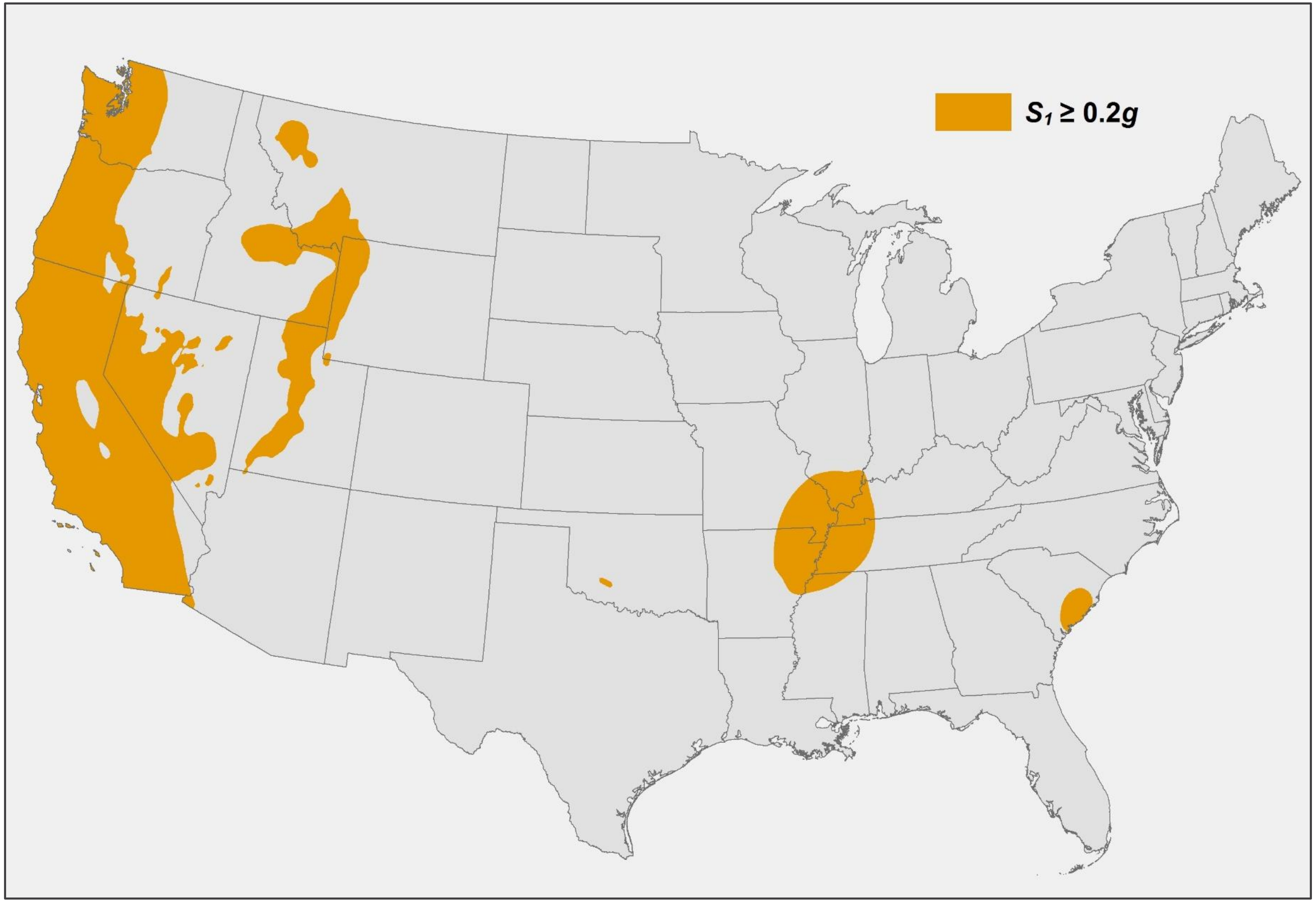
- Site Class D - Site-specific ground motion procedures are required for structures on Site Class D sites where values of S_1 are greater than or equal to 0.2.
  - An exception permits ELF (and MRSA) design using a "conservative" value of the seismic design coefficient based on a 50 percent increase in the value of the seismic parameter S_{M1} (S_{D1}), <u>effectively extending the acceleration domain to 1.5T_S</u>
- Site Class E - Site-specific ground motion procedures required for structures on Site Class E sites where values of S_S *are* greater than or equal to 1.0 (or S_1 greater than 0.2)
  - An exception permits ELF design using a "conservative" value of the seismic design coefficient based on the seismic parameter S_{MS} (S_{DS}) for Site Class C, regardless of the design period, *T*, <u>effectively eliminating the velocity domain</u>

Conterminous United States Regions with $S_1 \geq 0.2g$ (*ASCE 7-16*)

<u>Orange Shaded Regions ($S_1 \geq 0.2g$)</u>

10 percent of the area

90 percent of the risk (AEL, FEMA 366)



Long-Term Multi-Period Response Spectrum (MPRS) Solution of the 2020 NEHRP Provisions (and ASCE 7-22)

- Define design ground motions in terms of MPRS (e.g., for MRSA design or as the basis for selecting records for NRHA)
- Derive values of seismic design parameters (e.g., S_{MS} and S_{M1}) from the MPRS of interest (e.g., for ELF design)
- Provide MPRS and associated values of seismic design parameters for User-specified values of:
  - Site Location (latitude, longitude)
  - Site Class
  - From USGS web service at http://doi.org/10.5066/F7NK3C76 (aka USGS Seismic Design Geodatabase for ASCE 7-22) and
  - Other User-friendly providers (e.g., ASCE 7 Hazard Design Tool, etc.)

Multi-Period Response Spectra Format

(matrix showing the combinations of twenty-two response periods and eight site classes of the standard format of multi-period response spectra)

- CONUS regions with ground motion models for all 22 x 8 combinations of site class and period (USGS 2018 NSHM):
  - WUS
  - CEUS

Period *T* (s)	5%-Damped Response Spectral Acceleration or PGA by Site Class (g)							
	A	B	BC	C	CD	D	DE	E
0.00	0.501	0.565	0.658	0.726	0.741	0.694	0.607	0.547
0.010	0.503	0.568	0.662	0.730	0.748	0.703	0.617	0.547
0.020	0.519	0.583	0.676	0.739	0.749	0.703	0.617	0.547
0.030	0.596	0.662	0.750	0.792	0.778	0.703	0.617	0.547
0.050	0.811	0.888	0.955	0.958	0.888	0.758	0.620	0.551
0.075	1.040	1.142	1.214	1.193	1.076	0.900	0.713	0.624
0.10	1.119	1.252	1.371	1.368	1.241	1.040	0.825	0.724
0.15	1.117	1.291	1.535	1.606	1.497	1.266	1.002	0.875
0.20	1.012	1.194	**1.500**	1.710	1.662	1.440	1.153	1.010
0.25	0.897	1.075	1.397	1.714	1.766	1.584	1.299	1.153
0.30	0.810	0.976	1.299	1.665	1.829	1.705	1.443	1.301
0.40	0.689	0.833	1.138	1.525	1.823	1.802	1.607	1.484
0.50	0.598	0.724	1.009	1.385	1.734	1.803	1.681	1.596
0.75	0.460	0.536	0.760	1.067	1.407	1.566	1.598	1.589
1.0	0.368	0.417	**0.600**	0.859	1.168	1.388	1.512	1.578
1.5	0.261	0.288	0.410	0.600	0.839	1.086	1.348	1.540
2.0	0.207	0.228	0.309	0.452	0.640	0.877	1.192	1.458
3.0	0.152	0.167	0.214	0.314	0.449	0.632	0.889	1.111
4.0	0.120	0.132	0.164	0.238	0.339	0.471	0.655	0.815
5.0	0.100	0.109	0.132	0.188	0.263	0.359	0.492	0.607
7.5	0.063	0.068	0.080	0.110	0.148	0.194	0.256	0.311
10	0.042	0.045	0.052	0.069	0.089	0.113	0.144	0.170
PGA_G	0.373	0.429	**0.500**	0.552	0.563	0.527	0.461	0.416

Multi-Period Response Spectra Format

(matrix showing the combinations of twenty-two response periods and eight site classes of the standard format of multi-period response spectra)

- CONUS regions with ground motion models for all 22 x 8 combinations of site class and period (USGS 2018 NSHM):
  - WUS
  - CEUS
- OCONUS regions with only two ground motion response parameters (S_S and S_1) and *PGA* (2018 USGS NSHM):
  - Alaska
  - Hawaii
  - Puerto Rico and the Virgin Islands
  - Guam and American Samoa

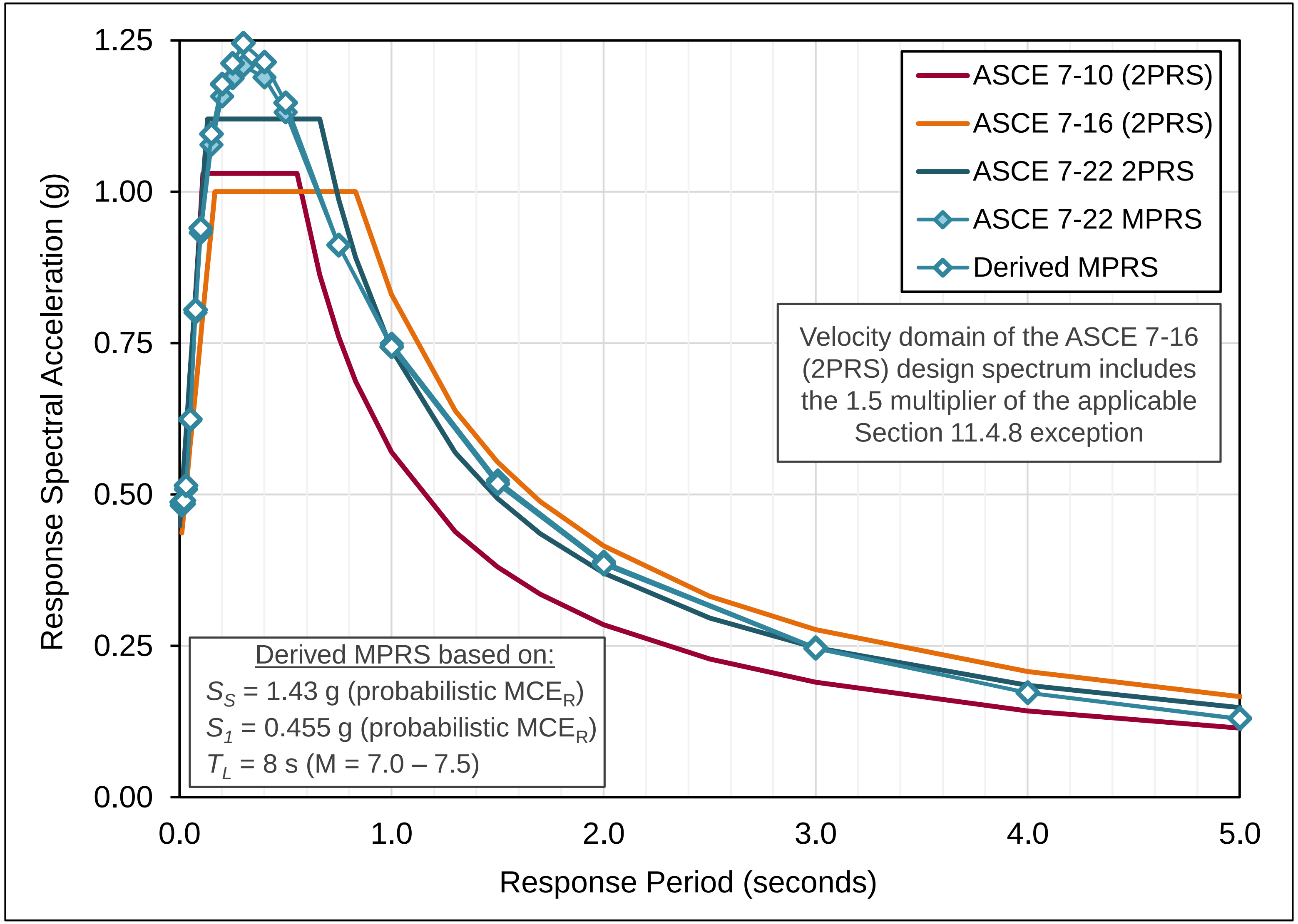
Period	5%-Damped Response Spectral Acceleration or PGA by Site Class (g)							
T (s)	A	B	BC	C	CD	D	DE	E
0.00								
0.010								
0.020								
0.030								
0.050								
0.075								
0.10								
0.15								
0.20			1.500					
0.25								
0.30								
0.40								
0.50								
0.75								
1.0			0.600					
1.5								
2.0								
3.0								
4.0								
5.0								
7.5								
10								
PGA_G			0.500					

Approach for Developing Multi-Period Response Spectra for United States Regions of Interest (CONUS and OCONUS sites)

- CONUS Sites (WUS and CEUS):
  - Science - 2018 Update of the USGS National Seismic Hazard Model (NSHM)
  - MCE_R Ground Motions – Site-specific requirements of Section 21.2 of the *2020 NEHRP Provisions* and *ASCE 7-22*
- OCONUS Sites (Alaska, Hawaii, etc.):
  - Science – Most current values of S_S and S_1 (and T_L)
  - MCE_R Ground Motions – Site-specific requirements of Section 21.2 of the *2020 NEHRP Provisions* and *ASCE 7-22* and the MPRS procedures of FEMA P-2018
- FEMA P-2078 (FEMA-funded ATC-136-1 Project)
  - "Procedures for Developing Multi-Period Response Spectra at Non-Conterminous United States Sites," FEMA P-2078, June 2020.

Comparison of Design Response Spectra – Irvine

(assuming default site conditions, Figure 8.2-1, FEMA P-2078, June 2020)



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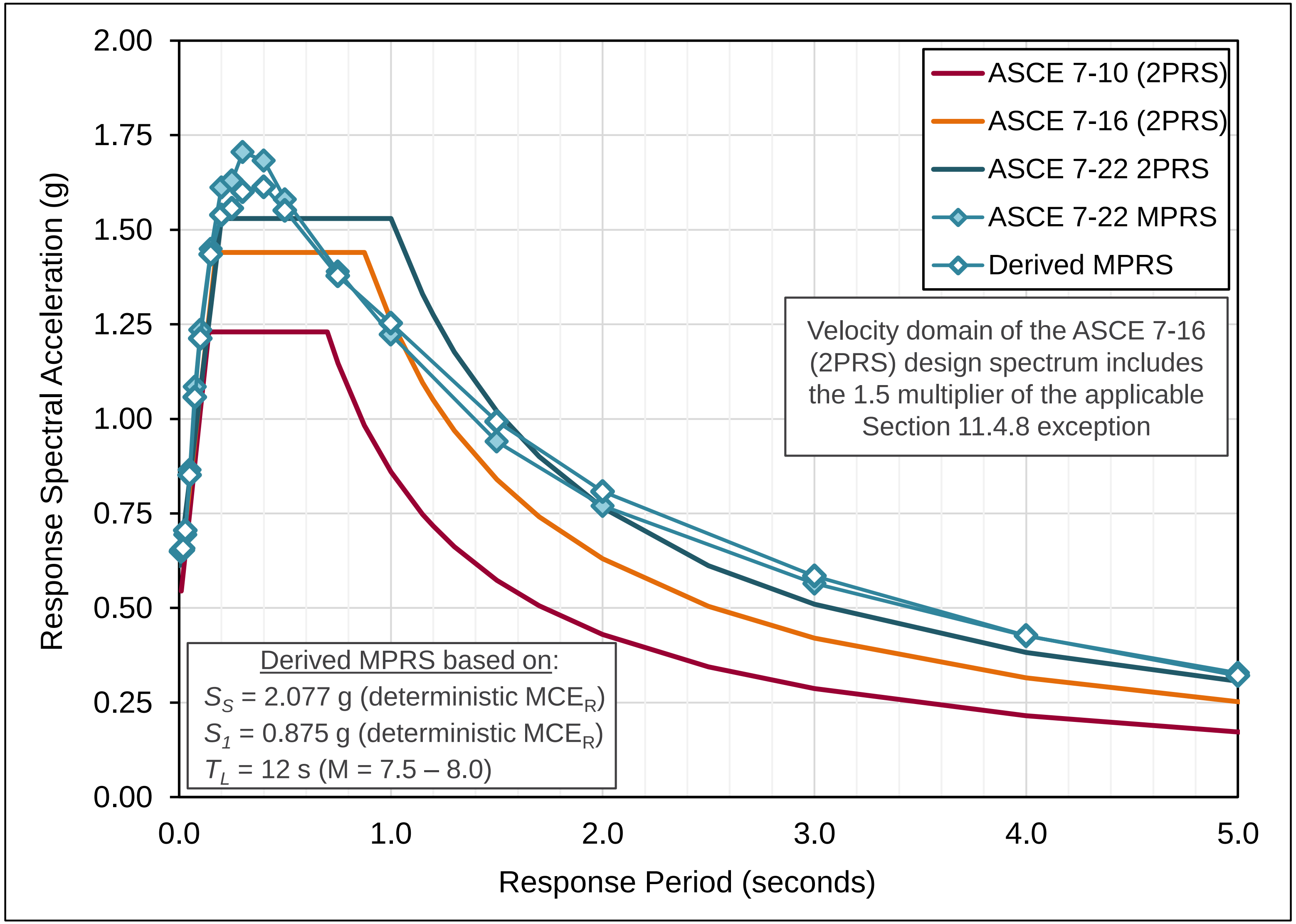
Comparison of Design Response Spectra – San Mateo

(assuming default site conditions, Figure 8.2-2, FEMA P-2078, June 2020)



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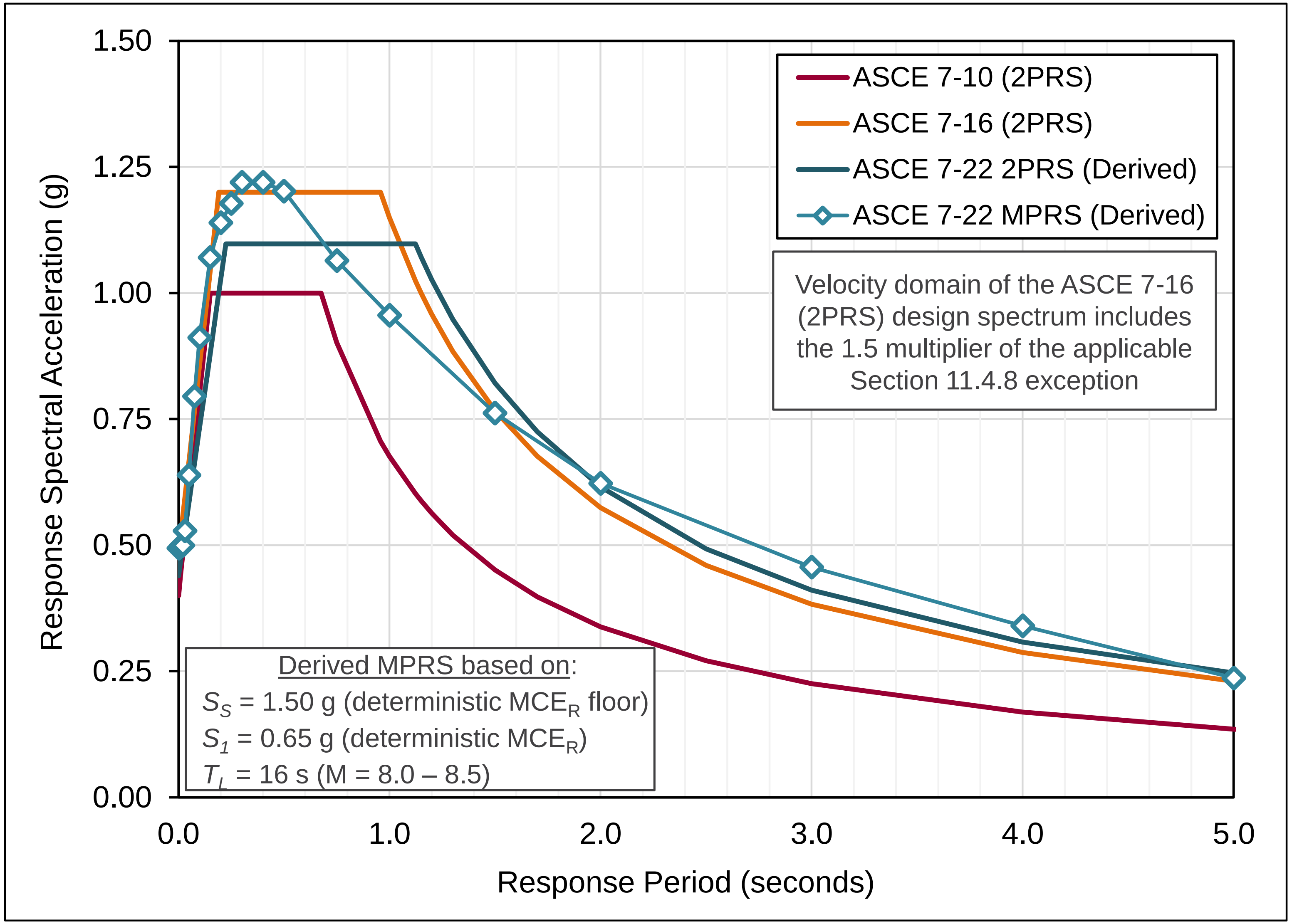
Comparison of Design Response Spectra – Anchorage

(assuming default site conditions, Figure 8.2-4, FEMA P-2078, June 2020)



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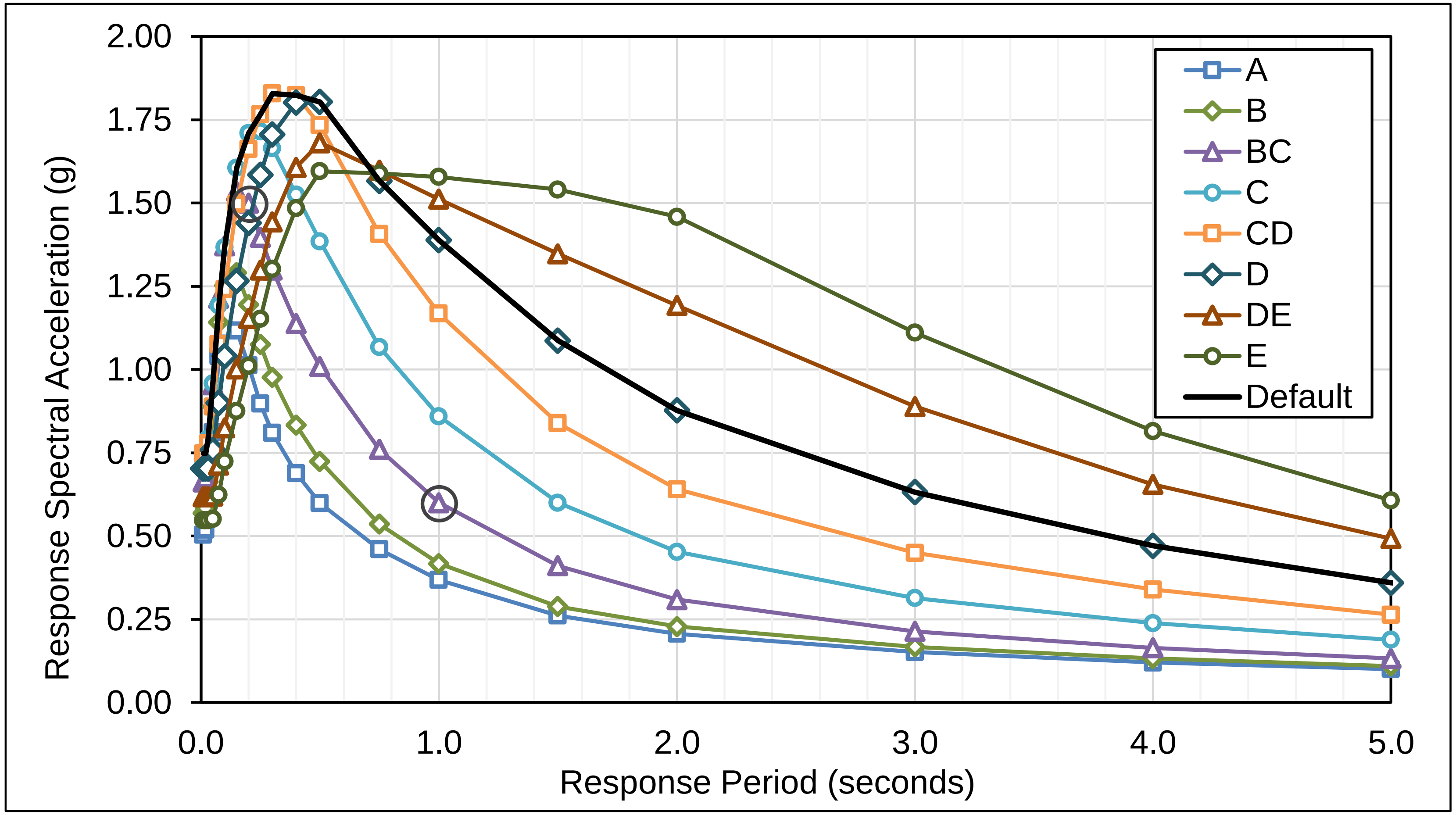
Site Classes and Associated Values of Shear Wave Velocities
(Table 2.2-1, FEMA P-2078, June 2020)

Site Class		Shear Wave Velocity, V_{s30} (fps)			USGS[2] V_{s30} (mps)
Name	**Description**	**Lower Bound[1]**	**Upper Bound[1]**	**Center**	
A	Hard rock	5,000			1,500
B	Medium hard rock	3,000	5,000	3,536	1,080
BC	**Soft rock**	**2,100**	**3,000**	**2,500**	**760**
C	Very dense soil or hard clay	1,450	2,100	1,732	530
CD	**Dense sand or very stiff clay**	**1,000**	**1,450**	**1,200**	**365**
D	Medium dense sand or stiff clay	700	1,000	849	260
DE	**Loose sand or medium stiff clay**	**500**	**700**	**600**	**185**
E	Very loose sand or soft clay		500		150

1. Upper and lower bounds, Table 20.3-1, ASCE 7-22.
2. Center of range (rounded) values used by USGS to develop MPRS.

Example Multi-Period Response Spectra (MPRS)

(Deterministic MCE_R Lower Limit, new Table 21.2-1, *2020 NEHRP Provisions/ASCE 7-22*, anchored to $S_S = S_{SD} = 1.5$ g, $S_1 = S_{1D} = 0.6$ g)



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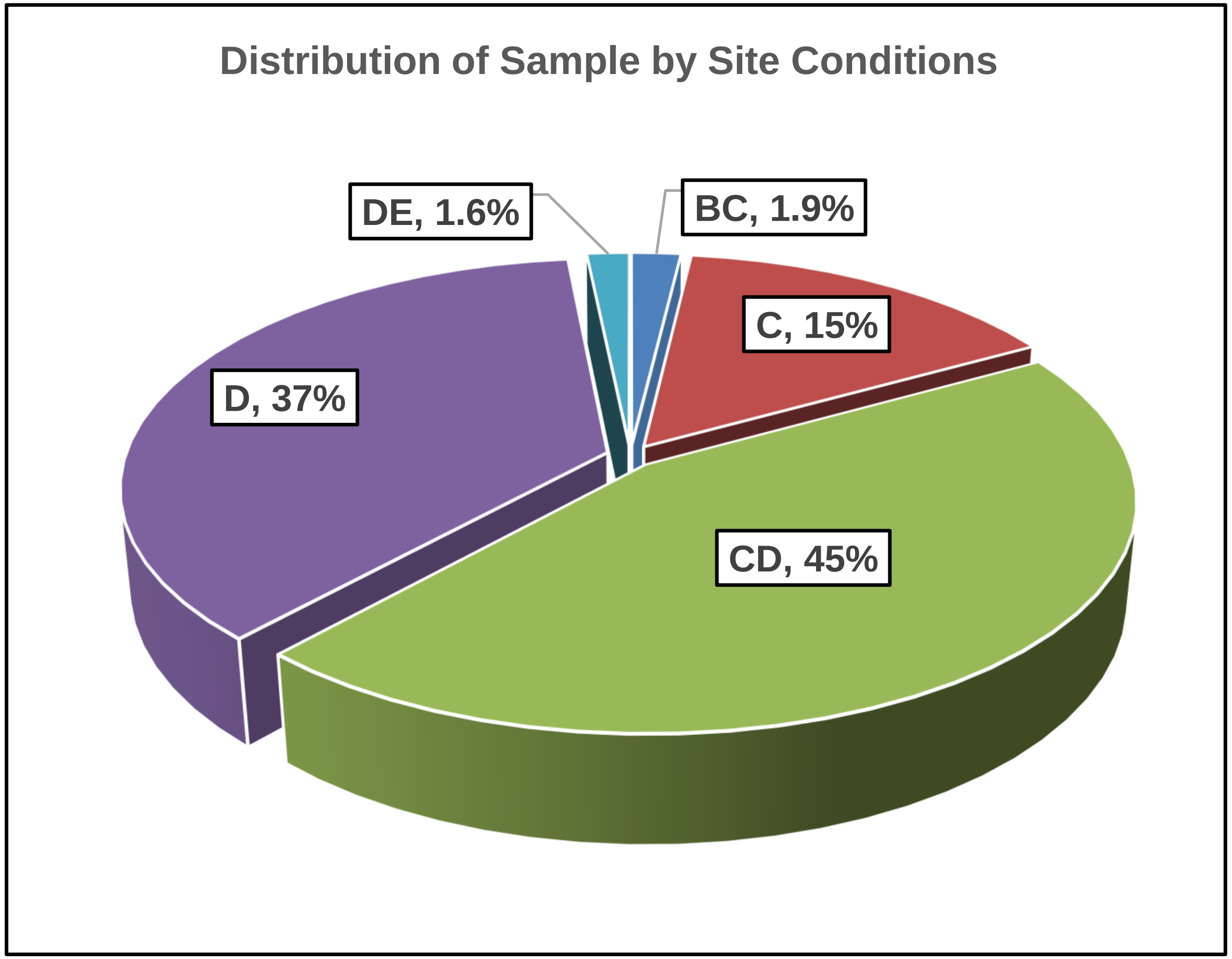
Distribution of 9,050 of census tracts of densely populated areas of California, Oregon and Washington by site class (90% of population)

(from Table A.2-1, FEMA P-2078, June 2020)

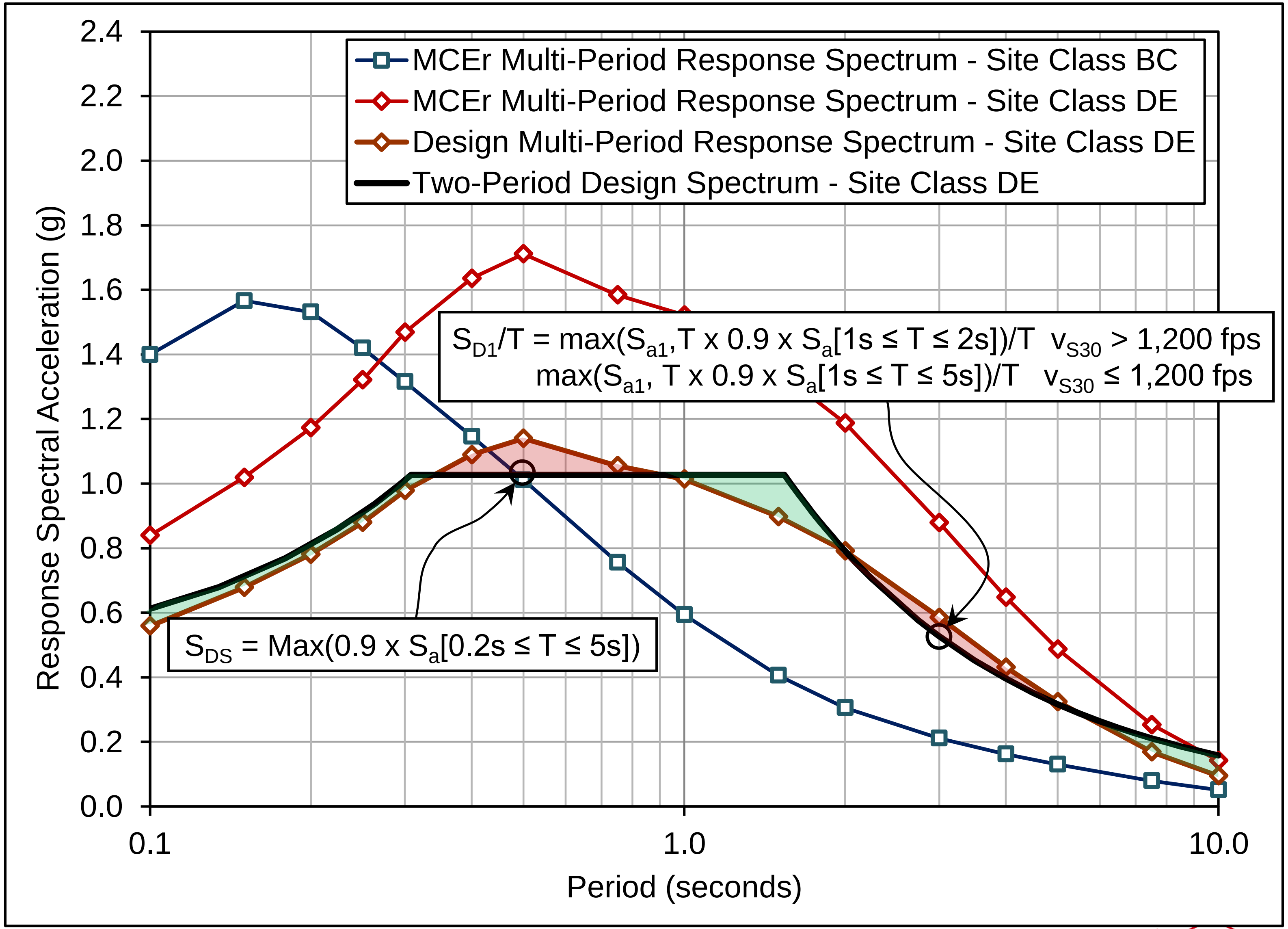


Improved Values of Seismic Design Parameters

- Derive values of seismic design parameters (S_{DS} and S_{D1}) from "best fit" of the 2-period spectrum to the multi-period design spectrum of the site of interest

Example derivation of values of S_{DS} and S_{D1} from a multi-period design spectrum

(Section 21.4, *2020 NEHRP Provisions/ASCE 7-22*)



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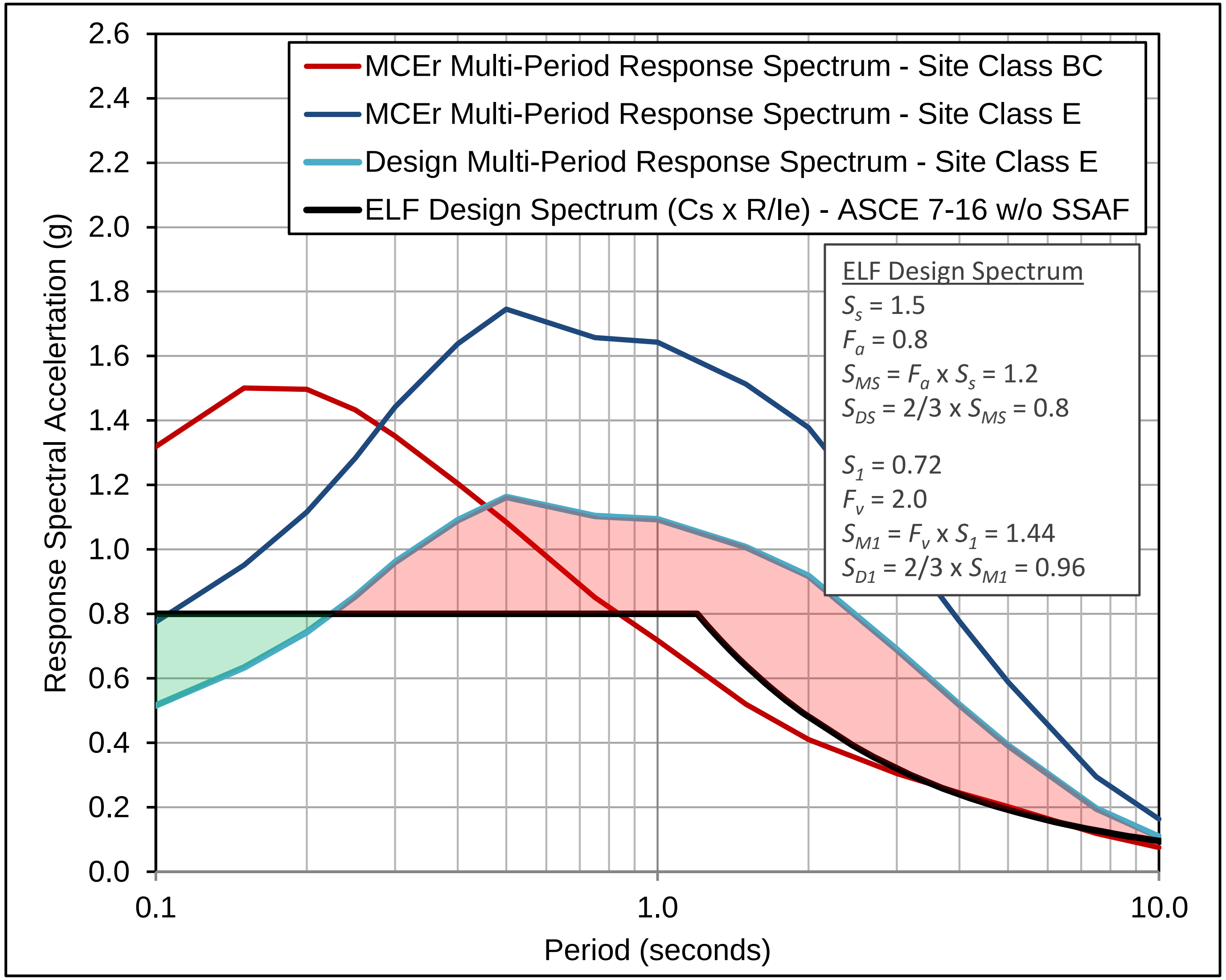
Comparison of ASCE 7-16 Two-Period (ELF) Design Spectrum w/o Spectrum Shape Adjustment and Multi-Period Response Spectra based on M8.0 earthquake ground motions at R_X = 9.9 km) – Site Class E



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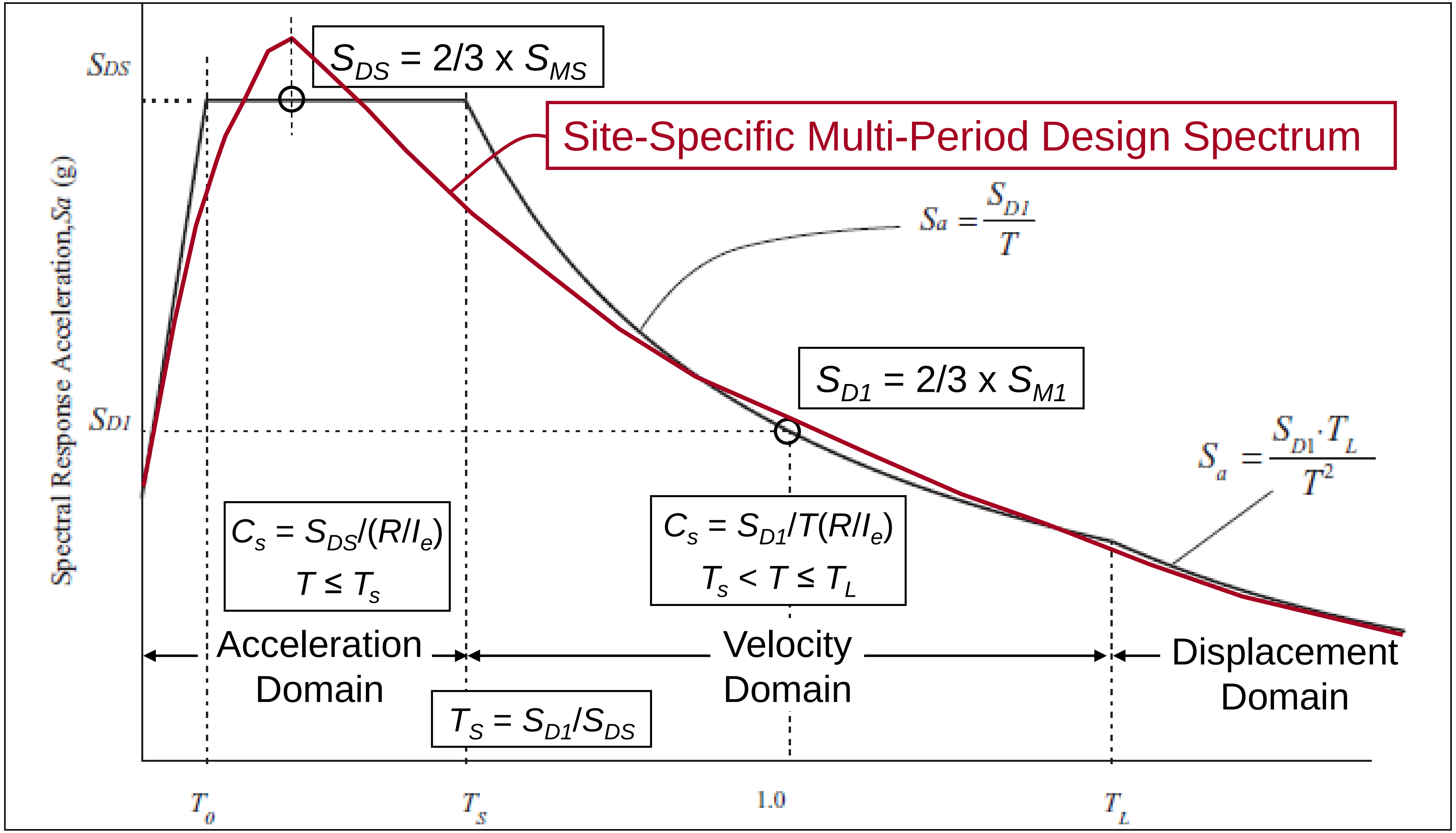
Multi-Period Design Spectrum

(Figure 11.4-1, *2020 NEHRP Provisions* and *ASCE 7-22* with annotation)



Design (As Usual) Using Proposed MPRS

- Design Ground Motions
  - Ground motion parameters (and MPRS) are available online from a USGS web service [https://doi.org/10.5066/F7NK3C76] for user specified site location (i.e., latitude and longitude) and site conditions (i.e., site class)
  - Site-specific ground motion procedures (Chapter 21) now permit use of MPRS obtained online from the USGS web service (in lieu of a hazard analysis)
- Design Procedures
  - ELF procedures (Chapter 12) are not affected by proposed changes (although values of design parameters, S_{DS} and S_{D1}, would better match the underlying response spectrum of the site of interest)
  - MRSA procedures (Chapter 12) are not affected by proposed changes (although multi-period design spectra would provide a more reliable calculation of dynamic response)

Some Key Milestones Underlying the New MPRS

Date and Reference	Description and Significance
1932 – USCGS	First deployment of seismographs in California
1933 Long Beach Earthquake	First (3) earthquake records (120 deaths, $40 billion loss)
1941 (1932) – Housner (Biot), CIT	Response spectrum (of an earthquake record) defined
1948 – USCGS (1949 UBC)	First US seismic zone map (non-mandatory)
1961 UBC (SEAOC “Blue Book”)	First US model building code w/mandatory seismic zone map
1968 – Cornell, Stanford	Probabilistic risk (hazard) methods introduced
1971 San Fernando Earthquake	Numerous earthquake records (50 deaths, $50 billion loss)
1976 – Seed et al., UC Berkeley	Site effects recognized from earthquake records
1978 ATC 3-06 (1985 NEHRP)	First model seismic code based conceptually on the “science”
1981 – Joyner & Boore (USGS)	Multi-period attenuation functions (developed from records)
1994 Northridge Earthquake	Hundreds of earthquake records (20 deaths, $60 billion loss)
1997 NEHRP (Project 97)	Seismic contour maps based on the “science”
2020 NEHRP (Project 17)	Multi-period response spectra based on the “science”

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THE 2018 UPDATE OF THE USGS NATIONAL SEISMIC HAZARD MODEL

Sanaz Rezaeian, Ph.D.
Research Structural Engineer
U.S. Geological Survey (USGS), Golden, CO

BSSC Council Meeting and Symposium on
2020 NEHRP Recommended Seismic Provisions
Virtual Event, March 4, 2021
https://www.nibs.org/page/bssc_2020nehrpsymposium

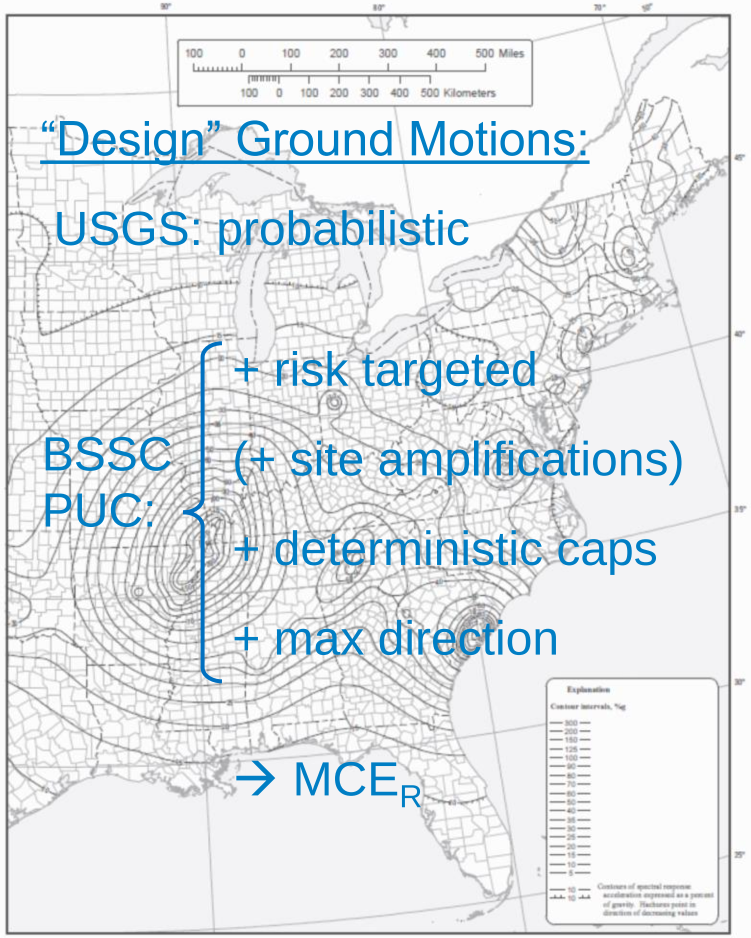
USGS science for a changing world | nehrp | FEMA

Outline:

1. Interplay between the USGS hazard models and the BSSC PUC requirements

2. The 2018 USGS National Seismic Hazard Model (NSHM) for Conterminous U.S.
   - Ground motion models in CEUS (e.g. NGA-East)
   - Deep basin effects in WUS

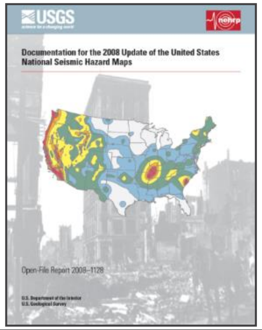
3. Outside of the Conterminous U.S. (HI, AK, PRVI, GNMI, AMSAM)

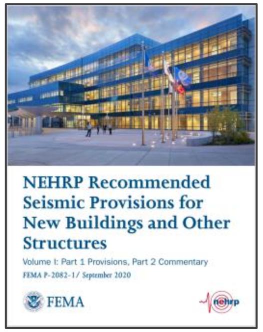


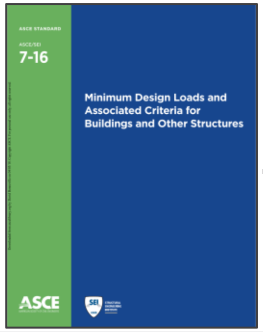
USGS NSHMs & BSSC PUC Requirements:

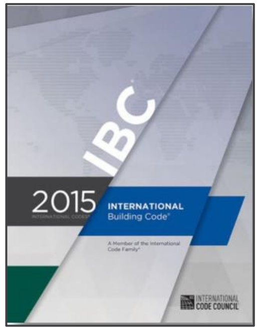
Hazard Model (PSHA)

Site-specific procedures of Ch21









	USGS NSHM	NEHRP Provisions	ASCE 7 Standards	IBC
PGA,0.2,1s 760m/s	1996	1997, 2000	1998,2002	2000, 2003
	2002	2003	2005	2006, 2009
	2008	2009	2010	2012, 2015
	2014	2015	2016	2018
22 Periods 8 Vs30s	**2018**	**2020**	2022*	TBD

Hazard Curves + (RiskTarget, MaxDir, ~~SiteAmpl~~, DetCaps) → **"Design" Ground Motions**

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Updates to 2020 NEHRP Design Ground Motions in Conterminous US:

2018 USGS NSHM

Check for updates

Research paper

EARTHQUAKE SPECTRA

Earthquake Spectra
2020, Vol. 36(1) 5–41
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The 2018 update of the US National Seismic Hazard Model: Overview of model and implications

Mark D. Petersen, M.EERI[1], Allison M. Shumway[1], Peter M. Powers, M.EERI[1], Charles S. Mueller[1], Morgan P. Moschetti, M.EERI[1], Arthur D. Frankel, M.EERI[2], Sanaz Rezaeian[1], Daniel E. McNamara[1], Nico Luco, M.EERI[1], Oliver S. Boyd, M.EERI[1], Kenneth S. Rukstales[1], Kishor S. Jaiswal, M.EERI[1], Eric M. Thompson[1], Susan M. Hoover[1], Brandon S. Clayton[1], Edward H. Field, M.EERI[1], and Yuehua Zeng[1]

Abstract
During 2017–2018, the National Seismic Hazard Model for the conterminous United States was updated as follows: (1) an updated seismicity catalog was incorporated, which includes new earthquakes that occurred from 2013 to 2017; (2) in the central and eastern United States (CEUS), new ground motion models were updated that incorporate updated median estimates, modified assessments of the associated epistemic uncertainties and aleatory variabilities, and new soil amplification factors; (3) in the western United States (WUS), amplified shaking estimates of long-period ground motions at sites overlying deep sedimentary basins in the Los Angeles, San Francisco, Seattle, and Salt Lake City areas were incorporated; and (4) in the conterminous United States, seismic hazard is calculated for 22 periods (from 0.01 to 10 s) and 8 uniform V_{S30} maps (ranging from 1500 to 150 m/s). We also include a description of updated computer codes and modeling details. Results show increased ground shaking in many (but not all) locations across the CEUS (up to ~30%), as well as near the four urban areas overlying deep sedi-

Updated hazard model (eqk sources, GMMs, etc)

[1]US Geological Survey, Denver Federal Center, Denver, CO, USA
[2]US Geological Survey, University of Washington, Seattle, WA, USA

Corresponding author:
Mark D. Petersen, US Geological Survey, Denver Federal Center, P.O. Box 25046, MS 966, Denver, CO 80225, USA.
Email: mpetersen@usgs.gov

BSSC Project '17

BSSC PROJECT 17 FINAL REPORT

National Institute of BUILDING SCIENCES

BSSC Project 17 Final Report

Development of Next Generation of Seismic Design Value Maps for the 2020 NEHRP Provisions

by

National Institute of Building Sciences
Building Seismic Safety Council
Project 17 Committee (chair: Ron Hamburger)

Sponsored by

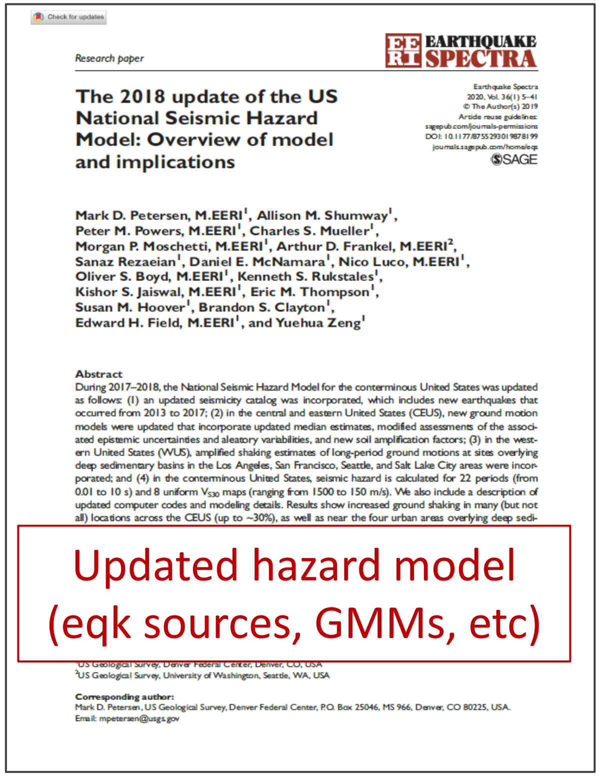
Federal Emergency Management Agency

Updated site-specific procedures of Ch21

DECEMBER 2019 | NATIONAL INSTITUTE OF BUILDING SCIENCES

Updates to 2020 NEHRP Design Ground Motions in Conterminous US:

2018 USGS NSHM


Check for updates

EERI EARTHQUAKE SPECTRA

Research paper

Earthquake Spectra
2020, Vol. 36(1) 5–41
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DOI: 10.1177/8755293019878199
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Email: mpetersen@usgs.gov

Updated hazard model
(eqk sources, GMMs, etc)

➕

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No change to risk-targeted calcs

1. Using **multi-period multi-Vs30 response spectrum (MPRS)**
2. Modifying **deterministic caps** based on deaggregation of probabilistic hazard
3. Updating the **max-direction** factors

MPRS issue directly influenced the 2018 update of USGS NSHM (GMMs applicable for all periods and site classes)

Updates to 2020 NEHRP Design Ground Motions in Conterminous US:

2018 USGS NSHM

Necessary for MPRS

1. New ground motion models (GMMs), including **NGA-East**, & amplification factors in the Central & Eastern US (CEUS)
2. Deep **basin effects** in Los Angeles, Seattle, San Francisco, and Salt Lake City regions
3. Minor modifications of GMMs (crustal & subduction) in the Western US (WUS)
4. Updating **background seismicity** to include 2013-2017 earthquakes

+

BSSC Project '17

No change to risk-targeted calcs

1. Using **m**ulti-**p**eriod multi-Vs30 **r**esponse **s**pectrum **(MPRS)**
2. Modifying **deterministic caps** based on deaggregation of probabilistic hazard
3. Updating the **max-direction** factors

MPRS issue directly influenced the 2018 update of USGS NSHM (GMMs applicable for all periods and site classes)

Old CEUS Ground Motion Models:

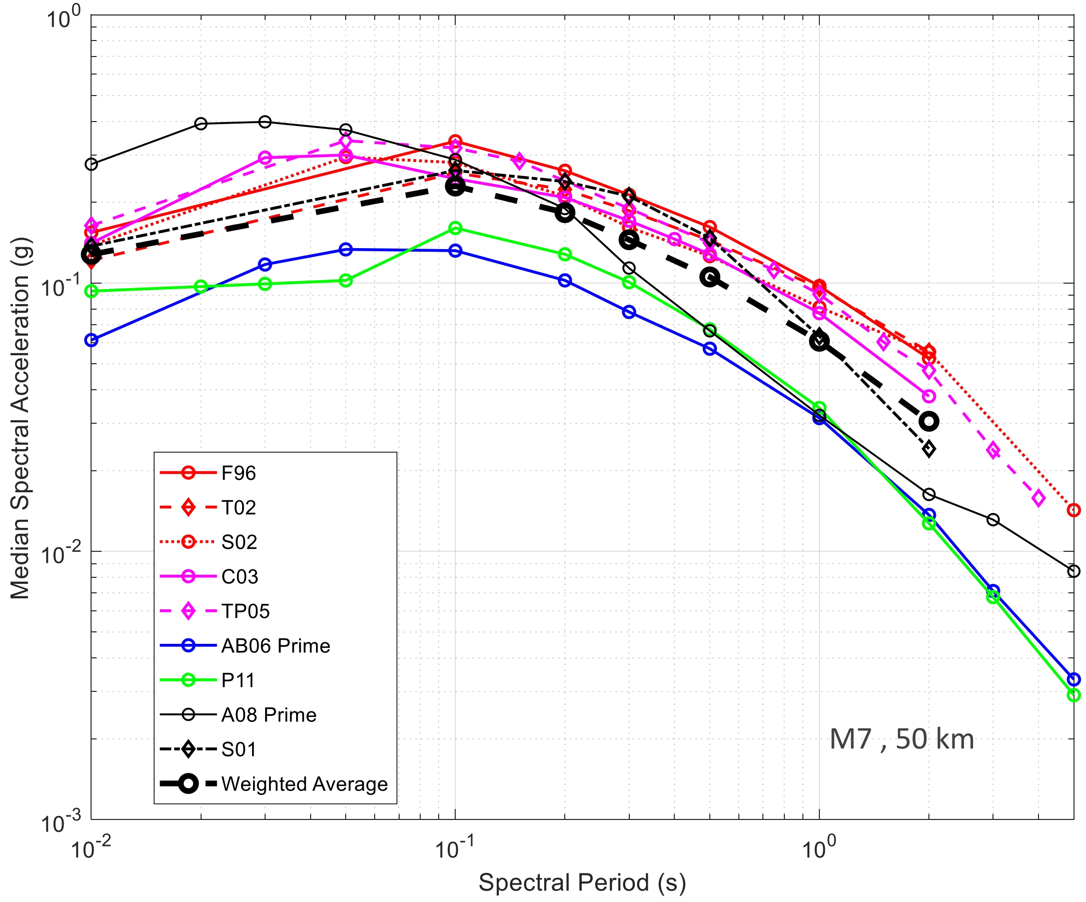


Table from Rezaeian et al. (2021):

2014 CEUS GMMs:	Period Range	Site Classes
AB06′	PGA to 5 s	A, BC (A to E)
A08′	PGA to 5 s	A, BC (A to E)
C03	PGA to 2 s (4 s)	A, BC*
F96	PGA to 2 s	A, BC
P11	PGA to 5 s (10 s)	A, BC*
S02	PGA to 5 s (10 s)	A, BC*
S01	PGA to 2 s (4 s)	A, BC*
TP05	PGA to 4 s	A, BC*
T02	PGA to 2 s	A, BC*

Parentheses indicate the published range when a different range is supported in the USGS codes.
*Through conversion factors.

Figure citation: Rezaeian et al. (2021). The 2018 update of the US National Seismic Hazard Model: Ground motion models in the central and eastern US. Earthquake Spectra. doi: 10.1177/8755293021993837

New CEUS Ground Motion Models:

PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER

NGA-East: Adjustments to Median Ground-Motion Models for Central and Eastern North America

PEER Report No. 2015/08
Pacific Earthquake Engineering Research Center
Headquarters at the University of Californ

August 2015

PEER 2015/08
August 2015

14 Updated Seed GMMs
from 19 published plus 2 new
varying weights based on
geometric spreading & model type
(1/3 weight)

+

PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER

NGA-East Ground-Motion Models for the U.S. Geological Survey National Seismic Hazard Maps

Gail M. Atkinson
Western University

PEER Report No. 2017/03
Pacific Earthquake Engineering Research Center
Headquarters at the University of California, Berkeley

March 2017

17 NGA-East GMMs
Sammon's Mapping
varying weights based on
frequency & magnitude
(2/3 weight)

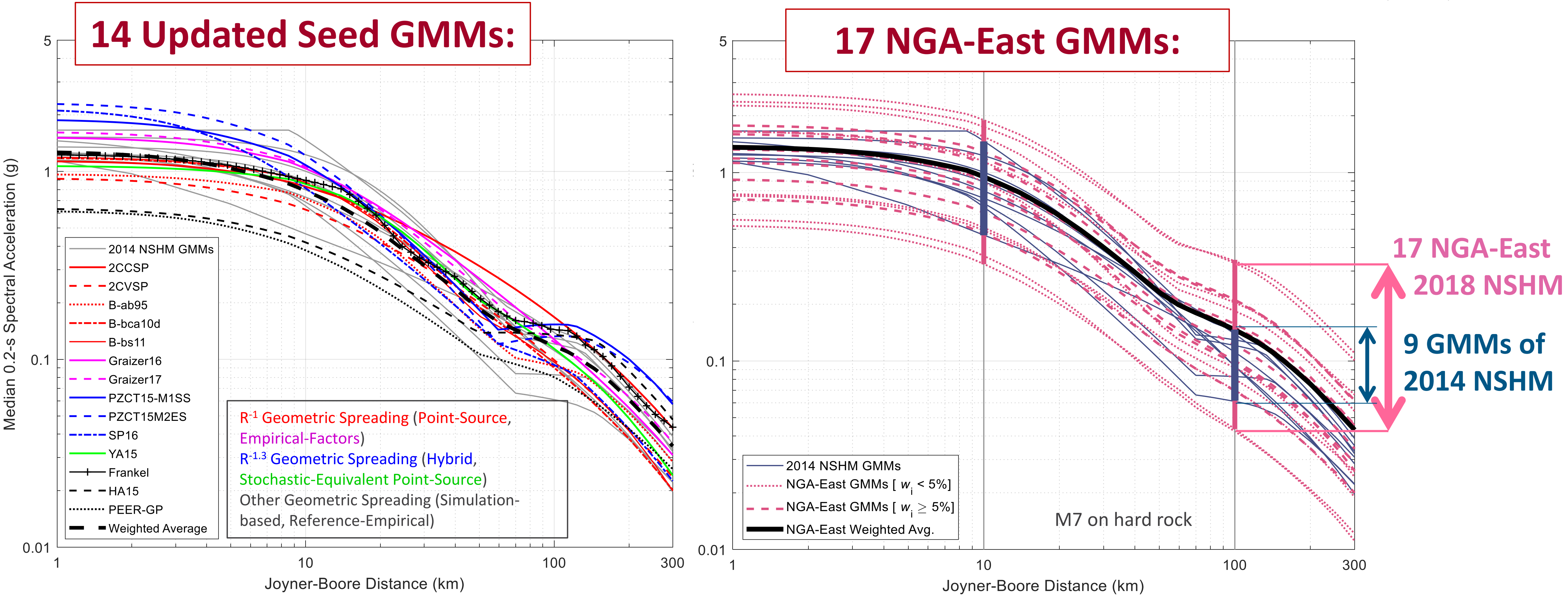
31 CEUS GMMs

Changes made to:

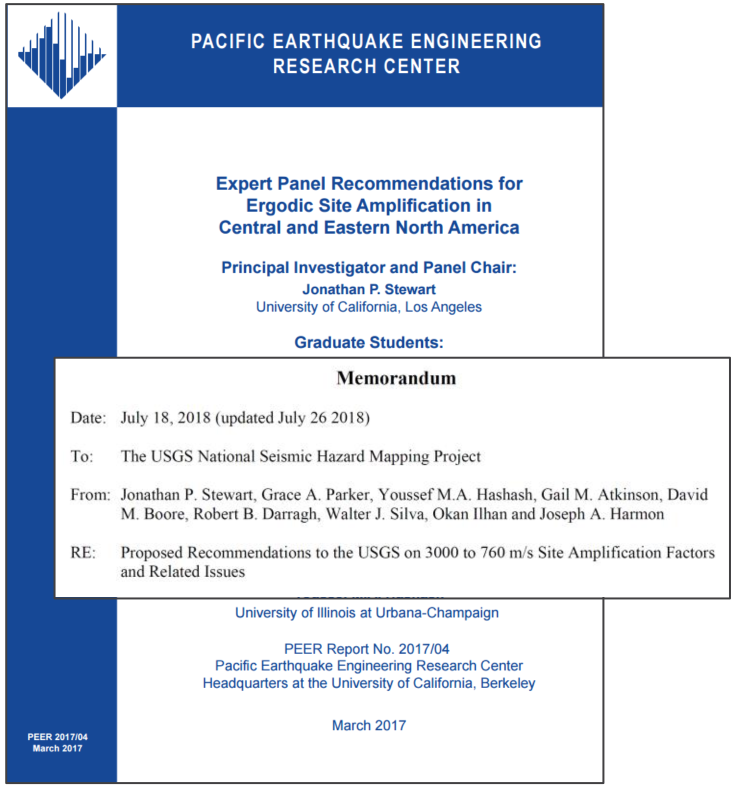
1. Median ground motions (increases for large M, middle to large distances)
2. Epistemic uncertainty (increased)
3. Aleatory uncertainty (minor)

New CEUS Ground Motion Models:

Figure citation: Rezaeian et al. (2021). The 2018 update of the US National Seismic Hazard Model: Ground motion models in the central and eastern US. Earthquake Spectra.



New CEUS Site-Effects Models:


PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER

Expert Panel Recommendations for Ergodic Site Amplification in Central and Eastern North America

Principal Investigator and Panel Chair:
Jonathan P. Stewart
University of California, Los Angeles

Graduate Students:

Memorandum

Date: July 18, 2018 (updated July 26 2018)

To: The USGS National Seismic Hazard Mapping Project

From: Jonathan P. Stewart, Grace A. Parker, Youssef M.A. Hashash, Gail M. Atkinson, David M. Boore, Robert B. Darragh, Walter J. Silva, Okan Ilhan and Joseph A. Harmon

RE: Proposed Recommendations to the USGS on 3000 to 760 m/s Site Amplification Factors and Related Issues

University of Illinois at Urbana-Champaign

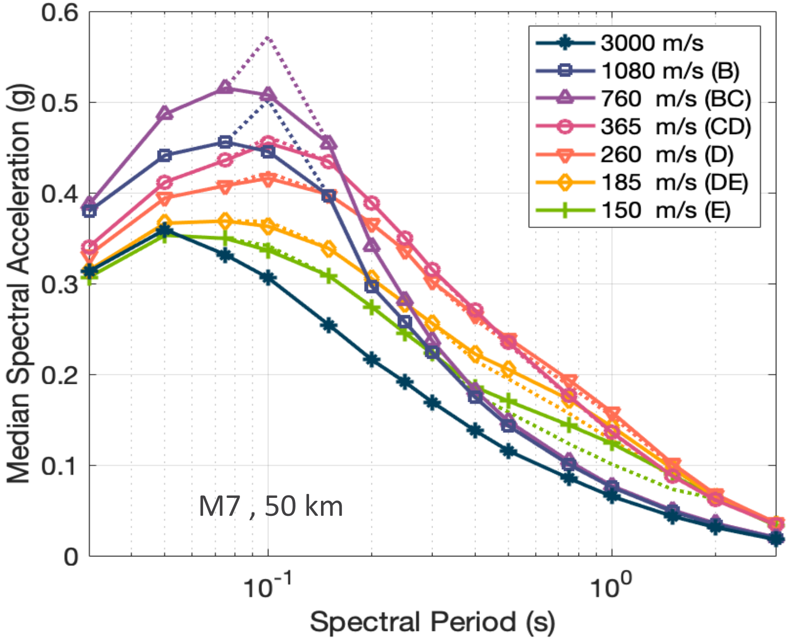
PEER Report No. 2017/04
Pacific Earthquake Engineering Research Center
Headquarters at the University of California, Berkeley

March 2017

PEER 2017/04
March 2017

<u>Later published (and slightly modified) by:</u>
Stewart et al. (2020), *Earthquake Spectra 36(1)*
Hashash et al. (2020), *Earthquake Spectra 36(1)*
Rezaeian et al. (2021), *Earthquake Spectra* (implementation details)

Site Effects = $F_{760} + F_{linear} + F_{nonlinear}$



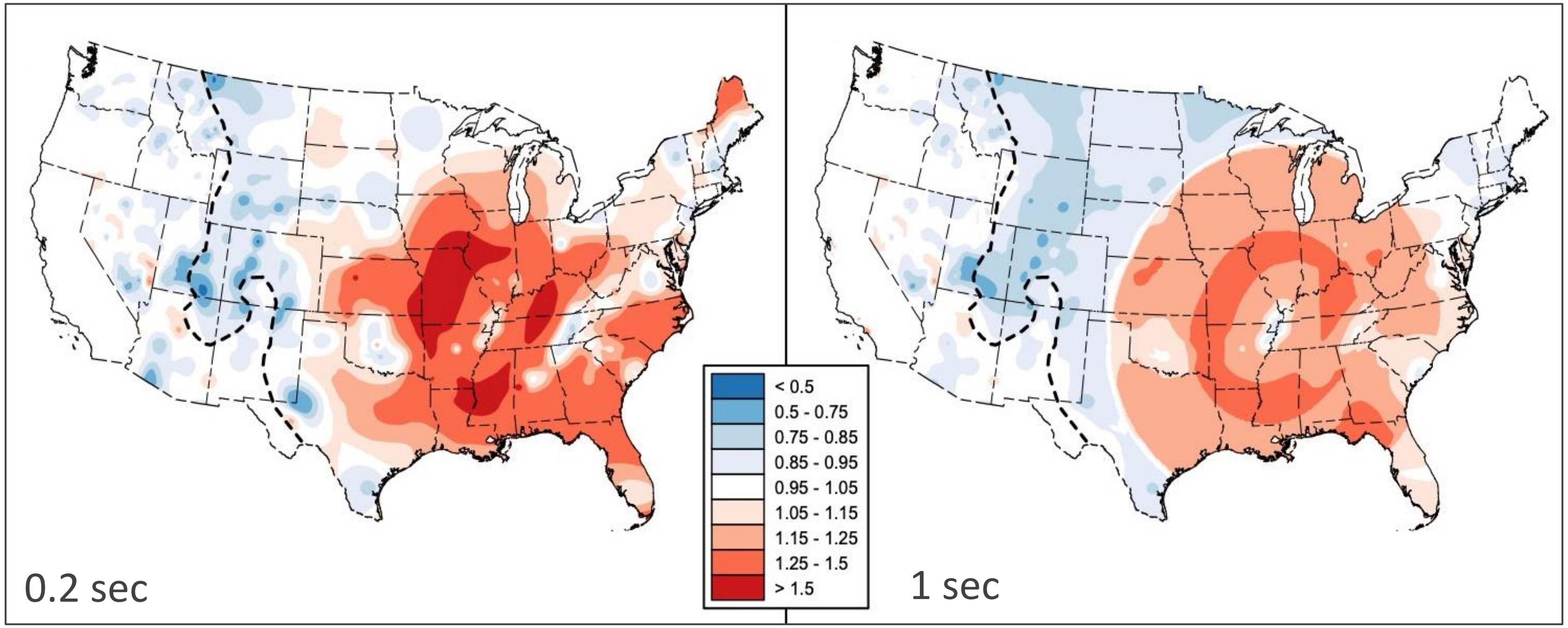
CEUS has very different spectral shapes compared to WUS, as expected!

This is the first time that site-effects specific to the CEUS have been implemented in the NSHMs (prior NEHRP coefficients were based on WUS)

Figure citation: Rezaeian et al. (2021). The 2018 update of the US National Seismic Hazard Model: Ground motion models in the central and eastern US. Earthquake Spectra.

Hazard Changes (CEUS):

Ratio Maps (2018/2014):
2% in 50yr uniform hazard, BC site class (760 m/s)



Medians: more significant increases for large M at mid-large distances

Epistemic uncertainty: increased significantly for large M, more around 70-100 km

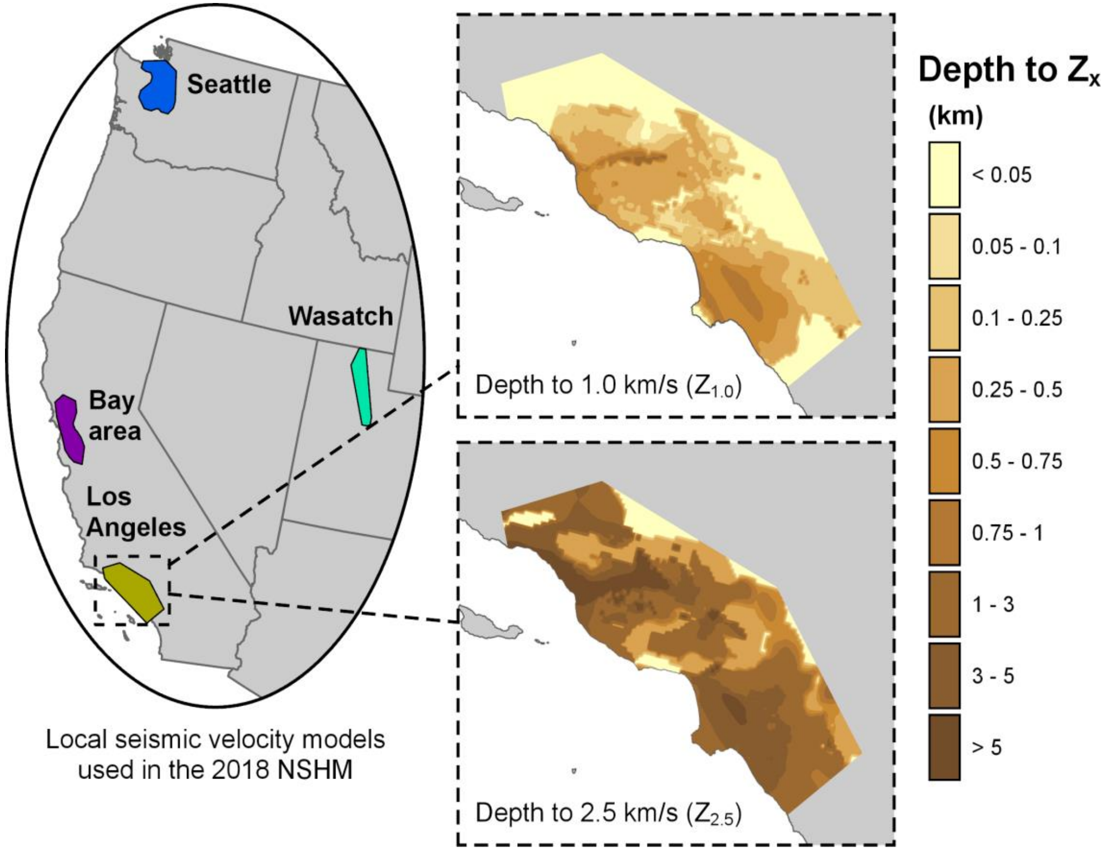
Aleatory uncertainty: minor changes

Site-effect model: only F_{760} in this figure

Seismicity catalog updates: outside CA, mostly affecting intermountain west region

Figure citation: Petersen et al. (2021). The 2018 update of the US National Seismic Hazard Model: Where, why, and how much probabilistic ground motion maps changed. Earthquake Spectra.

Deep Basin Effects:



Map of basin locations (Shumway et al., 2021)

Categorized by:
basin depth terms $Z_{1.0}$ & $Z_{2.5}$

Within basins:
measurements only in deep portions of basins are used, “default” values are used in shallow depths

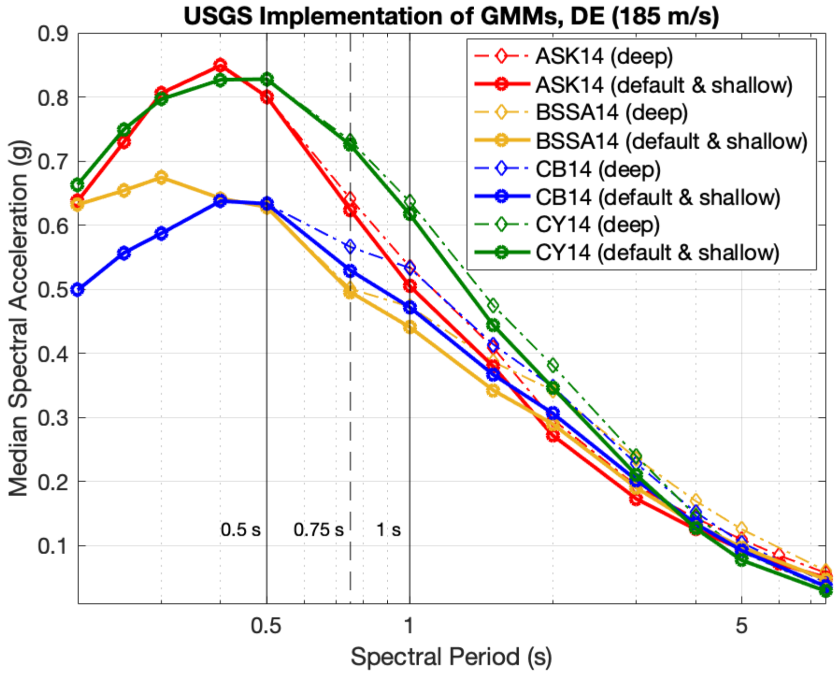
Outside basins:
“default” values are used

Deep Basin Effects:

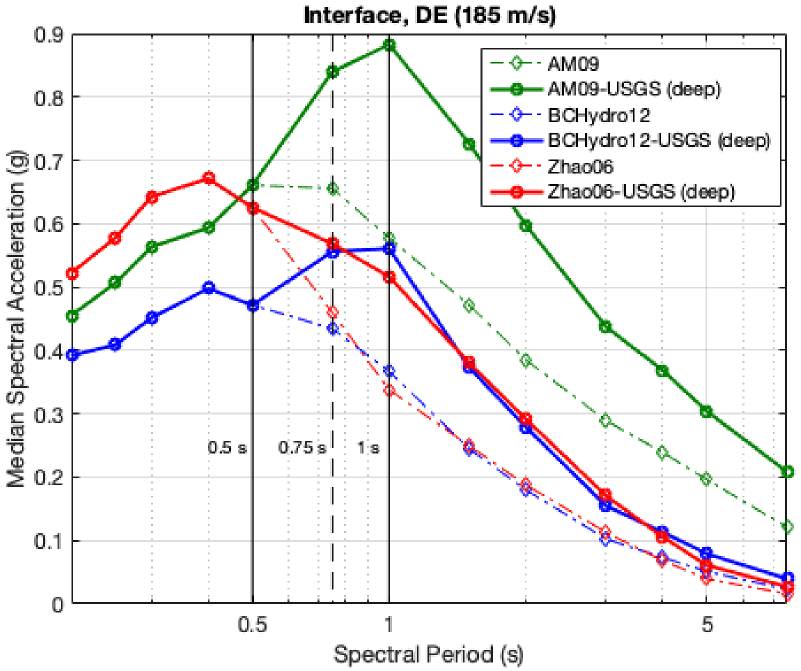
Minor modifications made to crustal and subduction models.
Basin effects fully applied at periods above 1 sec:

Figure citation: Powers et al. (2021). The 2018 update of the US National Seismic Hazard Model: Ground motion models in the western US. Earthquake Spectra. doi: 10.1177/87552930211011200

Implementation of Crustal Earthquake GMMs:



Modifications to Subduction Earthquake GMMs:



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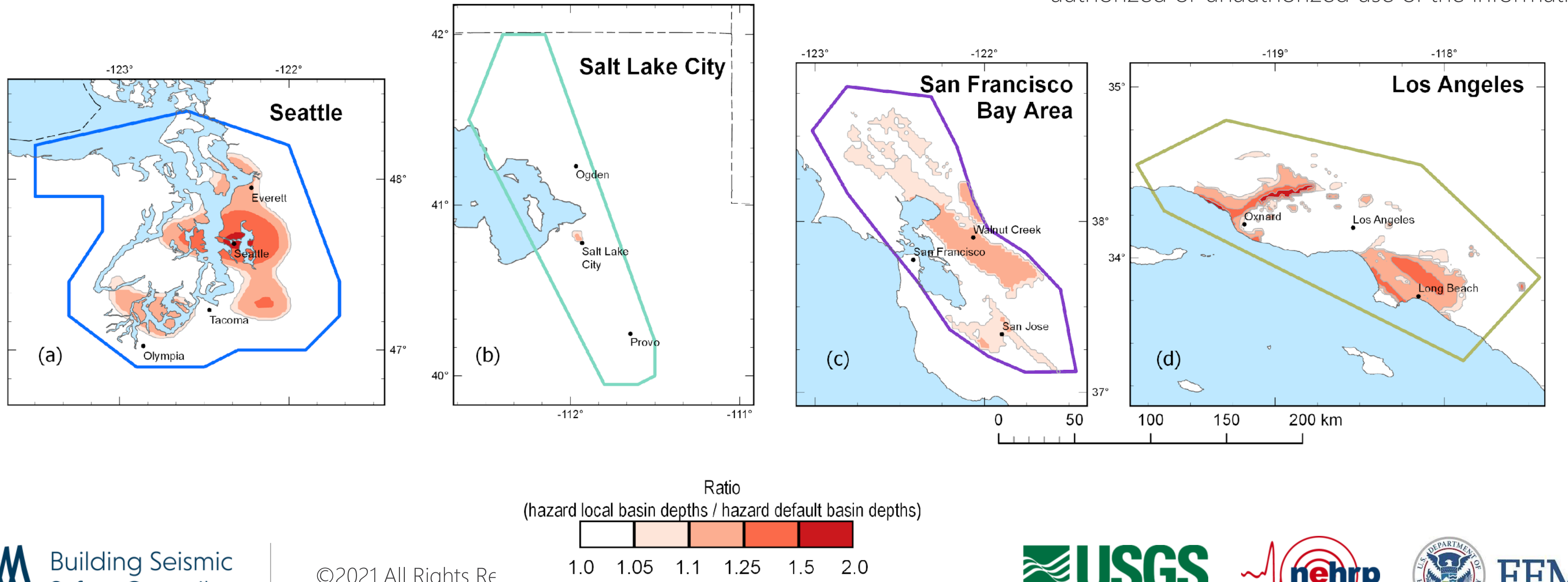
Hazard Changes (WUS):

Disclaimer: This information is preliminary and is subject to revision. It is being provided to meet the need for timely best science. The information is provided on the condition that neither the U.S. Geological Survey nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the information.

Ratio Maps (2018 local basin depth/2018 default basin depth):
2% in 50yr uniform hazard, 5 sec, Site Class D (260 m/s)



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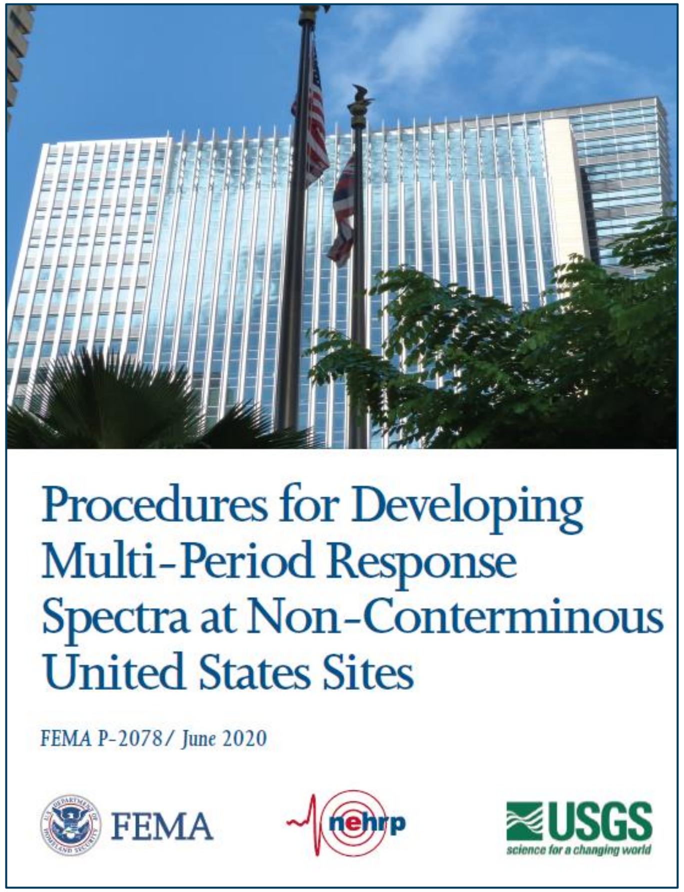
Outside of Conterminous US (OCONUS):



Developed Generic Spectral Shapes:

FEMA/ATC report, approved by BSSC PUC.

Shapes developed based on WUS data, function(S_S, S_S/S_1, T_L)

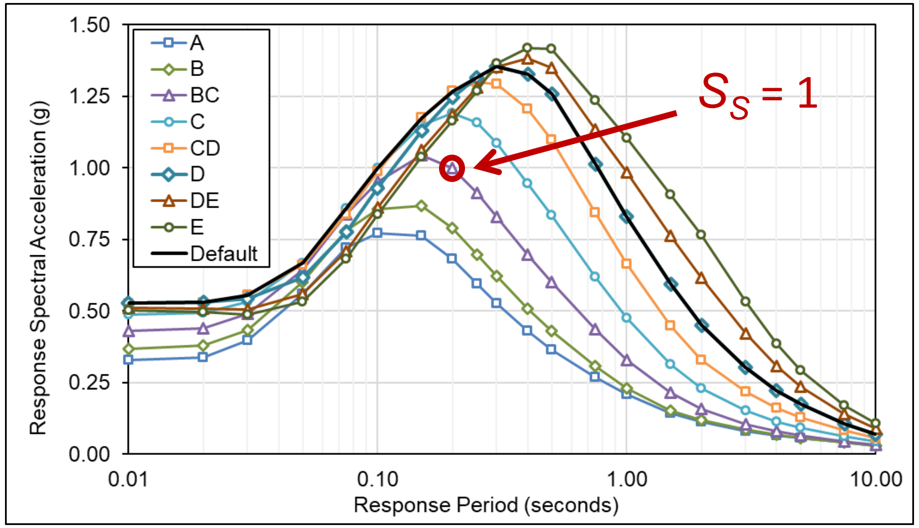
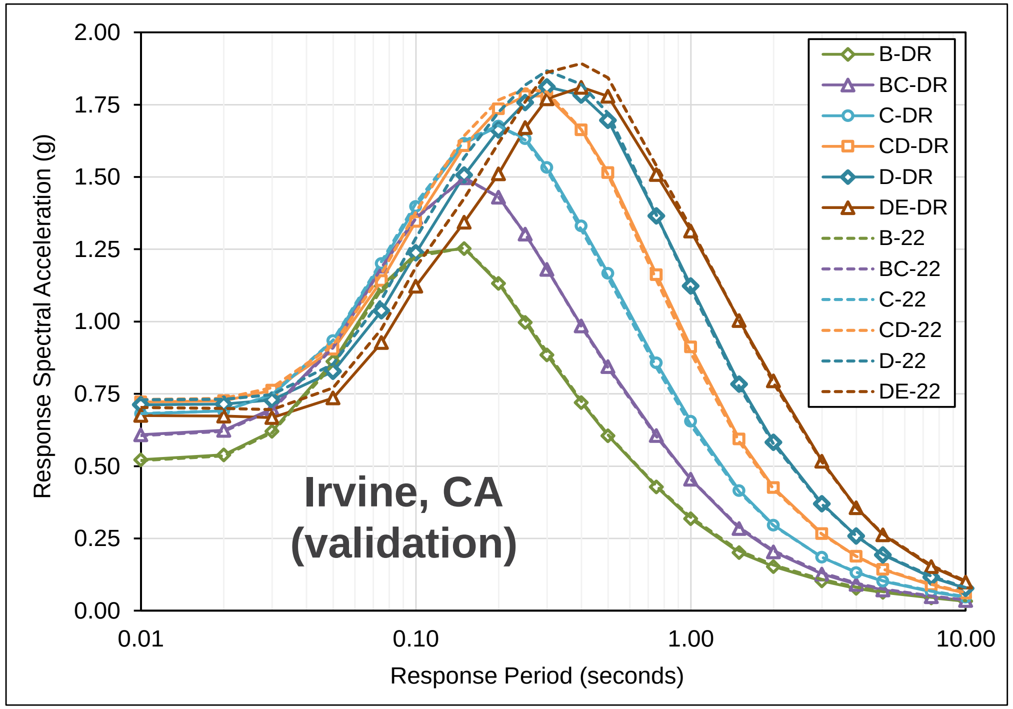


Figure B-17. Plots of probabilistic response spectrum shape parameters (RSSPs) by site class for Table B-17. GTL12S3R2.

Figure citation: Kircher C, Rezaeian S, Luco N – FEMA P-2078 (2020), Procedures for Developing Multi-Period Response Spectra of Non-Conterminous United States Sites. FEMA P-2078, Prepared by ATC for FEMA, Washington, D.C.

Outside of Conterminous US (OCONUS):



Solid Lines: Predicted values from *Ss* & *S1*
Dashed Lines: Exact values calculated for 2020 NEHRP

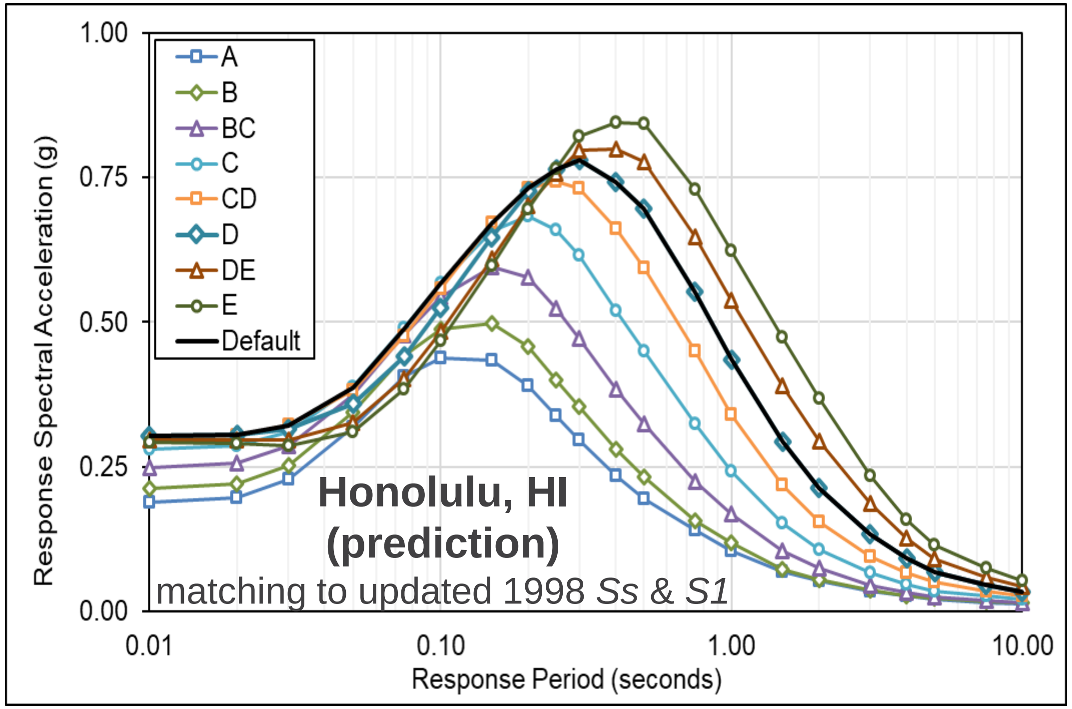


Figure citation: Kircher C, Rezaeian S, Luco N – FEMA P-2078 (2020), Procedures for Developing Multi-Period Response Spectra of Non-Conterminous United States Sites. FEMA P-2078, Prepared by ATC for FEMA, Washington, D.C.

Summary:

- The Multi-Period-Response-Spectra requirement of the BSSC PUC influenced the 2018 update of USGS NSHM because GMMs needed to be applicable for 22 periods and 8 site classes

- The 2018 USGS NSHM updates included: (1) new GMMs in CEUS (14 updated seeds + 17 NGA-East + new site-effects model), (2) incorporation of deep basin effects in WUS, (3) removal of one crustal and one subduction GMM and minor modifications in WUS, and (4) update of seismicity catalog.

1. *Petersen et al. (Feb 2020), Earthquake Spectra* (Overview paper)
2. *Petersen et al. (Dec 2020 online), Earthquake Spectra* (sensitivity analysis)
3. *Shumway et al. (Dec 2020 online), Earthquake Spectra* (data paper on added Ts and Vs30s)
4. *Rezaeian et al. (2021 in press), Earthquake Spectra* (CEUS GMM details)
5. *Powers et al. (2021 in press), Earthquake Spectra* (WUS and basin effect details)

Questions?

srezaeian@usgs.gov

- Generic spectral shapes used for OCONUS locations in 2020 NEHRP *(FEMA P-2078 / ATC 136)*

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DISSECTION OF EXAMPLE CHANGES TO THE MCE_R GROUND MOTION VALUES

Nicolas Luco, Ph.D., U.S. Geological Survey

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Commentary to Chapter 22

- Modifications to MCE_R and MCE_G ground motions from Project ’17 recommendations
- Modifications to MCE_R and MCE_G ground motions from 2018 USGS NSHM update
- Examples of changes in MCE_R and MCE_G values
- RISK-TARGETED MAXIMUM CONSIDERED EARTHQUAKE (MCE_R) SPECTRAL RESPONSE ACCELERATIONS
- MAXIMUM CONSIDERED EARTHQUAKE GEOMETRIC MEAN (MCE_G) PEAK GROUND ACCELERATIONS
- LONG-PERIOD TRANSITION MAPS
- USGS SEISMIC DESIGN GEODATABASE AND WEB SERVICE

USGS 2018 NSHM Updates

(NSHM = National Seismic Hazard Model)

Incorporation of ...

1) the NGA-East ground-motion models *
2) deep sedimentary basin effects in the Los Angeles, Seattle, San Francisco, and Salt Lake City regions *
3) earthquakes that occurred in 2013 through 2017
4) updated weighting of the western U.S. ground-motion models

* see Rezaeian's presentation

BSSC Project '17 Recommendations

Modifications to …

1) site-class effects *
2) spectral periods that define the S_{MS} & S_{M1} ground-motion parameters *
3) deterministic caps on the otherwise probabilistic ground motions
4) maximum-direction scale factors

* see Kircher's presentation

Maximum-Direction Scale Factors

RESOURCE PAPER 4
UPDATED MAXIMUM-RESPONSE SCALE FACTORS

RP4-1 UPDATED MAXIMUM-RESPONSE SCALE FACTORS

The proposed changes below update the "maximum-response scale factors" specified in the site-specific ground motion procedures (Chapter 21) of ASCE/SEI 7-10. These factors increase spectral response accelerations that represent the geometric mean (or a similar metric) of two horizontal ground motion components, such that they represent the maximum response in the horizontal plane. Recall that ASCE/SEI 7-10, via both Chapter 21 and the MCE_R ground motion maps, specifies maximum-response spectral response accelerations. Typical ground motion attenuation relations, including those applied by the USGS in preparing the MCE_R ground motion maps, provide geometric-mean spectral response accelerations.

Maximum-Direction Scale Factors

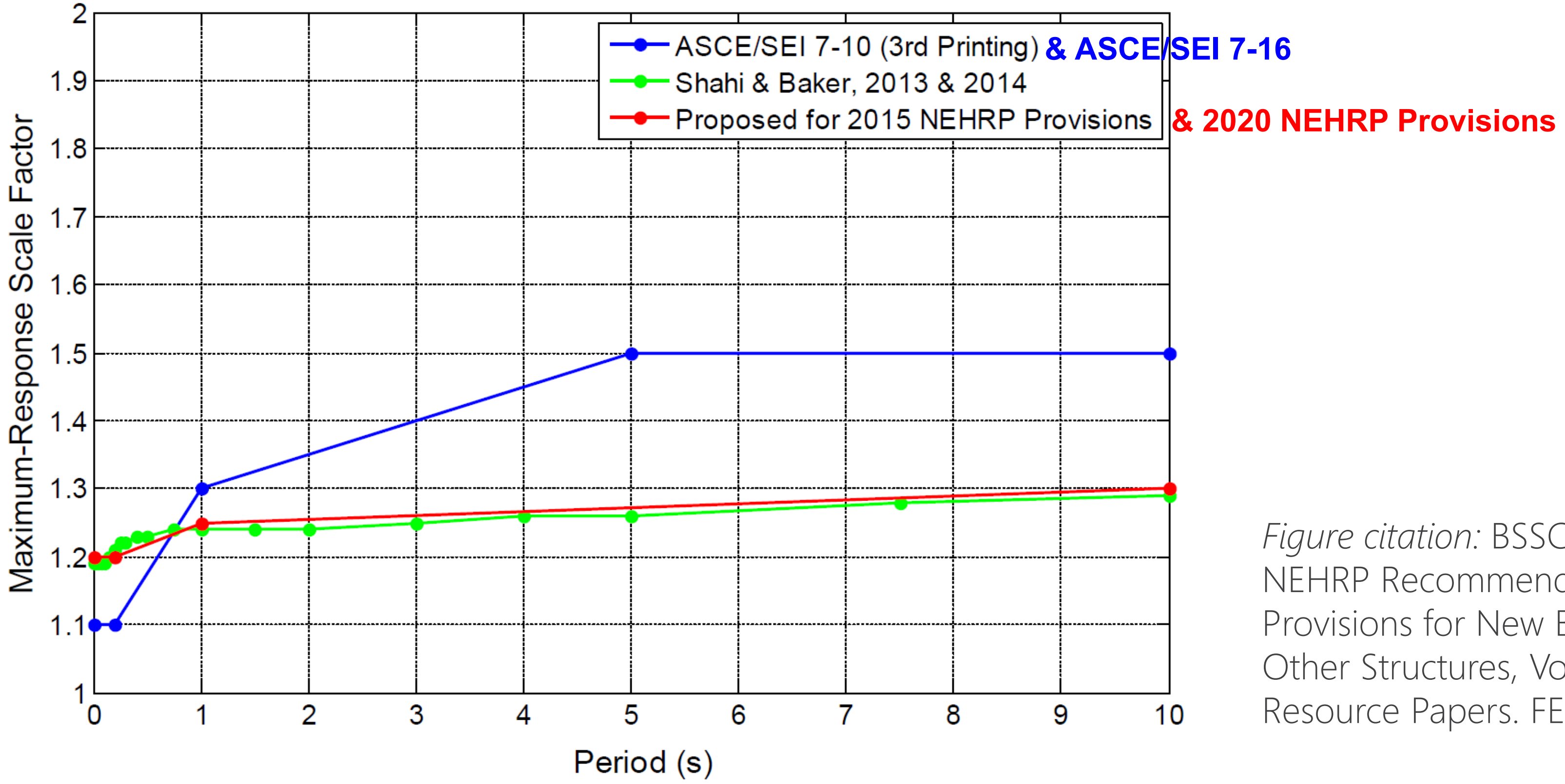

Figure citation: BSSC, 2015. NEHRP Recommended Seismic Provisions for New Buildings and Other Structures, Volume II: Part 3 Resource Papers. FEMA P-1050-2.

Deterministic Caps

21.2.2 Deterministic (MCE_R) Ground Motions

The deterministic spectral response acceleration at each period shall be calculated as an 84th-percentile 5% damped spectral response acceleration in the direction of maximum horizontal response computed at that period. The largest such acceleration calculated for ~~the characteristic~~ scenario earthquakes on all known ~~active~~ faults within the region shall be used. The scenario earthquakes shall be determined from deaggregation for the probabilistic spectral response acceleration at each period. Scenario earthquakes contributing less than 10% of the largest contributor at each period shall be ignored.

Deterministic Caps

Table C21.2.2-1 Examples of scenario earthquake from hazard deaggregations at a site in San Jose, California

Period T (s)	Scenario Earthquake							
	Hayward		Calaveras		San Andreas		Silver Creek	
	M	Contribution	M	Contribution	M	Contribution	M	Contribution
0.20	7.0	53%	7.2	16%	7.9	11%	6.9	3%
0.25	7.0	52%	7.2	16%	7.9	12%	6.9	3%
0.30	7.0	52%	7.2	16%	7.9	13%	6.9	3%
0.40	7.0	52%	7.2	16%	7.9	15%	7.0	3%
0.50	7.0	51%	7.3	16%	7.9	16%	7.0	3%
0.75	7.1	49%	7.3	16%	7.9	19%	7.0	3%
1.0	7.1	48%	7.3	16%	7.9	20%	7.1	2%

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Examples of Changes in MCE_R Values

2009 NEHRP Recommended Seismic Provisions

Table C11.4-1 Thirty-Four Cities, Site Locations (Latitude and Longitude), and Associated Counties and Populations At Risk for Which Values of Ground Motions Are Provided

Region	City and Location of Site				
	Name	Latitude	Longitude		
Southern California	Los Angeles	34.05	-118.25		
	Century City	34.05	-118.40		
	Northridge	34.20	-118.55		
	Long Beach	33.80	-118.20		
	Irvine	33.65	-117.80		
	Riverside	33.95	-117.40		
	San Bernardino	34.10	-117.30		
	San Luis Obispo	35.30	-120.65		
	San Diego	32.70	-117.15		
	Santa Barbara	34.45	-119.70		
	Ventura	34.30	-119.30		
	Total Population - S. California		22,349,098		
Northern California	Oakland	37.80	-122.25	Alameda	1,502,759
	Concord	37.95	-122.00	Contra Costa	955,810
	Monterey	36.60	-121.90	Monterey	421,333
	Sacramento	38.60	-121.50	Sacramento	1,233,449
	San Francisco	37.75	-122.40	San Francisco	776,733
	San Mateo	37.55	-122.30	San Mateo	741,444
	San Jose	37.35	-121.90	Santa Clara	1,802,328
	Santa Cruz	36.95	-122.05	Santa Cruz	275,359
	Vallejo	38.10	-122.25	Solano	423,473
	Santa Rosa	38.45	-122.70	Sonoma	489,290
	Total Population - N. California		14,108,451	Population - 10 Counties	8,621,978
Pacific Northwest	Seattle	47.60	-122.30	King WA	1,826,732
	Tacoma	47.25	-122.45	Pierce WA	766,878
	Everett	48.00	-122.20	Snohomish WA	669,887
	Portland	45.50	-122.65	Portland Metro OR (3)	1,523,690
	Total Population - OR and WA		10,096,556	Population - 6 Counties	4,787,187
Other WUS	Salt Lake City	40.75	-111.90	Salt Lake UT	978,701
	Boise	43.60	-116.20	Ada/Canyon ID (2)	532,337
	Reno	39.55	-119.80	Washoe NV	396,428
	Las Vegas	36.20	-115.15	Clarke NV	1,777,539
	Total Population - ID/UT/NV		6,512,057	Population - 5 Counties	3,685,005
CEUS	St. Louis	38.60	-90.20	St. Louis MSA (16)	2,786,728
	Memphis	35.15	-90.05	Memphis MSA (8)	1,269,108
	Charleston	32.80	-79.95	Charleston MSA (3)	603,178
	Chicago	41.85	-87.65	Chicago MSA (7)	9,505,748
	New York	40.75	-74.00	New York MSA (23)	18,747,320
	Total Population - MO/TN/SC/IL/NY		48,340,918	Population - 57 Counties	32,912,082

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Examples of Changes in MCE_R Values

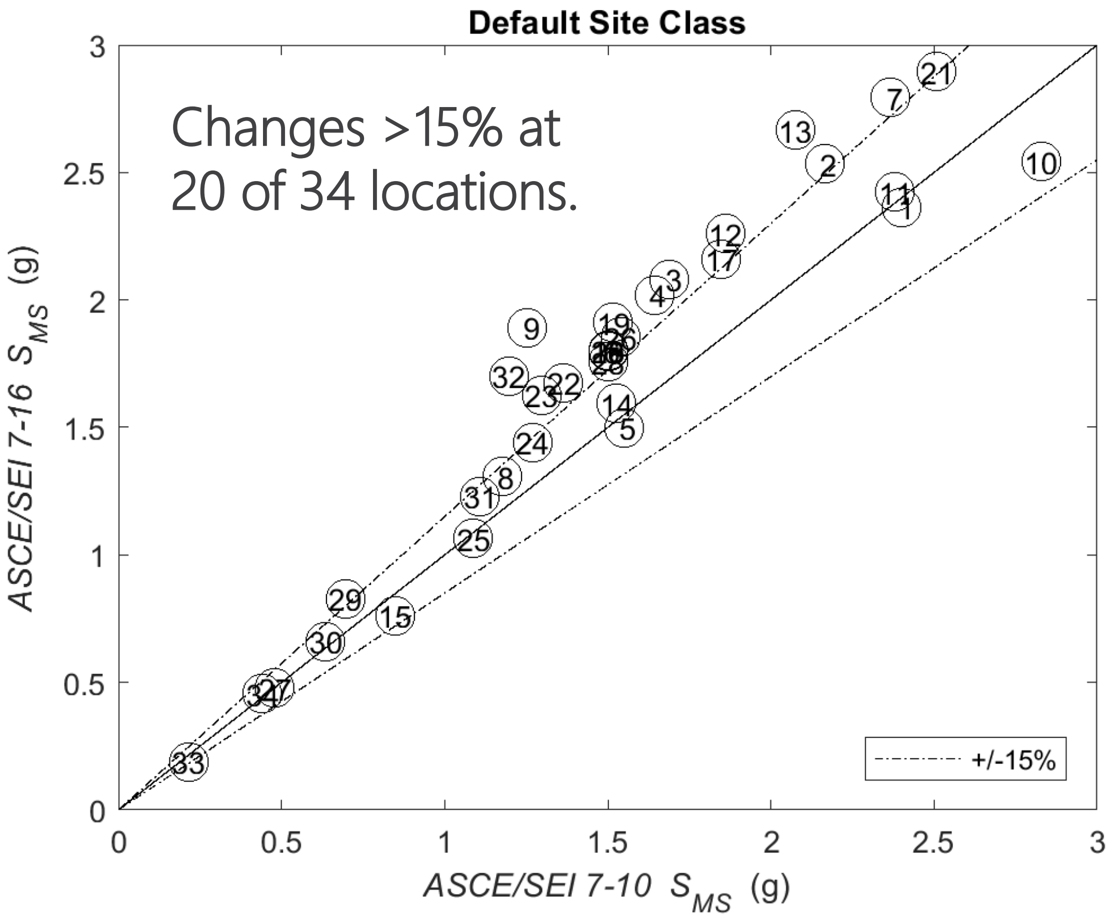
2020 NEHRP Provisions

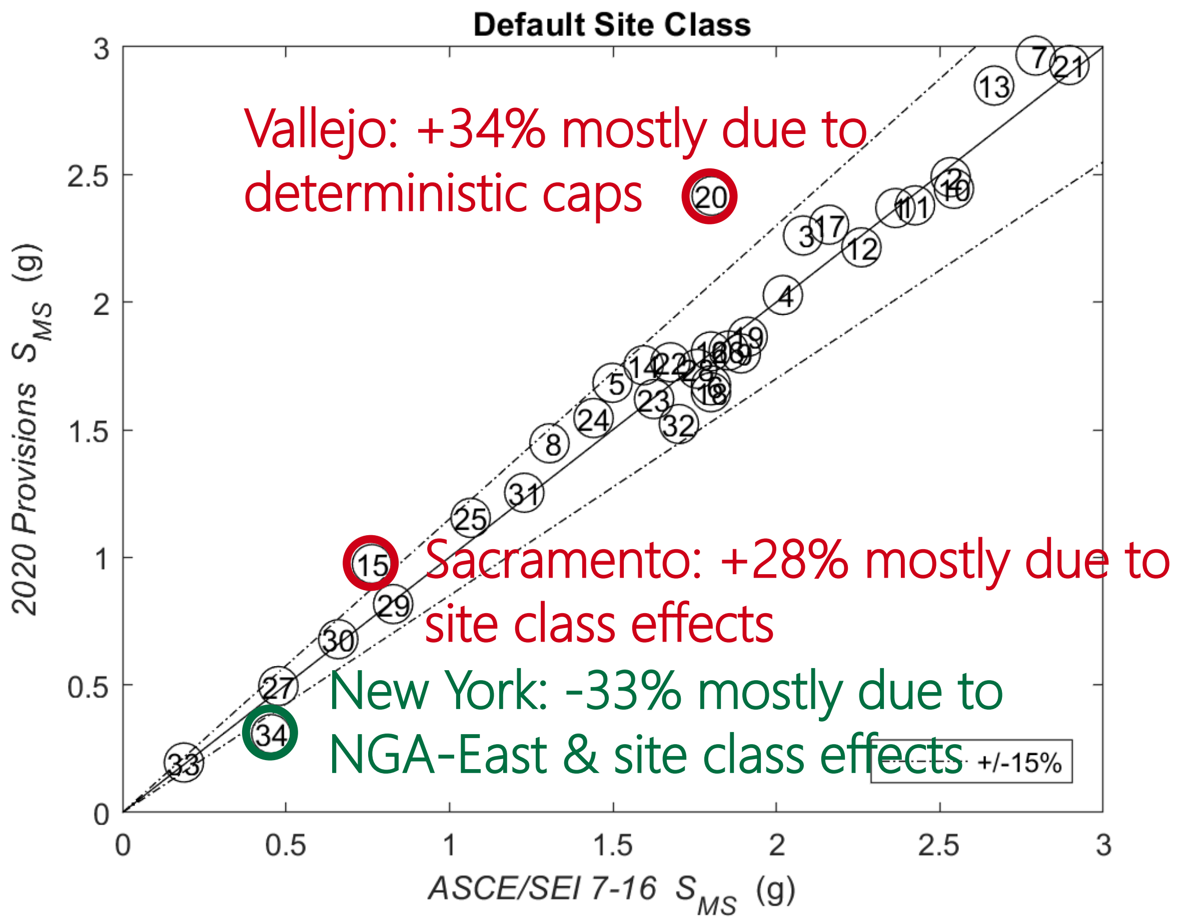
Table C22-3 Comparison of short-period MCE_R spectral response acceleration values from these *Provisions*, *ASCE/SEI 7-16*, and *ASCE/SEI 7-10*. The S_{MS} values are for the default site class.

	ASCE/SEI 7-10		*ASCE/SEI 7-16*		*2020 Provisions*	
Location Name	S_S (g)	S_{MS} (g)	S_S (g)	S_{MS} (g)	S_S (g)	S_{MS} (g)
Los Angeles, CA	2.40	2.40	1.97	2.36	2.25	2.37
Century City, CA	2.17	2.17	2.11	2.53	2.37	2.49
Northridge, CA	1.69	1.69	1.74	2.08	2.09	2.26
Long Beach, CA	1.64	1.64	1.68	2.02	1.90	2.03
Irvine, CA	1.55	1.55	1.25	1.50	1.43	1.68
Riverside, CA	1.50	1.50	1.50	1.80	1.50	1.67
San Bernardino, CA	2.37	2.37	2.33	2.79	2.78	2.97
San Luis Obispo, CA	1.12	1.18	1.09	1.31	1.23	1.45
San Diego, CA	1.25	1.25	1.58	1.89	1.74	1.80
Santa Barbara, CA	2.83	2.83	2.12	2.54	2.37	2.44
Ventura, CA	2.38	2.38	2.02	2.42	2.25	2.38

Examples of Changes in MCE_R Values

Figure citation: BSSC, 2015. NEHRP Recommended Seismic Provisions for New Buildings and Other Structures, Volume II: Part 3 Resource Papers. FEMA P-1050-2.





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Examples of Changes in MCE_R Values

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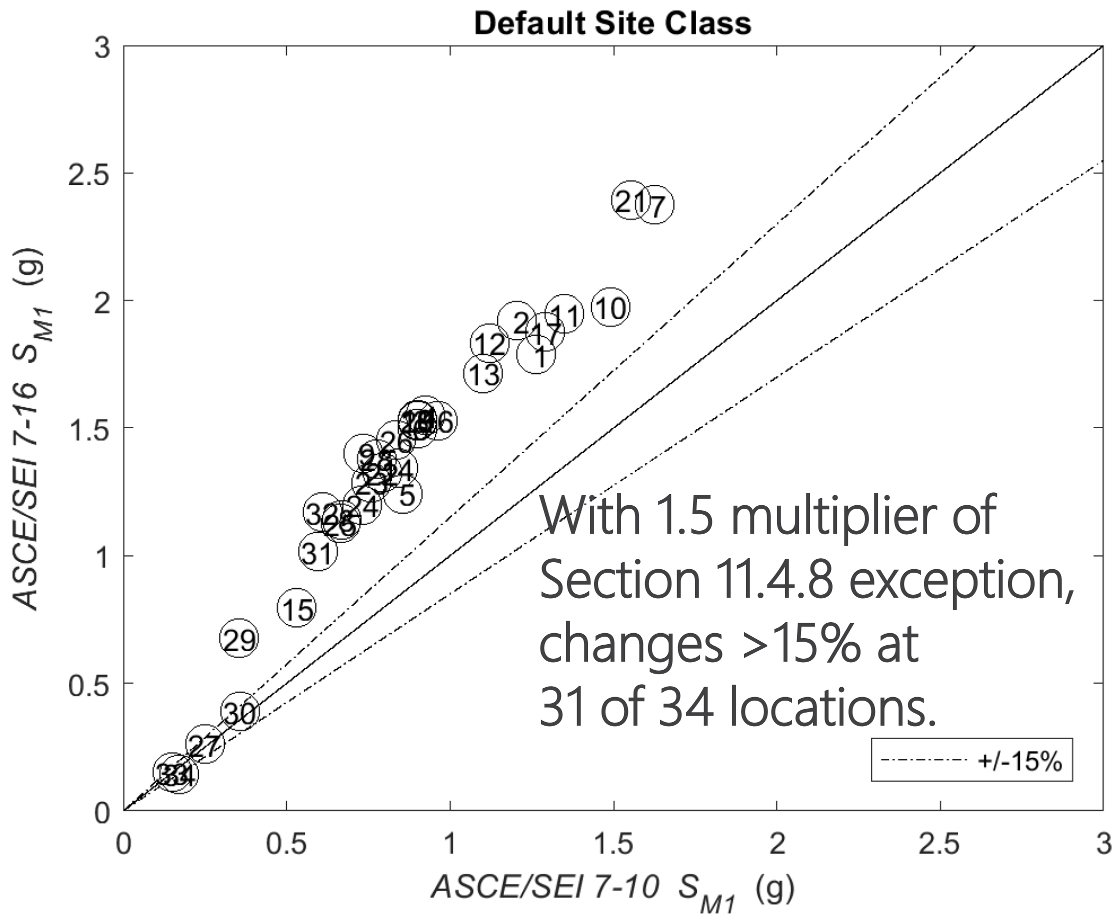

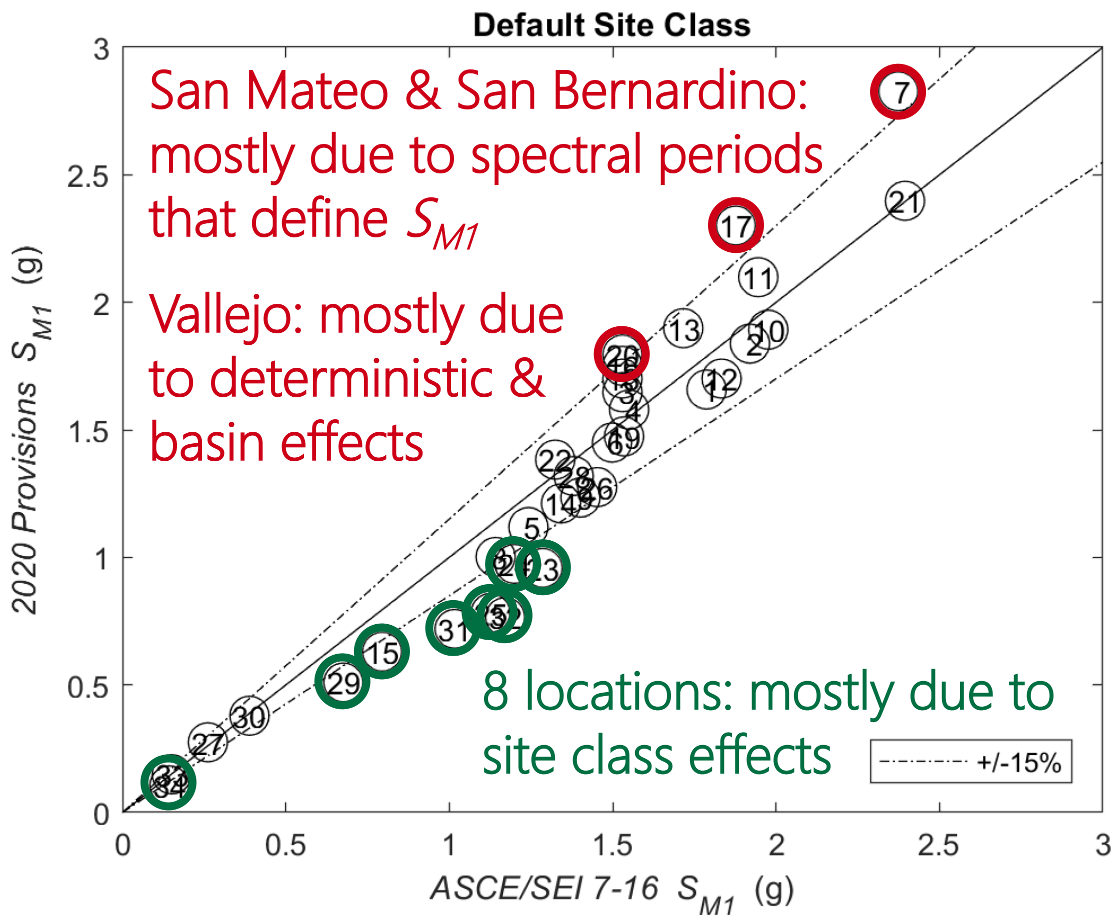

Examples of Changes in SDC

From *ASCE 7-10* to *ASCE 7-16*, SDC decreases at 2 of 34 locations, from E to D.

From *ASCE 7-16* to *2020 Provisions*, SDC increases at 4 of 34 locations, from D to E, mostly due to deterministic capping and basin effects.

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5g.

	ASCE/SEI 7-10		*ASCE/SEI 7-16*		*2020 Provisions*	
Location Name	**"SDC_S"**	**SDC**	**"SDC_S"**	**SDC**	**"SDC_S"**	**SDC**
Los Angeles, CA	N/A	E	D	D	D	D
Century City, CA	N/A	E	N/A	E	N/A	E
Northridge, CA	D	D	D	D	D	D
Long Beach, CA	D	D	D	D	N/A	E
Irvine, CA	D	D	D	D	D	D
Riverside, CA	D	D	D	D	D	D
San Bernardino, CA	N/A	E	N/A	E	N/A	E
San Luis Obispo, CA	D	D	D	D	D	D
San Diego, CA	D	D	D	D	D	D
Santa Barbara, CA	N/A	E	N/A	E	N/A	E
Ventura, CA	N/A	E	N/A	E	N/A	E

Examples of Changes in SDC

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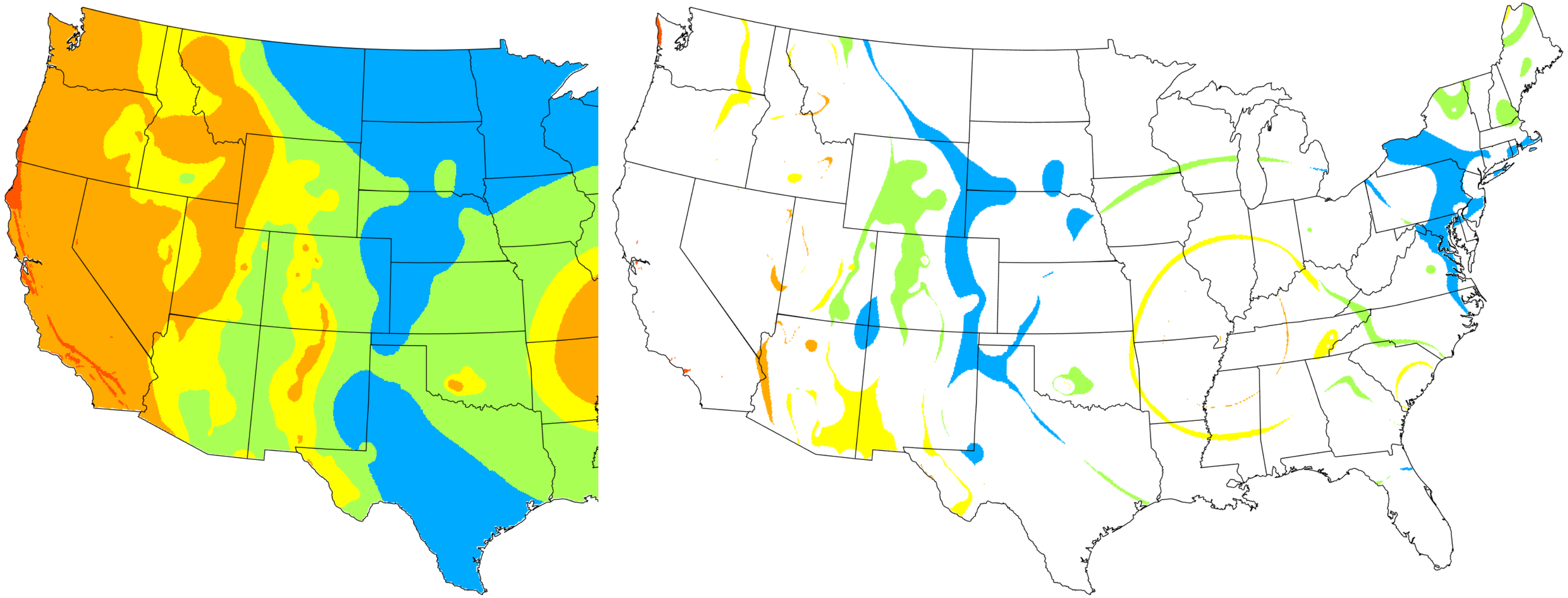
ASCE/SEI 7-16 | where different | *2020 Provisions*



Summary of Changes in MCE_R Values

For the default site conditions …

- S_{MS} changes by less than 15% at 31 of the 34 locations;
- S_{M1} changes by less than 15% at 23 of the 34 locations;
- SDC changes at 4 of the 34 locations, from SDC D to E;
- Most of these changes are due to the Project '17 modifications to site-class effects or deterministic caps, but some are caused by the other Project '17 and 2018 NSHM updates, particularly the 2018 NSHM incorporation of basin effects.

Changes for other site classes at other locations can be probed using the *USGS Seismic Design Web Services* and *BSSC Tool for Seismic Design Map Values*.

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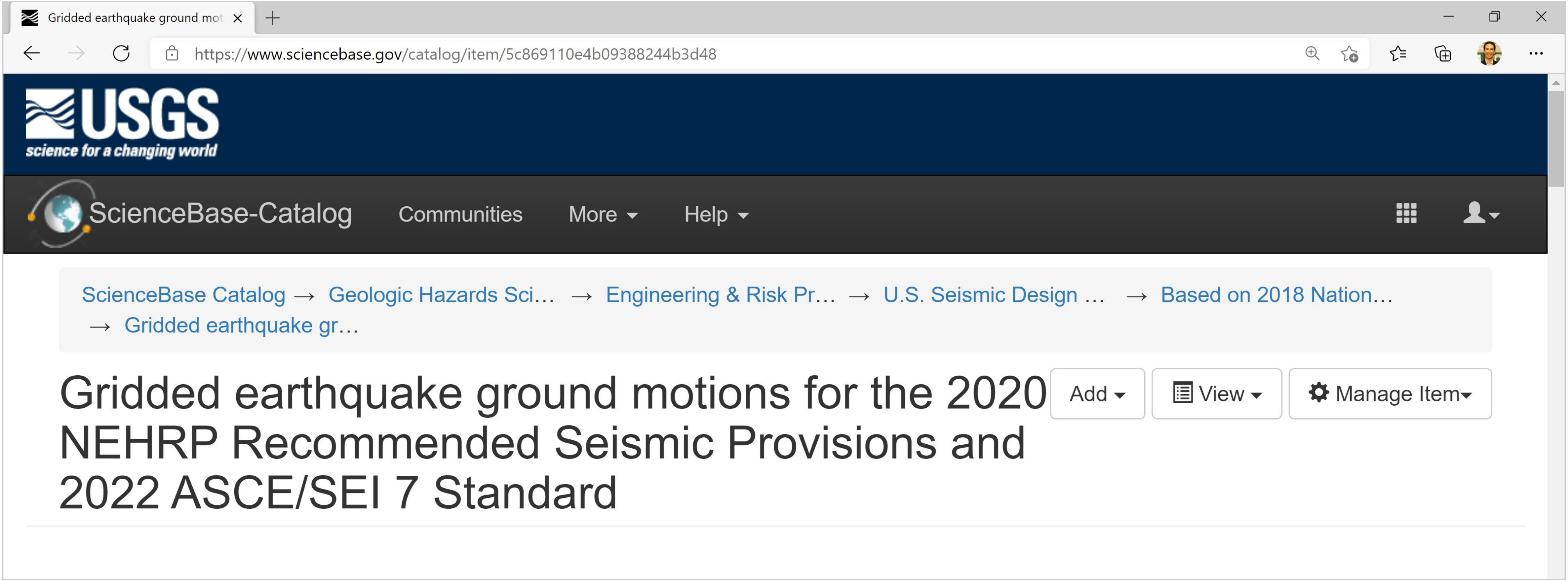
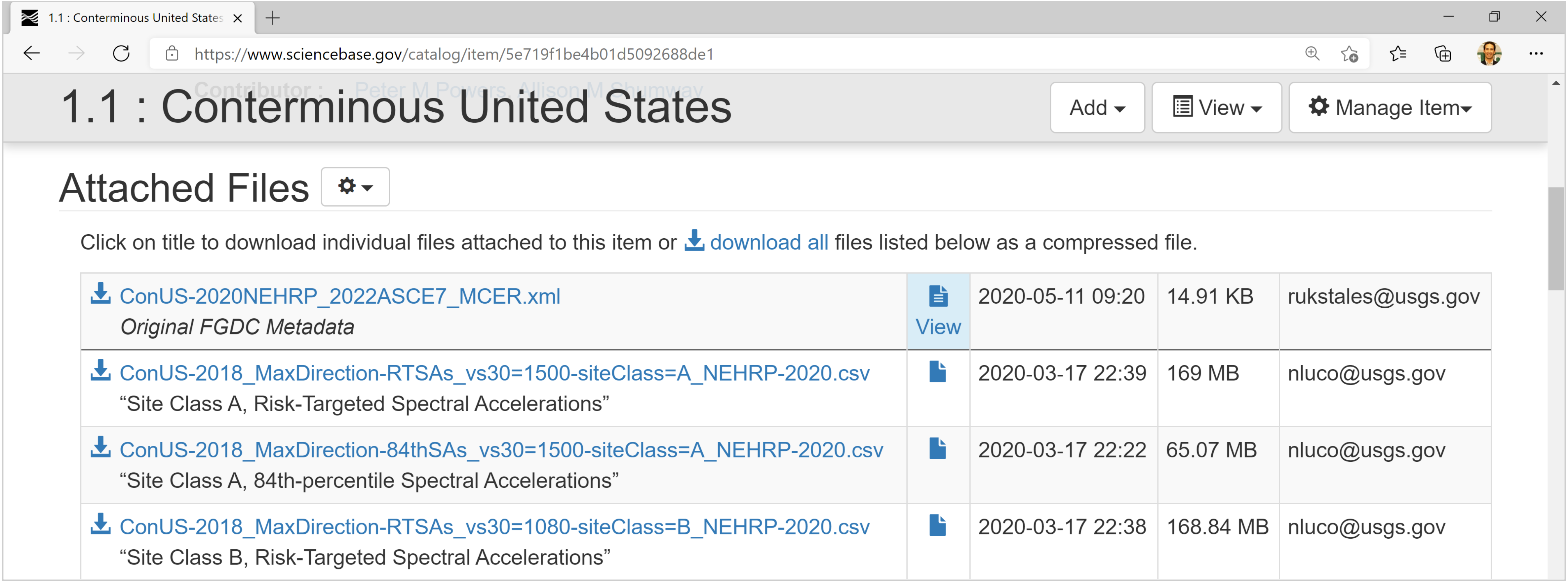
USGS Seismic Design Geodatabase



USGS Seismic Design Geodatabase



1.1 : Conterminous United States

https://www.sciencebase.gov/catalog/item/5e719f1be4b01d5092688de1

Contributor : Peter M Powers, Allison M Shumway

1.1 : Conterminous United States

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Attached Files

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ConUS-2020NEHRP_2022ASCE7_MCER.xml *Original FGDC Metadata*	View	2020-05-11 09:20	14.91 KB	rukstales@usgs.gov
ConUS-2018_MaxDirection-RTSAs_vs30=1500-siteClass=A_NEHRP-2020.csv "Site Class A, Risk-Targeted Spectral Accelerations"		2020-03-17 22:39	169 MB	nluco@usgs.gov
ConUS-2018_MaxDirection-84thSAs_vs30=1500-siteClass=A_NEHRP-2020.csv "Site Class A, 84th-percentile Spectral Accelerations"		2020-03-17 22:22	65.07 MB	nluco@usgs.gov
ConUS-2018_MaxDirection-RTSAs_vs30=1080-siteClass=B_NEHRP-2020.csv "Site Class B, Risk-Targeted Spectral Accelerations"		2020-03-17 22:38	168.84 MB	nluco@usgs.gov

USGS Seismic Design Web Service

NEHRP-2020 Web Service Docun

https://earthquake.usgs.gov/ws/designmaps/nehrp-2020.html

NEHRP-2020 Web Service Documentation

latitude

Latitude of site of interest, in decimal degrees

Example: `34.05`

longitude

Longitude of site of interest, in decimal degrees

Example: `-118.25`

siteClass

Site Class, as defined in Chapter 20

Options: `Default, A, B, BC, C, CD, D, DE, E`

USGS Seismic Design Web Service

https://earthquake.usgs.gov/ws/

https://earthquake.usgs.gov/ws/designmaps/nehrp-2020.json?latitude=34&longitude=-118&riskCategory=III&siteClass=C&title=Example


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    "sm1": 1.05,
    "sds": 1.46,
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        0.05,
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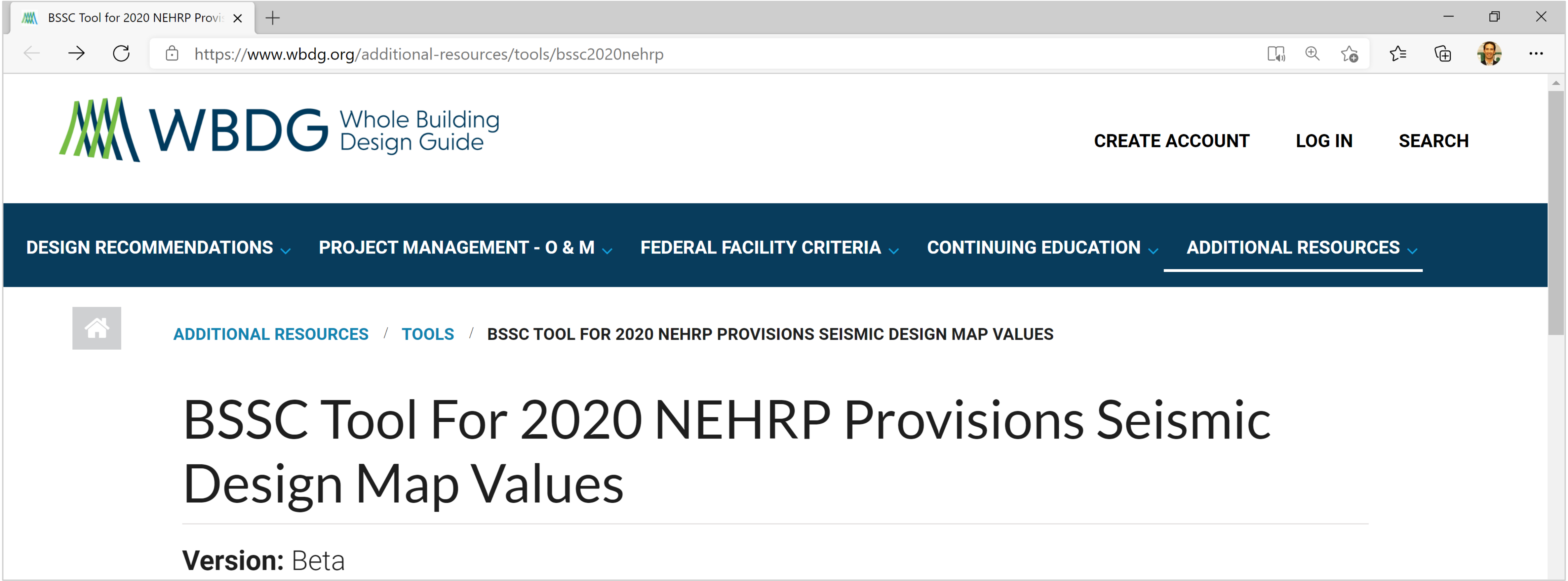
```

BSSC Tool for Seismic Design Map Values

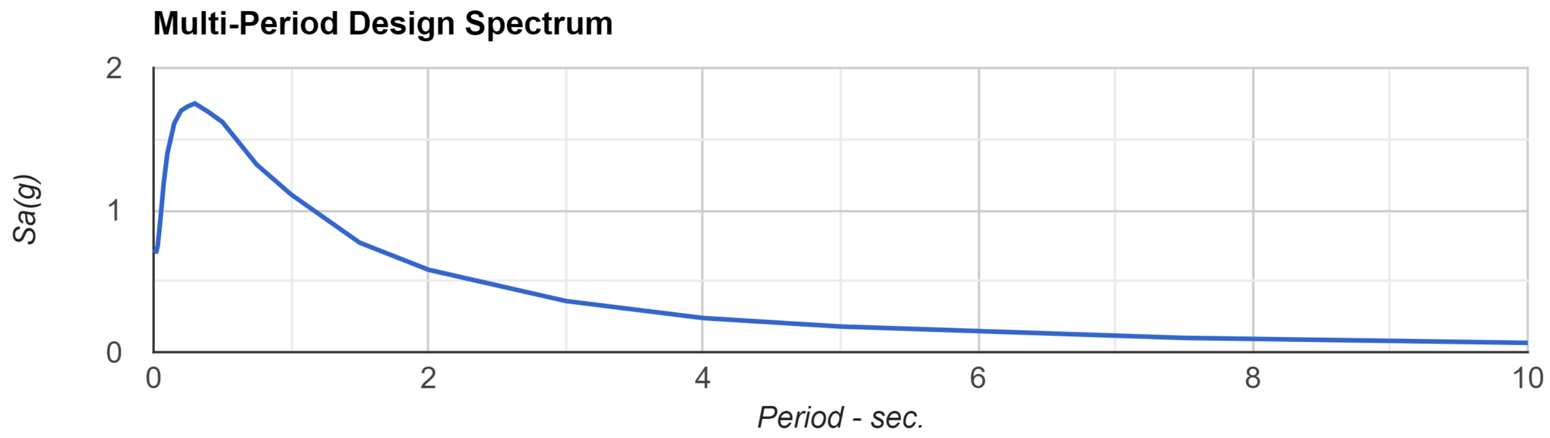


BSSC Tool for Seismic Design Map Values

BSSC Tool for 2020 NEHRP Provi

https://www.wbdg.org/additional-resources/tools/bssc-2020-nehrp

PGA_M	S_{MS}	S_{M1}	S_{DS}	S_{D1}	T_L	S_S	S_1	SDC	V_{S30} (m/s)
0.94	2.37	1.66	1.58	1.11	8	2.25	0.72	D	260



https://doi.org/10.5066/F7NK3C76

USGS Earthquake Hazards

https://sites.google.com/site/seismicdesignmaps/

USGS Earthquake Hazards

2020 NEHRP Provisions (NEHRP-2020)

Web Interface: BSSC Tool for 2020 NEHRP Provisions Seismic Design Maps Values

Web Service (source of data for Web Interface): "USGS Seismic Design Web Service" for NEHRP-2020

Maps (in document): See 2020 NEHRP Recommended Seismic Provisions for New Buildings and Other Structures

Maps (online only): USGS Online-only maps referenced by the 2020 NEHRP Recommended Seismic Provisions and 2022 ASCE/SEI 7 Standard *(preview one example)*

Data: "USGS Seismic Design Geodatabse" for NEHRP-2020 *(currently requires sign up)*