Chapter 3 (Section 3.3) New Multi-Period Response Spectra and Ground Motion Requirements

2020 NEHRP Provisions Training Materials

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1

Design (As Usual) Using New MPRS

- 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)
- 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)

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2

New Multi-Period Response Spectra (MPRS)

- 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/SEI 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

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3

Summary of MPRS and Related Changes (to ASCE/SEI 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/SEI 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*

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4

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

- 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

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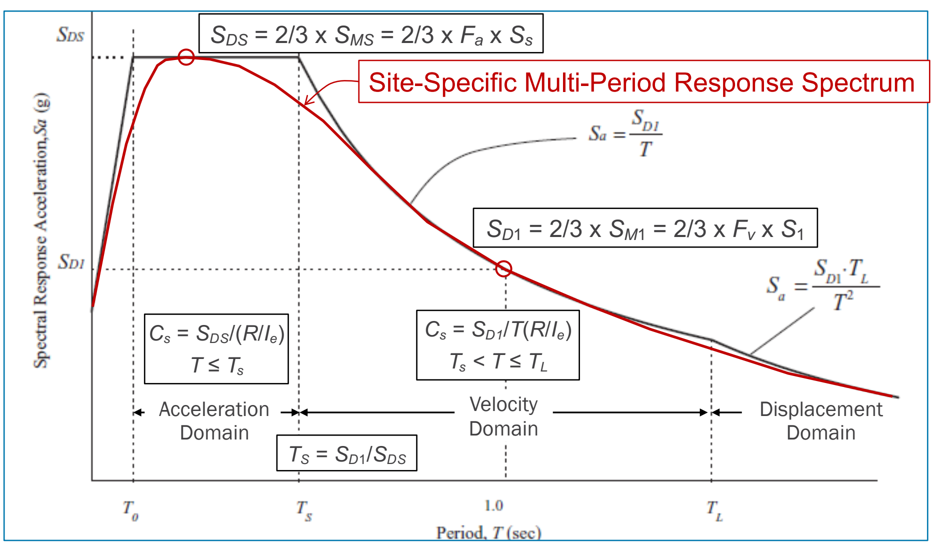
5

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

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



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6

The "Problem" with ASCE/SEI 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)

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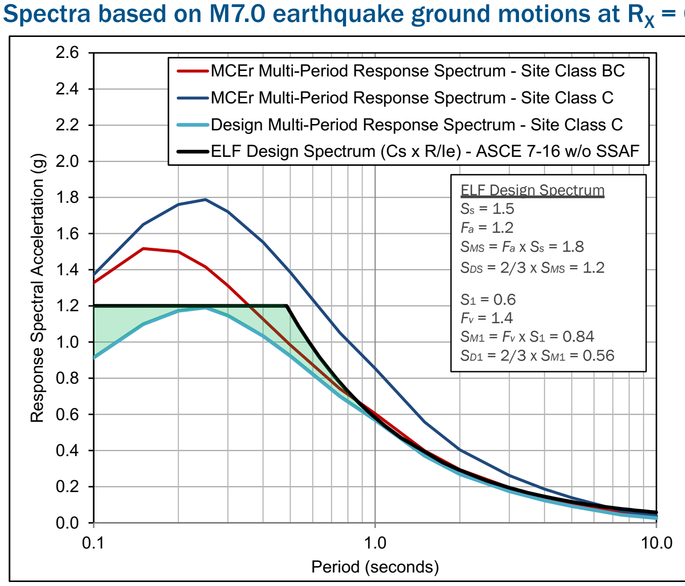
7

Comparison of ASCE/SEI 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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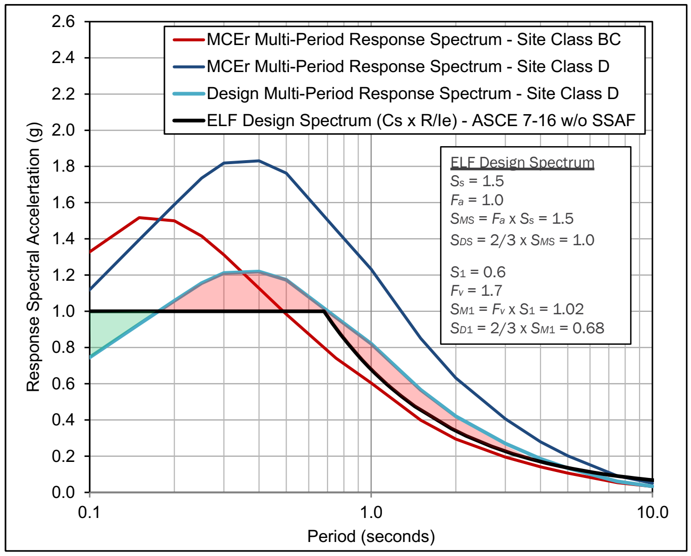
8

Comparison of ASCE/SEI 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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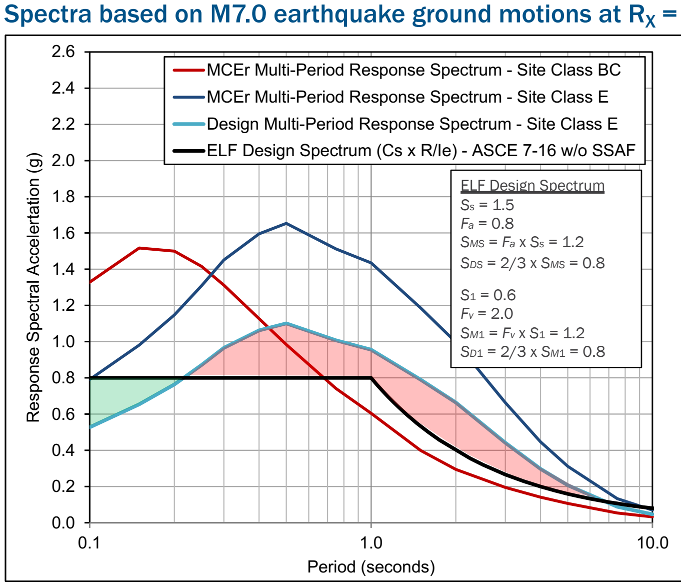
9

9

Comparison of ASCE/SEI 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



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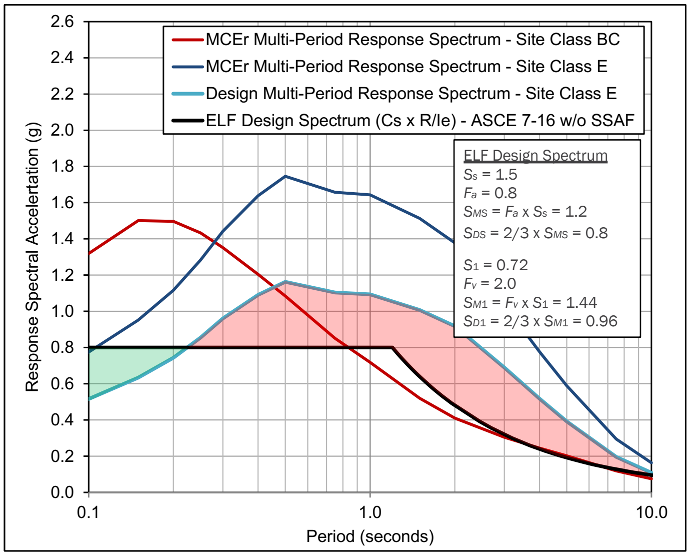
10

10

Comparison of ASCE/SEI 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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11

11

Interim Solution of ASCE/SEI 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

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12

12

Site-Specific Requirements of Section 11.4.7 of ASCE/SEI 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>

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13

13

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

- 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>

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14

14

Conterminous United States Regions with $S_1 \geq 0.2g$ (ASCE/SEI 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)

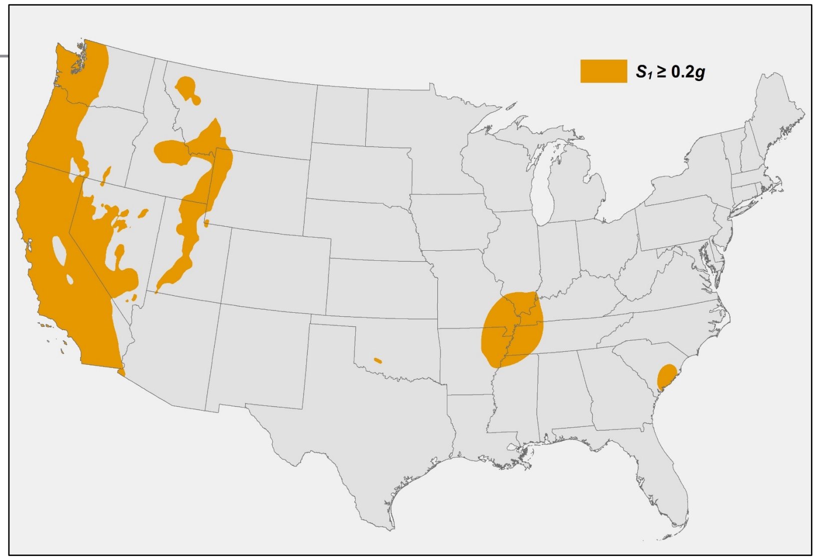

Image source: USGS

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Long-Term Solution - Multi-Period Response Spectra (MPRS) (2020 *NEHRP Provisions* and ASCE/SEI 7-22)

- Define MCE_R and 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_{DS} and S_{D1}) 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/SEI 7-22) and
  - Other User-friendly providers (e.g., WBDG, ASCE 7 Hazard Tool, etc.)

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MCE_R Ground Motions (Section 21.2)
(Site-specific requirements of the 2020 *NEHRP Provisions* and ASCE/SEI 7-22)

- Probabilistic MCE_R Ground Motions (Section 21.2.1):
  - Risk-Targeted – 1% probability of collapse in 50 years
  - Collapse Fragility – 10% probability of collapse given MCE_R ground motions assuming lognormal standard deviation of 0.6 (Risk Category II)
- (New) Deterministic MCE_R Ground Motions (Section 21.2.2):
  - Scenario-Based – 84th percentile ground motions of the governing source (ignoring sources that contribute less than 10% to site hazard)
  - Derived from probabilistic ground motion hazard
  - Not less than deterministic lower-limit MCE_R Ground Motions
- MCE_R Ground Motions (Section 21.2.3):
  - Lesser of probabilistic MCE_R and deterministic MCE_R ground motions

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17

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/SEI 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.

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18

Multi-Period Response Spectra Format

(example matrix showing the combinations of twenty-two response periods, plus PGA_G, and eight hypothetical 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	5%-Damped Response Spectral Acceleration or PGA by Site Class (g)							
T (s)	**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

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19

19

Multi-Period Response Spectra Format

(example matrix showing the combinations of twenty-two response periods, plus PGA_G, and eight hypothetical 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**
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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
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PGA_G	0.373	0.429	**0.500**	0.552	0.563	0.527	0.461	0.416

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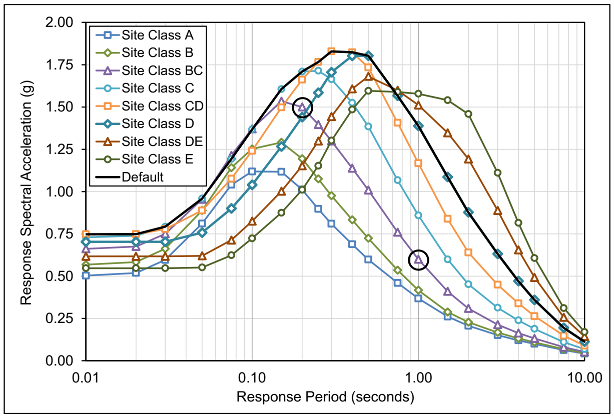
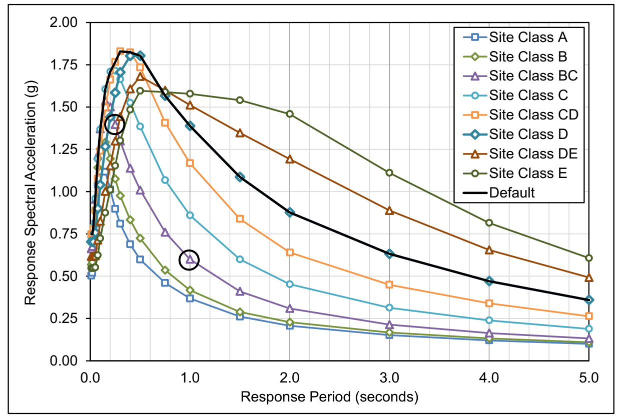
20

20

Example Multi-Period Response Spectra (MPRS)

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





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21

21

Conterminous United States Regions Governed Solely by Probabilistic MCE_R Ground Motions for Default Site Conditions

<u>Non-Orange Shaded Regions (Deterministic MCE_R)</u>

> 90 percent of the area

≈ 10 percent of the risk (AEL, FEMA 366)

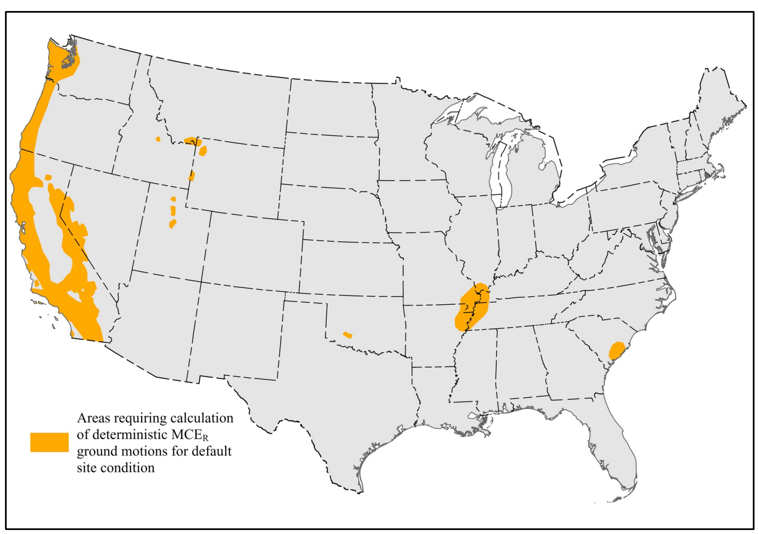

Image source: USGS

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22

22

New 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/SEI 7-22.
2. Center of range (rounded) values used by USGS to develop MPRS.

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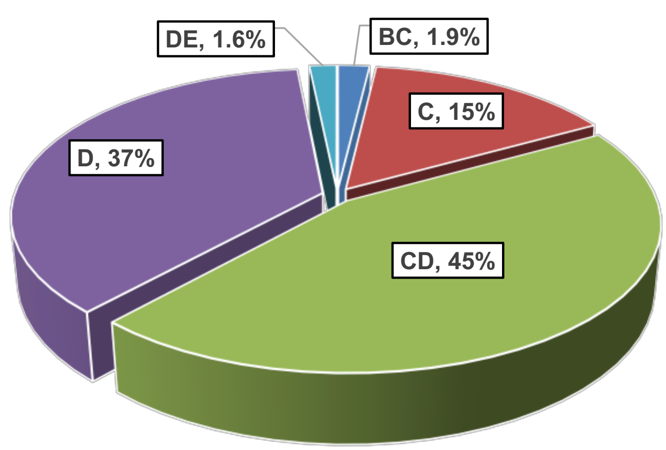
23

23

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

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24

24

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
- "Best Fit" based on site-specific requirements of Section 21.4:
  - S_{DS} based on 90% of peak short-period response (acceleration domain)
  - S_{D1} Based on 90% of peak response in the velocity domain (not less than 100% of 1-second response)

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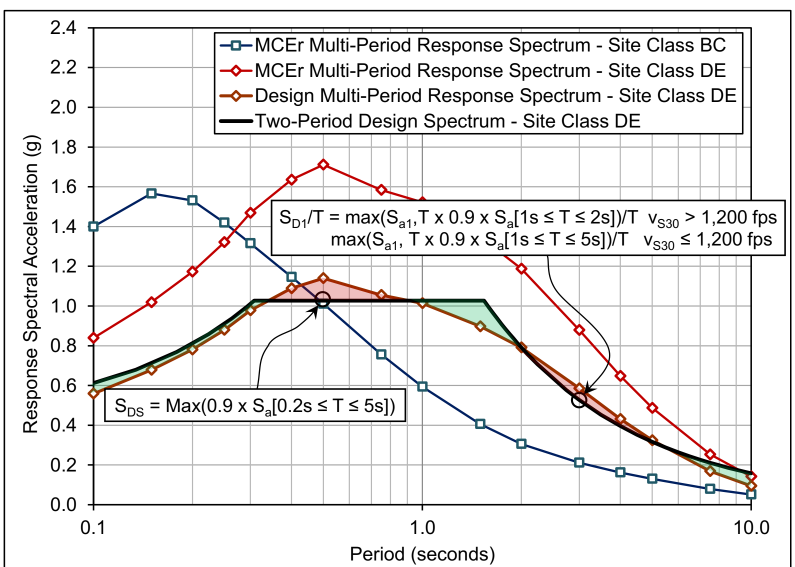
25

Example Derivation of S_{DS} and S_{D1} from a Multi-Period Design Spectrum



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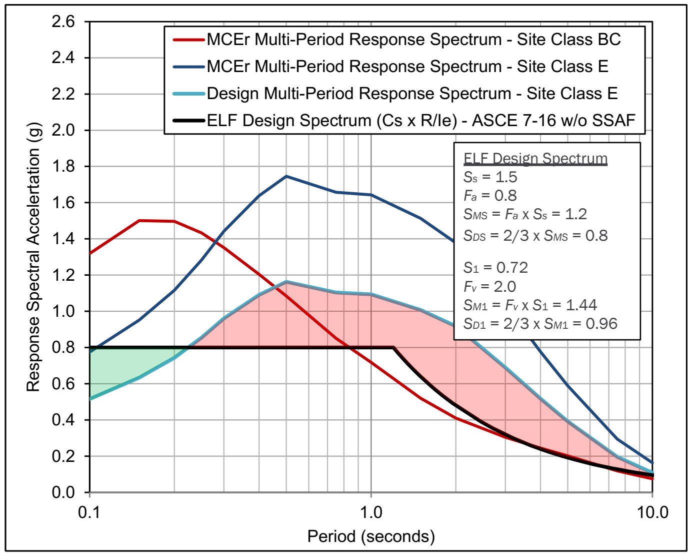
26

Comparison of ASCE/SEI 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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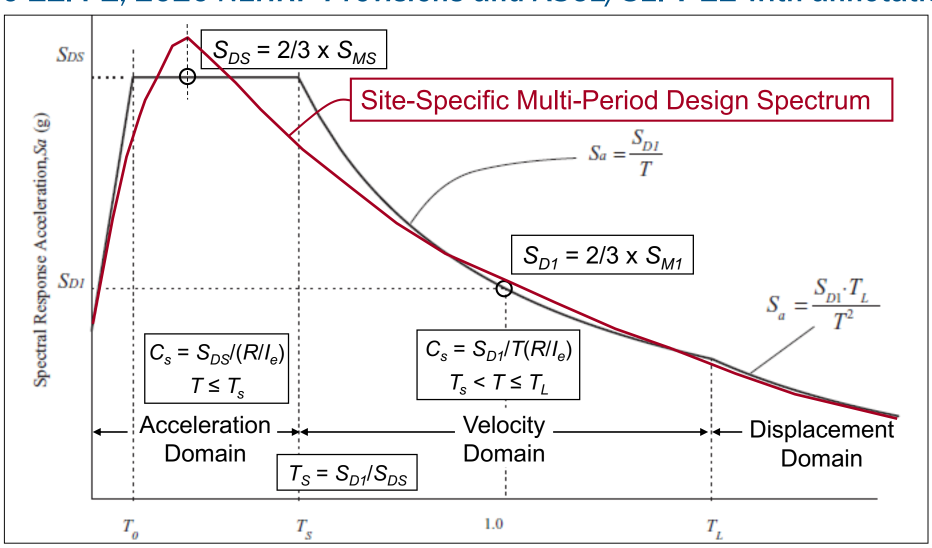
Multi-Period Design Spectrum

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



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Example Comparisons of Design Spectra (default site conditions)

- By Seismic Code Vintage
  - ASCE/SEI 7-10 - Two-period design spectrum
  - ASCE/SEI 7-16 - Two-period design spectrum
  - 2020 *NEHRP Provisions* (ASCE/SEI 7-22) - Multi-period design spectrum
  - 2020 *NEHRP Provisions* (ASCE/SEI 7-22) - Two-period design spectrum (for comparison with two-period spectra of ASCE/SEI 7-10 and ASCE/SEI 7-16)
- By Location
  - Irvine – WUS "probabilistic" site (magnitude M7.0 – M7.5)
  - San Mateo – WUS "deterministic" site (magnitude M7.5 - M8.0)
  - Anchorage – OCONUS "deterministic" site (magnitude M8.0 – M9.0)
  - Memphis – CEUS "probabilistic/deterministic" site (magnitude M7.5 – M8.0)

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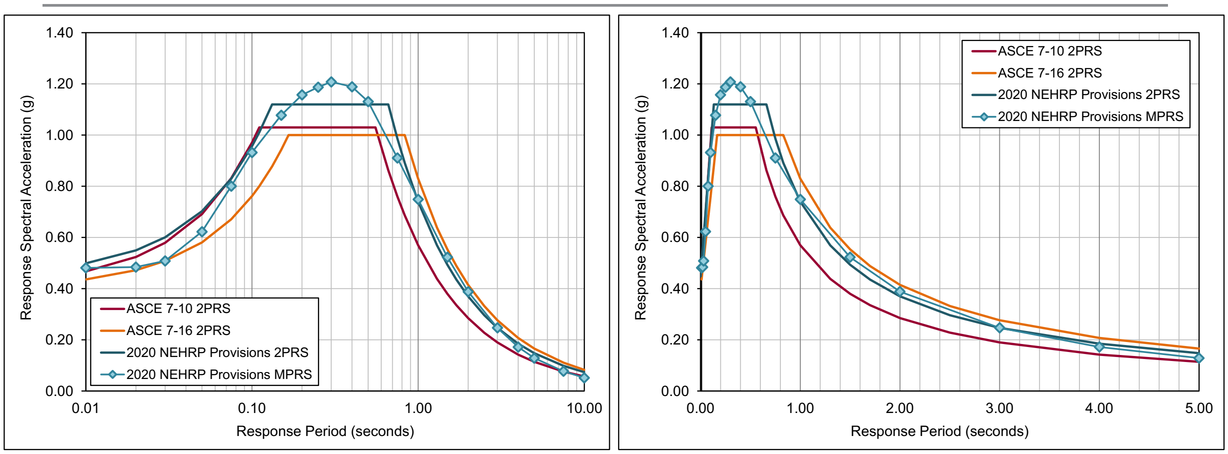
29

29

Comparison of Design Response Spectra – Irvine

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



Velocity domain of the ASCE/SEI 7-16 (2PRS) design spectrum includes the 1.5 multiplier of the applicable Section 11.4.8 exception.

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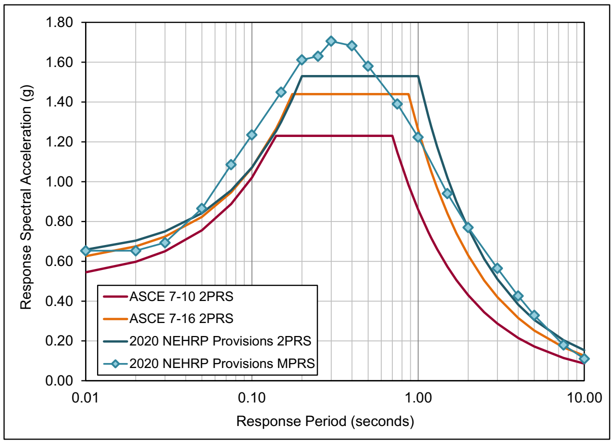
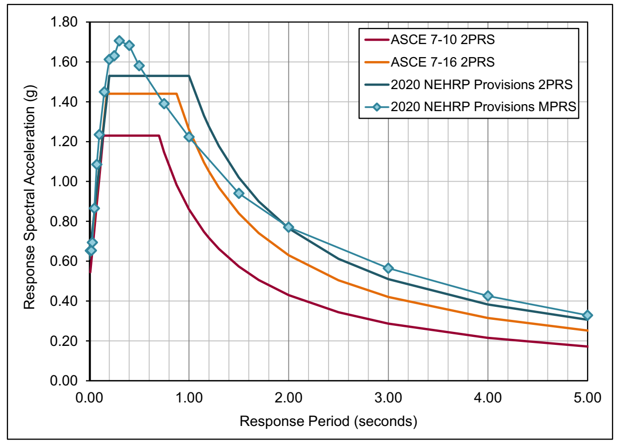
30

30

Comparison of Design Response Spectra – San Mateo

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





Velocity domain of the ASCE/SEI 7-16 (2PRS) design spectrum includes the 1.5 multiplier of the applicable Section 11.4.8 exception.

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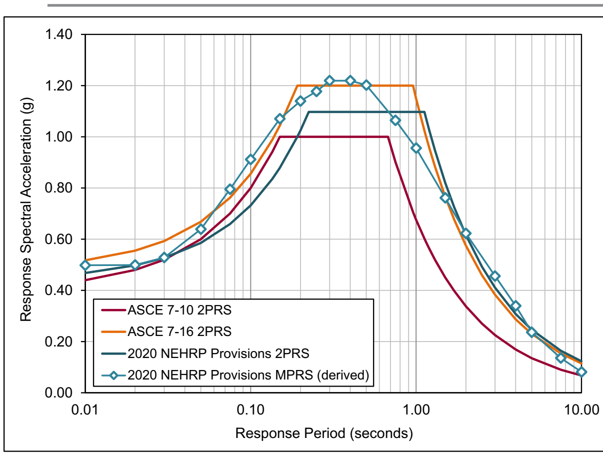
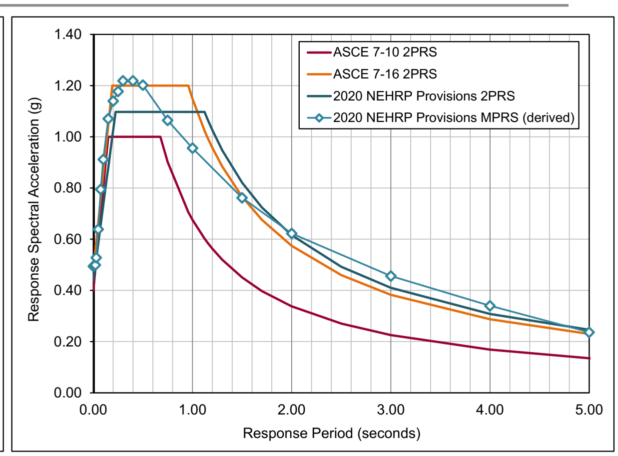
31

31

Comparison of Design Response Spectra – Anchorage

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





Velocity domain of the ASCE/SEI 7-16 (2PRS) design spectrum includes the 1.5 multiplier of the applicable Section 11.4.8 exception.

Derived MPRS based on:
S_S = 1.50 g (deterministic MCE_R floor)
S_1 = 0.65 g (deterministic MCE_R)
T_L = 16 s (M = 8.0 – 8.5)

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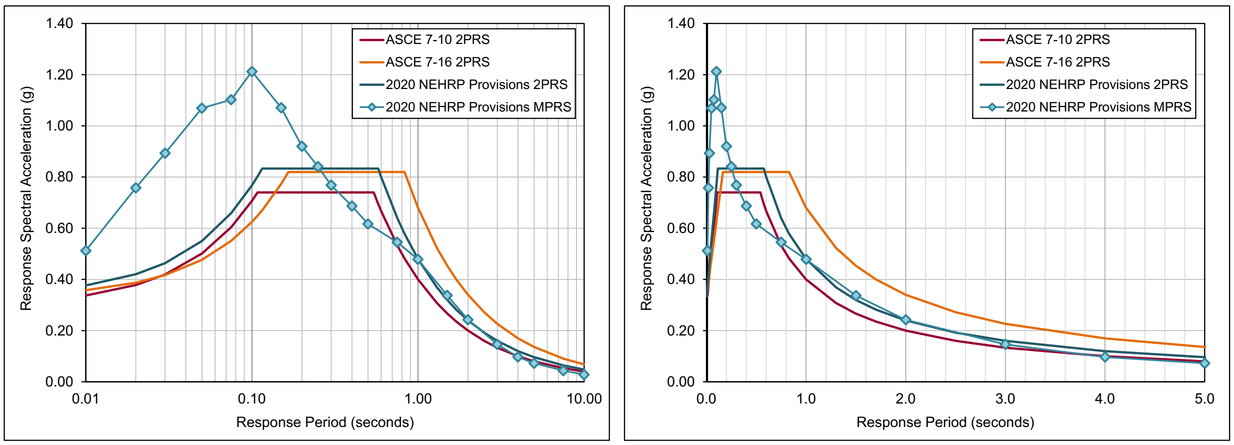
32

32

Comparison of Design Response Spectra – Memphis

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



Velocity domain of the ASCE/SEI 7-16 (2PRS) design spectrum includes the 1.5 multiplier of the applicable Section 11.4.8 exception.

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Design (As Usual) Using New 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)

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Questions

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35

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36

Chapter 3 (Section 3.2 - Part 2) Dissection of Example Changes to the MCE_R Ground Motion Values

2020 NEHRP Provisions Training Materials

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

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2

USGS 2018 National Seismic Hazard Model (NSHM) Updates

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

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3

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

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4

Maximum-Direction Scale Factors

2015 NEHRP Provisions | Part 3, Resource Paper 4

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

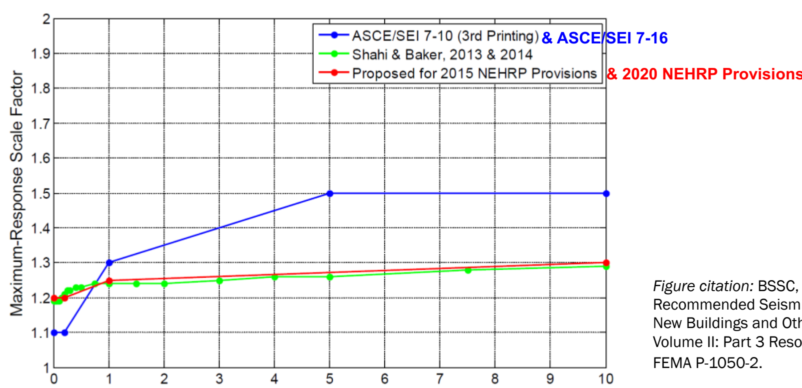

Figure citation: BSSC, 2015. NEHRP Recommended Seismic Provisions for New Buildings and Other Structures, Volume II: Part 3 Resource Papers. FEMA P-1050-2.

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.

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7

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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8

8

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
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- MAXIMUM CONSIDERED EARTHQUAKE GEOMETRIC MEAN (MCE_G) PEAK GROUND ACCELERATIONS
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- USGS SEISMIC DESIGN GEODATABASE AND WEB SERVICE

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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			County or Metropolitan Statistical Area	
	Name	Latitude	Longitude	Name	Population
Southern California	Los Angeles	34.05	-118.25	Los Angeles	9,948,081
	Century City	34.05	-118.40		
	Northridge	34.20	-118.55		
	Long Beach	33.80	-118.20		
	Irvine	33.65	-117.80	Orange	3,002,048
	Riverside	33.95	-117.40	Riverside	2,026,803
	San Bernardino	34.10	-117.30	San Bernardino	1,999,332
	San Luis Obispo	35.30	-120.65	San Luis Obispo	257,005
	San Diego	32.70	-117.15	San Diego	2,941,454
	Santa Barbara	34.45	-119.70	Santa Barbara	400,335
	Ventura	34.30	-119.30	Ventura	799,720
	Total Population - S. California		22,349,098	Population - 8 Counties	21,374,778

Region	Name	Latitude	Longitude
Northern California	Oakland	37.80	-122.25
	Concord	37.95	-122.00
	Monterey	36.60	-121.90
	Sacramento	38.60	-121.50
	San Francisco	37.75	-122.40
	San Mateo	37.55	-122.30
	San Jose	37.35	-121.90
	Santa Cruz	36.95	-122.05
	Vallejo	38.10	-122.25
	Santa Rosa	38.45	-122.70
	Total Population - N. California		14,108,451
Pacific Northwest	Seattle	47.60	-122.30
	Tacoma	47.25	-122.45
	Everett	48.00	-122.20
	Portland	45.50	-122.65
	Total Population - OR and WA		10,096,556
Other WUS	Salt Lake City	40.75	-111.90
	Boise	43.60	-116.20
	Reno	39.55	-119.80
	Las Vegas	36.20	-115.15
	Total Population - ID/UT/NV		6,512,057
CEUS	St. Louis	38.60	-90.20
	Memphis	35.15	-90.05
	Charleston	32.80	-79.95
	Chicago	41.85	-87.65
	New York	40.75	-74.00
	Total Population - MO/TN/SC/IL/NY		48,340,918

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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

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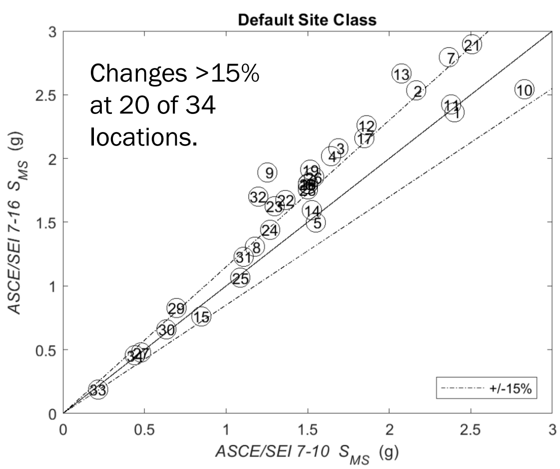
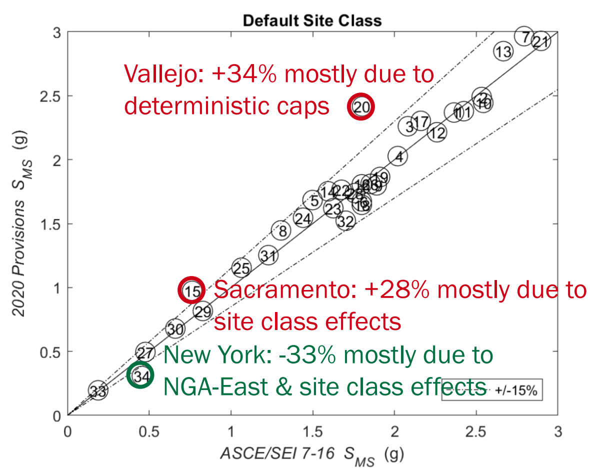
11

11

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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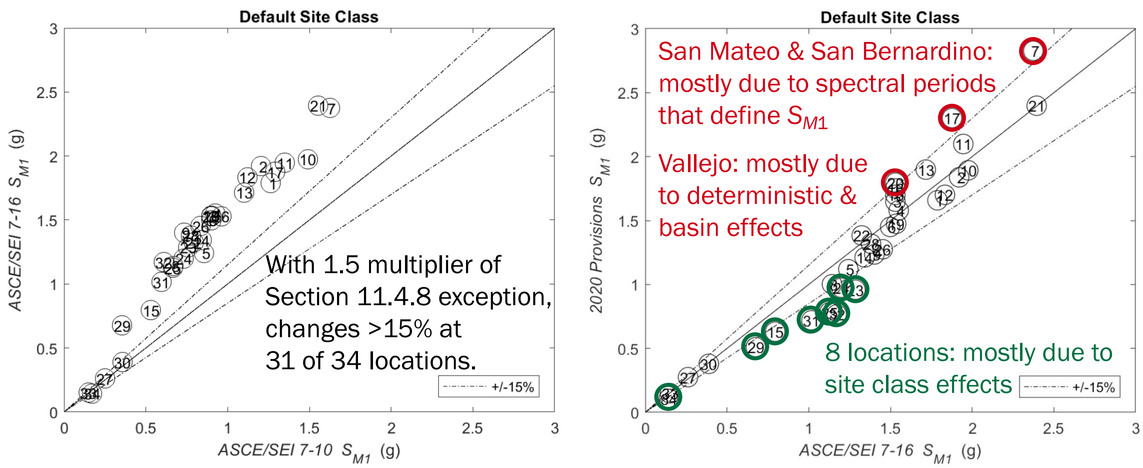
12

12

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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13

13

Examples of Changes in SDC

2020 NEHRP Provisions

Table C22-6 Comparison of seismic design categories from these *Provisions*, *ASCE/SEI 7-16*, and *ASCE/SEI 7-10*, for the default site class and risk categories I, II, or III. The "SDCs" categories are determined from Table 11.6-1 ("Seismic Design Category Based on Short-Period Response Acceleration Parameter") alone, but only where S_1<0.75g.

	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
			D	D	D	D
			D	D	N/A	E
			D	D	D	D
			D			
			N/A			
			D			
San Diego, CA	D	D	D			
Santa Barbara, CA	N/A	E	N/A			
Ventura, CA	N/A	E	N/A			

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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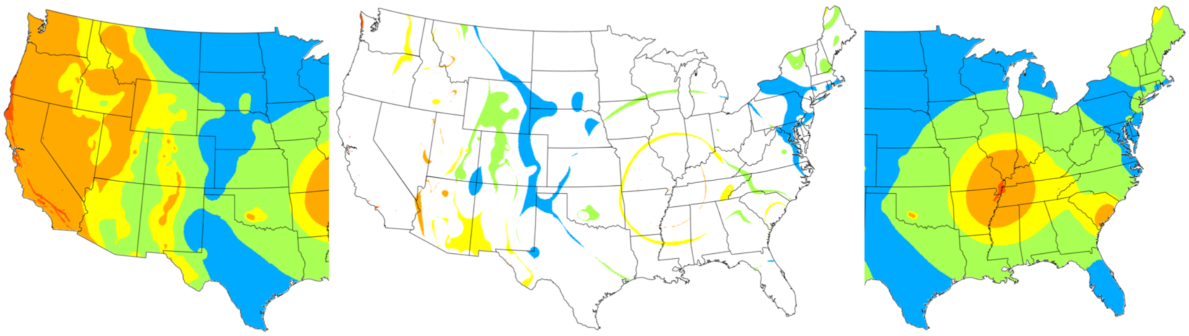
14

14

Examples of Changes in SDC



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.

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Summary of Changes in MCE_R Values

For 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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Commentary to Chapter 22

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- USGS SEISMIC DESIGN GEODATABASE AND WEB SERVICE

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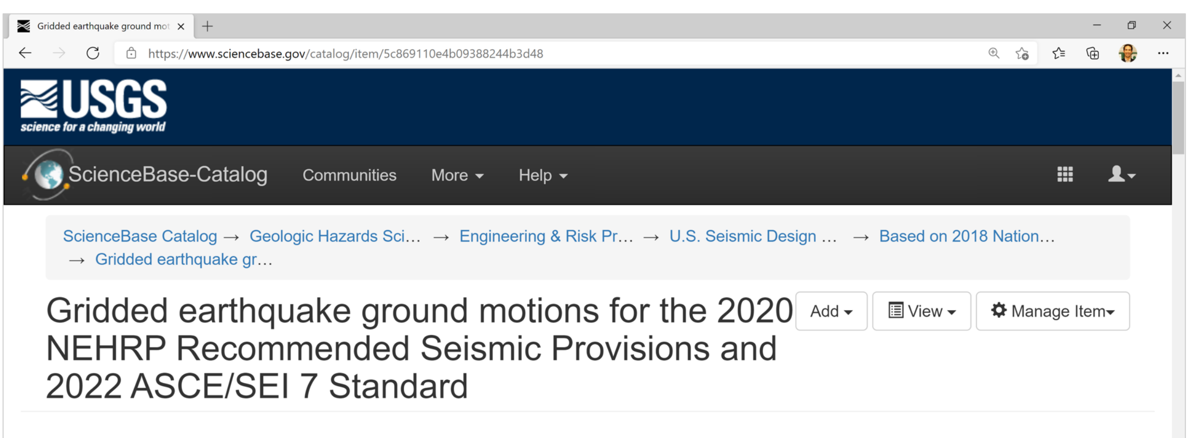
17

USGS Seismic Design Geodatabase



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18

USGS Seismic Design Geodatabase

1.1 : Conterminous United States

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

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

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19

19

USGS Seismic Design Web Service

NEHRP-2020 Web Service Docu

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`

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20

20

USGS Seismic Design Web Service

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


```
"response": {
  "data": {
    "pgam": 0.9,
    "sms": 2.19,
    "sm1": 1.05,
    "sds": 1.46,
    "sd1": 0.7,
    "sdc": "D",
    "ss": 2.15,
    "s1": 0.75,
    "ts": 0.479,
    "t0": 0.0958,
    "tl": 8,
    "cv": null,
    "multiPeriodDesignSpectrum": {
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        0,
        0.01,
        0.02,
        0.03,
        0.05,
        0.075,
```


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21

21

BSSC Tool for Seismic Design Map Values

https://www.wbdg.org/additional-resources/tools/bssc2020nehrp

WBDG Whole Building Design Guide

CREATE ACCOUNT LOG IN SEARCH

DESIGN RECOMMENDATIONS PROJECT MANAGEMENT - O & M FEDERAL FACILITY CRITERIA CONTINUING EDUCATION ADDITIONAL RESOURCES

ADDITIONAL RESOURCES / TOOLS / BSSC TOOL FOR 2020 NEHRP PROVISIONS SEISMIC DESIGN MAP VALUES

BSSC Tool For 2020 NEHRP Provisions Seismic Design Map Values

Version: Beta

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22

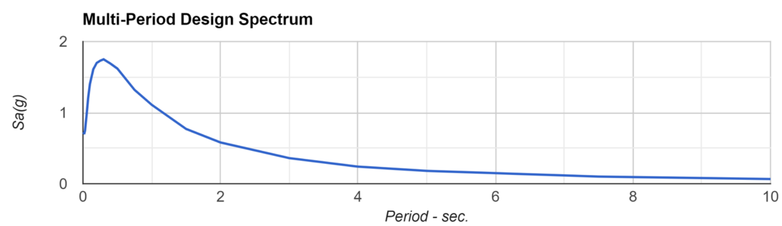
22

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



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23

23

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)*

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24

24

Questions

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Additional Revisions to Ground-Motion Provisions

2020 NEHRP Provisions Training Materials

C.B. Crouse, PhD, PE, Principal Engineer, AECOM

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1

Presentation

- Maximum Considered Earthquake Geometric Mean (MCE_G) Peak Ground Acceleration (ASCE/SEI 7-22, Section 21.5)
- Vertical Ground Motion for Seismic Design (ASCE/SEI 7-22, Section 11.9)
- Site Class when Shear Wave Velocity Data Unavailable (ASCE/SEI 7-22, Section 20.3)

2

MCE_G Peak Ground Acceleration (ASCE/SEI 7-22, Section 21.5)

- **Background:** In ASCE/SEI 7-16, Section 11.8.3, MCE_G Peak Ground Acceleration (PGA_M) was
  - $PGA_M = F_{PGA}$ PGA (Equation 11.8-1)
- where F_{PGA} = site coefficient; and, PGA = Mapped MCE_G Peak Ground Acceleration
- In Section 21.5.2 Deterministic MCE_G Peak Ground Acceleration, lower limit set at
  - 0.5 F_{PGA}

MCE_G Peak Ground Acceleration (ASCE/SEI 7-22, Section 21.5)

- **Update:** In ASCE/SEI 7-22, site coefficients eliminated because of MPRS
  - PGA_M in Section 11.8.3 obtained from USGS Seismic Design Geodatabase for the applicable site class.
  - Deterministic lower limit value listed in bottom row of Table 21.2-1, ASCE/SEI 7-22

Table 21.2-1 (Bottom Row) Deterministic Lower Limit Values of PGA_G (g)

Period T (s)	Site Class							
	A	B	BC	C	CD	D	DE	E
PGA_G	0.37	0.43	0.50	0.55	0.56	0.53	0.46	0.42

Additional Revisions (ASCE/SEI 7-22, Section 21.5)

- **Section 21.5.2 Deterministic MCE_G Peak Ground Acceleration:**
- Replaces "characteristic earthquakes" with "scenario earthquakes"
  - Determined from deaggregation of probabilistic MCE_G peak ground acceleration.
  - From PSHA output, obtain mean magnitude, M, and mean rupture distance, Rrup, for each fault and its % contribution to probabilistic MCE_G peak ground acceleration. The M and Rrup define the "scenario earthquake"
  - scenario earthquakes contributing < 10% of the largest contributor shall be ignored.

Example: Fault X has 75% contribution (largest)

Fault Y has 20% contribution (included)

Fault Z has 5% contribution (ignored)

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5

Additional Revisions (ASCE/SEI 7-22, Section 21.5)

- **Section 21.5.3 Site-Specific MCE_G Peak Ground Acceleration:**
- Determination of MCE_G PGA similar in ASCE/SEI 7-16 & 7-22, i.e.,
  - Take lower of probabilistic & deterministic MCE_G PGA
  - Resulting MCE_G PGA must be ≥ 80% of MCE_G PGA from USGS Seismic Design Geodatabase

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6

Vertical Ground Motion (ASCE/SEI 7-22, Section 11.9)

- **Background:** First introduced in ASCE/SEI 7-16 as S_{aMv}
  - Provision optional
  - S_{aMv} given by Equations (11.9-1 through 11.9-4) for four specific T_v ranges
  - S_{aMv} derived from vertical/horizontal (V/H) component ratios applied to MCE_R $S_a(T)$
  - Limitation: No S_{aMv} equation for T_v > 2 sec; site-specific determination required
  - Oversight: H component in V/H ratio was geomean; MCE_R $S_a(T)$ was for direction of maximum shaking

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7

Vertical Ground Motion (ASCE/SEI 7-22, Section 11.9)

- **Update:** Limitation & Oversight corrected in ASCE/SEI 7-22 S_{aMv}
  - Introduced S_{aMv} Equation (11.9-5) for T_v > 2 sec
  - Corrected oversight by dividing MCE_R S_{aM}, by F_{md} to covert max direction S_a to geomean S_a
  - F_{md} given by Equations (11.9-6 through 11.9-8) for three specific T_v ranges
  - F_{md} based on Shahi & Baker (2014)
- Vertical coefficient, C_v, also revised to accommodate the nine site classes
  - New C_v values in Table 11.9-1
  - C_v depend on S_{MS} (not S_S in Table 11.9-1 of ASCE/SEI 7-16)

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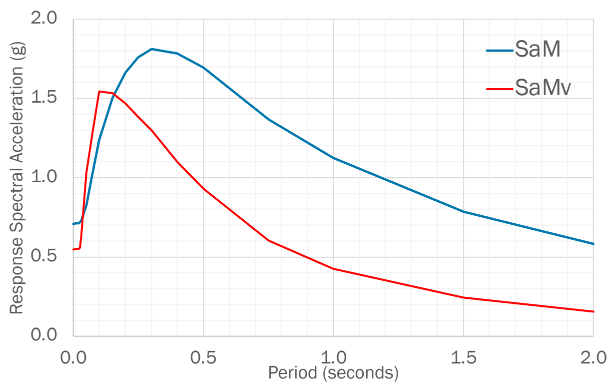
8

Vertical Ground Motion (ASCE/SEI 7-22, Section 11.9)

- **Example:** Comparison of S_{aMv} and S_{aM} for Irvine, CA site and Site Class D



Site Class when Shear Wave Velocity Data Unavailable (ASCE/SEI 7-22, Section 20.3)

- **Background:** In Section 20.3 of ASCE/SEI 7-16, site class determined from either
  - $\bar{v}_s$ - average shear-wave velocity in upper 100 ft (30 m)
  - *N* – average STP in upper 100 ft (30 m)
  - S_u – average undrained shear strength in upper 100 ft (30 m)
  - Ranges of these parameters for each site class provided in Table 20.3-1

- **Update:** In Section 20.2 of ASCE/SEI 7-22, Table 20.2-1 only includes $\bar{v}_s$; *N* and S_u have been eliminated

Site Class when Shear Wave Velocity Data Unavailable (ASCE/SEI 7-22, Section 20.3)

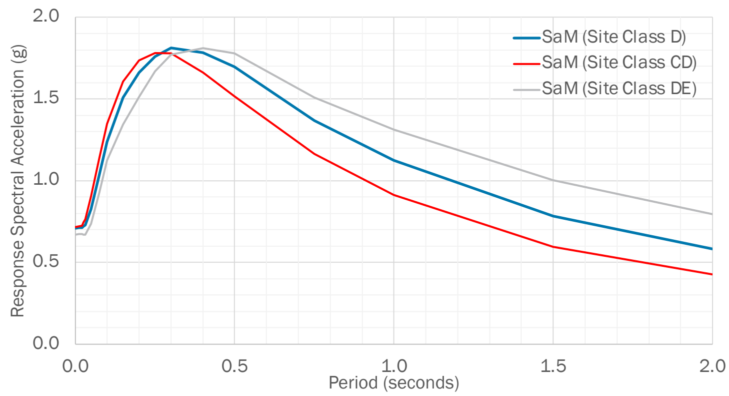
- **Reasons for Revisions to Table 20.3-1:**
  - $\bar{v}_s$ is better indicator of site response effects
  - *N* and S_u ranges were outdated and had no solid technical basis
  - Encourage the use of shear-wave velocity (Vs) measurements
- **Provision when Vs not Measured:**
  - Use applicable correlations between Vs & *N*, or Vs & CPT, etc. to obtain Vs profile
  - Compute $\bar{v}_s$ from Vs profile
  - Determine site classes from $\bar{v}_s$, 1.3 $\bar{v}_s$, and $\bar{v}_s/1.3$
  - Select most critical site class at each *T*, i.e., one resulting in largest MCE_R S_a

Site Class when Shear Wave Velocity Data Unavailable

- **Hypothetical Example:** Irvine, CA site
  - Vs profile constructed from correlation with another soil parameter
  - $\bar{v}_s$ computed as 850 ft/sec (Site Class D)
  - 1.3 $\bar{v}_s$ = 1,105 ft/sec (Site Class CD)
  - $\bar{v}_s/1.3$ = 654 ft/sec (Site Class DE)

Site Class when Shear Wave Velocity Data Unavailable

- **Hypothetical Example:** Irvine, CA site. Envelope of three S_{aM} must be taken.



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13

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14