Design Example 3
Site-specific Ground Motion Procedures §11.4.8

Per Section 11.4.8, a site-specific response spectrum may be derived for any structure based on the procedures set forth in Chapter 21. The site-specific ground motion procedures of Chapter 21 are required for the following cases:

- Structures on Site Class F sites, unless the exception to Section 20.3.1 is applicable.
- Seismically isolated structures and for structures with damping systems on sites with S_1 greater than or equal to 0.6.
- Structures on Site Class E sites with S_s greater than or equal to 1.0.
- Structures on Site Class D and E sites with S_1 greater than or equal to 0.2.

Except for seismically isolated structures and structures with damping systems, a ground motion hazard analysis is not required for:

- Structures on Site Class E sites with S_s greater than or equal to 1.0, provided that the site coefficient F_a is taken as equal to that of Site Class C.
- Structures on Site Class D sites with S_1 greater than or equal to 0.2, provided that the value of the seismic response coefficient C_s is determined by Equation 12.8-2 for values of $T < 1.5T_s$ and taken as equal to 1.5 times the value computed in accordance with either Equation 12.8-3 for $T_L > T > 1.5T_s$ or Equation 12.8-4 for $T > T_L$.
- Structures on Site Class E sites with S_1 greater than or equal to 0.2, provided that T is less than or equal to T_s and the equivalent static force procedure is used for design.

This example illustrates the general procedure for deriving the site-specific design response spectrum based on a given site-specific response spectrum analysis per Sections 21.1 and 21.2.

PROBLEM STATEMENT

The following site-specific response spectra have been provided by an official report in accordance with Section 21.1 or Section 21.2, and the mapped response acceleration parameters S_S and S_1 have been provided according to USGS. The response acceleration parameters S_S and S_1 may be derived using either Figures 22-1 through 22-8 or the "SEAOC/OSHPD Seismic Design Maps" website (seismicmaps.org).

Site Class = D, T_L = 12 sec

S_S = 1.500g, S_1 = 0.623g

F_a = 1.0, F_v = 2.5 §21.3

$S_{MS} = F_aS_S$ = 1.500g(1.0) = 1.500g §11.4.3, Eq 11.4-1

$S_{M1} = F_vS_1$ = 0.623g(2.5) = 1.558g §11.4.3, Eq 11.4-2

S_{DS} = (2/3)S_{MS} = (2/3)1.500g = 1.00g §11.4.4, Eq 11.4-3

S_{D1} = (2/3)S_{M1} = (2/3)1.558g = 1.039g §11.4.4, Eq 11.4-4

Site-specific response spectra from official report:

Period (sec)	Site-specific MCE_R Response Spectrum, S_{aM} (g)	DBE Response Spectrum, $S_a = 2/3S_{aM}$ (g)
0.00	0.452	0.301
0.03	0.711	0.474
0.07	1.083	0.722
0.10	1.301	0.867
0.20	1.402	0.935
0.30	1.390	0.927
0.50	1.210	0.807
1.00	0.554	0.369
1.50	0.322	0.215
2.00	0.212	0.141
3.00	0.113	0.075
4.00	0.085	0.057

DETERMINE THE FOLLOWING:

1. Design response spectrum per Section 11.4.6 (using map-based acceleration parameters).
2. Scaled site-specific design response spectrum per Section 21.3.
3. Design spectral response acceleration parameters S_{DS}, S_{D1}, S_{MS}, and S_{M1} per Section 21.4.

1. Design Response Spectrum per Section 11.4.6 (Using Map-based Acceleration Parameters)

$S_{DS} = 1.00\text{g}$

To determine T_0 and T_s, S_{DS} will be determined utilizing F_v from Table 11.4-2.

$S_1 = 0.623\text{g}$
$F_v = 1.7$

$S_{M1} = S_1 * F_v = 1.7*0.623\text{g} = 1.059\text{g}$
$S_{D1} = 2/3 * S_{M1} = 2/3*1.059\text{g} = 0.706\text{g}$

$T_0 = 0.2S_{D1}/S_{DS}$
$T_0 = 0.2(0.706\text{g})/(1.00\text{g}) = 0.141 \text{ sec}$

$T_S = S_{D1}/S_{DS}$
$T_S = (0.706\text{g})/(1.00\text{g}) = 0.706$ sec

$T_L = 12$ sec (given in the problem statement)

For $T < T_0$:

$S_a = S_{DS}\,(0.4 + 0.6T/T_0)$

For periods $T_0 \le T \le T_S$:

$S_a = S_{DS}$

For periods $T_S < T \le T_L$:

$S_a = S_{D1}/T$

For periods $T_L < T$:

$S_a = S_{D1}T_L/T^2$

Design response spectrum per Section 11.4.6 (using map-based acceleration parameters):

Period (sec)	S_a (g)
0.00	0.400
0.03	0.544
0.07	0.737
0.10	0.882
0.20	1.000
0.30	1.000
0.50	1.000
1.00	0.706
1.50	0.471
2.00	0.353
3.00	0.235
4.00	0.177

2. Scaled Site-specific Design Response Spectrum per Section 21.3

In accordance with Section 21.3, the design site-specific spectral response acceleration at any period shall not be less than 80 percent of the S_a determined in accordance with Section 11.4.6, as done in Part 1. Governing S_a values are shown in bold. Not all periods are shown in the following table. Therefore, the governing period(s) for the structure being designed shall be evaluated in the same way.

Period (sec)	Site-specific MCE_R Response Spectrum, S_{aM} (g)	Site-specific DBE Response Spectrum, $S_a = 2/3S_{aM}$ (g)	S_a per §11.4.6	80% of S_a per §11.4.6	Governing Site-specific Design Response Spectrum, S_a (g)	$T \times S_a$ (sec × g)
0.00	0.452	0.301	0.400	0.320	0.320	0.00
0.03	0.711	0.474	0.544	0.436	0.474	0.014
0.07	1.083	0.722	0.737	0.590	0.722	0.051
0.10	1.301	0.867	0.882	0.705	0.867	0.087
0.20	1.402	0.935	1.000	0.800	0.935	0.187
0.30	1.390	0.927	1.000	0.800	0.927	0.278
0.50	1.210	0.807	1.000	0.800	0.807	0.404
1.00	0.554	0.369	0.706	0.565	0.565	0.565
1.50	0.322	0.215	0.471	0.377	0.377	0.565
2.00	0.212	0.141	0.353	0.282	0.282	0.565
3.00	0.113	0.075	0.235	0.188	0.188	0.565
4.00	0.085	0.057	0.177	0.142	0.142	0.568

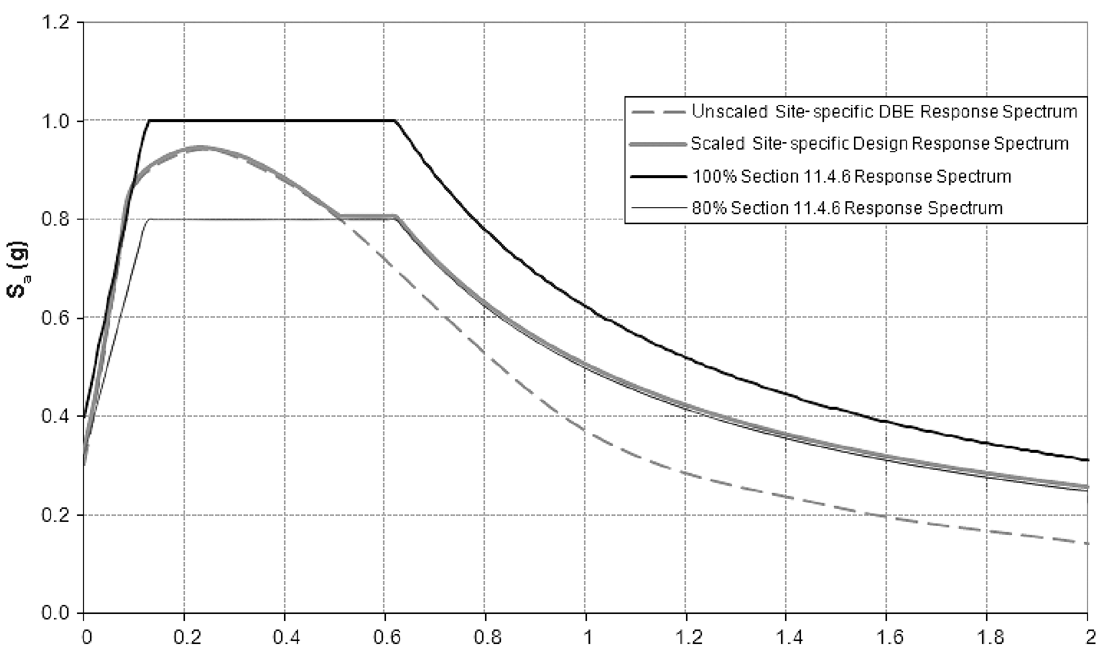

Figure 3-1.
Scaling of design site-specific response spectrum

3. Design Spectral Response Acceleration Parameters S_{DS}, S_{D1}, S_{MS}, and S_{M1} per Section 21.4

S_{DS} = greater of 90 percent of maximum spectral acceleration obtained from the site-specific spectrum, S_a, at any period within the range of 0.2 to 5 seconds, and 80 percent of S_{DS} (per §11.4.5)

S_{DS} = greater of {0.842g, (0.90)0.935g, (0.80)1.0}

$S_{DS} = 0.842g$

S_{D1} = greater of maximum value of $T \times S_a$ for periods from 1 to 2 seconds, and 80 percent of S_{D1} (per §11.4.5) for sites with V_s,30 > 1200 ft/sec

S_{D1} = greater of maximum value of $T \times S_a$ for periods from 1 to 5 seconds and 80 percent of S_{D1} (per §11.4.5) for sites with V_s,30 ≤ 1200 ft/sec

S_{D1} = greater of {0.565, (0.80) × 0.706g}

$S_{D1} = 0.565g$

S_{MS} = greater of $1.5S_{DS}$ (per §21.4) and 80 percent of S_{MS} (per §11.4.4)

S_{MS} = greater of {(1.5)0.935g = 1.403g, (0.80)1.50g = 1.20g}

$S_{MS} = 1.403g$

S_{M1} = greater of $1.5S_{D1}$ (per §21.4) and 80 percent of S_{M1} (per §11.4.4)

S_{M1} = greater of {(1.5)0.565g = 0.848g, (0.80)1.558g = 1.246g}

$S_{M1} = 1.246g$

Commentary

According to Section 21.4, for use with the equivalent lateral force procedure, the site-specific acceleration, S_a, at T shall be permitted to replace S_{D1}/T in Equation 12.8-3 and $S_{D1}T_L/T^2$ in Equation 12.8-4. Similarly, the parameter S_{DS}, calculated in accordance with Section 21.4 (governing S_a at $T = 0.20$ seconds from Part 3), may be used in Equations 12.8-2, 12.8-5, 15.4-1, and 15.4-3. However, the mapped value of S_1 shall be used in Equations 12.8-6, 15.4-2, and 15.4-4.

Note that Exception 2 of Section 11.4.8 may be used to determine C_s by using Equation 12.8-3 or 12.8-4 and multiplying C_s by 1.5. Utilizing this exception would avoid the requirement for a site-specific ground motion hazard analysis for this Site Class D site.