Design Example 1
Design Spectral Response Acceleration Parameters §11.4

OVERVIEW

For a given building site, the risk-targeted maximum considered earthquake spectral response accelerations S_S, at short periods, and S_1, at a 1-second period, are given by the acceleration contour maps in Chapter 22 in Figures 22-1 through 22-8. This example illustrates the general procedure for determining the design spectral response acceleration parameters S_{DS} and S_{D1} from the mapped values of S_S and S_1. The parameters S_{DS} and S_{D1} are used to calculate the design response spectrum in Section 11.4.6 and the design base shear in Section 12.8.

The easiest and most accurate way to obtain the spectral values is to use the "SEAOC/OSHPD Seismic Design Maps" website (seismicmaps.org). Values of S_S and S_1 are provided based on the address or the longitude and latitude of the site being entered.

Note that per Section 11.4.8 of Supplement 3 to ASCE 7-16, a site-specific ground motion hazard analysis shall be performed for structures located on Site Class F sites and for the following cases:

1. Structures on Site Class D sites with S_1 greater than or equal to 0.2 except where the value of the parameter S_{M1} determined by Equation 11.4-2 is increased by 50 percent for all applications of S_{M1} and the resulting value of the parameter S_{D1} determined by Equation 11.4-4 is used for all applications of S_{D1}.

2. Structures on Site Class E sites with S_s greater than or equal to 1.0 and with S_1 greater than or equal to 0.2 except where (1) the equivalent lateral force procedure is used for the design and the value of C_s is determined by Equation 12.8-2 for all values of T OR (2) where the value of S_{ai} is determined by Equation 15.7-7 for all values of T_i AND the value of the parameter S_{D1} is replaced with $1.5*S_{D1}$ in Equations 15.7-10 and 15.7-11.

PROBLEM STATEMENT

A building site in California is located at 38.123° North (Latitude 38.123°) and 121.123° West (Longitude −121.123°). The soil profile is Site Class D.

The value of S_{M1} will be increased by 50 percent to determine the base shear in order to avoid the requirement for a site-specific ground motion hazard analysis.

DETERMINE THE FOLLOWING:

1. Mapped risk-targeted maximum considered earthquake (MCE_R) spectral response acceleration parameters S_S and S_1.
2. Site coefficients F_a and F_v and MCE_R spectral response acceleration parameters S_{MS} and S_{M1} adjusted for Site Class effects.
3. Design spectral response acceleration parameters S_{DS} and S_{D1}.

1. Mapped MCE_R Spectral Response Acceleration Parameters S_s and S_1 §11.4.2

For the given site at 38.123° North (Latitude 38.123°) and 121.123° West (Longitude −121.123°), the “SEAOC/OSHPD Design Maps” website provides the values of

S_S = 0.52g
S_1 = 0.232g

2. Site Coefficients F_a and F_v and MCE_R Spectral Response Acceleration Parameters S_{MS} and S_{M1} Adjusted for Site Class Effects §11.4.3

For the given Site Class D and the values of S_S and S_1 determined above, the site coefficients are

F_a = 1.384 T11.4-1
F_v = 2.136 T11.4-2

Note that the value of F_v from Table 11.4-2 can only be used to determine T_s, to determine the seismic design category, for linear interpolation for intermediate values of S_1, and when taking the exceptions to Items 1 and 2 of Section 11.4.8 for the calculation of S_{D1} per Footnote a of this table. For a site-specific analysis, F_v shall be determined in accordance with Section 21.3.

The MCE_R spectral response acceleration parameters adjusted for Site Class effects are

$S_{MS} = F_a S_S$ = 1.384(0.52g) = 0.720g Eq 11.4-1
$S_{M1} = F_v S_1$ = 1.5*2.136(0.232g) = 0.743g Eq 11.4-2

3. Design Spectral Response Acceleration Parameters S_{DS} and S_{D1} §11.4.4

S_{DS} = (2/3) S_{MS} = (2/3)(0.720g) = 0.480g Eq 11.4-3
S_{D1} = (2/3) S_{M1} = (2/3)(0.743g) = 0.496g Eq 11.4-4

Commentary

The “SEAOC/OSHPD Design Maps” website requires the risk category to be specified, even though that category is not necessary for determining S_{DS} and S_{D1}.

Design Example 2
Design Response Spectrum §11.4.6

PROBLEM STATEMENT

A building site in California has the following design spectral response acceleration parameters determined in accordance with Section 11.4.5 and mapped long-period transition period evaluated from Figure 22-14:

S_{DS} = 0.55g
S_{D1} = 0.34g
T_L = 8 sec

Note that for the purposes of determining T_s, S_{DS} can be calculated using the value of F_v determined from Table 11.4-2.

DETERMINE THE FOLLOWING:

1. Design response spectrum.

1. Design Response Spectrum §11.4.6

Section 11.4.6 provides the equations for the 5 percent damped spectral response acceleration, S_a, relative to period, T, in the following ranges:

$0 \le T < T_0$, $T_0 \le T \le T_S$, $T_S < T \le T_L$, and $T_L < T$

where:

$T_0 = 0.2\ S_{D1} / S_{DS}$
$T_S = S_{D1} / S_{DS}$
T_L = long-period transition period from Figures 22-14 through 22-17

Given the values for this example,

$T_0 = 0.2\ S_{D1} / S_{DS} = 0.2(0.34\text{g} / 0.55\text{g}) = 0.12$ sec
$T_S = S_{D1} / S_{DS} = (0.34\text{g} / 0.55\text{g}) = 0.62$ sec
T_L = 8 sec

The spectral response acceleration, S_a, is calculated as follows:

1. For the interval $0 \le T < T_0$ ($0 \le T < 0.12$ sec),

$$S_a = S_{DS}(0.4 + 0.6T/T_0) \quad \text{Eq 11.4-5}$$

$$S_a = 0.55\text{g}(0.4 + 0.6T/0.12) = (0.22 + 2.75T)\text{g}$$

2. For the interval $T_0 \le T \le T_S$ (0.12 sec $\le T \le$ 0.62 sec),

$$S_a = S_{DS} = 0.55\text{g}$$

3. For the interval $T_S < T \le T_L$ (0.62 sec $< T \le$ 8 sec),

$$S_a = S_{D1}/T \quad \text{Eq 11.4-6}$$

$$S_a = (0.34/T)\text{g}$$

4. For the interval $T_L < T$ (8 sec $< T$),

$$S_a = S_{D1}T_L/T^2 \quad \text{Eq 11.4-7}$$

$$S_a = 0.34\text{g}(8)/T^2 = (2.72/T^2)\text{g}$$

From this information, the elastic design response spectrum for this site can be drawn, as shown in Figure 2-1, in accordance with Figure 11.4-1:

T (sec)	S_a (g)
0.00	0.22
0.12	0.55
0.62	0.55
0.75	0.45
1.00	0.34
1.50	0.23
2.00	0.17
4.00	0.09
8.00	0.04
10.00	0.03

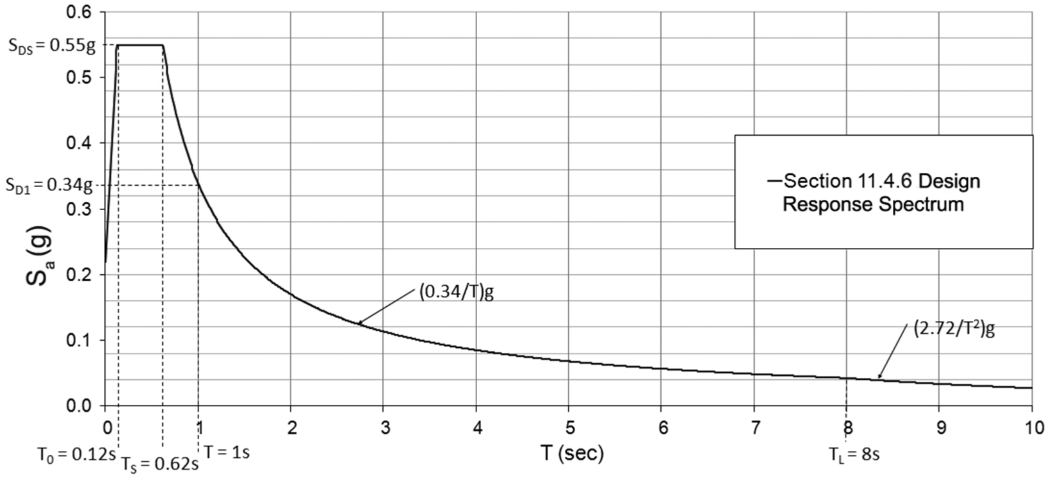

Figure 2-1.
Design response spectrum per Section 11.4.6

Design Example 3
Site-specific Ground Motion Procedures §11.4.8

Per Section 11.4.8 of Supplement 3 to ASCE 7-16, 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.
- Structures on Site Class E sites with S_1 greater than or equal to 0.2 or with S_s greater than or equal to 1.0.
- Structures on Site Class D sites with S_1 greater than or equal to 0.2.

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 (1) the equivalent lateral force procedure is used for the design and the value of C_s is determined by Equation 12.8-2 for all values of T OR (2) where the value of S_{ai} is determined by Equation 15.7-7 for all values of T_i AND the value of the parameter S_{D1} is replaced with $1.5{*}S_{D1}$ in Equations 15.7-10 and 15.7-11.
- Structures on Site Class D sites with S_1 greater than or equal to 0.2, provided that the value of the parameter S_{M1} determined by Equation 11.4-2 is increased by 50 percent for all applications of S_{M1} and the resulting value of the parameter S_{D1} determined by Equation 11.4-4 is used for all applications of S_{D1}.

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

$S_S = 1.500\text{g}$, $S_1 = 0.623\text{g}$

$F_a = 1.0$, $F_v = 2.5$ §21.3

$S_{MS} = F_a S_S = 1.500\text{g}(1.0) = 1.500\text{g}$ §11.4.3, Eq 11.4-1

$S_{M1} = F_v S_1 = 0.623\text{g}(2.5) = 1.558\text{g}$ §11.4.3, Eq 11.4-2

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

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