3.4 SITE-SPECIFIC PROCEDURE

A site-specific study shall account for the regional tectonic setting, geology, and seismicity, the expected recurrence rates and maximum magnitudes of earthquakes on known faults and source zones, the characteristics of ground motion attenuation, near-fault effects if any on ground motions, and the effects of subsurface site conditions on ground motions. The study shall incorporate current scientific interpretations, including uncertainties, for models and parameter values for seismic sources and ground motions. The study shall be documented in a report.

3.4.1 Probabilistic maximum considered earthquake. Where site-specific procedures are utilized, the probabilistic maximum considered earthquake ground motion shall be taken as that motion represented by a 5-percent-damped acceleration response spectrum having a 2 percent probability of exceedance in a 50 year period.

3.4.2 Deterministic maximum considered earthquake. The deterministic maximum considered earthquake spectral response acceleration at each period shall be taken as 150 percent of the largest median 5-percent-damped spectral response acceleration computed at that period for characteristic earthquakes on all known active faults within the region. For the purposes of these *Provisions*, the ordinates of the deterministic maximum considered earthquake ground motion response spectrum shall not be taken lower than the corresponding ordinates of the response spectrum determined in accordance with Figure 3.4-1, where F_a and F_v are determined using Tables 3.3-1 and 3.3-2, with the value of S_S taken as 1.5 and the value of S_1 taken as 0.6.

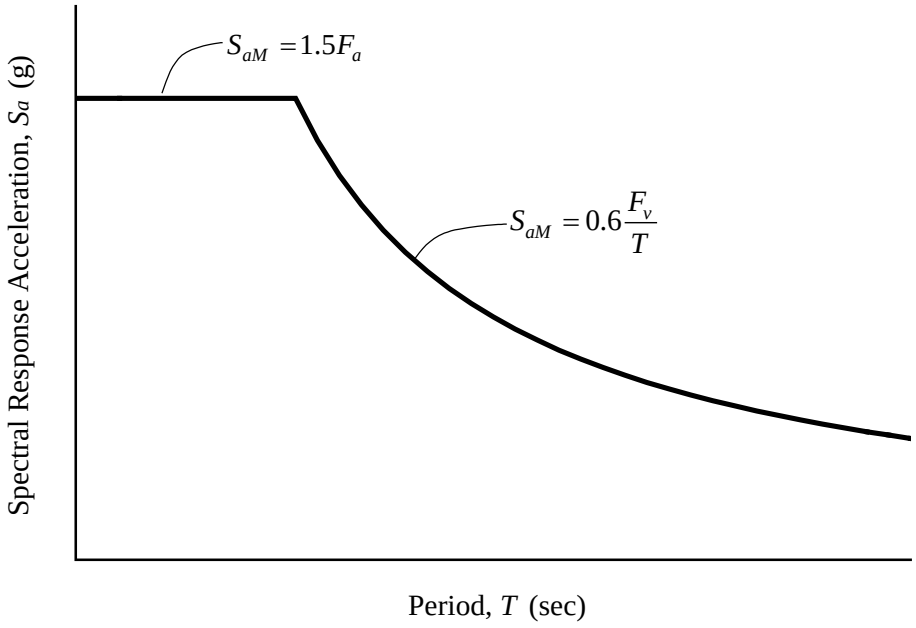

Figure 3.4-1 Deterministic Lower Limit on Maximum Considered Earthquake

3.4.3 Site-specific maximum considered earthquake. The site-specific maximum considered earthquake spectral response acceleration at any period, S_{aM}, shall be taken as the lesser of the spectral response accelerations from the probabilistic maximum considered earthquake ground motion of Sec. 3.4.1 and the deterministic maximum considered earthquake ground motion of Sec. 3.4.2.

3.4.4 Design response spectrum. Where site-specific procedures are used to determine the maximum considered earthquake ground motion, the design spectral response acceleration at any period shall be determined from Eq. 3.4-1:

$$S_a = \frac{2}{3} S_{aM} \tag{3.4-1}$$

and shall be greater than or equal to 80 percent of S_a determined in accordance with Sec. 3.3.4. For sites classified as Site Class F requiring site-specific evaluations (Note b to Tables 3.3-1 and 3.3-2 and Sec. 3.5.1), the design spectral response acceleration at any period shall be greater than or equal to 80 percent of Sa determined for Site Class E in accordance with Sec. 3.3.4.

3.4.5 Design acceleration parameters. Where the site-specific procedure is used to determine the design response spectrum in accordance with Section 3.4.4, the parameter S_{DS} shall be taken as the spectral acceleration, S_a, obtained from the site-specific spectrum at a period of 0.2 second, except that it shall not be taken as less than 90 percent of the peak spectral acceleration, S_a, at any period larger than 0.2 second. The parameter S_{D1} shall be taken as the greater of the spectral acceleration, S_a, at a period of 1 second or two times the spectral acceleration, S_a, at a period 2 seconds. The parameters S_{MS} and S_{M1} shall be taken as 1.5 times S_{DS} and $S_{D1,}$ respectively. The values so obtained shall not be taken as less than 80 percent of the values obtained from the general procedure of Section 3.3.

3.5 SITE CLASSIFICATION FOR SEISMIC DESIGN

Where the soil properties are not known in sufficient detail to determine the Site Class in accordance with Sec. 3.5.1, it shall be permitted to assume Site Class D unless the authority having jurisdiction determines that Site Class E or F could apply at the site or in the event that Site Class E or F is established by geotechnical data.

3.5.1 Site Class definitions. The Site Classes are defined as follows:

A Hard rock with measured shear wave velocity, $\overline{v}_s$ > 5,000 ft/sec (1500 m/s)

B Rock with 2,500 ft/sec < $\overline{v}_s \leq$ 5,000 ft/sec (760 m/s < $\overline{v}_s \leq$ 1500 m/s)

C Very dense soil and soft rock with 1,200 ft/sec < $\overline{v}_s \leq$ 2,500 ft/sec (360 m/s < $\overline{v}_s \leq$ 760 m/s) or with either $\overline{N}$ > 50 or $\overline{s}_u$ > 2,000 psf (100 kPa)

D Stiff soil with 600 ft/sec $\leq \overline{v}_s \leq$ 1,200 ft/sec (180 m/s $\leq \overline{v}_s \leq$ 360 m/s) or with either 15 $\leq \overline{N} \leq$ 50 or 1,000 psf $\leq \overline{s}_u \leq$ 2,000 psf (50 kPa $\leq \overline{s}_u \leq$ 100 kPa)

E A soil profile with $\overline{v}_s$ < 600 ft/sec (180 m/s) or with either

$\overline{N}$ < 15, $\overline{s}_u$ < 1,000 psf, or any profile with more than 10 ft (3 m) of soft clay defined as soil with PI > 20, $w \geq$ 40 percent, and s_u < 500 psf (25 kPa)

F Soils requiring site-specific evaluations:

1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils.

   Exception: For structures having fundamental periods of vibration less than or equal to 0.5 second, site-specific evaluations are not required to determine spectral accelerations for liquefiable soils. Rather, the Site Class may be determined in accordance with Sec. 3.5.2, assuming liquefaction does not occur, and the corresponding values of F_a and F_v determined from Tables 3.3-1 and 3.3-2.

2. Peat and/or highly organic clays (H > 10 ft [3 m] of peat and/or highly organic clay, where H = thickness of soil)

3. Very high plasticity clays (H > 25 ft [8 m] with PI > 75)

4. Very thick, soft/medium stiff clays (H > 120 ft [36 m]) with s_u < 1,000 psf (50 kPa)

The parameters used to define the Site Class are based on the upper 100 ft (30 m) of the site profile. Profiles containing distinctly different soil and rock layers shall be subdivided into those layers

designated by a number that ranges from 1 to *n* at the bottom where there are a total of *n* distinct layers in the upper 100 ft (30 m). The symbol *i* then refers to any one of the layers between 1 and *n*.

where:

v_{si} = the shear wave velocity in ft/sec (m/s).

d_i = the *thickness* of any layer (between 0 and 100 ft [30 m]).

$$\overline{v}_s = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{v_{si}}} \tag{3.5-1}$$

where $\sum_{i=1}^{n} d_i$ is equal to 100 ft (30 m).

N_i = the Standard Penetration Resistance determined in accordance with ASTM D 1586, as directly measured in the field without corrections, and shall not be taken greater than 100 blows/ft. Where refusal is met for a rock layer, N_i shall be taken as 100 blows/ft.

$$\overline{N} = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{N_i}} \tag{3.5-2}$$

where N_i and d_i in Eq. 3.5-2 are for cohesionless soil, cohesive soil, and rock layers.

$$\overline{N}_{ch} = \frac{d_s}{\sum_{i=1}^{m} \frac{d_i}{N_i}} \tag{3.5-3}$$

where N_i and d_i in Eq. 3.5-3 are for cohesionless soil layers only,

and $\sum_{i=1}^{m} d_i = d_s$

d_s = the total thickness of cohesionless soil layers in the top 100 ft (30 m).

s_{ui} = the undrained shear strength in psf (kPa), determined in accordance with ASTM D 2166 or D 2850, and shall not be taken greater than 5,000 psf (250 kPa).

$$\overline{s}_u = \frac{d_c}{\sum_{i=1}^{k} \frac{d_i}{s_{ui}}} \tag{3.5-4}$$

where $\sum_{i=1}^{k} d_i = d_c$.

d_c = the total thickness of cohesive soil layers in the top 100 ft (30 m).

PI = the plasticity index, determined in accordance with ASTM D 4318.

w = the moisture content in percent, determined in accordance with ASTM D 2216.

3.5.2 Steps for classifying a site

Step 1: Check for the four categories of Site Class F requiring site-specific evaluation. If the site corresponds to any of these categories, classify the site as Site Class F and conduct a site-specific evaluation.

Step 2: Check for the existence of a total thickness of soft clay > 10 ft (3 m) where a soft clay layer is defined by: s_u < 500 psf (25 kPa), $w \geq$ 40 percent, and PI > 20. If these criteria are satisfied, classify the site as Site Class E.

Step 3: Categorize the site using one of the following three methods with $\overline{v}_s$, $\overline{N}$ and $\overline{s}_u$ computed in all cases as specified in Sec. 3.5.1:

a. $\overline{v}_s$ for the top 100 ft (30 m) ($\overline{v}_s$ method)

b. $\overline{N}$ for the top 100 ft (30 m) ($\overline{N}$ method)

c. $\overline{N}_{ch}$ for cohesionless soil layers (PI < 20) in the top 100 ft (30 m) and average $\overline{s}_u$ for cohesive soil layers (PI > 20) in the top 100 ft (30 m) ($\overline{s}_u$ method)

Table 3.5-1 Site Classification

Site Class	$\overline{v}_s$	$\overline{N}$ or $\overline{N}_{ch}$	$\overline{s}_u$ [a]
E	< 600 fps (< 180 m/s)	< 15	< 1,000 psf (< 50 kPa)
D	600 to 1,200 fps (180 to 360 m/s)	15 to 50	1,000 to 2,000 psf (50 to 100 kPa)
C	> 1,200 to 2,500 fps (360 to 760 m/s)	> 50	> 2,000 (> 100 kPa)

[a] If the $\overline{s}_u$ method is used and the $\overline{N}_{ch}$ and $\overline{s}_u$ criteria differ, select the category with the softer soils (for example, use Site Class E instead of D).

Assignment of Site Class B shall be based on the shear wave velocity for rock. For competent rock with moderate fracturing and weathering, estimation of this shear wave velocity shall be permitted. For more highly fractured and weathered rock, the shear wave velocity shall be directly measured or the site shall be assigned to Site Class C.

Assignment of Site Class A shall be supported by either shear wave velocity measurements on site or shear wave velocity measurements on profiles of the same rock type in the same formation with an equal or greater degree of weathering and fracturing. Where hard rock conditions are known to be continuous to a depth of 100 ft (30 m), surficial shear wave velocity measurements may be extrapolated to assess $\overline{v}_s$.

Site Classes A and B shall not be used where there is more than 10 ft (3 m) of soil between the rock surface and the bottom of the spread footing or mat foundation.

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