CAPITULO 5.- DISEÑO SISMORESISTENTE DE EDIFICIOS

5.1 Espectros de diseño
5.2 Códigos sismo-resistentes

NORMA ASCE 7-10

Chapter 20

SITE CLASSIFICATION PROCEDURE FOR SEISMIC DESIGN

20.1 SITE CLASSIFICATION

The site soil shall be classified in accordance with Table 20.3-1 and Section 20.3 based on the upper 100 ft (30 m) of the site profile. Where site-specific data are not available to a depth of 100 ft, appropriate soil properties are permitted to be estimated by the registered design professional preparing the soil investigation report based on known geologic conditions. Where the soil properties are not known in sufficient detail to determine the site class, Site Class D shall be used unless the authority having jurisdiction or geotechnical data determines Site Class E or F soils are present at the site. Site Classes A and B shall not be assigned to a site if there is more than 10 ft of soil between the rock surface and the bottom of the spread footing or mat foundation.

20.2 SITE RESPONSE ANALYSIS FOR SITE CLASS F SOIL

A site-response analysis in accordance with Section 21.1 shall be provided for Site Class F soils, unless the exception to Section 20.3.1 is applicable.

20.3 SITE CLASS DEFINITIONS

Site class types shall be assigned in accordance with the definitions provided in Table 20.3-1 and this section.

TABLE 20.3-1 SITE CLASSIFICATION

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard rock	>5,000 ft/s	NA	NA
B. Rock	2,500 to 5,000 ft/s	NA	NA
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the following characteristics: - Plasticity index PI > 20, - Moisture content $w \geq 40\%$, and - Undrained shear strength $\bar{s}_u < 500$ psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1 ft/s = 0.3048 m/s 1 lb/ft^2 = 0.0479 kN/m^2

20.3.1 Site Class F. Where any of the following conditions is satisfied, the site shall be classified as Site Class F and a site response analysis in accordance with Section 21.1 shall be performed.

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

   EXCEPTION: For structures having fundamental periods of vibration equal to or less than 0.5 s, site-response analysis is not required to determine spectral accelerations for liquefiable soils. Rather, a site class is permitted to be determined in accordance with Section 20.3 and the corresponding values of F_a and F_v determined from Tables 11.4-1 and 11.4-2.
2. Peats 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 (7.6 m) with $PI > 75$].
4. Very thick soft/medium stiff clays [$H > 120$ ft (37 m)] with $s_u < 1000$ psf (50 kPa).

20.3.2 Soft Clay Site Class E. Where a site does not qualify under the criteria for Site Class F, and there is a total thickness of soft clay greater than 10 ft (3 m) where a soft clay layer is defined by $s_u < 500$ psf (25 kPa), $w \geq 40$ percent, and $PI > 20$, it shall be classified as Site Class E.

20.3.3 Site Classes C, D, and E. The existence of Site Class C, D, and E soils shall be classified by using one of the following three methods with $\bar{v}_s$, $\bar{N}$, and $\bar{s}_u$ computed in all cases as specified in Section 20.4:

1. $\bar{v}_s$ for the top 100 ft (30 m) ($\bar{v}_s$ method).
2. $\bar{N}$ for the top 100 ft (30 m) ($\bar{N}$ method).
3. $\bar{N}_{ch}$ for cohesionless soil layers ($PI < 20$) in the top 100 ft (30 m) and $\bar{s}_u$ for cohesive soil layers ($PI > 20$) in the top 100 ft (30 m) ($\bar{s}_u$ method). Where the $\bar{N}_{ch}$ and $\bar{s}_u$ criteria differ, the site shall be assigned to the category with the softer soil.

20.3.4 Shear Wave Velocity for Site Class B. The shear wave velocity for rock, Site Class B, shall be either measured on site or estimated by a geotechnical engineer, engineering geologist, or seismologist for competent rock with moderate fracturing and weathering. Softer and more highly fractured and weathered rock shall either be measured on site for shear wave velocity or classified as Site Class C.

20.3.5 Shear Wave Velocity for Site Class A. The hard rock, Site Class A, category shall be supported by shear wave velocity measurement either on site or 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 are permitted to be extrapolated to assess $\bar{v}_s$.

20.4 DEFINITIONS OF SITE CLASS PARAMETERS

The definitions presented in this section shall apply to the upper 100 ft (30 m) of the site profile. Profiles containing distinct 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). Where some of the n layers are cohesive and others are not, k is the number of cohesive layers and m is the number of cohesionless layers. The symbol i refers to any one of the layers between 1 and n.

20.4.1 $\bar{v}_s$, Average Shear Wave Velocity. $\bar{v}_s$ shall be determined in accordance with the following formula:

$$\bar{v}_s = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{v_{si}}} \qquad (20.4\text{-}1)$$

d_i is the thickness of any layer between 0 and 100 ft (30 m).

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

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

20.4.2 $\bar{N}$, Average Field Standard Penetration Resistance and $\bar{N}_{ch}$, Average Standard Penetration Resistance for Cohesionless Soil Layers. $\bar{N}$ and $\bar{N}_{ch}$ shall be determined in accordance with the following formulas:

$$\bar{N} = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{N_i}} \qquad (20.4\text{-}2)$$

where N_i and d_i in Eq. 20.4-2 are for cohesionless soil, cohesive soil, and rock layers.

$$\bar{N}_{ch} = \frac{d_s}{\sum_{i=1}^{m} \frac{d_i}{N_i}} \qquad (20.4\text{-}3)$$

where N_i and d_i in Eq. 20.4-3 are for cohesionless soil layers only and $\sum_{i=1}^{m} d_i = d_s$ where d_s is the total thickness of cohesionless soil layers in the top 100 ft (30 m). N_i is the standard penetration resistance (ASTM D1586) not to exceed 100 blows/ft (328 blows/m) as directly measured in the field without corrections. Where refusal is met for a rock layer, N_i shall be taken as 100 blows/ft (328 blows/m).

20.4.3 $\bar{s}_u$, Average Undrained Shear Strength. $\bar{s}_u$ shall be determined in accordance with the following formula:

$$\bar{s}_u = \frac{d_c}{\sum_{i=1}^{k} \frac{d_i}{s_{ui}}} \qquad (20.4\text{-}4)$$

where

$$\sum_{i=1}^{k} d_i = d_c \quad \text{and}$$

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

PI = the plasticity index as determined in accordance with ASTM D4318

w = the moisture content in percent as determined in accordance with ASTM D2216

s_{ui} = the undrained shear strength in psf (kPa), not to exceed 5,000 psf (240 kPa) as determined in accordance with ASTM D2166 or ASTM D2850

Granular Soils - Compactness

Terms	Blows/Foot Standard Penetration
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	over 50

N_{1-60}	ϕ'
<5	<30°
5-15	30°-36°
15-35	36°-41°
35-50	40°-45°
>50	>42°

N_{SPT}	Dr %
0-4	0-15
4-10	15-35
10-30	35-65
30-50	65-85
>50	85-100

Cohesive Soils - Consistency

Term	(q_u) Unconfined Compression tons/sq.ft. ≈ kg/cm²	Blows/Foot Standard Penetration	Hand Manipulation
Very Soft	less than 0.25	below 2	Easily penetrated by fist
Soft	0.25 - 0.50	2 - 4	Easily penetrated by thumb
Medium Stiff	0.50 - 1.00	4 - 8	Penetrated by thumb w/ moderate effort
Stiff	1.0 - 2.0	8 - 15	Readily indented by thumb but not penetrated
Very Stiff	2.0 - 4.0	15 - 30	Readily indented by thumb nail
Hard	over 4.0	over 30	Indented with difficulty by thumb nail

UNIVERSIDAD CATOLICA DE SANTIAGO DE GUAYAQUIL

GEOCON®
Consultoría en Geotecnia

Contratista:		Equipo:	Máquina Perforadora Petty II
Localización:	Pista de motocroos	Operador:	Ginson Muñoz
Inicio:	16 de marzo de 2011	Martillo:	Safety
Terminación:	16 de marzo de 2011	Peso Martillo:	140lbs.
Perforación:	P24	Diámetro:	4"
Profundidad:	0.00-17,28m	Cota:	-
		Nivel Freático:	4,00m

Nº muestra	Prof. (m.) muestras	# Golpes (N)	Estratigrafía SUCS	Descripcion Visual	Recuperación	Muestreador	ENSAYOS DE LABORATORIO Wn %	LL% %	IP %	% pas # 4	% pas # 200	qu (Kg/cm2)	Penetrómetro (Kg/cm2)	ε %	γv Kg/m3
1	0.00-0.50	5	MH	limo elástico café, consistencia media	45/45	SPT	36.13	69.62	23.03	100.00	98.00				
2	0,50-1,00	11	MH	limo elástico café, consistencia semidura	45/50	Shelby	43.55	69.30	22.71	100.00	98.00	1.2		3.6	1764
3	1,50-2,00	8	MH	limo elástico verdoso con pintas cafés, consistencia semidura	40/50	Shelby	50.88	64.40	27.58	100.00	98.00	1.0		3.2	1771
4	2,50-3,00	8	MH	limo elástico verdoso con pintas cafés, consistencia semidura	45/50	Shelby	46.71	64.60	27.78	100.00	98.00	1.0		3.6	1848
5	3,50-4,00	5	MH	limo elástico verdoso, consistencia blanda	50/50	Shelby	66.97	52.42	21.12	100.00	97.00	0.6		2.9	1764
6	4,50-5,00	3	CL	arcilla arenosa gris verdosa, consistencia blanda	40/45	SPT	42.42	40.62	16.21	100.00	54.67				
7	5,50-6,00	2	ML	limo con arena gris verdoso, consistencia blanda	45/45	SPT	65.73	40.10	15.69	100.00	72.26				
8	7,00-7,50	4	SC	arena arcillosa gris verdosa, compacidad relativa suelta	40/45	SPT	50.66	40.90	16.49	100.00	48.43				
9	8,50-9,00	2	CL	arcilla con arena gris verdosa, consistencia blanda	45/45	SPT	50.07	41.00	16.59	100.00	72.40				
10	10,00-10,50	18	SP-SM	arena verdosa mal graduada ligeramente limosa, compacidad relativa media	40/45	SPT	26.12	NP	NP	100.00	10.41				
11	11,50-12,00	11	SP-SM	arena verdosa mal graduada ligeramente limosa, compacidad relativa media	40/45	SPT	27.48	NP	NP	100.00	6.76				

EJEMPLO DE CLASIFICACION DE SUELO CONFORME NORMA ASCE 7-10

GEOCON®
Consultoría en Geotecnia

		Equipo:	Máquina Perforadora Petty II
Contratista:	Ing. Alejandro Lascano	Operador:	Ginson Muñoz
Localización:	Pista de motocroos	Martillo:	Safety
Inicio:	16 de marzo de 2011	Peso Martillo:	140lbs.
Terminación:	16 de marzo de 2011	Diámetro:	4"
Perforación:	P24	Cota:	-
Profundidad:	0.00-17,28m	Nivel Freático:	4,00m

Nº muestra	Prof. (m.) muestras	# Golpes (N)	Estratigrafía SUCS	Descripcion Visual	Recuperación	Muestreador	ENSAYOS DE LABORATORIO Wn %	LL% %	IP %	% pas # 4	% pas # 200	qu (Kg/cm2)	Penetrómetro (Kg/cm2)	ε %	γv Kg/m3
12	13,00-13,50	15	SP-SM	arena gris verdosa mal graduada ligeramente limosa, compacidad relativa media	40/45	SPT	24.55	NP	NP	100.00	11.20				
13	14,50-15,00	28	MH	limo elástico arenoso verdoso, consistencia firme a dura	40/45	SPT	19.47	58.49	20.17	96.95	61.95				
14	16,00-16,50	81	SM	arena limosa café, compacidad relativa muy compacta	45/45	SPT	25.62	49.07	7.20	76.41	29.75				
15	17,00-17,28	60 en 13cm	ML	limo arenoso verdoso, consistencia rígida	28/45	SPT	17.42	49.50	7.64	100.00	59.57				

Simbología:

- limos
- gravas
- arenas
- arcillas
- fragmentos de roca

Wn	Contenido de Humedad
% pas #4	Pasante Tamiz Nº4
% pas #200	Pasante Tamiz Nº200
LP	Límite Plástico
IP	Indice de Plasticidad
Rev.	Revestimiento

EJEMPLO DE CLASIFICACION DE SUELO CONFORME NORMA ASCE 7-10

ESTRATIGRAFIA

Profundidad	Estrato	N
0.0 – 10.0	Limos o Arcillas Blandas a Media (MH, CL, ML) Arenas Arcillosas Sueltas (SC)	N = 5
10.0 – 16.0	Arenas Medias (SM-SP) Limo Semiduro (MH)	N = 18
16.0 – 30.0	Arenas Compactas (SM) Limo Duro (ML)	N = 100

Any profile with more than 10 ft of soil having
- Plasticity index PI > 20,
- Moisture content $w \geq 40\%$, and
- Undrained shear strength $\bar{s}_u < 500$ psf

0.24 kg/cm^2

$$\bar{N} = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{N_i}} = 12$$

Como N < 15

Este suelo

Clasifica como

Tipo E

Chapter 11

SEISMIC DESIGN CRITERIA

11.4 SEISMIC GROUND MOTION VALUES

11.4.1 Mapped Acceleration Parameters. The parameters S_S and S_1 shall be determined from the 0.2 and 1.0 s spectral response accelerations shown on Figs. 22-1 through 22-14, respectively. Where S_1, is less than or equal to 0.04 and S_S is less than or equal to 0.15, the structure is permitted to be assigned to Seismic Design Category A and is only required to comply with Section 11.7.

11.4.2 Site Class. Based on the site soil properties, the site shall be classified as Site Class A, B, C, D, E, or F in accordance with Chapter 20. Where the soil properties are not known in sufficient detail to determine the site class, Site Class D shall be used unless the authority having jurisdiction or geotechnical data determines Site Class E or F soils are present at the site.

UNIVERSIDAD CATOLICA DE SANTIAGO DE GUAYAQUIL

Chapter 22

SEISMIC GROUND MOTION AND LONG-PERIOD TRANSITION MAPS

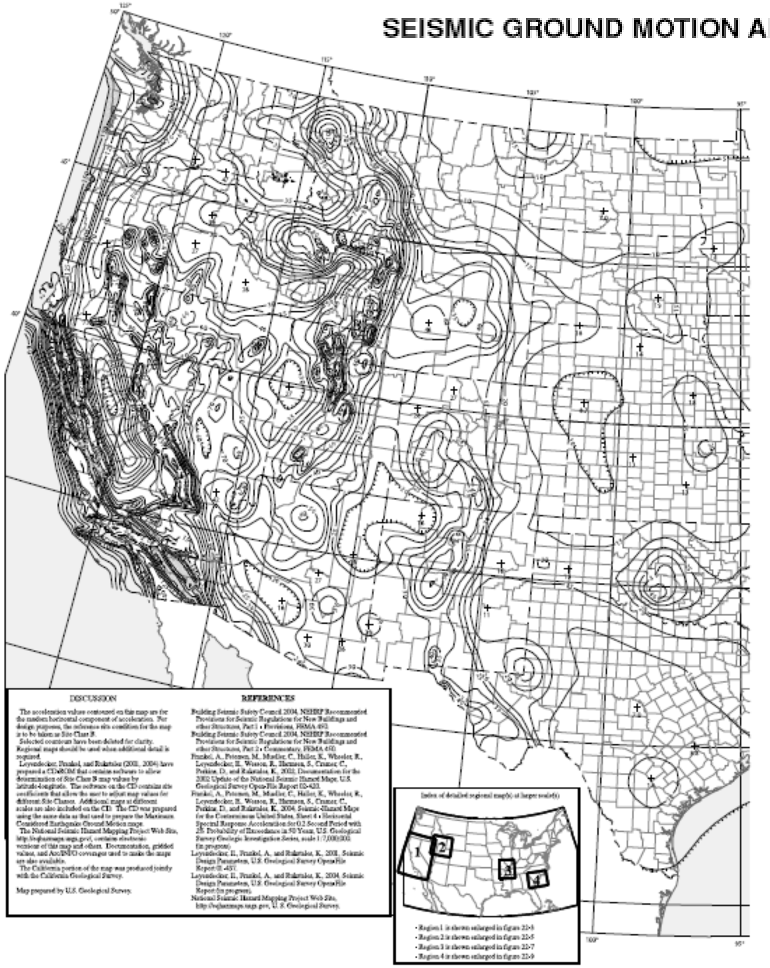

FIGURE 22-1 MAXIMUM CONSIDERED EARTHQUAKE GROUND MOTION FOR THE CONTERMINOUS UNITED STATES OF 0.2 SEC SPECTRAL RESPONSE ACCELERATION (5% OF CRITICAL DAMPING), SITE CLASS B

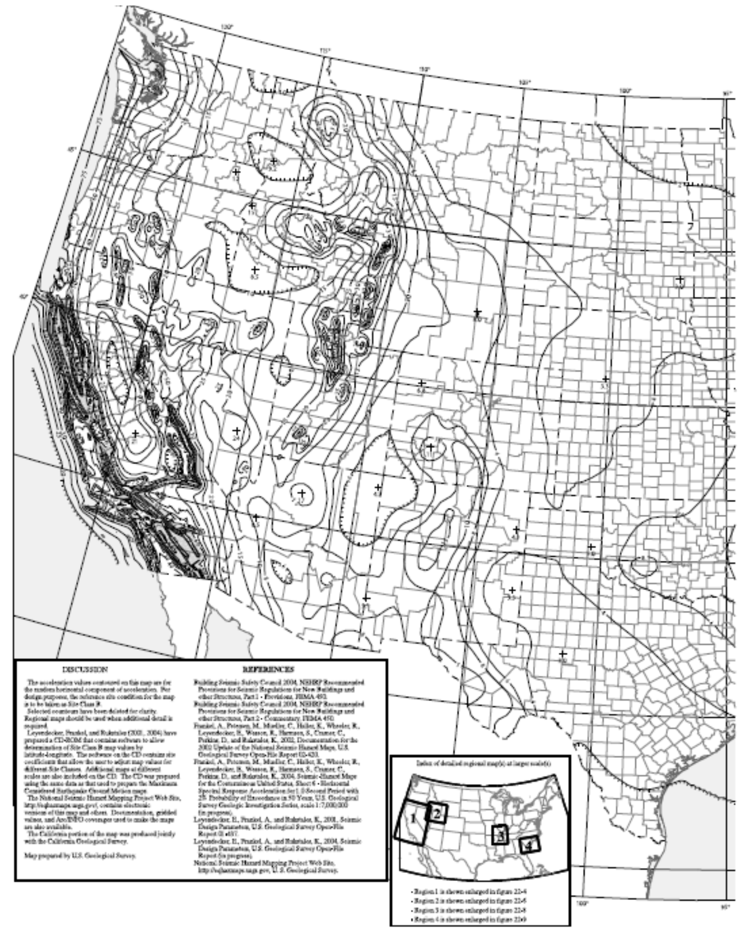

FIGURE 22-2 MAXIMUM CONSIDERED EARTHQUAKE GROUND MOTION FOR THE CONTERMINOUS UNITED STATES OF 1.0 SEC SPECTRAL RESPONSE ACCELERATION (5% OF CRITICAL DAMPING), SITE CLASS B

Chapter 11

SEISMIC DESIGN CRITERIA

11.4.3 Site Coefficients and Adjusted Maximum Considered Earthquake (MCE) Spectral Response Acceleration Parameters. The MCE spectral response acceleration for short periods (S_{MS}) and at 1 s (S_{M1}), adjusted for Site Class effects, shall be determined by Eqs. 11.4-1 and 11.4-2, respectively.

$$S_{MS} = F_a S_s \tag{11.4-1}$$

$$S_{M1} = F_v S_1 \tag{11.4-2}$$

where

S_S = the mapped MCE spectral response acceleration at short periods as determined in accordance with Section 11.4.1, and

S_1 = the mapped MCE spectral response acceleration at a period of 1 s as determined in accordance with Section 11.4.1

TABLE 11.4-1 SITE COEFFICIENT, F_a

Site Class	Mapped Maximum Considered Earthquake Spectral Response Acceleration Parameter at Short Period				
	$S_S \leq 0.25$	$S_S = 0.5$	$S_S = 0.75$	$S_S = 1.0$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7				

NOTE: Use straight-line interpolation for intermediate values of S_S.

TABLE 11.4-2 SITE COEFFICIENT, F_v

Site Class	Mapped Maximum Considered Earthquake Spectral Response Acceleration Parameter at 1-s Period				
	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \geq 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7				

NOTE: Use straight-line interpolation for intermediate values of S_1.

11.4.4 Design Spectral Acceleration Parameters. Design earthquake spectral response acceleration parameter at short period, S_{DS}, and at 1 s period, S_{D1}, shall be determined from Eqs. 11.4-3 and 11.4-4, respectively. Where the alternate simplified design procedure of Section 12.14 is used, the value of S_{DS} shall be determined in accordance with Section 12.14.8.1, and the value for S_{D1} need not be determined.

$$S_{DS} = \frac{2}{3} S_{MS} \qquad (11.4\text{-}3)$$

$$S_{D1} = \frac{2}{3} S_{M1} \qquad (11.4\text{-}4)$$

11.4.5 Design Response Spectrum. Where a design response spectrum is required by this standard and site-specific ground motion procedures are not used, the design response spectrum curve shall be developed as indicated in Fig. 11.4-1 and as follows:

1. For periods less than T_0, the design spectral response acceleration, S_a, shall be taken as given by Eq. 11.4-5:

$$S_a = S_{DS}\left(0.4 + 0.6\frac{T}{T_0}\right) \qquad (11.4\text{-}5)$$

2. For periods greater than or equal to T_0 and less than or equal to T_S, the design spectral response acceleration, S_a, shall be taken equal to S_{DS}.

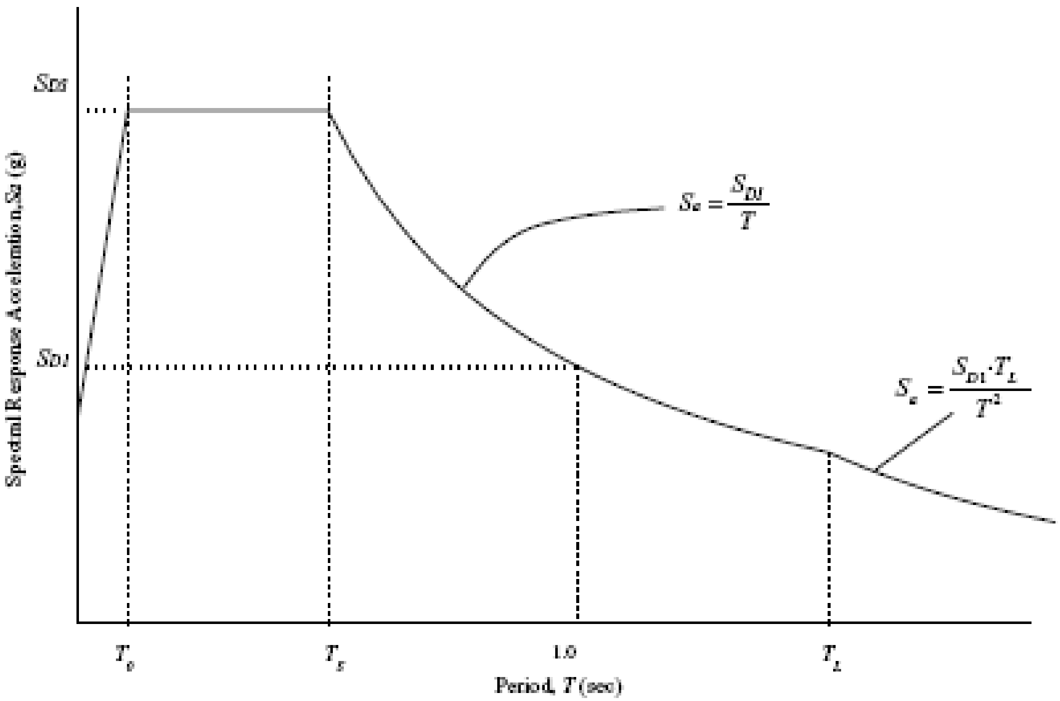

FIGURE 11.4-1 DESIGN RESPONSE SPECTRUM

3. For periods greater than T_S, and less than or equal to T_L, the design spectral response acceleration, S_a, shall be taken as given by Eq. 11.4-6:

$$S_a = \frac{S_{D1}}{T} \quad (11.4\text{-}6)$$

4. For periods greater than T_L, S_a shall be taken as given by Eq. 11.4-7:

$$S_a = \frac{S_{D1} T_L}{T^2} \quad (11.4\text{-}7)$$

where

S_{DS} = the design spectral response acceleration parameter at short periods

S_{D1} = the design spectral response acceleration parameter at 1-s period

T = the fundamental period of the structure, s

$$T_0 = 0.2 \frac{S_{D1}}{S_{DS}}$$

$$T_S = \frac{S_{D1}}{S_{DS}} \text{ and}$$

T_L = long-period transition period (s) shown in Fig. 22-15 (Conterminous United States), Fig. 22-16 (Region 1), Fig. 22-17 (Alaska), Fig. 22-18 (Hawaii), Fig. 22-19 (Puerto Rico, Culebra, Vieques, St. Thomas, St. John, and St. Croix), and Fig. 22-20 (Guam and Tutuila).

11.5 IMPORTANCE FACTOR AND OCCUPANCY CATEGORY

11.5.1 Importance Factor. An importance factor, *I*, shall be assigned to each structure in accordance with Table 11.5-1 based on the Occupancy Category from Table 1-1.

11.5.2 Protected Access for Occupancy Category IV. Where operational access to an Occupancy Category IV structure is required through an adjacent structure, the adjacent structure shall conform to the requirements for Occupancy Category IV structures. Where operational access is less than 10 ft from an interior lot line or another structure on the same lot, protection from potential falling debris from adjacent structures shall be provided by the owner of the Occupancy Category IV structure.

TABLE 11.5-1 IMPORTANCE FACTORS

Occupancy Category	*I*
I or II	1.0
III	1.25
IV	1.5

11.5 IMPORTANCE FACTOR AND OCCUPANCY CATEGORY

11.5.1 Importance Factor. An importance factor, *I*, shall be assigned to each structure in accordance with Table 11.5-1 based on the Occupancy Category from Table 1-1.

11.5.2 Protected Access for Occupancy Category IV. Where operational access to an Occupancy Category IV structure is required through an adjacent structure, the adjacent structure shall conform to the requirements for Occupancy Category IV structures. Where operational access is less than 10 ft from an interior lot line or another structure on the same lot, protection from potential falling debris from adjacent structures shall be provided by the owner of the Occupancy Category IV structure.

TABLE 11.5-1 IMPORTANCE FACTORS

Occupancy Category	*I*
I or II	1.0
III	1.25
IV	1.5

TABLE 1-1 OCCUPANCY CATEGORY OF BUILDINGS AND OTHER STRUCTURES FOR FLOOD, WIND, SNOW, EARTHQUAKE, AND ICE LOADS

Nature of Occupancy	Occupancy Category
Buildings and other structures that represent a low hazard to human life in the event of failure, including, but not limited to: • Agricultural facilities • Certain temporary facilities • Minor storage facilities	I
All buildings and other structures except those listed in Occupancy Categories I, III, and IV	II
Buildings and other structures that represent a substantial hazard to human life in the event of failure, including, but not limited to: • Buildings and other structures where more than 300 people congregate in one area • Buildings and other structures with daycare facilities with a capacity greater than 150 • Buildings and other structures with elementary school or secondary school facilities with a capacity greater than 250 • Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities • Health care facilities with a capacity of 50 or more resident patients, but not having surgery or emergency treatment facilities • Jails and detention facilities Buildings and other structures, not included in Occupancy Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure, including, but not limited to: • Power generating stations[a] • Water treatment facilities • Sewage treatment facilities • Telecommunication centers Buildings and other structures not included in Occupancy Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released. Buildings and other structures containing toxic or explosive substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the toxic or explosive substances does not pose a threat to the public.	III

TABLE 1-1 OCCUPANCY CATEGORY OF BUILDINGS AND OTHER STRUCTURES FOR FLOOD, WIND, SNOW, EARTHQUAKE, AND ICE LOADS

Buildings and other structures designated as essential facilities, including, but not limited to: • Hospitals and other health care facilities having surgery or emergency treatment facilities • Fire, rescue, ambulance, and police stations and emergency vehicle garages • Designated earthquake, hurricane, or other emergency shelters • Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response • Power generating stations and other public utility facilities required in an emergency • Ancillary structures (including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment) required for operation of Occupancy Category IV structures during an emergency • Aviation control towers, air traffic control centers, and emergency aircraft hangars • Water storage facilities and pump structures required to maintain water pressure for fire suppression • Buildings and other structures having critical national defense functions Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing highly toxic substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction. Buildings and other structures containing highly toxic substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the highly toxic substances does not pose a threat to the public. This reduced classification shall not be permitted if the buildings or other structures also function as essential facilities.	IV

[a] Cogeneration power plants that do not supply power on the national grid shall be designated Occupancy Category II.