

**TABLE 1615.1.2(1)**  
**VALUES OF SITE COEFFICIENT  $F_a$  AS A FUNCTION OF SITE CLASS**  
**AND MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIODS ( $S_s$ )<sup>a</sup>**

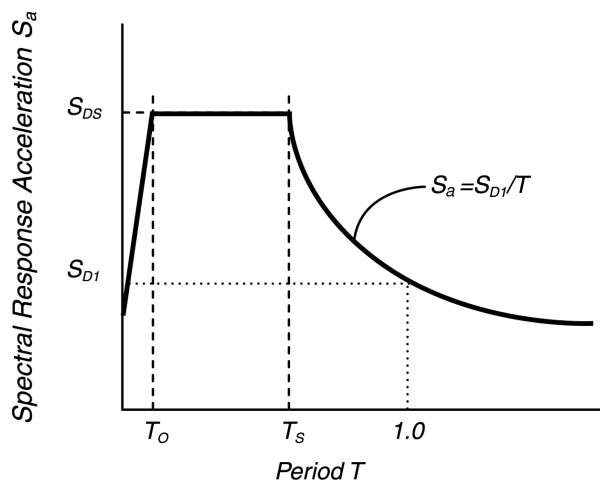
SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIODS				
	$S_s \leq 0.25$	$S_s = 0.50$	$S_s = 0.75$	$S_s = 1.00$	$S_s \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	Note b	Note b	Note b	Note b	Note b

- a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at short period,  $S_s$ .
- b. Site-specific geotechnical investigation and dynamic site response analyses shall be performed to determine appropriate values, except that for structures with periods of vibration equal to or less than 0.5 second, values of  $F_a$  for liquefiable soils are permitted to be taken equal to the values for the site class determined without regard to liquefaction in Section 1615.1.5.1.

**TABLE 1615.1.2(2)**  
**VALUES OF SITE COEFFICIENT  $F_v$  AS A FUNCTION OF SITE CLASS**  
**AND MAPPED SPECTRAL RESPONSE ACCELERATION AT 1-SECOND PERIOD ( $S_1$ )<sup>a</sup>**

SITE CLASS	MAPPED SPECTRAL RESPONSE ACCELERATION AT SHORT PERIODS				
	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \geq 0.5$
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	Note b	Note b	Note b	Note b	Note b

- a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at 1-second period,  $S_1$ .
- b. Site-specific geotechnical investigation and dynamic site response analyses shall be performed to determine appropriate values, except that for structures with periods of vibration equal to or less than 0.5 second, values of  $F_v$  for liquefiable soils are permitted to be taken equal to the values for the site class determined without regard to liquefaction in Section 1615.1.5.1.



**FIGURE 1615.1.4**  
**DESIGN RESPONSE SPECTRUM**

3. For periods greater than  $T_S$ , the design spectral response acceleration,  $S_a$ , shall be determined by Equation 16-43.

$$S_a = 0.6 \frac{S_{DS}}{T_O} T + 0.4 S_{DS} \quad \text{(Equation 16-42)}$$

$$S_a = \frac{S_{DI}}{T} \quad \text{(Equation 16-43)}$$

where:

$S_{DS}$  = The design spectral response acceleration at short periods as determined in Section 1615.1.3.

$S_{DI}$  = The design spectral response acceleration at 1-second period as determined in Section 1615.1.3.

$T$  = Fundamental period (in seconds) of the structure (see Section 9.5.5.3 of ASCE 7).

$$T_O = 0.2 S_{DI}/S_{DS}$$

$$T_S = S_{DI}/S_{DS}$$

**1615.1.5 Site classification for seismic design.** Site classification for Site Class C, D or E shall be determined from Table 1615.1.5.

The notations presented below apply to the upper 100 feet (30 480 mm) of the site profile. Profiles containing distinctly different soil layers shall be subdivided into those layers designated by a number that ranges from 1 to  $n$  at the bottom where there is a total of  $n$  distinct layers in the upper 100 feet (30 480 mm). The symbol,  $i$ , then refers to any one of the layers between 1 and  $n$ .

where:

- $v_{si}$  = The shear wave velocity in feet per second (m/s).
- $d_i$  = The thickness of any layer between 0 and 100 feet (30 480 mm).

$$\bar{v}_s = \frac{\sum_{i=1}^n d_i}{\sum_{i=1}^n \frac{d_i}{v_{si}}} \quad \text{(Equation 16-44)}$$

$$\sum_{i=1}^n d_i = 100 \text{ feet (30 480 mm)}$$

$N_i$  is the Standard Penetration Resistance (ASTM D 1586-84) not to exceed 100 blows/foot (mm) as directly measured in the field without corrections.

$$\bar{N} = \frac{\sum_{i=1}^n d_i}{\sum_{i=1}^n \frac{d_i}{N_i}} \quad \text{(Equation 16-45)}$$

$$\bar{N}_{ch} = \frac{d_s}{\sum_{i=1}^m \frac{d_i}{N_i}} \quad \text{(Equation 16-46)}$$

where:

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

Use only  $d_i$  and  $N_i$  for cohesionless soils.

$d_s$  = The total thickness of cohesionless soil layers in the top 100 feet (30 480 mm).

$s_{ui}$  = The undrained shear strength in psf (kPa), not to exceed 5,000 psf (240 kPa), ASTM D 2166-91 or D 2850-87.

$$\bar{s}_u = \frac{d_c}{\sum_{i=1}^k \frac{d_i}{s_{ui}}} \quad \text{(Equation 16-47)}$$

where:

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

$d_c$  = The total thickness (100 –  $d_s$ ) (For SI: 30 480 –  $d_s$ ) of cohesive soil layers in the top 100 feet (30 480 mm).

$PI$  = The plasticity index, ASTM D 4318.

$w$  = The moisture content in percent, ASTM D 2216.

The shear wave velocity for rock, Site Class B, shall be either measured on site or estimated by a geotechnical engineer or engineering geologist/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.

The hard rock, Site Class A, category shall be supported by shear wave velocity measurements 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 feet (30 480 mm), surficial shear wave velocity measurements are permitted to be extrapolated to assess  $\bar{v}_s$ .

The rock categories, Site Classes A and B, shall not be used if there is more than 10 feet (3048 mm) of soil between the rock surface and the bottom of the spread footing or mat foundation.

**1615.1.5.1 Steps for classifying a site.**

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.
2. Check for the existence of a total thickness of soft clay > 10 feet (3048 mm) where a soft clay layer is defined by:  $\bar{s}_u < 500$  psf (25 kPa),  $w \geq 40$  percent, and  $PI > 20$ . If these criteria are satisfied, classify the site as Site Class E.
3. Categorize the site using one of the following three methods with  $\bar{v}_s$ ,  $\bar{N}$ , and  $\bar{s}_u$  computed in all cases as specified.
  - 3.1.  $\bar{v}_s$  for the top 100 feet (30 480 mm) ( $\bar{v}_s$  method).

**TABLE 1615.1.5  
SITE CLASSIFICATION<sup>a</sup>**

SITE CLASS	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
E	< 600 ft/s	< 15	< 1,000 psf
D	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
C	1,200 to 2,500 ft/s	> 50	> 2,000

For SI: 1 foot per second = 304.8 mm per second, 1 pound per square foot = 0.0479 kN/m<sup>2</sup>.

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

- 3.2.  $\bar{N}$  for the top 100 feet (30 480 mm) ( $\bar{N}$  method).
- 3.3.  $\bar{N}_{ch}$  for cohesionless soil layers ( $PI < 20$ ) in the top 100 feet (30 480 mm) and average,  $\bar{s}_u$ , for cohesive soil layers ( $PI > 20$ ) in the top 100 feet (30 480 mm) ( $\bar{s}_u$  method).

**1615.2 Site-specific procedure for determining ground motion accelerations.** A site-specific study shall account for the regional seismicity and geology; the expected recurrence rates and maximum magnitudes of events on known faults and source zones; the location of the site with respect to these; near source effects if any and the characteristics of subsurface site conditions.

**1615.2.1 Probabilistic maximum considered earthquake.** Where site-specific procedures are used as required or permitted by Section 1615, the maximum considered earthquake ground motion shall be taken as that motion represented by an acceleration response spectrum having a 2-percent probability of exceedance within a 50-year period. The maximum considered earthquake spectral response acceleration at any period,  $S_{aM}$ , shall be taken from the 2-percent probability of exceedance within a 50-year period spectrum.

**Exception:** Where the spectral response ordinates at 0.2 second or 1 second for a 5-percent damped spectrum having a 2-percent probability of exceedance within a 50-year period exceed the corresponding ordinates of the deterministic limit of Section 1615.2.2, the maximum considered earthquake ground motion spectrum shall be taken as the lesser of the probabilistic maximum considered earthquake ground motion or the deterministic maximum considered earthquake ground motion spectrum of Section 1615.2.3, but shall not be taken as less than the deterministic limit ground motion of Section 1615.2.2.

**1615.2.2 Deterministic limit on maximum considered earthquake ground motion.** The deterministic limit for the maximum considered earthquake ground motion shall be the response spectrum determined in accordance with Figure 1615.2.2, where site coefficients,  $F_a$  and  $F_v$ , are determined in accordance with Section 1615.1.2, with the value of the mapped short-period spectral response acceleration,  $S_s$ , taken as 1.5g and the value of the mapped spectral response acceleration at 1 second,  $S_1$ , taken as 0.6g.

**1615.2.3 Deterministic maximum considered earthquake ground motion.** The deterministic maximum considered earthquake ground motion response spectrum shall be calculated as 150 percent of the median spectral response accelerations,  $S_{aM}$ , at all periods resulting from a characteristic earthquake on any known active fault within the region.

**1615.2.4 Site-specific design ground motion.** Where site-specific procedures are used to determine the maximum considered earthquake ground motion response spectrum, the design spectral response acceleration,  $S_a$ , at any period shall be determined from Equation 16-48:

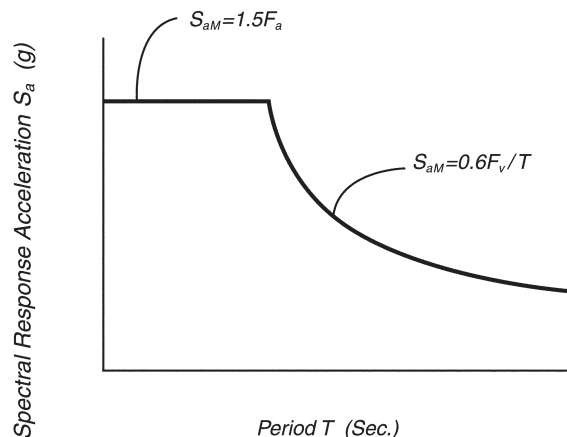
$$S_a = \frac{2}{3} S_{aM} \quad \text{(Equation 16-48)}$$

and shall be greater than or equal to 80 percent of the design spectral response acceleration,  $S_a$ , determined by the general response spectrum in Section 1615.1.4.

**1615.2.5 Design spectral response coefficients.** Where the site-specific procedure is used to determine the design ground motion in accordance with Section 1615.2.4, the parameter  $S_{DS}$  shall be taken as the spectral acceleration,  $S_a$ , obtained from the site-specific spectra 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. The parameter  $S_{DI}$  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 of 2 seconds. The parameters  $S_{MS}$  and  $S_{MI}$  shall be taken as 1.5 times  $S_{DS}$  and  $S_{DI}$ , respectively. The values so obtained shall not be taken as less than 80 percent of the values obtained from the general procedures of Section 1615.1.

**SECTION 1616  
EARTHQUAKE LOADS—CRITERIA SELECTION**

**1616.1 Structural design criteria.** Each structure shall be assigned to a seismic design category in accordance with Section 1616.3. Seismic design categories are used in this code to determine permissible structural systems, limitations on height and irregularity, those components of the structure that must be designed for seismic resistance and the types of lateral force analysis that must be performed. Each structure shall be provided with complete lateral- and vertical-force-resisting systems capable of providing adequate strength, stiffness and energy dissipation capacity to withstand the design earthquake ground motions determined in accordance with Section 1615 within the prescribed deformation limits of Section 1617.3. The design ground motions shall be assumed to occur along any horizontal direction of a structure. A continuous load path, or paths, with adequate strength and stiffness to transfer forces induced by the design earthquake ground motions from the points of application to the final point of resistance shall be provided.



**FIGURE 1615.2.2  
DETERMINISTIC LIMIT ON MAXIMUM CONSIDERED  
EARTHQUAKE RESPONSE SPECTRUM**

Allowable stress design is permitted to be used to evaluate sliding, overturning and soil bearing at the soil-structure interface regardless of the approach used in the design of the structure, provided load combinations of Section 1605.3 are utilized. When using allowable stress design for proportioning foundations, the value of  $0.2 S_{DS}D$  in Equations 16-50, 16-51, 16-52 and 16-53 or Equations 9.5.2.7-1, 9.5.2.7-2, 9.5.2.7.1-1 and 9.5.2.7.1-2 of ASCE 7 is permitted to be taken equal to zero. When the load combinations of Section 1605.3.2 are utilized, a one-third increase in soil allowable stresses is permitted for all load combinations that include  $W$  or  $E$ .

**1616.2 Seismic use groups and occupancy importance factors.** Each structure shall be assigned a seismic use group and a corresponding occupancy importance factor ( $I_E$ ) as indicated in Table 1604.5.

**1616.2.1 Seismic Use Group I.** Seismic Use Group I structures are those not assigned to either Seismic Use Group II or III.

**1616.2.2 Seismic Use Group II.** Seismic Use Group II structures are those, the failure of which would result in a substantial public hazard due to occupancy or use as indicated by Table 1604.5, or as designated by the building official.

**1616.2.3 Seismic Use Group III.** Seismic Use Group III structures are those having essential facilities that are required for postearthquake recovery and those containing substantial quantities of hazardous substances, as indicated in Table 1604.5, or as designated by the building official.

Where operational access to a Seismic Use Group III structure is required through an adjacent structure, the adjacent structure shall conform to the requirements for Seismic Use Group III structures. Where operational access is less than 10 feet (3048 mm) from an interior lot line or less than 10 feet (3048 mm) from another structure, access protection from potential falling debris shall be provided by the owner of the Seismic Use Group III structure.

**1616.2.4 Multiple occupancies.** Where a structure is occupied for two or more occupancies not included in the same seismic use group, the structure shall be assigned the classification of the highest seismic use group corresponding to the various occupancies.

Where structures have two or more portions that are structurally separated in accordance with Section 1620, each portion shall be separately classified. Where a structurally separated portion of a structure provides required access to, required egress from or shares life safety components with another portion having a higher seismic use group, both portions shall be assigned the higher seismic use group.

**1616.3 Determination of seismic design category.** All structures shall be assigned to a seismic design category based on their seismic use group and the design spectral response acceleration coefficients,  $S_{DS}$  and  $S_{DI}$ , determined in accordance with Section 1615.1.3 or 1615.2.5. Each building and structure shall be assigned to the most severe seismic design category in accordance with Table 1616.3(1) or 1616.3(2), irrespective of the fundamental period of vibration of the structure,  $T$ . All concrete and masonry structures shall be designed and constructed to meet as a minimum the requirements of Seismic Design Category C, when the seismic design category is calculated to be A or B. In such

instances Sections 903.3.5.2 and 1621 shall not apply except as applicable to Seismic Design Categories A and B.

**Exception:** The seismic design category is permitted to be determined from Table 1616.3(1) alone when all of the following apply:

1. The approximate fundamental period of the structure,  $T_a$ , in each of the two orthogonal directions determined in accordance with Section 9.5.5.3.2 of ASCE 7, is less than  $0.8 T_s$  determined in accordance with Section 1615.1.4,
2. Equation 9.5.5.2.1-1 of ASCE 7 is used to determine the seismic response coefficient,  $C_s$ , and
3. The diaphragms are rigid as defined in Section 1602.

**TABLE 1616.3(1)  
SEISMIC DESIGN CATEGORY BASED ON  
SHORT-PERIOD RESPONSE ACCELERATIONS**

VALUE OF $S_{DS}$	SEISMIC USE GROUP		
	I	II	III
$S_{DS} < 0.167g$	A	A	A
$0.167g \leq S_{DS} < 0.33g$	B	B	C
$0.33g \leq S_{DS} < 0.50g$	C	C	D
$0.50g \leq S_{DS}$	D <sup>a</sup>	D <sup>a</sup>	D <sup>a</sup>

a. Seismic Use Group I and II structures located on sites with mapped maximum considered earthquake spectral response acceleration at 1-second period,  $S_j$ , equal to or greater than  $0.75g$ , shall be assigned to Seismic Design Category E, and Seismic Use Group III structures located on such sites shall be assigned to Seismic Design Category F.

**TABLE 1616.3(2)  
SEISMIC DESIGN CATEGORY BASED ON  
1-SECOND PERIOD RESPONSE ACCELERATION**

VALUE OF $S_{DI}$	SEISMIC USE GROUP		
	I	II	III
$S_{DI} < 0.067g$	A	A	A
$0.067g \leq S_{DI} < 0.133g$	B	B	C
$0.133g \leq S_{DI} < 0.20g$	C	C	D
$0.20g \leq S_{DI}$	D <sup>a</sup>	D <sup>a</sup>	D <sup>a</sup>

a. Seismic Use Group I and II structures located on sites with mapped maximum considered earthquake spectral response acceleration at 1-second period,  $S_j$ , equal to or greater than  $0.75g$ , shall be assigned to Seismic Design Category E, and Seismic Use Group III structures located on such sites shall be assigned to Seismic Design Category F.

**1616.3.1 Site limitation for Seismic Design Category E or F.** A structure assigned to Seismic Design Category E or F shall not be sited over an identified active fault trace.

**Exception:** Detached Group R-3 as applicable in Section 101.2 of light-frame construction.

**1616.4 Design requirements for Seismic Design Category A.** Structures assigned to Seismic Design Category A need only comply with the requirements of Sections 1616.4.1 through 1616.4.5.

**1616.4.1 Minimum lateral force.** Structures shall be provided with a complete lateral-force-resisting system designed to resist the minimum lateral force,  $F_x$ , applied simultaneously at each floor level given by Equation 16-49:

$$F_x = 0.01 w_x \quad \text{(Equation 16-49)}$$

where:

- $F_x$  = The design lateral force applied at Level  $x$ .
- $w_x$  = The portion of the total gravity load of the structure,  $W$ , located or assigned to Level  $x$ .
- $W$  = The total dead load and other loads listed below:
1. In areas used for storage, a minimum of 25 percent of the reduced floor live load (floor live load in public garages and open parking structures need not be included).
  2. Where an allowance for partition load is included in the floor load design, the actual partition weight or a minimum weight of 10 psf (0.479 kN/m<sup>2</sup>) of floor area, whichever is greater.
  3. Total operating weight of permanent equipment.
  4. Twenty percent of flat roof snow load where flat roof snow load exceeds 30 psf (1.44 kN/m<sup>2</sup>).

The direction of application of seismic forces used in design shall be that which will produce the most critical load effect in each component. The design seismic forces are permitted to be applied separately in each of two orthogonal directions and orthogonal effects are permitted to be neglected.

The effect of this lateral force shall be taken as  $E$  in the load combinations prescribed in Section 1605.2 for strength or load and resistance factor design methods, or Section 1605.3 for allowable stress design methods. Special seismic load combinations that include  $E_m$  need not be considered.

**1616.4.2 Connections.** All parts of the structure between separation joints shall be interconnected, and the connections shall be capable of transmitting the seismic force,  $F_p$ , induced in the connection by the parts being connected. Any smaller portion of the structure shall be tied to the remainder of the structure for  $F_p$  equal to 0.05 times the weight of the smaller portion. A positive connection for resisting horizontal forces acting on the member shall be provided for each beam, girder or truss to its support. The connection shall have strength sufficient to resist 5 percent of the dead and live load vertical reaction applied horizontally.

**1616.4.3 Anchorage of concrete or masonry walls.** See Section 1604.8.2.

**1616.4.4 Conventional light-frame construction.** Buildings constructed in compliance with Section 2308 are deemed to comply with Sections 1616.4.1, 1616.4.2 and 1616.4.3.

**1616.4.5 Tank freeboard.** Tanks in Seismic Use Group III according to Table 9.14.5.1.2 of ASCE 7 shall also comply with the freeboard requirements of Section 9.14.7.3.6.1.2 of ASCE 7.

**1616.5 Building configuration.** Buildings shall be classified as regular or irregular based on the criteria in Section 9.5.2.3 of ASCE 7.

**Exception:** Buildings designed using the simplified analysis procedure in Section 1617.5 shall be classified in accordance with Section 1616.5.1.

**1616.5.1 Building configuration (for use in the simplified analysis procedure of Section 1617.5).** Buildings designed using the simplified analysis procedure in Section 1617.5

shall be classified as regular or irregular based on the criteria in this section. Such classification shall be based on the plan and vertical configuration. Buildings shall not exceed the limitations of Section 1616.6.1.

**1616.5.1.1 Plan irregularity.** Buildings having one or more of the features listed in Table 1616.5.1.1 shall be designated as having plan structural irregularity and shall comply with the requirements in the sections referenced in that table.

**1616.5.1.2 Vertical irregularity.** Buildings having one or more of the features listed in Table 1616.5.1.2 shall be designated as having vertical irregularity and shall comply with the requirements in the sections referenced in that table.

**Exceptions:**

1. Structural irregularities of Type 1a, 1b or 2 in Table 1616.5.1.2 do not apply where no story drift ratio under design lateral load is greater than 130 percent of the story drift ratio of the next story above. Torsional effects need not be considered in the calculation of story drifts for the purpose of this determination. The story drift ratio relationship for the top two stories of the building is not required to be evaluated.
2. Irregularities of Types 1a, 1b and 2 of Table 1616.5.1.2 are not required to be considered for one-story buildings in any seismic design category or for two-story buildings in Seismic Design Category A, B, C or D.

**1616.6 Analysis procedures.** A structural analysis conforming to one of the types permitted in Section 9.5.2.5.1 of ASCE 7 or to the simplified procedure in Section 1617.5 shall be made for all structures. The analysis shall form the basis for determining the seismic forces,  $E$  and  $E_m$ , to be applied in the load combinations of Section 1605 and shall form the basis for determining the design drift as required by Section 9.5.2.8 of ASCE 7 or Section 1617.3.

**Exceptions:**

1. Structures assigned to Seismic Design Category A.
2. Design drift need not be evaluated in accordance with Section 1617.3 when the simplified analysis method of Section 1617.5 is used.

**1616.6.1 Simplified analysis.** A simplified analysis, in accordance with Section 1617.5, shall be permitted to be used for any structure in Seismic Use Group I, subject to the following limitations, or a more rigorous analysis shall be made:

1. Buildings of light-framed construction not exceeding three stories in height, excluding basements.
2. Buildings of any construction other than light-framed construction, not exceeding two stories in height, excluding basements, with flexible diaphragms at every level as defined in Section 1602.

**TABLE 1616.5.1.1  
PLAN STRUCTURAL IRREGULARITIES**

IRREGULARITY TYPE AND DESCRIPTION		REFERENCE SECTION	SEISMIC DESIGN CATEGORY <sup>a</sup> APPLICATION
1a	Torsional Irregularity—to be considered when diaphragms are not flexible as determined in Section 1602.1.1 Torsional irregularity shall be considered to exist when the maximum story drift, computed including accidental torsion, at one end of the structure transverse to an axis is more than 1.2 times the average of the story drifts at the two ends of the structure.	9.5.5.5.2 of ASCE 7 1620.4.1 9.5.2.5.1 of ASCE 7 9.5.5.7.1 of ASCE 7	C, D, E and F D, E and F D, E and F C, D, E and F
1b	Extreme Torsional Irregularity—to be considered when diaphragms are not flexible as determined in Section 1602.1. Extreme torsional irregularity shall be considered to exist when the maximum story drift, computed and including accidental torsion, at one end of the structure transverse to an axis is more than 1.4 times the average of the story drifts at the two ends of the structure.	9.5.5.5.2 of ASCE 7 1620.4.1 1620.5.1 9.5.2.5.1 of ASCE 7 9.5.5.7.1 of ASCE 7	C, D, E and F D E and F D, E and F C, D, E and F
2	Reentrant Corners Plan configurations of a structure and its lateral-force-resisting system contain reentrant corners where both projections of the structure beyond a reentrant corner are greater than 15 percent of the plan dimension of the structure in the given direction.	1620.4.1	D, E and F
3	Diaphragm Discontinuity Diaphragms with abrupt discontinuities or variations in stiffness, including those having cutout or open areas greater than 50 percent of the gross enclosed diaphragm area, or changes in effective diaphragm stiffness of more than 50 percent from one story to the next.	1620.4.1	D, E and F
4	Out-of-Plane Offsets Discontinuities in a lateral-force-resistance path, such as out-of-plane offsets of the vertical elements.	1620.4.1 9.5.2.5.1 of ASCE 7 1620.2.9	D, E and F D, E and F B, C, D, E and F
5	Nonparallel Systems The vertical lateral-force-resisting elements are not parallel to or symmetric about the major orthogonal axes of the lateral-force-resisting system.	1620.3.2	C, D, E and F

a. Seismic design category is determined in accordance with Section 1616.

**TABLE 1616.5.1.2  
VERTICAL STRUCTURAL IRREGULARITIES**

IRREGULARITY TYPE AND DESCRIPTION		REFERENCE SECTION	SEISMIC DESIGN CATEGORY <sup>a</sup> APPLICATION
1a	Stiffness Irregularity—Soft Story A soft story is one in which the lateral stiffness is less than 70 percent of that in the story above or less than 80 percent of the average stiffness of the three stories above.	9.5.2.5.1 of ASCE 7	D, E, and F
1b	Stiffness Irregularity—Extreme Soft Story An extreme soft story is one in which the lateral stiffness is less than 60 percent of that in the story above or less than 70 percent of the average stiffness of the three stories above.	1620.5.1 9.5.2.5.1 of ASCE 7	E and F D, E and F
2	Weight (Mass) Irregularity Mass irregularity shall be considered to exist where the effective mass of any story is more than 150 percent of the effective mass of an adjacent story. A roof that is lighter than the floor below need not be considered.	9.5.2.5.1 of ASCE 7	D, E and F
3	Vertical Geometric Irregularity Vertical geometric irregularity shall be considered to exist where the horizontal dimension of the lateral-force-resisting system in any story is more than 130 percent of that in an adjacent story.	9.5.2.5.1 of ASCE 7	D, E and F
4	In-plane Discontinuity in Vertical Lateral-Force-Resisting Elements An in-plane offset of the lateral-force-resisting elements greater than the length of those elements or a reduction in stiffness of the resisting element in the story below.	1620.4.1 9.5.2.5.1 of ASCE 7 1620.2.9	D, E and F D, E and F B, C, D, E and F
5	Discontinuity in Capacity—Weak Story A weak story is one in which the story lateral strength is less than 80 percent of that in the story above. The story strength is the total strength of seismic-resisting elements sharing the story shear for the direction under consideration.	1620.2.3 9.5.2.5.1 of ASCE 7 1620.5.1	B, C, D, E and F D, E and F E and F

a. Seismic design category is determined in accordance with Section 1616.

## SECTION 1617

### EARTHQUAKE LOADS—MINIMUM DESIGN LATERAL FORCE AND RELATED EFFECTS

**1617.1 Seismic load effect  $E$  and  $E_m$ .** The seismic load effect,  $E$ , for use in the basic load combinations of Sections 1605.2 and 1605.3 shall be determined from Section 9.5.2.7 of ASCE 7. The maximum seismic load effect,  $E_m$ , for use in the special seismic load combination of Section 1605.4 shall be the special seismic load determined from Section 9.5.2.7.1 of ASCE 7.

**Exception:** For structures designed using the simplified analysis procedure in Section 1617.5, the seismic load effects,  $E$  and  $E_m$ , shall be determined from Section 1617.1.1.

**1617.1.1 Seismic load effects,  $E$  and  $E_m$  (for use in the simplified analysis procedure of Section 1617.5).** Seismic load effects,  $E$  and  $E_m$ , for use in the load combinations of Section 1605 for structures designed using the simplified analysis procedure in Section 1617.5 shall be determined as follows.

**1617.1.1.1 Seismic load effect,  $E$ .** Where the effects of gravity and the seismic ground motion are additive, seismic load,  $E$ , for use in Equations 16-5, 16-10 and 16-17, shall be defined by Equation 16-50:

$$E = \rho Q_E + 0.2S_{DS}D \quad \text{(Equation 16-50)}$$

where:

$D$  = The effect of dead load.

$E$  = The combined effect of horizontal and vertical earthquake-induced forces.

$\rho$  = A redundancy coefficient obtained in accordance with Section 1617.2.

$Q_E$  = The effect of horizontal seismic forces.

$S_{DS}$  = The design spectral response acceleration at short periods obtained from Section 1615.1.3 or 1615.2.5.

Where the effects of gravity and seismic ground motion counteract, the seismic load,  $E$ , for use in Equations 16-6, 16-12 and 16-18 shall be defined by Equation 16-51.

$$E = \rho Q_E - 0.2S_{DS}D \quad \text{(Equation 16-51)}$$

Design shall use the load combinations prescribed in Section 1605.2 for strength or load and resistance factor design methodologies, or Section 1605.3 for allowable stress design methods.

**1617.1.1.2 Maximum seismic load effect,  $E_m$ .** The maximum seismic load effect,  $E_m$ , shall be used in the special seismic load combinations in Section 1605.4.

Where the effects of the seismic ground motion and gravity loads are additive, seismic load,  $E_m$ , for use in Equation 16-19, shall be defined by Equation 16-52.

$$E_m = \Omega_0 Q_E + 0.2S_{DS}D \quad \text{(Equation 16-52)}$$

Where the effects of the seismic ground and gravity loads counteract, seismic load,  $E_m$ , for use in Equation 16-20, shall be defined by Equation 16-53.

$$E_m = \Omega_0 Q_E - 0.2S_{DS}D \quad \text{(Equation 16-53)}$$

where  $E$ ,  $Q_E$ ,  $S_{DS}$  are as defined above and  $\Omega_0$  is the system overstrength factor as given in Table 1617.6.2.

The term  $\Omega_0 Q_E$  need not exceed the maximum force that can be transferred to the element by the other elements of the lateral-force-resisting system.

Where allowable stress design methodologies are used with the special load combinations of Section 1605.4, design strengths are permitted to be determined using an allowable stress increase of 1.7 and a resistance factor,  $\phi$ , of 1.0. This increase shall not be combined with increases in allowable stresses or load combination reductions otherwise permitted by this code or the material reference standard except that combination with the duration of load increases in Chapter 23 is permitted.

**1617.2 Redundancy.** The provisions given in Section 9.5.2.4 of ASCE 7 shall be used.

**Exception:** Structures designed using the simplified analysis procedure in Section 1617.5 shall use the redundancy provisions in Sections 1617.2.2.

**1617.2.1 ASCE 7, Sections 9.5.2.4.2 and 9.5.2.4.3.** Modify Sections 9.5.2.4.2 and 9.5.2.4.3 as follows:

**9.5.2.4.2 Seismic Design Category D:** For structures in Seismic Design Category D,  $\rho$  shall be taken as the largest of the values of  $\rho_x$  calculated at each story “ $x$ ” of the structure in accordance with Equation 9.5.2.4.2-1 as follows:

$$\rho_x = 2 - \frac{20}{r_{max_x} \sqrt{A_x}}$$

where:

$r_{max_x}$  = The ratio of the design story shear resisted by the single element carrying the most shear force in the story to the total story shear, for a given direction of loading. For braced frames, the value of  $r_{max_x}$  is equal to the lateral force component in the most heavily loaded brace element divided by the story shear. For moment frames,  $r_{max_x}$  shall be taken as the maximum of the sum of the shears in any two adjacent columns in the plane of a moment frame divided by the story shear. For columns common to two bays with moment-resisting connections on opposite sides at the level under consideration, 70 percent of the shear in that column is permitted to be used in the column shear summation. For shear walls,  $r_{max_x}$  shall be taken equal to shear in the most heavily loaded wall or wall pier multiplied by  $10/l_w$  (the metric coefficient is  $3.3/l_w$ ), divided by the story shear, where  $l_w$  is the wall or wall pier length in feet (m). The value of the ratio of  $10/l_w$  need not be greater than 1.0 for buildings of light-framed construc-

tion. For dual systems,  $r_{max_x}$  shall be taken as the maximum value defined above, considering all lateral-load-resisting elements in the story. The lateral loads shall be distributed to elements based on relative rigidities considering the interaction of the dual system. For dual systems, the value of  $\rho$  need not exceed 80 percent of the value calculated above.

$A_x$  = The floor area in square feet of the diaphragm level immediately above the story.

Calculation of  $r_{max_x}$  need not consider the effects of accidental torsion and any dynamic amplification of torsion required by Section 9.5.5.5.2.

For a story with a flexible diaphragm immediately above,  $r_{max_x}$  shall be permitted to be calculated from an analysis that assumes rigid diaphragm behavior and  $\rho_x$  need not exceed 1.25.

The value of  $\rho$  need not exceed 1.5, which is permitted to be used for any structure. The value of  $\rho$  shall not be taken as less than 1.0.

**Exception:** For structures with seismic-force-resisting systems in any direction comprised solely of special moment frames, the seismic-force-resisting system shall be configured such that the value of  $\rho$  calculated in accordance with this section does not exceed 1.25. The calculated value of  $\rho$  is permitted to exceed this limit when the design story drift,  $\Delta$ , as determined in Section 9.5.5.7, does not exceed  $\Delta_d/\rho$  for any story where  $\Delta_d$  is the allowable story drift from Table 9.5.2.8.

The metric equivalent of Equation 9.5.2.4.2-1 is:

$$\rho_x = 2 - \frac{6.1}{r_{max_x} \sqrt{A_x}}$$

where:  $A_x$  is in square meters.

The value  $\rho$  shall be permitted to be taken equal to 1.0 in the following circumstances:

1. When calculating displacements for dynamic amplification of torsion in Section 9.5.5.5.2.
2. When calculating deflections, drifts and seismic shear forces related to Sections 9.5.5.7.1 and 9.5.5.7.2.
3. For design calculations required by Section 9.5.2.6, 9.6 or 9.14.

For structures with vertical combinations of seismic-force-resisting systems, the value of  $\rho$  shall be determined independently for each seismic-force-resisting system. The redundancy coefficient of the lower portion shall not be less than the following:

$$\rho_L = \frac{R_L \rho_u}{R_u}$$

where:

$\rho_L = \rho$  of lower portion.

$R_L = R$  of lower portion.

$\rho_u = \rho$  of upper portion.

$R_u = R$  of upper portion.

9.5.2.4.3 Seismic Design Categories E and F. For structures in Seismic Design Categories E and F, the value of  $\rho$  shall be calculated as indicated in Section 9.5.2.4.2, above.

**Exception:** For structures with lateral-force-resisting systems in any direction consisting solely of special moment frames, the lateral-force-resisting system shall be configured such that the value of  $\rho$  calculated in accordance with Section 9.5.2.4.2 does not exceed 1.1. The calculated value of  $\rho$  is permitted to exceed this limit when the design story drift,  $\Delta$ , as determined in Section 9.5.5.7, does not exceed  $\Delta_d/\rho$  for any story where  $\Delta_d$  is the allowable story drift from Table 9.5.2.8.

**1617.2.2 Redundancy (for use in the simplified analysis procedure of Section 1617.5).** A redundancy coefficient,  $\rho$ , shall be assigned to each structure designed using the simplified analysis procedure in Section 1617.5 in accordance with this section. Buildings shall not exceed the limitations of Section 1616.6.1.

**1617.2.2.1 Seismic Design Category A, B or C.** For structures assigned to Seismic Design Category A, B or C (see Section 1616), the value of the redundancy coefficient  $\rho$  is 1.0.

**1617.2.2.2 Seismic Design Category D, E or F.** For structures in Seismic Design Category D, E or F (see Section 1616), the redundancy coefficient,  $\rho$ , shall be taken as the largest of the values of,  $\rho_i$ , calculated at each story “ $i$ ” of the structure in accordance with Equation 16-54, as follows:

$$\rho_i = 2 - \frac{20}{r_{max_i} \sqrt{A_i}} \quad \text{(Equation 16-54)}$$

For SI:

$$\rho_i = 2 - \frac{6.1}{r_{max_i} \sqrt{A_i}}$$

where:

$r_{max_i}$  = The ratio of the design story shear resisted by the most heavily loaded single element in the story to the total story shear, for a given direction of loading.

$r_{max_i}$  = For braced frames, the value  $r_{max_i}$ , is equal to the horizontal force component in the most heavily loaded brace element divided by the story shear.

$r_{max_i}$  = For moment frames,  $r_{max_i}$ , shall be taken as the maximum of the sum of the shears in any two adjacent columns in a moment frame divided by the story shear. For columns common to two bays with moment-resisting connections on opposite sides at the level under consideration, it is permitted to use 70 percent of the shear in that column in the column shear summation.

$r_{max_i}$  = For shear walls,  $r_{max_i}$ , shall be taken as the maximum value of the product of the shear in the wall or wall pier and  $10/l_w$  (3.3/ $l_w$  for SI), divided by the story shear, where  $l_w$  is the length of the wall or wall pier in feet (m). In light-framed construction, the value of the ratio of  $10/l_w$  need not be greater than 1.0.

$r_{max_i}$  = For dual systems,  $r_{max_i}$ , shall be taken as the maximum value defined above, considering all lateral-load-resisting elements in the story. The lateral loads shall be distributed to elements based on relative rigidities considering the interaction of the dual system. For dual systems, the value of  $r$  need not exceed 80 percent of the value calculated above.

$A_i$  = The floor area in square feet of the diaphragm level immediately above the story.

For a story with a flexible diaphragm immediately above,  $r_{max_i}$  shall be permitted to be calculated from an analysis that assumes rigid diaphragm behavior and  $\rho$  need not exceed 1.25.

The value,  $\rho$ , shall not be less than 1.0, and need not exceed 1.5.

Calculation of  $r_{max_i}$  need not consider the effects of accidental torsion and any dynamic amplification of torsion required by Section 9.5.5.5.2 of ASCE 7.

For structures with seismic-force-resisting systems in any direction comprised solely of special moment frames, the seismic-force-resisting system shall be configured such that the value of  $\rho$  calculated in accordance with this section does not exceed 1.25 for structures assigned to Seismic Design Category D, and does not exceed 1.1 for structures assigned to Seismic Design Category E or F.

**Exception:** The calculated value of  $\rho$  is permitted to exceed these limits when the design story drift,  $\Delta$ , as determined in Section 1617.5.4, does not exceed  $\Delta_a/\rho$  for any story where  $\Delta_a$  is the allowable story drift from Table 1617.3.1.

The value  $\rho$  shall be permitted to be taken equal to 1.0 in the following circumstances:

1. When calculating displacements for dynamic amplification of torsion in Section 9.5.5.5.2 of ASCE 7.
2. When calculating deflections, drifts and seismic shear forces related to Sections 9.5.5.7.1 and 9.5.5.7.2 of ASCE 7.
3. For design calculations required by Section 1620, 1621 or 1622.

For structures with vertical combinations of seismic-force-resisting systems, the value,  $\rho$ , shall be determined independently for each seismic-force-resisting system. The redundancy coefficient of the lower portion shall not be less than the following:

$$\rho_L = \frac{R_L \rho_u}{R_u} \quad \text{(Equation 16-55)}$$

where:

- $\rho_L$  =  $\rho$  of lower portion.
- $R_L$  =  $R$  of lower portion.
- $\rho_u$  =  $\rho$  of upper portion.
- $R_u$  =  $R$  of upper portion.

**1617.3 Deflection and drift limits.** The provisions given in Section 9.5.2.8 of ASCE 7 shall be used.

**Exception:** Structures designed using the simplified analysis procedure in Section 1617.5 shall meet the provisions in Section 1617.3.1.

**1617.3.1 Deflection and drift limits (for use in the simplified analysis procedure of Section 1617.5).** The design story drift,  $\Delta$ , as determined in Section 1617.5.4, shall not exceed the allowable story drift,  $\Delta_a$ , as obtained from Table 1617.3.1 for any story. All portions of the building shall be designed to act as an integral unit in resisting seismic forces unless separated structurally by a distance sufficient to avoid damaging contact under total deflection as determined in Section 1617.5.4. Buildings shall not exceed the limitations of Section 1616.6.1.

**1617.4 Equivalent lateral force procedure for seismic design of buildings.** The provisions given in Section 9.5.5 of ASCE 7 shall be used.

**1617.5 Simplified analysis procedure for seismic design of buildings.** See Section 1616.6.1 for limitations on the use of this procedure. For purposes of this analytical procedure, a building is considered to be fixed at the base.

**1617.5.1 Seismic base shear.** The seismic base shear,  $V$ , in a given direction shall be determined in accordance with the following equation:

$$V = \frac{1.2 S_{DS}}{R} W \quad \text{(Equation 16-56)}$$

where:

- $S_{DS}$  = The design elastic response acceleration at short period as determined in accordance with Section 1615.1.3.
- $R$  = The response modification factor from Table 1617.6.2.
- $W$  = The effective seismic weight of the structure, including the total dead load and other loads listed below:
  1. In areas used for storage, a minimum of 25 percent of the reduced floor live load (floor live load in public garages and open parking structures need not be included).
  2. Where an allowance for partition load is included in the floor load design, the actual partition weight or a minimum weight of 10 psf of floor area, whichever is greater (0.48 kN/m<sup>2</sup>).
  3. Total weight of permanent operating equipment.
  4. 20 percent of flat roof snow load where flat snow load exceeds 30 psf (1.44 kN/m<sup>2</sup>).

**TABLE 1617.3.1**  
**ALLOWABLE STORY DRIFT,  $\Delta_a$  (inches)<sup>a</sup>**

BUILDING	SEISMIC USE GROUP		
	I	II	III
Buildings, other than masonry shear wall or masonry wall frame buildings, four stories or less in height with interior walls, partitions, ceilings and exterior wall systems that have been designed to accommodate the story drifts	0.025 $h_{sx}$ <sup>b</sup>	0.020 $h_{sx}$	0.015 $h_{sx}$
Masonry cantilever shear wall buildings <sup>c</sup>	0.010 $h_{sx}$	0.010 $h_{sx}$	0.010 $h_{sx}$
Other masonry shear wall buildings	0.007 $h_{sx}$	0.007 $h_{sx}$	0.007 $h_{sx}$
Masonry wall frame buildings	0.013 $h_{sx}$	0.013 $h_{sx}$	0.010 $h_{sx}$
All other buildings	0.020 $h_{sx}$	0.015 $h_{sx}$	0.010 $h_{sx}$

For SI: 1 inch = 25.4 mm.

- a. There shall be no drift limit for single-story buildings with interior walls, partitions, ceilings and exterior wall systems that have been designed to accommodate the story drifts.
- b.  $h_{sx}$  is the story height below Level  $x$ .
- c. Buildings in which the basic structural system consists of masonry shear walls designed as vertical elements cantilevered from their base or foundation support which are so constructed that moment transfer between shear walls (coupling) is negligible.

**1617.5.2 Vertical distribution.** The forces at each level shall be calculated using the following equation:

$$F_x = \frac{1.2 S_{DS}}{R} w_x \quad \text{(Equation 16-57)}$$

where:

$w_x$  = The portion of the effective seismic weight of the structure,  $W$ , at Level  $x$ .

**1617.5.3 Horizontal distribution.** Diaphragms constructed of untopped steel decking or wood structural panels or similar light-framed construction are permitted to be considered as flexible.

**1617.5.4 Design drift.** For the purposes of Sections 1617.3.1 and 1620.4.6, the design story drift,  $\Delta$ , shall be taken as 1 percent of the story height unless a more exact analysis is provided.

**1617.6 Seismic-force-resisting systems.** The provisions given in Section 9.5.2.2 of ASCE 7 shall be used except as modified in Section 1617.6.1.

**Exception:** For structures designed using the simplified analysis procedure in Section 1617.5, the provisions of Section 1617.6.2 shall be used.

**1617.6.1 Modifications to ASCE 7, Section 9.5.2.2.**

**1617.6.1.1 ASCE 7, Table 9.5.2.2.** Modify Table 9.5.2.2 as follows:

1. Bearing wall systems: Ordinary reinforced masonry shear walls shall use a response modification coefficient of  $2^{1/2}$ . Light-framed walls sheathed with wood structural panels rated for shear resistance or steel sheets shall use a response modification coefficient of  $6^{1/2}$ . Table 1617.6.2 entries for ordinary plain prestressed masonry shear walls, intermediate prestressed masonry shear walls and special prestressed masonry shear walls shall apply.

2. Building frame systems: Ordinary reinforced masonry shear walls shall use a response modification coefficient of 3. Light-framed walls sheathed with wood structural panels rated for shear resistance or steel sheets shall use a response modification coefficient of 7. Table 1617.6.2 entries for ordinary plain prestressed masonry shear walls, intermediate prestressed masonry shear walls and special prestressed masonry shear walls shall apply.
3. Dual systems with intermediate moment frames capable of resisting at least 25 percent of prescribed seismic forces. Special steel concentrically braced frames shall use a deflection amplification factor of 5.
4. The table column titled Detailing Reference Section in Table 1617.6.2 shall apply.

**1617.6.1.2 ASCE 7, Section 9.5.2.2.2.1.** Modify Section 9.5.2.2.2.1 by adding Exception 3 as follows:

3. The following two-stage static analysis procedure is permitted to be used for structures having a flexible upper portion supported on a rigid lower portion where both portions of the structure considered separately can be classified as being regular, the average story stiffness of the lower portion is at least 10 times the average story stiffness of the upper portion and the period of the entire structure is not greater than 1.1 times the period of the upper portion considered as a separate structure fixed at the base:
  - 3.1. The flexible upper portion shall be designed as a separate structure using the appropriate values of  $R$  and  $\rho$ .
  - 3.2. The rigid lower portion shall be designed as a separate structure using the appropriate values of  $R$  and  $\rho$ . The reactions from the upper portion shall be those determined

from the analysis of the upper portion amplified by the ratio of the  $R/\rho$  of the upper portion over  $R/\rho$  of the lower portion. This ratio shall not be less than 1.0.

**1617.6.2 Seismic-force-resisting systems (for use in the Simplified analysis procedure of Section 1617.5).** The basic lateral and vertical seismic-force-resisting systems shall conform to one of the types indicated in Table 1617.6.2 subject to the limitations on height indicated in the table based on seismic design category as determined in Section 1616. The appropriate response modification coefficient,  $R$ , system overstrength factor,  $\Omega_o$ , and deflection amplification factor,  $C_d$ , indicated in Table 1617.6.2 shall be used in determining the base shear, element design forces and design story drift. For seismic-force-resisting systems not listed in Table 1617.6.2, analytical and test data shall be submitted that establish the dynamic characteristics and demonstrate the lateral-force resistance and energy dissipation capacity to be equivalent to the structural systems listed in Table 1617.6.2 for equivalent response modification coefficient,  $R$ , system overstrength coefficient,  $\Omega_o$ , and deflection amplification factor,  $C_d$ , values. Buildings shall not exceed the limitations of Section 1616.6.1.

**Exception:** Structures assigned to Seismic Design Category A.

**1617.6.2.1 Dual systems.** For a dual system, the moment frame shall be capable of resisting at least 25 percent of the design forces. The total seismic force resistance is to be provided by the combination of the moment frame and the shear walls or braced frames in proportion to their stiffness.

**1617.6.2.2 Combination along the same axis.** For other than dual systems and shear wall-frame interactive systems, where a combination of different structural systems is utilized to resist lateral forces in the same direction, the value,  $R$ , used for design in that direction shall not be greater than the least value for any of the systems utilized in that same direction.

**Exception:** For light-framed, flexible diaphragm buildings, of Seismic Use Group I and two stories or less in height: Resisting elements are permitted to be designed using the least value of  $R$  for the different structural systems found on each independent line of resistance. The value of  $R$  used for design of diaphragms in such structures shall not be greater than the least value for any of the systems utilized in that same direction.

**1617.6.2.3 Combinations of framing systems.** Where different seismic-force-resisting systems are used along the two orthogonal axes of the structure, the appropriate response modification coefficient,  $R$ , system overstrength factor,  $\Omega_o$ , and deflection amplification factor,  $C_d$ , indicated in Table 1617.6.2 for each system shall be used.

**1617.6.2.3.1 Combination framing factor.** The response modification coefficient,  $R$ , in the direction under consideration at any story shall not exceed the lowest response modification coefficient,  $R$ , for the

seismic-force-resisting system in the same direction considered above that story, excluding penthouses. The system overstrength factor,  $\Omega_o$ , in the direction under consideration at any story, shall not be less than the largest value of this factor for the seismic-force-resisting system in the same direction considered above that story. In structures assigned to Seismic Design Category D, E or F, if a system with a response modification coefficient,  $R$ , with a value less than five is used as part of the seismic-force-resisting system in any direction of the structure, the lowest such value shall be used for the entire structure.

**Exceptions:**

1. Detached one- and two-family dwellings constructed of light framing.
2. The response modification coefficient,  $R$ , and system overstrength factor,  $\Omega_o$ , for supported structural systems with a weight equal to or less than 10 percent of the weight of the structure are permitted to be determined independent of the values of these parameters for the structure as a whole.
3. The following two-stage static analysis procedure is permitted to be used for structures having a flexible upper portion supported on a rigid lower portion where both portions of the structure considered separately can be classified as being regular, the average story stiffness of the lower portion is at least 10 times the average story stiffness of the upper portion and the period of the entire structure is not greater than 1.1 times the period of the upper portion considered as a separate structure fixed at the base:
  - 3.1. The flexible upper portion shall be designed as a separate structure using the appropriate values of  $R$  and  $\rho$ .
  - 3.2. The rigid lower portion shall be designed as a separate structure using the appropriate values of  $R$  and  $\rho$ . The reactions from the upper portion shall be those determined from the analysis of the upper portion amplified by the ratio of,  $R/\rho$ , of the upper portion over,  $R/\rho$ , of the lower portion. This ratio shall not be less than 1.0.

**1617.6.2.3.2 Combination framing detailing requirements.** The detailing requirements of Section 1620 required by the higher response modification coefficient,  $R$ , shall be used for structural components common to systems having different response modification coefficients.

**1617.6.2.4 System limitations for Seismic Design Category D, E or F.** In addition to the system limitation indicated in Table 1617.6.2, structures assigned to Seismic Design Category D, E or F shall be subject to the following.

TABLE 1617.6.2  
DESIGN COEFFICIENTS AND FACTORS FOR BASIC SEISMIC-FORCE-RESISTING SYSTEMS

BASIC SEISMIC-FORCE-RESISTING SYSTEM	DETAILING REFERENCE SECTION	RESPONSE MODIFICATION COEFFICIENT, $R^a$	SYSTEM OVERSTRENGTH FACTOR, $O_s^b$	DEFLECTION AMPLIFICATION FACTOR, $C_d^c$	SYSTEM LIMITATIONS AND BUILDING HEIGHT LIMITATIONS (FEET) BY SEISMIC DESIGN CATEGORY AS DETERMINED IN SECTION 1616.3 <sup>c</sup>			
					A or B	C	D <sup>d</sup>	E <sup>e</sup>
<b>1. Bearing Wall Systems</b>								
A. Ordinary steel braced frames in light-frame construction	2211	4	2	3 1/2	NL	NL	65	65
B. Special reinforced concrete shear walls	1910.2.4	5 1/2	2 1/2	5	NL	NL	160	100
C. Ordinary reinforced concrete shear walls	1910.2.3	4 1/2	2 1/2	4	NL	NL	NP	NP
D. Detailed plain concrete shear walls	1910.2.2	2 1/2	2 1/2	2	NL	NP	NP	NP
E. Ordinary plain concrete shear walls	1910.2.1	1 1/2	2 1/2	1 1/2	NL	NP	NP	NP
F. Special reinforced masonry shear walls	1.13.2.2.5 <sup>o</sup>	5	2 1/2	3 1/2	NL	NL	160	100
G. Intermediate reinforced masonry shear walls	1.13.2.2.4 <sup>o</sup>	3 1/2	2 1/2	2 1/4	NL	NL	NP	NP
H. Ordinary reinforced masonry shear walls	1.13.2.2.3 <sup>o</sup>	2 1/2	2 1/2	1 3/4	NL	160	NP	NP
I. Detailed plain masonry shear walls	1.13.2.2.2 <sup>o</sup>	2	2 1/2	1 3/4	NL	NP	NP	NP
J. Ordinary plain masonry shear walls	1.13.2.2.1 <sup>o</sup>	1 1/2	2 1/2	1 1/4	NL	NP	NP	NP
K. Light frame walls with shear panels—wood structural panels/sheet steel panels	2306.4.1/2211	6 1/2	3	4	NL	NL	65	65
L. Light framed walls with shear panels—all other materials	2306.4.5/2211	2	2 1/2	2	NL	NL	35	NP
M. Ordinary plain prestressed masonry shear walls	2106.1.1.1	1 1/2	2 1/2	1 1/4	NL	NP	NP	NP
N. Intermediate prestressed masonry shear walls	2106.1.1.2, 1.13.2.2.4 <sup>o</sup>	2 1/2	2 1/2	2 1/2	NL	35	NP	NP
O. Special prestressed masonry shear walls	2106.1.1.3, 1.13.2.2.5 <sup>o</sup>	4 1/2	2 1/2	3 1/2	NL	35	35	35
<b>2. Building Frame Systems</b>								
A. Steel eccentrically braced frames, moment-resisting, connections at columns away from links	(15) <sup>j</sup>	8	2	4	NL	NL	160	100
B. Steel eccentrically braced frames, nonmoment-resisting, connections at columns away from links	(15) <sup>j</sup>	7	2	4	NL	NL	160	100
C. Special steel concentrically braced frames	(13) <sup>j</sup>	6	2	5	NL	NL	160	100
D. Ordinary steel concentrically braced frames	(14) <sup>j</sup>	5	2	4 1/2	NL	NL	35 <sup>n</sup>	NP <sup>n</sup>
E. Special reinforced concrete shear walls	1910.2.4	6	2 1/2	5	NL	NL	160	100
F. Ordinary reinforced concrete shear walls	1910.2.3	5	2 1/2	4 1/2	NL	NL	NP	NP
G. Detailed plain concrete shear walls	1910.2.2	3	2 1/2	2 1/2	NL	NP	NP	NP

(continued)