

CHAPTER 16
STRUCTURAL DESIGN

SECTION BC 1601
GENERAL

1601.1 Scope. The provisions of this chapter shall govern the structural design of buildings, structures and portions thereof regulated by this code.

SECTION BC 1602
DEFINITIONS

1602.1 Definitions. The following words and terms shall, for the purposes of this code, have the meanings shown herein.

ALLOWABLE STRESS DESIGN. A method of proportioning structural members, such that elastically computed stresses produced in the members by nominal loads do not exceed specified allowable stresses (also called “working stress design”).

BALCONY, EXTERIOR. An exterior floor projecting from and supported by a structure without additional independent supports.

BASE SHEAR. Total design lateral force or shear at the base.

BASIC SEISMIC-FORCE-RESISTING SYSTEMS.

Bearing wall system. A structural system without a complete vertical load-carrying space frame. Bearing walls or bracing elements provide support for substantial vertical loads. Seismic lateral force resistance is provided by shear walls or braced frames.

Building frame system. A structural system with an essentially complete space frame providing support for vertical loads. Seismic lateral force resistance is provided by shear walls or braced frames.

Dual system. A structural system with an essentially complete space frame providing support for vertical loads. Seismic lateral force resistance is provided by a moment frame and shear walls or braced frames.

Inverted pendulum system. A structure with a large portion of its mass concentrated at the top; therefore, having essentially one degree of freedom in horizontal translation. Seismic lateral force resistance is provided by the columns acting as cantilevers.

Moment-resisting frame system. A structural system with an essentially complete space frame providing support for vertical loads. Seismic lateral force resistance is provided by moment frames.

Shear wall-frame interactive system. A structural system which uses combinations of shear walls and frames designed to resist seismic lateral forces in proportion to their rigidities, considering interaction between shear walls and frames on all levels. Support of vertical loads is provided by the same shear walls and frames.

BOUNDARY MEMBERS. Strengthened portions along shear wall and diaphragm edges (also called “boundary elements”).

Boundary element. In light-frame construction, diaphragms and shear wall boundary members to which sheathing transfers forces. Boundary elements include chords and drag struts at diaphragm and shear wall perimeters, interior openings, discontinuities and reentrant corners.

CANTILEVERED COLUMN SYSTEM. A structural system relying on column elements that cantilever from a fixed base and have minimal rotational resistance capacity at the top with lateral forces applied essentially at the top and are used for lateral resistance.

COLLECTOR ELEMENTS. Members that serve to transfer forces between floor diaphragms and members of the lateral-force-resisting system.

CONFINED REGION. The portion of a reinforced concrete component in which the concrete is confined by closely spaced special transverse reinforcement restraining the concrete in directions perpendicular to the applied stress.

DEAD LOADS. The weight of materials of construction incorporated into the building, including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding and other similarly incorporated architectural and structural items, and fixed service equipment, including the weight of cranes. All dead loads are considered permanent loads.

DECK. An exterior floor supported on at least two opposing sides by an adjacent structure, and/or posts, piers or other independent supports.

DEFORMABILITY. The ratio of the ultimate deformation to the limit deformation.

High deformability element. An element whose deformability is not less than 3.5 when subjected to four fully reversed cycles at the limit deformation.

Limited deformability element. An element that is neither a low deformability or a high deformability element.

Low deformability element. An element whose deformability is 1.5 or less.

DEFORMATION.

Limited deformation. Two times the initial deformation that occurs at a load equal to 40 percent of the maximum strength.

Ultimate deformation. The deformation at which failure occurs and which shall be deemed to occur if the sustainable load reduces to 80 percent or less of the maximum strength.

DESIGN STRENGTH. The product of the nominal strength and a resistance factor (or strength reduction factor).

DIAPHRAGM. A horizontal or sloped system acting to transmit lateral forces to the vertical-resisting elements. When the term “diaphragm” is used, it shall include horizontal bracing systems.

Diaphragm, blocked. In light-frame construction, a diaphragm in which all sheathing edges not occurring on a framing member are supported on and fastened to blocking.

Diaphragm boundary. In light-frame construction, a location where shear is transferred into or out of the diaphragm sheathing. Transfer is either to a boundary element or to another force-resisting element.

Diaphragm chord. A diaphragm boundary element perpendicular to the applied load that is assumed to take axial stresses due to the diaphragm moment.

Diaphragm, flexible. A diaphragm is flexible for the purpose of distribution of story shear and torsional moment when the computed maximum in-plane deflection of the diaphragm itself under lateral load is more than two times the average drift of adjoining vertical elements of the lateral-force-resisting system of the associated story under equivalent tributary lateral load (see Section 1617.5.3).

Diaphragm, rigid. A diaphragm is rigid for the purpose of distribution of story shear and torsional moment when the lateral deformation of the diaphragm is less than or equal to two times the average story drift.

DURATION OF LOAD. The period of continuous application of a given load, or the aggregate of periods of intermittent applications of the same load.

ELEMENT.

Ductile element. An element capable of sustaining large cyclic deformations beyond the attainment of its nominal strength without any significant loss of strength.

Limited ductile element. An element that is capable of sustaining moderate cyclic deformations beyond the attainment of nominal strength without significant loss of strength.

Nonductile element. An element having a mode of failure that results in an abrupt loss of resistance when the element is deformed beyond the deformation corresponding to the development of its nominal strength. Nonductile elements cannot reliably sustain significant deformation beyond that attained at their nominal strength.

EQUIPMENT SUPPORT. Those structural members or assemblies of members or manufactured elements, including braces, frames, lugs, snuggers, hangers or saddles, that transmit gravity load and operating load between the equipment and the structure.

ESSENTIAL FACILITIES. Buildings and other structures that are intended to remain operational in the event of extreme environmental loading from flood, wind, snow or earthquakes.

FACTORED LOAD. The product of a nominal load and a load factor.

FLEXIBLE EQUIPMENT CONNECTIONS. Those connections between equipment components that permit rotational and/or translational movement without degradation of performance.

FRAME.

Braced frame. An essentially vertical truss, or its equivalent, of the concentric or eccentric type that is provided in a building frame system or dual system to resist lateral forces.

Centrically braced frame (CBF). A braced frame in which the members are subjected primarily to axial forces.

Eccentrically braced frame (EBF). A diagonally braced frame in which at least one end of each brace frames into a beam a short distance from a beam-column or from another diagonal brace.

Ordinary concentrically braced frame (OCBF). A steel concentrically braced frame in which members and connections are designed in accordance with the provisions of AISC Seismic without modification.

Special concentrically braced frame (SCBF). A steel or composite steel and concrete concentrically braced frame in which members and connections are designed for ductile behavior.

Moment frame. A frame in which members and joints resist lateral forces by flexure as well as along the axis of the members. Moment frames are categorized as “intermediate moment frames” (IMF), “ordinary moment frames” (OMF), and “special moment frames” (SMF).

GUARD. See Section 1002.1.

IMPACT LOAD. The load resulting from moving machinery, elevators, craneways, vehicles and other similar forces and kinetic loads, pressure and possible surcharge from fixed or moving loads.

JOINT. A portion of a column bounded by the highest and lowest surfaces of the other members

framing into it.

LIMIT STATE. A condition beyond which a structure or member becomes unfit for service and is judged to be no longer useful for its intended function (serviceability limit state) or to be unsafe (strength limit state).

LIVE LOADS. Those loads produced by the use and occupancy of the building or other structure and do not include construction or environmental loads such as wind load, snow load, rain load, earthquake load, flood load or dead load.

LIVE LOADS (ROOF). Those loads produced (1) during maintenance by workers, equipment and materials; and (2) during the life of the structure by movable objects such as planters and by people.

LOAD AND RESISTANCE FACTOR DESIGN (LRFD). A method of proportioning structural members and their connections using load and resistance factors such that no applicable limit state is reached when the structure is subjected to appropriate load combinations. The term “LRFD” is used in the design of steel and wood structures.

LOAD FACTOR. A factor that accounts for deviations of the actual load from the nominal load, for uncertainties in the analysis that transforms the load into a load effect, and for the probability that more than one extreme load will occur simultaneously.

LOADS. Forces or other actions that result from the weight of building materials, occupants and their possessions, environmental effects, differential movement and restrained dimensional changes. Permanent loads are those loads in which variations over time are rare or of small magnitude, such as dead loads. All other loads are variable loads (see also “Nominal loads”).

LOADS EFFECTS. Forces and deformations produced in structural members by the applied loads.

NOMINAL LOADS. The magnitudes of the loads specified in this chapter (dead, live, soil, wind, snow, rain, flood and earthquake).

NOTATIONS.

D = Dead load.

E = Combined effect of horizontal and vertical earthquake-induced forces as defined in Section 1617.1.

E_m = Maximum seismic load effect of horizontal and vertical seismic forces as set forth in Section 1617.1.

F = Load due to fluids.

F_a = Flood load.

H = Load due to lateral pressure of soil and water in soil.

L = Live load, except roof live load, including any permitted live load reduction.

L_r = Roof live load including any permitted live load reduction.

P = Ponding load.

R = Rain load.

S = Snow load.

T = Self-straining force arising from contraction or expansion resulting from temperature change, shrinkage, moisture change, creep in component materials, movement due to differential settlement or combinations thereof.

W = Load due to wind pressure.

OTHER STRUCTURES. Structures, other than buildings, for which loads are specified in this chapter.

P-DELTA EFFECT. The second order effect on shears, axial forces and moments of frame members induced by axial loads on a laterally displaced building frame.

PANEL (PART OF A STRUCTURE). The section of a floor, wall or roof comprised between the supporting frame of two adjacent rows of columns and girders or column bands of floor or roof construction.

RESISTANCE FACTOR. A factor that accounts for deviations of the actual strength from the nominal strength and the manner and consequences of failure (also called “strength reduction factor”).

SHEAR PANEL. A floor, roof or wall component sheathed to act as a shear wall or diaphragm.

SHEAR WALL. A wall designed to resist lateral forces parallel to the plane of the wall.

SPACE FRAME. A structure composed of interconnected members, other than bearing walls, that is capable of supporting vertical loads and that also may provide resistance to seismic lateral forces.

SPECIAL TRANSVERSE REINFORCEMENT. Reinforcement composed of spirals, closed stirrups or hoops and supplementary cross ties provided to restrain the concrete and qualify the portion of the component, where used, as a confined region.

STRENGTH, NOMINAL. The capacity of a structure or member to resist the effects of loads, as determined by computations using specified material strengths and dimensions and equations derived from accepted principles of structural mechanics or by field tests or laboratory tests of scaled models, allowing for modeling effects and differences between laboratory and field conditions.

STRENGTH, REQUIRED. Strength of a member, cross section or connection required to resist factored loads or related internal moments and forces in such combinations as stipulated by these provisions.

STRENGTH DESIGN. A method of proportioning structural members such that the computed forces produced in the members by factored loads do not exceed the member design strength. The term “strength design” is used in the design of concrete and masonry structural elements.

WALL, LOAD BEARING. Any wall meeting either of the following classifications:

1. Any metal or wood stud wall that supports more than 100 pounds per linear foot (plf) (1459 N/m) of vertical load in addition to its own weight.
2. Any masonry or concrete wall that supports more than 200 plf (2919 N/m) of vertical load in addition to its own weight.

WALL, NONLOAD BEARING. Any wall that is not a load-bearing wall.

SECTION BC 1603 **CONSTRUCTION DOCUMENTS**

1603.1 General. Construction documents shall show the size, section and relative locations of structural members with floor levels, column centers and offsets fully dimensioned. The design loads and other information pertinent to the structural design required by Sections 1603.1.1 through 1603.1.7 shall be clearly indicated on the construction documents for parts of the building or structure.

Exception: Construction documents for buildings constructed in accordance with the conventional light-frame construction provisions of Section 2308 shall indicate the following structural design information:

1. Floor and roof live loads.
2. Ground snow load, P_g .
3. Basic wind speed (3-second gust), miles per hour (mph) (km/hr) and wind exposure.
4. Seismic design category and site class.

1603.1.1 Floor live load. The uniformly distributed, concentrated and impact floor live load used in the design shall be indicated for floor areas. Live load reduction of the uniformly distributed floor live loads, if used in the design, shall be indicated.

1603.1.2 Roof live load. The roof live load used in the design shall be indicated for roof areas (Section 1607.11).

1603.1.3 Roof snow load. The ground snow load, P_g , shall be indicated. The following additional information shall also be provided, regardless of whether snow loads govern the design of the roof:

1. Flat-roof snow load, P_f .
2. Snow exposure factor, C_e .
3. Snow load importance factor, I_s .
4. Thermal factor, C_t .

1603.1.4 Wind design data. The following information related to wind loads shall be shown, regardless of whether wind loads govern the design of the lateral-force-resisting system of the building:

1. Basic wind speed (3-second gust), miles per hour (km/hr).
2. Wind importance factor, I_W , and building category.
3. Wind exposure, if more than one wind exposure is utilized, the wind exposure and applicable wind direction shall be indicated.
4. The applicable internal pressure coefficient.
5. Components and cladding. The design wind pressures in terms of psf (kN/m^2) to be used for the design of exterior component and cladding materials not specifically designed by the registered design professional.

1603.1.5 Earthquake design data. The following information related to seismic loads shall be shown, regardless of whether seismic loads govern the design of the lateral-force-resisting system of the building:

1. Seismic importance factor, I_E , and seismic use group.
2. Mapped spectral response accelerations S_S and S_I .
3. Site class.

4. Spectral response coefficients S_{DS} and S_{D1} .
5. Seismic design category.
6. Basic seismic-force-resisting system(s).
7. Design base shear.
8. Seismic response coefficient(s), C_s .
9. Response modification factor(s), R .
10. Analysis procedure used.

1603.1.6 Flood load. For buildings located in areas of special flood hazard, construction documents shall comply with Appendix G.

1603.1.7 Special loads. Special loads that are applicable to the design of the building, structure or portions thereof shall be indicated along with the specified section of this code that addresses the special loading condition.

1603.2 Restrictions on loading. It shall be unlawful to place, or cause or permit to be placed, on any floor or roof of a building, structure or portion thereof, a load greater than is permitted by these requirements.

1603.3 Live loads posted. Where the live loads for which each floor or portion thereof of a building are or have been designed to exceed 50 psf (2.40 kN/m²), such design live loads shall be conspicuously posted by the owner in that part of each story in which they apply, using durable signs. It shall be unlawful to remove or deface such notices.

Exceptions: Residential occupancies.

1603.3.1 Data required. The following floor load data shall be shown on drawings:

1. The uniform distributed design live load for each floor or part thereof.
2. The weight of any piece of machinery or equipment weighing more than 1,000 pounds (4,400 N), and its identifying description and location. When this equipment includes oscillating or rotating components the description shall indicate the frequency of such movement.
3. The maximum design wheel load and total maximum weight of any vehicle that may be brought into the building.
4. The equivalent uniform partition loads or, in lieu of these, a statement to the effect that the design was predicated on actual partition loads.

1603.4 Occupancy permits for changed loads. Construction documents for other than residential buildings filed with the commissioner with applications for permits shall show on each drawing the live loads per square foot (m^2) of area covered for which the building is designed. Occupancy permits for buildings hereafter erected shall not be issued until the floor load signs, required by Section 1603.3, have been installed.

SECTION 1604 **GENERAL DESIGN REQUIREMENTS**

1604.1 General. Building, structures and parts thereof shall be designed and constructed in accordance with strength design, load and resistance factor design, allowable stress design, empirical design or conventional construction methods, as permitted by the applicable material chapters.

1604.2 Strength. Buildings and other structures, and parts thereof, shall be designed and constructed to support safely the factored loads in load combinations defined in this code without exceeding the appropriate strength limit states for the materials of construction. Alternatively, buildings and other structures, and parts thereof, shall be designed and constructed to support safely the nominal loads in load combinations defined in this code without exceeding the appropriate specified allowable stresses for the materials of construction. Loads and forces for occupancies or uses not covered in this chapter shall be subject to the approval of the commissioner.

1604.3 Serviceability. Structural systems and members thereof shall be designed to have adequate stiffness to limit deflections and lateral drift. See Section 1617.3 for drift limits applicable to earthquake loading.

1604.3.1 Deflections. The deflections of structural members shall not exceed the more restrictive of the limitations of Sections 1604.3.2 through 1604.3.5 or that permitted by Table 1604.3.

1604.3.2 Reinforced concrete. The deflection of reinforced concrete structural members shall not exceed that permitted by ACI 318.

1604.3.3 Steel. The deflection of steel structural members shall not exceed that permitted by AISC LRFD, AISC HSS, AISC 335, AISI-NASPEC, AISI-General, AISI-Truss, ASCE 3, ASCE 8-SSD-LRFD/ASD, and the standard specifications of SJI Standard Specifications, Load Tables and Weight Tables for Steel Joists and Joist Girders as applicable.

1604.3.4 Masonry. The deflection of masonry structural members shall not exceed that permitted by ACI 530/ASCE 5/TMS 402.

1604.3.5 Aluminum. The deflection of aluminum structural members shall not exceed that permitted by AA-94.

1604.3.6 Limits. For limits on the deflection of structural members, refer to the relevant material design standards. Should a design standard not provide for deflection limits, deflection of structural members over span, l , shall not exceed that permitted by Table 1604.3.

TABLE 1604.3
DEFLECTION LIMITS^{a, b, c, h, i}

CONSTRUCTION	<i>L</i>	<i>S</i> or <i>W</i> ^f	<i>D</i> + <i>L</i> ^{d, g}
Roof members: ^e			
Supporting plaster ceiling	<i>l</i> /360	<i>l</i> /360	<i>l</i> /240
Supporting nonplaster ceiling	<i>l</i> /240	<i>l</i> /240	<i>l</i> /180
Not supporting ceiling	<i>l</i> /180	<i>l</i> /180	<i>l</i> /120
Floor members	<i>l</i> /360	—	<i>l</i> /240
Exterior walls and interior partitions:			
With brittle finishes	—	<i>l</i> /240	—
With flexible finishes	—	<i>l</i> /120	—
Farm buildings	—	—	<i>l</i> /180
Greenhouses	—	—	<i>l</i> /120

For SI: 1 foot = 304.8 mm.

- a. For structural roofing and siding made of formed metal sheets, the total load deflection shall not exceed *l*/60. For secondary roof structural members supporting formed metal roofing, the live load deflection shall not exceed *l*/150. For secondary wall members supporting formed metal siding, the design wind load deflection shall not exceed *l*/90. For roofs, this exception only applies when the metal sheets have no roof covering.
- b. Interior partitions not exceeding 6 feet in height and flexible, folding and portable partitions are not governed by the provisions of this section. The deflection criterion for interior partitions is based on the horizontal load defined in Section 1607.13.
- c. See Section 2403 for glass supports.
- d. For wood structural members having a moisture content of less than 16 percent at time of installation and used under dry conditions, the deflection resulting from *L* + 0.5*D* is permitted to be substituted for the deflection resulting from *L* + *D*.
- e. The above deflections do not ensure against ponding. Roofs that do not have sufficient slope or camber to assure adequate drainage shall be investigated for ponding. See Section 1611 for rain and ponding requirements and Section 1503.4 for roof drainage requirements.
- f. The wind load is permitted to be taken as 0.7 times the "component and cladding" loads for the purpose of determining deflection limits herein.
- g. For steel structural members, the dead load shall be taken as zero.
- h. For aluminum structural members or aluminum panels used in roofs or walls of sunroom additions or patio covers, not supporting edge of glass or aluminum sandwich panels, the total load deflection shall not exceed *l*/60. For aluminum sandwich panels used in roofs or walls of sunroom additions or patio covers, the total load deflection shall not exceed *l*/120.
- i. For cantilever members, *l* shall be taken as twice the length of the cantilever.

1604.4 Analysis. Load effects on structural members and their connections shall be determined by methods of structural analysis that take into account equilibrium, general stability, geometric compatibility and both short- and long-term material properties.

Members that tend to accumulate residual deformations under repeated service loads shall have included in their analysis the added eccentricities expected to occur during their service life. Secondary stresses in trusses shall be considered and, where of significant magnitude, their effects shall be provided for in the design.

Any system or method of construction to be used shall be based on a rational analysis in accordance with well-established principles of mechanics. Such analysis shall result in a system that provides a complete load path capable of transferring loads from their point of origin to the load-resisting elements.

The total lateral force shall be distributed to the various vertical elements of the lateral-force-resisting system in proportion to their rigidities considering the rigidity of the horizontal bracing system or diaphragm. Rigid elements that are assumed not to be a part of the lateral-force-resisting system shall be permitted to be incorporated into buildings provided that their effect on the action of the system is considered and provided for in design. Provisions shall be made for the increased forces induced on resisting elements of the structural system resulting from torsion due to eccentricity between the center of application of the lateral forces and the center of rigidity of the lateral-force-resisting system.

Every structure shall be designed to resist the overturning effects caused by the lateral forces specified in this chapter. See Section 1609 for wind, Section 1610 for lateral soil loads and Sections 1613 through 1623 for earthquake.

1604.5 Importance factors. The value for snow load, wind load and seismic load importance factors shall be determined in accordance with Table 1604.5.

**TABLE 1604.5
CLASSIFICATION OF BUILDINGS AND OTHER STRUCTURES FOR IMPORTANCE FACTORS**

CATEGORY^a	NATURE OF OCCUPANCY	SEISMIC FACTOR I_E	SNOW FACTOR I_S	WIND FACTOR I_W
I	<u>Buildings and other structures that represent a low hazard to human life in the event of failure including, but not limited to:</u> <ul style="list-style-type: none"> • <u>Agricultural facilities</u> • <u>Certain temporary facilities</u> • <u>Minor storage facilities</u> 	<u>1.00</u>	<u>0.8</u>	<u>0.87</u>
II	<u>Buildings and other structures except those listed in Categories I, III and IV</u>	<u>1.00</u>	<u>1.0</u>	<u>1.00</u>
III	<u>Buildings and other structures that represent a substantial hazard to human life in the event of failure including, but not limited to:</u> <ul style="list-style-type: none"> • <u>Buildings and other structures where more than 300 people congregate in one area</u> • <u>Buildings and other structures with elementary school, secondary school or day care facilities with an occupant load greater than 250</u> • <u>Buildings and other structures with an occupant load greater than 500 for colleges or adult education facilities</u> • <u>Health care facilities with an occupant load of 50 or more resident patients but not having surgery or emergency treatment facilities</u> • <u>Jails and detention facilities</u> • <u>Power-generating stations, water treatment for potable water, waste water treatment facilities and other public utility facilities not included in Category IV</u> • <u>Buildings and other structures not included in Category IV containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released</u> 	<u>1.25</u>	<u>1.1</u>	<u>1.15</u>
IV	<u>Buildings and other structures designed as essential facilities including, but not limited to:</u> <ul style="list-style-type: none"> • <u>Hospitals and other health care facilities having surgery or emergency treatment facilities</u> • <u>Fire, rescue and police stations and emergency vehicle garages</u> • <u>Designated earthquake, hurricane or other emergency shelters</u> • <u>Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response</u> • <u>Power-generating stations and other public utility facilities required as emergency backup facilities for Category IV structures</u> • <u>Structures containing highly toxic materials as defined by Section 307 where the quantity of the material exceeds the maximum allowable quantities of Table 307.7(2)</u> • <u>Aviation control towers, air traffic control centers and</u> 	<u>1.50</u>	<u>1.2</u>	<u>1.15</u>

	<u>emergency aircraft hangars</u> <ul style="list-style-type: none">• <u>Buildings and other structures having critical national defense functions</u>• <u>Water treatment facilities required to maintain water pressure for fire suppression</u>			
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a. For the purpose of Section 1616.2, Categories I and II are considered Seismic Use Group I, Category III is considered Seismic Use Group II and Category IV is equivalent to Seismic Use Group III.

1604.6 In-situ load tests. The commissioner is authorized to require an engineering analysis or a load test, or both, of any construction whenever there is reason to question the safety of the construction for the intended occupancy. Engineering analysis and load tests shall be conducted in accordance with Section 1713.

1604.7 Preconstruction load tests. Materials and methods of construction that are not capable of being designed by recognized engineering analysis or that do not comply with the applicable material design standards listed in Chapter 35, or alternative test procedures in accordance with Section 1711, shall be load tested in accordance with Section 1714.3.

1604.8 Anchorage.

1604.8.1 General. Anchorage of the roof to walls and columns, and of walls and columns to foundations, shall be provided to resist the uplift and sliding forces that result from the application of the prescribed loads.

1604.8.2 Concrete and masonry walls. Concrete and masonry walls shall be anchored to floors, roofs and other structural elements that provide lateral support for the wall. Such anchorage shall provide a positive direct connection capable of resisting the horizontal forces specified in this chapter but not less than a minimum strength design horizontal force of 280 plf (4.10 kN/m) of wall, substituted for “E” in the load combinations of Section 1605.2 or 1605.3. Walls shall be designed to resist bending between anchors where the anchor spacing exceeds 4 feet (1219 mm). Required anchors in masonry walls of hollow units or cavity walls shall be embedded in a reinforced grouted structural element of the wall. See Sections 1609.6.2.2 and 1620 for wind and earthquake design requirements.

1604.8.3 Decks. Where supported by attachment to an exterior wall, decks shall be positively anchored to the primary structure and designed for both vertical and lateral loads as applicable. Such attachment shall not be accomplished by the use of toenails or nails subject to withdrawal. Where positive connection to the primary building structure cannot be verified during inspection, decks shall be self-supporting. For decks with cantilevered framing members, connections to exterior walls or other framing members shall be designed and constructed to resist uplift resulting from the full live load specified in Table 1607.1 acting on the cantilevered portion of the deck.

SECTION BC 1605 **LOAD COMBINATIONS**

1605.1 General. Buildings and other structures and portions thereof shall be designed to resist the load combinations specified in Section 1605.2 or 1605.3 and Chapters 18 through 23, and the special seismic load combinations of Section 1605.4. Applicable loads shall be considered, including both earthquake and wind, in accordance with the specified load combinations. Each load combination shall also be investigated with one or more of the variable loads set to zero.

1605.2 Load combinations using strength design or load and resistance factor design.

1605.2.1 Basic load combinations. Where strength design or load and resistance factor design is used, structures and portions thereof shall resist the most critical effects from the following combinations of factored loads:

$$1.4D \quad \text{(Equation 16-1)}$$

$$1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R) \quad \text{(Equation 16-2)}$$

$$1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (f_1L \text{ or } 0.8W) \quad \text{(Equation 16-3)}$$

$$1.2D + 1.6W + f_1L + 0.5(L_r \text{ or } S \text{ or } R) \quad \text{(Equation 16-4)}$$

$$1.2D + 1.0E + f_1L + f_2S \quad \text{(Equation 16-5)}$$

$$0.9D + (1.0E \text{ or } 1.6W) \quad \text{(Equation 16-6)}$$

where:

f_1 = 1.0 for floors in places of public assembly, for live loads in excess of 100 pounds per square foot (4.79 kN/m²), and for parking garage live load.

f_1 = 0.5 for other live loads.

f_2 = 0.7 for roof configurations (such as saw tooth) that do not shed snow off the structure.

f_2 = 0.2 for other roof configurations.

Exception: Where other factored load combinations are specifically required by the provisions of this code, such combinations shall take precedence.

where:

$f_1 = 1.0$ for floors in places of public assembly, for live loads in excess of 100 pounds per square foot (4.79 kN/m²), and for parking garage live load.

$f_1 = 0.5$ for other live loads.

$f_2 = 0.7$ for roof configurations (such as saw tooth) that do not shed snow off the structure.

$f_2 = 0.2$ for other roof configurations.

Exception: Where other factored load combinations are specifically required by the provisions of this code, such combinations shall take precedence.

1605.2.2 Other loads. Where F , H , P or T is to be considered in design, each applicable load shall be added to the above combinations in accordance with Section 2.3.2 of ASCE 7. Where F_a is to be considered in design, the load combinations of Section 2.3.3 of ASCE 7 shall be used. Where ice loads are to be considered in design, the load combinations of Section 2.3.4 of ASCE 7 shall be used. Refer to the following sections for other loads:

<u>Soil lateral loads</u>	<u>Section 1610</u>
<u>Rain loads</u>	<u>Section 1611</u>
<u>Flood loads</u>	<u>Appendix G</u>
<u>Snow and Thermal loads</u>	<u>Section 1608</u>

1605.3 Load combinations using allowable stress design.

1605.3.1 Basic load combinations. Where allowable stress design (working stress design), as permitted by this code, is used, structures and portions thereof shall resist the most critical effects resulting from the following combinations of loads:

$$D \quad \text{(Equation 16-7)}$$

$$D+L \quad \text{(Equation 16-8)}$$

$$D+L+(L, \text{ or } S \text{ or } R) \quad \text{(Equation 16-9)}$$

$$D+(W \text{ or } 0.7E)+L+(L, \text{ or } S \text{ or } R) \quad \text{(Equation 16-10)}$$

$$0.6D+W \quad \text{(Equation 16-11)}$$

$$0.6D+0.7E \quad \text{(Equation 16-12)}$$

Exceptions:

1. Crane hook loads need not be combined with roof live load or with more than three-fourths of the snow load or one-half of the wind load.
2. Flat roof snow loads of 30 psf (1.44 kN/m²) or less need not be combined with seismic loads. Where flat roof snow loads exceed 30 psf (1.44 kN/m²), 20 percent shall be combined with seismic loads.
3. Where allowable stress design is used to design foundations, refer to Chapter 18 of this code for combinations of load effects.

1605.3.1.1 Load reduction. It is permitted to multiply the combined effect of two or more variable loads by 0.75 and add to the effect of dead load. The combined load used in design shall not be less than the sum of the effects of dead load and any one of the variable loads. The 0.7 factor on E does not apply for this provision. Increases in allowable stresses specified in the appropriate materials section of this code or referenced standard shall not be used with the load combinations of Section 1605.3.1 except that a duration of load increase shall be permitted in accordance with Chapter 23.

1605.3.1.2 Other loads. Where F , H , P or T are to be considered in design, the load combinations of Section 2.4.1 of ASCE 7 shall be used. Where F_a is to be considered in design, the load combinations of Section 2.4.2 of ASCE 7 shall be used. Where ice loads are to be considered in design, the load combinations of Section 2.4.3-of ASCE 7 shall be used. Refer to the following sections for other loads:

<u>Soil lateral loads</u>	<u>Section 1610</u>
<u>Rain loads</u>	<u>Section 1611</u>
<u>Flood loads</u>	<u>Appendix G</u>
<u>Snow and Thermal loads</u>	<u>Section 1608</u>

1605.4 Special seismic load combinations. For both allowable stress design and strength design methods, where specifically required by Sections 1613 through 1622 or by Chapters 18 through 23, elements and components shall be designed to resist the forces calculated using Equation 16-19 when the effects of the seismic ground motion are additive to gravity forces and those calculated using Equation 16-20 when the effects of the seismic ground motion counteract gravity forces.

$$1.2D + f_2L + E_m$$

(Equation 16-19)

$$0.9D + E_m$$

(Equation 16-20)

where:

E_m = The maximum effect of horizontal and vertical forces as set forth in Section 1617.1.

f_l = 1.0 for floors in places of public assembly, for live loads in excess of 100 psf (4.79 kN/m²) and for parking garage live load.

f_l = 0.5 for other live loads.

1605.5 Heliports and helistops. Heliport and helistop landing or touchdown areas shall be designed for the following loads, combined in accordance with Section 1605:

1. Dead load, D , plus the gross weight of the helicopter, D_h , plus snow load, S .
2. Dead load, D , plus two single concentrated impact loads, L , approximately 8 feet (2438 mm) apart applied anywhere on the touchdown pad (representing each of the helicopter's two main landing gear, whether skid type or wheeled type), having a magnitude of 0.75 times the gross weight of the helicopter. Both loads acting together total 1.5 times the gross weight of the helicopter.
3. Dead load, D , plus a uniform live load, L , of 100 psf (4.79 kN/ m²).

1605.6 Structural integrity load combinations – alternate load path method. Where specifically required by Sections 1624 through 1629, elements and components shall be designed to resist the forces calculated using the following combination of factored loads:

$$D + f_1L + f_2W \quad \text{(Equation 16-65)}$$

Where:

f_1 = 0.25 for buildings in Category II.

f_1 = 0.5 for buildings in Category III or IV.

f_2 = 0 for buildings in Category II.

f_2 = 0.33 for buildings in Category III or IV.

The live load component f_1L need not be greater than the reduced live load.

1605.7 Structural integrity load combinations – vehicular impact and gas explosions. Where specifically required by Sections 1625.5 and 1625.6, elements and components shall be designed to resist the forces calculated using the following combination of factored loads:

$$\underline{1.2D + A_k + (0.5L \text{ or } 0.2S)} \quad \text{(Equation 16-66)}$$

$$\underline{0.9D + A_k + 0.2W} \quad \text{(Equation 16-67)}$$

Where A_k is the load effect of the vehicular impact or gas explosion.

1605.8 Structural integrity load combinations – specific local resistance method. Where the specific local resistance method is used in a key element analysis, the specified local loads shall be used as specified in Section 1626.7.

SECTION BC 1606
DEAD LOADS

1606.1 Weights of materials and construction. In determining dead loads for purposes of design, the actual weights of materials and construction shall be used. In the absence of definite information, values used shall be subject to the approval of the commissioner.

1606.2 Weights of fixed service equipment. In determining dead loads for purposes of design, the weight of fixed service equipment, such as plumbing stacks and risers, electrical feeders, heating, ventilating and air-conditioning systems (HVAC) and fire sprinkler systems, shall be included.

SECTION BC 1607
LIVE LOADS

1607.1 General. Live loads are those defined in Section 1602.1

TABLE 1607.1
MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS AND MINIMUM
CONCENTRATED LIVE LOADS – g.1

<u>OCCUPANCY OR USE</u>	<u>UNIFORM (psf)</u>	<u>CONCENTRATED (lbs.)</u>
1. Apartments (see residential)	=	=
2. Access floor systems		
Office use	50	2,000
Computer use	100	2,000
3. Armories and drill rooms	150	=
4. Assembly areas and theaters		
Fixed seats (fastened to floor)	60	
Lobbies	100	
Movable seats	100	
Private assembly spaces, including conference rooms and card rooms	50	=
Stages and platforms	125	
Follow spot, projections and control rooms	50	
Catwalks	40	
Other assembly spaces	Note i	
5. Balconies (exterior)	100	=
On one- and two-family residences only, and not exceeding 100 ft. ²	60	
6. Decks	Same as occupancy served ^h	=
7. Bowling alleys	75	=
8. Cornices	60	=
9. Corridors, except as otherwise indicated	100	=
10. Dance halls and ballrooms	100	=
11. Dining rooms and restaurants	100	=
12. Dwellings (see residential)	=	=
13. Elevator machine room grating (on area of 4 in. ²)	=	300

<u>OCCUPANCY OR USE</u>	<u>UNIFORM (psf)</u>	<u>CONCENTRATED (lbs.)</u>
Equipment rooms, including pump rooms, generator rooms, transformer vaults, and areas for switch gear, ventilating, air conditioning, and similar electrical and mechanical equipment	75	=
14. Finish light floor plate construction (on area of 1 in. ²)	=	200
15. Fire escapes (Exterior)		
Single -and multiple family dwellings	100 40	=
16. Garages (passenger vehicles only)	40	Note a
Trucks and buses		See Section 1607.6
17. Grandstands (see stadium and arena bleachers)	=	=
18. Gymnasiums, main floors and balconies	100	=
19. Handrails, guards and grab bars		See Section 1607.7
20. Hospitals		
Operating rooms, laboratories	60	1,000
Private rooms	40	1,000
Wards	40	1,000
Corridors above first floor	80	1,000
21. Hotels (see residential)	=	=
22. Libraries		
Reading rooms	60	1,000
Stack rooms	150 ^b	1,000
Corridors above first floor	80	1,000
23. Manufacturing		
Light	125	2,000
Heavy	250	3,000
24. Marquees	75	=
25. Office buildings		
File and computer rooms shall be designed for heavier loads based on anticipated occupancy		
Lobbies and first-floor corridors	100	2,000
Offices	50	2,000

<u>OCCUPANCY OR USE</u>	<u>UNIFORM (psf)</u>	<u>CONCENTRATED (lbs.)</u>
<u>Corridors above first floor</u>	<u>80</u>	<u>2,000</u>
26. Penal Institutions		
<u>Cell blocks</u>	<u>40</u>	<u>=</u>
<u>Corridors</u>	<u>100</u>	
27. Residential		
<u>One- and two-family dwellings</u>		
<u>Uninhabitable attics without storage</u>	<u>10</u>	
<u>Uninhabitable attics with storage</u>	<u>20</u>	
<u>Habitable attics and sleeping areas</u>	<u>30</u>	
<u>All other areas except balconies and decks</u>	<u>40</u>	<u>=</u>
<u>Hotels and multifamily dwellings</u>		
<u>Private rooms and corridors serving them</u>	<u>40</u>	
<u>Public rooms and corridors serving them</u>	<u>100</u>	
28. Reviewing stands, grandstands and bleachers	<u>Note c</u>	<u>=</u>
29. Roofs	<u>See Section 1607.11</u>	
30. Schools		
<u>Classrooms</u>	<u>40</u>	<u>1,000</u>
<u>Corridors above first floor</u>	<u>80</u>	<u>1,000</u>
<u>First-floor corridors</u>	<u>100</u>	<u>1,000</u>
31. Scuttles, skylight ribs and accessible ceilings	<u>=</u>	<u>200</u>
32. Sidewalks, vehicular driveways and yards, subject to trucking	<u>600^d</u>	<u>8,000^e</u>
<u>Plaza areas (open) accessible to the public (including landscaped portions)</u>	<u>100</u>	
33. Skating rinks	<u>100</u>	<u>=</u>
34. Stadiums and arenas		
<u>Bleachers</u>	<u>100^e</u>	<u>=</u>
<u>Fixed seats (fastened to floor)</u>	<u>60^c</u>	
35. Stairs and exits	<u>100</u>	<u>Note f</u>

<u>OCCUPANCY OR USE</u>	<u>UNIFORM (psf)</u>	<u>CONCENTRATED (lbs.)</u>
<u>One- and two-family dwellings</u>	<u>40</u>	
<u>All other</u>	<u>100</u>	
36. Storage		
<u>warehouses (shall be designed for heavier loads if required for anticipated storage)</u>		<u>=</u>
<u>Light</u>	<u>125</u>	
<u>Heavy</u>	<u>250</u>	
37. Stores		
<u>Retail</u>		
<u>Basement and First floor</u>	<u>100</u>	<u>1,000</u>
<u>Upper floors</u>	<u>75</u>	<u>1,000</u>
<u>Wholesale, all floors</u>	<u>100</u>	<u>1,000</u>
38. Vehicle barriers	<u>See Section 1607.7</u>	
39. Walkways and elevated platforms (other than exitways)	<u>60</u>	<u>=</u>
40. Yards and terraces, pedestrians	<u>100</u>	<u>=</u>

For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 mm², 1 pound per square foot = 0.0479 kN/m², 1 pound = 0.004448 kN.

1 pound per cubic foot = 16 kg/m³

a. Floors in garages or portions of buildings used for the storage of motor vehicles shall be designed for the uniformly distributed live loads of Table 1607.1 or the following concentrated loads: (1) for garages restricted to vehicles accommodating not more than nine passengers, 3,000 pounds acting on an area of 4.5 inches by 4.5 inches; (2) for mechanical parking structures without slab or deck which are used for storing passenger vehicles only, 2,250 pounds per wheel.

b. The loading applies to stack room floors that support nonmobile, double-faced library bookstacks, subject to the following limitations:

1. The nominal bookstack unit height shall not exceed 90 inches;

2. The nominal shelf depth shall not exceed 12 inches for each face; and

3. Parallel rows of double-faced bookstacks shall be separated by aisles not less than 36 inches wide.

c. Design in accordance with the ICC *Standard on Bleachers, Folding and Telescopic Seating and Grandstands*.

d. Other uniform loads in accordance with a recognized method acceptable to the commissioner which contains

provisions for truck loadings shall also be considered where appropriate.

e. The concentrated wheel load shall be applied on an area of 20 square inches.

f. Minimum concentrated load on stair treads (on area of 4 square inches) is 300 pounds.

g. Where snow loads occur that are in excess of the design conditions, the structure shall be designed to support the loads due to the increased loads caused by drift buildup or a greater snow design determined by the commissioner (see Section 1608). For special-purpose roofs, see Section 1607.11.2.2.

h. See Section 1604.8.3 for decks attached to exterior walls.

i. Live loads for assembly spaces other than those described in this table shall be determined from the occupant load requirements as established by Section 1004 of this code using the formula 1000/(net floor area per occupant) but shall not be less than 50 psf nor more than 100 psf.

j. For establishing live loads for occupancies not specifically listed herein, refer to Reference Standard ASCE 7 for guidance.

1607.2 Loads not specified. For occupancies or uses not designated in Table 1607.1, the live load shall be determined in accordance with a method approved by the commissioner.

1607.2.1 Stage areas using scenery or scenic elements. Scenery battens and suspension systems shall be designed for a load of 30 pounds per linear foot (437.7 N/m) of batten length. Loft block and head block beams shall be designed to support vertical and horizontal loads corresponding to a 4 inch (102 mm) spacing of battens for the entire depth of the gridiron. Direction and magnitude of total forces shall be determined from the geometry of the rigging system including load concentrations from spot line rigging. Locking rails shall be designed for a uniform uplift of 500 psf (3447 kN/m²) with a 1,000 pound (454 kg) concentration. Impact factor for batten design shall be 75 percent and for loft and head block beams shall be 25 percent. A plan drawn to a scale not less than ¼ inch (6.4 mm) equals one foot (305 mm) shall be displayed in the stage area indicating the framing plan of the rigging loft and the design loads for all members used to support scenery or rigging. Gridirons over stages shall be designed to support a uniformly distributed live load of 50 psf (2.40 kN/m²) in addition to the rigging loads indicated.

1607.3 Uniform live loads. The live loads used in the design of buildings and other structures shall be the maximum loads expected by the intended use or occupancy but shall in no case be less than the minimum uniformly distributed unit loads required by Table 1607.1.

1607.4 Concentrated loads. Floors and other similar surfaces shall be designed to support the uniformly distributed live loads prescribed in Section 1607.3 or the concentrated load, in pounds (kilonewtons), given in Table 1607.1, whichever produces the greater load effects. Unless otherwise specified, the indicated concentration shall be assumed to be uniformly distributed over an area 2.5 feet by 2.5 feet [6.25 ft² (0.58 m²)] and shall be located so as to produce the maximum load effects in the structural members.

1607.5 Partition loads. Weights of all partitions shall be considered, using either actual weights at locations shown on the plans or the equivalent uniform load given in Section 1607.5.2. Partition loads shall be taken as superimposed dead loads.

1607.5.1 Actual loads. Where actual partition weights are used, the uniform design live load may be omitted from the strip of floor area under each partition.

1607.5.2 Equivalent uniform load. The equivalent uniform partition loads in Table 1607.5 may be used in lieu of actual partition weights except for bearing partitions or partitions in toilet room areas (other than in one- and two-family dwellings), at stairs and elevators, and similar areas where partitions are concentrated. In such cases, actual partition weights shall be used in design. Except as otherwise exempted, equivalent uniform partition loads shall be used in areas where partitions are not definitely located on the plans, or in areas where partitions are subject to rearrangement or relocation

Table 1607.5
EQUIVALENT UNIFORM PARTITION LOADS

<u>Partition Weight (plf)</u>	<u>Equivalent Uniform Load (psf)</u> <u>(To be added to floor dead and live loads)</u>
<u>50 or less</u>	<u>0</u>
<u>51 to 100</u>	<u>6</u>
<u>101 to 200</u>	<u>12</u>
<u>201 to 350</u>	<u>20</u>
<u>Greater than 350</u>	<u>20 plus a concentrated live load of the weight in excess of 350 pfl.</u>

1607.6 Garages.

1607.6.1 Passenger vehicle garages. Areas used for, and restricted by physical limitations of clearance to, the transit or parking of passenger vehicles shall be designed for the uniformly distributed and concentrated loads for parking areas for such vehicles as provided in Table 1607.1 applied without impact. An exception is made for members or constructions which, because of physical limitations, cannot be subjected to direct load from the vehicle or from a jack or hoist used to raise or suspend the vehicle. Such members or constructions shall be designed for the loads corresponding to the actual usage.

1607.6.2 Truck and bus garages. Minimum live loads for garages having trucks or buses shall be as specified in Table 1607.6, but shall not be less than 50 psf (2.40 kN/m²), unless other loads are specifically justified and approved by the commissioner. Actual loads shall be used where they are greater than the loads specified in the table.

**TABLE 1607.6
UNIFORM AND CONCENTRATED LOADS**

LOADING CLASS ^a	UNIFORM LOAD (pounds/linear foot of lane)	CONCENTRATED LOAD (pounds) ^b	
		For moment design	For shear design
H20-44 and HS20-44	640	18,000	26,000
H15-44 and HS15-44	480	13,500	19,500

For SI: 1 pound per linear foot = 0.01459 kN/m, 1 pound = 0.004448 kN,
1 ton = 8.90 kN.

- a. An H loading class designates a two-axle truck with a semitrailer. An HS loading class designates a tractor truck with a semitrailer. The numbers following the letter classification indicate the gross weight in tons of the standard truck and the year the loadings were instituted.
- b. See Section 1607.6.1 for the loading of multiple spans.

1607.6.2.1 Truck and bus garage live load application. The concentrated load and uniform load shall be uniformly distributed over a 10 foot (3048 mm) width on a line normal to the centerline of the lane placed within a 12-foot-wide (3658 mm) lane. The loads shall be placed within their individual lanes so as to produce the maximum stress in each structural member. Vertical impact shall be taken as 10 percent of the vertical load. Single spans shall be designed for the uniform load in Table 1607.6 and one simultaneous concentrated load positioned to produce the maximum effect. Multiple spans shall be designed for the uniform load in Table 1607.6 on the spans and two simultaneous concentrated loads in two spans positioned to produce the maximum negative moment effect. Multiple span design loads, for other effects, shall be the same as for single spans.

1607.7 Loads on handrails, guards, grab bars and vehicle barriers. Handrails, guards, grab bars designed in accordance with Chapter 11, and vehicle barriers shall be designed and constructed to the structural loading conditions set forth in this section.

1607.7.1 Handrails and guards. Handrail assemblies and guards shall be designed to resist a load of 50 plf (0.73 kN/m) applied in any direction at the top and to transfer this load through the supports to the structure.

Exceptions:

1. For one- and two-family dwellings, only the single, concentrated load required by Section 1607.7.1.1 shall be applied.
2. In Group I-3, F, H, and S occupancies, for areas that are not accessible to the general public and that have an occupant load no greater than 50, the minimum load shall be 20 pounds per foot (0.29 kN/m).

1607.7.1.1 Concentrated load. Handrail assemblies and guards shall be able to resist a single concentrated load of 200 pounds (0.89 kN), applied in any direction at any point along the top, and have attachment devices and supporting structure to transfer this loading to appropriate structural elements of the building. This load need not be assumed to act concurrently with the loads specified in the preceding paragraph.

1607.7.1.2 Components. Intermediate rails (all those except the handrail), balusters and panel fillers shall be designed to withstand a horizontally applied normal load of 50 pounds (0.22 kN) on an area equal to 1 square foot (0.09 m²), including openings and space between rails. Reactions due to this loading are not required to be superimposed with those of Section 1607.7.1 or 1607.7.1.1.

1607.7.1.3 Stress increase. Where handrails and guards are designed in accordance with the provisions for allowable stress design (working stress design) exclusively for the loads specified in Section 1607.7.1, the allowable stress for the members and their attachments are permitted to be increased by one-third.

1607.7.2 Grab bars, shower seats and dressing room bench seats. Grab bars, shower seats and dressing room bench seat systems shall be designed to resist a single concentrated load of 250 pounds (1.11 kN) applied in any direction at any point.

1607.7.3 Vehicle barriers. Vehicle barrier systems for passenger cars shall be designed to resist a single load of 6,000 pounds (26.70 kN) applied horizontally in any direction to the barrier system and shall have anchorage or attachment capable of transmitting this load to the structure. For design of the system, the load shall be assumed to act at a minimum height of 1 foot, 6 inches (457 mm) above the floor or ramp surface on an area not to exceed 1 square foot (0.09 m²), and is not required to be assumed to act concurrently with any handrail or guard loadings specified in the preceding paragraphs of Section 1607.7.1. Garages accommodating trucks and buses shall be designed in accordance with a recognized method acceptable to the commissioner that contains provision for traffic railings.

1607.7.3.1 Columns in parking areas. Unless specially protected, columns in parking areas subject to impact of moving vehicles shall be designed to resist the lateral load due to impact and this load shall be considered a variable load. For passenger vehicles, this lateral load shall be taken as a minimum of 6,000 pounds (26.70 kN) applied at least 1 foot 6 inches (457 mm); above the roadway, and acting simultaneously with other design loads.

1607.8 Impact loads. The live loads specified in Section 1607.2 include allowance for impact conditions. Provisions shall be made in the structural design for uses and loads that involve unusual vibration and impact forces.

1607.8.1 Elevators. Elevator loads shall be increased by 100 percent for impact and the structural supports shall be designed within the limits of stress and deflection prescribed by ASME A17.1.

1607.8.2 Machinery. For the purpose of design, the weight of machinery and moving loads shall be increased as follows to allow for impact: (1) elevator machinery, 100 percent; (2) light machinery, shaft- or motor-driven, 20 percent; (3) reciprocating machinery or power-driven units, 50 percent; (4) hangers for floors or balconies, 33 percent. Percentages shall be increased where specified by the manufacturer.

1607.8.3 Railroad equipment. Minimum loads (including vertical, lateral, longitudinal, and impact) and the distribution thereof shall meet the applicable requirements of the AREMA Manual for Railway Engineering Chapter 15, Steel Structures.

1607.8.4 Assembly structures. Seating areas in grandstands, stadiums, and similar assembly structures shall be designed to resist the simultaneous application of a horizontal swaying load of at least 24 plf (36 kg/m) of seats applied in a direction parallel to the row of the seats, and of at least 10 plf (15 kg/m) of seats in a direction

perpendicular to the row of the seats. When this load is used in combination with wind for outdoor structures, the wind load shall be one-half of the design wind load.

1607.9 Reduction in live loads. The minimum uniformly distributed live loads, L_o , in Table 1607.1 are permitted to be reduced according to the following provisions.

1607.9.1 General. Subject to the limitations of Sections 1607.9.1.1 through 1607.9.1.4, members for which a value of $K_{LL} A_T$ is 400 square feet (37.16 m^2) or more are permitted to be designed for a reduced live load in accordance with the following equation:

$$L = L_o \left(0.25 + \frac{15}{\sqrt{K_{LL} A_T}} \right) \quad (\text{Equation 16-21})$$

$$\text{For SI: } L = L_o \left(0.25 + \frac{4.57}{\sqrt{K_{LL} A_T}} \right)$$

where:

L = Reduced design live load per square foot (meter) of area supported by the member.

L_o = Unreduced design live load per square foot (meter) of area supported by the member (see Table 1607.1).

K_{LL} = Live load element factor (see Table 1607.9.1).

A_T = Tributary area, in square feet (square meters). L shall not be less than $0.50L_o$ for members supporting one floor and L shall not be less than $0.40L_o$ for members supporting two or more floors.

where:

L = Reduced design live load per square foot (meter) of area supported by the member.

L_o = Unreduced design live load per square foot (meter) of area supported by the member (see Table 1607.1).

K_{LL} = Live load element factor (see Table 1607.9.1).

A_T = Tributary area, in square feet (square meters). L shall not be less than $0.50L_o$ for members supporting one floor and L shall not be less than $0.40L_o$ for members supporting two or more floors.

TABLE 1607.9.1
LIVE LOAD ELEMENT FACTOR, K_{LL}

ELEMENT	K_{LL}
Interior columns	4
Exterior columns without cantilever slabs	4
Edge columns with cantilever slabs	3
Corner columns with cantilever slabs	2
Edge beams without cantilever slabs	2
Interior beams	2
All other members not identified above including: Edge beams with cantilever slabs Cantilever beams Two-way slabs Members without provisions for continuous shear transfer normal to their span	1

1607.9.1.1 Heavy live loads. Live loads that exceed 100 psf (4.79 kN/m²) shall not be reduced except the live loads for members supporting two or more floors are permitted to be reduced by a maximum of 20 percent, but the live load shall not be less than L as calculated in Section 1607.9.1.

1607.9.1.2 Passenger vehicle garages. The live loads shall not be reduced in passenger vehicle garages except the live loads for members supporting two or more floors are permitted to be reduced by a maximum of 20 percent, but the live load shall not be less than L as calculated in Section 1607.9.1.

1607.9.1.3 Special occupancies. Live loads of 100 psf (4.79 kN/m²) or less shall not be reduced in public assembly occupancies or in areas used for retail or wholesale sales.

1607.9.1.4 Special structural elements. Live loads shall not be reduced for one-way slabs except as permitted in Section 1607.9.1.1. Live loads shall not be reduced for calculating shear stresses at the heads of columns in flat slab or flat plate construction. Live loads of 100 psf (4.79 kN/m²) or less shall not be reduced for roof members except as specified in Section 1607.11.2.

1607.9.2 Alternate floor live load reduction. As an alternative to Section 1607.9.1, floor live loads are permitted to be reduced in accordance with the following provisions. Such reductions shall apply to slab systems, beams, girders, columns, piers, walls and foundations.

1. A reduction shall not be permitted in Group A occupancies.
2. A reduction shall not be permitted when the live load exceeds 100 psf (4.79 kN/m²) except that the design live load for columns may be reduced by 20 percent.
3. For live loads not exceeding 100 psf (4.79 kN/m²), the design live load for any structural member supporting 150 square feet (13.94 m²) or more is permitted to be reduced in accordance with the following equation:

$$R = r(A - 150)$$

(Equation 16-22)

For SI: $R = r(A - 13.94)$

Such reduction shall not exceed 40 percent for horizontal members, 60 percent for vertical members, nor R as determined by the following equation:

Such reduction shall not exceed 40 percent for horizontal members, 60 percent for vertical members, nor R as determined by the following equation:

$$R = 23.1(1 + D/L_o) \quad (\text{Equation 16-23})$$

where:

A = Area of floor or roof supported by the member, square feet (m^2).

D = Dead load per square foot (m^2) of area supported.

L_o = Unreduced live load per square foot (m^2) of area supported.

R = Reduction in percent.

r = Rate of reduction equal to 0.08 percent for floors.

1607.10 Distribution of floor loads. Where uniform floor live loads are involved in the design of structural members arranged so as to create continuity, the minimum applied loads shall be the full dead loads on all spans in combination with the floor live loads on spans selected to produce the greatest effect at each location under consideration. It shall be permitted to reduce floor live loads in accordance with Section 1607.9.

1607.11 Roof loads. The structural supports of roofs and marquees shall be designed to resist wind and, where applicable, snow and earthquake loads, in addition to the dead load of construction and the appropriate live loads as prescribed in this section, or as set forth in Table 1607.1. The live loads acting on a sloping surface shall be assumed to act vertically on the horizontal projection of that surface.

1607.11.1 Distribution of roof loads. Where uniform roof live loads are involved in the design of structural members arranged so as to create continuity, the minimum applied loads shall be the full dead loads on all spans in combination with the roof live loads on adjacent spans or on alternate spans, whichever produces the greatest effect. See Section 1607.11.2 for minimum roof live loads and Section 1608.5 for partial snow loading.

1607.11.1.1 Arches and gabled frames. The following simplification is permissible:

1. Live load placed on ½ of the span adjacent to one support.
2. Live load placed on the center ¼ of the span.
3. Live load placed on ⅜ of the span adjacent to each support.

1607.11.2 Minimum roof live loads. Minimum roof loads shall be determined for the specific conditions in accordance with Sections 1607.11.2.1 through 1607.11.2.4.

1607.11.2.1 Flat, pitched and curved roofs. Ordinary flat, pitched and curved roofs shall be designed for the live loads specified in the following equation or other controlling combinations of loads in Section 1605, whichever produces the greater load. In structures where special scaffolding is used as a work surface for workers and materials during maintenance and repair operations, a lower roof load than specified in the following equation shall not be used unless approved by the commissioner. Greenhouses shall be designed for a minimum roof live load of 10 psf (0.479 kN/m²).

$$L_r = 20R_1R_2$$

(Equation 16-24)

where: $12 \leq L_r \leq 20$

For SI: $L_r = 0.96 R_1 R_2$

where: $0.58 \leq L_r \leq 0.96$

$L_r =$ Roof live load per square foot (m^2) of horizontal projection in pounds per square foot (kN/m^2).

For SI: $L_r = 0.96 R_1 R_2$

where: $0.58 \leq L_r \leq 0.96$

L_r = Roof live load per square foot (m^2) of horizontal projection in pounds per square foot (kN/m^2).

The reduction factors R_1 and R_2 shall be determined as follows:

$$R_1 = 1 \quad \text{for } A_t \leq 200 \text{ square feet} \\ \text{(18.58 m}^2\text{)} \\ \text{(Equation 16-25)}$$

$$R_1 = 1.2 - 0.001A_t \quad \text{for } 200 \text{ square feet} < A_t < \\ 600 \text{ square feet} \\ \text{(Equation 16-26)}$$

$$\text{For SI: } 1.2 - 0.011A_t \quad \text{for } 18.58 \text{ square meters} < A_t < \\ 55.74 \text{ square meters} \\ R_1 = 0.6 \quad \text{for } A_t \geq 600 \text{ square feet} \\ \text{(55.74 m}^2\text{)} \\ \text{(Equation 16-27)}$$

where:

A_t = Tributary area (span length multiplied by effective width) in square feet (m^2) supported by any structural member, and

F = for a sloped roof, the number of inches of rise per foot (for SI: $F = 0.12 \times$ slope, with slope expressed in percentage points), and

F = for an arch or dome, rise-to-span ratio multiplied by 32, and

$$R_2 = 1 \quad \text{for } F \leq 4 \quad (\text{Equation 16-28})$$

$$R_2 = 1.2 - 0.05 F \quad \text{for } 4 < F < 12 \quad (\text{Equation 16-29})$$

$$R_2 = 0.6 \quad \text{for } F \geq 12 \quad (\text{Equation 16-30})$$

1607.11.2.2 Special-purpose roofs. Roofs used for promenade purposes shall be designed for a minimum live load of 60 psf (2.87 kN/m²). Roofs used for roof gardens or assembly purposes shall be designed for a minimum live load of 100 psf (4.79 kN/m²). Roofs used for other special purposes shall be designed for appropriate loads, as directed or approved by the commissioner.

1607.11.2.3 Green roofs. Where roofs utilize a green roof system and are not intended for human occupancy, the uniform design live load in the area covered by the green roof shall be 20 psf (0.958 kN/m²). The weight of the landscaping materials shall be considered as dead load and shall be computed on the basis of saturation of the soil. Where roofs utilize a green roof system and are used for human occupancy, the minimum live load shall be as specified in Table 1607.1 or Section 1607.11.2.2, whichever is greater.

1607.11.2.4 Awnings and canopies. Awnings and canopies shall be designed for a uniform live load of 5 psf (0.240 kN/m²) as well as for snow loads and wind loads as specified in Sections 1608 and 1609.

1607.11.2.5 Hanging loads. Girders and roof trusses (other than joists) over garage areas regularly utilized for the repair of vehicles and over manufacturing floors or storage floors used for commercial purposes shall be capable of supporting, in addition to the specified live and wind loads, a concentrated live load of 2,000 pounds (908 kg) applied at any lower chord panel point for trusses, and at any point of the lower flange for girders.

1607.12 Crane loads. The crane live load shall be the rated capacity of the crane. Design loads for the runway beams, including connections and support brackets, of moving bridge cranes and monorail cranes shall include the maximum wheel loads of the crane and the vertical impact, lateral and longitudinal forces induced by the moving crane.

1607.12.1 Maximum wheel load. The maximum wheel loads shall be the wheel loads produced by the weight of the bridge, as applicable, plus the sum of the rated capacity and the weight of the trolley with the trolley positioned on its runway at the location where the resulting load effect is maximum.

1607.12.2 Vertical impact force. The maximum wheel loads of the crane shall be increased by the percentages shown below to determine the induced vertical impact or vibration force:

Monorail cranes (powered).....25 percent

Cab-operated or remotely operated bridge cranes (powered).....25 percent

Pendant-operated bridge cranes (powered).....10 percent

Bridge cranes or monorail cranes with hand-gearred bridge, trolley and hoist percent.....0 percent

1607.12.3 Lateral force. The lateral force on crane runway beams with electrically powered trolleys shall be calculated as 20 percent of the sum of the rated capacity of the crane and the weight of the hoist and trolley. The lateral force shall be assumed to act horizontally at the traction surface of a runway beam, in either direction perpendicular to the beam, and shall be distributed according to the lateral stiffness of the runway beam and supporting structure.

1607.12.4 Longitudinal force. The longitudinal force on crane runway beams, except for bridge cranes with hand-gearred bridges, shall be calculated as 10 percent of the maximum wheel loads of the crane. The longitudinal force shall be assumed to act horizontally at the traction surface of a runway beam, in either direction parallel to the beam.

1607.13 Interior walls and partitions. Interior walls and partitions that exceed 6 feet (1829 mm) in height, including their finish materials, shall have adequate strength to resist the loads to which they are subjected but not less than a horizontal load of 5 psf (0.240 kN/ m²).

SECTION BC 1608 **SNOW LOADS AND THERMAL LOADS**

1608.1 General. Design snow loads shall be determined in accordance with Section 7 of ASCE 7, but the design roof load shall not be less than that determined by Section 1607.

1608.2 Ground snow loads. The ground snow load, P_g , to be used in determining the design snow loads for roofs is 25 psf (1.2 kN/m²).

1608.3 Flat roof snow loads. The flat roof snow load, ρ_f , on a roof with a slope equal to or less than 5 degrees (0.09 rad) (1 inch per foot = 4.76 degrees) shall be calculated in accordance with Section 7.3 of ASCE 7.

1608.3.1 Exposure factor. The value for the snow exposure factor, C_e , used in the calculation of ρ_f shall be determined from Table 1608.3.1.

TABLE 1608.3.1
SNOW EXPOSURE FACTOR C_e

<u>TERRAIN CATEGORY^a</u>	<u>EXPOSURE OF ROOF^{a,b}</u>		
	<u>Fully exposed^c</u>	<u>Partially exposed</u>	<u>Sheltered</u>
A (see Section 1609.4)	<u>N/A</u>	<u>1.1</u>	<u>1.3</u>
B (see Section 1609.4)	<u>0.9</u>	<u>1.0</u>	<u>1.2</u>
C (see Section 1609.4)	<u>0.9</u>	<u>1.0</u>	<u>1.1</u>

For SI: 1 mile=1609m.

- a. The terrain category and roof exposure condition chosen shall be representative of the anticipated conditions during the life of the structure. An exposure factor shall be determined for each roof of a structure.
- b. Definitions of roof exposure are as follows:
 1. Fully exposed shall mean roofs exposed on all sides with no shelter afforded by terrain, higher structures or trees. Roofs that contain several large pieces of mechanical equipment, parapets which extend above the height of the balanced snow load, h_b , or other obstructions are not in this category.
 2. Partially exposed shall include all roofs except those designated as “fully exposed” or “sheltered”
 3. Sheltered roofs shall mean those roofs located tight in among conifers that qualify as ‘obstructions’
- c. Obstructions within a distance of $10 h_o$ provide “shelter”, where h_o is the height of the obstruction above the roof level. If the only obstructions are a few deciduous trees that are leafless in winter, the “fully exposed” category shall be used except for terrain category “A.” Note that these are heights above the roof. Heights used to establish the terrain category in Section 1609.4 are heights above the ground.

1608.3.2 Thermal factor. The value for the thermal factor, C_t , used in the calculation of ρ_f shall be determined from Table 1608.3.2.

**TABLE 1609.3.2
THERMAL FACTOR, C_t**

THERMAL CONDITION ^a	C_t
All structures except as indicated below	1.0
Structures kept just above freezing and others with cold, ventilated roofs in which the thermal resistance (<i>R</i> -value) between the ventilated space and the heated space exceeds $25\text{h} \cdot \text{ft}^2 \cdot ^\circ\text{F}/\text{Btu}$	1.1
Unheated structures	1.2
Continuously heated greenhouses ^b with a roof having a thermal resistance (<i>R</i> -value) less than $2.0\text{h} \cdot \text{ft}^2 \cdot ^\circ\text{F}/\text{Btu}$	0.85

For SI: $^\circ\text{C} = [^\circ\text{F} - 32] / 1.8$, 1 British thermal unit per hour = 0.2931 W.

a. The thermal condition shall be representative of the anticipated conditions during winters for the life of the structure.

b. A continuously heated greenhouse shall mean a greenhouse with a constantly maintained interior temperature of 50°F or more during winter months. Such greenhouse shall also have a maintenance attendant on duty at all times or a temperature alarm system to provide warning in the event of a heating system failure.

1608.3.3 Snow load importance factor. The value for the snow load importance factor, I_s , used in the calculation of p_f shall be determined in accordance with Table 1604.5. Greenhouses that are occupied for growing plants on production or research basis, without public access, shall be included in Importance Category I.

1608.3.4 Rain-on-snow surcharge load. Roofs with a slope less than ½ inch per foot (2.38 degrees) shall be designed for a rain-on-snow surcharge load determined in accordance with Section 7.10 of ASCE 7.

1608.3.5 Ponding instability. For roofs with a slope less than ¼ inch per foot (1.19 degrees), the design calculations shall include verification of the prevention of ponding instability in accordance with Section 7.11 of ASCE 7.

1608.3.6 Ice. For ice loads to be used in the design of ice sensitive structures such as open framed or guyed towers refer to ASCE 7.

1608.4 Sloped roof snow loads. The snow load, p_s , on a roof with a slope greater than 5 degrees (0.09 rad) (1 inch per foot = 4.76 degrees) shall be calculated in accordance with Section 7.4 of ASCE 7.

1608.5 Partial loading. The effect of not having the balanced snow load over the entire loaded roof area shall be analyzed in accordance with Section 7.5 of ASCE 7.

1608.6 Unbalanced snow loads. Unbalanced roof snow loads shall be determined in accordance with Section 7.6 of ASCE 7. Winds from all directions shall be accounted for when establishing unbalanced snow loads.

1608.7 Drifts on lower roofs. In areas where the ground snow load, p_g , as determined by Section 1608.2, is equal to or greater than 5 psf (0.240 kN/ m²), roofs shall be designed to sustain localized loads from snowdrifts in accordance with Section 7.7 of ASCE 7.

1608.8 Roof projections. Drift loads due to mechanical equipment, penthouses, parapets and other projections above the roof shall be determined in accordance with Section 7.8 of ASCE 7.

1608.9 Sliding snow. The extra load caused by snow sliding off a sloped roof onto a lower roof shall be determined in accordance with Section 7.9 of ASCE 7.

1608.10 Thermal forces. The design of enclosed buildings more than 250 feet (76 200 mm) in plan dimension shall provide for the forces and/or movements resulting from an assumed expansion corresponding to a change in temperature of 40°F (4.44°C). For exterior exposed frames, arches, or shells regardless of plan dimensions, the design shall provide for the forces and/or movements resulting from an assumed expansion and contraction corresponding to an increase or decrease in temperature of 40°F (4.44°C) for concrete or masonry construction and 60°F (15.55°C) for metal construction. For determination of the required anchorage for piping, the forces shall be determined on the

basis of temperature variations for the specific service conditions. Friction forces in expansion bearings shall be considered.

SECTION BC 1609 **WIND LOADS**

1609.1 Applications. Buildings, structures and parts thereof shall be designed to withstand the minimum wind loads prescribed herein. Decreases in wind loads shall not be made for the effect of shielding by other structures.

1609.1.1 Determination of wind loads. Wind loads on every building or structure shall be determined in accordance with Section 6 of ASCE 7. Wind shall be assumed to come from any horizontal direction and wind pressures shall be assumed to act normal to the surface considered. Exposure-A as defined in section 1609.4 can be considered using ASCE 7 where applicable.

Exceptions:

1. Wind loads determined by the provisions of Section 1609.6.
2. Subject to the limitations of Section 1609.1.1.1, the provisions of *SBCCI SSTD 10 Standard for Hurricane Resistant Residential Construction* shall be permitted for applicable Group R-2 and R-3 buildings.
3. Subject to the limitations of Section 1609.1.1.1, residential structures using the provisions of the *AF&PA Wood Frame Construction Manual for One-and Two-Family Dwellings*.
4. Designs using *NAAMM FP 1001 Guide Specification for Design of Metal Flagpoles*.
5. Designs using TIA/EIA-222 for antenna-supporting structures and antennas.

1609.1.1.1 Applicability. The provisions of SSTD10 are applicable only to buildings located within Exposure, B or C as defined in Section 1609.4. The provisions of SSTD 10 and the *AF&PA Wood Frame construction Manual for One- and Two-Family Dwellings* shall not apply to buildings sited on the upper half of an isolated hill, ridge or escarpment meeting the following conditions:

1. The hill, ridge or escarpment is 60 feet (18 288 mm) or higher if located in Exposure B or 30 feet (9144 mm) or higher if located in Exposure C;
2. The maximum average slope of the hill exceeds 10 percent; and
3. The hill, ridge or escarpment is unobstructed upwind by other such

topographic features for a distance from the high point of 50 times the height of the hill or 1 mile (1.61 km), whichever is greater.

1609.1.2 Minimum wind loads. The wind loads used in the design of the main wind-force-resisting system shall not be less than 20 psf (0.958 kN/m²) multiplied by the area of the building or structure projected on a vertical plane normal to the wind direction. In the calculation of design wind loads for components and cladding for buildings, the algebraic sum of the pressures acting on opposite faces shall be taken into account. The design pressure for components and cladding of buildings shall not be less than 20 psf (0.958 kN/m²) acting in either direction normal to the surface. The design force for open buildings and other structures shall not be less than 10 psf (0.479 kN/m²) multiplied by the area A_f .

1609.1.3 Anchorage against overturning, uplift and sliding. Structural members and systems and components and cladding in a building or structure shall be anchored to resist wind-induced overturning, uplift and sliding and to provide continuous load paths for these forces to the foundation. Where a portion of the resistance to these forces is provided by dead load, the dead load, including the weight of soils and foundations, shall be taken as the minimum dead load likely to be in place during a design wind event. Where the alternate basic load combinations of Section 1605.3.2 are used, only two-thirds of the minimum dead load likely to be in place during a design wind event shall be used.

1609.1.4 Wind and seismic detailing. Lateral-force-resisting systems shall meet seismic detailing requirements and limitations prescribed in this code, even when wind code prescribed load effects are greater than seismic load effects.

1609.2 Definitions. The following words and terms shall, for the purposes of Section 1609.6, have the meanings shown herein.

BUILDINGS AND OTHER STRUCTURES, FLEXIBLE. Buildings and other structures that have a fundamental natural frequency less than 1 Hz.

BUILDING, ENCLOSED. A building that does not comply with the requirements for open or partially enclosed buildings.

BUILDING, LOW-RISE. Enclosed or partially enclosed buildings that comply with the following conditions:

1. Mean roof height, h , less than or equal to 60 feet (18 288 mm).
2. Mean roof height, h , does not exceed least horizontal dimension.

BUILDING, OPEN. A building having each wall at least 80 percent open. This condition is expressed for each wall by the equation:

$$A_o \geq 0.8A_g \quad \text{(Equation 16-31)}$$

where:

A_o = Total area of openings in a wall that receives positive external pressure, in square feet (m^2).

A_g = The gross area of that wall in which A_o is identified, in square feet (m^2).

BUILDING, PARTIALLY ENCLOSED. A building that complies with both of the following conditions:

1. The total area of openings in a wall that receives positive external pressure exceeds the sum of the areas of openings in the balance of the building envelope (walls and roof) by more than 10 percent; and
2. The total area of openings in a wall that receives positive external pressure exceeds 4 square feet (0.37 m²) or 1 percent of the area of that wall, whichever is smaller, and the percentage of openings in the balance of the building envelope does not exceed 20 percent. These conditions are expressed by the following equations:

$$A_o > 1.10A_{oi} \quad (\text{Equation 16-32})$$

$$A_o > 4 \text{ square feet (0.37 m}^2\text{) or } > 0.01A_g, \text{ whichever is smaller,} \\ \text{and } A_{oi}/A_{gi} \leq 0.20 \quad (\text{Equation 16-33})$$

where:

A_o , A_g are as defined for an open building.

A_{oi} = The sum of the areas of openings in the building envelope (walls and roof) not including A_o , in square feet (m^2).

A_{gi} = The sum of the gross surface areas of the building envelope (walls and roof) not including A_g , in square feet (m^2).

BUILDING, SIMPLE DIAPHRAGM. A building in which wind loads are transmitted through floor and roof diaphragms to the vertical lateral-force-resisting systems.

COMPONENTS AND CLADDING. Elements of the building envelope that do not qualify as part of the main wind force-resisting system.

EFFECTIVE WIND AREA. The area used to determine GC_p . For component and cladding elements, the effective wind area in Tables 1609.6.2.1(2) and 1609.6.2.1(3) is the span length multiplied by an effective width that need not be less than one-third the span length. For cladding fasteners, the effective wind area shall not be greater than the area that is tributary to an individual fastener.

HURRICANE-PRONE REGIONS. New York City is within the hurricane prone region.

IMPORTANCE FACTOR, I . A factor that accounts for the degree of hazard to human life and damage to property.

MAIN WIND FORCE-RESISTING SYSTEM. An assemblage of structural elements assigned to provide support and stability for the overall structure. The system generally receives wind loading from more than one surface.

MEAN ROOF HEIGHT. The average of the roof eave height and the height to the highest point on the roof surface, except that eave height shall be used for roof angle of less than or equal to 10 degrees (0.1745 rad).

WIND-BORNE DEBRIS REGION. New York City is not in the Wind-Borne Debris Region.

1609.3 Basic wind speed. The basic wind speed for New York City which is measured at 33 feet (10 058 mm) above ground as 3-second gust speed is 98 mph (43.8 m/s). This wind speed is based on local wind climate with annual probability of 0.02 (50-year mean recurrence interval).

1609.3.1 Wind speed conversion. When required, the 3-second gust wind velocity of 98 mph (43.12 m/s) can be converted to 79 mph (35.2 m/s) fastest mile wind velocity.

1609.4 Exposure category. For each wind direction considered, an exposure category that adequately reflects the characteristics of ground surface irregularities shall be determined for the site at which the building or structure is to be constructed. For a site located in the transition zone between categories, the category resulting in the largest wind forces shall apply. Account shall be taken of variations in ground surface roughness that arise from natural topography and vegetation as well as from constructed features. For any given wind direction, the exposure in which a specific building or other structure is sited shall be assessed as being one of the following categories. When applying the simplified wind load method of Section 1609.6, a single exposure category shall be used based upon the most restrictive for any given wind direction.

1. Exposure A. Large city centers with at least 50 percent of the buildings having a height in excess of 70 feet (21 366 mm). Use of this exposure category shall be limited to those areas for which terrain representative of Exposure A prevails in the upwind direction for a distance of at least 2,500 feet (762 m) or 10 times the height of the building or structure, whichever is greater. Possible channeling effects or increased velocity pressures due to the building or structure being located in the wake of adjacent buildings shall be taken into account. See Table 1609.4.1-a and Table 1609.4.1-b for terrain and pressure coefficients related to Exposure-A.

Table- 1609.6.4.1-a
Terrain Exposure Constants

Exposure	α	z_g (ft)	\hat{a}	\hat{b}	$\bar{\alpha}$	\bar{b}	c	ℓ (ft)	$\bar{\epsilon}$	z_{min} (ft)*
A	5.0	1500	1/5	0.64	1/3.0	0.30	0.45	180	1/2.0	60

* z_{min} = minimum height used to ensure that the equivalent height \bar{z} is greater of $0.6h$ or z_{min} .
For buildings with $h \leq z_{min}$, \bar{z} shall be taken as z_{min} .

Table- 1609.6.4.1-b

Velocity Pressure Exposure Coefficients, K_h and K_z

Height above ground level, z		Exposure	
		A	
ft	(m)	Case 1	Case 2
0-15	(0-4.6)	0.68	0.32
20	(6.1)	0.68	0.36
25	(7.6)	0.68	0.39
30	(9.1)	0.68	0.42
40	(12.2)	0.68	0.47
50	(15.2)	0.68	0.52
60	(18)	0.68	0.55
70	(21.3)	0.68	0.59
80	(24.4)	0.68	0.62
90	(27.4)	0.68	0.65
100	(30.5)	0.68	0.68
120	(36.6)	0.73	0.73
140	(42.7)	0.78	0.78
160	(48.8)	0.82	0.82
180	(54.9)	0.86	0.86
200	(61.0)	0.90	0.90
250	(76.2)	0.98	0.98
300	(91.4)	1.05	1.05
350	(106.7)	1.12	1.12
400	(121.9)	1.18	1.18
450	(137.2)	1.24	1.24
500	(152.4)	1.29	1.29

- The velocity pressure exposure coefficient K_z may be determined from the following formula:
 For $15 \text{ ft.} \leq z \leq z_g$ For $z < 15 \text{ ft.}$

$$K_z = 2.01 (z/z_g)^{2/\alpha}$$

$$K_z = 2.01 (15/z_g)^{2/\alpha}$$
- Linear interpolation for intermediate values of height z is acceptable.

2. Exposure B. Urban and suburban areas, wooded areas or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger. Exposure B shall be assumed unless the site meets the definition of another type of exposure.
3. Exposure C. Open terrain with scattered obstructions, including surface undulations or other irregularities, having heights generally less than 30 feet (9144 mm) extending more than 1,500 feet (457.2 m) from the building site in any quadrant. This exposure shall also apply to any building located within Exposure B-type terrain where the building is directly adjacent to open areas of Exposure C-type terrain in any quadrant for a distance of more than 600 feet (182.9 m). This category includes flat open country, grasslands and shorelines in hurricane-prone regions.
4. Exposure D. Not applicable in New York City.

1609.5 Importance factor. Buildings and other structures shall be assigned a wind load importance factor, I_w , in accordance with Table 1604.5.

1609.6 Simplified wind load methods.

1609.6.1 Scope. The procedures in Section 1609.6 shall be permitted to be used for determining and applying wind pressures in the design of enclosed buildings as listed below:

1. For buildings with flat, gabled or hipped roofs having a mean roof height not exceeding the least horizontal dimension or 60 feet (18 288 mm), whichever is less, the use of Section 1609.6.2, Simplified Procedure-I, is permitted.
2. For buildings with a mean roof height of not more than 200 feet (60 960 mm) and located not closer than 2,000 feet (609.6 m) to the river, bay, or ocean shore line in any Borough other than Manhattan, the use of Section 1609.6.3, Simplified Procedure-II, is permitted.
3. For buildings with a mean roof height of not more than 300 feet (91 440 mm) within the Borough of Manhattan and located not closer than 2,000 feet (609.6 m) to the river, bay or ocean shore line, the use of Section 1609.6.3, Simplified Procedure-II, is permitted.

1609.6.1.1 Reduction of loads. The design wind pressures determined in accordance with Sections 1609.6.2 and 1609.6.3 may be reduced by one of the following methods:

1. Application of the directionality factor (K_d) as specified in Table 6-4 of ASCE 7 to the design wind pressures.

2. Reduction of the load factor for the wind load (W) from 1.6 to 1.3 for the load combinations specified in Section 1605.2.

1609.6.2 Simplified design procedure-I (for low-rise buildings).

1. The wind shall be assumed to come from any horizontal direction.
2. An importance factor I_w shall be determined in accordance with Section 1609.5.
3. An exposure category shall be determined in accordance with Section 1609.4.
4. A height and exposure adjustment coefficient, λ , shall be determined from Table 1609.6.2.1(4).

1609.6.2.1 Main wind force-resisting system. Simplified design wind pressures, p_s , for the main wind force-resisting systems represent the net pressures (sum of internal and external) to be applied to the horizontal and vertical projections of building surfaces as shown in Figure 1609.6.2.1. For the horizontal pressures (Zones A, B, C, D), p_s is the combination of the windward and leeward net pressures. p_s shall be determined from Equation 16-34).

$$P_s = \lambda I_w P_{s30}$$

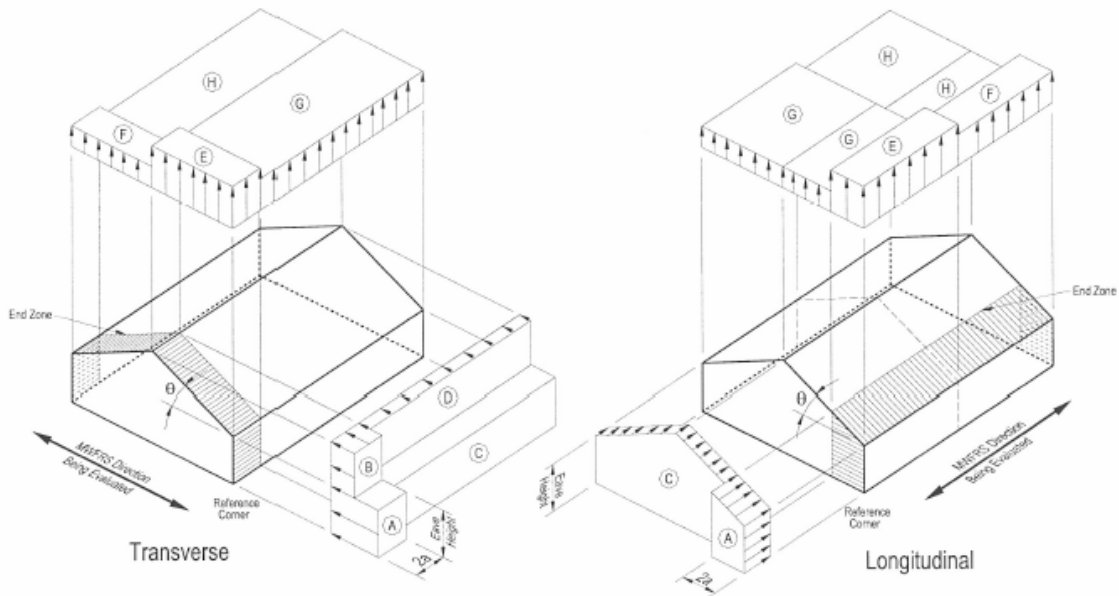
(Equation 16-34)

where:

λ = Adjustments factor for building height and exposure from Table 1609.6.2.1(4).

I_w = Importance factor as defined in Section 1609.5.

P_{s30} = Simplified design wind pressure for Exposure B, at h= 30 feet (9144 mm), and for $I_w = 1.0$, from Table 1609.6.2.1(1).



**FIGURE 1609.6.2.1
MAIN WINDFORCE LOADING DIAGRAM**

For SI: 1 foot = 304.8 mm, 1 degree = 0.0174 rad.

Notes:

1. Pressures are applied to the horizontal and vertical projections for Exposure B, at $h = 30$ feet, for $I_w = 1.0$. Adjust to other exposures and heights with adjustment factor λ .
2. The load patterns shown shall be applied to each corner of the building in turn as the reference corner.
3. For the design of the longitudinal MWFRS, use $\theta = 0^\circ$, and locate the Zone E/F, G/H boundary at the mid-length of the building.
4. Load Cases 1 and 2 must be checked for $25^\circ < \theta \leq 45^\circ$. Load Case 2 at 25° is provided only for interpolation between 25° to 30° .
5. Plus and minus signs signify pressures acting toward and away from the projected surfaces, respectively.
6. For roof slopes other than those shown, linear interpolation is permitted.
7. The total horizontal load shall not be less than that determined by assuming $p_s = 0$ in Zones B and D.
8. The zone pressures represent the following:
 - Horizontal pressure zones — Sum of the windward and leeward net (sum of internal and external) pressures on vertical projection of:

A — End zone of wall	C — Interior zone of wall
B — End zone of roof	D — Interior zone of roof
 - Vertical pressure zones — Net (sum of internal and external) pressures on horizontal projection of:

E — End zone of windward roof	G — Interior zone of windward roof
F — End zone of leeward roof	H — Interior zone of leeward roof
9. Where Zone E or G falls on a roof overhang on the windward side of the building, use E_{OH} and G_{OH} for the pressure on the horizontal projection of the overhang. Overhangs on the leeward and side edges shall have the basic zone pressure applied.
10. Notation:
 - a: 10 percent of least horizontal dimension or $0.4h$, whichever is smaller, but not less than either 4 percent of least horizontal dimension or 3 feet.
 - h: Mean roof height, in feet (meters), except that eave height shall be used for roof angles $< 10^\circ$.
 - θ : Angle of plane of roof from horizontal, in degrees.

Interior Zones
Roofs - Zone 1 / Walls - Zone 4

End Zones
Roofs - Zone 2 / Walls - Zone 5

Corner Zones
Roofs - Zone 3

TABLE 1609.6.2.1(1)
SIMPLIFIED DESIGN WIND PRESURE (MAIN WINDFORCE-RESISTING SYSTEM), p_{s30} (Exposure B at h = 30 feet with $I_w = 1.0$) (psf)

ROOF ANGLE (degrees)	ROOF RISE IN 12"	LOAD CASE	ZONES									
			Horizontal Pressures				Vertical Pressures				Overhangs	
			A	B	C	D	E	F	G	H	E_{OH}	G_{OH}
0 to 5°	Flat	1	11.5	-5.9	7.6	-3.5	-13.8	-7.8	-9.6	-6.1	-19.3	-15.1
10°	2	1	21.6	-9.0	14.4	-5.2	-23.1	-14.1	-16.0	-10.8	-32.3	-25.3
15°	3	1	24.1	-8.0	16.0	-4.6	-23.1	-15.1	-16.0	-11.5	-32.3	-25.3
20°	4	1	26.6	-7.0	17.7	-3.9	-23.1	-16.0	-16.0	-12.2	-32.3	-25.3
25°	6	1	24.1	3.9	17.4	4.0	-10.7	-14.6	-7.7	-11.7	-19.9	-17.0
		2	—	—	—	—	-4.1	-7.9	-1.1	-5.1	—	—
30° to 45°	7 to 12	1	21.6	14.8	17.2	11.8	1.7	-13.1	0.6	-11.3	-7.6	-8.7
		2	21.6	14.8	17.2	11.8	8.3	-6.5	7.2	-4.6	-7.6	-8.7

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0174 rad, 1 mile per hour = 0.44 m/s, 1 pound per square foot = 47.9 N/m².

TABLE 1609.6.2.(2)
NET DESIGN WIND PRESURE (COMPONENT AND CLADDING), p_{net30}
(Exposure B at $h = 30$ feet with $I_w = 1.0$) (psf)

	ZONE	EFFECTIVE WIND AREA		
Roof 0 to 7 degrees	1	10	8.9	-21.8
	1	20	8.3	-21.2
	1	50	7.6	-20.5
	1	100	7.0	-19.9
	2	10	8.9	-36.5
	2	20	8.3	-32.6
	2	50	7.6	-27.5
	2	100	7.0	-23.6
	3	10	8.9	-55.0
	3	20	8.3	-45.5
	3	50	7.6	-33.1
	3	100	7.0	-23.6
Roof > 7 to 27 degrees	1	10	12.5	-19.9
	1	20	11.4	-19.4
	1	50	10.0	-18.6
	1	100	8.9	-18.1
	2	10	12.5	-34.7
	2	20	11.4	-31.9
	2	50	10.0	-28.2
	2	100	8.9	-25.5
	3	10	12.5	-51.3
	3	20	11.4	-47.9
	3	50	10.0	-43.5
	3	100	8.9	-40.2
Roof > 27 to 45 degrees	1	10	19.9	-21.8
	1	20	19.4	-20.7
	1	50	18.6	-19.2
	1	100	18.1	-18.1
	2	10	19.9	-25.5
	2	20	19.4	-24.3
	2	50	18.6	-22.9
	2	100	18.1	-21.8
	3	10	19.9	-25.5
	3	20	19.4	-24.3
	3	50	18.6	-22.9
	3	100	18.1	-21.8
Wall	4	10	21.8	-23.6
	4	20	20.8	-22.6
	4	50	19.5	-21.3
	4	100	18.5	-20.4
	4	500	16.2	-18.1
	5	10	21.8	-29.1
	5	20	20.8	-27.2
	5	50	19.5	-24.6
	5	100	18.5	-22.6
	5	500	16.2	-18.1

For SI: 1 foot = 304.8 mm, 1 degree = 0.0174 rad, 1 mile per hour = 0.44 m/s, 1 pound per square foot = 47.9 N/m².

Note: For effective areas between those given above, the load is permitted to be interpolated, otherwise use the load associated with the lower effective area.

TABLE 1609.6.2.1(3)
ROOF OVERHANG NET DESIGN WIND PRESSURE (COMPONENT AND CLADDING), p_{net30} (Exposure B at $h = 30$ feet with $I_w = 1.0$) (psf)

	ZONE	EFFECTIVE WIND AREA (sq. ft.)	
Roof 0 to 7 degrees	2	10	-31.4
	2	20	-30.8
	2	50	-30.1
	2	100	-29.5
	3	10	-51.6
	3	20	-40.5
	3	50	-25.9
	3	100	-14.8
Roof > 7 to 27 degrees	2	10	-40.6
	2	20	-40.6
	2	50	-40.6
	2	100	-40.6
	3	10	-68.3
	3	20	-61.6
	3	50	-52.8
	3	100	-46.1
Roof > 27 to 45 degrees	2	10	-36.9
	2	20	-35.8
	2	50	-34.3
	2	100	-33.2
	3	10	-36.9
	3	20	-35.8
	3	50	-34.3
	3	100	-33.2

For SI: 1 foot = 304.8 mm, 1 degree = 0.0174 rad, 1 mile per hour = 0.45 m/s, 1 pound per square foot = 47.9 N/m².

Note: For effective areas between those given above, the load is permitted to be interpolated, otherwise use the load associated with the lower effective area.

TABLE 1609.6.2.1(4)
ADJUSTMENT FACTOR FOR BUILDING HEIGHT AND EXPOSURE, (λ)

MEAN ROOF HEIGHT (feet)	EXPOSURE		A
	B	C	
15	1.00	1.21	.7
20	1.00	1.29	.7
25	1.00	1.35	.7
30	1.00	1.40	.7
35	1.05	1.45	.7
40	1.09	1.49	.8
45	1.12	1.53	.8
50	1.16	1.56	.8
55	1.19	1.59	.8
60	1.22	1.62	.8

For SI: 1 foot = 304.8 mm.

a. All table values shall be adjusted for other exposures and heights by multiplying by the above coefficients.

1609.6.2.1.1 Minimum pressures. The load effects of the design wind pressures from Section 1609.6.2.1 shall not be less than assuming the pressures, p_s , for Zones A, B, C and D all equal to + 20 psf (0.96 kN/m²), while assuming Zones E, F, G, and H all equal to 0 psf.

1609.6.2.2 Components and cladding. Net design wind pressures, p_{net} , for the components and cladding of buildings represent the net pressures (sum of internal and external) to be applied normal to each building surface as shown in Figure 1609.6.2.2. The net design wind pressure, p_{net} , shall be determined from Equation 16-35:

$$P_{net} = \lambda I_w P_{net30}$$

(Equation 16-35)

where:

λ = Adjustments factor for building height and exposure from Table 1609.6.2.1(4).

I_w = Importance factor as defined in Section 1609.5.

P_{net30} = Net design wind pressure for Exposure B, at $h = 30$ feet (9144 mm), and for $I_w = 1.0$, from Tables 1609.6.2.1(2) and 1609.6.2.1(3).

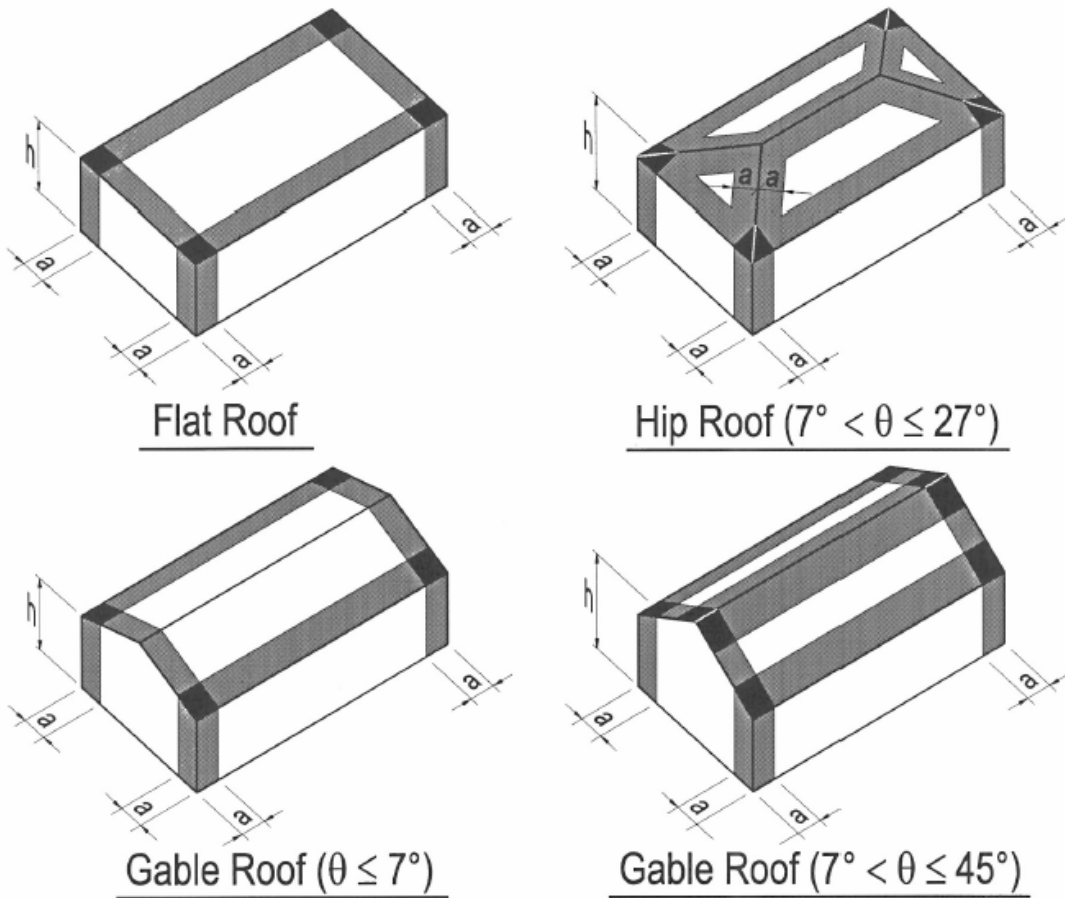


FIGURE 1609.6.2.2
COMPONENT AND CLADDING PRESSURE

For SI: 1 foot = 304.8 mm, 1 degree = 0.0174 rad.

Notes:

1. Pressures are applied normal to the surface for Exposure B, at $h = 30$ feet, for $I_w = 1.0$. Adjust to other exposures and heights with adjustment factor λ .
2. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
3. For hip roofs with $\theta \leq 25^\circ$, Zone 3 shall be treated as Zone 2.
4. For effective areas between those given, the value is permitted to be interpolated, otherwise use the value associated with the lower effective area.
5. Notation:
 - a : 10 percent of least horizontal dimension or $0.4h$, whichever is smaller, but not less than either 4 percent of least horizontal dimension or 3 feet.
 - h : Mean roof height, in feet (meters), except that eave height shall be used for roof angles $< 10^\circ$.
 - θ : Angle of plane of roof from horizontal, in degrees.

1609.6.2.2.1 Minimum pressures. The positive design wind pressures, p_{net} , from Section 1609.6.2.2 shall not be less than + 30 psf (1.44 kN/m²), and the negative design wind pressures, p_{net} , from Section 1609.6.2.2 shall not be less than - 30 psf (-1.44 kN/m²).

1609.6.2.3 Load case. Members that act as both part of the main wind force-resisting system and as components and cladding shall be designed for each separate load case.

1609.6.3 Simplified design procedure-II.

1609.6.3.1 Main wind force-resisting system. Main wind force-resisting systems shall comply with the following:

1. The building shall be designed for the following net lateral wind pressure to be applied to the horizontal projection of the building surfaces:
 - 1.1. From 0 to 100 feet elevation 20 psf (0.96 kN/m²).
 - 1.2. From 100 to 300 feet elevation 25 psf (1.2 kN/m²).
2. An importance factor I_w shall be determined in accordance with Section 1609.5. and shall be applied to the pressures indicated above.

1609.6.3.2 Design wind load cases. The main wind force-resisting system of buildings of all heights, whose wind loads have been determined pursuant to Section 1609.6.3, shall be designed for wind load cases as defined below:

Case-1. Full design wind pressure acting on the projected area perpendicular to each principal axis of the structure, considered separately along each principal axis.

Case-2. 75 percent of the design wind pressure acting on the projected area perpendicular to each principal axis of the structure to be applied eccentric to the center of the exposure with eccentricity equal to 15 percent of the exposure width, considered separately for each principal direction.

Case-3. Wind loading as defined in case-1, but considered to act simultaneously at 75 percent of the specified value.

1609.6.3.3 Components and cladding. Net design wind positive and negative pressures, (pressure and suction) for the components and cladding of buildings represent the net pressures (sum of internal and external) to be applied normal to each building surface. The net design wind pressure and suction shall be 30 psf (1.44 kN/m²).

1609.6.3.4 Roof. The design pressure and suction acting over the entire roof including purlins, roofing, and other roof elements (including their fastenings) shall be per values given in Section 1609.6.3.1.

1609.6.3.5 Other building elements. The following building elements of buildings whose wind loads have been determined under the provisions of Section 1609.6.3 shall be designed for wind pressures shown in Section 1609.6.3.1 multiplied by the following shape factors given in Table 1609.6.3.5.

TABLE 1609.6.3.5
OTHER BUILDING ELEMENTS

Construction Shape Factor

<u>Signs (and their supports), or portions thereof,</u>	<u>1.5</u>
<u>having 70 percent or more of solid surface</u>	
<u>Signs (and their supports), or portions thereof,</u>	<u>2.0</u>
<u>having less than 70 percent of solid surface</u>	
<u>Tanks, cooling towers, and similar constructions</u>	<u>1.5</u>
<u>Square and rectangular chimneys</u>	<u>1.5</u>

1609.6.3.5.1 Eaves and cornices. Eaves, cornices, and overhanging elements of the buildings shall be designed for upward pressures twice the values given in Section 1609.6.3.1.

1609.7 Roof systems.

1609.7.1 Roof deck. The roof deck shall be designed to withstand the wind pressures determined under either the provisions of Section 1609.6 for buildings satisfying the height and other requirements of the simplified methods or Section 1609.1.1 for buildings of any height.

1609.8 Runback structures. Runback structures shall be designed in compliance with the rules of the department.

SECTION BC 1610
SOIL LATERAL LOAD

1610.1 General. Basement, foundation and retaining walls shall be designed to resist lateral soil loads. Soil loads specified in Table 1610.1 shall be used as the minimum design lateral soil loads unless specified otherwise in a soil investigation report approved by the commissioner. Basement walls and other walls in which horizontal movement is restricted at the top shall be designed for at-rest pressure. Retaining walls free to move and rotate at the top are permitted to be designed for active pressure. Design lateral pressure from surcharge loads shall be added to the lateral earth pressure load. Design lateral pressure shall be increased if soils with expansion potential are present at the site.

Exception: Basement walls extending not more than 8 feet (2438 mm) below grade and supporting flexible floor systems shall be permitted to be designed for active pressure.

**TABLE 1610.1
SOIL LATERAL LOAD**

DESCRIPTION OF BACKFILL MATERIAL ^c	UNIFIED SOIL CLASSIFICATION	DESIGN LATERAL SOIL LOAD ^a (pound per square foot per foot of depth)	
		Active pressure	At-rest pressure
Well-graded, clean gravels; gravel-sand mixes	GW	30	60
Poorly graded clean gravels; gravel-sand mixes	GP	30	60
Silty gravels, poorly graded gravel-sand mixes	GM	40	60
Clayey gravels, poorly graded gravel-and-clay mixes	GC	45	60
Well-graded, clean sands; gravelly sand mixes	SW	30	60
Poorly graded clean sands; sand-gravel mixes	SP	30	60
Silty sands, poorly graded sand-silt mixes	SM	45	60
Sand-silt clay mix with plastic fines	SM-SC	45	100
Clayey sands, poorly graded sand-clay mixes	SC	60	100
Inorganic silts and clayey silts	ML	45	100
Mixture of inorganic silt and clay	ML-CL	60	100
Inorganic clays of low to medium plasticity	CL	60	100
Organic silts and silt clays, low plasticity	OL	Note b	Note b
Inorganic clayey silts, elastic silts	MH	Note b	Note b
Inorganic clays of high plasticity	CH	Note b	Note b
Organic clays and silty clays	OH	Note b	Note b

For SI: 1 pound per square foot per foot of depth = 0.157 kPa/m, 1 foot = 304.8 mm.

a. Design lateral soil loads are given for moist conditions for the specified soils at their optimum densities. Actual field conditions shall govern. Submerged or saturated soil pressures shall include the weight of the buoyant soil plus the hydrostatic loads.

b. Unsuitable as backfill material.

c. The definition and classification of soil materials shall be in accordance with ASTM D 2487.

SECTION BC 1611
RAIN LOADS

1611.1 Design rain loads. Each portion of a roof shall be designed to sustain the load of rainwater that will accumulate on it if the primary drainage system for that portion is blocked plus the uniform load caused by water that rises above the inlet of the secondary drainage system at its design flow.

$$R = 5.2(d_s + d_h)$$

(Equation 16-37)

For SI: $R = 0.0098$ ($d_s = d_h$)

where:

d_h = Additional depth of water on the undeflected roof above the inlet of secondary drainage system at its design flow (i.e., the hydraulic head), in inches (mm).

d_s = Depth of water on the undeflected roof up to the inlet of secondary drainage system when the primary drainage system is blocked (i.e., the static head), in inches (mm).

R = Rain load on the undeflected roof, in psf (kN/m²). When the phrase “undeflected roof” is used, deflections from loads (including dead loads) shall not be considered when determining the amount of rain on the roof.

1611.2 Ponding instability. Ponding refers to the retention of water due solely to the deflection of relatively flat roofs. Roofs with a slope less than one-fourth unit vertical in 12 units horizontal (2-percent slope) shall be investigated by structural analysis to ensure that they possess adequate stiffness to preclude progressive deflection (i.e., instability) as rain falls on them or melt water is created from snow on them. The larger of snow load or rain load shall be used in this analysis. The primary drainage system within an area subjected to ponding shall be considered to be blocked in this analysis.

1611.3 Controlled drainage. Roofs equipped with hardware to control the rate of drainage shall be equipped with a secondary drainage system at a higher elevation that limits accumulation of water on the roof above that elevation. Such roofs shall be designed to sustain the load of rainwater that will accumulate on them to the elevation of the secondary drainage system plus the uniform load caused by water that rises above the inlet of the secondary drainage system at its design flow determined from Section 1611.1. Such roofs shall also be checked for ponding instability in accordance with Section 1611.2.

SECTION BC 1612 **FLOOD LOADS**

1612.1 General. The requirements for flood loads shall be as specified in Appendix G of this code.

1612.2 Reserved.

1612.3 Reserved.

1612.4 Reserved.

1612.5 Reserved.

SECTION BC 1613
EARTHQUAKE LOADS DEFINITIONS

1613.1 Definitions. The following words and terms shall, for the purposes of this section, have the meanings shown herein.

ACTIVE FAULT/ACTIVE FAULT TRACE. A fault for which there is an average historic slip rate of 1 mm per year or more and geologic evidence of seismic activity within Holocene (past 11,000 years) times. Active fault traces are designated by the appropriate regulatory agency and/or registered design professional subject to identification by a geologic report.

ATTACHMENTS, SEISMIC. Means by which components and their supports are secured or connected to the seismic-force-resisting system of the structure. Such attachments include anchor bolts, welded connections and mechanical fasteners.

BASE. The level at which the horizontal seismic ground motions are considered to be imparted to the structure.

BOUNDARY ELEMENTS. Chords and collectors at diaphragm and shearwall edges, interior openings, discontinuities and reentrant corners.

BRITTLE. Systems, members, materials and connections that do not exhibit significant energy dissipation capacity in the inelastic range.

COLLECTOR. A diaphragm or shear wall element parallel to the applied load that collects and transfers shear forces to the vertical-force-resisting elements or distributes forces within a diaphragm or shear wall.

COMPONENT. A part or element of an architectural, electrical, mechanical or structural system.

Component, equipment. A mechanical or electrical component or element that is part of a mechanical and/or electrical system within or without a building system.

Component, flexible. Component, including its attachments, having a fundamental period greater than 0.06 second.

Component, rigid. Component, including its attachments, having a fundamental period less than or equal to 0.06 second.

DESIGN EARTHQUAKE. The earthquake effects that buildings and structures are specifically proportioned to resist in Sections 1613 through 1622.

DISPLACEMENT.

Design displacement. The design earthquake lateral displacement, excluding additional displacement due to actual and accidental torsion, required for design of the isolation system.

Total design displacement. The design earthquake lateral displacement, including additional displacement due to actual and accidental torsion, required for design of the isolation system.

Total maximum displacement. The maximum considered earthquake lateral displacement, including additional displacement due to actual and accidental torsion, required for verification of the stability of the isolation system or elements thereof, design of building separations and vertical load testing of isolator unit prototype.

DISPLACEMENT RESTRAINT SYSTEM. A collection of structural elements that limits lateral displacement of seismically isolated structures due to the maximum considered earthquake.

EFFECTIVE DAMPING. The value of equivalent viscous damping corresponding to energy dissipated during cyclic response of the isolation system.

EFFECTIVE STIFFNESS. The value of the lateral force in the isolation system, or an element thereof, divided by the corresponding lateral displacement.

HAZARDOUS CONTENTS. A material that is highly toxic or potentially explosive and in sufficient quantity to pose a significant life-safety threat to the general public if an uncontrolled release were to occur.

INVERTED PENDULUM-TYPE STRUCTURES. Structures that have a large portion of their mass concentrated near the top, and thus have essentially one degree of freedom in horizontal translation. The structures are usually T-shaped with a single column supporting the beams or framing at the top.

ISOLATION INTERFACE. The boundary between the upper portion of the structure, which is isolated, and the lower portion of the structure, which moves rigidly with the ground.

ISOLATION SYSTEM. The collection of structural elements that includes individual isolator units, structural elements that transfer force between elements of the isolation system and connections to other structural elements.

ISOLATOR UNIT. A horizontally flexible and vertically stiff structural element of the isolation system that permits large lateral deformations under design seismic load. An isolator unit is permitted to be used either as part of or in addition to the weight-supporting system of the building.

LOAD.

Gravity load (W). The total dead load and applicable portions of other loads as defined in Sections 1613 through 1622.

MAXIMUM CONSIDERED EARTHQUAKE. The most severe earthquake effects considered by this code.

NONBUILDING STRUCTURE. A structure, other than a building, constructed of a type included in Section 1622.

OCCUPANCY IMPORTANCE FACTOR. A factor assigned to each structure according to its seismic use group as prescribed in Table 1604.5.

SEISMIC DESIGN CATEGORY. A classification assigned to a structure based on its seismic use group and the severity of the design earthquake ground motion at the site.

SEISMIC-FORCE-RESISTING SYSTEM. The part of the structural system that has been considered in the design to provide the required resistance to the seismic forces prescribed herein.

SEISMIC FORCES. The assumed forces prescribed herein, related to the response of the structure to earthquake motions, to be used in the design of the structure and its components.

SEISMIC USE GROUP. A classification assigned to a building based on its use as defined in Section 1616.2.

SHEAR WALL. A wall designed to resist lateral forces parallel to the plane of the wall.

SHEAR WALL-FRAME INTERACTIVE SYSTEM. A structural system that uses combinations of shear walls and frames designed to resist lateral forces in proportion to their rigidities, considering interaction between shear walls and frames on all levels.

SITE CLASS. A classification assigned to a site based on the types of soils present and their engineering properties as defined in Section 1615.1.5.

SITE COEFFICIENTS. The values of, F_a , and, F_v , indicated in Tables 1615.1.2(1) and 1615.1.2(2), respectively.

STORY DRIFT RATIO. The story drift divided by the story height.

TORSIONAL FORCE DISTRIBUTION. The distribution of horizontal seismic forces through a rigid diaphragm when the center of mass of the structure at the level under consideration does not coincide with the center of rigidity (sometimes referred to as a “diaphragm rotation”).

TOUGHNESS. The ability of a material to absorb energy without losing significant strength.

WIND-RESTRAINT SEISMIC SYSTEM. The collection of structural elements that provides restraint of the seismic-isolated structure for wind loads. The wind-restraint system may be either an integral part of isolator units or a separate device.

SECTION BC 1614 **EARTHQUAKE LOADS—GENERAL**

1614.1 Scope. Every structure, and portion thereof, shall at a minimum, be designed and constructed to resist the effects of earthquake motions and assigned a seismic design category as set forth in Section 1616.3.

Exceptions:

1. Structures designed in accordance with the provisions of Sections 9.1 through 9.6, 9.13 and 9.14 of ASCE 7 shall be permitted.
2. One- and two-family dwellings not more than three stories in height are exempt from the requirements of Sections 1613 through 1622.
3. The seismic-force-resisting system of wood frame buildings that conform to the provisions of Section 2308 are not required to be analyzed as specified in Section 1616.1.
4. Agricultural storage structures intended only for incidental human occupancy are exempt from the requirements of Sections 1613 through 1623.

1614.1.1 Reserved.

1614.2 Reserved.

1614.3 Reserved.

1614.4 Quality assurance. A quality assurance plan shall be provided where required by Chapter 17.

1614.5 Seismic and wind. When the code-prescribed wind design produces greater effects, the wind design shall govern, but detailing requirements and limitations prescribed in this and referenced sections shall be followed.

SECTION BC 1615 **EARTHQUAKE LOADS—SITE GROUND MOTION**

1615.1 General procedure for determining maximum considered earthquake and

design spectral response accelerations. Ground motion accelerations, represented by response spectra and coefficients derived from these spectra, shall be determined in accordance with the general procedure of Section 1615.1, or the site-specific procedure of Section 1615.2. The site-specific procedure of Section 1615.2 shall be used for structures on sites classified as Site Class F, in accordance with Section 1615.1.1.

The mapped maximum considered earthquake spectral response acceleration at short periods (S_S) shall be 0.365g and at 1-second period (S_I) shall be 0.071g.

The site class shall be determined in accordance with Section 1615.1.1. The maximum considered earthquake spectral response accelerations at short period and 1-second period adjusted for site class effects, S_{MS} and S_{MI} , shall be determined in accordance with Section 1615.1.2. The design spectral response accelerations at short period, S_{DS} , and at 1-second period, S_{DI} , shall be determined in accordance with Section 1615.1.3. The general response spectrum shall be determined in accordance with Section 1615.1.4.

1615.1.1 Site class definitions. The site shall be classified as one of the site classes defined in Table 1615.1.1. Where the soil shear wave velocity, v_s , is not known, site class shall be determined, as permitted in Table 1615.1.1, from standard penetration resistance, N, or from soil undrained shear strength, s_u , calculated in accordance with Section 1615.1.5. Where site-specific data are not available to a depth of 100 feet (30 480 mm), appropriate soil properties are permitted to be estimated by the registered design professional preparing the soils report based on known geologic conditions. When the soil properties are not known in sufficient detail to determine the site class, Site Class D shall be used unless the commissioner determines that Site Class E or F soil is likely to be present at the site.

**TABLE 1615.1.1
SITE CLASS DEFINITIONS**

SITE CLASS	SOIL PROFILE NAME	AVERAGE PROPERTIES IN TOP 100 feet, AS PER SECTION 1615.1.5		
		Soil shear wave velocity, \bar{v}_s , (ft/s)	Standard penetration resistance, \bar{N}	Soil undrained shear strength, \bar{s}_u , (psf)
A	Hard rock	$\bar{v}_s > 5,000$	N/A	N/A
B	Rock	$2,500 < \bar{v}_s \leq 5,000$	N/A	N/A
C	Very dense soil and soft rock	$1,200 < \bar{v}_s \leq 2,500$	$\bar{N} > 50$	$\bar{s}_u \geq 2,000$
D	Stiff soil profile	$600 \leq \bar{v}_s \leq 1,200$	$15 \leq \bar{N} \leq 50$	$1,000 \leq \bar{s}_u \leq 2,000$
E	Soft soil profile	$\bar{v}_s < 600$	$\bar{N} < 15$	$\bar{s}_u < 1,000$
E	—	Any profile with more than 10 feet of soil having the following characteristics: 1. Plasticity index $PI > 20$, 2. Moisture content $w \geq 40\%$, and 3. Undrained shear strength $\bar{s}_u < 500$ psf		
F	—	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays ($H > 10$ feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays ($H > 25$ feet with plasticity index $PI > 75$) 4. Very thick soft/medium stiff clays ($H > 120$ feet)		

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m², 1 pound per square foot = 0.0479 kPa. N/A = Not applicable

1615.1.2 Site coefficients and adjusted maximum considered earthquake spectral response acceleration parameters. The maximum considered earthquake spectral response acceleration for short periods, S_{MS} , and at 1-second period, S_{M1} , adjusted for site class effects, shall be determined by Equations 16-38 and 16-39, respectively:

$$S_{M5} = F_c S_5 \quad (\text{Equation 16-38})$$

$$S_{M1} = F_v S_1 \quad (\text{Equation 16-39})$$

where:

F_a = Site coefficient defined in Table 1615.1.2(1).

F_v = Site coefficient defined in Table 1615.1.2(2).

S_s = The mapped spectral accelerations for short periods as determined in Section 1615.1.

S_l = The mapped spectral accelerations for a 1-second period as determined in Section 1615.1.

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
 $(S_s)^a$

<u>SITE CLASS</u>	<u>F_a</u>
<u>A</u>	<u>0.80</u>
<u>B</u>	<u>1.00</u>
<u>C</u>	<u>1.20</u>
<u>D</u>	<u>1.51</u>
<u>E</u>	<u>2.13</u>
<u>F</u>	<u>Note a</u>

- a. 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 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
 $(S_1)^a$

<u>SITE CLASS</u>	<u>F_v</u>
<u>A</u>	<u>0.80</u>
<u>B</u>	<u>1.00</u>
<u>C</u>	<u>1.70</u>
<u>D</u>	<u>2.4</u>
<u>E</u>	<u>3.5</u>
<u>F</u>	<u>Note a</u>

- a. 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 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.

1615.1.3 Design spectral response acceleration parameters. Five-percent damped design spectral response acceleration at short periods, S_{DS} , and at 1-second period, S_{D1} , shall be determined from Equations 16-40 and 16-41, respectively:

$$S_{DS} = \frac{2}{3} S_{MS} \quad (\text{Equation 16-40})$$

$$S_{DI} = \frac{2}{3} S_{M1} \quad (\text{Equation 16-41})$$

where:

S_{MS} = The maximum considered earthquake spectral response accelerations for short period as determined in Section 1615.1.2.

S_{M1} = The maximum considered earthquake spectral response accelerations for 1 second period as determined in Section 1615.1.2.

1615.1.4 General procedure response spectrum. The general design response spectrum curve shall be developed as indicated in Figure 1615.1.4 and as follows:

1. For periods less than or equal to T_O , the design spectral response acceleration, S_a , shall be determined by Equation 16-42.
2. For periods greater than or equal to T_O and less than or equal to T_S , the design spectral response acceleration, S_a , shall be taken equal to S_{DS} .
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_{D1} = 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).

$$\underline{T_o} = 0.2 S_{D1}/S_{DS}$$

$$\underline{T_s} = S_{D1}/S_{DS}$$

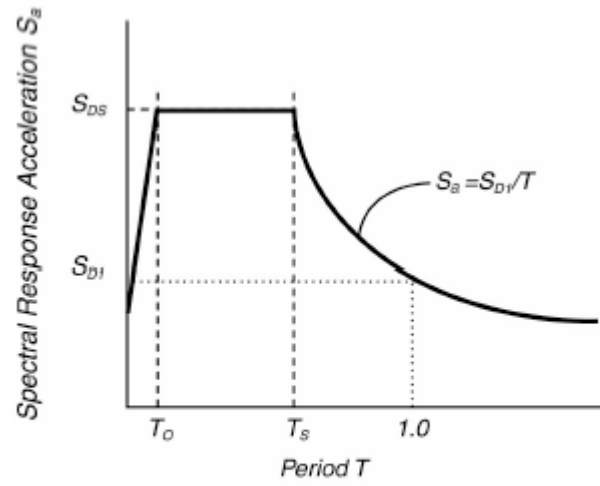


FIGURE 1615.1.4
DESIGN RESPONSE SPECTRUM

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).

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

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

N_i is the Standard Penetration Resistance (ASTM D1586) not to exceed 100 blow/foot (mm) as directly measured in the field without corrections.

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

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

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 psg (kPa), not to exceed 5,000 psf (240 kPa), ASTM D 2166 or D 2850.

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

where:

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

d_c = The total thickness (100- d_s) (For SI:30480- d_s) of cohesive soil layers in the top 100 feet (30480 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 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.

**TABLE 1615.1.5
SITE CLASSIFICATION^a**

SITE CLASS	\bar{v}_s	\bar{N} or \bar{N}_{60}	\bar{s}_v
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/m².

a. If the \bar{s}_v method is used and the \bar{N}_{60} and \bar{v}_s criteria differ, select the category with the softer soils (for example, use Site Class E instead of D).

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: $s_u < 500$ 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 v_s , N , and s_u computed in all cases as specified.
 - 3.1. v_s for the top 100 feet (30 480 mm) (v_s method).
 - 3.2. N for the top 100 feet (30 480 mm) (N method).
 - 3.3. N_{ch} for cohesionless soil layers ($PI < 20$) in the top 100 feet (30 480 mm) and average, s_u , for cohesive soil layers ($PI > 20$) in the top 100 feet (30 480 mm) (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.

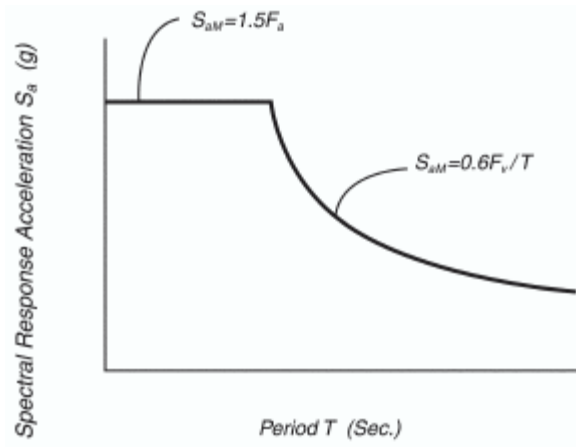


FIGURE 1615.2.2
DETERMINISTIC LIMIT ON MAXIMUM CONSIDERED
EARTHQUAKE RESPONSE SPECTRUM

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_d , at any period shall be determined from Equation 16-48:

$$S_a = \frac{2}{3} S_{aM}$$

(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 BC 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.

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 (IE) 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 commissioner.

1616.2.3 Seismic Use Group III. Seismic Use Group III structures are those having essential facilities that are required for post earthquake recovery and those containing substantial quantities of hazardous substances, as indicated in Table 1604.5, or as designated by the commissioner. 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 . Seismic Design Category B is the minimum design category allowed.

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

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

- a. Building structures in Seismic Use Groups I or II and on Site Class E may be designed in Seismic Design Category C if their Fundamental Period of Vibration is not between 1 and 2 seconds or a dynamic structural analysis based on a site specific spectrum is performed.

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

<u>VALUE OF S_{D1}</u>	<u>SEISMIC USE GROUP</u>		
	<u>I</u>	<u>II</u>	<u>III</u>
$S_{D1} < 0.067g$	<u>A</u>	<u>A</u>	<u>A</u>
$0.067g < S_{D1} < 0.133g$	<u>B</u>	<u>B</u>	<u>C</u>
$0.133g < S_{D1} < 0.20g$	<u>C</u>	<u>C</u>	<u>D</u>
$0.20g < S_{D1}$	<u>D</u>	<u>D</u>	<u>D</u>

1616.3.1 Seismic Design Category A, E or F. Requirements for Seismic Design Categories A, E and F have been eliminated from the *New York City Building Code* as such categories do not apply in New York City. References to these categories can be found in ASCE 7.

1616.4 Reserved.

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.

TABLE 1616.5.1.1
PLAN STRUCTURAL IRREGULARITIES

	<u>IRREGULARITY TYPE AND DESCRIPTION</u>	<u>REFERENCE SECTION</u>	<u>SEISMIC DESIGN CATEGORY^a APPLICATION</u>
<u>1a</u>	<p><u>Torsional Irregularity - to be considered when diaphragms are not flexible as determined in Section 1602.1.1</u></p> <p><u>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.</u></p>	<p><u>9.5.5.5.2 of ASCE 7</u> <u>1620.4.1</u> <u>9.5.2.1 of ASCE 7</u> <u>9.5.5.7.1 of ASCE 7</u></p>	<p><u>C and D,</u> <u>D,</u> <u>D,</u> <u>C and D</u></p>
<u>1b</u>	<p><u>Extreme Torsional Irregularity - to be considered when diaphragms are not flexible as determined in Section 1602.1.</u></p> <p><u>Extreme Torsional irregularity shall be considered to exist when the maximum story drift</u></p>	<p><u>9.5.5.5.2 of ASCE 7</u> <u>1620.4.1</u> <u>9.5.2.5.1 of ASCE 7</u> <u>9.5.5.7.1 of ASCE 7</u></p>	<p><u>C and D,</u> <u>D,</u> <u>D,</u> <u>C and D</u></p>
<u>2</u>	<p><u>Reentrant Corners</u> <u>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.</u></p>	<p><u>1620.4.1</u></p>	<p><u>D</u></p>
<u>3</u>	<p><u>Diaphragm Discontinuity</u> <u>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.</u></p>	<p><u>1620.4.1</u></p>	<p><u>D</u></p>
<u>4</u>	<p><u>Out-of Plane Offsets</u> <u>Discontinuities in a lateral-force-resistance path, such as out of plane offset of the vertical elements.</u></p>	<p><u>1620.4.1</u> <u>9.5.2.5.1 of ASCE 7</u> <u>1620.2.9</u></p>	<p><u>D,</u> <u>D,</u> <u>B, C and D</u></p>
<u>5</u>	<p><u>Nonparallel Systems</u> <u>The vertical lateral-force-resisting elements are not parallel to or symmetric about the major</u></p>	<p><u>1620.3.2</u></p>	<p><u>C and D</u></p>

	<u>orthogonal axes of the lateral-force-resisting system.</u>		
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- a. Seismic Design Category is determined in accordance with Section 1616.

2

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 B, C or D.

TABLE 1616.5.1.2
VERTICAL STRUCTURAL IRREGULARITIES

<u>IRREGULARITY TYPE AND DESCRIPTION</u>		<u>REFERENCE SECTION</u>	<u>SEISMIC DESIGN CATEGORY^a APPLICATION</u>
1a	<u>Stiffness Irregularity - Soft Story</u> <u>A soft story is one in which lateral stiffness is less than 70 percent of that in the story above or less than 80 percent for the average stiffness of the three stories above.</u>	<u>9.5.2.5.1 of ASCE 7</u>	<u>D</u>
1b	<u>Stiffness Irregularity - Extreme Soft Story</u> <u>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.</u>	<u>9.5.2.5.1 of ASCE 7</u>	<u>D̄</u>
<u>2</u>	<u>Weight (Mass) Irregularity</u> <u>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.</u>	<u>9.5.2.5.1 of ASCE 7</u>	<u>D</u>
<u>3</u>	<u>Vertical Geometric Irregularity</u> <u>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.</u>	<u>9.5.2.5.1 of ASCE 7</u>	<u>D</u>
4	<u>In-Plane Discontinuity in Vertical Lateral-Force-Resisting Elements</u> <u>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.</u>	<u>1620.4.1</u> <u>9.5.2.5.1 of ASCE 7</u> <u>1620.2.9</u>	<u>D,</u> <u>D,</u> <u>B, C and D</u>
<u>5</u>	<u>Discontinuity in Capacity - Weak Story</u> <u>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.</u>	<u>1620.2.3</u> <u>9.5.2.5.1 of ASCE 7</u>	<u>B, C and D,</u> <u>D</u>

a. Seismic Design Category is determined in accordance with Section 1616.

1616.6 Analysis procedures. A structural analysis conforming to one of the types permitted in Section 9.5.2.5.1 of ASCE7 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.

Exception: 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.

SECTION BC 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:

$$E = \rho Q_E + 0.2 S_{DS} D$$

(Equation 16-50)

where:

D = The effect of dead load.

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

ρ = 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.

$$E = \rho Q_E - 0.2 S_{DS} D$$

(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.

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

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.

$$E_m = \Omega_0 Q_E - 0.2 S_{D0} D \quad (\text{Equation 16-53})$$

Where E , Q_E , S_{DS} are as defined above and Ω_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, ϕ , 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 ASCE7, Section 9.5.2.4.2. Modify Section 9.5.2.4.2 as follows:

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

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

where:

r_{maxx} = 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_{maxx} is equal to the lateral force component in the most heavily loaded brace element divided by the story shear. For moment frames, r_{maxx} 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_{maxx} 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 to be greater than 1.0 for buildings of light-framed construction. For dual systems, r_{maxx} 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 \tilde{n} 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_{maxx} 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_{maxx} shall be permitted to be calculated from an analysis that assumes rigid diaphragm behavior and ρ_x , need not exceed 1.25.

The value of ρ need not exceed 1.5, which is permitted to be used for any structure. The value of ρ 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 ρ calculated in accordance with this section does not exceed 1.25. The calculated value of ρ is permitted to exceed this limit when the design story drift, Δ , as determined in Section 9.5.5.7, does not exceed Δ_a/ρ for any story where a is the allowable story drift from Table 9.5.2.8.

The metric equivalent of Equation 9.5.2.4.2-1 is:

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

Where: A_x is in square meters.

The value ρ 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 \tilde{n} shall be determined independently for each seismic-force-resisting system. The redundancy coefficient of the lower portion shall not be less than the following:

$$\rho_L = R_L \rho_U$$

 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.

1617.2.2 Redundancy (for use in the simplified analysis procedure of Section 1617.5). A redundancy coefficient, ρ , 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 B or C. For structures assigned to Seismic Design Category B or C (see Section 1616), the value of the redundancy coefficient ρ is 1.0.

1617.2.2.2 Seismic Design Category D. For structures in Seismic Design Category D (see Section 1616), the redundancy coefficient, ρ , shall be taken as the largest of the values of, ρ_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_{maxi} = 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_{maxi} = For braced frames, the value r_{maxi} is equal to the horizontal force component in the most heavily loaded brace element divided by the story shear.

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

r_{maxi} = For dual systems, r_{maxi} 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 ρ 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_{maxi} shall be permitted to be calculated from an analysis that assumes rigid diaphragm behavior and ρ need not exceed 1.25.

The value, ρ , shall not be less than 1.0, and need not exceed 1.5.

Calculation of r_{maxi} 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 ρ 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 ρ is permitted to exceed these limits when the design story drift, Δ , as determined in Section 1617.5.4, does not exceed Δ_a/ρ for any story where a is the allowable story drift from Table 1617.3.1.

The value ρ 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, ρ , shall be determined independently for each seismic-force-resisting system. The redundancy coefficient of the lower portion shall not be less than the following:

$$\rho_L = \frac{R_L \rho_a}{R_a}$$

(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 Δ , as determined in Section 1617.5.4, shall not exceed the allowable story drift Δ_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.

**TABLE 1617.3.1
ALLOWABLE STORY DRIFT, Δ_x (inches)^a**

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} ^b	0.020 h_{sx}	0.015 h_{sx}
Masonry cantilever shear wall buildings ^c	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.

1617.3.2 Structural separations. All structures shall be separated from adjacent structures. When a structure adjoins a property line not common to a public way (typically side or rear lot lines), that structure shall also be set back from the property line by at least 1 inch (25 mm) for each 50 feet (15 240) of height. For structures in Seismic Design Category D , refer to Section 1620.4.5 for additional requirements.

Exception: Smaller separations or property line setbacks shall be permitted when justified by rational analysis based on maximum expected ground motions.

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 with modifications. Modify Table 9.5.5.3.2 "Values of Approximate Period Parameters C_t and x " to include the following:

<u>Structure Type</u>	<u>C_t</u>	<u>x</u>
<u>Dual systems where the building height exceeds 400 feet (122 m)</u>	<u>$0.03 (0.07)^a$</u>	<u>0.75</u>
<u>Dual systems where the building height (h) exceeds 160 feet (48 768 mm) but is less than 400 feet (122 m)</u>	<u>$0.02 + 0.01 \times [h-160]/240$ <u>$(0.055 + 0.015 \times [h-48.8]/73.2)^a$</u></u>	<u>0.75</u>

^aMetric equivalents are shown in parenthesis.

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:

$$V = \frac{1.2S_{DS}}{R}W$$

(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/m²).
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/m²).

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

$$F_x = \frac{1.2S_{DS}}{R} w_x$$

(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, Δ , 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. Delete ASCE Table 9.5.2.2 and replace with Table 1617.6.2.

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 ρ .
 - 3.2. The rigid lower portion shall be designed as a separate structure using the appropriate values of R and ρ . The reactions from the upper portion shall be those determined from the analysis of the upper portion amplified by the ratio of the R/ρ of the upper portion over R/ρ of the lower portion. This ratio shall no be less than 1.0.

1617.6.1.3 ASCE 7, Section 9.5.2.2.4.3. Modify Section 9.5.2.2.4.3 by changing exception to read as follows:

Exception: Reinforced concrete frame members not designed as part of the seismic-force-resisting system and slabs shall comply with Section 21.11 of Ref. 9.9-1.

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 over-strength factor, Ω_0 , 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 over-strength coefficient, Ω_0 , and deflection amplification factor, C_d , values. Buildings shall not exceed the limitations of Section 1616.6.1.

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

<u>Basic Seismic Force-Resisting System</u>	<u>Response Modification Coefficient, R^a</u>	<u>System Over-strength Factor, Ω_0^f</u>	<u>Deflection Amplification Factor, C_d^b</u>	<u>Structural System Limitations And Building Height (ft) Limitations^c</u>		
				<u>Seismic Design Category</u>		
				<u>B</u>	<u>C</u>	<u>D^d</u>
A. Bearing Wall Systems						
1. <u>Ordinary steel concentrically braced frames</u>	4	2	3 ½	NL	NL	35 ⁱ
2. <u>Special reinforced concrete shear walls</u>	5	2 ½	5	NL	NL	NL
3. <u>Ordinary reinforced concrete shear walls</u>	4	2 ½	4	NL	NL	NP
4. <u>Detailed plain concrete shear walls</u>	2 ½	2 ½	2	NL	NP	NP
5. <u>Ordinary plain concrete shear walls</u>	1 ½	2 ½	1 ½	NL	NP	NP
6. <u>Special reinforced masonry shear walls</u>	5	2 ½	3 ½	NL	NL	NL
7. <u>Intermediate reinforced masonry shear walls</u>	3 ½	2 ½	2 ¼	NL	NL	NP
8. <u>Ordinary reinforced masonry shear walls</u>	2 ½	2 ½	1 ¾	NL	NL	NP
9. <u>Detailed plain masonry shear walls</u>	2	2 ½	1 ¾	NL	NP	NP
10. <u>Ordinary plain masonry shear walls</u>	1 ½	2 ½	1 ¼	NL	NP	NP
11. <u>Light-framed walls sheathed with wood structural panels rated for shear resistance or steel sheets</u>	6 ½	3	4	NL	NL	65
12. <u>Light-framed walls with shear panels of all other materials</u>	2	2 ½	2	NL	NL	35
13. <u>Light-framed wall systems using flat strap bracing</u>	4	2	3 ½	NL	NL	65
14. <u>Ordinary plain prestressed masonry shear walls</u>	1 ½	2 ½	1 ¼	NL	NP	NP
15. <u>Intermediate prestressed masonry shear walls</u>	2 ½	2 ½	2 ½	NL	35	NP
16. <u>Special prestressed masonry shear walls</u>	4 ½	2 ½	3 ½	NL	35	35
B. Building Frame System						

<u>Basic Seismic Force-Resisting System</u>	<u>Response Modification Coefficient, R^a</u>	<u>System Over-strength Factor, Ω_0^f</u>	<u>Deflection Amplification Factor, C_d^b</u>	<u>Structural System Limitations And Building Height (ft) Limitations^c</u>		
				<u>Seismic Design Category</u>		
				<u>B</u>	<u>C</u>	<u>D^d</u>
<u>1. Steel eccentrically braced frames, moment resisting connections at columns away from links</u>	8	2	4	NL	NL	NL
<u>2. Steel eccentrically braced frames, non-moment resisting connections at columns away from links</u>	7	2	4	NL	NL	NL
<u>3. Special steel concentrically braced frames</u>	6	2	5	NL	NL	NL
<u>4. Ordinary steel concentrically braced frames</u>	5	2	4 ½	NL	NL	35 ^f
<u>5. Special reinforced concrete shear walls</u>	6	2 ½	5	NL	NL	NL
<u>6. Ordinary reinforced concrete shear walls</u>	5	2 ½	4 ½	NL	NL	NP
<u>7. Detailed plain concrete shear walls</u>	3	2 ½	2 ½	NL	NP	NP
<u>8. Ordinary plain concrete shear walls</u>	2	2 ½	2	NL	NP	NP
<u>9. Composite eccentrically braced frames</u>	8	2	4	NL	NL	NL
<u>10. Composite concentrically braced frames</u>	5	2	4 ½	NL	NL	NL
<u>11. Ordinary composite braced frames</u>	3	2	3	NL	NL	NP
<u>12. Composite steel plate shear walls</u>	6 ½	2 ½	5 ½	NL	NL	NL
<u>13. Special composite reinforced concrete shear walls with steel elements</u>	6	2 ½	5	NL	NL	NL
<u>14. Ordinary composite reinforced concrete shear walls with steel elements</u>	5	2 ½	4 ¼	NL	NL	NP
<u>15. Special reinforced masonry shear walls</u>	5 ½	2 ½	4	NL	NL	NL
<u>16. Intermediate reinforced masonry shear walls</u>	4	2 ½	4	NL	NL	NP
<u>17. Ordinary reinforced masonry shear walls</u>	3	2 ½	2 ¼	NL	NL	NP
<u>18. Detailed plain masonry shear walls</u>	2 ½	2 ½	2 ¼	NL	160	NP
<u>19. Ordinary plain masonry shear walls</u>	1 ½	2 ½	1 ¼	NL	NP	NP

<u>Basic Seismic Force-Resisting System</u>	<u>Response Modification Coefficient, R^a</u>	<u>System Over-strength Factor, Ω_0^f</u>	<u>Deflection Amplification Factor, C_d^b</u>	<u>Structural System Limitations And Building Height (ft) Limitations^c</u>		
				<u>Seismic Design Category</u>		
				<u>B</u>	<u>C</u>	<u>D^d</u>
20. <u>Light-framed walls sheathed with wood structural panels rated for shear resistance or steel sheets</u>	<u>7</u>	<u>2 ½</u>	<u>4 ¼</u>	<u>NL</u>	<u>NL</u>	<u>65</u>
21. <u>Light-framed walls with shear panels of all other materials</u>	<u>2 ½</u>	<u>2 ½</u>	<u>2 ½</u>	<u>NL</u>	<u>NL</u>	<u>35</u>
22. <u>Ordinary plain prestressed masonry shear walls</u>	<u>1 ½</u>	<u>2 ½</u>	<u>1 ¼</u>	<u>NL</u>	<u>NP</u>	<u>NP</u>
23. <u>Intermediate prestressed masonry shear walls</u>	<u>3</u>	<u>2 ½</u>	<u>2 ½</u>	<u>NL</u>	<u>35</u>	<u>NP</u>
24. <u>Special prestressed masonry shear walls</u>	<u>4 ½</u>	<u>2 ½</u>	<u>4</u>	<u>NL</u>	<u>35</u>	<u>35</u>
C. <u>Moment Resisting Frame Systems</u>						
1. <u>Special steel moment frames</u>	<u>8</u>	<u>3</u>	<u>5 ½</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>
2. <u>Special steel truss moment frames</u>	<u>7</u>	<u>3</u>	<u>5 ½</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>
3. <u>Intermediate steel moment frames</u>	<u>4 ½</u>	<u>3</u>	<u>4</u>	<u>NL</u>	<u>NL</u>	<u>35^e</u>
4. <u>Ordinary steel moment frames</u>	<u>3 ½</u>	<u>3</u>	<u>3</u>	<u>NL</u>	<u>NL</u>	<u>NP^{e,h}</u>
5. <u>Special reinforced concrete moment frames</u>	<u>8</u>	<u>3</u>	<u>5 ½</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>
6. <u>Intermediate reinforced concrete moment frames</u>	<u>5</u>	<u>3</u>	<u>4 ½</u>	<u>NL</u>	<u>NL</u>	<u>NP</u>
7. <u>Ordinary reinforced concrete moment frames</u>	<u>3</u>	<u>3</u>	<u>2 ½</u>	<u>NL</u>	<u>NP</u>	<u>NP</u>
8. <u>Special composite moment frames</u>	<u>8</u>	<u>3</u>	<u>5 ½</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>
9. <u>Intermediate composite moment frames</u>	<u>5</u>	<u>3</u>	<u>4 ½</u>	<u>NL</u>	<u>NL</u>	<u>NP</u>
10. <u>Composite partially restrained moment frames</u>	<u>6</u>	<u>3</u>	<u>5 ½</u>	<u>NL</u>	<u>NL</u>	<u>100</u>
11. <u>Ordinary composite moment frames</u>	<u>3</u>	<u>3</u>	<u>2 ½</u>	<u>NL</u>	<u>NP</u>	<u>NP</u>
12. <u>Special masonry moment frames</u>	<u>5 ½</u>	<u>3</u>	<u>5</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>
D. <u>Dual Systems with Special Moment Frames Capable of Resisting at Least 25% of Prescribed Seismic Forces</u>						

<u>Basic Seismic Force-Resisting System</u>	<u>Response Modification Coefficient, R^a</u>	<u>System Over-strength Factor, Ω_0^f</u>	<u>Deflection Amplification Factor, C_d^b</u>	<u>Structural System Limitations And Building Height (ft) Limitations^c</u>		
				<u>Seismic Design Category</u>		
				<u>B</u>	<u>C</u>	<u>D^d</u>
<u>1. Steel eccentrically braced frames, moment resisting connections at columns away from links</u>	8	2 ½	4	NL	NL	NL
<u>2. Steel eccentrically braced frames, non-moment resisting connections at columns away from links</u>	7	2 ½	4	NL	NL	NL
<u>3. Special steel concentrically braced frames</u>	8	2 ½	6 ½	NL	NL	NL
<u>4. Special reinforced concrete shear walls</u>	8	2 ½	6 ½	NL	NL	NL
<u>5. Ordinary reinforced concrete shear walls</u>	7	2 ½	6	NL	NL	NP
<u>6. Composite eccentrically braced frames</u>	8	2 ½	4	NL	NL	NL
<u>7. Composite concentrically braced frames</u>	6	2 ½	5	NL	NL	NL
<u>8. Composite steel plate shear walls</u>	8	2 ½	6 ½	NL	NL	NL
<u>9. Special composite reinforced concrete shear walls with steel elements</u>	8	2 ½	6 ½	NL	NL	NL
<u>10. Ordinary composite reinforced concrete shear walls with steel elements</u>	7	2 ½	6	NL	NL	NP
<u>11. Special reinforced masonry shear walls</u>	7	3	6 ½	NL	NL	NL
<u>12. Intermediate reinforced masonry shear walls</u>	6	2 ½	5	NL	NL	NL
<u>13. Ordinary steel concentrically braced frames</u>	6	2 ½	5	NL	NL	NL
<u>E. Dual Systems with Intermediate Moment Frames Capable of Resisting at Least 25% of Prescribed Seismic Forces</u>						
<u>1. Special steel concentrically braced frames^e</u>	4 ½	2 ½	4 1/2	NL	NL	35
<u>2. Special reinforced concrete shear walls</u>	6	2 ½	5	NL	NL	NL
<u>3. Ordinary reinforced masonry shear walls</u>	3	3	2 ½	NL	NL	NP
<u>4. Intermediate reinforced masonry shear walls</u>	5	3	4 ½	NL	NL	NP

<u>Basic Seismic Force-Resisting System</u>	<u>Response Modification Coefficient, R^a</u>	<u>System Over-strength Factor, Ω_0^f</u>	<u>Deflection Amplification Factor, C_d^b</u>	<u>Structural System Limitations And Building Height (ft) Limitations^c</u>		
				<u>Seismic Design Category</u>		
				<u>B</u>	<u>C</u>	<u>D^d</u>
<u>5. Composite concentrically braced frames</u>	<u>5</u>	<u>2 ½</u>	<u>4 ½</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>
<u>6. Ordinary composite braced frames</u>	<u>4</u>	<u>2 ½</u>	<u>3</u>	<u>NL</u>	<u>NL</u>	<u>NP</u>
<u>7. Ordinary composite reinforced concrete shear walls with steel elements</u>	<u>5</u>	<u>3</u>	<u>4 ½</u>	<u>NL</u>	<u>NL</u>	<u>NP</u>
<u>8. Ordinary steel concentrically braced frames</u>	<u>5</u>	<u>2 ½</u>	<u>4 ½</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>
<u>9. Ordinary reinforced concrete shear walls</u>	<u>5 ½</u>	<u>2 ½</u>	<u>4 ½</u>	<u>NL</u>	<u>NL</u>	<u>NP</u>
<u>F. Shear Wall-frame Interactive System with Ordinary Moment Frames and Ordinary Reinforced Concrete Shear Walls</u>	<u>5 ½</u>	<u>2 ½</u>	<u>5</u>	<u>NL</u>	<u>NP</u>	<u>NP</u>
<u>G. Inverted Pendulum Systems and Cantilevered Column Systems</u>						
<u>1. Cantilevered Column System</u>	<u>2 ½</u>	<u>2</u>	<u>2 ½</u>	<u>NL</u>	<u>NL</u>	<u>35</u>
<u>2. Special steel moment frames</u>	<u>2 ½</u>	<u>2</u>	<u>2 ½</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>
<u>3. Ordinary steel moment frames</u>	<u>1 ¼</u>	<u>2</u>	<u>2 ½</u>	<u>NL</u>	<u>NL</u>	<u>NP</u>
<u>4. Special reinforced concrete moment frames</u>	<u>2 ½</u>	<u>2</u>	<u>1 ¼</u>	<u>NL</u>	<u>NL</u>	<u>NL</u>
<u>H. Structural Steel Systems Not Specifically Detailed for Seismic Resistance</u>	<u>3</u>	<u>3</u>	<u>3</u>	<u>NL</u>	<u>NL</u>	<u>NP</u>

Notes:

- a. Response modification coefficient, R, for use throughout the standard. Note R reduces forces to a strength level not an allowable stress level.
- b. Deflection amplification factor, C_d, for use in Sections 9.5.3.7.1 and 9.5.3.7.2
- c. NL = Not Limited and NP = Not Permitted. For metric units use 30 m for 100 ft and use 50 m for 160 ft. Heights are measured for the base of the structure as defined in section 9.2.1.
- d. See section 9.5.2.2.4.1 for a description of building systems limited to buildings with a height of 240 ft (75 m) or less.
- e. Ordinary moment frame is permitted to be used in lieu of intermediate moment frame in Seismic Design Categories B and C.
- f. The tabulated value of the overstrength factor, Ω_0 , may be reduced by subtracting ½ for structures with flexible diaphragms but shall not be taken as less than 2.0 for any structure.
- g. Steel ordinary moment frames and intermediate moment frames are permitted in single-story buildings up to a height of 60 ft, when the moment joints of field connections are constructed of bolted end plates and the dead load of the roof does not exceed 15 psf.

- h.** Steel ordinary moment frames are permitted in buildings up to a height of 35 ft when the dead load of the walls, floors, and roofs does not exceed 15 psf.
- i.** Steel ordinary concentrically braced frames are permitted in single-story buildings up to a height of 60 ft when the dead load of the roof does not exceed 15 psf and in penthouse structures.

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 over-strength factor, Ω_0 , 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 over-strength factor, Ω_0 , 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, 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 over-strength factor, Ω_0 , 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 ρ .

3.2. The rigid lower portion shall be designed as a separate structure using the appropriate values of R and ρ . The reactions from the upper portion shall be those determined from the analysis of the upper portion amplified by the ratio of, R/ρ , of the upper portion over, R/ρ , 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. In addition to the system limitation indicated in Table 1617.6.2, structures assigned to Seismic Design Category D shall be subject to the following.

1617.6.2.4.1 Interaction effects. Moment-resisting frames that are enclosed or adjoined by stiffer elements not considered to be part of the seismic-force-resisting system shall be designed so that the action or failure of those elements will not impair the vertical load and seismic-force-resisting capability of the frame. The design shall consider and provide for the effect of these rigid elements on the structural system at deformations corresponding to the design story drift, Δ , as determined in Section 1617.5.4. In addition, the effects of these elements shall be considered when determining whether a structure has one or more of the irregularities defined in Section 1616.5.1.

1617.6.2.4.2 Deformational compatibility. Every structural component not included in the seismic-force-resisting system in the direction under consideration shall be designed to be adequate for vertical load-carrying capacity and the induced moments and shears resulting from the design story drift, Δ , as determined in accordance with Section 1617.5.4. Where allowable stress design is used, Δ shall be computed without dividing the earthquake

force by 1.4. The moments and shears induced in components that are not included in the seismic-force-resisting system in the direction under consideration shall be calculated including the stiffening effects of adjoining rigid structural and nonstructural elements.

Exception: Reinforced concrete frame members not designed as part of the seismic-force-resisting system shall comply with Section 21.11 of ACI 318.

1617.6.2.4.3 Special moment frames. A special moment frame that is used but not required by Table 1617.6.2 is permitted to be discontinued and supported by a stiffer system with a lower response modification coefficient, R , provided the requirements of Sections 1620.2.3 and 1620.4.1 are met. Where a special moment frame is required by Table 1617.6.2, the frame shall be continuous to the foundation.

SECTION BC 1618 **DYNAMIC ANALYSIS PROCEDURE FOR THE SEISMIC DESIGN OF BUILDINGS**

1618.1 Dynamic analysis procedures. The following dynamic analysis procedures are permitted to be used in lieu of the equivalent lateral force procedure of Section 1617.4:

1. Modal Response Spectral Analysis.
2. Linear Time-history Analysis.
3. Nonlinear Time-history Analysis. The dynamic analysis procedures listed above shall be performed in accordance with the requirements of Sections 9.5.6, 9.5.7 and 9.5.8, respectively, of ASCE 7.

SECTION BC 1619 **EARTHQUAKE LOADS SOIL-STRUCTURE INTERACTION EFFECTS**

1619.1 Analysis procedure. If soil-structure interaction is considered in the determination of seismic design forces and corresponding displacements in the structure, the procedure given in Section 9.5.9 of ASCE 7 shall be used.

SECTION BC 1620 **EARTHQUAKE LOADS—DESIGN, DETAILING REQUIREMENTS AND STRUCTURAL COMPONENT LOAD EFFECTS**

1620.1 Structural component design and detailing. The design and detailing of the components of the seismic-force-resisting system shall comply with the requirements of Section 9.5.2.6 of ASCE 7 in addition to the nonseismic requirements of this code except as modified in Sections 1620.1.1, 1620.1.2 and 1620.1.3.

Exception: For structures designed using the simplified analysis procedure in Section 1617.5, the provisions of Sections 1620.2 through 1620.5 shall be used.

1620.1.1 ASCE 7, Section 9.5.2.6.2.5. Section 9.5.2.6.2.5 of ASCE 7 shall not apply.

1620.1.2 ASCE 7, Section 9.5.2.6.2.11. Modify ASCE 7, Section 9.5.2.6.2.11, to read as follows:

9.5.2.6.2.11 Elements supporting discontinuous walls or frames. Columns, beams, trusses or slabs supporting discontinuous walls or frames of structures and the connections of the discontinuous element to the supporting member having plan irregularity Type 4 of Table 9.5.2.3.2 or vertical irregularity Type 4 of Table 9.5.2.3.3 shall have the design strength to resist the maximum axial force that can develop in accordance with the special seismic loads of Section 9.5.2.7.1.

Exceptions:

1. The quantity E in Section 9.5.2.7.1 need not exceed the maximum force that can be transmitted to the element by the lateral-force-resisting system at yield.
2. Concrete slabs supporting light-framed walls.

1620.1.3 ASCE 7, Section 9.5.2.6.3. Modify ASCE 7, Section 9.5.2.6.3, to read as follows:

9.5.2.6.3 Seismic Design Category C. Structures assigned to Category C shall conform to the requirements of Section 9.5.2.6.2 for Category B and to the requirements of this section. Structures that have plan structural irregularity Type 1a or 1b of Table 9.5.2.3.2 along both principal plan axes, or plan structural irregularity Type 5 of Table 9.5.2.3.2, shall be analyzed for seismic forces in compliance with Section 9.5.2.5.2.2. When the square root of the sum of the squares method of combining directional effects is used, each term computed shall be assigned the sign that will yield the most conservative result.

The orthogonal combination procedure of Section 9.5.2.5.2.2, Item a, shall be required for any column or wall that forms part of two or more intersecting seismic-force-resisting systems and is subjected to axial load due to seismic forces acting along either principal plan axis equaling or exceeding 20 percent of the axial load design strength of the column or wall.

1620.2 Structural component design and detailing (for use in the simplified analysis procedure of Section 1617.5). The design and detailing of the components of the seismic-force-resisting system for structures designed using the simplified analysis procedure in Section 1617.5 shall comply with the requirements of this section in addition to the nonseismic requirements of this code. Buildings shall not exceed the

limitations of Section 1616.6.1.

Exception: Structures assigned to Seismic Design Category B (see Section 1616) shall conform to Sections 1620.2.1 through 1620.2.10.

1620.2.1 Second-order load effects. Where θ exceeds 0.10 as determined in Section 9.5.5.7.2 in ASCE 7, second-order load effects shall be included in the evaluation of component and connection strengths.

1620.2.2 Openings. Where openings occur in shear walls, diaphragms or other plate-type elements, reinforcement at the edges of the openings shall be designed to transfer the stresses into the structure. The edge reinforcement shall extend into the body of the wall or diaphragm a distance sufficient to develop the force in the reinforcement.

1620.2.3 Discontinuities in vertical system. Structures with a discontinuity in lateral capacity, vertical irregularity Type 5, as defined in Table 1616.5.1.2, shall not be over two stories or 30 feet (9144 mm) in height where the “weak” story has a calculated strength of less than 65 percent of the story above.

Exception: Where the “weak” story is capable of resisting a total seismic force equal to the over-strength factor, Ω_0 , as given in Table 1617.6.2, multiplied by the design force prescribed in Section 1617.5, the height limitation does not apply.

1620.2.4 Connections. All parts of the structure, except at separation joints, shall be interconnected and the connections shall be designed to resist the seismic force, F_p , induced by the parts being connected. Any smaller portion of the structure shall be tied to the remainder of the structure for the greater of:

$$F_p = 0.133 S_{DS} w_p \quad (\text{Equation 16-58})$$

or

$$F_p = 0.05 w_p \quad (\text{Equation 16-59})$$

S_{DS} = The design, 5-percent damped, spectral response acceleration at short periods as defined in Section 1615.

w_p = The weight of the smaller portion.

A positive connection for resisting a horizontal force acting parallel to the member shall be provided for each beam, girder or truss to its support for a force not less than 5 percent of the dead plus live load reaction.

1620.2.5 Diaphragms. Permissible deflection shall be that deflection up to which the diaphragm and any attached distributing or resisting element will maintain its structural integrity under design load conditions, such that the resisting element will continue to support design loads without danger to occupants of the structure.

Floor and roof diaphragms shall be designed to resist F_p as follows:

$$F_p = 0.2 I_E S_{DS} w_p + V_{px}$$

(Equation 16-60)

where:

F_p = The seismic force induced by the parts.

I_E = Occupancy importance factor (Table 1604.5).

S_{DS} = The short-period site design spectral response acceleration coefficient (Section 1615).

w_p = The weight of the diaphragm and other elements of the structure attached to the diaphragm.

V_{px} = The portion of the seismic shear force at the level of the diaphragm, required to be transferred to the components of the vertical seismic-force-resisting system because of the offsets or changes in stiffness of the vertical components above or below the diaphragm.

Diaphragms shall provide for both shear and bending stresses resulting from these forces. Diaphragms shall have ties or struts to distribute the wall anchorage forces into the diaphragm. Diaphragm connections shall be positive, mechanical or welded-type connections.

1620.2.6 Collector elements. Collector elements shall be provided that are capable of transferring the seismic forces originating in other portions of the structure to the element providing the resistance to those forces. Collector elements, splices and their connections to resisting elements shall have the design strength to resist the special load combinations of Section 1605.4.

Exception: In structures or portions thereof braced entirely by light-framed shear walls, collector elements, splices and connections to resisting elements need only have the strength to resist the load combinations of Section 1605.2 or 1605.3.

1620.2.7 Bearing walls and shear walls. Bearing walls and shear walls and their anchorage shall be designed for an out-of-plane force, F_p , that is the greater of 10 percent of the weight of the wall, or the quantity given by Equation 16-61:

$$F_p = 0.40 I_E S_{DS} w_w$$

(Equation 16-61)

where:

I_E = Occupancy importance factor (Table 1604.5).

S_{DS} = The short-period site design spectral response acceleration coefficient (Section 1615.1.3 or 1615.2.5).

w_w = The weight of the wall.

In addition, concrete and masonry walls shall be anchored to the roof and floors and members that provide lateral support for the wall or that are supported by the wall. The anchorage shall provide a direct connection between the wall and the supporting construction capable of resisting the greater of the force, F_p , as given by Equation 16-61 or $(400 S_{DS} I_E)$ pounds per linear foot of wall. For SI: $5838 S_{DS} I_E$ N/m. Walls shall be designed to resist bending between anchors where the anchor spacing exceeds 4 feet (1219 mm). Parapets shall conform to the requirements of Section 9.6.2.2 of ASCE 7.

1620.2.8 Inverted pendulum-type structures. Supporting columns or piers of inverted pendulum-type structures shall be designed for the bending moment calculated at the base determined using the procedures given in Section 1617.4 and varying uniformly to a moment at the top equal to one-half the calculated bending moment at the base.

1620.2.9 Elements supporting discontinuous walls or frames. Columns or other elements subject to vertical reactions from discontinuous walls or frames of structures having plan irregularity Type 4 of Table 1616.5.1.1 or vertical irregularity Type 4 of Table 1616.5.1.2 shall have the design strength to resist special seismic load combinations of Section 1605.4. The connections from the discontinuous walls or frames to the supporting elements need not have the design strength to resist the special seismic load combinations of Section 1605.4.

Exceptions:

1. The quantity, E_m , in Section 1617.1.1.2 need not exceed the maximum force that can be transmitted to the element by the lateral-force-resisting system at yield.
2. Concrete slabs supporting light-framed walls.

1620.2.10 Direction of seismic load. 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 requirement will be deemed satisfied if the design seismic forces are applied separately and independently in each of the two orthogonal directions.

1620.3 Seismic Design Category C. Structures assigned to Seismic Design Category C

(see Section 1616) shall conform to the requirements of Section 1620.2 for Seismic Design Category B and to Sections 1620.3.1 through 1620.3.2.

1620.3.1 Anchorage of concrete or masonry walls. Concrete or masonry walls shall be anchored to floors and roofs and members that provide out-of-plane lateral support for the wall or that are supported by the all. The anchorage shall provide a positive direct connection between the wall and floor or roof capable of resisting the horizontal forces specified in Equation 16-62 for structures with flexible diaphragms or in Section 9.6.1.3 of ASCE 7 (using a_p of 1.0 and R_p of 2.5) for structures with diaphragms that are not flexible.

$$F_p = 0.8 S_{DS} I_E w_w$$

(Equation 16-62)

where:

F_p = The design force in the individual anchors.

I_E = Occupancy importance factor in accordance with Section 1616.2.

S_{DS} = The design earthquake spectral response acceleration at short period in accordance with Section 1615.1.3.

w_w = The weight of the wall tributary to the anchor.

Diaphragms shall be provided with continuous ties or struts between diaphragm chords to distribute these anchorage forces into the diaphragms. Where added chords are used to form subdiaphragms, such chords shall transmit the anchorage forces to the main cross ties. The maximum length-to-width ratio of the structural subdiaphragm shall be 2½ to 1. Connections and anchorages capable of resisting the prescribed forces shall be provided between the diaphragm and the attached components. Connections shall extend into the diaphragms a sufficient distance to develop the force transferred into the diaphragm.

The strength design forces for steel elements of the wall anchorage system shall be 1.4 times the force otherwise required by this section.

In wood diaphragms, the continuous ties shall be in addition to the diaphragm sheathing. Anchorage shall not be accomplished by use of toenails or nails subject to withdrawal, nor shall wood ledgers or framing be used in cross-grain bending or cross-grain tension. The diaphragm sheathing shall not be considered effective as providing the ties or struts required by this section.

In metal deck diaphragms, the metal deck shall not be used as the continuous ties required by this section in the direction perpendicular to the deck span.

Diaphragm-to-wall anchorage using embedded straps shall be attached to or hooked around the reinforcing steel or otherwise terminated so as to directly transfer force to the reinforcing steel.

1620.3.2 Direction of seismic load. For structures that have plan structural irregularity Type 1a or 1b of Table 1616.5.1.1 along both principal plan axes, or plan structural irregularity Type 5 in Table 1616.5.1.1, the critical direction requirement of Section 1620.2.10 shall be deemed satisfied if components and their foundations are designed for the following orthogonal combination of prescribed loads.

One hundred percent of the forces for one direction plus 30 percent of the forces for the perpendicular direction. The combination requiring the maximum component strength shall be used. Alternatively, the effects of the two orthogonal directions are permitted to be combined on a square root of the sum of the squares (SRSS) basis.

When the SRSS method of combining directional effects is used, each term computed shall be assigned the sign that will result in the most conservative result.

The orthogonal combination procedure above shall be required for any column or wall that forms part of two or more intersecting seismic-force-resisting systems and is subjected to axial load due to seismic forces acting along either principal plan axis equaling or exceeding 20 percent of the axial load design strength of the column or wall.

1620.4 Seismic Design Category D. Structures assigned to Seismic Design Category D shall conform to the requirements of Section 1620.3 for Seismic Design Category C and to Sections 1620.4.1 through 1620.4.6.

1620.4.1 Plan or vertical irregularities. For buildings having a plan structural irregularity of Type 1a, 1b, 2, 3 or 4 in Table 1616.5.1.1 or a vertical structural irregularity of Type 4 in Table 1616.5.1.2, the design forces determined from Section 1617.5 shall be increased 25 percent for connections of diaphragms to vertical elements and to collectors, and for connections of collectors to the vertical elements.

Exception: When connection design forces are determined using the special seismic load combinations of Section 1605.4

1620.4.2 Vertical seismic forces. In addition to the applicable load combinations of Section 1605, horizontal cantilever and horizontal prestressed components shall be designed to resist a minimum net upward force of 0.2 times the dead load.

1620.4.3 Diaphragms. Floor and roof diaphragms shall be designed to resist design seismic forces determined in accordance with Equation 16-63 as follows:

$$F_{\mu} = \frac{\sum_{i=x}^n F_i}{\sum_{i=x}^n w_i} w_{\mu}$$

(Equation 16-63)

where:

F_i = The design force applied to Level i .

F_{px} = The diaphragm design force.

w_i = The weight tributary to Level i .

w_{px} = The weight tributary to the diaphragm at Level x .

The force determined from Equation 16-63 need not exceed $0.4S_{DS}I_Ew_{px}$ but shall not be less than $0.2S_{DS}I_Ew_{px}$ where S_{DS} is the design spectral response acceleration at short period determined in Section 1615.1.3 and I_E is the occupancy importance factor determined in Section 1616.2. When the diaphragm is required to transfer design seismic force from the vertical-resisting elements above the diaphragm to other vertical-resisting elements below the diaphragm due to offsets in the placement of the elements or to changes in relative lateral stiffness in the vertical elements, these forces shall be added to those determined from Equation 16-63 and to the upper and lower limits on that equation.

1620.4.4 Collector elements. Collector elements shall be provided that are capable of transferring the seismic forces originating in other portions of the structure to the element providing resistance to those forces.

Collector elements, splices and their connections to resisting elements shall resist the forces determined in accordance with Equation 16-63. In addition, collector elements, splices and their connections to resisting elements shall have the design strength to resist the earthquake loads as defined in the special load combinations of Section 1605.4.

Exception: In structures, or portions thereof, braced entirely by light-framed shear walls, collector elements, splices and their connections to resisting elements need only be designed to resist forces in accordance with Equation 16-63.

1620.4.5 Building separations. All structures shall be separated from adjoining structures. Separations shall allow for the displacement δ_M . Adjacent buildings on the same property shall be separated by at least δ_{MT} where

$$\delta_{MT} = \sqrt{(\delta_{M1})^2 + (\delta_{M2})^2} \quad \text{(Equation 16-64)}$$

and δ_{M1} and δ_{M2} are the displacements of the adjacent buildings.

When a structure adjoins a property line not common to a public way, that structure shall also be set back from the property line by at least the displacement, δ_M , of that structure.

Exception: Smaller separations or property line setbacks shall be permitted when justified by rational analyses based on maximum expected ground motions.

1620.4.6 Anchorage of concrete or masonry walls to flexible diaphragms. In addition to the requirements of Section 1620.3.1, concrete and masonry walls shall be anchored to flexible diaphragms based on the following:

1. When elements of the wall anchorage system are not loaded concentrically or are not perpendicular to the wall, the system shall be designed to resist all components of the forces induced by the eccentricity.
2. When pilasters are present in the wall, the anchorage force at the pilasters shall be calculated considering the additional load transferred from the wall panels to the pilasters. The minimum anchorage at a floor or roof shall not be less than that specified in Item 1.

1620.5 Reserved.

SECTION BC 1621
ARCHITECTURAL, MECHANICAL AND ELECTRICAL COMPONENT
SEISMIC DESIGN REQUIREMENTS

1621.1 Component design. Architectural, mechanical, electrical and nonstructural systems, components and elements permanently attached to structures, including supporting structures and attachments (hereinafter referred to as “components”), and nonbuilding structures that are supported by other structures, shall meet the requirements of Section 9.6 of ASCE 7 except as modified in Sections 1621.1.1, 1621.1.2 and 1621.1.3, excluding Section 9.6.3.11.2, of ASCE 7, as amended in this section.

1621.1.1 ASCE 7, Section 9.6.3.11.2: Section 9.6.3.11.2 of ASCE 7 shall not apply.

1621.1.2 ASCE 7, Section 9.6.2.8.1. Modify ASCE 7, Section 9.6.2.8.1, to read as follows:

9.6.2.8.1 General. Partitions that are tied to the ceiling and all partitions greater than 6 feet (1829 mm) in height shall be laterally braced to the building structure. Such bracing shall be independent of any ceiling splay bracing. Bracing shall be spaced to limit horizontal deflection at the partition head to be compatible with ceiling deflection requirements as determined in Section 9.6.2.6 for suspended ceilings and Section 9.6.2.6 for other systems.

Exception: Partitions not taller than 9 feet (2743 mm) when the horizontal seismic load does not exceed 5 psf (0.240 KN/m²) required in Section 1607.13.

1621.1.3 ASCE 7, Section 9.6.3.13. Modify ASCE 7, Section 9.6.3.13, to read as follows:

9.6.3.13 Mechanical equipment, attachments and supports. Attachments and supports for mechanical equipment not covered in Sections 9.6.3.8 through 9.6.3.12 or Section 9.6.3.16 shall be designed to meet the force and displacement provisions of Section 9.6.1.3 and 9.6.1.4 and the additional provisions of this section. In addition to their attachments and supports, such mechanical equipment designated as having an $I_p = 1.5$, which contains hazardous or flammable materials in quantities that exceed the maximum allowable quantities for an open system listed in Section 307, shall, itself, be designed to meet the force and displacement provisions of Sections 9.6.1.3 and 9.6.1.4 and the additional provisions of this section. The seismic design of mechanical equipment, attachments and their supports shall include analysis of the following: the dynamic effects of the equipment, its contents and, when appropriate, its supports. The interaction between the equipment and the supporting structures, including other mechanical and electrical equipment, shall also be considered.

SECTION BC 1622

NONBUILDING STRUCTURES SEISMIC DESIGN REQUIREMENTS

1622.1 Nonbuilding structures. The requirements of Section 9.14 of ASCE 7 shall apply to nonbuilding structures except as modified by Sections 1622.1.1, 1622.1.2 and 1622.1.3.

1622.1.1 ASCE 7, Section 9.14.5.1. Modify Section 9.14.5.1, Item 9, to read as follows:

9. Where an approved national standard provides a basis for the earthquake-resistant design of a particular type of nonbuilding structure covered by Section 9.14, such a standard shall not be used unless the following limitations are met:

1. The seismic force shall not be taken as less than 80 percent of that given by the remainder of Section 9.14.5.1.
2. The seismic ground acceleration, and seismic coefficient, shall be in conformance with the requirements of Sections 9.4.1 and 9.4.1.2.5, respectively.
3. The values for total lateral force and total base overturning moment used in design shall not be less than 80 percent of the base shear value and

overturning moment, each adjusted for the effects of soil structure interaction that is obtained by using this standard.

1622.1.2 ASCE 7, Section 9.14.7.2.1. Modify Section 9.14.7.2.1 to read as follows:

9.14.7.2.1 General. This section applies to all earth-retaining walls. The applied seismic forces shall be determined in accordance with Section 9.7.5.1 with a geotechnical analysis prepared by a registered design professional.

The seismic use group shall be determined by the proximity of the retaining wall to other nonbuilding structures or buildings. If failure of the retaining wall would affect an adjacent structure, the seismic use group shall not be less than that of the adjacent structure, as determined in Section 9.1.3. Earth-retaining walls are permitted to be designed for seismic loads as either yielding or nonyielding walls. Cantilevered reinforced concrete retaining walls shall be assumed to be yielding walls and shall be designed as simple flexural wall elements.

1622.1.3 ASCE 7, Section 9.14.7.9. Add a new Section 9.14.7.9 to read as follows:

9.14.7.9 Buried structures. As used in this section, the term “buried structures” means subgrade structures such as tanks, tunnels and pipes. Buried structures that are designated as Seismic Use Group II or III, as determined in Section 9.1.3, or are of such a size or length as to warrant special seismic design as determined by the registered design professional, shall be identified in the geotechnical report. Buried structures shall be designed to resist seismic lateral forces determined from a substantiated analysis using standards approved by the commissioner. Flexible couplings shall be provided for buried structures where changes in the support system, configurations or soil condition occur.

SECTION BC 1623
SEISMICALLY ISOLATED STRUCTURES

1623.1 Design requirements. Every seismically isolated structure and every portion thereof shall be designed and constructed in accordance with the requirements of Section 9.13 of ASCE 7, except as modified in Section 1623.1.1.

1623.1.1 ASCE 7, Section 9.13.6.2.3. Modify ASCE 7, Section 9.13.6.2.3, to read as follows:

9.13.6.2.3 Fire resistance. Fire-resistance ratings for the isolation system shall comply with Section 714.7 of the *New York City Building Code*.

SECTION BC 1624
STRUCTURAL INTEGRITY DEFINITIONS

1624.1 Definitions. The following words and terms shall, for the purposes of this section, have the meanings shown herein.

ALTERNATE LOAD PATH. A secondary or redundant load path capable of transferring the load from one structural element to other structural elements.

ALTERNATE LOAD PATH METHOD. A design approach that accounts for an extreme event by providing alternate load paths for elements that are no longer able to carry load. In an alternate load path design, key elements are considered notionally removed, one at a time, and the structure is designed to transfer the loads from the removed element to other structural elements, as required by Section 1626.

ASPECT RATIO. The height of any portion of a building divided by its least dimension at the elevation from which the height is being measured.

COLLAPSE. Failure of a structural element to the extent that it can no longer support any load.

ELEMENT. A structural member or structural assembly.

KEY ELEMENT. An element of the structural system, including its connections, that meets one or more of the following criteria:

1. An element which when lost, results in more than local collapse.
2. An element that braces a key element, the failure of which results in failure of the key element (further secondary elements need not be considered key elements).

LOCAL COLLAPSE. Failure of a structural element that results in the collapse of areas being directly supported by that element and not extending vertically more than three stories.

RESPONSE RATIO. The ratio of an ultimate response quantity (e.g., deflection) to its value at yield.

ROTATION. The angle, measured at the ends of a member, whose tangent is equal to the deflection of the member at mid-span divided by half the length of the member.

SPECIFIC LOCAL LOAD. A load applied to a structural element or structural system as specified in Section 1626.7.

SPECIFIC LOCAL RESISTANCE METHOD. A design approach that accounts for extreme event loads by providing sufficient strength for elements that may fail. In a specific local resistance design, key elements are designed for specific local loads as required by Section 1626.

SECTION BC 1625
STRUCTURAL INTEGRITY—PRESCRIPTIVE REQUIREMENTS

1625.1 Scope. The intent of these provisions is to enhance structural performance under extreme event scenarios by providing additional overall system redundancy and local robustness. All structures shall be designed to satisfy the prescriptive requirements of this Section.

Exception: Structures in Category I of Table 1604.5 and structures in occupancy group R-3 are exempt from the requirements of Sections 1624 through 1626.

1625.2 Continuity and ties. All structural elements shall have a minimum degree of continuity and shall be tied together horizontally and vertically as specified in Chapters 19, 21, and 22 for concrete, masonry and steel, respectively.

1625.3 Lateral bracing. Floor and roof diaphragms or other horizontal elements shall be tied to the lateral load resisting system.

1625.4 Reserved.

1625.5 Vehicular impact. Structural columns that are directly exposed to vehicular traffic shall be designed for vehicular impact. Structural columns that are adequately protected by bollards, guard walls, vehicle arrest devices or other elements need not be designed for vehicular impact. The load combinations for vehicular impact shall be as specified in Section 1605.7.

Specific loads for vehicular impact shall be as follows:

1. Exterior corner columns shall be designed for a concentrated load of 40 kips applied horizontally in any direction from which a vehicle can approach at a height of either 18 inches (457 mm) or 36 inches (914 mm) above the finished driving surface, whichever creates the worst effect.
2. All other exterior columns exposed to vehicular traffic, and columns within loading docks, and columns in parking garages along the driving lane shall be designed for a concentrated load of 20 kips applied horizontally in any direction from which a vehicle can approach at a height of either 18 inches (457 mm) or 36 inches (914 mm) above the finished driving surface, whichever creates the worst effect.

1625.6 Gas explosions. In buildings with gas piping operating at pressures in excess of 15 psig (103 kPa guage), all key elements and their connections within 15 feet (4572 mm) of such piping shall be designed to resist a potential gas explosion. The structure shall be designed to account for the potential loss of the affected key elements one at a time by the Alternate Load Path Method. Load combinations for the Alternate Load Path shall be as specified in Section 1605.6. In lieu of the Alternate Load Path Method, the

affected key elements shall be designed to withstand a load of 430 psf (20.6 kPa) applied using the load combinations specified in Section 1605.7. The load shall be applied along the entire length of the element, and shall be applied in the manner and direction that produces the most damaging effect.

Exceptions:

1. If a structural enclosure designed to resist the specified pressure is provided around the high-pressure gas piping, only the key elements within the structural enclosure need to comply with this section.
2. A reduced pressure for gas explosions can be used based on an engineering analysis approved by the commissioner.

1625.7 Design criteria. Alternate load path design and/or specific local resistance design shall conform to the appropriate design criteria as determined from Sections 1626.9, 1626.10 and 1626.11. Load combinations for the alternate load path shall be as specified in Section 1605.6.

SECTION BC 1626
STRUCTURAL INTEGRITY — KEY ELEMENT ANALYSIS

1626.1 Scope. A Key Element Analysis shall be performed for the following buildings:

1. Buildings with Importance Factor Category of IV as defined in this chapter and more than 50,000 square feet (4645 m²) of framed area.
2. Buildings with the aspect ratios of seven or greater.
3. Buildings greater than 600 feet (183 m) in height or more than 1,000,000 square feet (92 903 m²) in gross floor area.
4. In Buildings taller than seven stories for any element which supports in aggregate more than 15 percent of the building area a Key Element Analysis shall be performed.
5. Buildings designed using non-linear time history analysis or with special seismic energy dissipation systems.
6. Buildings where a structural peer review is requested by the commissioner.

1626.2 Load combination. Where specifically required by Sections 1626.1, elements and components shall be designed to resist the forces calculated using the combination specified in Section 1605.6.

1626.3 Multiple occupancies. Where a structure is used for two or more occupancies not included in the same category of Table 1604.5, the structure shall be assigned the classification of the highest category corresponding to the various occupancies.

1626.4 Seismic and wind. When the code-prescribed seismic or wind design produces greater effects, the seismic or wind design shall govern, but the detailing requirements and limitations prescribed in this and referenced sections shall also be followed

1626.5 Joints. Where a structure is divided by joints that allow for movement, each portion of the structure between joints shall be considered as a separate structure.

1626.6 Key Element Analysis. Where key elements are present in a structure, the structure shall be designed to account for their potential loss one at a time by the Alternate Load Path Method or by the Specific Local Resistance Method as specified in Section 1626.7.

1626.7 The Specific Local Resistance Method. Where the specific local resistance method is used key elements shall be designed using specific local loads as follows:

1. Each compression element shall be designed for a concentrated load equal to 2 percent of its axial load but not less than 15 kips, applied at mid-span in any direction, perpendicular to its longitudinal axis. This load shall be applied in combination with the full dead load and 50 percent of the live load in the compression element.
2. Each bending element shall be designed for the combination of the principal acting moments plus an additional moment, equal to 10 percent of the principal acting moment applied in the perpendicular plane.
3. Connections of each tension element shall be designed to develop the smaller of the ultimate tension capacity of the member or 3 times the force in the member.
4. All structural elements shall be designed for a reversal of load. The reversed load shall be equal to 10 percent of the design load used in sizing the member.

1626.8 Design criteria. Alternate load path method and/or specific local resistance method for key elements shall conform to the appropriate design criteria as determined from Sections 1626.9, 1626.10 and 1626.11. Load combinations shall be as specified in Section 1605.6.

1626.9 Analysis procedures. All structural analysis for specific local loads and/or key elements shall be made by one of the following methods:

1626.9.1 Static elastic analysis. For analysis of this type, dynamic effects of member loss or dynamic effects of specific local loads need not be considered. The structure shall be assumed to remain elastic; however, structural elements may reach yield

across their entire cross-section. The response ratio of structural elements so designed shall be limited to one.

1626.9.2 Dynamic inelastic analysis. For analysis of this type, dynamic effects of member loss or specific local loads shall be considered. The structure need not remain elastic; however, the response ratio and rotation limits obtained from Table 1626.9.3 shall not be exceeded.

1626.9.3 Energy methods. Static inelastic analysis using energy equilibrium may also be used. The structure need not remain elastic; however, the response ratio and rotation limits obtained from Table 1626.9.3 shall not be exceeded.

TABLE 1626.9.3
RESPONSE RATIO AND ROTATION LIMITS

<u>ELEMENT</u>	<u>RESPONSE</u>	
	<u>RATIO</u>	<u>ROTATION</u>
<u>Concrete Slabs</u>	$\mu < 10$	$\theta < 4^\circ$
<u>Post-Tensioned Beams</u>	$\mu < 2$	$\theta < 1.5^\circ$
<u>Concrete Beams</u>	$\mu < 20$	$\theta < 6^\circ$
<u>Concrete Columns</u>	$\mu < 2$	$\theta < 6^\circ$
<u>Long Span Acoustical Deck</u>	$\mu < 2$	$\theta < 3^\circ$
<u>Open Web Steel Joists</u>	$\mu < 2$	$\theta < 6^\circ$
<u>Steel Beams</u>	$\mu < 20$	$\theta < 10^\circ$
<u>Steel Columns</u>	$\mu < 5$	$\theta < 6^\circ$

Table 1624.2 is intended for SDOF and simplified MDOF response calculations and a low level of protection. Table 1624.2 does not apply for explicit finite element methods that calculate the performance of the structural elements in response to the specified loading intensity. Steel Joists: downward loading 6-degrees, upward loading ductility of 2.

1626.10 Minimum response. Structural response of elements determined using a dynamic inelastic analysis shall not be less than 80 percent of the structural response determined using a static elastic analysis.

1626.11 Strength reduction factors. For structural design for specific local loads and/or key elements, all strength reduction factors may be taken as one.

SECTION BC 1627 **STRUCTURAL PEER REVIEW**

1627.1 General. The provisions of this section specify where structural peer review is required, how and by whom it is to be performed.

1627.2 Where required. A structural peer review of the primary structure shall be performed and a report provided for the following buildings:

1. Buildings with Importance Factor Category of IV as defined in this chapter and more than 50,000 square feet (4645 m²) of framed area.
2. Buildings with aspect ratios of seven or greater.
3. Buildings greater than 600 feet (183 m) in height or more than 1,000,000 square feet (92 903 m²) in gross floor area.
4. Buildings taller than seven stories where any element supports in aggregate more than 15 percent of the building area.
5. Buildings designed using non-linear time history analysis or with special seismic energy dissipation systems.
6. Buildings where a structural peer review is requested by the commissioner.

1627.3 Structural design review. It shall be verified that the structural design of the primary structure is in general conformance with the requirements of this code.

1627.4 Structural peer reviewer. The structural peer review shall be performed by a qualified independent structural engineer who has been retained by or on behalf of the owner. A structural peer reviewer shall meet the requirements of the rules of the department.

1627.5 Definitions. The following words and terms shall, for the purposes of this chapter and as used elsewhere in this code, have the meanings shown herein.

PRIMARY STRUCTURE. The structural frame and the load supporting parts of floors, roofs, and walls, and the foundations. Cladding, cladding framing, stairs, equipment

supports, ceiling supports, non-load bearing partitions, and railings and other secondary structural items are excluded from this definition of primary structure.

1627.6 Extent of the structural peer review.

1627.6.1 Scope. The reviewing engineer shall review the plans and specifications submitted with the permit application for general compliance with the structural and foundation design provisions of this code. The reviewing engineer shall perform the following tasks at a minimum:

1. Confirm that the design loads conform to this code.
2. Confirm that other structural design criteria, and design assumptions, conform to this code and are in accordance with generally accepted engineering practice.
3. Review geotechnical and other engineering investigations that are related to the foundation and structural design and confirm that the design properly incorporates the results and recommendations of the investigations.
4. Confirm that the structure has a complete load path.
5. Perform independent calculations for a representative fraction of systems, members, and details to check their adequacy. The number of representative systems, members, and details verified shall be sufficient to form a basis for the reviewer's conclusions.
6. Verify that performance-specified structural components (such as certain precast concrete elements) have been appropriately specified and coordinated with the primary building structure.
7. Confirm that the structural integrity provisions of the code are being followed.
8. Review the structural and architectural plans for the building. Confirm that the structural plans are in general conformance with the architectural plans regarding loads and other conditions that may affect the structural design.
9. Confirm that major mechanical items are accommodated in the structural plans.
10. Attest to the general completeness of the structural plans and specifications.

1627.6.2 Structural calculations. The structural calculations prepared by the structural engineer of record shall be submitted to the reviewing engineer, upon the reviewing engineer's request, for reference only. The reviewing engineer shall not be obliged to review or check these calculations. If the design criteria and design

assumptions are not shown on the drawings or in the computations, the structural engineer of record shall provide a statement of these criteria and assumptions for the reviewer.

1627.7 Structural peer review report.

1627.7.1 General. The reviewing engineer shall submit a report to the department stating whether or not the structural design shown on the plans and specifications generally conforms to the structural and foundation requirements of this code.

1627.7.2 Contents. The report shall demonstrate at a minimum compliance with items 1 through 10 of section 1630.6.1. In addition, the report shall also include the following:

1. The codes and standards used in the structural design of the project.
2. The structural design criteria, including loads and performance requirements.
3. The basis for design criteria that are not specified directly in applicable codes and standards. This should include reports by specialty consultants such as wind tunnel study reports and geotechnical reports. Generally, the report should confirm that existing conditions at the site have been investigated as appropriate and that the design of the proposed structure is in general conformance with these conditions.

1627.7.3 Phased submission. If an application is submitted for a permit for the construction of foundations or any other part of a building before the construction documents for the whole building have been submitted, then the structural peer review and report shall be phased. The structural peer reviewer shall be provided with sufficient information on which to make a structural peer review of the phased submission.

1627.8 Responsibility.

1627.8.1 Structural engineer of record. The structural engineer of record shall retain sole responsibility for the structural design. The activities and reports of the structural peer reviewer shall not relieve the structural engineer of record of this responsibility.

1627.8.2 Structural peer reviewer. The structural peer reviewer's report states his or her opinion regarding the design by the engineer of record. The standard of care to which the structural peer reviewer shall be held in the performance of the structural peer review and report is that level of skill and care consistent with structural peer review services performed by professional engineers licensed in the State of New York for similar types of projects.