

CHAPTER 16

STRUCTURAL DESIGN

SECTION 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.

Exception: Buildings and structures located within the high-velocity hurricane zone shall comply with the provisions of Sections 1615 through 1626, and, as applicable in flood hazard areas, Section 1612.

SECTION 1602 DEFINITIONS AND NOTATIONS

1602.1 Definitions. The following words and terms shall, for the purposes of this chapter, 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”).

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

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 the weight of fixed service equipment, such as cranes, plumbing stacks and risers, electrical feeders, heating, ventilating and air-conditioning systems and automatic sprinkler systems.

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 where so indicated in Section 12.3.1 of ASCE 7, as modified in Section 1613.6.1.

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.

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.

FABRIC PARTITION. A partition consisting of a finished surface made of fabric, without a continuous rigid backing, that is directly attached to a framing system in which the vertical framing members are spaced greater than 4 feet (1219 mm) on center.

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

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.

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

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”).

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

OCCUPANCY CATEGORY. A category used to determine structural requirements based on occupancy.

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

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.

■ **PRODUCTION GREENHOUSE.** Greenhouses that are occupied for growing plants on a product or research basis without public access.

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”).

■ **RISK CATEGORY.** A categorization of buildings and other structures for determination of flood and wind loads based on the risk associated with unacceptable performance.

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 [also called “load and resistance factor design” (LRFD)]. The term “strength design” is used in the design of concrete and masonry structural elements.

VEHICLE BARRIER SYSTEM. A system of building components near open sides of a garage floor or ramp or building walls that act as restraints for vehicles.

NOTATIONS.

- D = Dead load.
- F = Load due to fluids with well-defined pressures and maximum heights.
- F_a = Flood load in accordance with Chapter 5 of ASCE 7.
- H = Load due to lateral earth pressures, ground water pressure or pressure of bulk materials.
- L = Live load, except roof live load, including any permitted live load reduction.

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

R = Rain 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.

V_{asd} = nominal design wind speed (3-sec gust), miles per hour (mph) (km/hr) where applicable.

V_{ult} = ultimate design wind speeds (3-sec gust), miles per hour (mph) (km/hr) determined from Figures 1609A, 1609B, or 1609C or ASCE 7.

W = Load due to wind pressure.

**SECTION 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 dimensioned. The design loads and other information pertinent to the structural design required by Sections 1603.1.1 through 1603.1.9 shall be indicated on the *construction documents*.

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. Reserved.
3. Ultimate design wind speed, V_{ult} , (3-second gust), miles per hour (mph) (km/hr) and nominal design wind speed, V_{asd} , as determined in accordance with Section 1609.3.1 and wind exposure.
4. Reserved.
5. Flood design data, if located in *flood hazard areas* established in Section 1612.3.
6. Design load-bearing values of soils.

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. Use of live load reduction in accordance with Section 1607.9 shall be indicated for each type of live load used in the design.

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. Reserved.

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. Ultimate design wind speed V_{ult} , (3-second gust), miles per hour (km/hr) and nominal design wind

speed, V_{asd} , as determined in accordance with Section 1609.3.1.

2. Risk Category from Table 1604.5 or Table 1.5-1 of ASCE 7.
3. Wind exposure. Where more than one wind exposure is utilized, the wind exposure and applicable wind direction shall be indicated.
4. The applicable enclosure classifications and, if designing with ASCE 7, internal pressure coefficient.
5. Components and cladding. The design wind pressures in terms of psf (kN/m²) to be used for the selection of exterior component and cladding materials not specifically designed by the *registered design professional*.

1603.1.5 Earthquake design data. Reserved.

1603.1.6 Geotechnical information. The design load-bearing values of soils shall be shown on the *construction documents*.

1603.1.7 Flood design data. For buildings located in whole or in part in *flood hazard areas* as established in Section 1612.3, the documentation pertaining to design, if required in Section 1612.5, shall be included and the following information, referenced to the datum on the community’s Flood Insurance Rate Map (FIRM), shall be shown, regardless of whether flood loads govern the design of the building:

1. In *flood hazard areas* not subject to high-velocity wave action, the elevation of the proposed lowest floor, including the basement.
2. In *flood hazard areas* not subject to high-velocity wave action, the elevation to which any nonresidential building will be dry floodproofed.
3. In *flood hazard areas* subject to high-velocity wave action, the proposed elevation of the bottom of the lowest horizontal structural member of the lowest floor, including the basement.

1603.1.8 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.

1603.1.9 Systems and components requiring special inspections for seismic resistance. Reserved.

**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 *building official*.

1604.3 Serviceability. Structural systems and members thereof shall be designed to have adequate stiffness to limit deflections and lateral drift. See Section 12.12.1 of ASCE 7 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.

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

CONSTRUCTION	L	S or W ^f	D + L ^{d, g}
Roof members: ^e			
Supporting plaster ceiling	//360	//360	//240
Supporting nonplaster ceiling	//240	//240	//180
Not supporting ceiling	//180	//180	//120
Members supporting screen surface	—	—	//60
Floor members	//360	—	//240
Exterior walls and interior partitions:			
With brittle finishes	—	//240	—
With flexible finishes	—	//120	—
Farm buildings	—	—	//180
Greenhouses	—	—	//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 //60. For secondary roof structural members supporting formed metal roofing, the live load deflection shall not exceed //150. For secondary wall members supporting formed metal siding, the design wind load deflection shall not exceed //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 $L + 0.5D$ 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 0.42 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 skylights and sloped glazing framing, 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 //60. For continuous aluminum structural members supporting edge of glass, the total load deflection shall not exceed //175 for each glass lite or //60 for the entire length of the member, whichever is more stringent. For aluminum sandwich panels used in roofs or walls of sunroom additions or patio covers, the total load deflection shall not exceed //120.
- i. For cantilever members, l shall be taken as twice the length of the cantilever.
- j. Screen surfaces shall be permitted to include a maximum of 25% solid flexible finishes.

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 360, AISI S100, ASCE 3, ASCE 8, SJI CJ-1.0, SJI JG-1.1, SJI K-1.1 or SJI LH/DLH-1.1, as applicable.

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

1604.3.5 Aluminum. The deflection of aluminum structural members shall not exceed that permitted by AA ADM1.

1604.3.6 Limits. Deflection of structural members over span, l , shall not exceed that permitted by Table 1604.3.

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.

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 assumed not to be a part of the lateral-force-resisting system are permitted to be incorporated into buildings provided their effect on the action of the system is considered and provided for in the design. Except where diaphragms are flexible, or are permitted to be analyzed as flexible, 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 loads and Section 1610 for lateral soil loads.

1604.5 Risk category. Each building and structure shall be assigned a *risk category* in accordance with Table 1604.5.

1604.5.1 Multiple occupancies. Where a building or structure is occupied by two or more occupancies not included in the same *risk category*, it shall be assigned the classification of the highest *risk category* corresponding to the various occupancies. Where buildings or structures have two or more portions that are structurally separated, each portion shall be separately classified. Where a separated portion of a

building or structure provides required access to, required egress from or shares life safety components with another portion having a higher *risk category*, both portions shall be assigned to the higher *risk category*.

1604.6 In-situ load tests. The *building official* 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 1714.

1604.7 Preconstruction load tests. Materials and methods of construction that are not capable of being designed by *approved* 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 1712, shall be load tested in accordance with Section 1715.

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 Walls. 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 unless the lateral force has otherwise been calculated by the Engineer of Record. Concrete and masonry 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 for wind 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. Connections of decks with cantilevered framing members to exterior walls or other framing members shall be designed for both of the following:

1. The reactions resulting from the dead load and live load specified in Table 1607.1, or the snow load specified in Section 1608, in accordance with Section 1605, acting on all portions of the deck.
2. The reactions resulting from the dead load and live load specified in Table 1607.1, or the snow load specified in Section 1608, in accordance with Section 1605, acting on the cantilevered portion of the deck, and no live load or snow load on the remaining portion of the deck.

1604.9 Counteracting structural actions. Structural members, systems, components and cladding shall be designed to resist forces due to wind, with consideration of overturning, sliding and uplift. Continuous load paths shall be provided for

**TABLE 1604.5
RISK CATEGORY OF BUILDINGS AND OTHER STRUCTURES**

RISK CATEGORY	NATURE OF OCCUPANCY
I	Buildings and other structures that represent a low hazard to human life in the event of failure, including but not limited to: <ul style="list-style-type: none"> • Agricultural facilities. • Certain temporary facilities. • Minor storage facilities. • Screen enclosures.
II	Buildings and other structures except those listed in Risk Categories I, III and IV
III	Buildings and other structures that represent a substantial hazard to human life in the event of failure, including but not limited to: <ul style="list-style-type: none"> • Buildings and other structures whose primary occupancy is public assembly with an occupant load greater than 300. • Buildings and other structures containing elementary school, secondary school or day care facilities with an occupant load greater than 250. • Buildings and other structures containing adult education facilities, such as colleges and universities, with an occupant load greater than 500. • Group I-2 occupancies with an occupant load of 50 or more resident patients but not having surgery or emergency treatment facilities. • Group I-3 occupancies. • Any other occupancy with an occupant load greater than 5,000^a. • Power-generating stations, water treatment facilities for potable water, waste water treatment facilities and other public utility facilities not included in Risk Category IV. • Buildings and other structures not included in Risk Category IV containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released.
IV	Buildings and other structures designated as essential facilities, including but not limited to: <ul style="list-style-type: none"> • Group I-2 occupancies having surgery or emergency treatment facilities. • Fire, rescue, ambulance and police stations and emergency vehicle garages. • Designated earthquake, hurricane or other emergency shelters. • Designated emergency preparedness, communications and operations centers and other facilities required for emergency response. • Power-generating stations and other public utility facilities required as emergency backup facilities for Risk Category IV structures. • Structures containing highly toxic materials as defined by Section 307 where the quantity of the material exceeds the maximum allowable quantities of Table 307.1(2). • Aviation control towers, air traffic control centers and emergency aircraft hangars. • Buildings and other structures having critical national defense functions. • Water storage facilities and pump structures required to maintain water pressure for fire suppression.

a. For purposes of occupant load calculation, occupancies required by Table 1004.1.1 to use gross floor area calculations shall be permitted to use net floor areas to determine the total occupant load.

transmitting these forces to the foundation. Where sliding is used to isolate the elements, the effects of friction between sliding elements shall be included as a force.

■ **1604.10 Wind and seismic detailing.** Reserved.

**SECTION 1605
LOAD COMBINATIONS**

■ **1605.1 General.** Buildings and other structures and portions thereof shall be designed to resist:

1. The load combinations specified in Section 1605.2, 1605.3.1 or 1605.3.2,
2. The load combinations specified in Chapters 18 through 23.

■ Applicable loads shall be considered, including 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.

1605.1.1 Stability. Regardless of which load combinations are used to design for strength, where overall structure stability (such as stability against overturning, sliding, or buoyancy) is being verified, use of the load combinations specified in Section 1605.2 or 1605.3 shall be permitted. Where the load combinations specified in Section 1605.2 are used, strength reduction factors applicable to soil resistance shall be provided by a *registered design professional*. The stability of retaining walls shall be verified in accordance with Section 1807.2.3.

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:

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

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

$$1.2D + 1.6(L_r \text{ or } R) + (f_1 L \text{ or } 0.5W) \quad \text{(Equation 16-3)}$$

$$1.2D + 1.0W + f_1 L + 0.5(L_r \text{ or } R) \quad \text{(Equation 16-4)}$$

$$1.2D + f_1 L \quad \text{(Equation 16-5)}$$

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

$$0.9D + 1.6H \quad \text{(Equation 16-7)}$$

where:

- $f_1 = 1$ 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, and
- $= 0.5$ for other live loads.

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

1605.2.2 Flood loads. Where flood loads, F_a , are to be considered in the design, the load combinations of Section 2.3.3 of ASCE 7 shall be used.

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:

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

$$D + H + F + L + T \quad \text{(Equation 16-9)}$$

$$D + H + F + (L_r \text{ or } R) \quad \text{(Equation 16-10)}$$

$$D + H + F + 0.75(L + T) + 0.75(L_r \text{ or } R) \quad \text{(Equation 16-11)}$$

$$D + H + F + (0.6W) \quad \text{(Equation 16-12)}$$

$$D + H + F + 0.45(W) + 0.75L + 0.75(L_r \text{ or } R) \quad \text{(Equation 16-13)}$$

$$0.6D + 0.6W + H \quad \text{(Equation 16-14)}$$

$$0.6D + H \quad \text{(Equation 16-15)}$$

Exceptions:

1. Crane hook loads need not be combined with roof live load or one-half of the wind load.
2. Reserved.

1605.3.1.1 Load reduction.

1. Increases in allowable stress specified in the materials, sections of this code or a referenced standard shall not be permitted to be used with load combinations of Sections 1605.3.1. Duration of load

increase shall be permitted in accordance with Chapter 23.

Exception: Increases in allowable stress shall be permitted in accordance with ACI 530/ASCE 5/TMS 402 provided the loads in the load combinations of Equations 16-11 and 16-13 are not reduced.

1605.3.1.2 Flood loads. Where flood loads, F_a , are to be considered in design, the load combinations of Section 2.4.2 of ASCE 7 shall be used.

1605.3.2 Alternative basic load combinations. In lieu of the basic load combinations specified in Section 1605.3.1, structures and portions thereof shall be permitted to be designed for the most critical effects resulting from the following combinations. When using these alternative basic load combinations that include wind or seismic loads, allowable stresses are permitted to be increased or load combinations reduced where permitted by the material chapter of this code or the referenced standards. For load combinations that include the counteracting effects of dead and wind loads, only two-thirds of the minimum dead load likely to be in place during a design wind event shall be used. Where wind loads are calculated in accordance with Chapters 26 through 31 of ASCE 7, the coefficient ω in the following equations shall be taken as 0.78. For other wind loads, ω shall be taken as 1. When using these alternative load combinations to evaluate sliding, overturning and soil bearing at the soil-structure interface, the reduction of foundation overturning from Section 12.13.4 in ASCE 7 shall not be used.

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

$$D + L + (\omega W) \quad \text{(Equation 16-17)}$$

$$D + L + \omega W \quad \text{(Equation 16-18)}$$

$$D + L + \omega W/2 \quad \text{(Equation 16-19)}$$

$$D + L \quad \text{(Equation 16-20)}$$

$$0.9D \quad \text{(Equation 16-21)}$$

Exceptions:

1. Crane hook loads need not be combined with roof live loads or one-half of the wind load.
2. Reserved.

1605.3.2.1 Other loads. Where F , H or T are to be considered in the design, each applicable load shall be added to the combinations specified in Section 1605.3.2.

1605.4 Heliports and helistops. Heliport and helistop landing 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 .
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.

- Dead load, *D*, plus a uniform live load, *L*, of 100 psf (4.79 kN/m²).

Exception: Landing areas designed for helicopters with gross weights not exceeding 3,000 pounds (13.34 kN) in accordance with Items 1 and 2 shall be permitted to be designed using a 40 psf (1.92 kN/m²) uniform live load in Item 3, provided the landing area is identified with a 3,000-pound (13.34 kN) weight limitation. This 40-psf (1.92 kN/m²) uniform live load shall not be reduced. The landing area weight limitation shall be indicated by the numeral “3” (kips) located in the bottom right corner of the landing area as viewed from the primary approach path. The indication for the landing area weight limitation shall be a minimum 5 feet (1524 mm) in height.

SECTION 1606 DEAD LOADS

1606.1 General. Dead loads are those loads defined in Section 1602.1. Dead loads shall be considered permanent loads.

1606.2 Design dead load. For purposes of design, the actual weights of materials of construction and fixed service equipment shall be used. In the absence of definite information, values used shall be subject to the approval of the *building official*.

SECTION 1607 LIVE LOADS

1607.1 General. Live loads are those loads defined in Section 1602.1.

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 *building official*.

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 2½ feet by 2½ feet (0.76 m by 0.76 m) [6¼ square feet (0.58 m²)] and shall be located so as to produce the maximum *load effects* in the structural members.

1607.5 Partition loads. In office buildings and in other buildings where partition locations are subject to change, provisions for partition weight shall be made, whether or not partitions are shown on the *construction documents*, unless the specified live load exceeds 80 psf (3.83 kN/m²). The partition load shall not be less than a uniformly distributed live load of 15 psf (0.72 kN/m²).

**TABLE 1607.1
MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS, *L_o*, AND
MINIMUM CONCENTRATED LIVE LOADS^g**

OCCUPANCY OR USE	UNIFORM (psf)	CONCENTRATED (lbs.)
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	
Follow spot, projections and control rooms	50	—
Lobbies	100	
Movable seats	100	
Stages and platforms	125	
Other assembly areas	100	
5. Balconies (exterior) and decks ^h	Same as occupancy served	—
6. Bowling alleys	75	—
7. Catwalks	40	300
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
14. Finish light floor plate construction (on area of 1 in ²)	—	200
15. Fire escapes	100	—
On single-family dwellings only	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		
Corridors above first floor	80	1,000
Operating rooms, laboratories	60	1,000
Patient rooms	40	1,000
21. Hotels (see residential)	—	—
22. Libraries		
Corridors above first floor	80	1,000
Reading rooms	60	1,000
Stack rooms	150 ^b	1,000

continued

TABLE 1607.1—continued
MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS, L_o , AND
MINIMUM CONCENTRATED LIVE LOADS^g

OCCUPANCY OR USE	UNIFORM (psf)	CONCENTRATED (lbs.)
23. Manufacturing Heavy Light	250 125	3,000 2,000
24. Marquees	75	—
25. Office buildings Corridors above first floor File and computer rooms shall be designed for heavier loads based on anticipated occupancy Lobbies and first-floor corridors Offices	80 — 100 50	2,000 — 2,000 2,000
26. Penal institutions Cell blocks Corridors	40 100	—
27. Residential One- and two-family dwellings Uninhabitable attics without storage ⁱ Uninhabitable attics with limited storage ^{i, j, k} Habitable attics and sleeping areas All other areas Hotels and multifamily dwellings Private rooms and corridors serving them Public rooms and corridors serving them	10 20 30 40 40 100	—
28. Reviewing stands, grandstands and bleachers	Note c	
29. Roofs All roof surfaces subject to maintenance workers Awnings and canopies Fabric construction supported by a lightweight rigid skeleton structure All other construction Ordinary flat, pitched, and curved roofs Primary roof members, exposed to a work floor Single panel point of lower chord of roof trusses or any point along primary structural members supporting roofs: Over manufacturing, storage warehouses, and repair garages All other occupancies Roofs used for other special purposes Roofs used for promenade purposes Roofs used for roof gardens or assembly purposes	nonreducible 5 20 20	300 2,000 300 Note 1 60 100
30. Schools Classrooms Corridors above first floor First-floor corridors	40 80 100	1,000 1,000 1,000
31. Scuttles, skylight ribs and accessible ceilings	—	200
32. Sidewalks, vehicular driveways and yards, subject to trucking	250 ^d	8,000 ^e
33. Skating rinks	100	—

continued

TABLE 1607.1—continued
MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS, L_o , AND
MINIMUM CONCENTRATED LIVE LOADS^g

OCCUPANCY OR USE	UNIFORM (psf)	CONCENTRATED (lbs.)
34. Stadiums and arenas Bleachers Fixed seats (fastened to floor)	100 ^c 60 ^c	—
35. Stairs and exits One- and two-family dwellings All other	40 100	Note f
36. Storage warehouses (shall be designed for heavier loads if required for anticipated storage) Heavy Light	250 125	
37. Stores Retail First floor Upper floors Wholesale, all floors	100 75 125	1,000 1,000 1,000
38. Vehicle barrier systems	See Section 1607.7.3	
39. Walkways and elevated platforms (other than exitways)	60	—
40. Yards and terraces, pedestrians	100	—

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 square inch = 645.16 mm²,
 1 square foot = 0.0929 m²,
 1 pound per square foot = 0.0479 kN/m², 1 pound = 0.004448 kN.

- 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 passenger 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 ICC 300.
- d. Other uniform loads in accordance with an approved method which contains provisions for truck loadings shall also be considered where appropriate.
- e. The concentrated wheel load shall be applied on an area of 4.5 inches by 4.5 inches.
- f. Minimum concentrated load on stair treads (on area of 4 square inches) is 300 pounds.
- g. Reserved.
- h. See Section 1604.8.3 for decks attached to exterior walls.
- i. Attics without storage are those where the maximum clear height between the joist and rafter is less than 42 inches, or where there are not two or more adjacent trusses with the same web configuration capable of containing a rectangle 42 inches high by 2 feet wide, or greater, located within the plane of the truss. For attics without storage, this live load need not be assumed to act concurrently with any other live load requirements.
- j. For attics with limited storage and constructed with trusses, this live load need only be applied to those portions of the bottom chord where there are two or more adjacent trusses with the same web configuration capable of containing a rectangle 42 inches high by 2 feet wide or greater, located within the plane of the truss. The rectangle shall fit between the top of the bottom chord and the bottom of any other truss member, provided that each of the following criteria is met:
 - i. The attic area is accessible by a pull-down stairway or framed opening in accordance with Section 1209.2, and
 - ii. The truss shall have a bottom chord pitch less than 2:12.
 - iii. Bottom chords of trusses shall be designed for the greater of actual imposed dead load or 10 psf, uniformly distributed over the entire span.
- k. Attic spaces served by a fixed stair shall be designed to support the minimum live load specified for habitable attics and sleeping rooms.
- l. Roofs used for other special purposes shall be designed for appropriate loads as approved by the building official.

1607.6 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 *building official*. Actual loads shall be used where they are greater than the loads specified in the table.

1607.6.1 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. 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.

**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.

1607.7 Loads on handrails, guards, grab bars, seats and vehicle barrier systems. Handrails, *guards*, grab bars, accessible seats, accessible benches and vehicle barrier systems shall be designed and constructed to the structural loading conditions set forth in this section.

1607.7.1 Handrails and guards. Handrails and *guards* shall be designed to resist a load of 50 pounds per linear foot (plf) (0.73 kN/m) applied in any direction at the top and to transfer this load through the supports to the structure. Glass handrail assemblies and *guards* shall also comply with Section 2407.

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* less than 50, the minimum load shall be 20 pounds per foot (0.29 kN/m).

1607.7.1.1 Concentrated load. Handrails 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 to transfer this load through the supports to the structure. This load need not be assumed to

act concurrently with the loads specified in Section 1607.7.1.

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 (0.0929 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.

1607.7.2 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 barrier systems. Vehicle barrier systems for passenger vehicles 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, two loading conditions shall be analyzed. The first condition shall apply the load at a height of 1 foot, 6 inches (457 mm) above the floor or ramp surface. The second loading condition shall apply the load at 2 feet, 3 inches (686 mm) above the floor or ramp surface. The more severe load condition shall govern the design of the barrier restraint system. The load shall be assumed to act on an area not to exceed 1 square foot (0.0929 m²), and is not required to be assumed to act concurrently with any handrail or *guard* loadings specified in Section 1607.7.1. Garages accommodating trucks and buses shall be designed in accordance with an *approved* method that contains provisions for traffic railings.

1607.8 Impact loads. The live loads specified in Section 1607.3 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 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.

1607.9 Reduction in live loads. Except for uniform live loads at roofs, all other minimum uniformly distributed live loads, L_o , in Table 1607.1 are permitted to be reduced in accordance with Section 1607.9.1 or 1607.9.2. Roof uniform live loads, other than special purpose roofs of Section 1607.11.2.2, are permitted to be reduced in accordance with Section 1607.11.2. Roof uniform live loads of special purpose roofs are permitted to be reduced in accordance with Section 1607.9.1 or 1607.9.2.

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 m²) or more are permitted to be designed for a reduced live load in accordance with the following equation:

$$L = L_o \left(0.25 + \frac{15}{\sqrt{K_{LL}A_T}} \right) \quad \text{(Equation 16-22)}$$

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 (square meter) of area supported by the member.

L_o = Unreduced design live load per square foot (square 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 One-way slabs Two-way slabs Members without provisions for continuous shear transfer normal to their span	1

1607.9.1.1 One-way slabs. The tributary area, A_T , for use in Equation 16-22 for one-way slabs shall not exceed an area defined by the slab span times a width normal to the span of 1.5 times the slab span.

1607.9.1.2 Heavy live loads. Live loads that exceed 100 psf (4.79 kN/m²) shall not be reduced.

Exceptions:

1. 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.

2. For uses other than storage, where *approved*, additional live load reductions shall be permitted where shown by the *registered design professional* that a rational approach has been used and that such reductions are warranted.

1607.9.1.3 Passenger vehicle garages. The live loads shall not be reduced in passenger vehicle garages.

Exception: 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.

1607.9.1.4 Group A occupancies. Live loads of 100 psf (4.79 kN/m²) and at areas where fixed seats are located shall not be reduced in Group A occupancies.

1607.9.1.5 Roof members. 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 where the live load exceeds 100 psf (4.79 kN/m²) except that the design live load for members supporting two or more floors is permitted to be reduced by 20 percent.
Exception: For uses other than storage, where *approved*, additional live load reductions shall be permitted where shown by the *registered design professional* that a rational approach has been used and that such reductions are warranted.
3. A reduction shall not be permitted in passenger vehicle parking garages except that the live loads for members supporting two or more floors are permitted to be reduced by a maximum of 20 percent.
4. 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 Equation 16-23.
5. For one-way slabs, the area, A , for use in Equation 16-23 shall not exceed the product of the slab span and a width normal to the span of 0.5 times the slab span.

$$R = 0.08(A - 150) \quad \text{(Equation 16-23)}$$

For SI: $R = 0.861(A - 13.94)$

Such reduction shall not exceed the smallest of:

1. 40 percent for horizontal members;
2. 60 percent for vertical members; or
3. R as determined by the following equation.

$$R = 23.1(1 + D/L_o) \quad \text{(Equation 16-24)}$$

where:

A = Area of floor supported by the member, square feet (m²).

D = Dead load per square foot (m²) of area supported.

L_o = Unreduced live load per square foot (m²) of area supported.

R = Reduction in percent.

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 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 reduced to less than 20 psf (0.96 kN/m²) in accordance with Section 1607.11.2.1 and are applied to the design of structural members arranged so as to create continuity, the reduced roof live load shall be applied to adjacent spans or to alternate spans, whichever produces the most unfavorable *load effect*. See Section 1607.11.2 for reductions in minimum roof live loads.

1607.11.2 Reduction in roof live loads. The minimum uniformly distributed live loads of roofs and marquees, L_o , in Table 1607.1 are permitted to be reduced in accordance with Section 1607.11.2.1 or 1607.11.2.2.

1607.11.2.1 Flat, pitched and curved roofs. Ordinary flat, pitched and curved roofs, and awnings and canopies other than of fabric construction supported by lightweight rigid skeleton structures, are permitted to be designed for a reduced roof live load as specified in the following equations or other controlling combinations of loads in Section 1605, whichever produces the greater load.

In structures such as greenhouses, 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 equations shall not be used unless *approved* by the *building official*. Such structures shall be designed for a minimum roof live load of 12 psf (0.58 kN/m²).

$$L_r = L_o R_1 R_2 \quad \text{(Equation 16-25)}$$

where: $12 \leq L_r \leq 20$

For SI: $L_r = L_o R_1 R_2$

where: $0.58 \leq L_r \leq 0.96$

L_r = Reduced live load per square foot (m²) of horizontal projection in pounds per square foot (kN/m²).

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

$$R_1 = 1 \text{ for } A_t \leq 200 \text{ square feet (18.58 m}^2\text{)} \quad \text{(Equation 16-26)}$$

$$R_1 = 1.2 - 0.001A_t \text{ for } 200 \text{ square feet} < A_t < 600 \text{ square feet} \quad \text{(Equation 16-27)}$$

For SI: $1.2 - 0.011A_t$ for 18.58 square meters $< A_t < 55.74$ square meters

$$R_1 = 0.6 \text{ for } A_t \geq 600 \text{ square feet (55.74 m}^2\text{)} \quad \text{(Equation 16-28)}$$

where:

A_t = Tributary area (span length multiplied by effective width) in square feet (m²) supported by any structural member, and

$$R_2 = 1 \text{ for } F \leq 4 \quad \text{(Equation 16-29)}$$

$$R_2 = 1.2 - 0.05 F \text{ for } 4 < F < 12 \quad \text{(Equation 16-30)}$$

$$R_2 = 0.6 \text{ for } F \geq 12 \quad \text{(Equation 16-31)}$$

where:

F = For a sloped roof, the number of inches of rise per foot (for SI: $F = 0.12 \times$ slope, with slope expressed as a percentage), or for an arch or dome, the rise-to-span ratio multiplied by 32.

1607.11.2.2 Special-purpose roofs. Roofs used for promenade purposes, roof gardens, assembly purposes or other special purposes, and marquees, shall be designed for a minimum live load, L_o , as specified in Table 1607.1. Such live loads are permitted to be reduced in accordance with Section 1607.9. Live loads of 100 psf (4.79 kN/m²) or more at areas of roofs classified as Group A occupancies shall not be reduced.

1607.11.3 Landscaped roofs. Where roofs are to be landscaped, the uniform design live load in the landscaped area 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.

1607.11.4 Awnings and canopies. Awnings and canopies shall be designed for uniform live loads as required in Table 1607.1 as well as for wind loads as specified in Section 1609.

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-gear bridge, trolley and hoist 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-gear 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).

Exception: Fabric partitions complying with Section 1607.13.1 shall not be required to resist the minimum horizontal load of 5 psf (0.24 kN/m²).

1607.13.1 Fabric partitions. Fabric partitions that exceed 6 feet (1829 mm) in height, including their finish materials, shall have adequate strength to resist the following load conditions:

1. A horizontal distributed load of 5 psf (0.24 kN/m²) applied to the partition framing. The total area used to determine the distributed load shall be the area of the fabric face between the framing members to which the fabric is attached. The total distributed load shall be uniformly applied to such framing members in proportion to the length of each member.
2. A concentrated load of 40 pounds (0.176 kN) applied to an 8-inch diameter (203 mm) area [50.3 square inches (32 452 mm²)] of the fabric face at a height of 54 inches (1372 mm) above the floor.

**SECTION 1608
SNOW LOADS
RESERVED**

**SECTION 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.

All exterior wall coverings and soffits shall be capable of resisting the design pressures specified for walls for components and cladding loads in accordance with Section 1609.1.1. Manufactured soffits shall be labeled in accordance with Section 1715.9 of this code.

1609.1.1 Determination of wind loads. Wind loads on every building or structure shall be determined in accordance with Chapters 26 through 30 of ASCE 7 or the provisions of the alternate all heights method in Section 1609.6. Wind shall be assumed to come from any horizontal direction and wind pressures shall be assumed to act normal to the surface considered.

Exceptions:

1. Subject to the limitations of Section 1609.1.1.1, the provisions of ICC 600 shall be permitted for applicable Group R-2 and R-3 buildings.
2. Subject to the limitations of Section 1609.1.1.1, 1609.1.4, and 1609.3, provisions of ANSI/AF&PA WFCM, Wood Frame Construction Manual for One- and Two-Family Dwellings shall be permitted for applicable wood frame buildings of Group R-3 occupancy where V_{asd} determined in accordance with Section 1609.3.1 is 150 mph or less.
3. Subject to the limitations of Section 1609.1.1.1, residential structures using the provisions of AISI S230.
4. Designs using NAAMM FP 1001. Specification for Design Loads of Metal Flagpoles.
5. Designs using TIA-222 for antenna-supporting structures and antennas shall be permitted for communication tower and steel antenna support structures.
6. Wind tunnel tests in accordance with Chapter 31 of ASCE 7.
7. Designs using AASHTO LTS-4 Structural Specifications for Highway Signs, Luminaries, and Traffic Signals.
8. Wind loads for screened enclosures shall be determined in accordance with Section 2002.4.

The wind speeds in Figure 1609A, 1609B and 1609C shall be converted to nominal wind speeds, V_{asd} in accordance with Section 1609.3.1 when the provisions of the standards referenced in Exceptions 1 through 5 and 7 are

used unless the wind provisions in the standards are based on Ultimate Wind Speeds as specified in Figures 1609A, 1609B or 1609C or Chapter 26 of ASCE 7.

1609.1.1.1 Applicability. The provisions of ICC 600 are applicable only to buildings located within Exposure B or C as defined in Section 1609.4. The provisions of ICC 600, AF&PA WFCM, and AISI S230 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 Protection of openings. Glazed openings in buildings located in wind-borne debris regions shall be protected from wind-borne debris. Glazed opening protection for wind-borne debris shall meet the requirements of SST12, ASTM E 1886 and ASTM E 1996, ANSI/DASMA 115 (for garage doors and rolling doors) or TAS 201, 202 and 203 or AAMA 506 referenced therein.

1. Glazed openings located within 30 feet (9.1 m) of grade shall meet the requirements of the large missile test of ASTM E 1996.
2. Glazed openings located more than 30 feet (9.1 m) above grade shall meet the provisions of the small missile test of ASTM E 1996.
3. Storage sheds that are not designed for human habitation and that have a floor area of 720 square feet (67 m²) or less are not required to comply with the mandatory windborne debris impact standards of this code.
4. Openings in sunrooms, balconies or enclosed porches constructed under existing roofs or decks are not required to be protected provided the spaces are separated from the building interior by a wall and all openings in the separating wall are protected in accordance with Section 1609.1.2 above. Such spaces shall be permitted to be designed as either partially enclosed or enclosed structures.

Exceptions:

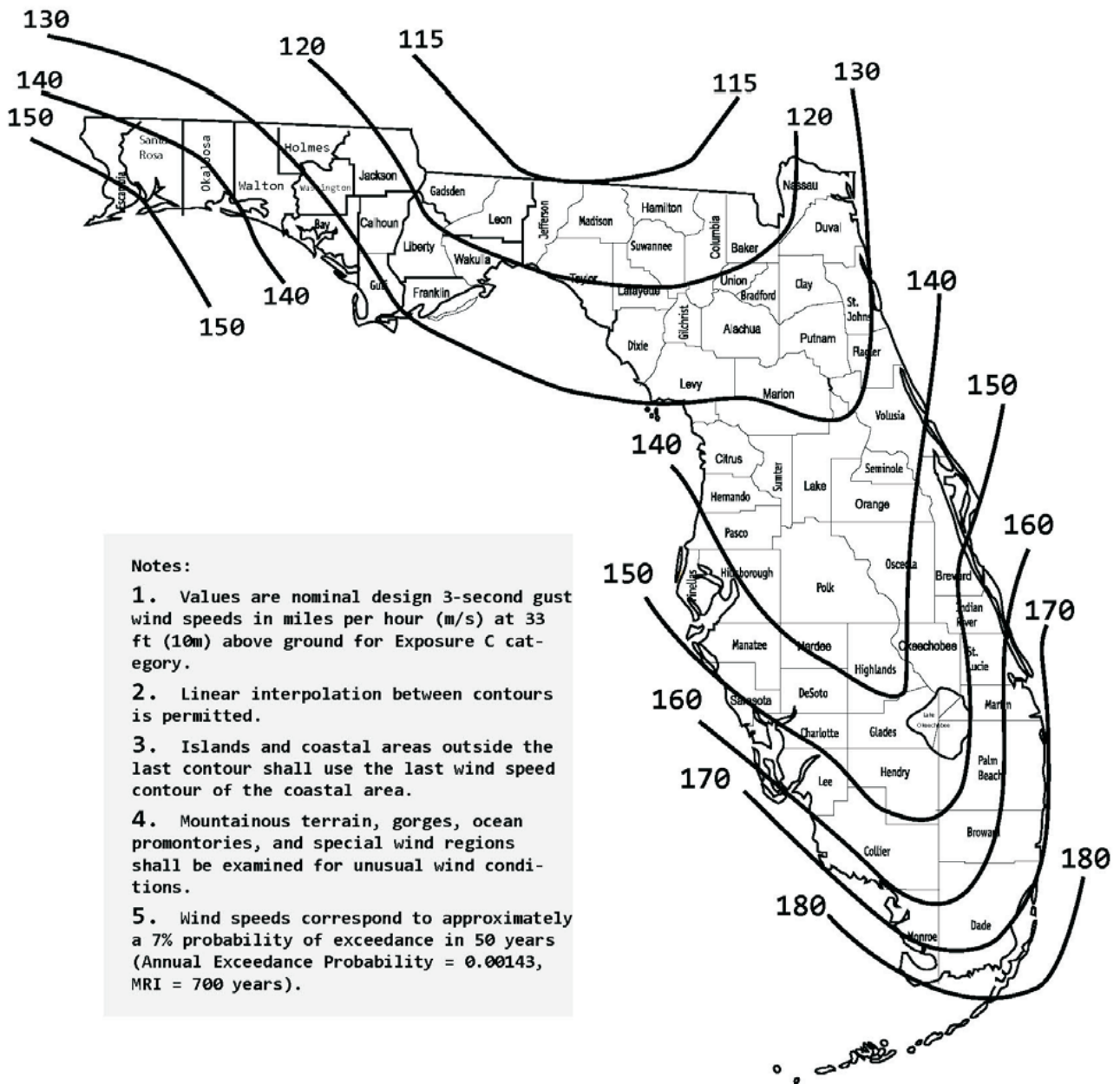
1. Wood structural panels with a minimum thickness of $\frac{7}{16}$ inch (11.1 mm) and maximum panel span of

8 feet (2438 mm) shall be permitted for opening protection in one- and two-story buildings classified as Group R-3 or R-4 occupancy. Panels shall be precut so that they shall be attached to the framing surrounding the opening containing the product with the glazed opening. Panels shall be predrilled as required for the anchorage method and shall be secured with the attachment hardware provided. Attachments shall be designed to resist the components and cladding loads determined in accordance with the provisions of ASCE 7, with corrosion-resistant attachment hardware provided and anchors permanently installed on the building. Attachment in accordance with Table 1609.1.2 with corrosion-resistant attachment hardware provided and anchors permanently installed on the building is permitted for buildings with a mean roof height of 45 feet (13 716 mm) or less where V_{asd} , determined in accordance with Section 1609.3.1 does not exceed 140 mph (63 m/s).

2. Glazing in *Risk Category I* buildings as defined in Section 1604.5, including greenhouses that are occupied for growing plants on a production or research basis, without public access shall be permitted to be unprotected.
3. Glazing in *Risk Category II, III or IV* buildings located over 60 feet (18 288 mm) above the ground and over 30 feet (9144 mm) above aggregate surface roofs located within 1,500 feet (458 m) of the building shall be permitted to be unprotected.
4. Exterior balconies or porches under existing roofs or decks enclosed with screen or removable vinyl and acrylic panels complying with Section 2002.3.3 shall not be required to be protected and openings in the wall separating the unit from the balcony or porch shall not be required to be protected unless required by other provisions of this code.

1609.1.2.1 Louvers. Louvers protecting intake and exhaust ventilation ducts not assumed to be open that are located within 30 feet (9144 mm) of grade shall meet requirements of AMCA 540 or shall be protected by an impact resistant cover complying with an approved impact-resistance standard or the large missile test of ASTM E 1996.

1609.1.2.2 Garage doors. Reserved.



Notes:

1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = 700 years).

FIGURE 1609A
 ULTIMATE DESIGN WIND SPEEDS, V_{alt} FOR RISK CATEGORY II BUILDINGS AND OTHER STRUCTURES

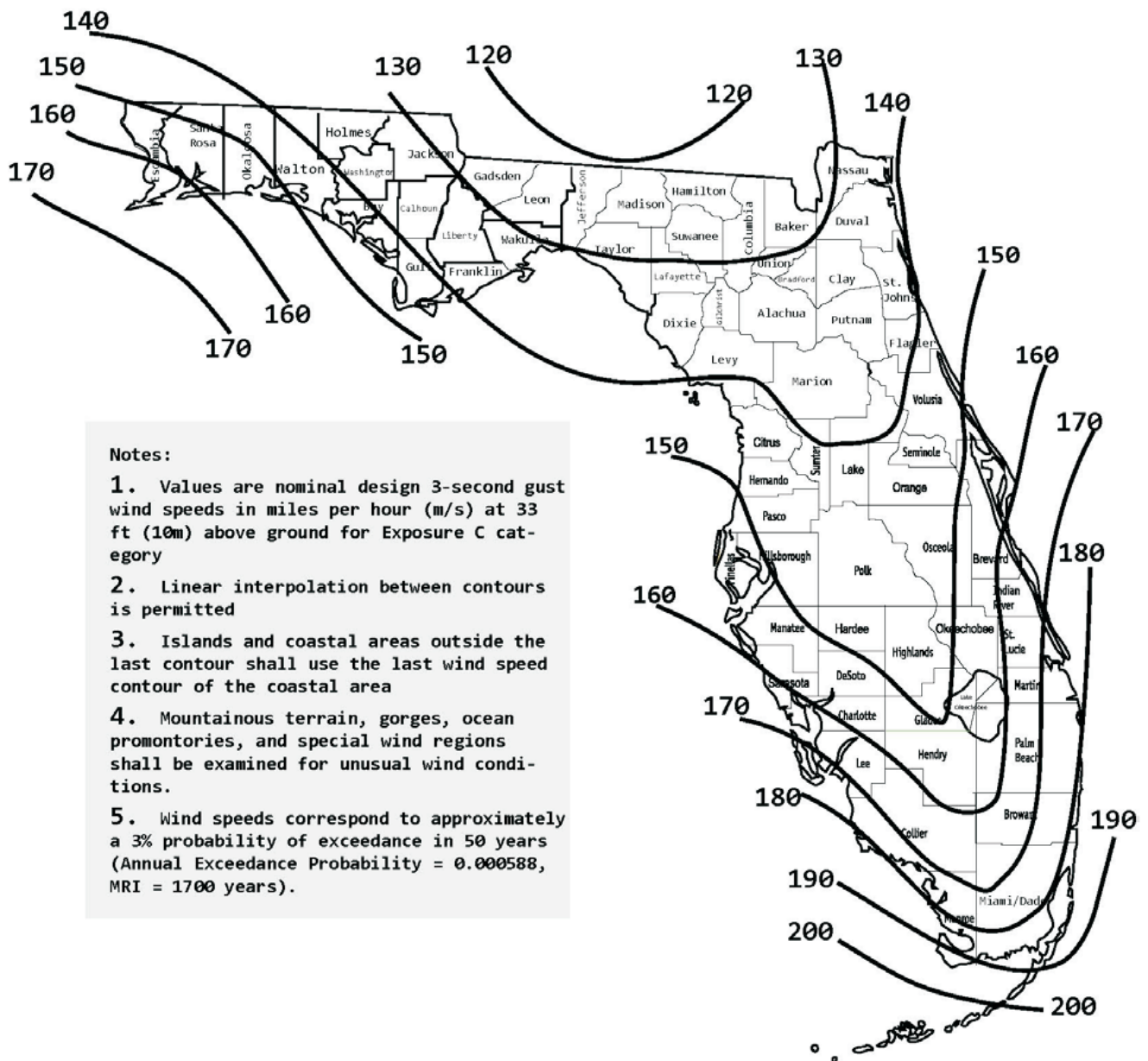
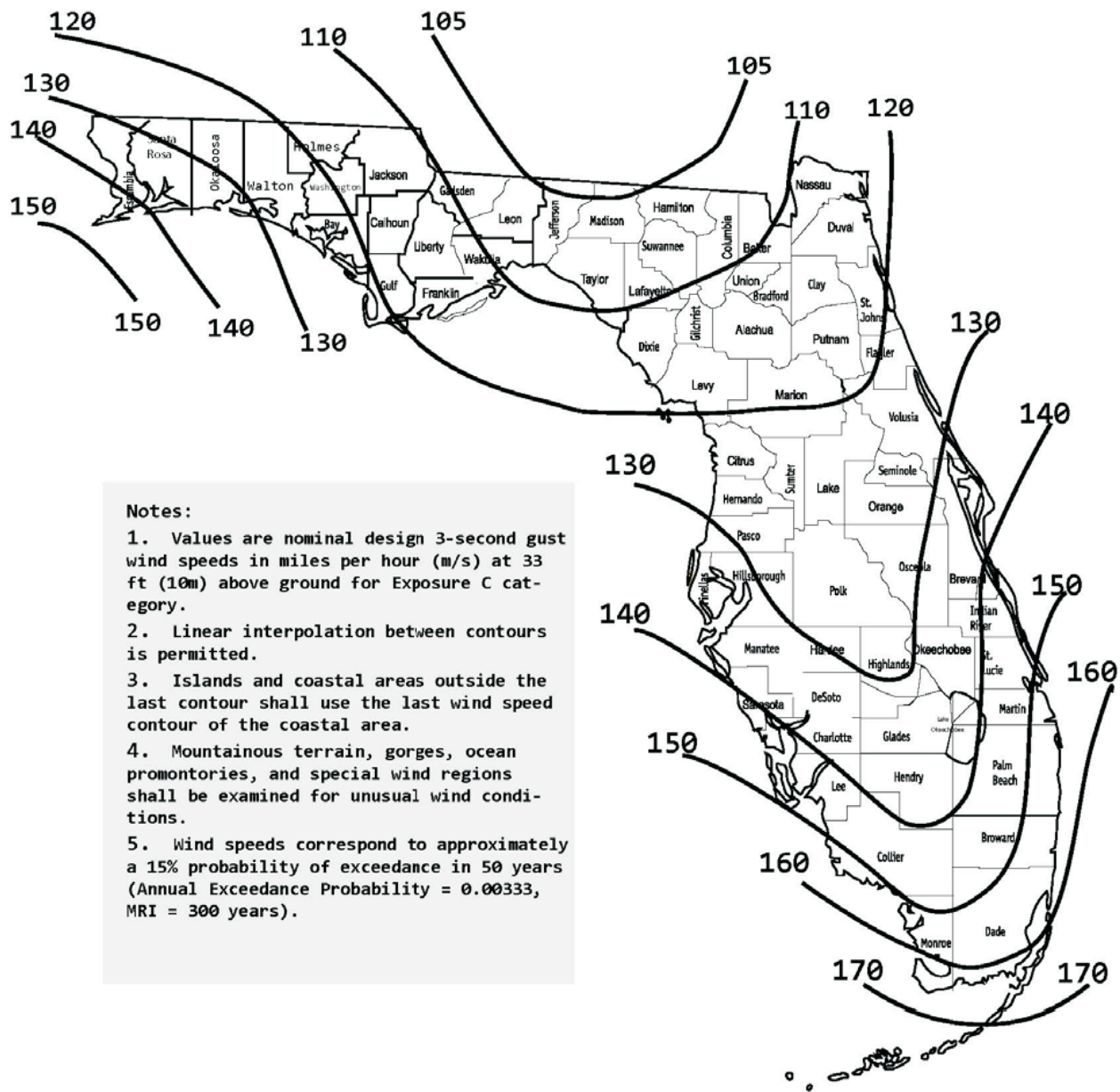


FIGURE 1609B
 ULTIMATE DESIGN WIND SPEEDS, V_{alt} FOR RISK CATEGORY III AND IV BUILDINGS AND OTHER STRUCTURES



Notes:

1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 15% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00333, MRI = 300 years).

FIGURE 1609C
 ULTIMATE DESIGN WIND SPEEDS, V_{alt} FOR RISK CATEGORY I BUILDINGS AND OTHER STRUCTURES

TABLE 1609.1.2
WIND-BORNE DEBRIS PROTECTION FASTENING
SCHEDULE FOR WOOD STRUCTURAL PANELS^{a, b, c, d}

FASTENER TYPE	FASTENER SPACING (inches)		
	Panel Span ≤ 4 feet	4 feet < Panel Span ≤ 6 feet	6 feet < Panel Span ≤ 8 feet
No. 8 wood-screw-based anchor with 2-inch embedment length	16	10	8
No. 10 wood-screw-based anchor with 2-inch embedment length	16	12	9
1/4-inch diameter lag-screw-based anchor with 2-inch embedment length	16	16	16

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound = 4.448 N, 1 mile per hour = 0.447 m/s.

- a. This table is based on a V_{asd} , determined in accordance with Section 1609.3.1 of 140 mph and a 45-foot mean roof height.
- b. Fasteners shall be installed at opposing ends of the wood structural panel. Fasteners shall be located a minimum of 1 inch from the edge of the panel.
- c. Anchors shall penetrate through the exterior wall covering with an embedment length of 2 inches minimum into the building frame. Fasteners shall be located a minimum of 2 1/2 inches from the edge of concrete block or concrete.
- d. Where panels are attached to masonry or masonry/stucco, they shall be attached using vibration-resistant anchors having a minimum ultimate withdrawal capacity of 1,500 pounds.

1609.1.2.3 Impact resistant coverings.

1609.1.2.3.1 Impact resistant coverings shall be tested at 1.5 times the design pressure (positive or negative) expressed in pounds per square feet as determined by the *Florida Building Code, Building Section 1609* or ASCE 7, for which the specimen is to be tested. The design pressures, as determined from ASCE 7, are permitted to be multiplied by 0.6.

1609.1.2.3.2 Impact resistant coverings. Impact resistant coverings shall be labeled in accordance with the provisions of Section 1714.8.

1609.1.2.4 Modifications to ASTM E 1996. Section 6.2.2 of ASTM E 1996 shall be modified as follows:

6.2.2 Unless otherwise specified, select the wind zone based on the basic wind speed as follows:

6.2.2.1 *Wind Zone 1*—130 mph ≤ basic wind speed < 140 mph, and Hawaii.

6.2.2.2 *Wind Zone 2*—140 mph ≤ basic wind speed < 150 mph at greater than 1.6 km (one mile) from the coastline. The coastline shall be measured from the mean high water mark.

6.2.2.3 *Wind Zone 3*—150 mph (58 m/s) ≤ basic wind speed ≤ 160 mph (63 m/s), or 140 mph (54 m/s) ≤ basic wind speed ≤ 160 mph (63 m/s) and within 1.6 km (one mile) of the coastline. The coastline shall be measured from the mean high water mark.

6.2.2.4 *Wind Zone 4*—basic wind speed > 160 mph (63 m/s).

1609.1.2.4.1 Table 1 of ASTM E 1886 and ASTM E 1996 shall be modified to read as follows:

Air Pressure Cycles

0.2 to 0.5 P_{pos}^1

0.0 to 0.6 P_{pos}^1

0.5 to 0.8 P_{pos}^1

0.3 to 1.0 P_{pos}^1

0.3 to 1.0 P_{neg}^2

0.5 to 0.8 P_{neg}^2

0.0 to 0.6 P_{neg}^2

0.2 to 0.5 P_{neg}^2

Notes:

- 1. P_{pos} = 0.6 × positive ultimate design load in accordance with ASCE 7.
- 2. P_{neg} = 0.6 × negative ultimate design load in accordance with ASCE 7.

1609.1.3 Optional exterior door component testing.

Exterior side-hinged door assemblies shall have the option to have the components of the assembly tested and rated for impact resistance in accordance with the following specification: SDI 250.13.

1609.1.4 The wind-borne debris regions requirements shall not apply landward of the designated contour line in Figure 1609A or 1609B. A geographical boundary that coincides with the contour line shall be established.

1609.1.5 Testing to allowable or nominal loads. Where testing for wind load resistance is based on allowable or nominal wind loads, the design wind loads determined in accordance with ASCE 7 or Section 1609 are permitted to be multiplied by 0.6 for the purposes of the wind load resistance testing.

1609.2 Definitions. The following words and terms shall, for the purposes of Section 1609, have the meanings shown herein.

HURRICANE-PRONE REGIONS. Areas vulnerable to hurricanes defined as:

- 1. The U. S. Atlantic Ocean and Gulf of Mexico coasts where the basic wind speed for Risk Category II buildings is greater than 115 mph (40 m/s) and
- 2. Hawaii, Puerto Rico, Guam, Virgin Islands and American Samoa.

WIND-BORNE DEBRIS REGION. Areas within *hurricane-prone regions* located:

- 1. Within 1 mile (1.61 km) of the coastal mean high water line where the ultimate design wind speed V_{ult} is 130 (48 m/s) or greater; or
- 2. In areas where the ultimate design wind speed V_{ult} is 140 mph (53 m/s) or greater.

For Risk Category II buildings and structures and Risk Category III buildings and structures, except health care facilities, the windborne debris region shall be based on Figure 1609A. For Risk Category IV buildings and structures and Risk Category III health care facilities, the windborne debris region shall be based on Figure 1609B.

WIND SPEED, V_{ult} . Ultimate design wind speeds.

WIND SPEED, V_{asd} . Nominal design wind speeds.

1609.3 Basic wind speed. The ultimate design wind speed V_{ult} , in miles per hour, for the development of the wind loads shall be determined by Figures 1609A, 1609B and 1609C. The ultimate design wind speed V_{ult} for use in the design of Risk Category II buildings and structures shall be obtained from Figure 1609A. The ultimate design wind speed V_{ult} for use in the design of Risk Category III and IV buildings and structures shall be obtained from Figure 1609B. The ultimate design wind speed V_{ult} for use in the design of Risk Category I buildings and structures shall be obtained from Figure 1609C. The exact location of wind speed lines shall be established by local ordinance using recognized physical landmarks such as major roads, canals, rivers and lake shores wherever possible.

1609.3.1 Wind speed conversion. When required, ultimate design wind speeds of Figure 1609A, B and C shall be converted to nominal design wind speeds, V_{asd} , using Table 1609.3.1 or Equation 16-32.

$$V_{asd} = V_{ult} \sqrt{0.6} \quad \text{(Equation 16-32)}$$

where:

V_{asd} = nominal design wind speed

V_{ult} = strength design wind speeds determined from Figures 1609A, 1609B, or 1609C.

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. Account shall be taken of variations in ground surface roughness that arise from natural topography and vegetation as well as from constructed features.

Exception: An intermediate exposure between the exposure categories defined is permitted in a transition zone provided that it is determined by a rational analysis method.

1609.4.1 Wind directions and sectors. For each selected wind direction at which the wind loads are to be evaluated, the exposure of the building or structure shall be determined for the two upwind sectors extending 45 degrees (0.79 rad) either side of the selected wind direction. The exposures in these two sectors shall be determined in accordance with Sections 1609.4.2 and 1609.4.3 and the exposure resulting in the highest wind loads shall be used to represent winds from that direction.

1609.4.2 Surface roughness categories. A ground surface roughness within each 45-degree (0.79 rad) sector shall be determined for a distance upwind of the site as defined in Section 1609.4.3 from the categories defined below, for the

purpose of assigning an exposure category as defined in Section 1609.4.3.

Surface Roughness B. Urban and suburban areas, wooded areas or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger.

Surface Roughness C. Open terrain with scattered obstructions having heights generally less than 30 feet (9144 mm). This category includes flat open country and grasslands. This surface roughness shall also apply to any building located within surface roughness B-type terrain where the building is within 100 feet horizontally in any direction of open areas of surface roughness C or D-type terrain that extends more than 600 feet (182.9 m) and width greater than 150 feet in the upwind direction. Short-term (less than two year) changes in the pre-existing terrain exposure, for the purposes of development, shall not be considered surface roughness C. Where development buildout will occur within three years and the resultant condition will meet the definition of surface roughness B, surface roughness B shall be regulating for the purpose of permitting. This category includes flat open country and grasslands and shall extend downwind for a distance of 1500 feet.

Surface Roughness D. Flat, unobstructed areas and water surfaces. This category includes smooth mud flats, salt flats and unbroken ice.

1609.4.3 Exposure categories. An exposure category shall be determined in accordance with the following:

Exposure B. For buildings with a mean roof height of less than or equal to 30 feet, Exposure B shall apply where the ground surface roughness as defined by Surface Roughness B prevails in the upwind direction for a distance of at least 1,500 ft (457 m). For buildings with a mean roof height greater than 30 feet, Exposure B shall apply where Surface Roughness B prevails in the upwind direction for a distance of at least 2,600 feet (792 m) or 20 times the height of the building, whichever is greater.

Exposure C. Exposure C shall apply for all cases where Exposures B or D do not apply.

Exposure D. Exposure D shall apply where the ground surface roughness, as defined by Surface Roughness D, prevails in the upwind direction for a distance of at least 5,000 feet (1524 m) or 20 times the height of the building, whichever is greater. Exposure D shall extend inland from the shoreline for a distance of 600 feet (183 m) or 20 times the height of the building, whichever is greater from an Exposure D condition as defined in the previous sentence.

TABLE 1609.3.1
WIND SPEED CONVERSIONS^{a, b, c}

V_{ult}	100	110	120	130	140	150	160	170	180	190	200
V_{asd}	78	85	93	101	108	116	124	132	139	147	155

For SI: 1 mile per hour = 0.447 m/s.

a. Linear interpolation is permitted.

b. V_{asd} = nominal design wind speed.

c. V_{ult} = ultimate design wind speed determined from Figures 1609A, 1609B, or 1609C.

1609.5 Roof systems.

1609.5.1 Roof deck. The roof deck shall be designed to withstand the wind pressures determined in accordance with ASCE 7.

1609.5.2 Roof coverings. Roof coverings shall comply with Section 1609.5.1.

Exception: Rigid tile roof coverings that are air permeable and installed over a roof deck complying with Section 1609.5.1 are permitted to be designed in accordance with Section 1609.5.3.

Asphalt shingles installed over a roof deck complying with Section 1609.5.1 shall comply with the wind-resistance requirements of Section 1507.2.7.1.

1609.5.3 Rigid tile. Wind loads on rigid tile roof coverings shall be determined in accordance with the following equation:

$$M_a = q_h C_L b L L_a [1.0 - GC_p] \quad \text{(Equation 16-33)}$$

For SI:
$$M_a = \frac{q_h C_L b L L_a [1.0 - GC_p]}{1,000}$$

where:

b = Exposed width, feet (mm) of the roof tile.

C_L = Lift coefficient. The lift coefficient for concrete and clay tile shall be 0.2 or shall be determined by test in accordance with Section 1716.2.

GC_p = Roof pressure coefficient for each applicable roof zone determined from Chapter 30 of ASCE 7. Roof coefficients shall not be adjusted for internal pressure.

L = Length, feet (mm) of the roof tile.

L_a = Moment arm, feet (mm) from the axis of rotation to the point of uplift on the roof tile. The point of uplift shall be taken at $0.76L$ from the head of the tile and the middle of the exposed width. For roof tiles with nails or screws (with or without a tail clip), the axis of rotation shall be taken as the head of the tile for direct deck application or as the top edge of the batten for battened applications. For roof tiles fastened only by a nail or screw along the side of the tile, the axis of rotation shall be determined by testing. For roof tiles installed with battens and fastened only by a clip near the tail of the tile, the moment arm shall be determined about the top edge of the batten with consideration given for the point of rotation of the tiles based on straight bond or broken bond and the tile profile.

M_a = Aerodynamic uplift moment, feet-pounds (N-mm) acting to raise the tail of the tile.

q_h = Wind velocity pressure, psf (kN/m²) determined from Section 27.3.2 of ASCE 7.

Concrete and clay roof tiles complying with the following limitations shall be designed to withstand the aerodynamic uplift moment as determined by this section.

1. The roof tiles shall be either loose laid on battens, mechanically fastened, mortar set or adhesive set.
2. The roof tiles shall be installed on solid sheathing which has been designed as components and cladding.
3. An underlayment shall be installed in accordance with Chapter 15.
4. The tile shall be single lapped interlocking with a minimum head lap of not less than 2 inches (51 mm).
5. The length of the tile shall be between 1.0 and 1.75 feet (305 mm and 533 mm).
6. The exposed width of the tile shall be between 0.67 and 1.25 feet (204 mm and 381 mm).
7. The maximum thickness of the tail of the tile shall not exceed 1.3 inches (33 mm).
8. Roof tiles using mortar set or adhesive set systems shall have at least two-thirds of the tile's area free of mortar or adhesive contact.

1609.6 Alternate all-heights method. The alternate wind design provisions in this section are simplifications of Chapter 27, Part 1—Directional Procedure of ASCE 7.

1609.6.1 Scope. As an alternative to ASCE 7 Chapter 27, Part 1 and Chapter 30, Part 3, the following provisions are permitted to be used to determine the wind effects on regularly shaped buildings, or other structures that are regularly shaped, which meet all of the following conditions:

1. The building or other structure is less than or equal to 75 feet (22 860 mm) in height with a height-to-least-width ratio of 4 or less, or the building or other structure has a fundamental frequency greater than or equal to 1 hertz.
2. The building or other structure is not sensitive to dynamic effects.
3. The building or other structure is not located on a site for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration.
4. The building shall meet the requirements of a simple diaphragm building as defined in ASCE 7 Section 26.2, where wind loads are only transmitted to the main wind-force-resisting system (MWFRS) at the diaphragms.
5. For open buildings, multispans gable roofs, stepped roofs, sawtooth roofs, domed roofs, roofs with slopes greater than 45 degrees (0.79 rad), solid free-standing walls and solid signs, and rooftop equipment, apply ASCE 7 provisions.

1609.6.1.1 Modifications. The following modifications shall be made to certain subsections in ASCE 7: in Section 1609.6.2, symbols and notations that are specific to this section are used in conjunction with the symbols and notations in ASCE 7 Section 26.3.

1609.6.2 Symbols and notations. Coefficients and variables used in the alternative all-heights method equations are as follows:

C_{net} = Net-pressure coefficient based on $K_d [(G) (C_p) - (GC_{pi})]$, in accordance with Table 1609.6.2(2).

G = Gust effect factor for rigid structures in accordance with ASCE 7 Section 26.9.

K_d = Wind directionality factor in accordance with ASCE 7 Table 26.6-1.

P_{net} = Design wind pressure to be used in determination of wind loads on buildings or other structures or their components and cladding, in psf (kN/m²).

q_s = Wind stagnation pressure in psf (kN/m²) in accordance with Table 1609.6.2(1).

1609.6.3 Design equations. When using the alternative all-heights method, the MWFRS, and components and cladding of every structure shall be designed to resist the effects of wind pressures on the building envelope in accordance with Equation 16-34.

$$P_{net} = q_s K_z C_{net} [K_{zt}] \quad \text{(Equation 16-34)}$$

Design wind forces for the MWFRS shall not be less than 16 psf (0.77 kN/m²) multiplied by the wall area of the building and 8 psf (0.38 kN/m²) multiplied by the roof area of the building projected on a plane normal to the assumed wind direction (see ASCE 7 Section 27.4.7 for criteria). Design net wind pressure for components and cladding shall not be less than 16 psf (0.77 kN/m²) acting in either direction normal to the surface.

1609.6.4 Design procedure. The MWFRS and the components and cladding of every building or other structure shall be designed for the pressures calculated using Equation 16-34.

1609.6.4.1 Main wind-force-resisting systems. The MWFRS shall be investigated for the torsional effects identified in ASCE 7 Figure 27.4-8.

1609.6.4.2 Determination of K_z and K_{zt} . Velocity pressure exposure coefficient, K_z , shall be determined in accordance with ASCE 7 Sections 27.3 and 30.3 and the topographic factor, K_{zt} , shall be determined in accordance with ASCE 7 Section 26.8.

1. For the windward side of a structure, K_{zt} and K_z shall be based on height z .
2. For leeward and sidewalls, and for windward and leeward roofs, K_{zt} and K_z shall be based on mean roof height h .

1609.6.4.3 Determination of net pressure coefficients, C_{net} . For the design of the MWFRS and for components and cladding, the sum of the internal and external net pressure shall be based on the net pressure coefficient, C_{net} .

1. The pressure coefficient, C_{net} , for walls and roofs shall be determined from Table 1609.6.2(2).
2. Where C_{net} has more than one value, the more severe wind load condition shall be used for design.

1609.6.4.4 Application of wind pressures. When using the alternative all-heights method, wind pressures shall be applied simultaneously on, and in a direction normal to, all building envelope wall and roof surfaces.

1609.6.4.4.1 Components and cladding. Wind pressure for each component or cladding element is applied as follows using C_{net} values based on the effective wind area, A , contained within the zones in areas of discontinuity of width and/or length “a,” “2a” or “4a” at: corners of roofs and walls; edge strips for ridges, rakes and eaves; or field areas on walls or roofs as indicated in figures in tables in ASCE 7 as referenced in Table 1609.6.2(2) in accordance with the following:

1. Calculated pressures at local discontinuities acting over specific edge strips or corner boundary areas.
2. Include “field” (Zone 1, 2 or 4, as applicable) pressures applied to areas beyond the boundaries of the areas of discontinuity.
3. Where applicable, the calculated pressures at discontinuities (Zones 2 or 3) shall be combined with design pressures that apply specifically on rakes or eave overhangs.

1609.7 Garage doors and rolling doors. Pressures from Table 1604.7(1) for wind loading actions on garage doors and rolling doors for buildings designed as enclosed shall be permitted.

1609.8 Rooftop structures and equipment. The lateral force on rooftop structures and equipment with A_f less than $(0.1Bh)$ located on buildings of all heights shall be determined from Equation 29.5-1 of ASCE 7 in which the value of GC_f shall be taken as 3.1. GC_f shall be permitted to be reduced linearly from 3.1 to 1.1 as the value of A_f is increased from $(0.1Bh)$ to (Bh) . The value of G from Section 26.9 of ASCE 7 shall not be used. Additionally, a simultaneous uplift force shall be applied, given by Equation 29.5-1 of ASCE 7 in which $GC_f = 1.5$ and A_f is replaced by the horizontal projected area, A_p , of the rooftop structure or equipment. For the uplift force GC_f shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_f is increased from $(0.1BL)$ to (BL) .

TABLE 1609.6.2(1)
WIND STAGNATION PRESSURE (q_s) AT STANDARD HEIGHT OF 33 FEET^a

BASIC WIND SPEED (mph)	105	110	120	125	130	140	150	160	170	180	190	200
PRESSURE, q_s (psf)	28.2	31.0	36.9	40.0	43.3	50.2	57.6	65.5	74.0	83.0	92.4	102.4

For SI: 1 foot = 304.8 mm, 1 mile per hour = 0.447 m/s, 1 pound per square foot = 47.88 Pa.

a. For basic wind speeds not shown, use $q_s = 0.00256 V^2$.

TABLE 1609.6.2(2)
NET PRESSURE COEFFICIENTS, C_{net} ^{a, b}

STRUCTURE OR PART THEREOF	DESCRIPTION		C_{net} FACTOR			
			Enclosed		Partially enclosed	
	Walls:		+ Internal pressure	- Internal pressure	+ Internal pressure	- Internal pressure
1. Main wind-force-resisting frames and systems	Windward wall		0.43	0.73	0.11	1.05
	Leeward wall		-0.51	-0.21	-0.83	0.11
	Sidewall		-0.66	-0.35	-0.97	-0.04
	Parapet wall	Windward	1.28		1.28	
		Leeward	-0.85		-0.85	
	Roofs:		Enclosed		Partially enclosed	
	Wind perpendicular to ridge		+ Internal pressure	- Internal pressure	+ Internal pressure	- Internal pressure
	Leeward roof or flat roof		-0.66	-0.35	-0.97	-0.04
	Windward roof slopes					
	Slope = 2:12 (10°)	Condition 1	-1.09	-0.79	-1.41	-0.47
		Condition 2	-0.28	0.02	-0.60	0.34
	Slope = 4:12 (18°)	Condition 1	-0.73	-0.42	-1.04	-0.11
		Condition 2	-0.05	0.25	-0.37	0.57
	Slope = 5:12 (23°)	Condition 1	-0.58	-0.28	-0.90	0.04
		Condition 2	0.03	0.34	-0.29	0.65
	Slope = 6:12 (27°)	Condition 1	-0.47	-0.16	-0.78	0.15
		Condition 2	0.06	0.37	-0.25	0.68
	Slope = 7:12 (30°)	Condition 1	-0.37	-0.06	-0.68	0.25
		Condition 2	0.07	0.37	-0.25	0.69
	Slope = 9:12 (37°)	Condition 1	-0.27	0.04	-0.58	0.35
		Condition 2	0.14	0.44	-0.18	0.76
	Slope = 12:12 (45°)		0.14	0.44	-0.18	0.76
	Wind parallel to ridge and flat roofs		-1.09	-0.79	-1.41	-0.47
	Nonbuilding Structures: Chimneys, Tanks and Similar Structures:					
			h/D			
			1	7	25	
	Square (Wind normal to face)		0.99	1.07	1.53	
	Square (Wind on diagonal)		0.77	0.84	1.15	
	Hexagonal or Octagonal		0.81	0.97	1.13	
	Round		0.65	0.81	0.97	
Open signs and lattice frameworks		Ratio of solid to gross area				
		< 0.1	0.1 to 0.29	0.3 to 0.7		
Flat		1.45	1.30	1.16		
Round		0.87	0.94	1.08		

(continued)

TABLE 1609.6.2(2)—continued
NET PRESSURE COEFFICIENTS, C_{net} ^{a, b}

STRUCTURE OR PART THEREOF	DESCRIPTION	C_{net} FACTOR		
		Enclosed	Partially enclosed	
2. Components and cladding not in areas of discontinuity—roofs and overhangs	Roof elements and slopes	Enclosed	Partially enclosed	
	Gable of hipped configurations (Zone 1)			
	Flat < Slope < 6:12 (27°) See ASCE 7 Figure 30.4-2B Zone 1			
	Positive	10 square feet or less	0.58	0.89
		100 square feet or more	0.41	0.72
	Negative	10 square feet or less	-1.00	-1.32
		100 square feet or more	-0.92	-1.23
	Overhang: Flat < Slope < 6:12 (27°) See ASCE 7 Figure 30.4-2A Zone 1			
	Negative	10 square feet or less	-1.45	
		100 square feet or more	-1.36	
		500 square feet or more	-0.94	
	6:12 (27°) < Slope < 12:12 (45°) See ASCE 7 Figure 30.4-2C Zone 1			
	Positive	10 square feet or less	0.92	1.23
		100 square feet or more	0.83	1.15
	Negative	10 square feet or less	-1.00	-1.32
		100 square feet or more	-0.83	-1.15
	Monosloped configurations (Zone 1)		Enclosed	Partially enclosed
	Flat < Slope < 7:12 (30°) See ASCE 7 Figure 30.4-5A Zone 1			
	Positive	10 square feet or less	0.49	0.81
		100 square feet or more	0.41	0.72
Negative	10 square feet or less	-1.26	-1.57	
	100 square feet or more	-1.09	-1.40	
Tall flat-topped roofs $h > 60'$		Enclosed	Partially enclosed	
Flat < Slope < 2:12 (10°) (Zone 1) See ASCE 7 Figure 30.6-1 Zone 1				
Negative	10 square feet or less	-1.34	-1.66	
	500 square feet or more	-0.92	-1.23	

(continued)

TABLE 1609.6.2(2)—continued
NET PRESSURE COEFFICIENTS, C_{net} ^{a, b}

STRUCTURE OR PART THEREOF	DESCRIPTION	C_{net} FACTOR		
		Enclosed	Partially enclosed	
3. Components and cladding in areas of discontinuities—roofs and overhangs	Roof elements and slopes		Enclosed	Partially enclosed
	Gable or hipped configurations at ridges, eaves and rakes (Zone 2)			
	Flat < Slope < 6:12 (27°) See ASCE 7 Figure 30.4-2B Zone 2			
	Positive	10 square feet or less	0.58	0.89
		100 square feet or more	0.41	10.72
	Negative	10 square feet or less	-1.68	-2.00
		100 square feet or more	-1.17	-1.49
	Overhang for Slope Flat < Slope < 6:12 (27°) See ASCE 7 Figure 30.4-2B Zone 2			
	Negative	10 square feet or less	-1.87	
		100 square feet or more	-1.87	
	6:12 (27°) < Slope < 12:12 (45°) Figure 30.4-2C		Enclosed	Partially enclosed
	Positive	10 square feet or less	0.92	1.23
		100 square feet or more	0.83	1.15
	Negative	10 square feet or less	-1.17	-1.49
		100 square feet or more	-1.00	-1.32
	Overhang for 6:12 (27°) < Slope < 12:12 (45°) See ASCE 7 Figure 30.4-2C Zone 2			
	Negative	10 square feet or less	-1.70	
		500 square feet or more	-1.53	
	Monosloped configurations at ridges, eaves and rakes (Zone 2)			
	Flat < Slope < 7:12 (30°) See ASCE 7 Figure 30.4-5A Zone 2			
	Positive	10 square feet or less	0.49	0.81
		100 square feet or more	0.41	0.72
	Negative	10 square feet or less	-1.51	-1.83
		100 square feet or more	-1.43	-1.74
	Tall flat topped roofs $h > 60'$		Enclosed	Partially enclosed
	Flat < Slope < 2:12 (10°) (Zone 2) See ASCE 7 Figure 30.6-1 Zone 2			
	Negative	10 square feet or less	-2.11	-2.42
		500 square feet or more	-1.51	-1.83
Gable or hipped configurations at corners (Zone 3) See ASCE 7 Figure 30.4-2B Zone 3				
Flat < Slope < 6:12 (27°)		Enclosed	Partially enclosed	
Positive	10 square feet or less	0.58	0.89	
	100 square feet or more	0.41	0.72	
Negative	10 square feet or less	-2.53	-2.85	
	100 square feet or more	-1.85	-2.17	

(continued)

TABLE 1609.6.2(2)—continued
NET PRESSURE COEFFICIENTS, C_{net} ^{a, b}

STRUCTURE OR PART THEREOF	DESCRIPTION		C_{net} FACTOR	
3. Components and cladding in areas of discontinuity—roofs and overhangs (continued)	Overhang for Slope Flat < Slope < 6:12 (27°) See ASCE 7 Figure 30.4-2B Zone 3			
	Negative	10 square feet or less	-3.15	
		100 square feet or more	-2.13	
	6:12 (27°) < 12:12 (45°) See ASCE 7 Figure 30.4-2C Zone 3			
	Positive	10 square feet or less	0.92	1.23
		100 square feet or more	0.83	1.15
	Negative	10 square feet or less	-1.17	-1.49
		100 square feet or more	-1.00	-1.32
	Overhang for 6:12 (27°) < Slope < 12:12 (45°)		Enclosed	Partially enclosed
	Negative	10 square feet or less	-1.70	
		100 square feet or more	-1.53	
	Monosloped Configurations at corners (Zone 3) See ASCE 7 Figure 30.4-5A Zone 3			
	Flat < Slope < 7:12 (30°)			
	Positive	10 square feet or less	0.49	0.81
		100 square feet or more	0.41	0.72
	Negative	10 square feet or less	-2.62	-2.93
		100 square feet or more	-1.85	-2.17
	Tall flat topped roofs $h > 60'$		Enclosed	Partially enclosed
Flat < Slope < 2:12 (10°) (Zone 3) See ASCE 7 Figure 30.6-1 Zone 3				
Negative	10 square feet or less	-2.87	-3.19	
	500 square feet or more	-2.11	-2.42	
4. Components and cladding not in areas of discontinuity—walls and parapets	Wall Elements: $h = 60'$ (Zone 4) Figure 6-11A			
	Positive	10 square feet or less	1.00	1.32
		500 square feet or more	0.75	1.06
	Negative	10 square feet or less	-1.09	-1.40
		500 square feet or more	-0.83	-1.15
	Wall Elements: $h > 60'$ (Zone 4) See ASCE 7 Figure 30.6-1 Zone 4			
	Positive	20 square feet or less	0.92	1.23
		500 square feet or more	0.66	0.98
	Negative	20 square feet or less	-0.92	-1.23
		500 square feet or more	-0.75	-1.06
	Parapet Walls			
	Positive			2.87
Negative			-1.68	-2.00

(continued)

**TABLE 1609.6.2(2)—continued
NET PRESSURE COEFFICIENTS, C_{net} ^{a, b}**

STRUCTURE OR PART THEREOF	DESCRIPTION	C_{net} FACTOR		
		Enclosed	Partially enclosed	
5. Components and cladding in areas of discontinuity—walls and parapets	Wall elements: $h \leq 60'$ (Zone 5) Figure 30.4-1			
	Positive	10 square feet or less	1.00	1.32
		500 square feet or more	0.75	1.06
	Negative	10 square feet or less	-1.34	-1.66
		500 square feet or more	-0.83	-1.15
	Wall elements: $h > 60'$ (Zone 5) See ASCE 7 Figure 30.6-1 Zone 4			
	Positive	20 square feet or less	0.92	1.23
		500 square feet or more	0.66	0.98
	Negative	20 square feet or less	-1.68	-2.00
		500 square feet or more	-1.00	-1.32
	Parapet walls			
	Positive		3.64	3.95
Negative		-2.45	-2.76	

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m², 1 degree = 0.0175 rad.

a. Linear interpolation between values in the table is permitted.

b. Some C_{net} values have been grouped together. Less conservative results may be obtained by applying ASCE 7 provisions.

**TABLE 1609.7(1)
GARAGE DOOR AND ROLLING DOOR WIND LOADS FOR A BUILDING WITH
A MEAN ROOF HEIGHT OF 30 FEET LOCATED IN EXPOSURE B (psf)**

EFFECTIVE WIND AREA		V_{asd} determined in accordance with Section 1609.3.1															
Width (ft)	Height (ft)	85		90		100		110		120		130		140		150	
Roof Angle 0 - 10 degrees																	
8	8	10.5	-11.9	11.7	-13.3	14.5	-16.4	17.5	-19.9	20.9	-23.6	24.5	-27.7	28.4	-32.2	32.6	-36.9
10	10	10.1	-11.4	11.4	-12.7	14.0	-15.7	17.0	-19.0	20.2	-22.7	23.7	-26.6	27.5	-30.8	31.6	-35.4
14	14	10.0	-10.7	10.8	-12.0	13.3	-14.8	16.1	-17.9	19.2	-21.4	22.5	-25.1	26.1	-29.1	30.0	-33.4
Roof Angle > 10																	
9	7	11.4	-12.9	12.8	-14.5	15.8	-17.9	19.1	-21.6	22.8	-25.8	26.7	-30.2	31.0	-35.1	35.6	-40.2
16	7	10.9	-12.2	12.3	-13.7	15.2	-16.9	18.3	-20.4	21.8	-24.3	25.6	-28.5	29.7	-33.1	34.1	-38.0

For SI: 1 Square foot = 0.929 m², 1 mph = 0.447 m/s, 1 psf = 47.88 N/m²

- For effective areas or wind speeds between those given above the load may be interpolated, otherwise use the load associated with the lower effective area.
- Table values shall be adjusted for height and exposure by multiplying by adjustment coefficients in Table 1609.7(2).
- Plus and minus signs signify pressures acting toward and away from the building surfaces.
- Negative pressures assume door has 2 feet of width in building's end zone.

**TABLE 1609.7(2)
ADJUSTMENT FACTOR FOR BUILDING HEIGHT AND EXPOSURE, (λ)**

MEAN ROOF HEIGHT (feet)	EXPOSURE		
	B	C	D
15	1.00	1.21	1.47
20	1.00	1.29	1.55
25	1.00	1.35	1.61
30	1.00	1.40	1.66
35	1.05	1.45	1.70
40	1.09	1.49	1.74
45	1.12	1.53	1.78
50	1.16	1.56	1.81
55	1.19	1.59	1.84
60	1.22	1.62	1.87

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.

**SECTION 1610
SOIL LATERAL LOADS**

1610.1 General. Foundation walls 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 determined otherwise by a geotechnical investigation in accordance with Section 1803. Foundation 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 shall be 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 at the site are expansive. Foundation walls shall be designed to support the weight of the full hydrostatic pressure of undrained backfill unless a drainage system is installed in accordance with Sections 1805.4.2 and 1805.4.3.

Exception: Foundation walls extending not more than 8 feet (2438 mm) below grade and laterally supported at the top by flexible diaphragms shall be permitted to be designed for active pressure.

**SECTION 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. The design rainfall shall be based on the 100-year hourly rainfall rate indicated in Figure 1611.1 or on other rainfall rates determined from *approved* local weather data.

$$R = 5.2(d_s + d_h) \quad \text{(Equation 16-35)}$$

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

**TABLE 1610.1
LATERAL SOIL 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.

considered when determining the amount of rain on the roof.

1611.2 Ponding instability. For roofs with a slope less than $\frac{1}{4}$ inch per foot [1.19 degrees (0.0208 rad)], the design calculations shall include verification of adequate stiffness to preclude progressive deflection in accordance with Section 8.4 of ASCE 7.

1611.3 Controlled drainage. Roofs equipped with hardware to control the rate of drainage shall be equipped with a secondary

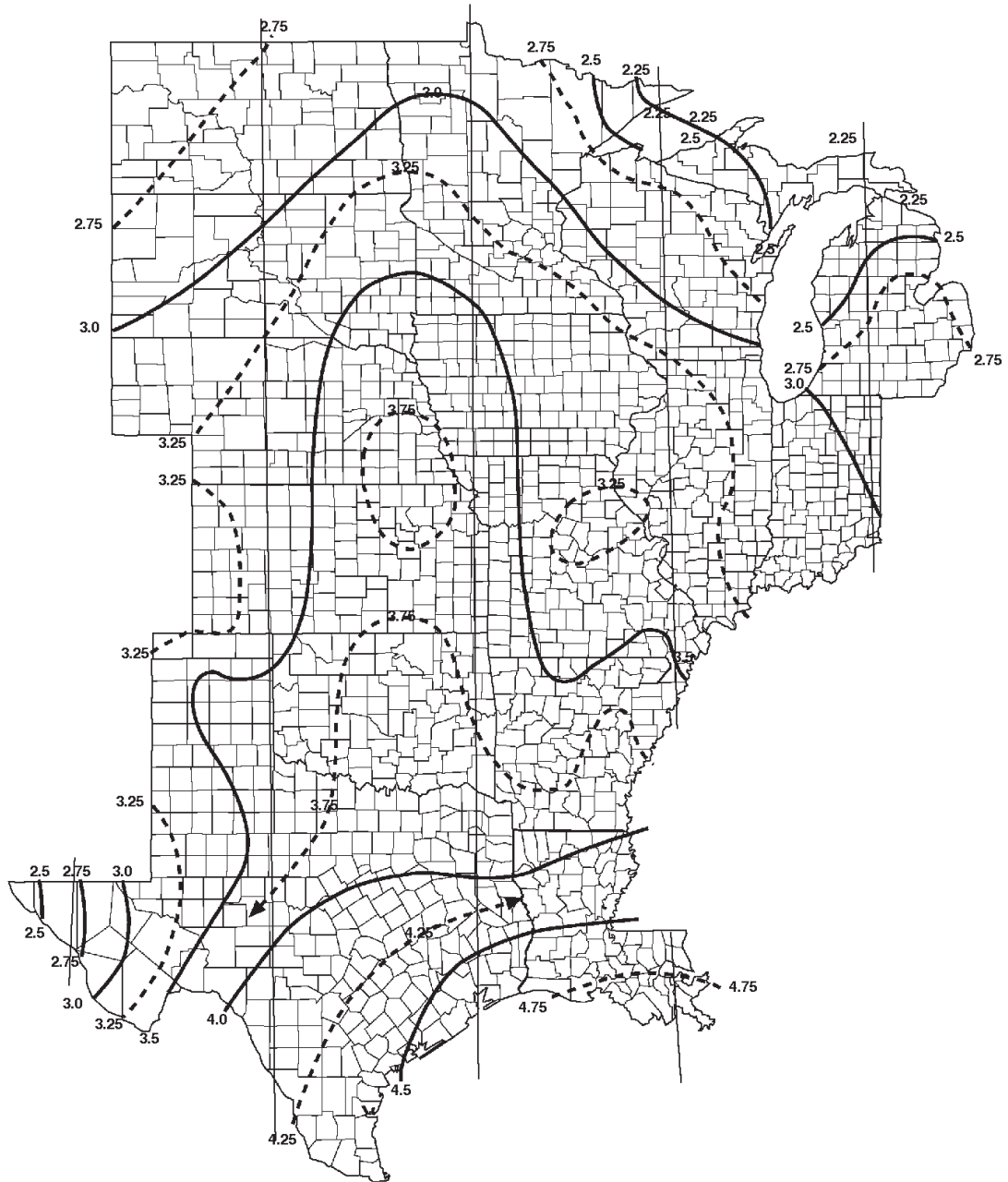
drainage system at a higher elevation that limits accumulation of water on the roof above that elevation. Such roofs shall be designed to sustain the load of rainwater that will accumulate on them to the elevation of the secondary drainage system plus the uniform load caused by water that rises above 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.



[P] FIGURE 1611.1
100-YEAR, 1-HOUR RAINFALL (INCHES) EASTERN UNITED STATES

For SI: 1 inch = 25.4 mm.

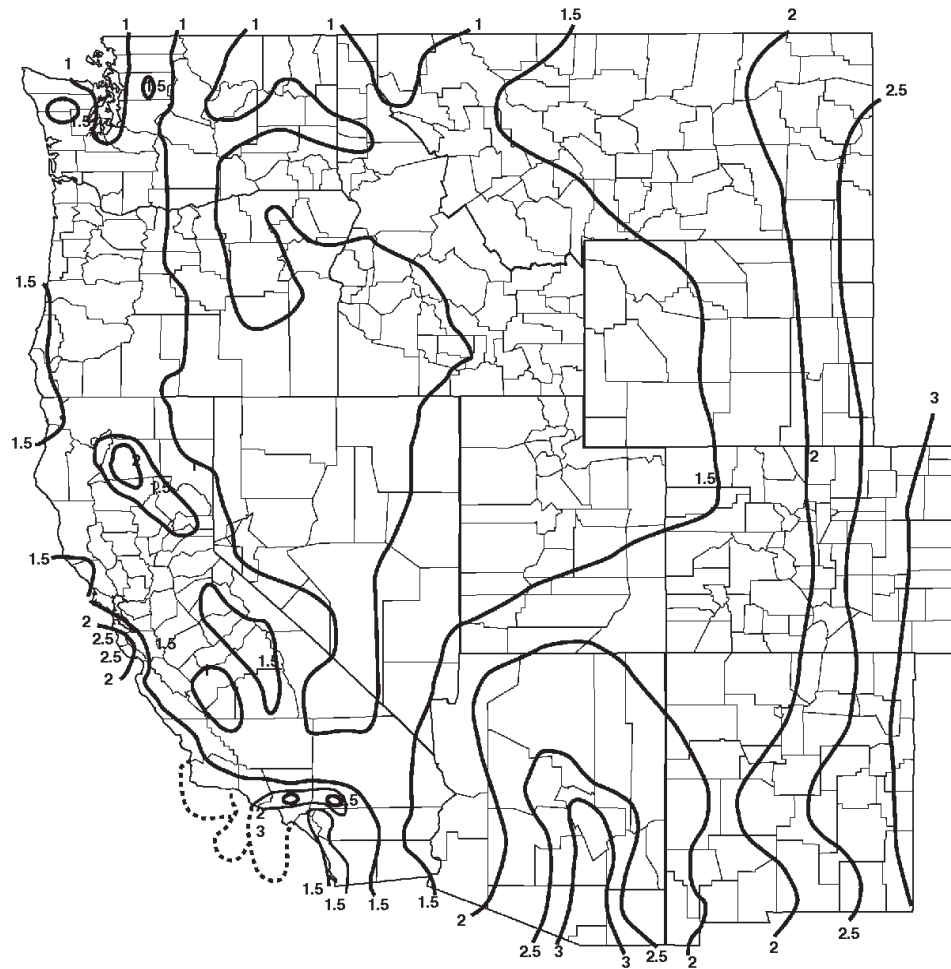
Source: National Weather Service, National Oceanic and Atmospheric Administration, Washington, DC.



[P] FIGURE 1611.1—continued
100-YEAR, 1-HOUR RAINFALL (INCHES) CENTRAL UNITED STATES

For SI: 1 inch = 25.4 mm.

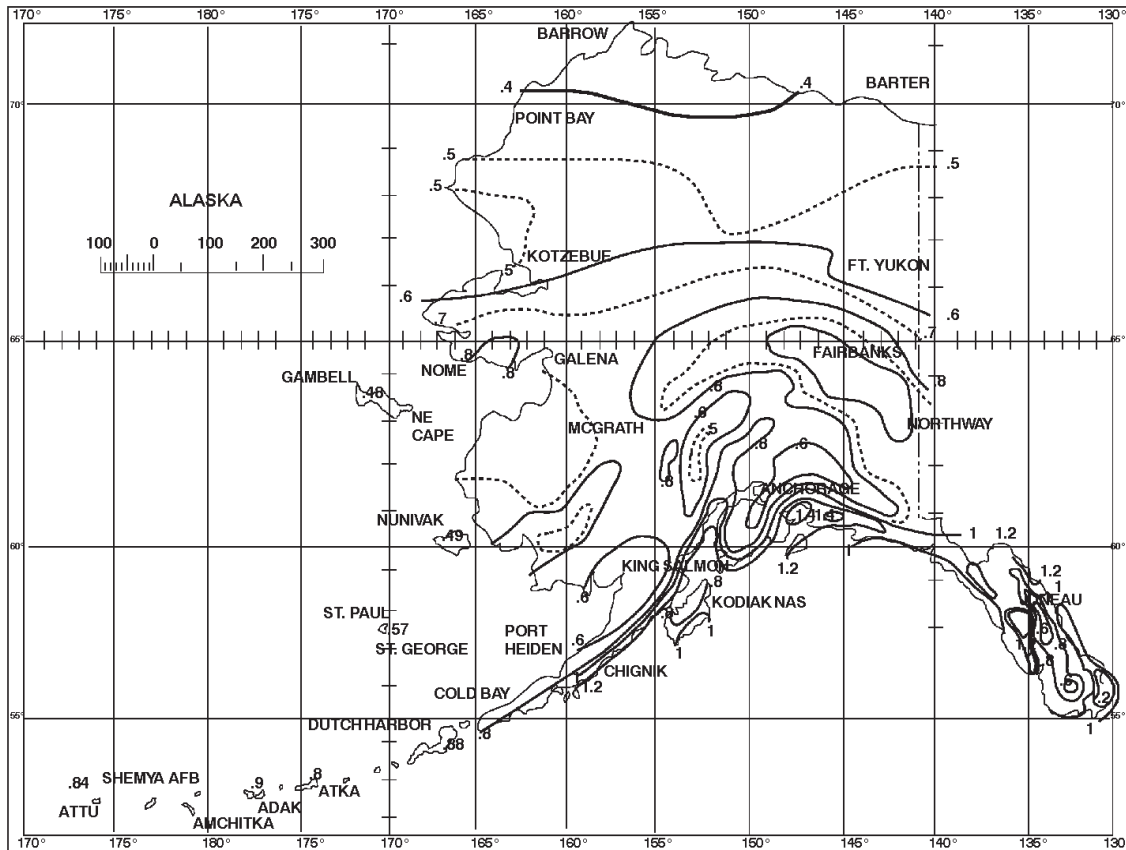
Source: National Weather Service, National Oceanic and Atmospheric Administration, Washington, DC.



[P] FIGURE 1611.1—continued
 100-YEAR, 1-HOUR RAINFALL (INCHES) WESTERN UNITED STATES

For SI: 1 inch = 25.4 mm.

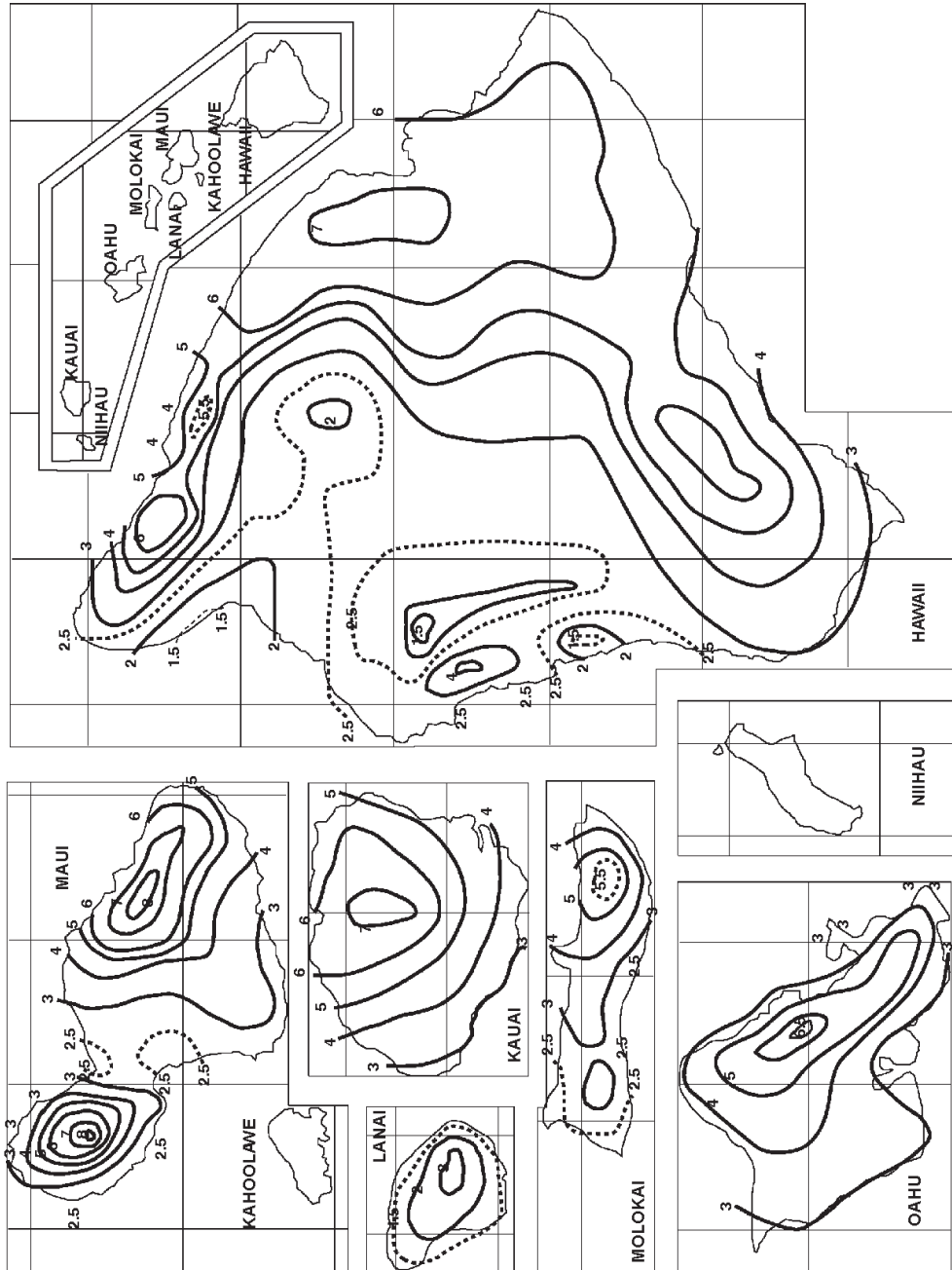
Source: National Weather Service, National Oceanic and Atmospheric Administration, Washington, DC.



[P] FIGURE 1611.1—continued
 100-YEAR, 1-HOUR RAINFALL (INCHES) ALASKA

For SI: 1 inch = 25.4 mm.

Source: National Weather Service, National Oceanic and Atmospheric Administration, Washington, DC.



[P] FIGURE 1611.1—continued
 100-YEAR, 1-HOUR RAINFALL (INCHES) HAWAII

For SI: 1 inch = 25.4 mm.

Source: National Weather Service, National Oceanic and Atmospheric Administration, Washington, DC.

SECTION 1612 FLOOD LOADS

1612.1 General. Within *flood hazard areas* as established in Section 1612.3, all new construction of buildings, structures and portions of buildings and structures, including substantial improvement and restoration of substantial damage to buildings and structures, shall be designed and constructed to resist the effects of flood hazards and flood loads. For buildings that are located in more than one *flood hazard area*, the provisions associated with the most restrictive *flood hazard area* shall apply.

1612.2 Definitions. The following words and terms shall, for the purposes of this section, have the meanings shown herein.

BASE FLOOD. The flood having a 1-percent chance of being equaled or exceeded in any given year.

BASE FLOOD ELEVATION. The elevation of the *base flood*, including wave height, relative to the National Geodetic Vertical Datum (NGVD), North American Vertical Datum (NAVD) or other datum specified on the Flood Insurance Rate Map (FIRM).

BASEMENT. The portion of a building having its floor subgrade (below ground level) on all sides.

This definition of “Basement” is limited in application to the provisions of Section 1612 (see “Basement” in Section 502.1).

DESIGN FLOOD. The flood associated with the greater of the following two areas:

1. Area with a flood plain subject to a 1-percent or greater chance of flooding in any year; or
2. Area designated as a *flood hazard area* on a community’s flood hazard map, or otherwise legally designated.

DESIGN FLOOD ELEVATION. The elevation of the “*design flood*,” including wave height, relative to the datum specified on the community’s legally designated flood hazard map. In areas designated as Zone AO, the design flood elevation shall be the elevation of the highest existing grade of the building’s perimeter plus the depth number (in feet) specified on the flood hazard map. In areas designated as Zone AO where a depth number is not specified on the map, the depth number shall be taken as being equal to 2 feet (610 mm).

DRY FLOODPROOFING. A combination of design modifications that results in a building or structure, including the attendant utility and sanitary facilities, being water tight with walls substantially impermeable to the passage of water and with structural components having the capacity to resist loads as identified in ASCE 7.

EXISTING CONSTRUCTION. Any buildings and structures for which the “start of construction” commenced before the effective date of the community’s first flood plain management code, ordinance or standard. “Existing construction” is also referred to as “existing structures.”

EXISTING STRUCTURE. See “Existing construction.”

FLOOD or FLOODING. A general and temporary condition of partial or complete inundation of normally dry land from:

1. The overflow of inland or tidal waters.

2. The unusual and rapid accumulation or runoff of surface waters from any source.

FLOOD DAMAGE-RESISTANT MATERIALS. Any construction material capable of withstanding direct and prolonged contact with floodwaters without sustaining any damage that requires more than cosmetic repair.

FLOOD HAZARD AREA. The greater of the following two areas:

1. The area within a flood plain subject to a 1-percent or greater chance of flooding in any year.
2. The area designated as a *flood hazard area* on a community’s flood hazard map, or otherwise legally designated.

FLOOD HAZARD AREA SUBJECT TO HIGH-VELOCITY WAVE ACTION. Area within the *flood hazard area* that is subject to high-velocity wave action, and shown on a Flood Insurance Rate Map (FIRM) or other flood hazard map as Zone V, VO, VE or V1-30.

FLOOD INSURANCE RATE MAP (FIRM). An official map of a community on which the Federal Emergency Management Agency (FEMA) has delineated both the special flood hazard areas and the risk premium zones applicable to the community.

FLOOD INSURANCE STUDY. The official report provided by the Federal Emergency Management Agency containing the Flood Insurance Rate Map (FIRM), the Flood Boundary and Floodway Map (FBFM), the water surface elevation of the *base flood* and supporting technical data.

FLOODWAY. The channel of the river, creek or other watercourse and the adjacent land areas that must be reserved in order to discharge the *base flood* without cumulatively increasing the water surface elevation more than a designated height.

LOCAL FLOODPLAIN MANAGEMENT ORDINANCE. An ordinance or regulation adopted pursuant to the authority granted to local governments by Title 44 Code of Federal Regulations, Sections 59 and 60 for participation in the National Flood Insurance Program.

LOWEST FLOOR. The floor of the lowest enclosed area, including basement, but excluding any unfinished or flood-resistant enclosure, usable solely for vehicle parking, building access or limited storage provided that such enclosure is not built so as to render the structure in violation of this section.

SPECIAL FLOOD HAZARD AREA. The land area subject to flood hazards and shown on a Flood Insurance Rate Map or other flood hazard map as Zone A, AE, A1-30, A99, AR, AO, AH, V, VO, VE or V1-30.

START OF CONSTRUCTION. The date of issuance for new construction and substantial improvements to existing structures, provided the actual start of construction, repair, reconstruction, rehabilitation, *addition*, placement or other improvement is within 180 days after the date of issuance. The actual start of construction means the first placement of permanent construction of a building (including a manufactured home) on a site, such as the pouring of a slab or footings, installation of pilings or construction of columns.

Permanent construction does not include land preparation (such as clearing, excavation, grading or filling), the installation of streets or walkways, excavation for a basement, footings, piers or foundations, the erection of temporary forms or the installation of accessory buildings such as garages or sheds not occupied as *dwelling units* or not part of the main building. For a substantial improvement, the actual “start of construction” means the first *alteration* of any wall, ceiling, floor or other structural part of a building, whether or not that *alteration* affects the external dimensions of the building.

SUBSTANTIAL DAMAGE. Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

SUBSTANTIAL IMPROVEMENT. Any repair, reconstruction, rehabilitation, *addition* or improvement of a building or structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the improvement or repair is started. If the structure has sustained substantial damage, any repairs are considered substantial improvement regardless of the actual repair work performed. The term does not, however, include either:

1. Any project for improvement of a building required to correct existing health, sanitary or safety code violations identified by the *building official* and that are the minimum necessary to assure safe living conditions.
2. Any *alteration* of a historic structure provided that the *alteration* will not preclude the structure’s continued designation as a historic structure.

1612.3 Establishment of flood hazard areas. To establish flood hazard areas, the applicable governing authority shall, by local floodplain management ordinance, adopt a flood hazard map and supporting data. The flood hazard map shall include, at a minimum, areas of special flood hazard as identified by the Federal Emergency Management Agency in an engineering report entitled “The Flood Insurance Study for [INSERT NAME OF JURISDICTION],” dated [INSERT DATE OF ISSUANCE], as amended or revised with the accompanying Flood Insurance Rate Map (FIRM) and Flood Boundary and Floodway Map (FBFM) and related supporting data along with any revisions thereto. The adopted flood hazard map and supporting data are hereby adopted by reference and declared to be part of this Section.

1612.3.1 Design flood elevations. Where design flood elevations are not included in the *flood hazard areas* established in Section 1612.3, or where floodways are not designated, the *building official* is authorized to require the applicant to:

1. Obtain and reasonably utilize any design flood elevation and floodway data available from a federal, state or other source; or
2. Determine the design flood elevation and/or floodway in accordance with accepted hydrologic and hydraulic engineering practices used to define special flood hazard areas. Determinations shall be undertaken by a *registered design professional* who

shall document that the technical methods used reflect currently accepted engineering practice.

1612.3.2 Determination of impacts. In riverine *flood hazard areas* where design flood elevations are specified but floodways have not been designated, the applicant shall provide a floodway analysis that demonstrates that the proposed work will not increase the design flood elevation more than 1 foot (305 mm) at any point within the jurisdiction of the applicable governing authority.

1612.4 Design and construction. The design and construction of buildings and structures located in *flood hazard areas*, including flood hazard areas subject to high-velocity wave action, shall be in accordance with Chapter 5 of ASCE 7 and with ASCE 24.

1612.5 Flood hazard documentation. The following documentation shall be prepared and sealed by a registered design professional and shall be submitted to the building official:

1. For construction in flood hazard areas not subject to high-velocity wave action:
 - 1.1 The elevation of the lowest floor, including basement, as required by the foundation inspection and the final inspection in Section 110.3.
 - 1.2. For fully enclosed areas below the design flood elevation where provisions to allow for the automatic entry and exit of floodwaters do not meet the minimum requirements in Section 2.6.2.1, ASCE 24, construction documents shall include a statement that the design will provide for equalization of hydrostatic flood forces in accordance with Section 2.6.2.2 of ASCE 24.
 - 1.3. For dry floodproofed nonresidential buildings, construction documents shall include a statement that the dry floodproofing is designed in accordance with ASCE 24.
2. For construction in flood hazard areas subject to high-velocity wave action:
 - 2.1 The elevation of the bottom of the lowest horizontal structural member as required by the foundation inspection and the final inspection in Section 110.3.
 - 2.2 Construction documents shall include a statement that the building is designed in accordance with ASCE 24, including that the pile or column foundation and building or structure to be attached thereto is designed to be anchored to resist flotation, collapse and lateral movement due to the effects of wind and flood loads acting simultaneously on all building components, and other load requirements of Chapter 16.
 - 2.3 For breakaway walls designed to resist a nominal load of less than 10 psf (0.48 kN/m²) or more than 20 psf (0.96 kN/m²), construction documents shall include a statement that the breakaway wall is designed in accordance with ASCE 24.

**TABLE 1612.1
CROSS REFERENCES DEFINING FLOOD RESISTANT PROVISIONS OF THE *FLORIDA BUILDING CODE***

Florida Building Code – Building			
Section		Section	
Chapter 1	Administration	Chapter 14	Exterior Walls
102	Applicability	1403	Performance Requirements
107	Construction Documents		
110	Inspections	Chapter 16	Structural Design
111	Certificates of Occupancy and Completion	1601	General
		1603	Construction Documents
Chapter 2	Definitions	1605	Load Combinations
202	Definitions	1612	Flood Loads
Chapter 4	Special Detailed Requirements Based on Use and Occupancy	Chapter 18	Soils and Foundations
419	Hospitals	1801	General
420	Nursing Homes	1804	Excavation, Grading and Fill
424	Swimming Pools and Bathing Places (Public And Private)	1807	Dampproofing and Waterproofing
Chapter 8	Interior Finishes	Chapter 30	Elevators and Conveying Systems
801	General	3001	General
Chapter 12	Interior Environment	Chapter 31	Special Construction
1203	Ventilation	3102	Membrane Structures
Florida Building Code – Residential			
Section		Section	
Chapter 2	Definitions	Chapter 22	Special Piping and Storage Systems
202	Definitions	M2201	Oil Tanks
Chapter 3	Building Planning	Chapter 24	Fuel Gas
R301	Design Criteria	G2404 (301)	General
R309	Garages and Carports		
R322	Flood Resistant Construction	Chapter 26	General Plumbing Requirements
		P2601	General
Chapter 4	Foundations		
R401	General	Chapter 27	Plumbing Fixtures
R408	Under-Floor Space	P2705	Installation
Chapter 13	General Mechanical System Requirements	Chapter 30	Sanitary Drainage
M1301	General	P3001	General
Chapter 14	Heating and Cooling Equipment	Chapter 31	Vents
M1401	General	P3101	Vent Systems

(continued)

**TABLE 1612.1—continued
CROSS REFERENCES DEFINING FLOOD RESISTANT PROVISIONS OF THE *FLORIDA BUILDING CODE***

Florida Building Code – Residential			
Section		Section	
Chapter 16	Duct Systems	Chapter 41	Swimming Pools
M1601	Duct Construction	R4101	Private Swimming Pools
Chapter 17	Combustion Air	Chapter 44	High-Velocity Hurricane Zones
M1701	General	R4403	High-Velocity Hurricane Zones – General
Chapter 20	Boilers and Water Heaters		
M2001	Boilers		
Florida Building Code – Existing			
Section		Section	
Chapter 1	Administration	Chapter 10	Additions
101	General	1003	Structural
Chapter 2	Definitions		
202	Definitions		
Chapter 3	Prescriptive Compliance Method	Chapter 11	Historic Buildings
302	Additions, Alterations or Repairs	1101	General
303	Alterations		
304	Repairs		
Chapter 5	Repairs	Chapter 12	Relocated or Moved Buildings
501	General	1202	Requirements
506	Structural		
Chapter 6	Alterations – Level I	Chapter 13	Performance Compliance Methods
601	General	1301	General
Florida Building Code – Mechanical			
Section		Section	
Chapter 3	General Regulations	Chapter 6	Duct Systems
M301	General	M602	Plenums
		M603	Duct Construction and Installation
Chapter 4	Ventilation		
M401	General	Chapter 12	Hydronic Piping
		M1206	Piping Installation
Chapter 5	Exhaust Systems		
M501	General	Chapter 13	Fuel Oil Piping and Storage
		M1305	Fuel Oil System Installation
Florida Building Code – Plumbing			
Section			
Chapter 3	General Regulations		
P309	Flood Hazard Resistance		
Florida Building Code – Fuel Gas			
Section			
Chapter 3	General Regulations		

**SECTION 1613
EARTHQUAKE LOADS
RESERVED**

**SECTION 1614
STRUCTURAL INTEGRITY**

1614.1 General. Buildings classified as high-rise buildings in accordance with Section 403 and assigned to *Risk Category* III or IV shall comply with the requirements of this section. Frame structures shall comply with the requirements of Section 1614.3. Bearing wall structures shall comply with the requirements of Section 1614.4.

1614.2 Definitions. The following words and terms shall, for the purposes of Section 1614, have the meanings shown herein.

BEARING WALL STRUCTURE. A building or other structure in which vertical loads from floors and roofs are primarily supported by walls.

FRAME STRUCTURE. A building or other structure in which vertical loads from floors and roofs are primarily supported by columns.

1614.3 Frame structures. Frame structures shall comply with the requirements of this section.

1614.3.1 Concrete frame structures. Frame structures constructed primarily of reinforced or prestressed concrete, either cast-in-place or precast, or a combination of these, shall conform to the requirements of ACI 318 Sections 7.13, 13.3.8.5, 13.3.8.6, 16.5, 18.12.6, 18.12.7 and 18.12.8 as applicable. Where ACI 318 requires that nonprestressed reinforcing or prestressing steel pass through the region bounded by the longitudinal column reinforcement, that reinforcing or prestressing steel shall have a minimum nominal tensile strength equal to two-thirds of the required one-way vertical strength of the connection of the floor or roof system to the column in each direction of beam or slab reinforcement passing through the column.

Exception: Where concrete slabs with continuous reinforcing having an area not less than 0.0015 times the concrete area in each of two orthogonal directions are present and are either monolithic with or equivalently bonded to beams, girders or columns, the longitudinal reinforcing or prestressing steel passing through the column reinforcement shall have a nominal tensile strength of one-third of the required one-way vertical strength of the connection of the floor or roof system to the column in each direction of beam or slab reinforcement passing through the column.

1614.3.2 Structural steel, open web steel joist or joist girder, or composite steel and concrete frame structures. Frame structures constructed with a structural steel frame or a frame composed of open web steel joists, joist girders with or without other structural steel elements or a frame composed of composite steel or composite steel joists and reinforced concrete elements shall conform to the requirements of this section.

1614.3.2.1 Columns. Each column splice shall have the minimum design strength in tension to transfer the

design dead and live load tributary to the column between the splice and the splice or base immediately below.

1614.3.2.2 Beams. End connections of all beams and girders shall have a minimum nominal axial tensile strength equal to the required vertical shear strength for *allowable stress design* (ASD) or two-thirds of the required shear strength for *load and resistance factor design* (LRFD) but not less than 10 kips (45 kN). For the purpose of this section, the shear force and the axial tensile force need not be considered to act simultaneously.

Exception: Where beams, girders, open web joist and joist girders support a concrete slab or concrete slab on metal deck that is attached to the beam or girder with not less than $\frac{3}{8}$ -inch-diameter (9.5 mm) headed shear studs, at a spacing of not more than 12 inches (305 mm) on center, averaged over the length of the member, or other attachment having equivalent shear strength, and the slab contains continuous distributed reinforcement in each of two orthogonal directions with an area not less than 0.0015 times the concrete area, the nominal axial tension strength of the end connection shall be permitted to be taken as half the required vertical shear strength for ASD or one-third of the required shear strength for LRFD, but not less than 10 kips (45 kN).

1614.4 Bearing wall structures. Bearing wall structures shall have vertical ties in all load-bearing walls and longitudinal ties, transverse ties and perimeter ties at each floor level in accordance with this section and as shown in Figure 1614.4.

1614.4.1 Concrete wall structures. Precast bearing wall structures constructed solely of reinforced or prestressed concrete, or combinations of these shall conform to the requirements of Sections 7.13, 13.3.8.5 and 16.5 of ACI 318.

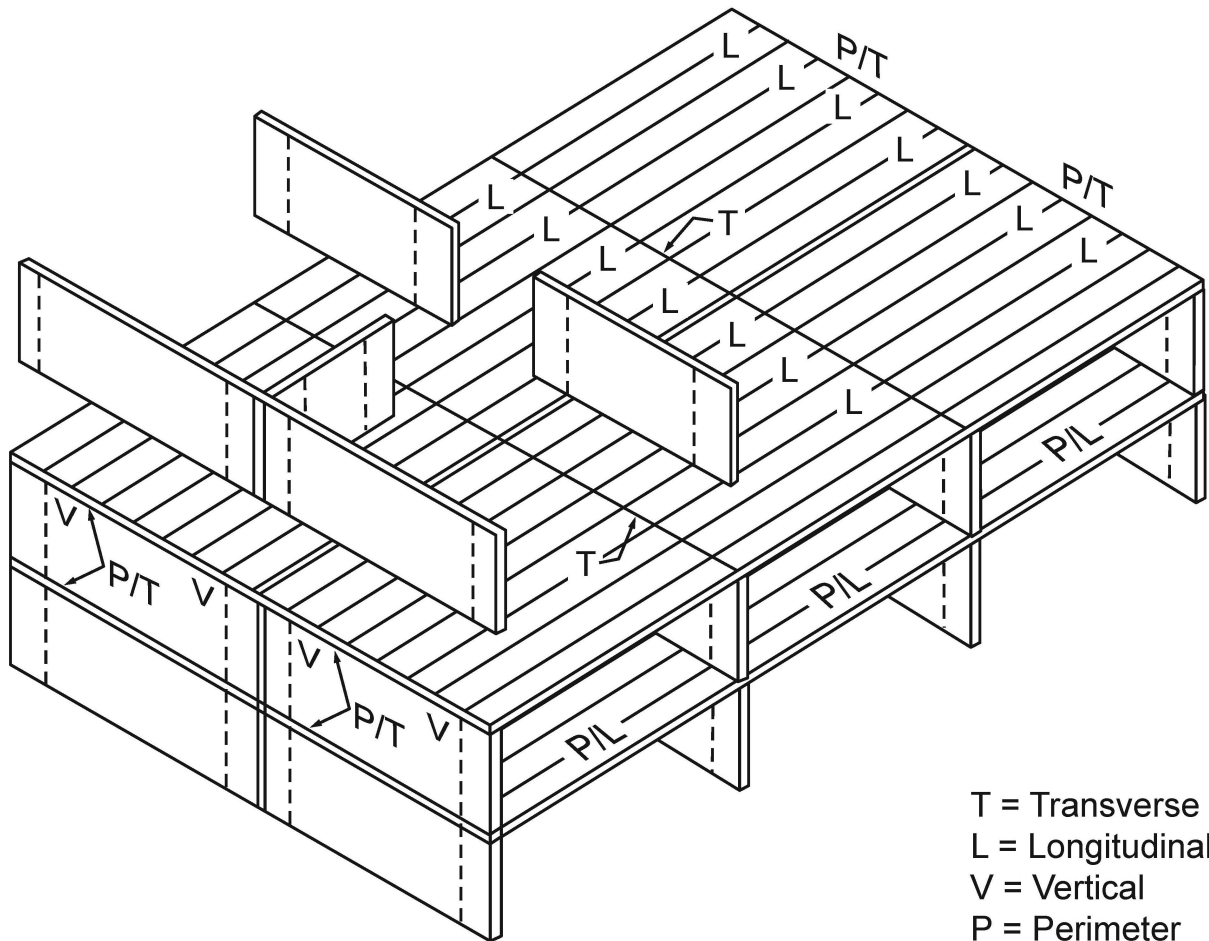
1614.4.2 Other bearing wall structures. Ties in bearing wall structures other than those covered in Section 1614.4.1 shall conform to this section.

1614.4.2.1 Longitudinal ties. Longitudinal ties shall consist of continuous reinforcement in slabs; continuous or spliced decks or sheathing; continuous or spliced members framing to, within or across walls; or connections of continuous framing members to walls. Longitudinal ties shall extend across interior load-bearing walls and shall connect to exterior load-bearing walls and shall be spaced at not greater than 10 feet (3038 mm) on center. Ties shall have a minimum nominal tensile strength, T_T , given by Equation 16-46. For ASD the minimum nominal tensile strength shall be permitted to be taken as 1.5 times the allowable tensile stress times the area of the tie.

$$T_T = wLS \leq \alpha_T S \quad \text{(Equation 16-46)}$$

where:

L = The span of the horizontal element in the direction of the tie, between bearing walls, feet (m).



T = Transverse
 L = Longitudinal
 V = Vertical
 P = Perimeter

FIGURE 1614.4
 LONGITUDINAL, PERIMETER, TRANSVERSE AND VERTICAL TIES

w = The weight per unit area of the floor or roof in the span being tied to or across the wall, psf (N/m²).

S = The spacing between ties, feet (m).

α_T = A coefficient with a value of 1,500 pounds per foot (2.25 kN/m) for masonry bearing wall structures and a value of 375 pounds per foot (0.6 kN/m) for structures with bearing walls of cold-formed steel light-frame construction.

1614.4.2.2 Transverse ties. Transverse ties shall consist of continuous reinforcement in slabs; continuous or spliced decks or sheathing; continuous or spliced members framing to, within or across walls; or connections of continuous framing members to walls. Transverse ties shall be placed no farther apart than the spacing of load-bearing walls. Transverse ties shall have minimum nominal tensile strength T_T , given by Equation 16-46. For ASD the minimum nominal tensile strength shall be permitted to be taken as 1.5 times the allowable tensile stress times the area of the tie.

1614.4.2.3 Perimeter ties. Perimeter ties shall consist of continuous reinforcement in slabs; continuous or spliced decks or sheathing; continuous or spliced members framing to, within or across walls; or connections of continuous framing members to walls. Ties around the perimeter of each floor and roof shall be located within 4 feet (1219 mm) of the edge and shall provide a nominal strength in tension not less than T_p , given by Equation 16-47. For ASD the minimum nominal tensile strength shall be permitted to be taken as 1.5 times the allowable tensile stress times the area of the tie.

$$T_p = 200w \leq \beta_T \quad \text{(Equation 16-47)}$$

For SI:

$$T_p = 90.7w \leq \beta_T$$

where:

w = As defined in Section 1614.4.2.1.

β_T = A coefficient with a value of 16,000 pounds (7200 kN) for structures with masonry bearing walls and

a value of 4,000 pounds (1300 kN) for structures with bearing walls of cold-formed steel light-frame construction.

1614.4.2.4 Vertical ties. Vertical ties shall consist of continuous or spliced reinforcing, continuous or spliced members, wall sheathing or other engineered systems. Vertical tension ties shall be provided in bearing walls and shall be continuous over the height of the building. The minimum nominal tensile strength for vertical ties within a bearing wall shall be equal to the weight of the wall within that *story* plus the weight of the diaphragm tributary to the wall in the *story* below. No fewer than two ties shall be provided for each wall. The strength of each tie need not exceed 3,000 pounds per foot (450 kN/m) of wall tributary to the tie for walls of masonry construction or 750 pounds per foot (140 kN/m) of wall tributary to the tie for walls of cold-formed steel light-frame construction.

**SECTION 1615
HIGH-VELOCITY HURRICANE ZONES—
DEFLECTION, VOLUME CHANGES AND MINIMUM
LOADS**

1615.1 General design requirements.

1615.1.1 Any system, method of design or method of construction shall admit of a rational analysis in accordance with well-established principles of mechanics and sound engineering practices.

1615.1.2 Buildings, structures and all parts thereof shall be designed and constructed to be of sufficient strength to support the estimated or actual imposed dead, live, wind, and any other loads, both during construction and after completion of the structure, without exceeding the allowable materials stresses specified by this code.

1615.1.3 No building structure or part thereof shall be designed for live loads less than those specified in this Chapter or ASCE 7 with commentary, except as otherwise noted in this code.

1615.1.4 The live loads set forth herein shall be assumed to include the ordinary impact but where loading involves unusual impact, provision shall be made by increasing the assumed live load.

1615.1.5 In the design of floors, not less than the actual live load to be imposed shall be used. Special provisions shall be made for machine or apparatus loads where applicable.

1615.1.6 Floor and roof systems shall be designed and constructed to transfer horizontal forces to such parts of the structural frame as are designed to carry these forces to the foundation. Where roofs or floors are constructed of individual prefabricated units and the transfer of forces to the building frame and foundation is totally or partially dependent on such units, the units and their attachments shall be capable of resisting applied loads in both vertical and both horizontal directions. Where roofs or floors are constructed of individual prefabricated units and the transfer of forces to the building frame and foundation is wholly independent of

such units, the units and their attachments shall be capable of resisting applied loads normal to the surface, in and out.

1615.2 General design for specific occupancies and structures.

1615.2.1 Fences. Fences not exceeding 6 feet (1829 mm) in height from grade may be designed for 75 mph (33 m/s) fastest mile wind speed or 115 mph (40 m/s) 3-second gust.

1615.2.1.1 Wood fences. Wood fence design shall be as specified by Section 2328.

1615.2.2 Sway forces in stadiums.

1. The sway force applied to seats in stadiums, grandstands, bleachers and reviewing stands shall be not less than 24 pounds per lineal foot (350 N/m), applied perpendicularly and along the seats.
2. Sway forces shall be applied simultaneously with gravity loads.
3. Sway forces need not be applied simultaneously with other lateral forces.

1615.3 Deflection.

1615.3.1 Allowable deflections. The deflection of any structural member or component when subjected to live, wind and other superimposed loads set forth herein shall not exceed the following:

1. Roof and ceiling or components supporting plaster.....L/360
2. Roof members or components not supporting plaster under.....L/240
3. Floor members or components.....L/360
4. Vertical members and wall members or components consisting of or supporting material that hardens in place, is brittle or lacks resistance to cracking caused by bending strains.....L/360
5. Vertical members and wall members or components not required to meet the conditions of Section 1615.3.1, Item 4.....L/180
6. Roof and vertical members, wall members and panels of carports, canopies, marquees, patio covers, utility sheds and similar minor structures not to be considered living areas, where the roof projection is greater than 12 feet (3.7 m) in the direction of the span, for free-standing roofs and roofs supported by existing structures. Existing structures supporting such roofs shall be capable of supporting the additional loading.....L/180
7. For Group R-3 occupancies only, roof and vertical members, wall members and panels of carports, canopies, marquees, patio covers, utility sheds and similar minor structures not to be considered living areas, where the roof projection is 12 feet (3.7 m) or less in the direction of the span and for free standing roofs and roofs supported by existing structures.....L/80
8. Members supporting screens only.....L/80

- 9. Storm shutters and fold-down awnings, which in the closed position shall provide a minimum clear separation from the glass of 1 inch (25 mm) but not to exceed 2 inches (51 mm) when the shutter or awning is at its maximum point of permissible deflection.....L/30
- 10. Roofs and exterior walls of utility sheds having maximum dimensions of 10 feet (3 m) length, 10 feet (3 m) width, and 7 feet (2.1 m) height.....L/80
- 11. Roofs and exterior walls of storage buildings larger than utility sheds.....L/180

1615.4 Volume change. In the design of any building, structure or portion thereof, consideration shall be given to the relief of stresses caused by expansion, contraction and other volume changes.

1615.5 Live loads. Minimum uniformly distributed live loads shall not be less than as set forth in and Table 4-1 of ASCE 7 with commentary, except as otherwise noted in this code.

1615.6 Concentrated loads. Minimum concentrated loads shall not be less than as set forth in Table 4-1 of ASCE 7 with commentary, except as otherwise noted.

1615.6.1 Concentrated loads on trusses. Any single panel point of the lower chord of roof trusses or any point of other primary structural members supporting roofs over manufacturing, commercial storage and warehousing, and commercial garage floors shall be capable of safely carrying a suspended, concentrated load of not less than 2,000 pounds (8896 N) in addition to dead load. For all other occupancies, a minimum load of 200 pounds (890 N) shall be used.

**TABLE 1615
MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS**
See Tables 4-1 of ASCE 7 with commentary,
except as otherwise noted below

OCCUPANCY OR USE	LIVE LOAD POUNDS PER SQUARE FOOT
Assembly projection room	100
Balconies, Exterior (see also assembly) Serving private units of Group R occupancies and not for assembly use	60
Balconies serving occupancies 80 psf or less	80
All other balconies	100
Cabanas and bath house	50
Path of egress servicing occupancies 80 psf or less	80
Path of egress servicing occupancies over 80 psf	100
Recreational facilities Including bowling centers, pool rooms and similar uses	75
Storage: Light Medium Heavy	75 125 250 ^{1,2}

For SI: 1 pound per square foot = 47.88 Pa.
1. Use actual equipment weight when greater.
2. Increase when occupancy exceeds this amount.

**SECTION 1616
HIGH-VELOCITY HURRICANE ZONES—
ROOF LIVE LOADS**

1616.1 Minimum roof live loads. Roofs shall be designed for a live load of not less than 30 psf (1436 Pa), except as set forth herein.

Exceptions:

1. Glass areas of greenhouse roofs shall be designed for a live load of not less than 15 psf (718 Pa).
2. Ordinary pitched and curved roofs, with a slope of 1½:12, or greater, where water is not directed to the interior of the roof, without parapet or other edge of roof drainage obstructions, may be designed for an allowable live load of not less than 20 psf (958 Pa).
3. Utility sheds shall be designed for a live load of not less than 15 psf (718 Pa).

1616.2 Special purpose roofs. Roofs used for assembly, roof gardens, promenade or walkway purposes shall be designed for a minimum live load of 100 psf (4788 Pa). Other special purpose roofs shall be designed for appropriate loads as directed or approved by the building official.

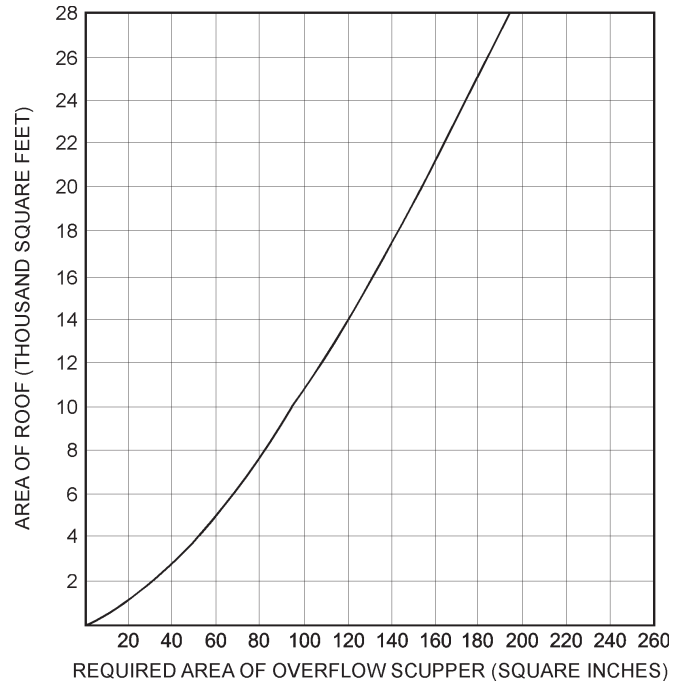
1616.3 Roof decking. Roof decking shall be designed to support the live load set forth in Section 1616.1 or a load of 100 pounds per foot (445 N) applied as a 1 foot (305 mm) wide strip perpendicular to, and at the center of, the span of the decking between supports, whichever is more critical.

**SECTION 1617
HIGH-VELOCITY HURRICANE ZONES—
ROOF DRAINAGE**

1617.1 Roof drainage. Where parapets or curbs are constructed above the level of the roof, provision shall be made to prevent rain water from accumulating on the roof in excess of that considered in the design, in the event the rain water drains, conductors or leaders become clogged.

1617.2 Where roofs are not designed in accordance with Section 1617.1, overflow drains or scuppers shall be placed to prevent an accumulation of more than 5 inches (927 mm) of water on any portion of the roof. In determining the load that could result should the primary drainage system be blocked, the loads caused by the depth of water (i.e., head) needed to cause the water to flow out the scuppers or secondary drainage system shall be included.

1617.3 Drains or scuppers installed to provide overflow drainage shall be not less in aggregate area than as shown in Figure 1617.3, but not less than 4 inches (102 mm) dimension in any direction and shall be placed in parapets not less than 2 inches (51 mm) nor more than 4 inches (102 mm) above the low point of the finished roofing surface and shall be located as close as practical to required vertical leaders, conductors or downspouts. The roof area to be taken in the sizing of the scuppers is the horizontal projection, except that, where a building wall extends above the roof in such a manner as to drain into the area considered, the one-half of the area of the vertical wall shall be added to the horizontal projection.



**FIGURE 1617.3
REQUIRED AREA OF OVERFLOW SCUPPERS**

1617.4 All roofs shall be designed with sufficient slope or camber to assure adequate drainage after the long term deflection from dead load, or shall be designed to support maximum loads including possible ponding of water caused by deflection.

1617.5 Ponding loads. Roofs shall be designed to preclude instability from ponding loads.

1617.6 Each portion of a roof shall be designed to sustain the loads of all rainwater that could accumulate on it if the primary drainage system for that portion is obstructed. Ponding instability shall be considered in this situation. If the overflow drainage provisions contain drain lines, such lines shall be independent of any primary drain lines.

**SECTION 1618
HIGH-VELOCITY HURRICANE ZONES—
SPECIAL LOAD CONSIDERATIONS**

1618.1 Floors. In the design of floors, consideration shall be given to the effect of known or probable concentration of loads, partial concentrations of loads, partial load, vibratory, transitory, impact and machine loads. Design shall be based on the load or combination of loads that produces the higher stresses.

1618.2 Below grade structures.

1618.2.1 In the design of basements, tanks, swimming pools and similar below grade structures, provisions shall be made for the forces resulting from hydrostatic pressure and lateral pressure of adjacent soil.

1618.2.2 For the lateral loads of soil on below grade structures, unless substantiated by more specific information, the angle of repose of fragmental rock and natural confined

sand shall be 30 degrees and the angle of repose of filled soil and muck shall be 15 degrees to a horizontal line.

1618.2.3 For the hydrostatic pressure on any floor below a ground water level, calculations shall be based on full hydrostatic pressure, and such floors shall be designed for live load without hydrostatic uplift, and hydrostatic uplift without live load.

1618.2.4 Private swimming pools may be designed with an approved hydrostatic relief valve or other device capable of preventing the pool water from being pumped to a level lower than the surrounding ground water but such device shall not be credited for more than 2 feet (610 mm) of the difference of head between the pool bottom and the flood criteria.

1618.3 Helistops/heliports. In addition to other design requirements of this chapter, heliport and helistop loading or touchdown areas shall be designed for the maximum stress induced by the following:

1. Dead load plus actual weight of the helicopter.
2. Dead load plus two single concentrated impact loads approximately 8 feet (2.4 m) apart anywhere on the touchdown pad (representing each of the helicopter's two main landing gear, whether skid type or wheeled type), with each concentrated load covering 1 square foot (0.09 m²) and having a minimum magnitude of 0.75 times the gross weight of the helicopter. Both loads acting together total a minimum of 1.5 times the gross weight of the helicopter.
3. The dead load plus a uniform live load of 60 psf (2873 Pa).

1618.4 Safeguards. Safeguards shall be required in and around buildings and structures such as covers, railings, stair-railings, handrails or other safeguards as defined in the regulations of the Occupational Safety and Health Administration (OSHA) 29 CFR Part 1910 as applied to permanent structures and as specified herein.

1618.4.1 Open or glazed wall openings; open or glazed sides of balconies, landings and other walking surfaces; unenclosed floor and roof openings; roofs used for other than services for the building or structure and any other abrupt differences in level exceeding 30 inches (762 mm), including yard areas, shall be provided with safeguards not less than 42 inches (1067 mm) in height.

1618.4.2 Safeguards may be omitted at loading docks, truck wells and similar locations where it is apparent that the edge of the higher level is for loading, and on docks, seawalls and decorative fountains where the lower level is the water surface.

1618.4.3 Safeguards in and around buildings of other than Group R occupancies shall be provided with additional rails, vertical pickets or ornamental filler below the top rail that will reject a 6-inch (152 mm) diameter object.

1618.4.4 Safeguards in and around buildings of Group R occupancies shall provide protection for children by providing additional rails, vertical pickets or an ornamental filler below the top rail which will reject a 4-inch (102 mm) diameter object; permitting, however, such ornamental fillers to

have individual openings not exceeding 64 square inches (.04 m²) in area.

1618.4.5 Where a balustrade is used to comply with the requirements of this paragraph, the maximum clearance between the bottom rail of the balustrade and the adjacent surface shall not exceed 2 inches (51 mm). For safeguards on stairs, the 2-inch (51 mm) clearance shall be measured from the bottom rail of the balustrade to a line passing through the tread nosings.

1618.4.6 Railing.

1618.4.6.1 Railings, stair-railings and other similar safeguards shall be designed to resist a load of 50 pounds per lineal foot (74 kg/m) or a concentrated load of 200 pounds (690 N) applied in any direction at the top of such barriers at any location on the safeguard, whichever condition produces the maximum stresses. The reactions and stresses caused by the above referenced uniform and concentrated loads shall be considered to not be acting simultaneously.

1618.4.6.2 Intermediate rails, balusters and panel fillers shall be designed for a uniform horizontal load of not less than 25 psf (1197 Pa) over the gross area of the guard, including the area of any openings in the guard, of which they are a part without restriction by deflection. Reactions resulting from this loading need not be added to the loading specified in Section 1618.4.6.1 in designing the main supporting members of guards.

1618.4.6.3 Laminated glazing will be permitted as an equal alternate to pickets, if tested by an accredited laboratory to satisfy the resistance requirements of this code for wind, live and kinetic energy impact loading conditions. The kinetic energy impact loading shall comply with ANSI Z97.1 using a 400 foot-pound (542 N) energy impact. The safety requirements of the impact test shall be judged to have been satisfactorily met if breakage does not occur or numerous cracks and fissures occur but no shear or opening through which a 3-inch (76 mm) diameter sphere may freely pass. The glass panel shall remain within the supporting frame.

1618.4.6.4 If the posts that support the top rail of exterior railings are substituted with glass, the assembly shall be tested to TAS 201, where the impacted glass continues to support the top rail and all applicable loads after impact.

1618.4.7 Areas in all occupancies from which the public is excluded requiring such protection may be provided with vertical barriers having a single rail midway between a top rail and the walking surface.

1618.5 Vehicle safeguard barriers. Vehicle safeguard barriers are required in parking garages whenever there is a difference in level exceeding 1 foot (305 mm).

1618.5.1 Unless separate pedestrian safeguards are provided vehicle safeguard barriers shall, in addition to the requirements of this section, meet all other requirements of Section 1618.4.

1618.5.2 The requirement of Section 1618.4.3 for the rejection of a 6-inch (152 mm) diameter object shall be met when

the barrier is subjected to a horizontal load of 25 psf (1197 Pa), applied as specified in Section 1618.4.6.2.

1618.5.3 Vehicle safeguard barriers shall be capable of resisting a minimum horizontal ultimate load of 10,000 pounds (44.5 kN) applied 18 inches (457 mm) above the floor at any point in the barrier system. This load need not be applied in combination with loads specified in Section 1618.4.6.1 and Section 1618.4.6.2. Vehicle safeguard barrier systems of metal framing, concrete or masonry may be designed by allowable stress design for a concentrated horizontal load of 7,500 pounds (33 361 N) in lieu of the 10,000 pounds (44.5 kN) ultimate load specified above.

1618.6 Special requirements for cable safeguard barriers.

1618.6.1 Horizontal deflection under design load shall not exceed 18 inches (457 mm).

1618.6.2 The design load shall be assumed to be resisted by not more than two cables.

1618.6.3 The cable system including anchors shall be protected against corrosion.

1618.6.4 Cable tension under design load shall not exceed 90 percent of the yield strength of the cable.

1618.6.5 The uppermost cable shall be at least 42 inches (1067 mm) above the adjacent surface. Cables shall not be spaced more than 6 inches (152 mm) apart.

1618.6.6 An installation plan prepared by the structural engineer of record shall be submitted to the building official for his or her approval.

1618.6.7 Installation shall be witnessed by the structural engineer of record who shall certify the following:

1. That the installation has been in accordance with the approved installation plan.
2. That the initial tension designated by the structural engineer of record has been provided in all cables.
3. That all anchors have been seated at a total load, including initial tension, equal to 85 percent of the yield strength of the cable, unless a positive locking device is provided that does not require a tension jack for the tensioning of the barrier strand.

1618.6.8 Drawings shall indicate the initial tension, the expected increase in tension under vehicular impact and the required maximum capacity of the strand barrier system.

1618.7 Ornamental projections. Ornamental cantilevered projections on the exterior of buildings shall be designed for not less than 60 psf live load (2873 Pa) or 200 pounds per lineal foot (2919 N/m) applied at the outer edge, whichever is more critical.

1618.8 Interior wall and partitions. Permanent, full-height interior walls and partitions shall be designed to resist a lateral live load not less than 5 psf (239 Pa) and if sheathed with lath and plaster, deflection at this load shall not exceed $L/360$.

1618.9 Load combination. The safety of structures shall be checked using the provisions of 2.3 and 2.4 of ASCE 7 with commentary. Flood Load F_a mentioned in these load combinations shall be in accordance with Chapter 5 of ASCE 7.

Exception: Increases in allowable stress shall be permitted in accordance with ACI 530/ASCE 5/TMS 402 provided the load reduction factor of 0.75 of combinations 4 and 6 of ASCE 7 Section 2.4.1 shall not be applied.

**SECTION 1619
HIGH VELOCITY HURRICANE ZONES—
LIVE LOAD REDUCTIONS**

1619.1 Application. No reduction in assumed live loads set forth in this section shall be allowed in the design of columns, walls, beams, girders and foundations, except as permitted by the provisions of Section 4.7 ASCE 7 with commentary.

Exceptions:

1. No reduction of the assumed live loads shall be allowed in the design of any slabs, joists or other secondary members, except as set forth herein.
2. No reduction in roof live loads shall be permitted except as set forth by Section 1616.1.

1619.2 Allowable live load reductions.

1619.2.1 Permissible reduction in live loads shall be as provided in Section 4.7 of ASCE 7 with commentary.

1619.2.2 Limitations on live load reduction shall be as noted in Section 4.7 of ASCE 7 with commentary.

1619.2.3 No reduction in live loads shall be permitted for buildings or structures of Group A assembly occupancy.

**SECTION 1620
HIGH-VELOCITY HURRICANE ZONES—
WIND LOADS**

1620.1 Buildings and structures, and every portion thereof, shall be designed and constructed to meet the requirements of Chapters 26 through 31 of ASCE 7.

1620.2 Wind velocity (3-second gust) used in structural calculations shall be as follows:

Miami-Dade County

Risk Category I Buildings and Structures: 165 mph

Risk Category II Buildings and Structures: 175 mph

Risk Category III and IV Buildings and Structures: 186 mph

Broward County

Risk Category I Buildings and Structures: 156 mph

Risk Category II Buildings and Structures: 170 mph

Risk Category III and IV Buildings and Structures: 180 mph

1620.3 All buildings and structures shall be considered to be in Exposure Category C, unless Exposure Category D applies, as defined in Section 26.7 of ASCE 7.

1620.4 For wind force calculations, roof live loads shall not be considered to act simultaneously with the wind load.

1620.5 Utility sheds shall be designed for a wind load of not less than 15 psf (718 Pa).

1620.6 Rooftop structures and equipments. The lateral force on rooftop structures and equipment with A_r less than $(0.1Bh)$ located on buildings of all heights shall be determined from Equation 29.5-1 of ASCE 7 in which the value of GC_r shall be taken as 3.1. GC_r shall be permitted to be reduced linearly from 3.1 to 1.1 as the value of A_r is increased from $(0.1Bh)$ to (Bh) . The value of G from Section 26.9 of ASCE 7 shall not be used. Additionally, a simultaneous uplift force shall be applied, given by Equation 29.5-1 of ASCE 7 in which $GC_r = 1.5$ and A_r is replaced by the horizontal projected area, A_p , of the rooftop structure or equipment. For the uplift force GC_r shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from $(0.1BL)$ to (BL) .

SECTION 1621 HIGH-VELOCITY HURRICANE ZONES— OVERTURNING MOMENT AND UPLIFT

1621.1 Computations for overturning moment and uplift shall be based on ASCE 7.

1621.2 Overturning and uplift stability of any building, structure or part thereof taken as a whole shall be provided, and shall be satisfied by conforming to the load combination requirements of ASCE 7.

SECTION 1622 HIGH-VELOCITY HURRICANE ZONES— SCREEN ENCLOSURES

1622.1 Screen enclosures.

1622.1.1 The wind loads on screen surfaces shall be per ASCE 7 based on the ratio of solid to gross area.

1622.1.2 Design shall be based on such loads applied horizontally inward and outward to the walls with a shape factor of 1.3 and applied vertically upward and downward on the roof with a shape factor of 0.7.

Exception: Screen enclosures shall be permitted to be designed in accordance with the *AAF Guide to Aluminum Construction in High Wind Areas*. Construction documents based on the *AAF Guide to Aluminum Construction in High Wind Areas* shall be prepared and signed and sealed by an Florida registered architect or engineer.

1622.2 Windbreakers.

1622.2.1 Vinyl and acrylic glazed panels shall be removable. Removable panels shall be identified as removable by a decal. The identification decal shall essentially state "Removable panel SHALL be removed when wind speeds exceed 75 mph (34 m/s)." Decals shall be placed such that the decal is visible when the panel is installed.

1622.2.2 Permanent frame shall be designed per Section 1620 and 1622.1.2.

SECTION 1623 HIGH-VELOCITY HURRICANE ZONES— LIVE LOADS POSTED AND OCCUPANCY PERMITS

1623.1 Live loads posted. The live loads in every building, structure or part thereof of Group F, M or S Storage occupancy approved by the building official shall be shown on plates supplied by the owner or his authorized agent, in that part of each space to which such loads apply.

1623.1.1 Such plates shall be of approved durable materials displaying letters and figures not less than $\frac{3}{8}$ inch (9.5 mm) in height, and shall be securely affixed to the structure in conspicuous places.

1623.1.2 Such notices shall not be removed or defaced and where defaced, removed or lost, it shall be the responsibility of the owner to cause replacement as soon as possible.

1623.2 Occupant loads. Plans for proposed buildings or structures of Group F, M or S storage occupancy areas in buildings of any occupancy shall show the allowable loading for each portion of the floor and roof areas and certificates of use and occupancy, as defined in Section 110 of this code, shall not be issued until such loads are posted as set forth in Section 1623.1.

1623.2.1 Change in occupant load. No change in the occupancy of any building shall be made until a certificate of occupancy has been issued certifying that the building official has approved the building as suitable for the loads characteristic of the proposed occupancy.

1623.2.2 Maximum floor and roof loads observed. It shall be unlawful at any time to place, or permit to be placed, on any floor or roof of a building or structure, a load greater than that for which the floor or roof is approved by the building official.

SECTION 1624 HIGH-VELOCITY HURRICANE ZONES— FOUNDATION DESIGN

1624.1 Design procedure. The minimum area of a footing or number of piles under a foundation shall be determined in the following manner:

1624.1.1 The total load of the column that has the largest percentage of the live load to the total load shall be divided by the allowable soil pressure or pile capacity.

1624.1.2 The balance soil pressure or pile capacity shall be determined by dividing the total dead load by the area of the footing or the number of piles.

1624.1.3 The minimum area of other footings or number of piles shall be designed on the basis of their respective dead loads only.

1624.1.4 In no case shall the total load of the combined dead, live, wind and any other loads exceed the allowable bearing pressure of the soil for capacity of any pile upon which the foundation is supported.

1624.1.5 The live load used in the above calculations may be the total reduced live load in the member immediately above the foundation.

1624.1.6 The building official may require submittal of design computations employed in foundation design.

1624.2 Wind effects. Reserved.

1624.2.1 Reserved.

**SECTION 1625
HIGH-VELOCITY HURRICANE ZONES—
LOAD TESTS**

1625.1 Application. Whenever there is insufficient evidence of compliance with the provisions of this code or evidence that any material or any construction does not conform to the requirements of this code, or in order to substantiate claims for alternate materials or methods of construction, the building official may require testing by an approved agency, at the expense of the owner or his agent, as proof of compliance. Testing methods shall be as specified by this code for the specific material.

1625.2 Testing method. Such testing shall follow a nationally recognized standard test, or when there is no standard test procedure for the material or assembly in question, the building official shall require the material or assembly under dead plus live load shall deflect not more than as set forth in Section 1615.3, and that the material or assembly shall sustain dead load plus twice the live load for a period of 24 hours, with a recovery of at least 80 percent or a 100 percent recovery after one-half test load.

1625.3 Alternate test methods. When elements, assemblies or details of structural members are such that their load-carrying capacity, deformation under load, or deflection cannot be calculated by rational analysis, their structural performance shall be established by test in accordance with test procedures as approved by the building official based on consideration of all probable conditions of loading.

1625.4 Fatigue load testing. Where cladding assemblies (including cladding and connections) or roofing framing assemblies (including portions of roof structure and connections) are such that their load-carrying capacity or deformation under load cannot be calculated by rational analysis, the assemblies may be tested to resist the fatigue loading sequence given by Table 1625.4.

Assemblies shall be tested with no resultant failure or distress and shall have a recovery of at least 90 percent over maximum deflection.

Any cladding assembly not incorporated into the *Florida Building Code, Building* after successfully completing the impact test outlined in Section 1626, shall be subject to fatigue loading testing and shall obtain product approval by the building official.

**TABLE 1625.4
FATIGUE LOADING SEQUENCE**

RANGE OF TEST	NUMBER OF CYCLES ¹
0 to $0.5p_{max}^2$	600
0 to $0.6p_{max}$	70
0 to $1.3p_{max}$	1

1. Each cycle shall have minimum duration of 1 second and a maximum duration of 3 seconds and must be performed in a continuous manner
2. $p_{max} = 0.6 \times$ ultimate design load in accordance with ASCE 7.

**SECTION 1626
HIGH-VELOCITY HURRICANE ZONES—
IMPACT TESTS FOR WIND-BORNE DEBRIS**

1626.1 All parts or systems of a building or structure envelope such as, but not limited to, exterior walls, roof, outside doors, skylights, glazing and glass block shall meet impact test criteria or be protected with an external protection device that meets the impact test criteria. Test procedures to determine resistance to wind-borne debris of wall cladding, outside doors, skylights, glazing, glass block, shutters and any other external protection devices shall be performed in accordance with this section.

Exception: The following structures or portion of structures shall not be required to meet the provisions of this section:

- a. Roof assemblies for screen rooms, porches, canopies, etc; attached to a building that do not breach the exterior wall or building envelope and have no enclosed sides other than screen.
- b. Soffits, soffit vents and ridge vents. Size and location of such vents shall be detailed by the designer and shall not compromise the integrity of the diaphragm boundary.
- c. Vents in a garage with four or fewer cars. Size and location of such vents shall be detailed by the designer and shall not exceed the minimum required area by more than 25 percent.
- d. Exterior wall or roof openings for wall- or roof-mounted HVAC equipment.
- e. Openings for roof-mounted personnel access roof hatches.
- f. Storage sheds that are not designed for human habitation and that have a floor area of 720 square feet (67 m²) or less are not required to comply with the mandatory windborne debris impact standards of this code.
- g. Louvers as long as they properly considered ASCE 7 in the design of the building.
- h. Buildings and structures for marinas, cabanas, swimming pools and greenhouses.
- i. Exterior balconies or porches under existing roofs or decks enclosed with screen or removable vinyl and acrylic panels complying with Section 1622.1 or Section 1622.2 shall not be required to be protected and openings in the wall separating the unit from the balcony or porch shall not be required to be protected unless required by other provisions of this code.

1626.2 Large missile impact tests.

1626.2.1 This test shall be conducted on three test specimens. This test shall be applicable to the construction units, assemblies and materials to be used up to and including 30 feet (9.1 m) in height in any and all structures.

**TABLE 1626
CYCLIC WIND PRESSURE LOADING**

INWARD ACTING PRESSURE		OUTWARD ACTING PRESSURE	
RANGE	NUMBER OF CYCLES ¹	RANGE	NUMBER OF CYCLES ¹
0.2 P _{MAX} to 0.5 P _{MAX} ²	3,500	0.3 P _{MAX} to 1.0 P _{MAX}	50
0.0 P _{MAX} to 0.6 P _{MAX}	300	0.5 P _{MAX} to 0.8 P _{MAX}	1,050
0.5 P _{MAX} to 0.8 P _{MAX}	600	0.0 P _{MAX} to 0.6 P _{MAX}	50
0.3 P _{MAX} to 1.0 P _{MAX}	100	0.2 P _{MAX} to 0.5 P _{MAX}	3,350

NOTES:

- Each cycle shall have minimum duration of 1 second and a maximum duration of 3 seconds and must be performed in a continuous manner
- P_{MAX} = 0.6 × ultimate design load in accordance with ASCE 7. The pressure spectrum shall be applied to each test specimen beginning with inward acting pressures followed by the outward acting pressures in the order from the top of each column to the bottom of each column.

1626.2.2 The test specimens shall consist of the entire assembled unit, including frame and anchorage as supplied by the manufacturer for installation in the building, or as set forth in a referenced specification, if applicable. Fasteners used in mounting the test specimen shall be identical in size and spacing to what is used in field installations.

1626.2.3 The large missile shall be comprised of a piece of timber having nominal dimensions of 2 inches by 4 inches (51 mm by 102 mm) weighing 9 pounds (4.1 kg).

1626.2.4 The large missile shall impact the surface of each test specimen at a speed of 50 feet per second (15.2 m/s).

1626.2.5 Each test specimen shall receive two impacts except as noted in Sections 1626.2.5.1 and 1626.2.5.2, the first within a 5-inch (127 mm) radius circle having its center on the midpoint of the test specimen and the second within a 5-inch (127 mm) radius circle in a corner having its center in a location 6 inches (152 mm) away from any supporting members.

1626.2.5.1 For window, glass block, fixed glass and skylight assemblies, both impacts shall be to glass or other glazing infill. For test specimens with more than one light of glass, a single light closest to the center of the assembly shall be selected and impacted twice in accordance with Section 1626.2.5. If a light of glass is sufficiently small to cause the 5-inch (127 mm) radius circle to overlap, two separate lights shall be impacted one time each.

1626.2.5.1.1 For window, fixed glass and skylight assemblies comprised of different glass thickness, types of glass or different types of glazing infill, each separate thickness or type shall be impacted twice in accordance with Section 1626.2.5.

1626.2.5.2 For doors, wall cladding and external protection devices, both impacts shall be to the thinnest section through the assembly. For doors, wall cladding and external protection devices with horizontal and/or vertical bracing, both impacts shall be within a single area that is not reinforced and shall be in accordance with Section 1626.2.5.

1626.2.5.2.1 For doors with glass, the glass shall be impacted twice and the thinnest section through the

assembly that is not glass shall be impacted twice in accordance with Section 1626.2.5.

1626.2.6 In the case of glazing, if the three test specimens that comprise a test successfully reject the two missile impacts, they shall then be subjected to the cyclic pressure loading defined in Table 1626.

1626.2.6.1 If external protection devices are employed to protect windows, fixed doors or skylights, they must resist the large missile impacts specified in Sections 1626.2.3 and 1626.2.4 without deformations which result in contact with the windows, fixed glass, glass block, and doors or skylights they are intended to protect.

1626.2.6.2 If external protection devices are not designed to be air tight, following the large missile impact test, they must resist an application of force corresponding to those listed in Table 1625.4 (fatigue load testing) without detaching from their mountings. The acting pressure cycles shall be simulated with loads applied through a mechanical system attached to the shutter specimen to apply uniformly around the shutter perimeter a force equal to the product of the required pressure and the area of the shutter specimen.

1626.2.7 If air leakage through the test specimen is excessive, tape may be used to cover any cracks and joints through which leakage is occurring. Tape shall not be used when there is a probability that it may significantly restrict differential movement between adjoining members. It is also permissible to cover both sides of the entire specimen and mounting panel with a single thickness of polyethylene film no thicker than 0.050 mm (2 mils). The technique of application is important in order that the full load is transferred to the specimen and that the membrane does not prevent movement or failure of the specimen. Apply the film loosely with extra folds of material at each corner and at all offsets and recesses. When the load is applied, there shall be no fillet caused by tightness of plastic film.

1626.2.8 A particular system of construction shall be deemed to comply with this recommended practice if three test specimens reject the two missile impacts without penetration and resist the cyclic pressure loading with no crack forming longer than 5 inches (127 mm) and 1/16 inch (1.6 mm) wide through which air can pass.

1626.2.9 If only one of the three test specimens in a test fails to meet the above listed criteria, one retest of this system of construction (another test sequence with three specimens) shall be permitted.

1626.3 Small missile impact test.

1626.3.1 This test shall be conducted on three test specimens. This test shall be applicable to the construction units, assemblies, and materials to be used above 30 feet (9.1 m) in height in any and all structures.

1626.3.2 Each test specimen shall consist of the entire assembled unit, including frame and anchorage as supplied by the manufacturer for installation in the building, or as set forth in a referenced specification, if applicable. The fasteners used in mounting the test specimen shall be identical in size and spacing to those to be used in field installations.

1626.3.3 The missiles shall consist of solid steel balls each having a mass of 2 grams (0.07 oz) (+/-5 percent) with a $5/16$ -in. (7.9 mm) nominal diameter.

1626.3.4 Each missile shall impact the surface of each test specimen at a speed of 130 feet per second (40 m/s).

1626.3.5 Each test specimen shall receive 30 small missile impacts, except as noted in Sections 1626.3.5.1 and 1626.3.5.2, delivered in groups of 10 at a time: the first 10 distributed uniformly over a 2 square foot (0.19 m²) area located at the center of the test specimen, the second 10 distributed uniformly over a 2 square foot area (0.19 m²) located at the center of the long dimension of the specimen near the edge, and the third 10 distributed uniformly over a 2 square foot (0.19 m²) area located at a corner of the specimen.

1626.3.5.1 For window and skylight assemblies, all impacts shall be to glass or other glazing infill. For test specimens with more than one light of glass, a single light closest to the center of the assembly shall be selected and impacted in accordance with Section 1626.3.5. If a light of glass is sufficiently small to cause the 5-inch (127 mm) radius circles to overlap, separate lights may be impacted; however, there must be a total of 30 impacts within the assembly.

1626.3.5.1.1 For window, fixed glass and skylight assemblies comprised of glass with different thickness, types of glass or different types of glazing infill, each separate thickness or type shall be impacted in accordance with Section 1626.3.5.

1626.3.5.2 For doors, wall cladding and external protection devices, all impacts shall be to the thinnest section through the assembly. For doors, wall cladding and external protection devices with horizontal and/or vertical bracing, all impacts shall be within a single area that is not reinforced and shall be impacted in accordance with Section 1626.3.5.

1626.3.5.2.1 For doors with glass, the glass shall be impacted in accordance with Section 1626.3.5 and the thinnest section through the assembly that is not glass shall be impacted in accordance with Section 1626.3.5.

1626.3.6 In the case of glazing, after completion of the small missile impacts, each test specimen shall then be subjected to the cyclic pressure loading defined in Table 1626.

1626.3.6.1 If external protection devices are employed to protect windows, doors or skylights, they must resist the small missile impacts specified in Sections 1626.3.3 and 1626.3.4 without deformations that result in contact with the windows, glass, doors or skylights they are intended to protect.

1626.3.6.2 If external protection devices are not designed to be air tight, following the small missile impact test, they must resist an application of force corresponding to those listed in Table 1625.4 (fatigue load testing) without detaching from their mountings. The acting pressure cycles shall be simulated with loads applied through a mechanical system attached to the shutter specimen to apply uniformly around the shutter perimeter a force equal to the product of the required pressure and the area of the shutter specimen.

1626.3.7 If air leakage through the test specimen is excessive, tape may be used to cover any cracks and joints through which leakage is occurring. Tape shall not be used when there is a probability that it may significantly restrict differential movement between adjoining members. It is also permissible to cover both sides of the entire specimen and mounting panel with a single thickness of polyethylene film no thicker than 0.050 mm (2 mils). The technique of application is important for the full load to be transferred to the specimen and to insure the membrane does not prevent movement or failure of the specimen. Apply the film loosely with extra folds of material at each corner and at all offsets and recesses. When the load is applied, there shall be no fillet caused by tightness of plastic film.

1626.3.8 A particular system of construction shall be deemed to comply with this test if three test specimens reject the small missile impacts without penetration and resist the cyclic pressure loading with no crack forming longer than 5 inches (127 mm) and $1/16$ inch (1.6 mm) in width through which air can pass.

1626.3.9 If only one of the three test specimens in a test fails to meet the above listed criteria, one retest of the system (another test sequence with three specimens) of construction shall be permitted.

1626.4 Construction assemblies deemed to comply with Section 1626.

1. Exterior concrete masonry walls of minimum nominal 8-inch (203 mm) thickness, constructed in accordance with Chapter 21 (High-Velocity Hurricane Zones) of this code.
2. Exterior frame walls or gable ends constructed in accordance with Chapter 22 and Chapter 23 (High-Velocity Hurricane Zones) of this code, sheathed with a minimum $19/32$ -inch (15 mm) CD exposure 1 plywood and clad with wire lath and stucco installed in accordance with Chapter 25 of this code.
3. Exterior frame walls and roofs constructed in accordance with Chapter 22 (High-Velocity Hurricane Zones) of

this code sheathed with a minimum 24-gage rib deck type material and clad with an approved wall finish.

4. Exterior reinforced concrete elements constructed of solid normal weight concrete (no voids), designed in accordance with Chapter 19 (High-Velocity Hurricane Zones) of this code and having a minimum 2-in. (51 mm) thickness.
5. Roof systems constructed in accordance with Chapter 22 or Chapter 23 (High-Velocity Hurricane Zones) of this code, sheathed with a minimum $1\frac{9}{32}$ -inch (15 mm) CD exposure 1 plywood or minimum nominal 1-inch (25 mm) wood decking and surfaced with an approved roof system installed in accordance with Chapter 15 of this code.

All connectors shall be specified by the building designer of record for all loads except impact.

