Chapter 6
WIND LOADS

6.1 GENERAL

6.1.1 Scope. Buildings and other structures, including the Main Wind-Force Resisting System (MWFRS) and all components and cladding thereof, shall be designed and constructed to resist wind loads as specified herein.

6.1.2 Allowed Procedures. The design wind loads for buildings and other structures, including the MWFRS and component and cladding elements thereof, shall be determined using one of the following procedures: (1) Method 1—Simplified Procedure as specified in Section 6.4 for buildings meeting the requirements specified therein; (2) Method 2—Analytical Procedure as specified in Section 6.5 for buildings meeting the requirements specified therein; (3) Method 3—Wind Tunnel Procedure as specified in Section 6.6.

6.1.3 Wind Pressures Acting on Opposite Faces of Each Building Surface. In the calculation of design wind loads for the MWFRS and for components and cladding for buildings, the algebraic sum of the pressures acting on opposite faces of each building surface shall be taken into account.

6.1.4 Minimum Design Wind Loading. The design wind load, determined by any one of the procedures specified in Section 6.1.2, shall be no less than specified in this section.

6.1.4.1 Main Wind-Force Resisting System. The wind load to be used in the design of the MWFRS for an enclosed or partially enclosed building or other structure shall not be less than 10 lb/ft² (0.48 kN/m²) multiplied by the area of the building or structure projected onto a vertical plane normal to the assumed wind direction. The design wind force for open buildings and other structures shall not be less than 10 lb/ft² (0.48 kN/m²) multiplied by the area Az.

6.1.4.2 Components and Cladding. The design wind pressure for components and cladding of buildings shall not be less than 10 lb/ft² (0.48 kN/m²) acting in any direction normal to the surface.

6.2 DEFINITIONS

The following definitions apply only to the provisions of Chapter 6.

APPROVED: Acceptable to the authority having jurisdiction.

BASIC WIND SPEED, \( V_b \): Three-second gust speed at 33 ft (10 m) above the ground in Exposure C (see Section 6.5.6.3) as determined in accordance with Section 6.5.4.

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

BUILDING ENVELOPE: Cladding, roofing, exterior walls, glazing, door assemblies, window assemblies, skylight assemblies, and other components enclosing the building.

BUILDING AND OTHER STRUCTURE, FLEXIBLE: Slender buildings and other structures that have a fundamental natural frequency less than 1 Hz.

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

1. Mean roof height \( h \) less than or equal to 60 ft (18 m).
2. Mean roof height \( h \) does not exceed 40 percent horizontal dimension.

BUILDING, OPEN: A building having each wall at least 80 percent open. This condition is expressed for each wall by the equation \( A_b \geq 0.8A_e \), where

\[ A_b = \text{total area of openings in a wall that receives positive external pressure, in ft}^2 \]

\[ A_e = \text{the gross area of that wall in which } A_b \text{ is identified, in ft}^2 \]

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

1. The total area of openings in a wall that receives positive external pressure exceeds the sum of the areas of openings in the balance of the building envelope (walls and roof) by more than 10 percent.
2. The total area of openings in a wall that receives positive external pressure exceeds 4 ft² (0.37 m²) or 1 percent of the area of that wall, whichever is smaller, and the percentage of openings in the balance of the building envelope does not exceed 20 percent.

These conditions are expressed by the following equations:

\[ A_o > 1.10A_d \]

\[ A_o > 4 \text{ sq ft (0.37 m²) or } 0.01A_e, \text{ whichever is smaller, and } A_d/A_o < 0.20 \]

where

\( A_v, A_o \) are as defined for Open Building

\( A_p = \text{the sum of the areas of openings in the building envelope (walls and roof) not including } A_o, \text{ in ft}^2 \)

\( A_d = \text{the sum of the gross surface areas of the building envelope (walls and roof) not including } A_o, \text{ in ft}^2 \)

BUILDING OR OTHER STRUCTURE, REGULAR-SHAPED: A building or other structure having no unusual geometrical irregularity in spatial form.

BUILDING OR OTHER STRUCTURES, RIGID: A building or other structure whose fundamental frequency is greater than or equal to 1 Hz.

BUILDING, SIMPLE DIAPHRAGM: A building in which both windward and leeward wind loads are transmitted through floor and roof diaphragms to the same vertical MWFRS (e.g., no structural separations).

COMPONENTS AND CLADDING: Elements of the building envelope that do not qualify as part of the MWFRS.
DESIGN FORCE, \( F \): Equivalent static force to be used in the determination of wind loads for open buildings and other structures.

DESIGN PRESSURE, \( p \): Equivalent static pressure to be used in the determination of wind loads for buildings.

EAVE HEIGHT, \( h \): The distance from the ground surface adjacent to the building to the roof eave line at a particular wall. If the height of the eave varies along the wall, the average height shall be used.

EFFECTIVE WIND AREA, \( A \): The area used to determine \( GC_p \). For component and cladding elements, the effective wind area in Figs. 6-13 through 6-17 and Fig. 6-19 is the span length multiplied by an effective width that need not be less than one-third the span length. For cladding fasteners, the effective wind area shall not be greater than the area that is tributary to an individual fastener.

ESCARPMENT: Also known as escarp, with respect to topography, refers to the steep slope generally separating two levels or gently sloping areas (see Fig. 6-4).

FREE ROOF: Roof with a configuration generally conforming to those shown in Figs. 6-18A through 6-18D (monoslope, pitched, or sloping) in an open building with no enclosing walls underneath the roof surface.

GLAZING: Glass or transparent or translucent plastic sheet used in windows, doors, skylights, or curtain walls.

GLAZING, IMPACT RESISTANT: Glazing that has been shown by testing in accordance with ASTM E1886 and ASTM E1996 or other approved test methods to withstand the impact of wind-borne missiles likely to be generated in wind-borne debris regions during design winds.

HILL: With respect to topographic effects in Section 6.5.7, a land surface characterized by strong relief in any horizontal direction (see Fig. 6-4).

HURRICANE PRONE REGIONS: Areas vulnerable to hurricanes; in the United States and its territories defined as:
1. The U.S. Atlantic Ocean and Gulf of Mexico coasts where the basic wind speed is greater than 90 mph, and
2. Hawaii, Puerto Rico, Guam, Virgin Islands, and American Samoa.

IMPACT RESISTANT COVERING: A covering designed to protect glazing, which has been shown by testing in accordance with ASTM E1886 and ASTM E1996 or other approved test methods to withstand the impact of wind-borne debris missiles likely to be generated in wind-borne debris regions during design winds.

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

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

MEAN ROOF HEIGHT, \( h \): The average of the roof eave height and the height to the highest point on the roof surface, except that, for roof area of less than or equal to \( 10^4 \), the mean roof height shall be the roof eave height.

OPENINGS: Apertures or holes in the building envelope that allow air to flow through the building envelope and that are designed as "open" during design winds as defined by these provisions.

RECOGNIZED LITERATURE: Published research findings and technical papers that are approved.

RIDGE: With respect to topographic effects in Section 6.5.7, an elongated crest of a hill characterized by strong relief in two directions (see Fig. 6-4).

WIND-BORNE DEBRIS REGIONS: Areas within hurricane prone regions located:
1. Within 1 mile of the coastal mean high water line where the basic wind speed is equal to or greater than 110 mph and in Hawaii, or
2. In areas where the basic wind speed is equal to or greater than 120 mph.

6.3 SYMBOLS AND NOTATION
The following symbols and notation apply only to the provisions of Chapter 6:

\[ A = \text{effective wind area, in} \cdot \text{ft}^2 \text{ (m}^2) \]
\[ A_f = \text{area of open buildings and other structures either normal to the wind direction or projected on a plane normal to the wind direction, in} \cdot \text{ft}^2 \text{ (m}^2) \]
\[ A_s = \text{the gross area of that wall in which} \ A_s \text{is identified, in} \cdot \text{ft}^2 \text{ (m}^2) \]
\[ A_G = \text{the sum of the gross surface areas of the building envelope (walls and roof) not including} \ A_s, \text{in} \cdot \text{ft}^2 \text{ (m}^2) \]
\[ A_{o} = \text{total area of openings in a wall that receives positive external pressure, in} \cdot \text{ft}^2 \text{ (m}^2) \]
\[ A_{o} = \text{the sum of the areas of openings in the building envelope (walls and roof) not including} \ A_s, \text{in} \cdot \text{ft}^2 \text{ (m}^2) \]
\[ \frac{A_{o}}{A_G} = \text{total area of openings in the building envelope in} \cdot \text{ft}^2 \text{ (m}^2) \]
\[ A_f = \text{gross area of the solid freestanding wall or solid sign, in} \cdot \text{ft}^2 \text{ (m}^2) \]
\[ a = \text{width of pressure coefficient zone, in ft (m)} \]
\[ B = \text{horizontal dimension of building measured normal to wind direction, in ft (m)} \]
\[ \overline{b} = \text{mean hourly wind speed factor in Eq. 6-14 from Table 6-2} \]
\[ b = 3-a \text{ gust speed factor from Table 6-2} \]
\[ C_f = \text{force coefficient to be used in determination of wind loads for open buildings} \]
\[ C_p = \text{net pressure coefficient to be used in determination of wind loads for open buildings} \]
\[ c = \text{external pressure coefficient to be used in determination of wind loads for buildings} \]
\[ c_t = \text{turbulence intensity factor in Eq. 6-5 from Table 6-2} \]
\[ D = \text{diameter of a circular structure or member, in ft (m)} \]
\[ D_p = \text{depth of protruding elements such as ribs and spacers, in ft (m)} \]
\[ F = \text{design wind force for other structures, in lb (N)} \]
\[ G = \text{gust effect factor} \]
\[ G_s = \text{gust effect factor for MWFRSs of flexible buildings and other structures} \]
\[ GC_f = \text{combined net pressure coefficient for a pampet} \]
\[ GC_p = \text{product of external pressure coefficient and gust effect factor to be used in determination of wind loads for buildings} \]
Minimum Design Loads for Buildings and Other Structures

6.4 METHOD 1—SIMPLIFIED PROCEDURE

6.4.1 Scope. A building whose design wind loads are determined in accordance with this section shall meet all the conditions of
6.4.1.1 or 6.4.1.2. If a building qualifies only under 6.4.1.2 for design of its components and cladding, then its MWFRS shall be designed by Method 2 or Method 3.

6.4.1.1 Main Wind-Force Resisting Systems. For the design of MWFRSs the building must meet all of the following conditions:
1. The building is a simple diaphragm building as defined in Section 6.2.
2. The building is a low-rise building as defined in Section 6.2.
3. The building is enclosed as defined in Section 6.2 and conforms to the wind-borne debris provisions of Section 6.5.9.3.
4. The building is a regular-shaped building or structure as defined in Section 6.2.
5. The building is not classified as a flexible building as defined in Section 6.2.
6. The building does not have response characteristics making it subject to crosswind loading, vortex shedding, instability due to galloping or flutter, and does not have a site location for which channeling effects or buffering in the wake of upward obstructions warrant special consideration.
7. The building has an approximately symmetrical cross-section in each direction with either a flat roof or a gable or hip roof with \( \theta \leq 45^\circ \).
8. The building is exempted from torsional load cases as indicated in Note 5 of Fig. 6-10, or the torsional load cases defined in Note 5 do not control the design of any of the MWFRS of the building.

6.4.1.2 Components and Cladding. For the design of components and cladding the building must meet all the following conditions:
1. The mean roof height \( h \) must be less than or equal to 60 ft \((h \leq 60\, \text{ft})\).
2. The building is enclosed as defined in Section 6.2 and conforms to the wind-borne debris provisions of Section 6.5.9.3.
3. The building is a regular-shaped building or structure as defined in Section 6.2.
4. The building does not have response characteristics making it subject to crosswind loading, vortex shedding, instability due to galloping or flutter; and does not have a site location for which channeling effects or buffering in the wake of upward obstructions warrant special consideration.
5. The building has either a flat roof, a gable roof with \( \theta \leq 45^\circ \), or a hip roof with \( \theta \leq 27^\circ \).

6.4.2 Design Procedure.
1. The basic wind speed \( V \) shall be determined in accordance with Section 6.5.4. The wind shall be assumed to come from any horizontal direction.
2. An importance factor \( I \) shall be determined in accordance with Section 6.5.5.
3. An exposure category shall be determined in accordance with Section 6.5.6.
4. A height and exposure adjustment coefficient, \( \lambda \), shall be determined from Fig. 6-2.

6.4.2.1 Main Wind-Force Resisting System. Simplified design wind pressures, \( p_{e} \), for the MWFRS of low-rise simple diaphragm buildings represent the net pressures (sum of internal and external) to be applied to the horizontal and vertical projections of building surfaces as shown in Fig. 6-2. For the horizontal pressures (zones A, B, C, D), \( p_{h} \) is the combination of the windward and leeward net pressures. \( p_{h} \) shall be determined by the following equation:

\[
p_{h} = \lambda K_{a} \text{net} p_{50}
\]

where
\( \lambda = \) adjustment factor for building height and exposure from Fig. 6-2
\( K_{a} = \) topographic factor as defined in Section 6.5.7 evaluated at mean roof height, \( h \)
\( I = \) importance factor as defined in Section 6.2
\( p_{50} = \) simplified design wind pressure for Exposure B, at \( h = 30 \text{ ft} \), and for \( I = 1.0 \), from Fig. 6-2

6.4.2.1.1 Minimum Pressures. The load effects of the design wind pressures from Section 6.4.2.1 shall not be less than the minimum load case from Section 6.1.4.1 assuming the pressures, \( p_{e} \), for zones A, B, C, and D all equal to +10 psf, while assuming zones E, F, G, and H all equal to 0 psf.

6.4.2.2 Components and Cladding. For the components and cladding of buildings designed using Method 1 represent the net pressures (sum of internal and external) to be applied normal to each building surface as shown in Fig. 6-3. \( p_{e} \), shall be determined by the following equation:

\[
p_{e} = \lambda K_{a} I p_{50}\text{net}
\]

where
\( \lambda = \) adjustment factor for building height and exposure from Fig. 6-2
\( K_{a} = \) topographic factor as defined in Section 6.5.7 evaluated at mean roof height, \( h \)
\( I = \) importance factor as defined in Section 6.2
\( p_{50}\text{net} = \) net design wind pressure for exposure B, at \( h = 30 \text{ ft} \), and for \( I = 1.0 \), from Fig. 6-3

6.4.2.2.1 Minimum Pressures. The positive design wind pressures, \( p_{e} \), from Section 6.4.2.2 shall not be less than +10 psf, and the negative design wind pressures, \( p_{e} \), from Section 6.4.2.2 shall not be less than –10 psf.

6.4.3 Air Permeable Cladding. Design wind loads determined from Fig. 6-3 shall be used for all air permeable cladding unless approved test data or the recognized literature demonstrate lower loads for the type of air permeable cladding being considered.

6.5 METHOD 2—ANALYTICAL PROCEDURE

6.5.1 Scope. A building or other structure whose design wind loads are determined in accordance with this section shall meet all of the following conditions:
1. The building or other structure is a regular-shaped building or structure as defined in Section 6.2.
2. The building or other structure does not have response characteristics making it subject to crosswind loading, vortex shedding, instability due to galloping or flutter; and does not have a site location for which channeling effects or buffering in the wake of upward obstructions warrant special consideration.

6.5.2 Limitations. The provisions of Section 6.5 take into consideration the load magnification effect caused by gussets in resonance with alongwind vibrations of flexible buildings or other structures. Buildings or other structures not meeting the requirements of Section 6.5.1, or having unusual shapes or response
characteristics, shall be designed using recognized literature documenting such wind load effects or shall use the wind tunnel procedure specified in Section 6.6.

6.5.2.1 Shielding. There shall be no reductions in velocity pressure due to apparent shielding afforded by buildings and other structures or terrain features.

6.5.2.2 Air Permeable Cladding. Design wind loads determined from Section 6.5 shall be used for air permeable cladding unless approved test data or recognized literature demonstrate lower loads for the type of air permeable cladding being considered.

6.5.3 Design Procedure.

1. **The basic wind speed** $V$ and wind directionality factor $K_d$ shall be determined in accordance with Section 6.5.4.

2. An *importance factor* $I$ shall be determined in accordance with Section 6.5.5.

3. An *exposure category or exposure categories and velocity pressure exposure coefficients* $K_v$, or $K_{vp}$, as applicable, shall be determined for each wind direction in accordance with Section 6.5.6.

4. A *topographic factor* $K_t$ shall be determined in accordance with Section 6.5.7.

5. A *gear effect factor* $G$ or $G_p$, as applicable, shall be determined in accordance with Section 6.5.8.

6. An *enclosure classification shall be determined in accordance with Section 6.5.9.*

7. *Internal pressure coefficients* $C_{pi}$ shall be determined in accordance with Section 6.5.11.1.

8. *External pressure coefficients* $C_p$, or $C_{pe}$, or *force coefficients* $C_f$, as applicable, shall be determined in accordance with Section 6.5.11.2 or 6.5.11.3, respectively.

9. *Velocity pressure* $q$, or $q_p$, as applicable, shall be determined in accordance with Section 6.5.10.

10. **Design wind load** $p$ or $F$ shall be determined in accordance with Sections 6.5.12, 6.5.13, 6.5.14, and 6.5.15, as applicable.

6.5.4 Basic Wind Speed. The basic wind speed, $V$, used in the determination of design wind loads on buildings and other structures shall be as given in Fig. 6-1 except as provided in Sections 6.5.4.1 and 6.5.4.2. The wind shall be assumed to come from any horizontal direction.

6.5.4.1 Special Wind Regions. The basic wind speed shall be increased where records or experience indicate that the wind speeds are higher than those reflected in Fig. 6-1. Mountainous terrain, passages, and special regions shown in Fig. 6-1 shall be examined for unusual wind conditions. The authority having jurisdiction shall, if necessary, adjust the values given in Fig. 6-1 to account for higher local wind speeds. Such adjustment shall be based on meteorological information and an estimate of the basic wind speed obtained in accordance with the provisions of Section 6.5.4.2.

6.5.4.2 Estimation of Basic Wind Speeds from Regional Climatic Data. In areas outside hurricane-prone regions, regional climatic data shall only be used in lieu of the basic wind speeds given in Fig. 6-1 when (1) approved extreme-value statistical-analysis procedures have been employed in reducing the data, and (2) the length of record, sampling error, averaging time, anemometer height, data quality, and terrain exposure of the anemometer have been taken into account. Reduction in basic wind speed below that of Fig. 6-1 shall be permitted.

In hurricane-prone regions, wind speeds derived from simulation techniques shall only be used in lieu of the basic wind speeds given in Fig. 6-1 when (1) approved simulation and extreme-value statistical analysis procedures are used (the use of regional wind speed data obtained from anemometers is not permitted to define the hurricane wind-speed risk along the Gulf and Atlantic coasts, the Caribbean, or Hawaii) and (2) the design wind speeds resulting from the studies shall not be less than the resulting 50-year return period wind speed divided by $\sqrt{5}$.

In areas outside hurricane-prone regions, when the basic wind speed is estimated from regional climatic data, the basic wind speed shall not be less than the wind speed associated with an annual probability of 0.02 (50-year mean recurrence interval), and the estimate shall be adjusted for equivalence to a 3-s gust wind speed at 33 ft (10 m) above ground in exposure Category C. The data analysis shall be performed in accordance with this chapter.

6.5.4.3 Limitation. Tornadoes have not been considered in developing the basic wind-speed distributions.

6.5.4.4 Wind Directionality Factor. The wind directionality factor, $K_d$, shall be determined from Table 6-4. This factor shall only be applied when used in conjunction with load combinations specified in Sections 2.3 and 2.4.

6.5.5 Importance Factor. An importance factor, $I$, for the building or other structure shall be determined from Table 6-1 based on building and structure categories listed in Table 6-1.

6.5.6 Exposure. For each wind direction considered, the upward exposure category shall be based on ground surface roughness that is determined from natural topography, vegetation, and constructed facilities.

6.5.6.1 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° either side of the selected wind direction. The exposures in these two sectors shall be determined in accordance with Sections 6.5.6.2 and 6.5.6.3 and the exposure resulting in the highest wind loads shall be used to represent the winds from that direction.

6.5.6.2 Surface Roughness Categories. A ground surface roughness within each 45° sector shall be determined for a distance upward of the site as defined in Section 6.5.6.3 from the categories defined in the following text, for the purpose of assigning an exposure category as defined in Section 6.5.6.3.

- **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 ft (9.1 m). This category includes flat open country, grasslands, and all water surfaces in hurricane-prone regions.
- **Surface Roughness D**: Flat, unobstructed areas and water surfaces outside hurricane-prone regions. This category includes smooth mud flats, salt flats, and unbroken ice.

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

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 greater than 5,000 ft (1,524 m) or 20 times the building height, whichever is greater. Exposure D shall also extend into downwind areas of Surface Roughness B or C for a distance of 600 ft (200 m) or 20 times the height of the building, whichever is greater.

For a site located in the transition zone between exposure categories, the category resulting in the largest wind forces shall be used.

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

6.5.6.4 Exposure Category for Main Wind-Force Resisting System.

6.5.6.4.1 Buildings and Other Structures. For each wind direction considered, wind loads for the design of the MWFRS determined from Table 6-6 shall be based on the exposure categories defined in Section 6.5.6.3.

6.5.6.4.2 Low-Rise Buildings. Wind loads for the design of the MWFRS for low-rise buildings shall be determined using a velocity pressure \( q_v \) based on the exposure resulting in the highest wind loads for any wind direction at the site where external pressure coefficients \( C_{pE} \) given in Fig. 6-10 are used.

6.5.6.5 Exposure Category for Components and Cladding. Components and cladding design pressures for all buildings and other structures shall be based on the exposure resulting in the highest wind loads for any direction at the site.

6.5.6.6 Velocity Pressure Exposure Coefficient. Based on the exposure category determined in Section 6.5.6.3, a velocity pressure exposure coefficient \( K_v \) or \( K_a \), as applicable, shall be determined from Table 6-3. For a site located in a transition zone between exposure categories, that is, near to a change in ground surface roughness, intermediate values of \( K_v \) or \( K_a \), between those shown in Table 6-3, are permitted, provided that they are determined by a rational analysis method defined in the recognized literature.

6.5.7 Topographic Effects.

6.5.7.1 Wind Speed-Up over Hills, Ridges, and Escarpments. Wind speed-up effects at isolated hills, ridges, and escarpments constituting abrupt changes in the general topography, located in any exposure category, shall be included in the design when buildings and other site conditions and locations of structures meet all of the following conditions:

1. The hill, ridge, or escarpment is isolated and unobstructed upwind by other similar topographic features of comparable height for 100 times the height of the topographic feature (100H) or 2 mi (3.22 km), whichever is less. This distance shall be measured horizontally from the point at which the height \( H \) of the hill, ridge, or escarpment is determined.

2. The hill, ridge, or escarpment protrudes above the height of upwind terrain features within a 2-rci (3.22 km) radius in any quadrant by a factor of two or more.

3. The structure is located as shown in Fig. 6-4 in the upper one-half of a hill or ridge or near the crest of an escarpment.

4. \( H/2\sigma_0 \leq 0.2 \).

5. \( H \) is greater than or equal to 15 ft (4.5 m) for Exposures C and D and 60 ft (18 m) for Exposure B.

6.5.7.2 Topographic Factor. The wind speed-up effect shall be included in the calculation of design wind loads by using the factor \( K_s \):

\[
K_s = (1 + K_v K_a K_r)^2
\]

(6-3)

where \( K_v, K_a, \) and \( K_r \) are given in Fig. 6-4.

If site conditions and locations of structures do not meet all the conditions specified in Section 6.5.7.1 then \( K_s = 1.0 \).

6.5.8 Gust Effect Factor.

6.5.8.1 Rigid Structures. For rigid structures as defined in Section 6.2, the gust-effect factor shall be taken as 0.85 or calculated by the formula:

\[
G = 0.925 \left( \frac{1 + 1.7q_v I_1 Q}{1 + 1.7q_v I_2} \right)
\]

(6-4)

\[
I_1 = \epsilon \left( \frac{33}{2} \right)^{1/6}
\]

(6-5)

In SI:

\[
I_1 = \epsilon \left( \frac{10}{2} \right)^{1/6}
\]

where \( I_1 \) is the intensity of turbulence at height \( z \) where \( z = \) the equivalent height of the structure defined as 0.6H, but not less than 2\( z_{ref} \) for all building heights \( h, z_{ref} \), and \( \epsilon \) are listed for each exposure in Table 6-2. \( q_v \) and \( \epsilon \) shall be taken as 3.4. The background response \( G \) is given by

\[
G = \frac{1}{1 + 0.63 \left( \frac{B + h}{L_5} \right)^{0.85}}
\]

(6-6)

where \( B, h \) are defined in Section 6.3; and \( L_5 = \) the integral length scale of turbulence at the equivalent height given by

\[
L_5 \geq \left( \frac{z}{33} \right)^{1/3}
\]

(6-7)

In SI:

\[
L_5 \geq \left( \frac{z}{10} \right)^{1/3}
\]

(6-7)

where \( \epsilon \) and \( \tau \) are constants listed in Table 6-2.

6.5.8.2 Flexible or Dynamically Sensitive Structures. For flexible or dynamically sensitive structures as defined in Section 6.2, the gust-effect factor shall be calculated by

\[
G = 0.925 \left( \frac{1 + 1.7q_v g_s^2 + g_s R^2}{1 + 1.7q_v I_2} \right)
\]

(6-8)

\( g_s \) and \( g_s \) shall be taken as 3.4 and \( g_s \) is given by

\[
g_s = \sqrt{2 \ln(3.600m)} + 0.577
\]

(6-9)

\( R \), the resonant response factor, is given by

\[
R = \frac{1}{\sqrt{\beta R_s R_s (0.53 + 0.47R_s)}}
\]

(6-10)

\[
R_s = \frac{7.47 \epsilon_i}{(1 + 10.3 \epsilon_i)^{1/3}}
\]

(6-11)
Notes:
1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure C category.
2. Linear interpolation between wind 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.

FIGURE 8-1 continued
BASIC WIND SPEED
Main Wind Force Resisting System – Method 1

Figure 6-2  Design Wind Pressures

Enclosed Buildings

Walls & Roofs

Notes:
1. Pressures shown are applied to the horizontal and vertical projections, for exposure B, at h=30 ft (9.14m), l=1.0, and K_a = 1.0. Adjust to other conditions using Equation 6-1.
2. The load patterns shown shall be applied to each corner of the building in turn as the reference corner. (See Figure 6-10)
3. For the design of the longitudinal M/WFRS use \( \theta = 0^\circ \), and locate the zero LEP/GHP boundary at the mid-length of the building.
4. Load cases 1 and 2 must be checked for \( 25^\circ < \theta < 45^\circ \). Load case 2 at \( 25^\circ \) is provided only for interpolation between \( 25^\circ \) to \( 30^\circ \).
5. Plus and minus signs signify pressures acting toward and away from the projected surfaces, respectively.
6. For roof slopes other than those shown, linear interpolation is permitted.
7. The total horizontal load shall not be less than that determined by assuming \( p_e = 0 \) in zones B & D.
8. The zone pressures represent the following:
   - Horizontal pressure zones = sum of the windward and leeward net (sum of internal and external) pressures on vertical projection of:
     - A – End zone of wall
     - B – End zone of roof
     - C – Interior zone of wall
     - D – Interior zone of roof
   - Vertical pressure zones = Net (sum of internal and external) pressures on horizontal projection of:
     - E – End zone of windward roof
     - F – End zone of leeward roof
     - G – Interior zone of windward roof
     - H – Interior zone of leeward roof
9. Where zone E or G falls on a roof overhang on the windward side of the building, use \( E_{(1)} \) and \( E_{(2)} \) for the pressure on the horizontal projection of the overhang. Overhangs on the leeward and side edges shall have the basic zone pressure applied.
10. Notations:
    - a: 10 percent of least horizontal dimension or 8 ft, whichever is smaller, but not less than either 4% of least horizontal dimension or 6 ft (0.9m).
    - b: Mean roof height, in feet (metres), except that eave height shall be used for roof angles <10°.
    - \( \theta \): Angle of plane of roof from horizontal, in degrees.

Minimum Design Loads for Buildings and Other Structures 37
<table>
<thead>
<tr>
<th>Basic Wind Speed (mph)</th>
<th>Roof Angle (degrees)</th>
<th>Load Class</th>
<th>Zones</th>
<th>Horizontal Pressure</th>
<th>Vertical Pressure</th>
<th>Overhangs</th>
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</thead>
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Unit Conversions: 1.0 ft = 0.3048 m; 1.0 psf = 0.0479 kN/m²
### Simplified Design Wind Pressure, \( p_{d,s} \) (psf)

#### Exposure B at \( h = 30 \) ft, \( K_v = 1.0, \) with \( f = 1.0 \)

<table>
<thead>
<tr>
<th>Zones</th>
<th>Horizontal Pressures</th>
<th>Vertical Pressures</th>
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**Unit Conversions:** 1.0 ft = 0.3048 m; 1.0 psf = 0.0479 kN/m²

**Minimum Design Loads for Buildings and Other Structures**
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<th>Exposure</th>
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EXPOSURE B: SUBURBAN RESIDENTIAL AREA WITH MOSTLY SINGLE-FAMILY DWELLINGS, LOW-RISE STRUCTURES, LESS THAN 50 FT (15.2 M) HIGH, IN THE CENTER OF THE PHOTOGRAPH HAVE SITES DESIGNATED AS EXPOSURE B WITH SURFACE ROUGHNESS CATEGORY B TERRAIN AROUND THE SITE FOR A DISTANCE GREATER THAN 1500 FT (457 M) IN ANY WIND DIRECTION.

EXPOSURE B: URBAN AREA WITH NUMEROUS CLOSELY SPACED OBSTRUCTIONS HAVING SIZE OF SINGLE FAMILY DWELLINGS OR LARGER, FOR ALL STRUCTURES SHOWN, TERRAIN REPRESENTATIVE OF SURFACE ROUGHNESS CATEGORY B EXTENDS MORE THAN TWENTY TIMES THE HEIGHT OF THE STRUCTURE OR 2000 FT (600 M), WHICHEVER IS GREATER, IN THE UPWIND DIRECTION.
EXPOSURE B STRUCTURES IN THE FOREGROUND ARE LOCATED IN EXPOSURE B. STRUCTURES IN THE CENTER TOP OF THE PHOTOGRAPH ADJACENT TO THE CLEARING TO THE LEFT, WHICH IS GREATER THAN APPROXIMATELY 698 FT (200 M) IN LENGTH, ARE LOCATED IN EXPOSURE C WHEN WIND COMES FROM THE LEFT OVER THE CLEARING. (SEE FIGURE C6-B.)

EXPOSURE C FLAT OPEN GRASSLAND WITH SCATTERED OBSTRUCTIONS HAVING HEIGHTS GENERALLY LESS THAN 30 FT.
EXPOSURE C: OPEN TERRAIN WITH SCATTERED OBSTRUCTIONS HAVING HEIGHTS
GENERALLY LESS THAN 30 FT FOR MOST WIND DIRECTIONS. ALL 1-STORY STRUCTURES
WITH A MEAN ROOF HEIGHT LESS THAN 30 FT IN THE PHOTOGRAPH ARE LESS THAN 1500
FT OR TEN TIMES THE HEIGHT OF THE STRUCTURE, WHICHEVER IS GREATER, FROM AN
OPEN FIELD THAT PREVENTS THE USE OF EXPOSURE B.

EXPOSURE D: A BUILDING AT THE SHORELINE (EXCLUDING SHORELINES
IN HURRICANE-PRONE REGIONS) WITH WIND FLOWING OVER OPEN WATER FOR A
DISTANCE OF AT LEAST 1 MILE. SHORELINES IN EXPOSURE D INCLUDE INLAND
WATERSHEDS, THE GREAT LAKES, AND COASTAL AREAS OF CALIFORNIA, OREGON,
WASHINGTON, AND ALASKA.
## Importance Factor, I (Wind Loads)

### Table 6-1

<table>
<thead>
<tr>
<th>Category</th>
<th>Non-Hurricane Prone Regions and Hurricane Prone Regions with V = 85-100 mph and Alaska</th>
<th>Hurricane Prone Regions with V &gt; 100 mph</th>
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</tr>
<tr>
<td>IV</td>
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</tbody>
</table>

**Note:**

1. The building and structure classification categories are listed in Table 1-1.
### 1.7 LOAD TESTS

A load test of any construction shall be conducted when required by the authority having jurisdiction whenever there is reason to question its safety for the intended occupancy or use.

### 1.8 CONSENSUS STANDARDS AND OTHER REFERENCED DOCUMENTS

This section lists the consensus standards and other documents which are adopted by reference within this chapter:

<table>
<thead>
<tr>
<th>TABLE 1-1 OCCUPANCY CATEGORY OF BUILDINGS AND OTHER STRUCTURES FOR FLOOD, WIND, SNOW, EARTHQUAKE, AND ICE LOADS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of Occupancy</td>
</tr>
<tr>
<td>Buildings and other structures that represent a low hazard to human life in the event of failure, including, but not limited to:</td>
</tr>
<tr>
<td>• Agricultural facilities</td>
</tr>
<tr>
<td>• Certain temporary facilities</td>
</tr>
<tr>
<td>• Minor storage facilities</td>
</tr>
<tr>
<td>All buildings and other structures except those listed in Occupancy Categories I, III, and IV</td>
</tr>
<tr>
<td>Buildings and other structures that represent a substantial hazard to human life in the event of failure, including, but not limited to:</td>
</tr>
<tr>
<td>• Buildings and other structures where more than 300 people congregate in one area</td>
</tr>
<tr>
<td>• Buildings and other structures with daycare facilities with a capacity greater than 150</td>
</tr>
<tr>
<td>• Buildings and other structures with elementary school or secondary school facilities with a capacity greater than 250</td>
</tr>
<tr>
<td>• Buildings and other structures with a capacity greater than 50 for colleges or adult education facilities</td>
</tr>
<tr>
<td>• Health care facilities with a capacity of 50 or more resident patients, but not having surgery or emergency treatment facilities</td>
</tr>
<tr>
<td>• Jails and detention facilities</td>
</tr>
<tr>
<td>Buildings and other structures, not included in Occupancy Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure, including, but not limited to:</td>
</tr>
<tr>
<td>• Power generating stations*</td>
</tr>
<tr>
<td>• Water treatment facilities</td>
</tr>
<tr>
<td>• Sewage treatment facilities</td>
</tr>
<tr>
<td>• Telecommunication centers</td>
</tr>
<tr>
<td>Buildings and other structures not included in Occupancy Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released). Buildings and other structures containing toxic or explosive substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the toxic or explosive substances does not pose a threat to the public.</td>
</tr>
<tr>
<td>Buildings and other structures designated as essential facilities, including, but not limited to:</td>
</tr>
<tr>
<td>• Hospitals and other health care facilities having surgery or emergency treatment facilities</td>
</tr>
<tr>
<td>• Fire, rescue, ambulance, and police stations and emergency vehicle garages</td>
</tr>
<tr>
<td>• Designated earthquake, hurricane, or other emergency shelters</td>
</tr>
<tr>
<td>• Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response</td>
</tr>
<tr>
<td>• Power generating stations and other public utility facilities required in an emergency</td>
</tr>
<tr>
<td>• Auxiliary structures (including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire suppression material or equipment) required for operation of Occupancy Category IV structures during an emergency</td>
</tr>
<tr>
<td>• Aviation control towers, air traffic control centers, and emergency aircraft hangars</td>
</tr>
<tr>
<td>• Water storage facilities and pump structures required to maintain water pressure for fire suppression</td>
</tr>
<tr>
<td>• Buildings and other structures having critical national defense functions</td>
</tr>
<tr>
<td>Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous wastes containing highly toxic substances whose quantity of the material exceeds a threshold quantity established by the authority having jurisdiction). Buildings and other structures containing highly toxic substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the highly toxic substances does not pose a threat to the public. This reduced classification shall not be permitted if the buildings or other structures also function as essential facilities.</td>
</tr>
</tbody>
</table>

*Generation power plants that do not supply power on the national grid shall be designated Occupancy Category II.