CHAPTER 24
RESERVED FOR FUTURE PROVISIONS

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CHAPTER 25
RESERVED FOR FUTURE PROVISIONS

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CHAPTER 26
WIND LOADS: GENERAL REQUIREMENTS

26.1 PROCEDURES

26.1.1 Scope. Buildings and other structures, including the main wind force resisting system (MWFRS) and all components and cladding (C&C) thereof, shall be designed and constructed to resist the wind loads determined in accordance with Chapters 26 through 31. The provisions of this chapter define basic wind parameters for use with other provisions contained in this standard.

26.1.2 Permitted Procedures. The design wind loads for buildings and other structures, including the MWFRS and C&C elements thereof, shall be determined using one of the procedures as specified in this section. An outline of the overall process for the determination of the wind loads, including section references, is provided in Fig. 26.1-1.

26.1.2.1 Main Wind Force Resisting System. Wind loads for the MWFRS shall be determined using one of the following procedures:

1. Directional Procedure for buildings of all heights as specified in Chapter 27 for buildings meeting the requirements specified therein;
2. Envelope Procedure for low-rise buildings as specified in Chapter 28 for buildings meeting the requirements specified therein;
3. Directional Procedure for Building Appurtenances (rooftop structures and rooftop equipment) and Other Structures (such as solid freestanding walls and solid freestanding signs, chimneys, tanks, open signs, single-plane open frames, and trussed towers) as specified in Chapter 29; or
4. Wind Tunnel Procedure for all buildings and all other structures as specified in Chapter 31.

26.1.2.2 Components and Cladding. Wind loads on C&C on all buildings and other structures shall be designed using one of the following procedures:

1. Analytical Procedures provided in Parts 1 through 6, as appropriate, of Chapter 30; or
2. Wind Tunnel Procedure as specified in Chapter 31.

26.2 DEFINITIONS

The following definitions apply to the provisions of Chapters 26 through 31:

APPROVED: Acceptable to the Authority Having Jurisdiction.

ATTACHED CANOPY: A horizontal (maximum slope of 2%) patio cover attached to the building wall at any height; it is different from an overhang, which is an extension of the roof surface.

BASIC WIND SPEED, *V*: Three-second gust speed at 33 ft (10 m) above the ground in Exposure C (see Section 26.7.3) as determined in accordance with Section 26.5.1.

BUILDING, ENCLOSED: A building that has the total area of openings in each wall, that receives positive external pressure, less than or equal to 4 sq ft (0.37 m^2) or 1% of the area of that wall, whichever is smaller. This condition is expressed for each wall by the following equation:

$$A_o < 0.01A_g, \text{ or } 4 \text{ sq ft } (0.37 \text{ m}^2), \text{ whichever is smaller,}$$

where A_o and A_g are as defined for Open Buildings.

BUILDING, LOW-RISE: Enclosed or partially enclosed building that complies 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 least horizontal dimension.

BUILDING, OPEN: A building that has each wall at least 80% open. This condition is expressed for each wall by the equation $A_o \geq 0.8A_g$, where

A_o = total area of openings in a wall that receives positive external pressure, in ft^2 (m^2); and
A_g = the gross area of that wall in which A_o is identified, in ft^2 (m^2).

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

1. The total area of openings in a wall that receives positive external pressure exceeds the sum of the areas of openings in the balance of the building envelope (walls and roof) by more than 10%.
2. The total area of openings in a wall that receives positive external pressure exceeds 4 ft^2 (0.37 m^2) or 1% 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%.

These conditions are expressed by the following equations:

$$A_o > 1.10A_{oi}$$

$$A_o > 4 \text{ ft}^2 (0.37 \text{ m}^2) \text{ or}$$

$$> 0.01A_g, \text{ whichever is smaller, and } A_{oi}/A_{gi} \leq 0.20$$

where A_o and A_g are as defined for Open Building;

A_{oi} = sum of the areas of openings in the building envelope (walls and roof) not including A_o, in ft^2 (m^2); and
A_{gi} = sum of the gross surface areas of the building envelope (walls and roof) not including A_g, in ft^2 (m^2).

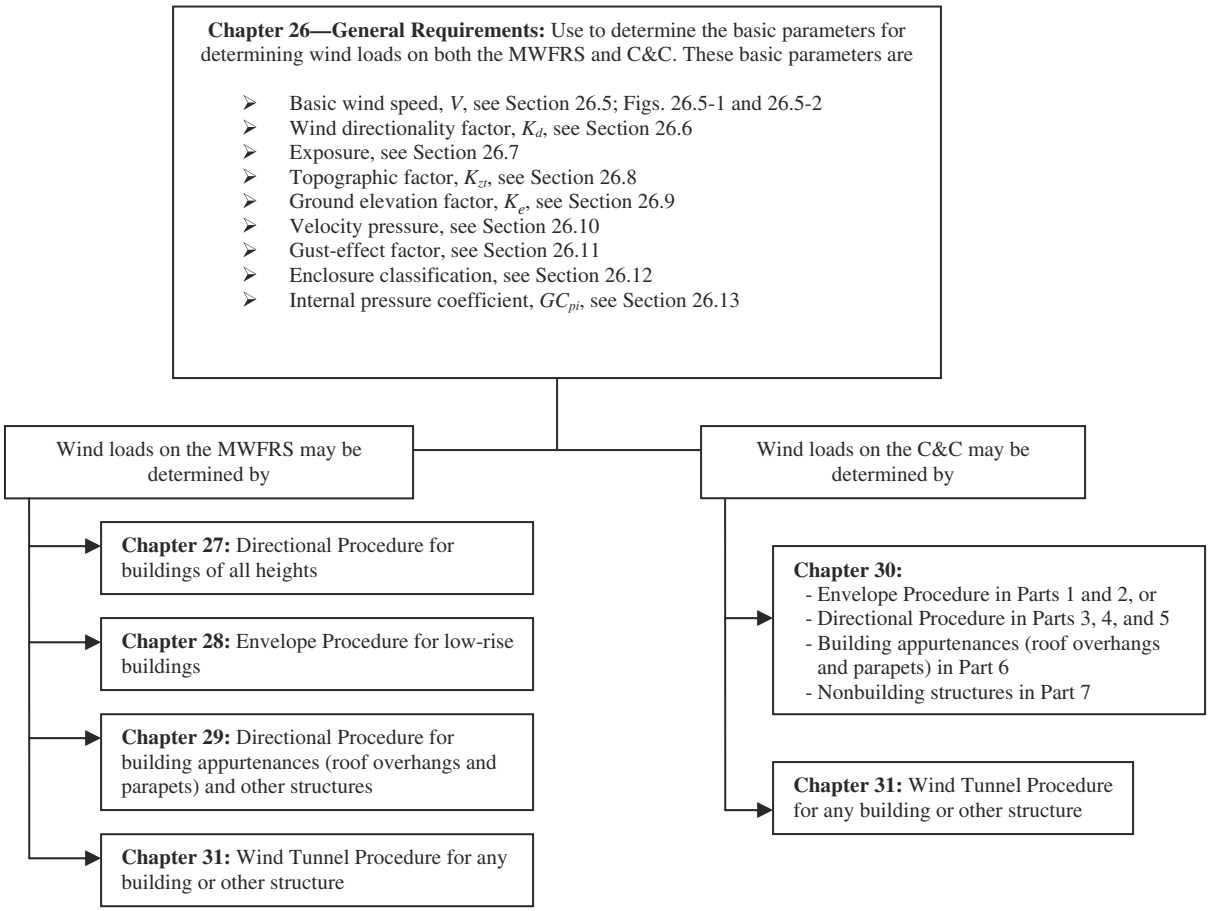


FIGURE 26.1-1 Outline of Process for Determining Wind Loads

Additional outlines and User Notes are provided at the beginning of each chapter for more detailed step-by-step procedures for determining the wind loads.

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

BUILDING, SIMPLE DIAPHRAGM: A building in which both windward and leeward wind loads are transmitted by roof and vertically spanning wall assemblies, through continuous floor and roof diaphragms, to the MWFRS.

BUILDING, TORSIONALLY REGULAR UNDER WIND LOAD: A building with the MWFRS about each principal axis proportioned so that the maximum displacement at each story under Case 2, the torsional wind load case, of Fig. 27.3-8 does not exceed the maximum displacement at the same location under Case 1 of Fig. 27.3-8, the basic wind load case.

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

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

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

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

COMPONENTS AND CLADDING (C&C): Elements of the building envelope or elements of building appurtenances and rooftop structures and equipment 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 other structures.

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

DIAPHRAGM: Roof, floor, or other membrane or bracing system acting to transfer lateral forces to the vertical MWFRS. For analysis under wind loads, diaphragms constructed of untopped steel decks, concrete-filled steel decks, and concrete slabs, each having a span-to-depth ratio of 2 or less, shall be permitted to be idealized as *rigid*. Diaphragms constructed of wood structural panels are permitted to be idealized as *flexible*.

DIRECTIONAL PROCEDURE: A procedure for determining wind loads on buildings and other structures for specific wind directions, in which the external pressure coefficients used are based on past wind tunnel testing of prototypical building models for the corresponding direction of wind.

EAVE HEIGHT, h_e: 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 the external pressure coefficient, (GC_p) and (GC_{rn}). For C&C elements, the effective wind area in Figs. 30.3-1 through 30.3-7, 30.4-1, 30.5-1, and 30.7-1 through 30.7-3 is the span length multiplied by an effective width that need not be less than

one-third the span length. For rooftop solar arrays, the effective wind area in Fig. 29.4-7 is equal to the tributary area for the structural element being considered, except that the width of the effective wind area need not be less than one-third its length. For cladding fasteners, the effective wind area shall not be greater than the area that is tributary to an individual fastener.

ENVELOPE PROCEDURE: A procedure for determining wind load cases on buildings, in which pseudoexternal pressure coefficients are derived from past wind tunnel testing of prototypical building models successively rotated through 360°, such that the pseudopressure cases produce key structural actions (e.g., uplift, horizontal shear, and bending moments) that envelop their maximum values among all possible wind directions.

ESCARPMENT: With respect to topographic effects in Section 26.8, a cliff or steep slope generally separating two levels or gently sloping areas (see Fig. 26.8-1). Also known as a scarp.

FREE ROOF: Roof with a configuration generally conforming to those shown in Figs. 27.3-4 through 27.3-6 (monoslope, pitched, or troughed) 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 to withstand the impact of test missiles. See Section 26.12.3.2.

HILL: With respect to topographic effects in Section 26.8, a land surface characterized by strong relief in any horizontal direction (see Fig. 26.8-1).

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 for Risk Category II buildings is greater than 115 mi/h (51.4 m/s); and
2. Hawaii, Puerto Rico, Guam, Virgin Islands, and American Samoa.

IMPACT-PROTECTIVE SYSTEM: Construction that has been shown by testing to withstand the impact of test missiles and that is applied, attached, or locked over exterior glazing. See Section 26.12.3.2.

MAIN WIND FORCE RESISTING SYSTEM (MWFRS): An assemblage of structural elements assigned to provide support and stability for the overall building or other 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 angles less than or equal to 10°, the mean roof height is permitted to be taken as 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 26.8, an elongated crest of a hill characterized by strong relief in two directions (see Fig. 26.8-1).

ROOFTOP SOLAR PANEL: A device to receive solar radiation and convert it into electricity or heat energy. Typically this is a photovoltaic module or solar thermal panel.

SOLAR ARRAY: Any number of rooftop solar panels grouped closely together.

WIND-BORNE DEBRIS REGIONS: Areas within hurricane-prone regions where impact protection is required for glazed openings; see Section 26.12.3.

WIND TUNNEL PROCEDURE: A procedure for determining wind loads on buildings and other structures, in which pressures and/or forces and moments are determined for each wind direction considered, from a model of the building or other structure and its surroundings, in accordance with Chapter 31.

26.3 SYMBOLS

The following symbols apply only to the provisions of Chapters 26 through 31:

A = effective wind area, in ft^2 (m^2)
A_f = area of open buildings and other structures either normal to the wind direction or projected on a plane normal to the wind direction, in ft^2 (m^2)
A_g = gross area of that wall in which A_o is identified, in ft^2 (m^2)
A_{gi} = sum of the gross surface areas of the building envelope (walls and roof) not including A_g, in ft^2 (m^2)
A_n = normalized wind area for rooftop solar panels in Fig. 29.4-7
A_o = total area of openings in a wall that receives positive external pressure, in ft^2 (m^2)
A_{og} = total area of openings in the building envelope in ft^2 (m^2)
A_{oi} = sum of the areas of openings in the building envelope (walls and roof) not including A_o, in ft^2 (m^2)
A_s = gross area of the solid freestanding wall or solid sign, in ft^2 (m^2)
a = width of pressure coefficient zone, in ft (m)
B = horizontal dimension of building measured normal to wind direction, in ft (m)
$\bar{b}$ = mean hourly wind speed factor in Eq. (26.11-16) from Table 26.11-1
$\hat{b}$ = 3-s gust speed factor from Table 26.11-1
c = turbulence intensity factor in Eq. (26.11-7) from Table 26.11-1
C_f = force coefficient to be used in determination of wind loads for other structures
C_N = net pressure coefficient to be used in determination of wind loads for open buildings
C_p = external pressure coefficient to be used in determination of wind loads for buildings
D = diameter of a circular structure or member, in ft (m)
D' = depth of protruding elements such as ribs and spoilers, in ft (m)
d_1 = for rooftop solar arrays, horizontal distance orthogonal to the panel edge to an adjacent panel or the building edge, ignoring any rooftop equipment in Fig. 29.4-7, in ft (m)
d_2 = for rooftop solar arrays, horizontal distance from the edge of one panel to the nearest edge in the next row of panels in Fig. 29.4-7, in ft (m)
F = design wind force for other structures, in lb (N)
G = gust-effect factor
G_f = gust-effect factor for MWFRS of flexible buildings and other structures
(GC_p) = product of external pressure coefficient and gust-effect factor to be used in determination of wind loads for buildings

(GC_{pf}) = product of the equivalent external pressure coefficient and gust-effect factor to be used in determination of wind loads for MWFRS of low-rise buildings

(GC_{pi}) = product of internal pressure coefficient and gust-effect factor to be used in determination of wind loads for buildings

(GC_{pn}) = combined net pressure coefficient for a parapet

(GC_r) = product of external pressure coefficient and gust-effect factor to be used in determination of wind loads for rooftop structures

(GC_{rn}) = net pressure coefficient for rooftop solar panels, in Eqs. (29.4-4) and (29.4-5)

$(GC_{rn})_{\text{nom}}$ = nominal net pressure coefficient for rooftop solar panels determined from Fig. 29.4-7

g_Q = peak factor for background response in Eqs. (26.11-6) and (26.11-10)

g_R = peak factor for resonant response in Eq. (26.11-10)

g_v = peak factor for wind response in Eqs. (26.11-6) and (26.11-10)

H = height of hill, ridge, or escarpment in Fig. 26.8-1, in ft (m)

h = mean roof height of a building or height of other structure, except that eave height shall be used for roof angle θ less than or equal to 10°, in ft (m)

h_1 = height of a solar panel above the roof at the lower edge of the panel, in ft (m)

h_2 = height of a solar panel above the roof at the upper edge of the panel, in ft (m)

h_e = roof eave height at a particular wall, or the average height if the eave varies along the wall

h_p = height to top of parapet in Figs. 27.5-2 and 30.6-1

h_{pt} = mean parapet height above the adjacent roof surface for use with Eq. (29.4-5), in ft (m)

$I_{\bar{z}}$ = intensity of turbulence from Eq. (26.11-7)

K_1, K_2, K_3 = multipliers in Fig. 26.8-1 to obtain K_{zt}

K_d = wind directionality factor in Table 26.6-1

K_e = Ground elevation factor

K_h = velocity pressure exposure coefficient evaluated at height $z = h$

K_z = velocity pressure exposure coefficient evaluated at height z

K_{zt} = topographic factor as defined in Section 26.8

L = horizontal dimension of a building measured parallel to the wind direction, in ft (m)

L_b = normalized building length, for use with Fig. 29.4-7, in ft (m)

L_h = distance upwind of crest of hill, ridge, or escarpment in Fig. 26.8-1 to where the difference in ground elevation is half the height of the hill, ridge, or escarpment, in ft (m)

L_p = panel chord length for use with rooftop solar panels in Fig. 29.4-7, in ft (m)

L_r = horizontal dimension of return corner for a solid freestanding wall or solid sign from Fig. 29.3-1, in ft (m)

L_z = integral length scale of turbulence, in ft (m)

ℓ = integral length scale factor from Table 26.11-1, ft (m)

N_1 = reduced frequency from Eq. (26.11-14)

n_1 = fundamental natural frequency, in Hz

n_a = approximate lower bound natural frequency (Hz) from Section 26.11.2

p = design pressure to be used in determination of wind loads for buildings, in lb/ft^2 (N/m^2)

P_L = wind pressure acting on leeward face in Fig. 27.3-8, in lb/ft^2 (N/m^2)

p_{net} = net design wind pressure from Eq. (30.4-1), in lb/ft^2 (N/m^2)

p_{net30} = net design wind pressure for Exposure B at $h = 30$ ft (9.1 m) and $I = 1.0$ from Fig. 30.4-1, in lb/ft^2 (N/m^2)

p_p = combined net pressure on a parapet from Eq. (27.3-4), in lb/ft^2 (N/m^2)

p_s = net design wind pressure from Eq. (28.5-1), in lb/ft^2 (N/m^2)

p_{s30} = simplified design wind pressure for Exposure B at $h = 30$ ft (9.1 m) and $I = 1.0$ from Fig. 28.5-1, in lb/ft^2 (N/m^2)

P_W = wind pressure acting on windward face in Fig. 27.3-8, in lb/ft^2 (N/m^2)

Q = background response factor from Eq. (26.11-8)

q = velocity pressure, in lb/ft^2 (N/m^2)

q_h = velocity pressure evaluated at height $z = h$, in lb/ft^2 (N/m^2)

q_i = velocity pressure for internal pressure determination, in lb/ft^2 (N/m^2)

q_p = velocity pressure at top of parapet, in lb/ft^2 (N/m^2)

q_z = velocity pressure evaluated at height z above ground, in lb/ft^2 (N/m^2)

R = resonant response factor from Eq. (26.11-12)

r = rise-to-span ratio for arched roofs

R_B, R_h, R_L = values from Eqs. (26.11-15a) and (26.11-15b)

R_i = reduction factor from Eq. (26.13-1)

R_n = value from Eq. (26.11-13)

s = vertical dimension of the solid freestanding wall or solid sign from Fig. 29.3-1, in ft (m)

V = basic wind speed obtained from Figs. 26.5-1A through 26.5-1D and 26.5-2A through 26.5-2D, in mi/h (m/s). The basic wind speed corresponds to a 3-s gust speed at 33 ft (10 m) above the ground in Exposure Category C

V_i = unpartitioned internal volume, in ft^3 (m^3)

$\bar{V}_{\bar{z}}$ = mean hourly wind speed at height $\bar{z}$, in ft/s (m/s)

W = width of building in Figs. 30.3-3, 30.3-5A, and 30.3-5B and width of span in Figs. 30.3-4 and 30.3-6, in ft (m)

W_L = width of a building on its longest side in Fig. 29.4-7, in ft (m)

W_S = width of a building on its shortest side in Fig. 29.4-7, in ft (m)

x = distance upwind or downwind of crest in Fig. 26.8-1, in ft (m)

z = height above ground level, in ft (m)

$\bar{z}$ = equivalent height of structure, in ft (m)

z_g = nominal height of the atmospheric boundary layer used in this standard (values appear in Table 26.11-1)

z_{min} = exposure constant from Table 26.11-1

α = 3-s gust-speed power law exponent from Table 26.11-1

$\hat{\alpha}$ = reciprocal of α from Table 26.11-1

$\bar{\alpha}$ = mean hourly wind-speed power law exponent in Eq. (26.11-16) from Table 26.11-1

β = damping ratio, percent critical for buildings or other structures

γ_c = panel chord factor for use with rooftop solar panels in Eq. (29.4-5)

γ_E = array edge factor for use with rooftop solar panels in Fig. 29.4-7 and Eqs. (29.4-4) and (29.4-5)

γ_p = parapet height factor for use with rooftop solar panels in Eq. (29.4-5)
ε = ratio of solid area to gross area for solid freestanding wall, solid sign, open sign, face of a trussed tower, or lattice structure
$\bar{\varepsilon}$ = integral length scale power law exponent in Eq. (26.11-9) from Table 26.11-1
η = value used in Eqs. (26.11-15a) and (26.11-15b) (see Section 26.11.4)
θ = angle of plane of roof from horizontal, in degrees
λ = adjustment factor for building height and exposure from Figs. 28.5-1 and 30.4-1
ν = height-to-width ratio for solid sign
ω = angle that the solar panel makes with the roof surface in Fig. 29.4-7, in degrees

26.4 GENERAL

26.4.1 Sign Convention. Positive pressure acts toward the surface and negative pressure acts away from the surface.

26.4.2 Critical Load Condition. Values of external and internal pressures shall be combined algebraically to determine the most critical load.

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

26.5 WIND HAZARD MAP

26.5.1 Basic Wind Speed. The basic wind speed, V, used in the determination of design wind loads on buildings and other structures shall be determined from Figs. 26.5-1 and 26.5-2 as follows, except as provided in Sections 26.5.2 and 26.5.3:

For Risk Category I buildings and structures, use Figs. 26.5-1A and 26.5-2A.
For Risk Category II buildings and structures, use Figs. 26.5-1B and 26.5-2B.
For Risk Category III buildings and structures, use Figs. 26.5-1C and 26.5-2C.
For Risk Category IV buildings and structures, use Figs. 26.5-1D and 26.5-2D.

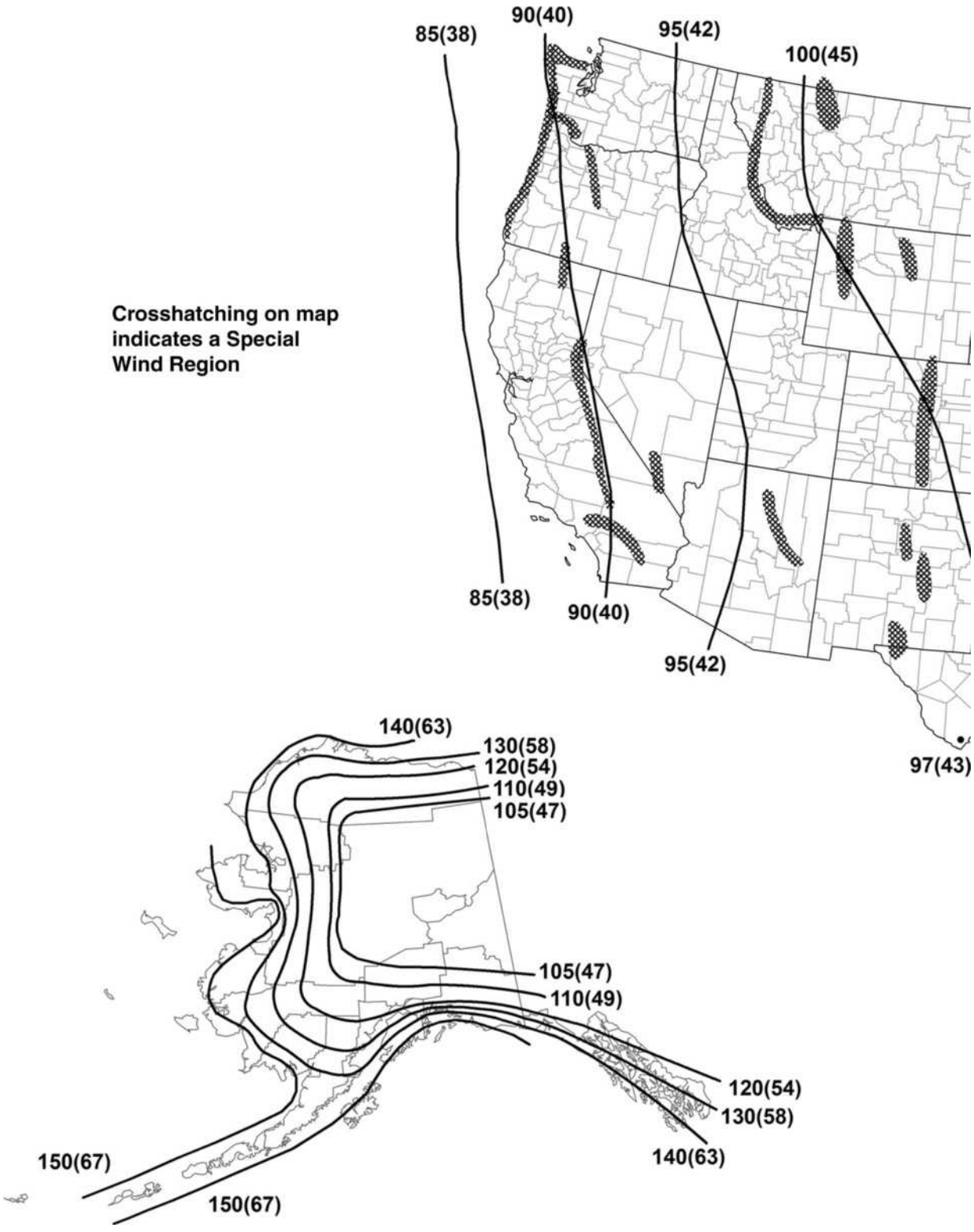
The wind shall be assumed to come from any horizontal direction. The basic wind speed shall be increased where records or experience indicate that the wind speeds are higher than those reflected in Figs. 26.5-1 and 26.5-2.

26.5.2 Special Wind Regions. Mountainous terrain, gorges, and special wind regions shown in Fig. 26.5-1 shall be examined for unusual wind conditions. The Authority Having Jurisdiction shall, if necessary, adjust the values given in Fig. 26.5-1 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 26.5.3.

26.5.3 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 Figs. 26.5-1 and 26.5-2 when (1) approved extreme-value statistical analysis procedures have been used 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 Figs. 26.5-1 and 26.5-2 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 Figs. 26.5-1 and 26.5-2 when 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.

When the basic wind speed is estimated from regional climatic data or simulation, the estimate shall correspond to the applicable 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 C.



Notes

1. Values are nominal design 3-s gust wind speeds in mi/h (m/s) at 33 ft (10 m) above ground for Exposure Category C.
2. Linear interpolation is permitted between contours. Point values are provided to aid with interpolation.
3. Islands, coastal areas, and land boundaries outside the last contour shall use the last wind speed contour.
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).
6. Location-specific basic wind speeds shall be permitted to be determined using www.atcouncil.org/windspeed.

FIGURE 26.5-1A Basic Wind Speeds for Risk Category I Buildings and Other Structures

continues