ANSI/SPRI Wind Design Standard Practice for Roofing Assemblies

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DISCLAIMER
This standard is for use by architects, engineers, roofing contractors and owners of low slope roofing systems.
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1.0 INTRODUCTION

This Wind Design Standard Practice provides a two-part methodology of designing for wind uplift resistance of non-ballasted Built-Up, Modified Bitumen, and Single-Ply roofing system assemblies installed over any type of roof deck. (Refer to the ANSI/SPRI RP-4 Standard for wind design requirements of ballasted single-ply roofing systems).

First Part: Determine the rooftop wind uplift design pressures for the field, perimeter and corner areas of a building using the Quick Reference Tables provided in this Standard Practice or by calculating these values following the requirements of the current version of the ASCE 7 Standard, Minimum Design Loads for Buildings and Other Structures. The Quick Reference Tables are based on ASCE 7-05 and can only be used if a particular building meets the criteria identified in Appendix A.

Second Part: Select an appropriate roofing system assembly by comparing the tested wind uplift resistance of that assembly to the wind uplift design pressures determined from the First Part. The safety factor is applied to the tested wind uplift resistance value before comparison to the design pressures.

This Wind Design Standard Practice shall be used in conjunction with the installation specifications and requirements of the manufacturer or supplier of the specified roofing system assembly. It is applicable to new roofing projects, reroofing projects (removing the existing materials and replacing with new materials) and recovering projects (covering over the existing materials with new materials).

2.0 GENERAL DESIGN CONSIDERATIONS AND DEFINITIONS

The following factors shall be considered as a matter of course prior to the calculation of the rooftop wind uplift design pressure for any building and the actual installation of any roofing system assembly.

2.1 Roof Structure

The building owner shall consult with a qualified and licensed professional such as an architect, architectural engineer, civil engineer or structural engineer to verify that the structure and deck will support the installed roofing system load in combination with all other design loads. The roof deck shall also be examined by the owner or his designated professional representative to verify that it can support the fastener design load requirements. If fasteners are used, on-site pullout tests shall be conducted, as directed by the owner or his designated professional representative, to verify that the fastener/deck will provide acceptable holding power. (Refer to the ANSI/SPRI FX-1 Standard for the methodology of conducting the pullout tests.) When pullout tests are conducted, the fastener density shall be based on either the spacing of the fasteners determined as outlined in Section 3.2 or the spacing needed based on the pullout tests, whichever is more conservative.

2.2 Roof Slope

Determine the slope of the finished surface of the roofing system assembly.

2.3 Wind Speed

Determine the basic wind speed for the building location by referring to Figure 6-1 in Appendix B of this Standard Practice or the Basic Wind Speed Map from the current ASCE 7 Standard.

2.4 Building Height

Determine the building height by measuring from the ground to the eave of the roof. Specific topographic features such as hills must be considered when calculating building height. For roof slopes greater than 10º (2 inch in 12 inch), use the mean roof height. ASCE 7 provides additional information regarding the determination of building height.

2.5 Roof Areas

Wind impacts different areas of the roof surface in different ways so separate design considerations are required. Determine the field, perimeter/ridge and corner areas as described in the following sections (Sections 2.5.1 to 2.5.4).

2.5.1 Perimeter:
The perimeter area is defined as the outer boundary of the roof with a width equal to 40% of the building height or 10% of the building width, whichever is less, but not less than 6 feet (1.8 m). The perimeter area may be enlarged depending upon the building configuration.

2.5.2 Corners:
The corner area is defined as the portion of the perimeter area beginning at the intersection of two roof edges and proceeding in both directions a distance equal to the width of the perimeter area. Corner areas on buildings with minimum 3 feet high continuous parapet walls and a maximum 2 inch in 12 inch roof slope can be treated as perimeter areas.

2.5.3 Ridge:
The ridge is defined as the high point in a roof area formed by two intersecting planes with a slope greater than 10˚ (2 inch in 12 inch). The ridge area proceeds from that point down the slope (in both directions) a distance equal to the width of the perimeter area.

2.5.4 Field:
The field of the roof is defined as that portion of the roof surface that is not included in the perimeter, corner or ridge areas.

2.6 Surface Roughness Categories

The terrain surrounding a building will influence the degree of exposure of that building to the wind. The building shall be classified into one of the following surface roughness categories:

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. Use of this exposure category shall be limited to those areas for which terrain representative of Exposure B prevails in the upwind direction for a distance of at least 2,600 ft (800 m) or 20 times the height of the building, whichever is greater.

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

Surface Roughness D: Flat, unobstructed areas and water surfaces outside hurricane-prone regions. This category includes smooth mud flats, salt flats and unbroken ice. Use of this exposure category shall be limited to those areas for which terrain representative of Exposure D prevails in the upwind direction for a distance of at least 5,000 ft (1524 m) or 20 times the height of the building, whichever is greater.

2.7 Classification of Buildings (Building Importance Factor)

Buildings shall be classified according to the hazard to human life in the event of a failure. Additional information concerning the following categories is available in Table 1-1 of ASCE 7-05.

Category I: Buildings that represent a low hazard to human life.
Category II: Buildings not covered by categories I, III or IV.
Category III: Buildings that represent a substantial hazard to human life.
Category IV: Buildings that are considered essential facilities.

2.8 Building Openings

All buildings shall be categorized into one of the following:

Enclosed Building: A building is considered enclosed if it does not comply with the requirements for open or partially enclosed buildings listed below. For multi-story buildings, consider only the openings and wall areas associated with the top floor.

Open Building: A building having each wall at least 80% open.

Partially Enclosed Building: A building with a windward wall that complies with both of the following conditions:

a. 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%, **and**

b. The total area of openings in a wall that receives positive external pressure exceeds 4 sq ft (0.37m2) 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%.

Wind-Borne Debris Areas: 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 greater than or equal to 120 mph. The lower 60 feet of glazing of Category II, III and IV buildings sited in wind borne debris Regions shall be impact resistant glazing or be protected by an impact resistant covering. If not, the glazing area shall be considered to be an opening.

2.9 Eaves, Overhangs and Canopies

Eaves, overhangs and canopies, by their design, may be subject to greater uplift forces than the roof surface because of pressure differential. Design enhancements for such conditions shall be investigated as described in the current ASCE 7 Standard.

2.10 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, where necessary, in the wind uplift design calculation.

2.11 Building Edge Condition

The performance of the roofing assembly depends not only on the membrane and insulation attachment, but also on the attachment of roof edging device and on the parapet wall height. Roof edging installation shall be completed in accordance with the requirements of the ANSI/SPRI ES-1 Standard.

3.0 TWO-PART METHODOLOGY:

3.1 First Part - Calculate the wind uplift design loads for the field, perimeter and corner areas of a building

The design wind uplift load shall be calculated for the field, perimeter (or ridge) and corner areas of the roof in accordance with current ASCE 7 Standard (as referenced in the International Building Code).

As a matter of convenience, quick reference design wind uplift load tables have been created and are included in Appendix A of this document. These tables are applicable when the building under consideration meets the criteria noted for each table. If the criteria do not match, the design loads shall be calculated in accordance with the current ASCE 7 Standard.

3.2 Second Part - Select an appropriate roofing system assembly by comparing the tested wind uplift resistance capacity to the calculated design loads

The wind uplift resistance load capacity of a roofing system assembly shall be determined by testing in accordance with one of the wind uplift testing procedures contained in

FM 4450, FM 4470, ANSI/FM 4474, UL 580, UL 1897 or CSA A123.21-04. (Tested wind uplift load capacity values are available from the roofing system assembly supplier as well as from reports, publications and websites provided and maintained by various third party testing laboratories.) A safety factor of 2.0, unless otherwise specified, shall be applied to the tested value to obtain the Factored Tested Load Capacity as follows:

Factored Tested Load Capacity =
tested uplift capacity (Lt) / safety factor, psf

Select an appropriate roofing system assembly for use on a particular building by comparing the factored tested load capacity of the assembly to the design loads of the building. When the factored tested load capacity meets or exceeds the design load for the field of the roof, the system is suitable for use. The factored tested load capacity shall then be compared to the perimeter and corner design loads. When the factored tested load capacity meets or exceeds both of these values, the assembly, as tested, is suitable for use across the entire roof area.

When the factored tested load capacity is less than the design load for the field of the roof, the assembly is not suitable for use on that particular building.

In some instances, the factored tested load capacity will exceed the field design load, but will be less than the perimeter and/or corner design loads. When this occurs, it is permissible, as described below, to use an extrapolation method to meet the perimeter and corner design loads. The extrapolation process shall be completed as follows.

Extrapolation Method Adhered System Assemblies

The adhered roofing system assembly extrapolation method is only applicable when all of the following criteria are met:

1. The adhered roofing system assembly utilizes either mechanical fasteners or ribbons/beads of an adhesive for insulation attachment, **and**
2. The tested wind uplift load capacity of the proposed adhered roofing system assembly was determined utilizing a test chamber of sufficient size to allow side-by-side positioning of a minimum of three full-size insulation/coverboard/substrate boards/panels on the test frame, **and**
3. The calculated field design load does not exceed 53 psf.

Extrapolation for adhered roofing system assemblies is not possible when the insulation layer(s) is (are) attached using a 100% coverage rate of an adhesive.

1. Mechanically Attached Insulation - For insulation attached with mechanical fasteners, determine the increased number of fasteners per insulation board ($\mathbf{F_n}$) needed to meet the calculated design load(s) using the following equation: $\mathbf{F_n = (F_t \times L_d) / L_t}$

Where: $\mathbf{F_n}$ is the number of fasteners per board needed to meet the design load.

$\mathbf{F_t}$ is the number of fasteners per board used to achieve the tested load capacity.

$\mathbf{L_d}$ is the calculated design load for the perimeter or corner area of a roof, psf.

$\mathbf{L_t}$ is the factored tested load capacity, psf.

Refer to Commentary A for a practical example of extrapolation for an adhered system assembly utilizing mechanically attached insulation.

2. Ribbon/Bead Adhesive Attached Insulation - For insulation attached with ribbons/beads of adhesive, determine the reduced ribbon/bead spacing ($\mathbf{R_n}$) needed to meet the calculated design load(s) using the following equation: $\mathbf{R_n = R_t /(L_d / L_t)}$

Where: $\mathbf{R_n}$ is the ribbon/bead spacing needed to meet the design load, inches.

$\mathbf{R_t}$ is the ribbon/bead spacing used to achieve the tested load capacity, inches.

$\mathbf{L_d}$ is the calculated design load for the perimeter or corner area of a roof, psf.

$\mathbf{L_t}$ is the factored tested load capacity, psf.

Note: When ribbon/bead-attached insulation is applied directly to a fluted steel deck, the ribbon/bead spacing will be dictated by the center-to-center spacing of the top (high) flutes of the steel deck. The extrapolated ribbon/bead spacing must be rounded down (when necessary) to coincide with a top (high) flute. If the extrapolated ribbon/bead spacing is less than the center-to-center spacing of the top (high) flutes of a steel deck, ribbon/bead attachment of the insulation in that area is not acceptable.

Refer to Commentary A for a practical example of extrapolation for an adhered system assembly utilizing ribbon/bead-attached insulation.

Cautionary Note: The $\mathbf{F_n}$ and $\mathbf{R_n}$ equations shall only be used to increase the number of fasteners or decrease the spacing of ribbons/beads of adhesive needed in the corner and perimeter areas. These equations shall not be used to extrapolate backwards and reduce the number of fasteners or increase the spacing of ribbons/beads of adhesive used in the field of the roof, unless specifically tested.

Extrapolation Method Mechanically Fastened System Assemblies

The mechanically fastened roofing system assembly extrapolation method is only applicable when the following criteria are met:

1. Linearly-attached (Rows) Assemblies:
   The tested wind uplift load capacity of the proposed linearly-attached (rows) mechanically fastened roofing system assembly was determined utilizing a test chamber of sufficient size to allow positioning of a minimum of three attachment rows on the test frame. The minimum frame width shall be 8 feet.
2. Spot-attached Assemblies:
   The tested wind uplift load capacity of the proposed spot-attached mechanically fastened roofing system assembly was determined utilizing a test chamber of sufficient size to allow positioning of a minimum of nine attachment locations on the test frame. The

minimum frame width shall be 8 feet.

For mechanically fastened system assemblies, first determine the influence area per fastener for the tested assembly (**IA_t**) by multiplying the row spacing by the fastener spacing (along the row). For spot attached systems, multiply the distance between the attachment locations in each direction (2 ft x 2 ft, 2 ft x 3 ft, etc.). This gives the number of square feet of membrane held in place by one fastener. Next, calculate the influence area needed to meet the design load using the following equation:

$$IA_n = (L_t \times IA_t) / L_d$$

Where: **IA_n** is the area of membrane needed to be held in place by one fastener to meet the design load, ft^2.

IA_t is the area of membrane held in place by one fastener for the tested assembly, ft^2.

L_d is the calculated design load for the perimeter or corner area of a roof, psf.

L_t is the factored tested load capacity, psf.

The fastener row spacing or the spot attachment grid spacing of the assembly being evaluated shall be reduced so the ft^2 of membrane held in place by each fastener does not exceed **IA_n**. Use the same fastener spacing (along the row) as was tested.

Refer to Commentary A for a practical example of extrapolation for membrane attachment on a mechanically fastened roofing system assembly. It is permissible, as explained in Commentary A, to use the perimeter fastener row spacing in the corner areas provided the perimeter rows are installed in both directions.

Cautionary Note: For mechanically fastened system assemblies with linear (row) attachment, only the spacing between fastener rows shall be reduced to meet **IA_n**. This extrapolation method shall not be used to reduce the spacing between fasteners along the row (12 inches to 6 inches, for example) in place of reducing the spacing between fastener rows. This extrapolation method also shall not be used to extrapolate backwards and increase the spacing between fasteners along the row (12 inches to 18 inches, for example) or increase the spacing between fastener rows (8 feet to 10 feet, for example).

Appendix A

Quick Reference Tables

Reference Design Load Tables have been developed using the ASCE 7-05 Standard *(Minimum Design Loads For Buildings And Other Structures*) and are contained in Appendix A of this document. These tables are applicable to buildings in exposure categories B, C and D when **ALL** of the following criteria are met:

1. The building is not situated on a hill, ridge or escarpment (Refer to Section 2.4, Building Height, of this document)
2. The building is Category II (Refer to Section 2.7, Classification of Buildings (Building Importance Factor), of this document or Table 1-1 of ASCE 7-05)
3. The building is enclosed (Refer to Section 2.8, Building Openings, of this document or Section 6.2 of ASCE 7-05)
4. The roof slope does not exceed 1.5 inches per foot (7º)

When a building is exposed to factors such as wind directionality, wind gust effect or large volume reduction factors, or the building is situated on a hill, ridge or escarpment, or the roof slope is greater than 1.5 inches per foot (all of which are referenced in the ASCE 7 Standard), these Quick Reference Tables shall not be used. When these Quick Reference Tables are not usable, the design loads shall be calculated using the methodology of the current ASCE 7 Standard.

To use the Reference Tables, simply match the building criteria with the proper table. The design load is listed for the field, perimeter and corner areas based on building height.

Note: When a building is classified as Category I, the Quick Reference Tables are usable if the field, perimeter and corner design loads are multiplied by 0.85. Likewise, when a building is classified as Category III or IV, the Quick Reference Tables are usable if the field, perimeter and corner design loads are multiplied by 1.15.

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Exposure B applies to urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger. Use of this exposure category shall be limited to those areas for which terrain representative of Exposure B prevails in the upwind direction for a distance of at least 2,600 ft (800 m) or 20 times the height of the building, whichever is greater.

Exposure C applies to 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. Exposure C shall apply for all cases where exposures B or D do not apply.

Exposure D applies to flat, unobstructed areas and water surfaces outside hurricane-prone regions. This category includes smooth mud flats, salt flats and unbroken ice. Use of this exposure category shall be limited to those areas for which terrain representative of Exposure D prevails in the upwind direction for a distance of at least 5,000 ft (1524 m) or 20 times the height of the building, whichever is greater.

Building Category II, Exposure B - 90 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-17.1	-28.7	-43.3
20	-17.1	-28.7	-43.3
25	-17.1	-28.7	-43.3
30	-17.1	-28.7	-43.3
40	-18.6	-31.2	-47.0
50	-19.8	-33.3	-50.1
60	-20.8	-34.9	-52.5
70	-29.2	-45.8	-62.4
80	-30.5	-47.8	-65.2
90	-31.5	-49.4	-67.3
100	-32.4	-50.9	-69.4
120	-34.1	-53.5	-72.9
140	-35.7	-56.1	-76.4
160	-37.0	-58.1	-79.2
180	-38.3	-60.2	-82.0
200	-39.3	-61.7	-84.1
250	-41.9	-65.8	89.7
300	-44.2	-69.4	-94.6
350	-46.2	-72.5	-98.8
400	-48.2	-75.6	-103.0
450	-49.8	-78.2	-106.5
500	-51.1	-80.2	-109.3

Building Category II, Exposure B - 100 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-21.1	-35.5	-53.4
20	-21.1	-35.5	-53.4
25	-21.1	-35.5	-53.4
30	-21.1	-35.5	-53.4
40	-23.0	-38.5	-58.0
50	-24.5	-41.1	-61.8
60	-25.7	-43.1	-64.8
70	-36.0	-56.5	-77.0
80	-37.6	-59.0	-80.5
90	-38.8	-60.9	-83.1
100	-40.0	-62.9	-85.7
120	-42.1	-66.0	-90.0
140	-44.1	-69.2	-94.3
160	-45.7	-71.7	-97.8
180	-47.3	-74.3	-101.2
200	-48.5	-76.2	-103.8
250	-51.8	-81.3	-110.8
300	-54.6	-85.7	-116.8
350	-57.0	-89.5	-122.0
400	-59.5	-93.3	-127.2
450	-61.5	-96.5	-131.5
500	-63.1	-99.0	-135.0

Building Category II, Exposure B -110 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-25.6	-42.9	-64.6
20	-25.6	-42.9	-64.6
25	-25.6	-42.9	-64.6
30	-25.6	-42.9	-64.6
40	-27.8	-46.6	-70.2
50	-29.6	-49.7	-74.8
60	-31.1	-52.1	-78.5
70	-43.6	-68.4	-93.2
80	-45.5	-71.4	-97.4
90	-47.0	-73.7	-100.5
100	-48.5	-76.1	-103.7
120	-50.9	-79.9	-108.9
140	-53.3	-83.7	-114.1
160	-55.3	-86.8	-118.3
180	-57.3	-89.9	-122.5
200	-58.7	-92.2	-125.6
250	-62.6	-98.3	-134.0
300	-66.1	-103.7	-141.3
350	-69.0	-108.3	-147.6
400	-71.9	-112.9	-153.9
450	-74.4	-116.8	-159.1
500	-76.3	-119.8	-163.3

Building Category II, Exposure B -120 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-30.4	-51.1	-76.9
20	-30.4	-51.1	-76.9
25	-30.4	-51.1	-76.9
30	-30.4	-51.1	-76.9
40	-33.1	-55.5	-83.5
50	-35.2	-59.1	-89.0
60	-37.0	-62.0	-93.4
70	-51.8	-81.4	-110.9
80	-54.2	-85.0	-115.9
90	-55.9	-87.8	-119.6
100	-57.7	-90.5	-123.4
120	-60.6	-95.1	-129.6
140	-63.5	-99.7	-135.8
160	-65.8	-103.3	-140.8
180	-68.1	-107.0	-145.8
200	-69.9	-109.7	-149.5
250	-74.6	-117.0	-159.5
300	-78.6	-123.4	-168.2
350	-82.1	-128.9	-175.7
400	-85.6	-134.4	-183.2
450	-88.5	-139.0	-189.4
500	-90.9	-142.6	-194.4

Building Category II, Exposure B - 130 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-35.7	-60.0	-90.2
20	-35.7	-60.0	-90.2
25	-35.7	-60.0	-90.2
30	-35.7	-60.0	-90.2
40	-38.8	-65.1	-98.0
50	-41.4	-69.4	-104.4
60	-43.4	-72.8	-109.6
70	-60.8	-95.5	-130.1
80	-63.6	-99.8	-136.0
90	-65.6	-103.0	-140.4
100	-67.7	-106.2	-144.8
120	-71.1	-111.6	-152.1
140	-74.5	-117.0	-159.4
160	-77.2	-121.2	-165.2
180	-80.0	-125.5	-171.1
200	-82.0	-128.8	-175.5
250	-87.5	-137.3	-187.2
300	-92.3	-144.8	-197.4
350	-96.4	-151.3	-206.2
400	-100.5	-157.7	-215.0
450	-103.9	-163.1	-222.3
500	-106.6	-167.4	-228.1

Building Category II, Exposure B - 140 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-41.4	-69.5	-104.7
20	-41.4	-69.5	-104.7
25	-41.4	-69.5	-104.7
30	-41.4	-69.5	-104.7
40	-45.0	-75.5	-113.6
50	-48.0	-80.5	-121.1
60	-50.3	-84.4	-127.1
70	-70.6	-110.7	-150.9
80	-73.7	-115.7	-157.7
90	-76.1	-119.5	-162.8
100	-78.5	-123.2	-167.9
120	-82.4	-129.4	-176.4
140	-86.4	-135.6	-184.9
160	-89.6	-140.6	-191.6
180	-92.8	-145.6	-198.4
200	-95.1	-149.3	-203.5
250	-101.5	-159.3	-217.1
300	-107.0	-168.0	-229.0
350	-111.8	-175.5	-239.1
400	-116.5	-182.9	-249.3
450	-120.5	-189.1	-257.8
500	-123.7	194.1	-264.6

Building Category II, Exposure B -150 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-47.6	-79.8	-120.2
20	-47.6	-79.8	-120.2
25	-47.6	-79.8	-120.2
30	-47.6	-79.8	-120.2
40	-51.7	-86.7	-130.5
50	-55.1	-92.4	-139.0
60	-57.8	-96.9	-145.9
70	-81.0	-127.1	-173.3
80	-84.6	-132.8	-181.1
90	-87.4	-137.1	-186.9
100	-90.1	-141.4	-192.7
120	-94.6	-148.6	-202.5
140	-99.2	-155.7	-212.2
160	-102.8	-161.4	-220.0
180	-106.5	-167.1	-227.8
200	-109.2	-171.4	-233.6
250	-116.5	-182.8	-249.2
300	-122.9	-192.8	-262.8
350	-128.3	-201.4	-274.5
400	-133.8	-210.0	-286.2
450	-138.3	-217.1	-295.9
500	-142.0	-222.8	-303.7

Building Category II, Exposure C - 90 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-20.8	-34.8	-52.4
20	-22.1	-37.0	-55.7
25	-23.0	-38.6	-58.1
30	-24.0	-40.2	-60.5
40	-25.5	-42.8	-64.4
50	-26.7	-44.7	-67.3
60	-27.6	-46.3	-69.7
70	-38.4	-60.3	-82.1
80	-39.7	-62.2	-84.8
90	-40.6	-63.7	-86.9
100	-41.2	-64.7	-88.2
120	-43.0	-67.5	-91.9
140	-44.6	-69.9	-95.3
160	-45.5	-71.4	-97.3
180	-46.9	-73.7	-100.4
200	-47.9	-75.1	-102.4
250	-50.1	-78.6	-107.1
300	-52.1	-81.8	-111.5
350	-53.7	-84.3	-114.9
400	-55.3	-86.8	-118.3
450	-56.7	-89.0	-121.3
500	-58.0	-91.0	-124.0

Building Category II, Exposure C - 100 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-25.7	-43.1	-64.8
20	-27.2	-45.6	-68.7
25	-28.4	-47.6	-71.7
30	-29.6	-49.7	-74.8
40	-31.4	-52.7	-79.3
50	-32.9	-55.2	-83.2
60	-34.1	-57.3	-86.2
70	-47.3	-74.3	-101.2
80	-48.9	-76.8	-104.7
90	-50.2	-78.7	-107.3
100	-51.0	-80.0	-109.0
120	-53.0	-83.2	-113.4
140	-55.0	-86.3	-117.7
160	-56.2	-88.2	-120.3
180	-57.8	-90.8	-123.7
200	-59.1	-92.7	-126.3
250	-61.9	-97.1	-132.4
300	-64.3	-100.9	-137.6
350	-66.3	-104.1	-141.9
400	-68.4	-107.3	-146.2
450	-70.0	-109.8	-149.7
500	-71.6	-112.4	-153.2

Building Category II, Exposure C -110 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-31.1	-52.1	-78.5
20	-32.9	-55.2	-83.1
25	-34.4	-57.7	-86.8
30	-35.8	-60.1	-90.5
40	-38.0	-63.8	-96.0
50	-39.8	-66.9	-100.6
60	-41.3	-69.3	-104.3
70	-57.3	-89.9	-122.5
80	-59.2	-93.0	-126.7
90	-60.7	-95.3	-129.8
100	-61.7	-96.8	-131.9
120	-64.1	-100.6	-137.2
140	-66.6	-104.5	-142.4
160	-68.0	-106.8	-145.5
180	-70.0	-109.9	-149.7
200	-71.5	-112.2	-152.9
250	-74.9	-117.5	-160.2
300	-77.8	-122.1	-166.5
350	-80.3	-126.0	-171.7
400	-82.7	-129.8	-176.9
450	-84.7	-132.9	-181.1
500	-86.6	-136.0	-185.3

Building Category II, Exposure C -120 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-37.0	-62.0	-93.4
20	-39.1	-65.7	-98.9
25	-40.9	-68.6	-103.3
30	-42.6	-71.5	-107.7
40	-45.2	-75.9	-114.2
50	-47.4	-79.6	-119.7
60	-49.2	-82.5	-124.1
70	-68.1	-107.0	-145.8
80	-70.5	-110.6	-150.8
90	-72.2	-113.4	-154.5
100	-73.4	-115.2	-157.0
120	-76.3	-119.8	-163.2
140	-79.2	-124.3	-169.5
160	-81.0	-127.1	-173.2
180	-83.3	-130.7	-178.2
200	-85.0	-133.5	-181.9
250	-89.1	-139.9	-190.6
300	-92.6	-145.4	-198.1
350	-95.5	-149.9	-204.3
400	-98.4	-154.5	-210.6
450	-100.8	-158.2	-215.6
500	-103.1	-161.8	-220.5

Building Category II, Exposure C - 130 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-43.4	-72.8	-109.6
20	-45.9	-77.1	-116.0
25	-48.0	-80.5	-121.2
30	-50.0	-83.9	-126.3
40	-53.1	-89.1	-134.1
50	-55.6	-93.4	-140.5
60	-57.7	-96.8	-145.7
70	-80.0	-125.5	-171.1
80	-82.7	-129.8	-176.9
90	-84.8	-133.0	-181.3
100	-86.1	-135.2	-184.3
120	-89.5	-140.6	-191.6
140	-93.0	-145.9	-198.9
160	-95.0	-149.1	-203.3
180	-97.8	-153.4	-209.1
200	-99.8	-156.7	-213.5
250	-104.6	-164.2	-223.7
300	-108.7	-170.6	-232.5
350	-112.1	-176.0	-239.8
400	-115.5	-181.3	-247.1
450	-118.3	-185.6	-253.0
500	-121.0	-189.9	-258.8

Building Category II, Exposure C - 140 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-50.3	-84.4	-127.1
20	-53.3	-89.4	-134.6
25	-55.7	-93.4	-140.6
30	-58.0	-97.4	-146.5
40	-61.6	-103.3	-155.5
50	-64.5	-108.3	-163.0
60	-66.9	-112.3	-169.0
70	-92.8	-145.6	-198.4
80	-95.9	-150.6	-205.2
90	-98.3	-154.3	-210.3
100	-99.9	-156.8	-213.7
120	-103.9	-163.0	-222.2
140	-107.8	-169.2	-230.6
160	-110.2	-173.0	-235.7
180	-113.4	-177.9	-242.5
200	-115.7	-181.7	-247.6
250	-121.3	-190.4	-259.5
300	-126.1	-197.9	-269.7
350	-130.0	-204.1	-278.1
400	-134.0	-210.3	-286.6
450	-137.2	-215.3	-293.4
500	-140.3	-220.3	-300.2

Building Category II, Exposure C -150 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-57.8	-96.9	-145.9
20	-61.2	-102.6	-154.5
25	-63.9	-107.2	-161.3
30	-66.6	-111.8	-168.2
40	-70.7	-118.6	-178.5
50	-74.1	-124.3	-187.1
60	-76.8	-128.9	-194.0
70	-106.5	-167.1	-227.8
80	-110.1	-172.8	-235.6
90	-112.8	-177.1	-241.4
100	-114.7	-180.0	-245.3
120	-119.2	-187.1	-255.0
140	-123.8	-194.3	-264.8
160	-126.5	-198.6	-270.6
180	-130.1	-204.3	-278.4
200	-132.9	-208.6	-284.2
250	-139.2	-218.6	-297.9
300	-144.7	-227.1	-309.6
350	-149.3	-234.3	-319.3
400	-153.8	-241.4	-329.0
450	-157.4	-247.1	-336.8
500	-161.1	-252.8	-344.6

Building Category II, Exposure D - 90 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-25.2	-42.3	-63.6
20	-26.4	-44.3	-66.7
25	-27.4	-46.0	-69.2
30	-28.4	-47.6	-71.7
40	-29.9	-50.1	-75.4
50	-31.1	-52.1	-78.5
60	-32.1	-53.8	-80.9
70	-43.9	-68.9	-93.9
80	-45.2	-71.0	-96.7
90	-45.9	-72.0	-98.1
100	-46.9	-73.5	-100.2
120	-48.5	-76.1	-103.7
140	-49.8	-78.2	-106.5
160	-50.8	-79.7	-108.6
180	-51.8	-81.3	-110.7
200	-52.7	-82.8	-112.8
250	-55.0	-86.4	-117.7
300	-56.7	-89.0	-121.3
350	-58.3	-91.5	-124.8
400	-59.6	-93.6	-127.6
450	-60.9	-95.7	-130.4
500	-61.9	-97.2	-132.5

Building Category II, Exposure D - 100 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-31.1	-52.2	-78.6
20	-32.6	-54.7	-82.4
25	-33.8	-56.8	-85.4
30	-35.0	-58.8	-88.5
40	-36.9	-61.8	-93.1
50	-38.4	-64.4	-96.9
60	-39.6	-66.4	-99.9
70	-54.2	-85.1	-115.9
80	-55.8	-87.6	-119.4
90	-56.6	-88.9	-121.1
100	-57.8	-90.8	-123.7
120	-59.9	-94.0	-128.1
140	-61.5	-96.5	-131.5
160	-62.7	-98.4	-134.1
180	-63.9	-100.3	-136.7
200	-65.1	-102.2	-139.3
250	-68.0	-106.7	-145.4
300	-70.0	-109.8	-149.7
350	-72.0	-113.0	-154.0
400	-73.6	-115.5	-157.5
450	-75.2	-118.1	-160.9
500	-76.4	-120.0	-163.5

Building Category II, Exposure D -110 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-37.6	-63.2	-95.1
20	-39.5	-66.2	-99.7
25	-40.9	-68.7	-103.4
30	-42.4	-71.1	-107.1
40	-44.6	-74.8	-112.6
50	-46.4	-77.9	-117.2
60	-47.9	-80.3	-120.9
70	-65.6	-102.9	-140.3
80	-67.5	-106.0	-144.5
90	-68.5	-107.5	-146.6
100	-70.0	-109.9	-149.7
120	-72.4	-113.7	-155.0
140	-74.4	-116.8	-159.1
160	-75.9	-119.1	-162.3
180	-77.3	-121.4	-165.4
200	-78.8	-123.7	-168.6
250	-82.2	-129.1	-175.9
300	-84.7	-132.9	-181.1
350	-87.1	-136.7	-186.4
400	-89.1	-139.8	-190.6
450	-91.0	-142.9	-194.7
500	-92.5	-145.2	-197.9

Building Category II, Exposure D -120 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-44.8	-75.2	-113.2
20	-47.0	-78.8	-118.6
25	-48.7	-81.7	-123.0
30	-50.5	-84.7	-127.4
40	-53.1	-89.0	-134.0
50	-55.2	-92.7	-139.5
60	-57.0	-95.6	-143.9
70	-78.0	-122.5	-167.0
80	-80.4	-126.2	-171.9
90	-81.5	-128.0	-174.4
100	-83.3	-130.7	-178.2
120	-86.2	-135.3	-184.4
140	-88.5	-139.0	-189.4
160	-90.3	-141.7	-193.1
180	-92.0	-144.4	-196.9
200	-93.8	-147.2	-200.6
250	-97.9	-153.6	-209.3
300	-100.8	-158.2	-215.6
350	-103.7	-162.7	-221.8
400	-106.0	-166.4	-226.8
450	-108.3	-170.0	-231.8
500	-110.1	-172.8	-235.5

Building Category II, Exposure D - 130 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-52.6	-88.2	-132.8
20	-55.1	-92.5	-139.2
25	-57.2	-95.9	-144.4
30	-59.2	-99.4	-149.6
40	-62.3	-104.5	-157.3
50	-64.8	-108.8	-163.7
60	-66.9	-112.2	-168.9
70	-91.6	-143.8	-196.0
80	-94.3	-148.1	-201.8
90	-95.7	-150.2	-204.7
100	-97.8	-153.4	-209.1
120	-101.2	-158.8	-216.4
140	-103.9	-163.1	222.3
160	-106.0	-166.3	-226.7
180	-108.0	-169.5	-231.0
200	-110.1	-172.7	-235.4
250	-114.8	-180.3	-245.7
300	-118.3	-185.6	-253.0
350	-121.7	-191.0	-260.3
400	-124.4	-195.3	-266.1
450	-127.1	-199.6	-272.0
500	-129.2	-202.8	-276.4

Building Category II, Exposure D - 140 MPH Peak Gust Wind Zone

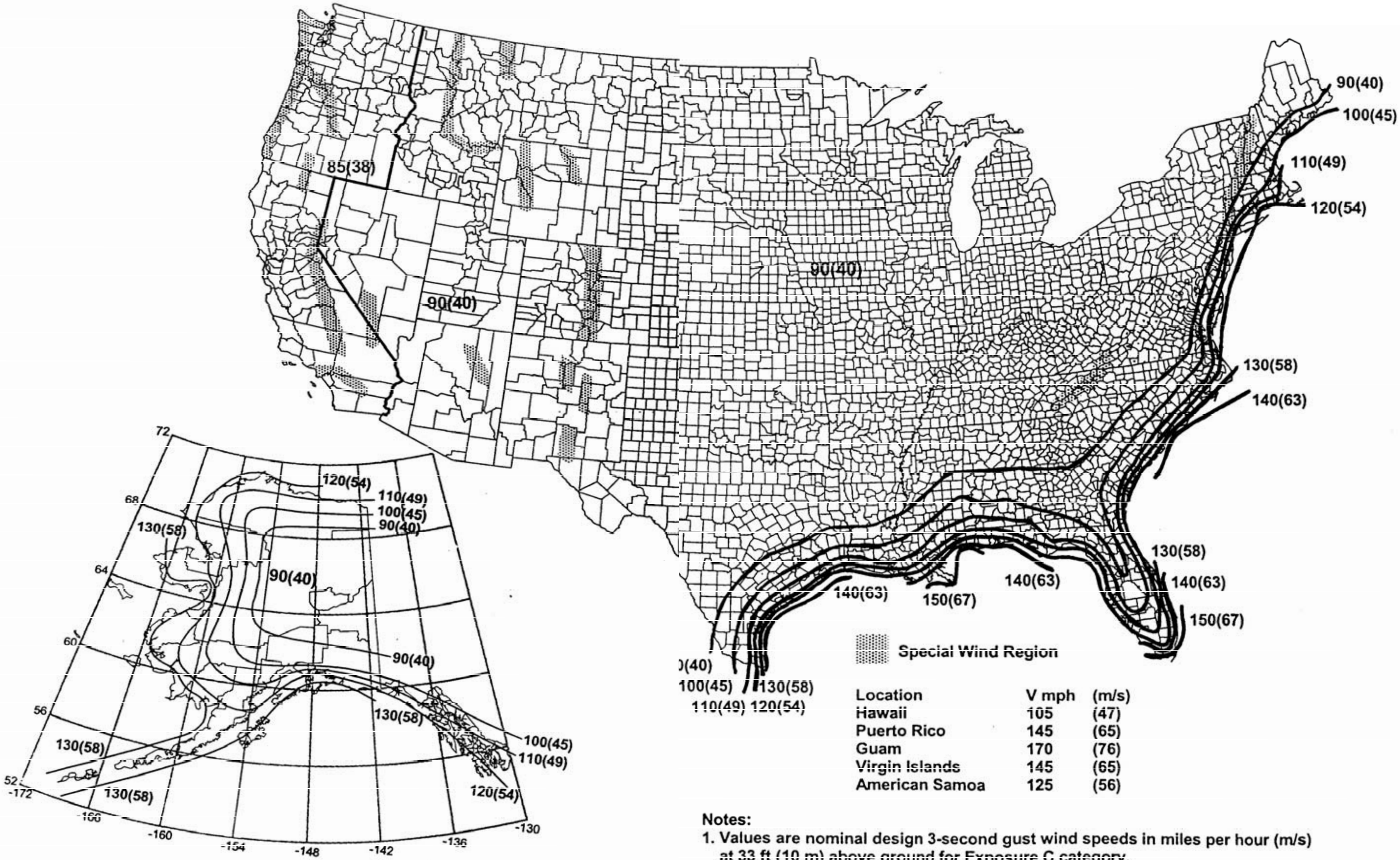
Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-61.0	-102.3	-154.0
20	-63.9	-107.3	-161.5
25	-66.3	-111.3	-167.5
30	-68.7	-115.2	-173.4
40	-72.2	-121.2	-182.4
50	-75.2	-126.2	-189.9
60	-77.6	-130.1	-195.9
70	-106.2	-166.7	-227.3
80	-109.4	-171.7	-234.0
90	-111.0	-174.2	-237.4
100	-113.4	-177.9	-242.5
120	-117.3	-184.2	-251.0
140	-120.5	-189.1	-257.8
160	-122.9	-192.9	-262.9
180	-125.3	-196.6	-268.0
200	-127.6	-200.3	-273.0
250	-133.2	-209.1	-284.9
300	-137.2	-215.3	-293.4
350	-141.1	-221.5	-301.9
400	-144.3	-226.5	-308.7
450	-147.5	-231.5	-315.4
500	-149.8	-235.2	-320.5

Building Category II, Exposure D -150 MPH Peak Gust Wind Zone

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
0 - 15	-70.0	-117.5	-176.8
20	-73.4	-123.2	-185.4
25	--76.1	-127.7	-192.2
30	-78.8	-132.3	-199.1
40	-82.9	-139.1	-209.4
50	-86.3	-144.8	-218.0
60	-89.0	-149.4	-224.9
70	-122.0	-191.4	-260.9
80	-125.6	-197.1	-268.7
90	-127.4	-200.0	-272.6
100	-130.1	-204.3	-278.4
120	-134.7	-211.4	-288.1
140	-138.3	-217.1	-295.9
160	-141.1	-221.4	-301.8
180	-143.8	-225.7	-307.6
200	-146.5	-230.0	-313.4
250	152.9	-240.0	-327.1
300	-157.4	-247.1	-336.8
350	-162.0	-254.3	-346.5
400	-165.6	-260.0	-354.3
450	-169.3	-265.7	-362.1
500	-172.0	-270.0	-368.0

Appendix B

Wind Speed Map & Insulation Fastening Patterns

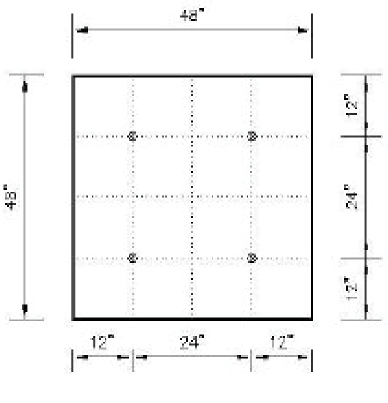


Location	V mph	(m/s)
Hawaii	105	(47)
Puerto Rico	145	(65)
Guam	170	(76)
Virgin Islands	145	(65)
American Samoa	125	(56)

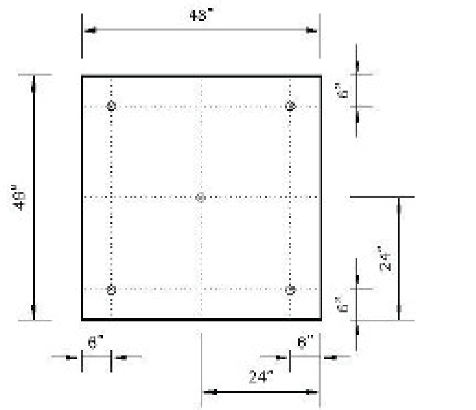
Notes:

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.

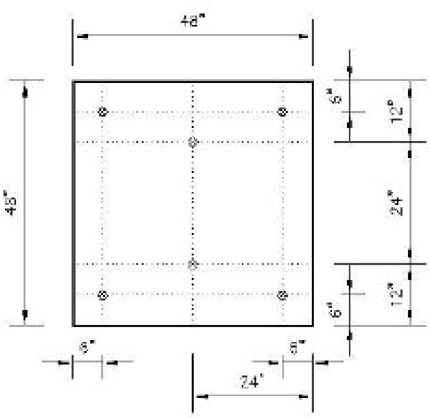
FIG. 6-1. Basic Wind Speed



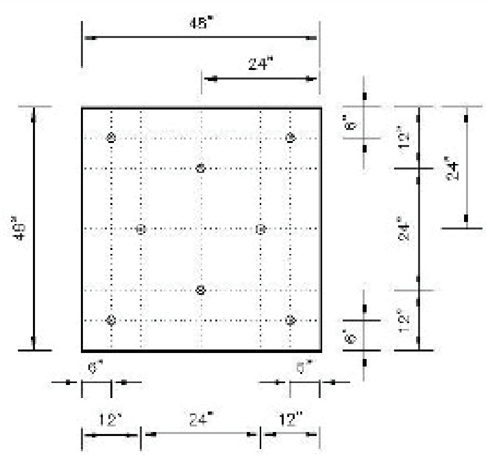
BOARD SIZE 4'X4'
4 FASTENERS PER BOARD



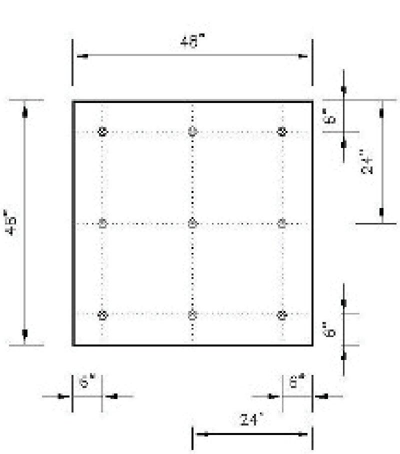
BOARD SIZE 4'X4'
5 FASTENERS PER BOARD



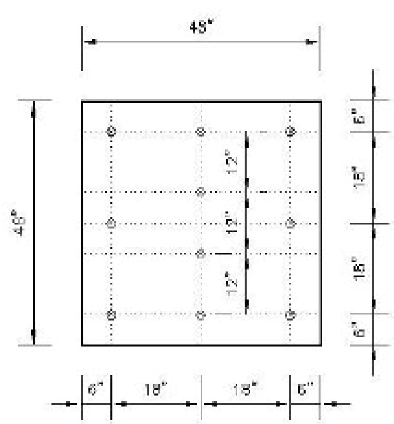
BOARD SIZE 4'X4'
6 FASTENERS PER BOARD



BOARD SIZE 4'X4'
8 FASTENERS PER BOARD

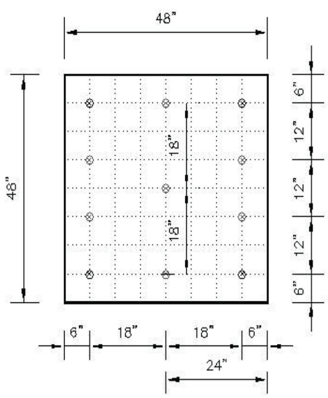


BOARD SIZE 4'X4'
9 FASTENERS PER BOARD

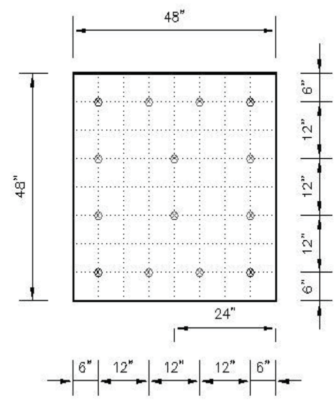


BOARD SIZE 4'X4'
10 FASTENERS PER BOARD

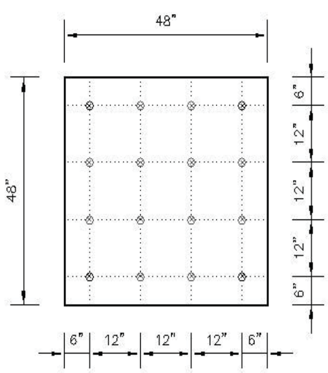
1



BOARD SIZE 4'X4'
11 FASTENERS PER BOARD

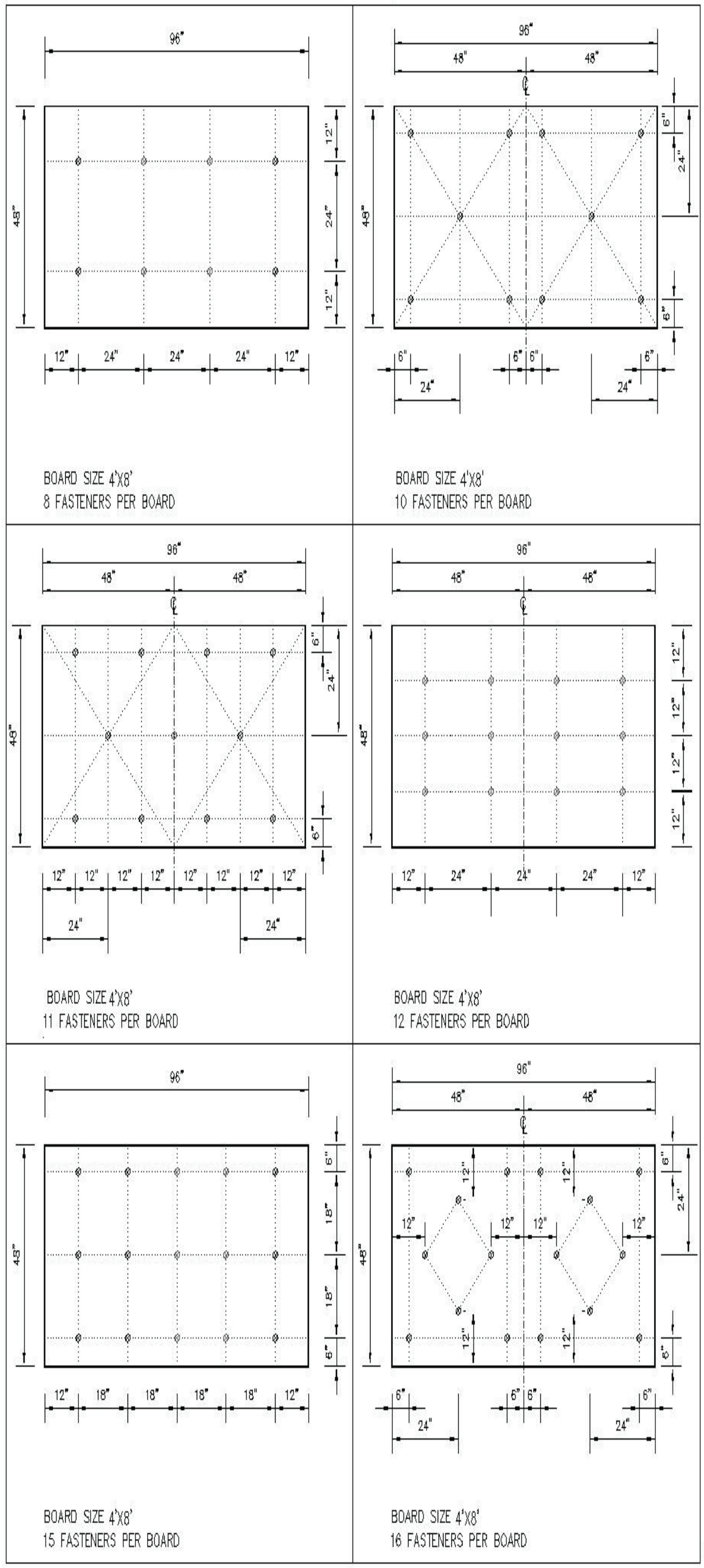


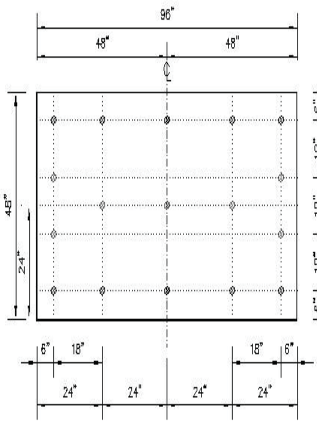
BOARD SIZE 4'X4'
14 FASTENERS PER BOARD



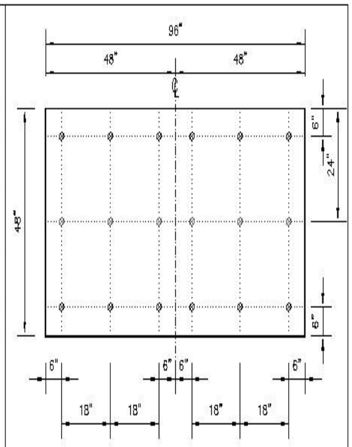
BOARD SIZE 4'X4'
16 FASTENERS PER BOARD

2

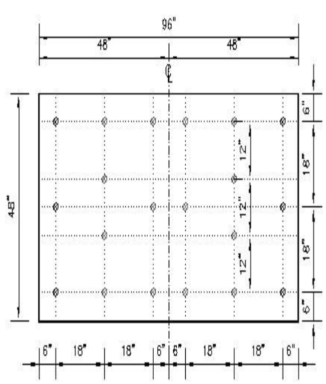

96"
48"
12"
24"
12"
12" 24" 24" 24" 12"
BOARD SIZE 4'X8'
8 FASTENERS PER BOARD
96"
48" 48"
6"
24"
6"
24"
BOARD SIZE 4'X8'
10 FASTENERS PER BOARD
96"
48" 48"
12" 12" 12" 12" 12" 12" 12" 12"
24" 24"
BOARD SIZE 4'X8'
11 FASTENERS PER BOARD
96"
48" 48"
12" 24" 24" 24" 12"
BOARD SIZE 4'X8'
12 FASTENERS PER BOARD
96"
18"
6"
12" 18" 18" 18" 18" 12"
BOARD SIZE 4'X8'
15 FASTENERS PER BOARD
96"
48" 48"
12"
BOARD SIZE 4'X8'
16 FASTENERS PER BOARD
3



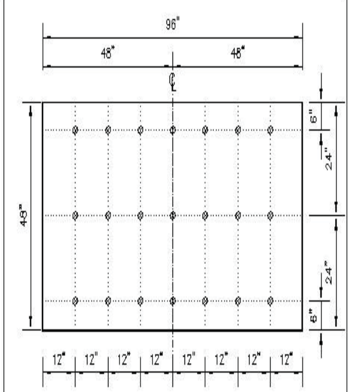
BOARD SIZE 4'X8'
17 FASTENERS PER BOARD



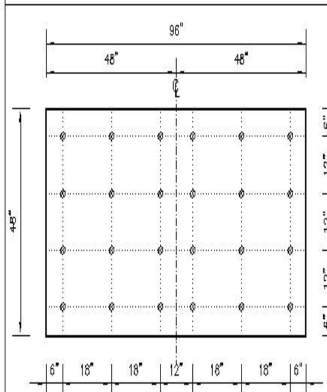
BOARD SIZE 4'X8'
18 FASTENERS PER BOARD



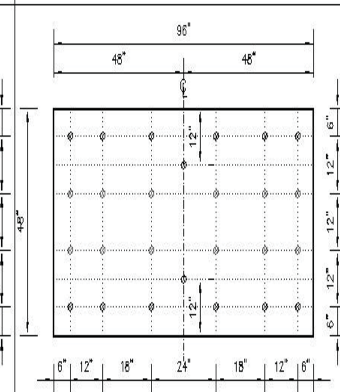
BOARD SIZE 4'X8'
20 FASTENERS PER BOARD



BOARD SIZE 4'X8'
21 FASTENERS PER BOARD

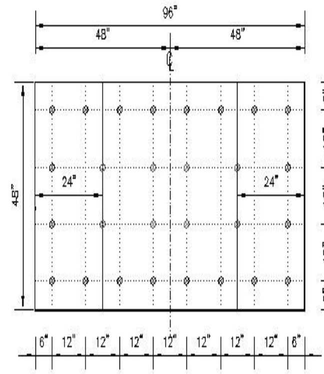


BOARD SIZE 4'X8'
24 FASTENERS PER BOARD

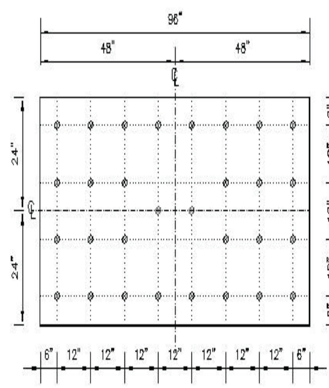


BOARD SIZE 4'X8'
26 FASTENERS PER BOARD

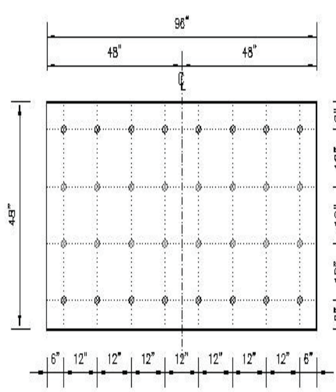
4



BOARD SIZE 4'X8'
28 FASTENERS PER BOARD



BOARD SIZE 4'X8'
30 FASTENERS PER BOARD



BOARD SIZE 4'X8'
32 FASTENERS PER BOARD 5

Commentary A

Practical Examples

Design Pressure Calculation and Roofing System Assembly Selection (for the following example building)

Example Building Criteria (used for all examples to follow)

A 40-foot high warehouse building located outside of Pittsburgh, PA has a plan dimension of 200 feet by 400 feet. The building has metal roof deck with flutes spaced 6 inches on center. The walls have no large openings. The roof slope is 1/2 inch per foot. The architect/designer has selected a 2.0 safety factor to be used for this project.

Task

Design three roofing system assemblies for this building using the two-part method outlined in Section 3.0 of this Standard Practice. The roofing system assemblies to be designed are as follows:

System 1 – Adhered membrane over insulation attached with mechanical fasteners
System 2 – Adhered membrane over insulation attached with ribbons/beads of a cold adhesive
System 3 – Mechanically fastened membrane

First Part: Calculate the wind uplift design loads for the field, perimeter and corner areas of the building which will be used for all three examples.

Step 1: Determine if the Quick Reference Tables contained in this document can be used.

Building is Category II (from Section 2.7 of this document or Table 1-1 of ASCE 7-05)

Building is not situated on a hill

Building is enclosed (from Section 2.8 of this document or Section 6.2 of ASCE 7-05)

Building is in 90 mph wind zone (from the wind speed map of Appendix B of this document or figure 6-1 of ASCE 7-05)

Roof slope is $\leq 7^{o}$ (1.5 inches / foot)

All the conditions referenced in Appendix A are met so the Quick Reference Tables can be used. When the conditions of Appendix A are not met, the design loads shall be calculated in accordance with the current ASCE 7 Standard. The equations used to calculate the design loads are referenced in Commentary C of this document.

Step 2: Determine Design Loads Using the Quick Reference Tables.

Refer to the Quick Reference Tables for Building Category II, Exposure C and 90 mph wind zone (page number 9 of this document):

Field Design Load = -25.5

Perimeter Design Load = -42.8

Corner Design Load = -64.4

The negative sign merely indicates that the uplift load is outward (away from the building). The negative sign will be ignored for the calculation purposes.

Second Part: Select an appropriate roofing system assembly by comparing the tested wind uplift resistance capacity of that assembly to the design loads.

System 1 - Adhered Roofing System Assembly Selection Example for Mechanically Fastened Insulation

The adhered membrane roofing system assembly being considered for this building was tested on a 12 foot x 24 foot test chamber to a maximum wind uplift resistance capacity of 90 psf **(L_t)** using 16 fasteners **(F_t)** per board. Apply the 2.0 safety factor to the 90 psf tested value to determine the Factored Tested Load Capacity:

Factored Tested Load Capacity = Lt / 2.0 = 90 psf / 2.0 = 45 psf

The factored tested load capacity (45 psf) exceeds the design loads for both the field (25.5 psf) and perimeter (42.8 psf) areas of the roof but not the corner area (64.4 psf). Consequently, the as-tested assembly is acceptable for use in the field and perimeter areas. To determine if extrapolation is acceptable for the corner areas, check the extrapolation requirements of the Extrapolation Method - Adhered System Assemblies section of this document on page 4. Since all the extrapolation method requirements are satisfied, extrapolation is acceptable.

To determine the number of fasteners **(F_n)** needed per insulation board for the corner areas of the roof, use the equation:

$$\mathbf{F_n = (F_t \times L_d) / L_t}$$

Where: **F_n** is the number of fasteners per board needed to meet the corner design load.
F_t is the number of fasteners per board used to achieve the tested load capacity.
L_d is the calculated design load for the corner area of the roof, psf.
L_t is the factored tested load capacity.

Corner Area

F_n = (16 fasteners x 64.4 psf) / 45 psf = 23 fasteners per board

The final design for this assembly scenario is to use 16 fasteners per insulation board in the field and perimeter areas and 23 fasteners per board in the corner areas. The extra 7 fasteners added to the corner areas shall be evenly distributed around the tested fastener layout pattern. Fastening pattern examples for insulation boards are included in Appendix B of this document.

System 2 - Adhered Roofing System Assembly Selection Example for Ribbon/Bead Adhesive Attached Insulation

The adhered membrane roofing system assembly being considered for this building was tested on a 12 foot x 24 foot test chamber to a maximum wind uplift resistance capacity of 75 psf **(L_t)** using ribbons/beads of adhesive spaced 12 inches on center **(R_t)** for insulation attachment. Apply the 2.0 safety factor to the 75 psf tested value to determine the Factored Tested Load Capacity:

Factored Tested Load Capacity = L_t / 2.0 = 75 psf / 2.0 = 37.5 psf

The factored tested load capacity (37.5 psf) exceeds the design load for the field (25.5 psf) of the roof but not the perimeter (43.8 psf) or corner (64.4 psf) areas. Consequently, the as-tested system assembly is acceptable for use only in the field of the roof. To determine if extrapolation is allowable for the perimeter and corner areas, check the extrapolation requirements of the Extrapolation Method - Adhered System Assemblies section of this document on page 4. Since all the extrapolation method requirements are satisfied, extrapolation is acceptable.

To determine the reduced ribbon/bead spacing **(R_n)** for the perimeter and corner areas of the roof, use the equation:

$$\mathbf{R_n = R_t / (L_d / L_t)}$$

Where: **R_n** is the ribbon/bead spacing needed to meet the design load, inches.
R_t is the ribbon/bead spacing used to achieve the tested load capacity, inches.
L_d is the calculated design load for the perimeter and corner areas of the roof, psf.
L_t is the factored tested load capacity, psf.

Perimeter Area

R_n = 12 in. / (42.8 psf / 37.5 psf) = 10.5 inches maximum on center spacing for ribbons/beads

Corner Area

R_n = 12 in. / (64.4 psf / 37.5 psf) = 7.0 inches maximum on center spacing for ribbons/beads

Since the deck flutes are spaced 6 inches on center, the perimeter and corner ribbons/bead spacing must be rounded down to 6 inches on center. Therefore, the final design for this assembly scenario is to use ribbons/beads of adhesive spaced 12 inches on center for insulation attachment in the field of the roof and ribbons/beads of adhesive spaced 6 inches on center for insulation attachment in the perimeter and corner areas.

Note: If the deck had a smooth (non-fluted) top surface such as concrete, cementitious wood fiber, wood, etc., the final design for this assembly would be to use ribbons/beads of adhesive spaced 12 inches on center in the field of the roof, 10.5 inches on center in the perimeter and 7.0 inches on center in the corners.

System 3 - Mechanically Fastened Roofing System Assembly Example

The linearly-attached mechanically fastened roofing assembly being considered for this building was tested on a 12 foot x 24 foot test chamber to a maximum wind uplift resistance capacity of 60 psf **(L_t)** using a 9.5 foot row spacing with fasteners spaced 18 inches on center along the row. Apply the 2.0 safety factor to the 60 psf tested value to determine the Factored Tested Load Capacity:

Factored Tested Load Capacity = L_t / 2.0 = 60 psf / 2.0 = 30 psf

The factored tested load capacity (30 psf) exceeds the design load for the field (25.5 psf) of the roof, but not the perimeter (42.8 psf) or corner (64.4 psf) areas. Consequently, the as-tested assembly is acceptable for use only in the field of the roof. To determine if extrapolation is possible for the perimeter and corner areas, check the extrapolation requirements of the Extrapolation Method – Mechanically Fastened System Assemblies section of this document on page 4. Since all the extrapolation method requirements are satisfied, extrapolation is acceptable.

To determine the appropriate perimeter and corner row spacing, first calculate the influence area per fastener **(IA_n)** using the equation:

$$IA_n = (L_t \times IA_t) / L_d$$

Where: **IA_n** is the maximum area of membrane to be held in place by one fastener to meet the design load, ft^2.
IA_t is the area of membrane held in place by one fastener for the tested assembly, ft^2.
L_d is the calculated design load for the perimeter or corner area of the roof, psf.
L_t is the factored tested load capacity, psf.

IA_t = fastener row spacing times the fastener spacing along the row
IA_t = 9.5 ft. x 1.5 ft. = 14.25 ft^2 per fastener

Perimeter Area

IAn = (30 psf x 14.25 ft^2) / 42.8 psf = 10.0 ft^2 maximum per fastener

Corner Area

IA_n = (30 psf x 14.25 ft^2) / 64.4 psf = 6.6 ft^2 maximum per fastener

The row spacing for the corner and perimeter areas shall be determined by dividing IA_n by the tested fastener spacing, as follows:

Perimeter Areas: 10.0 ft^2 / 1.5 ft. = 6.7 ft
Corner Areas: 6.6 ft^2 / 1.5 ft. = 4.4 ft

There are two final designs for this assembly scenario. The first design is to use a maximum fastener row spacing of 9.5 foot in the field of the roof, maximum 6.7 foot in the perimeter areas and maximum 4.4 foot in the corner areas, all with fasteners spaced 18 inches on center along the row. The second design is to use a maximum fastener row spacing of 9.5 foot in the field of the roof and a maximum 6.7 foot in the perimeter and corner areas. In the second design however, the perimeter rows must extend into the corners from both directions, creating a cross-hatched fastening pattern.

Commentary B

General Considerations

The following design and installation recommendations should be considered before starting roofing projects:

1. Consult with an architect or engineer to ensure the roof deck is adequately secured to resist the wind uplift forces that will be imposed upon it by the installed roofing system assembly.
2. Conduct fastener pullout tests, where appropriate, to ensure the selected fastener/deck combination will provide adequate wind uplift resistance to the forces that will be imposed upon it by the installed roofing system assembly. This is particularly important for steel roof decks and for recover (covering over an existing roofing system assembly) applications. Pullout testing should be conducted in accordance with the ANSI/SPRI FX-1 Standard.
3. Mechanical fasteners used for insulation or membrane securement should penetrate through the top flange of a steel deck whenever possible.
4. Rows of mechanical fastener, spaced greater than 3 feet apart, should be installed perpendicular to the steel deck ribs to avoid overloading a single rib.
5. Ensure that all mechanical fasteners have the proper penetration into the roof deck. Typical fastener penetrations include: 3/4 inch for steel, 1 inch for wood and 1-1/4 inch for structural concrete. Consult with the system supplier for verification.
6. Install an edging detail, where appropriate, that will meet the requirements of the ANSI/SPRI ES-1 Standard. The use of an edging detail that meets the requirements of the FM Approvals 4435 Standard is an acceptable alternative.

Commentary C

ASCE 7-05 Design Wind Load Pressure Calculation Method Summary

The following is a summary of the Wind Uplift Design Pressure Calculation equations excerpted from the ASCE 7-05 Standard. These calculations shall be completed when the Quick Reference Tables contained in Appendix A of this Standard Practice are not usable. To obtain a copy of the current ASCE 7 Document, visit the publications link on the ASCE website, https://www.asce.org/asce.cfm.

The following items are required to complete the calculations:

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 coefficient* K_z *or* K_h, as applicable, shall be determined for each wind direction in accordance with Section 6.5.6.
4. A *topographic factor* Kz_t shall be determined in accordance with Section 6.5.7.
5. A *gust effect factor G or* G_f, 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. The *internal pressure coefficient* GC_{pi} shall be determined in accordance with Section 6.5.11.1.
8. The e*xternal pressure coefficients* C_p *or* GC_{pf}, or *force coefficients* C_f, as applicable, shall be determined in accordance with Sections 6.5.11.2 or 6.5.11.3, respectively.
9. The v*elocity pressure* q_z *or* q_h, as applicable, shall be determined in accordance with Section 6.5.10.
10. The d*esign wind load pressure p* shall be determined in accordance with Sections 6.5.12 and 6.5.13, as applicable.

Step 1 – Determine the Velocity Pressure, q_z

Velocity Pressure $\mathbf{q_h}$**,** evaluated at a height z, shall be calculated using one of the following equations:

$q_h = 0.00256\ K_z\ K_{zt}\ K_d\ V^2\ I$ (for results expressed in lb/ft^2, V in mph)

$q_h = 0.613\ K_z\ K_{zt}\ K_d\ V^2\ I$ (for results expressed in N/m^2, V in m/s)

Step 2 – Determine the Design Wind Load Pressure, p

Design Wind Load Pressure of buildings <u>of all heights</u> shall be determined by using the following equation:

$p = q_h(GC_p) - q_h(GC_{pi})$ (for results expressed in both lb/ft^2 and N/m^2)

Related Reference Documents

1. ASCE 7-05, Minimum Design Loads for Buildings and Other Structures
2. FM 4450, Approval Standard for Class 1 Insulated Steel Deck Roofs
3. FM 4470, Approval Standard for Class 1 Roof Covers
4. UL 580, Standard for Tests for Uplift Resistance of Roof Assemblies
5. UL 1897, Standard for Uplift Tests for Roof Covering Systems
6. CSA A123.21-04, Standard Test Method for the Dynamic Wind Uplift Resistance of Mechanically Attached Membrane-Roofing Systems
7. FM Global Loss Prevention Data Sheets 1-28, 1-29 and 1-49
8. ANSI/SPRI RP-4, Wind Design Standard for Ballasted Single-Ply Roofing Systems
9. ANSI/SPRI FX-1, Standard Field Test Procedure For Determining The Withdrawal Resistance Of Roofing Fasteners
10. ANSI/SPRI ES-1, Wind Design Standard For Edge Systems Used With Low Slope Roofing Systems
11. SPRI Wind Load Design Guide For Low Sloped Flexible Membrane Roofing Systems