ANSI/SPRI WD-1

Wind Design Standard Procedure for Non-Ballasted Roofing Assemblies

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Disclaimer
This standard is for use by architects, engineers, consultants, roofing contractors and owners of low slope roofing systems. This standard specifically does not address existing building drainage capacity or overflow drainage requirements and should not be used for those purposes. It is intended to provide data and guidance necessary to understand the implementation and use of retrofit roof drainage elements. Do not assume all existing buildings have code compliant drainage. SPRI, IT'S MEMBERS AND EMPLOYEES DO NOT WARRANT THAT THIS STANDARD IS PROPER AND APPLICABLE UNDER ALL CONDITIONS.

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1.0 Introduction

This Wind Design Standard Procedure provides general building design considerations as well as a methodology for selecting an appropriate roofing assembly to meet the building's calculated rooftop design wind uplift pressures. This document is appropriate for non-ballasted Built-Up, Modified Bitumen, and Single-Ply roofing systems installed over any type of roof deck. (Refer to the Related Reference Documents on page 15, Design Standards Item 2, for the single-ply ballasted roofing system design standard reference).

A Commentary section is provided at the end of this document to offer explanatory and supplementary information designed to assist users in complying with this Standard Procedure. The commentary is intended to create an understanding of the requirements through brief explanations of the reasoning employed in arriving at these requirements, or to provide other clarification.

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

This document does not address the wind uplift design of the structural deck.

2.0 Methodology

2.1 Rooftop Design Load Pressures

The rooftop design load pressures shall be calculated by the design professional or the designated local engineer in accordance with the ASCE 7 Standard and the requirements of the applicable building code. If a level of safety is required by the design professional, refer to Commentary C. This Standard Procedure will be based on a minimum safety factor of 1.

2.2 Determine the Tested Uplift Load Capacity of the Roofing Assembly

The Tested Uplift Load Capacity of a roofing assembly shall be determined by testing in accordance with applicable building code. Refer to Commentary D. Tested Uplift Load Capacity pressures are available from the roofing assembly supplier through independent laboratory testing reports or evaluation reports, and from website listings that are developed and maintained by various independent testing/evaluation entities and laboratories.

2.3 Verify Suitability of a Roofing Assembly

In order for a roofing assembly to be considered for use, the Tested Uplift Load Capacity ($\mathbf{L_t}$) of that assembly must be greater than or equal to the calculated Wind Design Load ($\mathbf{L_d}$) for the Zone 1' of the roof. If $\mathbf{L_t}$ is less than $\mathbf{L_d}$ for the Zone 1' area, the roofing assembly shall not be used on that particular building.

When $\mathbf{L_t}$ is greater than or equal to $\mathbf{L_d}$ for the Zone 1' area, the roofing assembly, as tested, is suitable for use in the field Zone 1' area of the roof. In order to determine the appropriate assembly layout for Zone 1, Zone 2, and Zone 3 of the roof, compare $\mathbf{L_t}$ to $\mathbf{L_d}$ for the Zone 1, Zone 2, and Zone 3. When $\mathbf{L_t}$ meets or exceeds $\mathbf{L_d}$ for of these Zones, the roofing system assembly, as tested, is suitable for use in those respective Zones.

When $\mathbf{L_t}$ is less than $\mathbf{L_d}$ for the roof Zones 1, 2, and 3, one of the rational analysis methods described in Sections 2.5 and 2.6 is permitted to be used for enhancing the roofing assembly in Zones 1, 2, and 3. Refer to Commentary B.

As an alternative to using Rational Analysis, the design professional could choose a roof assembly with a Tested Uplift Load that meets or exceeds Zone 3 pressures and utilize this roof assembly installed throughout all Zones.

2.4 Rational Analysis Method—Adhered Membrane Roofing Assemblies

2.4.1 Rational Analysis Criteria for Adhered Membrane Assemblies

This rational analysis method shall only be used when *all* of the following criteria are met:

1. The roofing assembly utilizes either mechanical fasteners or ribbons/beads of an adhesive for insulation/substrate attachment.
2. When mechanically fastened base or anchor sheets are utilized, the tested attachment pattern must be uniform or repeating such that the number of fasteners utilized per a specified square foot area can be determined.
3. The maximum fastener securement extrapolation shall not be greater than 300 percent. Example: Tested assembly has a Tested Uplift Compacity associated to insulation securement density per 4 ft.x8 ft. with 8 insulation fasteners and plates. 8×300%=maximum 24 insulation fasteners and plates per 4 ft.x8 ft.
4. The minimum fastener separation shall not be less than 4 inches on center.
5. Refer to Commentary B for possible limitation beyond this procedure.

This rational analysis method shall not be used for adhered roofing assemblies when the insulation/substrate layer(s) is (are) attached using 100% coverage of any adhesive or hot asphalt. Adhesives applied in ribbons/beads spaced 4 in. or less on center are considered to constitute 100% coverage.

2.4.1.1 Rational Analysis Method–Adhered Membrane with Mechanically Attached Insulation/Substrates, and Induction Welded Attachment

For insulation/substrates attached with mechanical fasteners, the increased number of fasteners (**F_n**) needed to meet the calculated design wind uplift load(s) shall be determined using the following equation: $\mathbf{F_n=(F_t \times L_d)/L_t}$

Where:

F_n is the number of fasteners needed to meet the calculated design load.

F_t is the number of fasteners used to achieve the tested uplift load capacity.

L_d is the calculated design load for the Zone 1, 2, and 3 of a roof, psf (kPa).

L_t is the Tested Uplift Load Capacity, psf (kPa).

Refer to Commentary A for a practical example of rational analysis for an adhered roofing assembly utilizing mechanically attached insulation/substrate.

2.4.1.2 Rational Analysis Method–Adhered Membrane with Ribbon/Bead Adhesive Attached Insulation/Substrates

For insulation/substrates attached with ribbons/beads of an adhesive, the reduced ribbon/bead spacing (**R_n**) needed to meet the calculated design wind uplift load(s) shall be determined using the following equation: $\mathbf{R_n=R_t/(L_t/L_d)}$

Where:

R_n is the ribbon/bead spacing needed to meet the calculated design load, inches (cm).

R_t is the ribbon/bead spacing used to achieve the tested uplift load capacity, inches (cm).

L_d is the calculated design load for the Zone 1, 2, and 3 of a roof, psf (kPa).

L_t is the Tested Uplift Load Capacity, psf (kPa).

Note:

When ribbon/bead-attached insulation/substrate 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 rationalized ribbon/bead spacing shall be rounded down (when necessary) to coincide with a top (high) flute spacing. If the rationalized 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 shall not be acceptable.

In addition, this method can be used for membranes adhered to the insulation/substrate in ribbons/beads.

Refer to Commentary A for a practical example of rational analysis for an adhered roofing assembly utilizing ribbon/bead-attached for insulation/substrate.

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 Zone 1, 2, and 3 areas. These equations shall not be used to rationalize backwards and reduce the number of fasteners or increase the spacing of ribbons/beads of adhesive used in the Zone 1' of the roof.

2.5 Rational Analysis Method–Mechanically Fastened Membrane Roofing Assemblies with Fastener Density in Rows are Constant

2.5.1 Rational Analysis Criteria—Mechanically Fastened Membrane Roofing Assemblies

1. This membrane roofing assembly rational analysis method shall only be used when all of the following criteria are met:
2. The maximum extrapolation shall not be greater than 300 percent.

The minimum fastener separation shall not be less than 6 inches on center. When installing over steel decks with flute span no greater than 6 inches. Refer to Commentary B.

Mechanically fastened membrane roofing assemblies can be installed in different ways, the most common method of installation is row spacing (**RS**) in feet (cm) and fastening density within those rows in inches (cm). In this rational analysis the fastening density will be constant, and the reduction of the row spacing will be used to compensate for additional calculated design wind loads over the tested uplift load capacity within the appropriate Zones of the roof.

For membrane attached with rows of fasteners and plates the reduced row spacing ($\mathbf{RS_n}$) needed to meet the calculated design wind uplift load(s) shall be determined using the following equation: $\mathbf{RS_n=(L_d/L_t)\times RS_t}$

Where:

$\mathbf{RS_n}$ is the row spacing needed to meet the calculated design load, inches (cm).

$\mathbf{RS_t}$ is the row spacing used to achieve the tested uplift load capacity, inches (cm).

$\mathbf{L_d}$ is the calculated design load for the Zone 1, 2, and 3 of a roof, psf (kPa).

$\mathbf{L_t}$ is the Tested Uplift Load Capacity, psf (kPa).

Refer to Commentary A for practical examples of rational analysis for membrane attachment on mechanically fastened membrane roofing assemblies.

Cautionary Note: For mechanically fastened membrane roofing assemblies with linear (row) attachment, only the spacing between fastener rows shall be reduced to meet zonal pressures. In addition, this rational analysis method shall not be used to rationalize backwards to increase the spacing between fastener rows (8 ft. to 10 ft. [2.4 m to 3.0 m], for example).

Commentary Section

This Commentary is not a part of this standard. It consists of explanatory and supplementary material designed to assist users in complying with the requirements. It is intended to create an understanding of the requirements through brief explanations of the reasoning employed in arriving at these requirements or to provide other clarifications. It therefore has not been processed in accordance with ANSI Essential Requirements and may contain material that has not been subjected to public review or a consensus process. Thus, it does not contain requirements necessary for conformance with the standard.

The sections of the Commentary are numbered to correspond to the sections of the standard to which they refer. Since it is not necessary to have supplementary material for every section in the standard itself, there may be gaps in the numbering in the Commentary.

Commentary A

Practical Examples
Roofing Assembly Selection

Example Building—Allowable Stress Design Loads
(Used for the following 4 evaluation examples)

A building with a structural deck has the following calculated Allowable Stress Design loads for cladding determined by using the ASCE 7 Standard. The following is based on the most current ASCE 7 Standard for buildings that are 60 ft. or less with a roof slope 7 degrees or less. Note that ASCE 7-10 only has three Zones.

Calculated Ultimate Strength Design Loads

- Zone 1′=-55.0 psf (-2.63 kPa)
- Zone 1=-97.7 psf (-4.68 kPa)
- Zone 2=-126.3 psf (-6.05 kPa)
- Zone 3=-172.1 psf (-8.24 kPa)

Convert Ultimate Strength Design Loads to Allowable Stress Design Loads using the equation:

Allowable Stress Design Load ($\mathbf{L_d}$)=Ultimate Strength Load (psf or kPa)×0.6

Converted Allowable Stress Design Loads ($\mathbf{L_d}$)

- Zone 1′=-33.0 psf (-1.58 kPa)
- Zone 1=-58.6 psf (-2.81 kPa)
- Zone 2=-75.8 psf (-3.63 kPa)
- Zone 3=-103.2 psf (-4.94 kPa)

Note:

The ASCE 7-10 and earlier Standards do not include a Zone 1′ area nor is Zone 1′ used on roof areas that have heights greater than 60 ft.

Task

Evaluate the potential use of four roofing assemblies for this building using the methodology outlined in Section 2 of this Standard Procedure. The roofing assemblies to be evaluated are as follows:

- Assembly 1—Adhered membrane over insulation attached with mechanical fasteners.
- Assembly 2—Adhered membrane over insulation attached with ribbons/beads of a cold adhesive.
- Assembly 3—Linear attached mechanically fastened membrane.
- Assembly 4—Induction-Welded (grid-attached) mechanically fastened membrane.

Example Building—Evaluation Roofing Assembly 1

Adhered Membrane over Insulation Attached with Mechanical Fasteners

The recognized listing for the adhered membrane roofing assembly being considered for this building was tested to a Tested Uplift Load Capacity of -45 psf (-2.16 kPa). The 4 ft.×8 ft. (1.22 m×2.44 m) insulation boards were attached using 8 fasteners (**F_t**) per board.

Zone Layout Evaluation

L_t (-45 psf, -2.16 kPa) exceeds the calculated wind uplift design load for Zone 1' (-33.0 psf, -1.586 kPa), but **L_t** is less than the pressures for Zone 1 (-58.6 psf, -2.81 kPa), Zone 2 (-75.8 psf, -3.62 kPa), and Zone 3 (-103.2 psf, -4.94 kPa). Consequently, the as-tested assembly is suitable for use in Zones 1' but not in Zone 1, Zone 2, and Zone 3.

Rational Analysis

To determine the number of fasteners (**F_n**) needed per insulation board for Zone 1, Zone 2, and Zone 3 of the roof, use the equation **$F_n=(F_t \times L_d)/L_t$**.

Where:

F_n is the number of fasteners per board needed to meet the calculated design load.

Ft is the number of fasteners per board used to achieve the tested uplift load capacity.

Ld is the calculated design wind uplift load for the Zones 1, 2, and 3 of the roof, psf (kPa).

Lt is the Tested Uplift Load Capacity, psf (kPa).

Zone 1

F_n=(8 fasteners×-58.6 psf)/-45 psf)=**11 fasteners per board**

or

F_n=(8 fasteners×-2.81 kPa)/-2.16 kPa)=**11 fasteners per board**

Zone 2

F_n=(8 fasteners×-75.8 psf)/-45 psf)=**14 fasteners per board**

or

F_n=(8 fasteners×-3.62 kPa)/-2.16 kPa)=**14 fasteners per board**

Zone 3

F_n=(8 fasteners×-103.2 psf)/-45 psf)=**19 fasteners per board**

or

F_n=(8 fasteners×-4.94 kPa)/-2.16 kPa)=**19 fasteners per board**

The final layout for this adhered membrane assembly scenario is to use 8 fasteners per 4 ft.×8 ft. (1.22 m×2.44 m) insulation board in Zone 1', 11 fasteners per 4 ft.×8 ft. (1.22 m×2.44 m) insulation board in Zone 1, 14 fasteners per 4 ft.×8 ft. (1.22 m×2.44 m) insulation board in Zone 2 and 19 fasteners per 4 ft.×8 ft. (1.22 m×2.44 m) insulation board in Zone 3. The extra fasteners added to Zone 1, Zone 2, and Zone 3 shall be evenly distributed (as best as possible) around the tested fastener layout pattern.

An alternate method with the following formula, after determining the fasteners per square foot: **$F_s=F_{ts}/(L_t/L_d)$**

Where:

F_s is the number of fasteners per square foot needed to meet the calculated design load.

F_{ts} is the number of fasteners per square foot used to achieve the tested uplift load capacity.

L_d is the calculated design wind uplift load for the Zones 1, 2, and 3 of the roof, psf (kPa).

L_t is the Tested Uplift Load Capacity, psf (kPa).

Zone 1

F_s=(0.25 fastener/sq. ft./(-45.0 psf)/-58.6 psf)=**0.33 fastener/sq. ft.**
4.0 ft×8.0 ft. board size (32 board size×0.33 fastener)=**11 fasteners per board**

or

F_n=(2.69 fastener/sq m/(-2.16 kPa/-2.81 kPa)=**3.44 fasteners sq m**
1.22 m×2.44 m board size (2.97 board size×3.44 fastener)=**11 fasteners per board**

Zone 2

F_s=(0.25 fastener/sq. ft./(-45.0 psf)/-75.8 psf)=**0.42 fastener/sq. ft.**
4.0 ft×8.0 ft. board size (32 board size×0.42 fastener)=**14 fasteners per board**

or

F_n=(2.69 fastener/sq m/(-2.16 kPa/-3.62 kPa)=**4.43 fasteners sq m**
1.22 m×2.44 m board size (2.97 board size×4.43 fastener)=**14 fasteners per board**

Zone 3

F_s=(0.25 fastener/sq. ft./(-45.0 psf)/-103.2 psf)=**0.57 fastener/sq. ft.**
4.0 ft×8.0 ft. board size (32 board size×0.57 fastener)=**19 fasteners per board**

or

F_n=(2.69 fastener/sq m/(-2.16 kPa/-4.94 kPa)=**6.15 fasteners sq m**
1.22 m×2.44 m board size (2.97 board size×6.15 fastener)=**19 fasteners per board**

Example Building -Evaluation Roofing Assembly 2

Adhered Membrane over Insulation Attached with Ribbons/Beads of a Cold Adhesive

An Evaluation Report listing for an adhered membrane roofing assembly identifies the Tested Uplift Load Capacity (**L_t**) as being -75 psf (-3.59 kPa). The listing also indicates that testing was conducted using 4 ft.×4 ft. (1.2 m×1.2 m) insulation boards attached using ribbons/beads of adhesive spaced 12 inches (30.5 cm) on center (**R_t**).

Zone Layout Evaluation

L_t (-75 psf or -3.59 kPa) is less than both the Zone 2 (-75.8 psf or -3.62 kPa) and Zone 3 (-103.2 psf or -4.94 kPa) area design loads. Consequently, the as-tested assembly is not suitable for use in the Zone 2 or Zone 3.

Rational Analysis

To determine the reduced ribbon/bead spacing (**R_n**) for Zone 2 and Zone 3 of the roof, use the equation **$R_n=R_t/(L_d/L_t)$**

Where:

R_n is the ribbon/bead spacing needed to meet the design load, inches (cm).

R_t is the ribbon/bead spacing used to achieve the tested uplift load capacity, inches (cm).

L_d is the calculated design wind uplift load for the Zone 2, and 3 of the roof, psf (kPa).

L_t is the Tested Uplift Load Capacity, psf (kPa).

Zone 2

R_n=12 in./(-75.8 psf/-75 psf) =**11 in. maximum on center spacing for ribbons/beads**

or

R_n=30.5 cm/(-3.62 kPa/-3.29 kPa) =**30 cm maximum on center spacing for ribbons/beads**

Zone 3

R_n=12 in./(-103.2 psf/-75 psf) =**8.0 inches maximum on center spacing for ribbons/beads**

or

R_n=30.5 cm/(-4.94 kPa/-3.29 kPa) =**22 cm maximum on center spacing for ribbons/beads**

Example Building -Evaluation Roofing Assembly 3

Mechanically Fastened Membrane Linear Attached Assembly

The recognized listing for this linear attached mechanically fastened roofing assembly being considered for this building was tested to a Tested Uplift Load Capacity of -60 psf (-2.87 kPa). The assembly utilizes an 11.5 ft. (3.5 m) fastener row spacing with fasteners spaced 12 in. (30.5 cm/0.3 m) on center along the row.

Zone Layout Evaluation

$\mathbf{L_t}$ (-60 psf or -2.87 kPa) is less than both the Zone 2 (-75.8 psf or -3.62 kPa) and Zone 3 (-103.2 psf or -4.9 kPa) design loads. Consequently, the as-tested assembly is not suitable for use in Zone 2 and Zone 3. Use the rational analysis method referenced in Section 2.6 to determine the assembly layout for these two areas.

Rational Analysis

To determine the reduced row spacing ($\mathbf{RS_n}$) for Zone 2 and Zone 3 of the roof, use the equation: $\mathbf{RS_n=(L_t/L_d)\times RS_t}$

Where:

$\mathbf{RS_n}$ is row spacing to meet the design load, ft. (m).

$\mathbf{RS_t}$ is row spacing for the tested uplift load capacity, ft. (m).

$\mathbf{L_d}$ is the calculated design load for the Zone 2 and Zone 3 of the roof, psf (kPa).

$\mathbf{L_t}$ is tested load capacity, psf (kPa).

Zone 2

$\mathbf{RS_n}$=(-60 psf/-75.8 psf)×11.5 ft.= **9.1 ft.**

or

$\mathbf{RS_n}$=(-2.9 kPa)/-3.62 kPa)×3.5 m = **2.8 m**

Zone 3

$\mathbf{RS_n}$=(-60 psf/-103.2 psf)×11.5 ft.= **6.7 ft.**

or

$\mathbf{RS_n}$=(-2.9 kPa)/-4.94 kPa)×3.5 m = **2.0 m**

Example Building—Evaluation Roofing Assembly 4

Induction-Welded (Grid-Attached) Membrane

The recognized listing for the induction-welded (grid-attached) roofing assembly being considered for this building was tested to a Tested Uplift Load Capacity of -37.5 psf (-1.8 kPa) using a 2 ft.×3 ft. (0.6 m×0.9 m) grid membrane fastener spacing pattern. This grid pattern results in the use of 6 membrane fasteners per 4 ft.×8 ft. (1.22 m×2.44 m) insulation board.

Zone Layout Evaluation

$\mathbf{L_t}$ (-37.5 psf or -1.8 kPa) is less than Zone 1 (-58.6 psf/-2.81 psf), Zone 2 (-75.8 psf or -3.62 kPa) and Zone 3 (-103.2 psf or -4.94 kPa) area design loads. Consequently, the as-tested assembly is not suitable for use in Zone 1, 2, or 3. Use the rational analysis method referenced in Section 2.6 to determine the assembly layout for these three areas.

Rational Analysis

To determine the number of membrane fasteners ($\mathbf{F_n}$) needed per insulation board for the Zone 1, Zone 2, and Zone 3 of the roof, use the 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 calculated design load.

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

$\mathbf{L_d}$ is the calculated design load for the Zone 1, Zone 2, and Zone 3 of the roof, psf (kPa).

$\mathbf{L_t}$ is the Tested Uplift Load Capacity, psf (kPa).

Zone 1:

$\mathbf{F_n}$=(6 fasteners×-58.6 psf)/-37.5 psf=**10 fasteners per board**

or

$\mathbf{F_n}$=(6 fasteners×-2.81 kPa)/-1.8 kPa=**10 fasteners per board**

Zone 2:

$\mathbf{F_n}$=(6 fasteners×-75.8 psf)/-37.5 psf=**13 fasteners per board**

or

$\mathbf{F_n}$=(6 fasteners×-3.62 kPa)/-1.8 kPa=**13 fasteners per board**

Zone 3:

$\mathbf{F_n}$=(6 fasteners×-103.2 psf)/-37.5 psf=**17 fasteners per board**

or

$\mathbf{F_n}$=(6 fasteners×-4.94 kPa)/-1.8 kPa=**17 fasteners per board**

The final layout for this assembly scenario is to use a minimum of 6 membrane fasteners per 4 ft.×8 ft. (1.22 m×2.44 m) insulation board in the Zone 1' of the roof, 10 fasteners per board in Zone 1, 13 fasteners per board in Zone 2 and 17 fasteners per board in the Zone 3. However, consideration should be given to using 14 membrane fasteners in Zone 2 and 18 in Zone 3. The extra fasteners will retain a grid-type pattern which will facilitate locating the fasteners after the membrane is installed, particularly if a membrane welding operation is involved.

Commentary B

General Considerations

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

1. This Standard Procedure limitations are based on:
    a. ASCE 7-2016 Figure 30.3-2A Components and Cladding [h ≤ 60 ft. (h ≤ 18 m)]: External Pressure Coefficients, (GCp) for Enclosed and Partially Enclosed Buildings—Gable Roofs, θ ≤ 7°.
    b. Zone 1' is the starting point for rational analysis within this Standard Procedure, since Zone 1' would be part of any calculation on a roof based on the parameters listed within 1.a. Even so, any given roof may not have a Zone 1' or even a Zone 1 based on the determination of the roof zones within Figure 30.3-2A. The design professional or the insurance carrier must offer guidance on the starting point.
    c. ASCE 7-2022 Chapter 32 Tornado: where the building is required to be calculated, these pressures should be compared with the Wind Design Loads. Whichever load is greater per roof zone should be used.
2. Consult with an 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 assembly.
3. Consult building owner's insurance carrier to determine if any limitation to roof installations is required, such as the location of the building:
    a. Zone 1 rating needed in any location does not exceed 90-psf (3.6 kPa), or the building is in a non-tropical cyclone-prone region and the Zone 1 rating does not exceed 105-psf (4.3 kPa).
4. It is recommended that each roof elevation be calculated separately for verification of Tested Uplift Load Capacity of roofing assembly.
5. 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 assembly. This is particularly important for steel roof decks and for recover (covering over an existing roofing assembly) applications. Pullout testing should be conducted in accordance with the ANSI/SPRI FX-1 Standard.
6. Mechanical fasteners used for insulation or membrane securement shall penetrate through the top flange of a steel deck.
7. Ensure that all mechanical fasteners have the proper penetration into the roof deck. Typical fastener penetrations include: 3/4 in. (19 mm) for steel, 1 in. (25 mm) for wood and 1-1/4 in. (32 mm) for structural concrete. Consult with the roofing system supplier and the product listing for verification.
8. Install an edging or coping detail, where appropriate, that will meet the requirements of the ANSI/SPRI/FM 4435/ES-1 Standard. Gutter detail installed that will meet the requirements of ANSI/SPRI GT-1 Standard.
9. The use of the Rational Analysis Method described in Sections 2.5 and 2.6 may be affected by the test table size used to determine the tested wind uplift load capacity of a particular roofing assembly. It is general industry practice that the following criteria be followed:
    a. For adhered membrane roofing assemblies: The Tested Uplift Load Capacity of the proposed adhered roofing assembly should have been 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.
    b. For linear attached mechanically fastened roofing assemblies: The tested uplift load capacity of the proposed linear attached (rows) mechanically fastened roofing assembly should have been determined utilizing a test chamber of sufficient size such that the tested row spacing did not exceed one half of the table length. The minimum frame width should have been 8 ft. (2.44 m).
    c. For spot-attached mechanically fastened roofing assemblies: The tested uplift load capacity of the proposed spot-attached mechanically fastened roofing assembly should have been 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 should have been 8 ft. (2.44 m).
    d. Typically, the steel deck flutes are spaced 6 in. (15 cm) on center, the perimeter and corner ribbons/

bead spacing must be rounded down to 6 in. (15 cm) on center. Therefore, the final layout for this assembly scenario is to use ribbons/beads of adhesive spaced 12 in. (30.5 cm) on center for insulation attachment in the field of the roof and ribbons/beads of adhesive spaced 6 in. (15 cm) on center for insulation attachment in the perimeter and corner areas.

i. If deck has modules with a profile that exceeds flutes spaced at 6-inches, adhesive ribbons spacing must be verified by an engineer.

ii. If the deck had a smooth (non-fluted) top surface such as concrete, cementitious wood fiber, wood, etc., or if the adhesive was being used to attach multiple layers of insulation, the final layout for this assembly would be to use ribbons/beads of adhesive spaced a maximum of 12 in. (30.5 cm) on center in the field of the roof, 10.5 in. (27 cm) on center in the perimeter area and 7.0 in. (18 cm) on center in the corner areas.

Commentary C

Safety Factor Discussion

The Wind Design Standards has been developed to be usable with the model International Building Code (IBC), the Florida Building Code (FBC), and the National Building Code of Canada (NBC), each with their own subtle differences. As of this publication, the IBC and ASCE 7 do not require a safety factor be applied to roofing assemblies. While the FBC requires all tested uplift pressures be divided by a safety factor 2. The NBC requires that all tested uplift pressures are divided by a safety factor of 1.5. As an alternative, the design professional could specify a safety factor as referenced in ASTM D6630. Insurance companies may require safety factors, and the safety factor should be verified with those carriers.

Determination for the need of a safety factor is the responsibility of the designer professional but typical values range between 1.0 and 2.0. Ultimate Design Load calculations have factors of safety inherently included in the wind speed maps making them more conservative than Allowable Design Load values and lessening the need for additional safety factors.

Some wind uplift website listings and most testing reports do not reference a safety factor as they simply identify the maximum Tested Uplift Load Capacity that a particular roofing assembly is capable of resisting. Tested Uplift Load Capacity values available from evaluation reports, publications and some other websites may include a safety factor, which means that the listed wind uplift resistance value is actually the Factored Tested Load Capacity. In this instance the Tested Uplift Load Capacity is determined by multiplying $\mathbf{L_t}$ by the specified safety factor. When a safety factor of 1.0 is utilized, $\mathbf{L_t}$=Tested Uplift Load Capacity

Various methods exist for applying safety factors and include the following:

a. Allowable Design Load results multiply by safety factor:
Factored Design Load (Lfd)=Design Load ($\mathbf{L_d}$)×safety factor

b. Tested Load Capacity divided by safety factor:
Factored Tested Load Capacity (Lft)=Tested Uplift Load Capacity ($\mathbf{L_t}$) ÷ safety factor

Commentary D

Applicable Building Code Testing

This Wind Design Standard has been developed to be usable with the model International Building Code (IBC), the Florida Building Code (FBC), and the National Building Code of Canada (NBC), each with their own subtle differences. As of this publication, the IBC and FBC have the following codified testing: ANSI/FM 4474, UL 580, or UL 1897; while the NBC codified testing is CAN/ULC A123. All four tests report Tested Uplift Load Compacity in pounds per square foot (kPa).

Related Reference Documents

Design Standards

1. *ASCE 7 Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (available at www.asce.org)
2. *ANSI/SPRI RP-4, Wind Design Standard for Ballasted Single-Ply Roofing Systems* (available at www.spri.org)
3. *ANSI/SPRI RP-14, Wind Design Standard for Vegetative Roofing Systems* (available at www.spri.org)
4. *ANSI/SPRI/FM 4435/ES-1, Wind Design Standard For Edge Systems Used with Low Slope Roofing Systems* (available at www.spri.org)
5. *ANSI/SPRI GD-1, Structural Design Standard for Gutter Systems Used with Low-Slope Roofs* (available at www.spri.org)
6. *ANSI/SPRI GT-1 Test Standard for External Gutter Systems* (available at www.spri.org)

Florida Roofing Application Standards

1. *RAS No. 117-20 Standard Requirements for Bonding or Mechanical Attachment of Insulation Panels and Mechanically Attachment of Anchor and/or Base Sheet to Substrates* (available at codes.iccsafe.org)
2. *RAS No. 137-20 Standard Requirements for Mechanical Attachment of Single-Ply Roof Coverages to Various Substrates* (available at codes.iccsafe.org)

North American Testing Standards

1. *ANSI/FM 4474, American National Standard for Evaluating the Simulated Wind Uplift Resistance of Roof Assemblies Using Static Positive and/or Negative Differential Pressures* (available at www.fmglobal.com)
2. *ANSI/SPRI FX-1, Standard Field Test Procedure for Determining the Withdrawal Resistance of Roofing Fasteners* (available at www.spri.org)
3. *ANSI/SPRI IA-1, Standard Field Test Procedure for Determining the Mechanical Uplift Resistance of Insulation Adhesives over Various Substrates* (available at www.spri.org)
4. *UL 580, Standard for Tests for Uplift Resistance of Roof Assemblies* (available at www.ul.com)
5. *UL 1897, Standard for Uplift Tests for Roof Covering Systems* (available at www.ul.com)
6. *CSA Standard A123.21, Standard Test Method for the Dynamic Wind Uplift Resistance of Membrane-Roofing Systems* (available at www.ShopCSA.ca)