ANSI/SPRI ED-1 2019

Design Standard for Edge Systems Used with Low Slope Roofing Systems

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465 Waverley Oaks Road
Suite 421
Waltham, MA 02452

www.spri.org.

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1 Introduction

1.1 Scope

This Standard provides the basic requirements for wind load design for roof edge securement of roof edge systems, including gutters and nailers. It also provides information on material thicknesses that lead to satisfactory flatness, accommodating thermal movement, how to minimize corrosion, methods for testing roof edge systems, and other factors affecting roof edge performance. This Standard is intended for use by those that design, specify, and manufacturer roofing materials and roof edge systems used in the roofing industry. The membrane manufacturer shall be consulted for specific recommendations for making the roof watertight at the edge.

This Standard applies to low slope membrane roof systems, with low slope defined here as roofs having a slope ≤ 9.5 degrees (2:12). The design and installation information found in this document addresses copings, horizontal roof edges, and gutters as well as the following factors which shall be considered in designing a roof edge:

- Structural integrity of the substrate that anchors the edge (e.g. nailers)
- Wind resistance of the edge detail
- Material specifications

This Standard provides perimeter edge loads based upon the field of roof pressure for the building under consideration. The user is required to know, or be able to calculate using ASCE 7 *Minimum Design Loads for Buildings and Other Structures*[1] or other means, the field of roof pressure. The intent of this Standard is to provide condensed design information pertaining to the design of roof edge systems; the Authority Having Jurisdiction (AHJ) for the project under design shall dictate the method for determining perimeter edge load requirements. See Commentary.

1.2 Definitions

ANSI: American National Standards Institute

ASCE: American Society of Civil Engineers

Aluminum: a non-rusting, malleable *metal* sometimes used for *roof edge systems*.

Ballast: an anchoring material, such as aggregate or precast concrete pavers, which employs its mass and the force of gravity to hold (or assist in holding) single-ply roof *membranes* in place.

Cleat: a continuous *metal* strip, or angled piece, used to secure *metal* components.

Clip: a non-continuous *metal* component or angle piece used to secure two or more *metal* components together.

Cold rolled: the process of forming steel, *aluminum*, and *copper* into sheets, panels, or shapes on a series of rollers at room temperature.

Coping: the covering piece on top of a *parapet wall* exposed to the weather, usually made of *metal*, and sloped to carry off water.

Copper: a natural weathering *metal* used in *metal* roofing or flashings.

Deck: the uppermost structural component of the building immediately below the *roof system*. The *deck* must be capable of safely supporting the weight of the *roof system*, and the loads required by the governing building codes.

Design load: the total load on a structural system for the most severe combination of loads and forces which it is designed to sustain.

Design pressure: the *design load* on a structure due to pressure, either negative or positive, caused by wind.

Drip: the lower most portion of a *metal* flashing or other overhanging component, which projects away from the building with the intention preventing capillary action and controlling the direction of dripping water to help protect underlying building components.

Fascia: the vertical or steeply sloped roof or trim located at the perimeter of a building. Typically, it is a border for the *low-slope roof system*.

Fastener: any of a wide variety of mechanical securement devices and assemblies, including nails, screws, *cleats*, *clips* and bolts, which may be used to secure various edge components.

Field of Roof Pressure: the wind pressure (generally upwards) imparted on a central area of the roof.

Flatness: a three-dimensional geometric tolerance that controls how much a feature can deviate from a flat plane.

Galvanic series: a list of *metals* and alloys arranged according to their relative electrolytic potentials in a given environment.

Galvanize: to coat steel or iron with *zinc*.

Gravel stop: a flanged device, frequently metallic, designed to prevent loose aggregate from washing off the roof and to provide a continuous finish edge for the roofing *membrane*.

Gutter: a generally U-shaped channel for collecting water runoff from the roof and leading it to an *outlet*.

Gutter Bracket: a device that supports a *gutter* from underneath.

Gutter Strap: a device that helps support a *gutter* from the top.

Gutter System: a system consisting of *gutter*, *gutter straps*, *gutter brackets*, joints, *fasteners*, and roof flange.

Low-slope roof: a category of roofs that generally include weatherproof *membrane* types of *roof systems* installed on slopes at or less than 2:12 (9.5 degrees).

Membrane: a flexible or semi-flexible roof covering or waterproofing whose primary function is to exclude water.

Metal: any of a category of electropositive elements that usually have a shiny surface, are generally good conductors of heat and electricity, and can be melted or fused, hammered into thin sheets.

Nailer: a longitudinal member, typical wooden, to which a *roof edge system* may be fastened to the building. Such fastening can be direct or through *clips*, *cleats*, *gutter brackets*, or *gutter straps*.

NRCA: National Roofing Contractors Association

Outlet: an opening in a *gutter* that allows water discharge.

Parapet wall: the part of a perimeter wall that extends above the roof.

Roof Edge: the point of transition from a *low-slope roof* to a lower vertical or near vertical building element, including but not limited to walls, windows, *fascia* boards, and mansard roofs.

Roof Edge System: a component or system of components at the perimeter of the roof that typically is integrated in to the *roof system* for the purpose of flashing and securing the roof *membrane*.

Roof slope: the angle a roof surface makes with the horizontal, expressed as a ratio of the units of vertical rise to the units of horizontal length (sometimes referred to as run), the amount or degree of such deviation. If the slope is given in inches, slope may be expressed as a ratio of rise of run, such as 2:12, or as an angle.

Roof system: a system of interacting roof components, generally consisting of a *membrane*, roof insulation and edge materials (not including the roof *deck*) designed to weatherproof and, sometimes, to improve the building's thermal resistance.

Safety Factor: a multiplier to design calculations selected to cover uncertainties in the calculation results and to address normally anticipated variances in, and deterioration/aging of, materials.

Soffit: the exposed undersurface of any exterior overhanging section of a roof eave.

SMACNA: Sheet Metal and Air Conditioning Contractors National Association, Incorporated.

Substrate: the upper surface of the roof *deck*, insulation, or other roofing structure upon which a roofing *membrane* or other component of the roofing system is placed or to which it is attached.

Thermal expansion: the increase in the dimension or volume of a body due to temperature variations.

Wind load: force exerted by the wind on a roof or any component of a roof.

Wind uplift: wind that is deflected at *roof edges*, roof peaks or obstructions can cause a drop in air pressure immediately above the roof surface. The resultant force is transmitted to the roof surface and is called *wind uplift*.

Zinc: A bluish-white, lustrous metallic element which is used to form a wide variety of alloys including brass, bronze, in galvanizing iron and other *metals*, for roofing and *gutters* and other various components.

2 Background Information

2.1 Wind Related Roofing Damage

No area of the country is exempt from wind related roofing damage. A study of 145 FM Global losses involving built-up roof (BUR) systems showed 85 losses (59 percent) occurred because the roof perimeter failed[2]. The Roofing Industry Committee on Weather Issues (RICOWI) has issued several reports summarizing their findings regarding roof damage after significant wind events. The committee found “many examples of damage appeared to originate at failed edge details”[3]. RICOWI notes that their “studies reinforced the need for secure *roof edges*, and codes that require secure roof edging need to be enforced”[4].

Findings from a two-year study of in-situ *roof edge systems* conducted by the National Research Council of Canada (NRCC), *Wind Uplift Standard for Roof Edge Systems and Technologies (REST) Project*[5], are reported by Baskaran et al, (2017), Development of Wind Loaded Criteria for Commercial *Roof Edge Metals* in the journal of Architectural Engr, ASCE found that actual *wind load* measurements correlated very closely with the wind *design loads* outlined in this standard. However, when local code requires other *design loads*, they shall be used. See Commentary.

3 General Design Factors

3.1 Roof Slope

Roof Slope is accounted for in the pressure coefficient factors used in this document. Only *roof slopes* ≤ 9.5° (2:12) are addressed by this document.

3.2 Roof Edge Conditions

Roof edges composed of *low-slope roofs* terminating into a *parapet wall* or a lower vertical element of the building are addressed in this document.

3.3 Field of Roof Pressure

The *field of roof pressures* (q_{fz}) used in this document are in pounds per square foot (psf) and kilopascals (KPa). Calculation of the *field of roof pressure* for the building under design is outside of the scope of this document, and shall be calculated using ASCE 7 *Minimum Design Loads for Buildings and Other Structures*[1] or other means.

3.4 Building Height

The building height shall be measured from the ground to the eave of the roof section. Specific topographic features, such as hills, shall be considered as per ASCE 7 when calculating building height.

3.5 Roof Edge Regions

Wind forces near building corner regions are of greater intensity than in the perimeter regions between corners. These regions are defined as follows:

3.5.1 Corner Region

Corner region is determined by building height and width. The method of determining the size of the corner region varies based upon which version of ASCE 7 is used. Reference Code and the Authority Having Jurisdiction (AHJ) for the required version of ASCE 7 to be used, and calculate the corner region accordingly. See Commentary.

3.5.2 Perimeter Region

The perimeter is the section of *roof edge* between building corner regions as defined in Section 3.5.1 (above). The edge condition includes the *roof edge system* and the *nailer* or other *substrate* to which the *roof edge system* is attached.

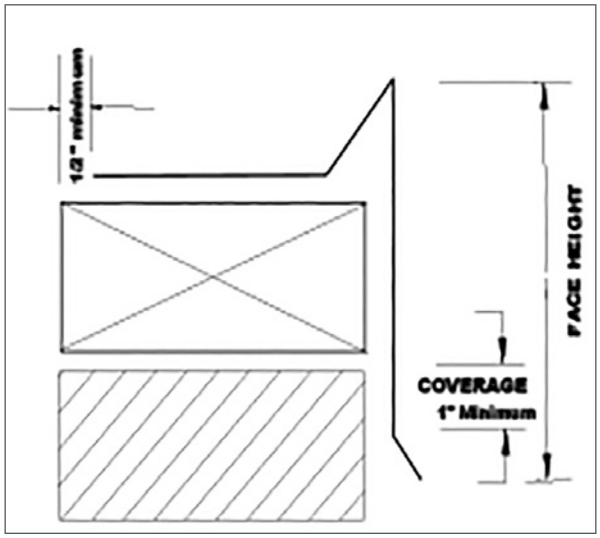


Figure 1: Face Height and Coverage

3.5.3 Face Height and Coverage

Coverage is the location of the lowest vertical point of the *roof edge system* or any extension of it, exclusive of any *drip* or other protrusion. The coverage shall extend a minimum of 1 in. (25 mm) below the bottom of the bottom *nailer*, or a minimum of 1 in. (25 mm) over the face of the wall when no *nailer* is present. The roof *membrane* shall not extend below the coverage (see Figure 1).

3.6 Importance Factor

Buildings shall have an Importance Factor included in the wind design calculations. When using ASCE 7-05 an importance factor multiplier is used. Table A1 (see Appendix A) defines these building classifications. The tables in this document all use a Risk category II importance factor of 1.0. When designing per ASCE 7-05 the loads listed in the tables shall be multiplied by the importance factor appropriate for the building under design. No adjustment is needed when designing per ASCE 7-10. See Commentary

3.7 Membrane Termination

Two types of **membrane** termination are industry accepted: dependently and independently terminated systems. See Commentary.

3.7.1 Dependently Terminated Systems

Ballasted Systems, ribbon adhered systems, or systems in which the mechanically attached roof cover is secured to the *substrate* at a distance greater than 12 in. (305 mm) from the outside edge of the *nailer* are considered dependently terminated by the *roof edge system*. See Commentary.

3.7.2 Independently Terminated Systems

Systems in which the roof cover is fully adhered to the *substrate* or a mechanically attached roof cover is secured to the *substrate* at a distance less than or equal to 12 in. (305 mm) from the outside edge of the *nailer* are considered independently terminated. See Commentary.

3.8 Nailer System Requirements

3.8.1 Nailer Secured Systems

Wood blocking or *nailers* used to attach *roof edge system* components shall be designed and installed to resist the design outward and upward loads determined for the *roof edge system* per Tables A6 and A7. See Commentary.

Wood *nailers* shall have minimum thickness of 1.5 in. (38 mm). For *roof edge systems* used to secure the roofing (e.g., *gravel stops*), the *substrate* (e.g. *nailer*) shall extend at least ½ in (13 mm) beyond the back edge of the horizontal flange of the *roof edge system* (See Figure 1).

3.8.1.1 Nailer Attachment to Masonry

All anchor bolts shall be designed to resist the design *wind load* and shall be firmly attached to the masonry structure to provide a\load path. See Commentary.

3.8.1.2 Nailer Attachment to Lightweight Concrete and Gypsum

Anchors and anchor *substrates* shall be designed to resist the design *wind load*. Alternatively, all roof perimeter *nailers* shall be attached directly to building structural members to provide a continuous load path. See commentary.

3.8.1.3 Nailer Attachment to Steel Deck

All roof perimeter *nailers* attached to steel *decks* shall be designed to resist the design *wind loads*. The steel *decks* shall be attached to the structure to provide a continuous load path. See commentary.

3.8.2 Nailerless Systems

The direct attachment of *roof edge systems* to masonry or steel shall be designed to resist the design *wind loads*. See commentary.

3.8.3 Re-roofing

Edge *nailers* shall be in good condition with no rotted wood or splits. *Fasteners* shall be adequate to resist the design *wind load* and not be corroded or missing. See commentary.

3.9 Other Design Requirements

3.9.1 Local building codes

A local or state building code may have additional *wind load* provisions, which contain additional wind design requirements beyond those listed in this document.

3.9.2 Main Wind Force Resisting System

The project engineer of record shall provide the *roof edge system* manufacturer with additional design requirements of the *roof edge system* as a result of special or non-typical design considerations of the building's main wind force resisting system.

4 Wind Design of Edge Systems

4.1 General Information

The wind design of *roof edge systems* is comprised of two parts, the determination of the *roof edge wind loads* (Section 4.2), and the determination of the *roof edge system* resistance (Section 6). All materials for *roof edge* construction shall have sufficient strength (resistance) to withstand the design *wind load*.

4.2 Edge Pressure Wind Load Tables

Horizontal and vertical edge pressure values are given in Tables A2 (roof height (h) ≤ 60 ft.) and A3 (h > 60 ft.) for various *field of roof pressures*.

Membrane tension loads are given in Tables A4 (roof height (h) ≤ 60 ft.), and A5 (h > 60 ft.). See Commentary.

4.3 Nailer Securement Load Tables

The load values shown in Tables A6 (roof height (h) ≤ 60 ft.) and A7 (h > 60 ft.) are based on the load imparted to a *fastener* for a given *fastener* spacing. See Commentary.

5 Static Load Design for Gutters

5.1 Water Loads

If *gutter* outlets are blocked or clogged, the *gutter* will fill to capacity with water. The downward force per unit length of a filled *gutter* is equal to the density of water times the cross-sectional area of the portion of the *gutter* filled with water when the *gutter* is filled to capacity.

$F_s = S_f \times p_w \times A_w$

In which:

F_s = Downward static load per unit length of *gutter*

A_w = Cross-sectional area of the water when the *gutter* is filled to capacity

p_w = Density of water

S_f = Safety Factor = 1.67

The *gutter system* shall therefore be subjected to downward loads of

$F_w = 104 \times A_w$ with F_w in pounds per foot and A_w in $ft.^2$

5.2 Ice and Snow Loads

In regions where ground snow loads are greater than zero, the force of ice forming around the *gutter* shall be considered in the static load design. Static load on the *gutter* shall be the downward static load as defined in Section 5.1 above plus 2.0 times the ground snow load p_g with p_g = maximum of 20 $lb./ft.^2$

$F_s = S_f \times p_w \times A_w + 2.0 \times pf \times Aw$

In which p_f = Flat Roof Snow Load

In regions where $p_g < 20$ $lb./ft.^2$, then

$p_f = p_g$

In regions exceeding 20 $lb./ft.^2$

Ground snow load p_g shall be derived from Attachment I.

6 Edge System Resistance

Roof edge systems shall be tested in accordance with ANSI/SPRI/FM 4435/ES-1 and or ANSI/SPRI GT-1 as appropriate for the application.

6.1 Dependently Terminated Systems

Edge devices designed to act as *membrane* termination shall be tested according ANSI/SPRI/FM 4435/ES-1 Test RE-1.

6.2 Edge Flashing, Gravel Stops

Roof edge systems where the *expose*d horizontal component is 4 in. (102 mm) or less, shall be tested according to ANSI/SPRI/FM 4435/ES-1 Test RE-2. For *exposed* horizontal components greater than 4 in. (102 mm), ANSI/SPRI/FM 4435/ES-1 Test RE-3 is applicable.

6.3 Copings

Coping and other edge devices for which the *exposed* horizontal component exceeds 4 in. (102 mm) shall be tested according to ANSI/SPRI/FM 4435/ES-1Test RE-3.

6.4 Gutters

Gutters shall be tested in accordance with ANSI/SPRI GT-1 Tests G-1 for resistance to outward (horizontal) *wind loads*, G-2 for resistance to upward (vertical) *wind loads*, and G-3 for resistance to downward (vertical) static loads

6.5 Perimeter and Corner Regions

Roof edge systems installed within perimeter regions shall have been tested to meet perimeter *design loads*. Similarly, *roof edge systems* installed within corner regions shall have been tested to meet corner *design loads*.

7 Performance of Light Gauge Metal

7.1 Thermal Expansion

Roof edge systems shall be designed to allow for free thermal movement due to any differing rates of expansion/contraction between components of the *roof edge system*, and between the *roof edge system* and the *substrate* to which it is attached. *Roof edge system* elements, which are not allowed to expand/contract freely, can cause internal stresses and unwanted deflections (including face bowing) that may compromise both the appearance and performance of the *roof edge system*. Sections of the *roof edge system* should be designed to allow for the expected expansion/contraction of each section. Figure 2 shows the amount of expansion or contraction in 64ths of an inch that will occur to a 10-foot (3 m) section of *roof edge* or *roof edge system* due to a 100° F (37.8° C) temperature change.

7.1.1 Fastener Holes

When attaching materials with differing coefficients of expansion the *fastener* clearance holes shall be slotted or oversized to allow for differing amounts of *thermal expansion*.

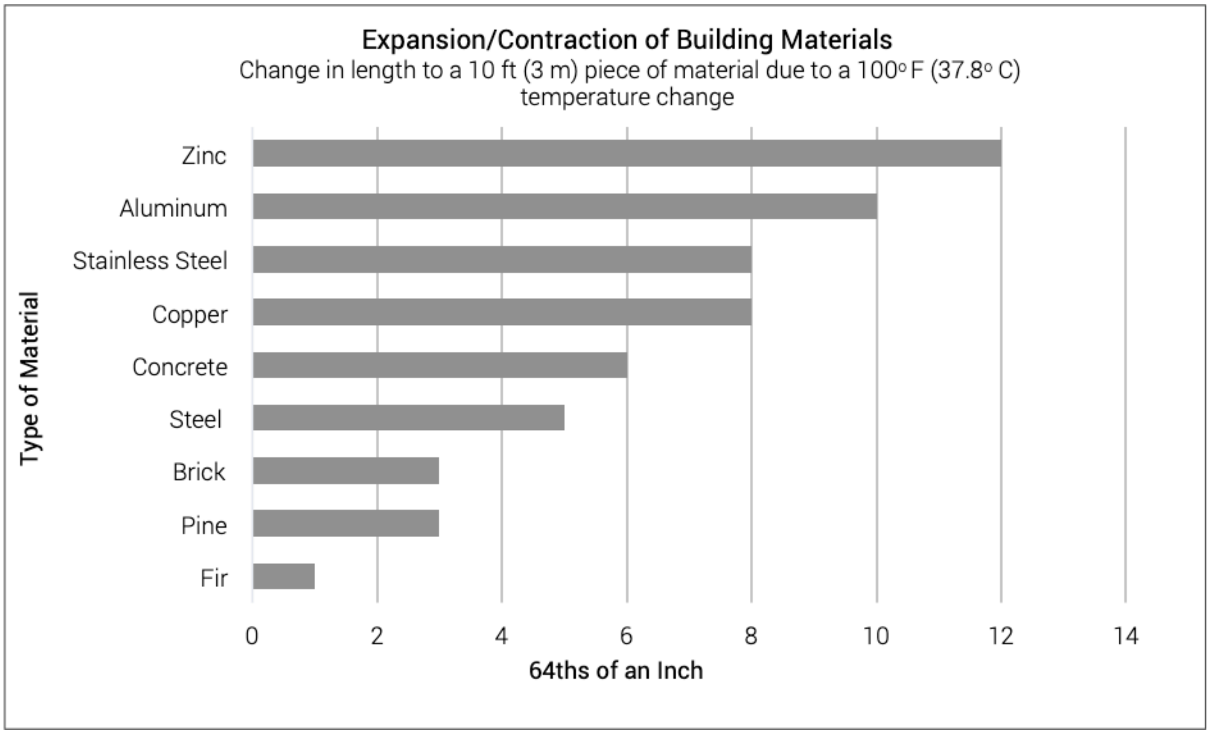
7.1.2 Cleats and Clips

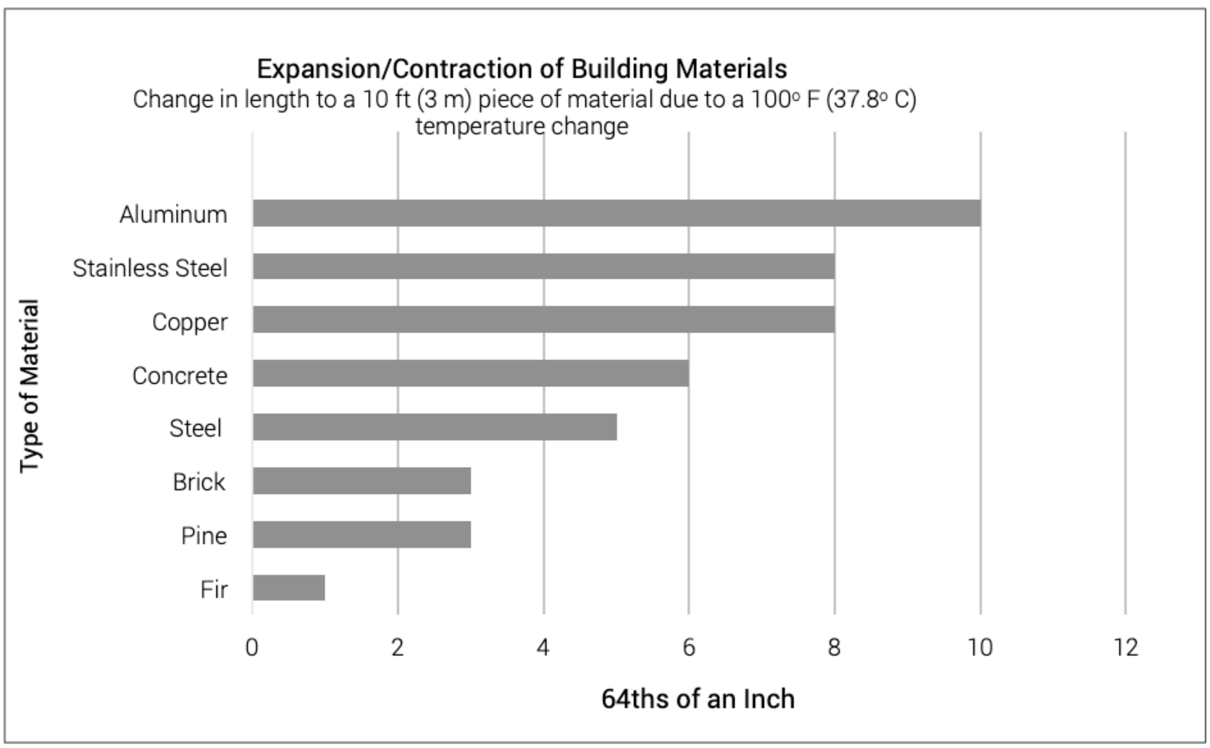
Engaging *roof edge system* components on *cleats* or *clips* will allow for thermal movement of the *roof edge system*; however, no linear edge component shall be tightly crimped or fastened to the *cleat* or *clip*

7.1.3 Joints

Joints where lineal sections of *roof edge system* components meet shall either be lapped to allow joining sections to move, or have a gap wide enough to allow for the expected thermal movement with a splice plate to prevent water infiltration where needed.

Figure 2


Expansion/Contraction of Building Materials
Change in length to a 10 ft (3 m) piece of material due to a 100° F (37.8° C) temperature change
Type of Material
Zinc
Aluminum
Stainless Steel
Copper
Concrete
Steel
Brick
Pine
Fir
0
2
4
6
8
10
12
14
64ths of an Inch


Expansion/Contraction of Building Materials
Change in length to a 10 ft (3 m) piece of material due to a 100° F (37.8° C) temperature change
Type of Material
Aluminum
Stainless Steel
Copper
Concrete
Steel
Brick
Pine
Fir
0
2
4
6
8
10
12
64ths of an Inch

7.2 Metal Thickness

7.2.1 Flatness

Minimum gauges for *flatness* of exposed faces shall be determined from Figure 3. See Commentary.

Figure 3

Minimum Metal Thickness for Flatness

Exposed Face	Metallic Coated Steel or Zinc	Cold Rolled Copper	Aluminum Sheet	Stainless Steel
Up to 4 in. (to 102 mm)	24 ga. (0.028 in. 0.7 mm)	16 oz. (0.022 in. 0.6 mm)	0.032 in. (0.82 mm)	26 ga. (0.016 in. 0.4 mm)
> 4 in.–8 in. (> 102 mm–203 mm)	24 ga. (0.028 in. 0.7 mm)	16 oz. (0.022 in. 0.6 mm)	0.040 in. (1.0 mm)	26 ga. (0.016 in. 0.4 mm)
> 8 in.–10 in. (> 203 mm–254 mm)	22 ga. (0.034 in. 0.9 mm)	20 oz. (0.027 in. 0.7 mm)	0.050 in. (1.3 mm)	24 ga. (0.023 in. 0.6 mm)
> 10 in.–16 in. (> 254 mm–406 mm)	20 ga. (0.040 in. 1.0 mm)	20 oz. w/stiffening ribs	0.063 in. (1.6 mm)	22ga. (0.029 in. 0.7 mm)
> 16 in.–24 in. (> 406 mm–610 mm)	20 ga. (0.040 in. 1.0 mm)	20 oz. w/stiffening ribs	0.063 in. (1.6 mm)	22ga. (0.029 in. 0.7 mm)

7.2.2 Strength

Increasing material thickness typically increases the strength of a *metal* component. Because *cleats* are a critical component for restraining edge systems, it is generally recommended that *cleats* be one gauge heavier than the material engaged on the *cleat*. However, many other factors such as elasticity of the materials, *fastener* location, and others, greatly contribute to the strength or performance of an edge system. For that reason, edge system performance shall be tested per Section 6 above.

7.3 Galvanic Corrosion

Metal components of *roof edge systems* (face, *cleats*, *clips*, straps, brackets, and *fasteners*) shall be comprised of the same kind of *metal*, or shall be galvanically compatible *metal* pairs.

Fasteners shall be galvanically compatible with the other *roof edge system* components[6]. When used with *aluminum*, steel *fasteners* shall have a dielectric resistive coating. *Copper* shall not be used in combination with mill finish steel, *zinc* or *aluminum*. Only *copper*, stainless steel, or *copper*-alloy *fasteners* shall be used with *copper* components.

Pressure treated lumber, which is commonly used for wood blocking (*Nailers*), is frequently treated with a solution containing *copper*. When such pressure treated wood is used, the *roof edge system* shall be galvanically compatible with, or separated from, the treated wood, and *fasteners* installed into the wood shall be galvanically compatible with the treated wood.

Corrosion and strength should be considered in the choice of materials used for *metal roof edge systems*. Corrosive potential can be roughly predicted by knowing the placement of the two *metals* in the *galvanic series* [4, 5]. The farther apart the *metals* are in the *galvanic series*, the greater is this potential for corrosion. *Metals* adjacent to each other in the series have little potential for corrosion. In Figure 4, the *metals* low on the list are potentially corroded while those high on this list are protected. Basically, pairs of *metals* such as *aluminum* and *zinc* or *aluminum* and stainless steel will show no perceptible corrosion between them, because of their proximity to each other on the list. On the other hand, pairing *copper* and *zinc* or *aluminum* or steel must be avoided because *copper* is far from them in the *galvanic series* and the potential for corrosion is great.

Frequently, the corrosion rate of “sacrificed” *metals* will be low, even if there is a potential for corrosion.

Thus, there will generally be little corrosion between *metals* that are close to each other on the list; however, when they are in contact, the higher of a pair will be protected by the lower even if no perceptible corrosion is taking place. For this reason, steel, being higher on the list than *zinc* will be protected by the *zinc*, which is “sacrificed” to save the steel. Fortunately, though there is a potential for corrosion between *zinc* and steel, under most conditions, the rate of corrosion is minuscule so that the *zinc* lasts many years while protecting the steel.

The immediate environment or “medium” of *metals* used in *roof edge systems* greatly affects the rate of galvanic corrosion[4, 5]; materials in a salt water spray environment will corrode faster than areas far from a salt water lagoon or ocean. In extremely corrosive environments such as salt-water environments, chemical plants or paper mills, corrosion resistant materials such as stainless steel shall be used. When plastic materials are used, corrosion is not usually a factor (although environmental deterioration must be considered). However, as with *metals* the strength of the materials must be considered.

7.4 Non-typical Building Environments

Metal to be used for highly acidic, caustic or other non-typical environments shall be designed and/or specified by the owner’s representative or building’s engineer of record.

7.5 Water Drainage

Roof Edge Systems shall be designed to prevent ponding water and infiltration of water into the *roof system*. The tops of *coping* shall be sloped to carry off water. The front lip of external *gutters* shall be a minimum of 1" lower than the back leg to allow water to flow over the front lip before infiltrating the *roof system* at the back in the event *gutter* drainage is blocked. *Gutter systems* shall have openings at the low points, or positive slope to outlets.

8 Appliances

Appliance attachments, such as air terminals (lightning rods), signs or antennae that penetrate the water seal, induce a galvanic reaction, restrain *thermal expansion* and contraction, or induce a *wind load* may compromise the effectiveness of the *roof edge system*. Appliances shall not be attached to the *roof edge system*, or shall be isolated to prevent the transfer of wind, thermal, or other forces which may compromise the performance of the *roof edge system*. Any attached appliances shall also be isolated to prevent galvanic reaction, see Section 7.3.

9 Packaging and Identification

Roof edge system components or packaging shall contain written documentation, which identifies the components, which have been tested in accordance with the ANSI/SPRI/FM 4435/ES-1 or ANSI/SPRI GT-1 test standards. Documentation, in the form of a label, manufacturer’s printed product literature or letter, shall be made available to the building owner or his/her representative.

Figure 4

Galvanic Corrosion Series Chart[6]

More Protected
Platinum
Gold
Graphite
Silver
316 Stainless steel (passive)
304 Stainless steel (passive)
Monel
Inconel (passive)
Nickel (passive)
70-30 cupro-nickel
Silicon bronze
Copper
Red brass
Admiralty bronze
Admiralty brass
Yellow brass
Hastelloy C (active)
Inconel (active)
Nickel (active)
Naval bronze
Muntz metal
Tin
Lead
316 Stainless steel (active)
304 Stainless steel (active)
400 Series stainless steels
50-50 lead-tin solder
13% Cr stainless steel (active)
Ni—resist
Cast iron
Wrought iron
Mild steel
Cadmium
Alclad
Aluminum
Aluminum 2024
Aluminum 3003
Aluminum 6053
Galvanized steel
Zinc
Magnesium alloys
Magnesium
More Corroded

10 Installation Instructions

Installation instructions shall be provided for all *roof edge systems* tested in accordance with the ANSI/SPRI/FM 4435/ES-1 or ANSI/SPRI GT-1 test standards, and shall include as tested *fastener*, *cleat*, *clip*, strap, and bracket requirements.

11 References

1. *Minimum Design Loads for Buildings and Other Structures*, ASCE 7, American Society of Civil Engineers (ASCE), New York.
2. Factory Mutual Approved Product News Vol. 21, No. 2, 2005
3. Roofing Industry Committee on Weather Issues (RICOWI), *Hurricane Katrina Wind Investigation Report*, 2007, pp. xiv
4. Roofing Industry Committee on Weather Issues (RICOWI), *Hurricanes Charley and Ivan Wind Investigation Report*, 2006, pp.xxiv
5. *Wind Uplift Standard for Roof Edge Systems and Technologies (REST) Project*, National Research Council of Canada (NRCC), Presentation at REST Meeting 7, Ottawa, November 2015
6. *Procedure for Evaluation of Corrosion Resistance of Steel Fasteners,* SPRI, Needham MA, 1988.

Appendix A

Tables

Table A1—Importance Factors

Nature of Occupancy	Risk Category	Importance Factor	
		Non-Hurricane Prone Regions & Alaska. V = 85–100 mph	Hurricane Prone Regions. V > 100 mph
Buildings and other structures that represent a low hazard to human life in the event of failure including, but not limited to: ▶ Agricultural facilities ▶ Certain temporary facilities ▶ Minor storage facilities	I	0.87	0.77
All buildings and other structures except those listed in Categories I, III, and IV	II	1.00	1.00
Buildings and other structures that represent a substantial hazard to human life in the event of failure including, but not limited to: ▶ Buildings and other structures where more than 300 people congregate in one area ▶ Buildings and other structures with day care facilities with capacity greater than 150 ▶ Buildings and other structures with elementary school or secondary school facilities with capacity greater than 250 ▶ Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities ▶ Health care facilities with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities ▶ Jails and detention facilities ▶ Power generating stations and other public utility facilities not included in Category IV ▶ Buildings and other structures not included in Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing sufficient quantities of hazardous materials to be dangerous to the public if released.	III	1.15	1.15
Buildings and other structures designated as essential facilities including, but not limited to: ▶ Hospitals and other health care facilities having surgery or emergency treatment facilities ▶ Fire, rescue, ambulance, and police stations and emergency vehicle garages ▶ Designated earthquake, hurricane, or other emergency shelters ▶ Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response ▶ Power generating stations and other public utility facilities required in an emergency ▶ Ancillary structures (including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment) required for operation of Category IV structures during an emergency ▶ Aviation control towers, air traffic control centers, and emergency aircraft hangars ▶ Water storage facilities and pump structures required to maintain water pressure for fire suppression ▶ Buildings and other structures having critical national defense functions ▶ Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing extremely hazardous materials where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction.	IV	1.15	1.15

From Table 1-1 and 6-1 of ASCE 7-05

ASCE 7-10 has separate maps that do not require use of an importance factor

Table A2
Horizontal and Vertical Edge Pressures
Enclosed Buildings[1]
h ≤ 60 ft.

Field of Roof Pressure q_{fz} Psf (KPa)	Horizontal Load psf (KPa)		Vertical Load psf (KPa)	
	Perimeter P_{hp}	Corner P_{hc}	Perimeter P_{vp}	Corner P_{vc}
30 (1.44)	58 (2.8)	73 (3.5)	101 (4.8)	152 (7.3)
37.5 (1.80)	73 (3.5)	91 (4.3)	126 (6.0)	190 (9.1)
45 (2.15)	87 (4.2)	109 (5.2)	151 (7.2)	228 (10.9)
52.5 (2.51)	102 (4.9)	127 (6.1)	176 (8.4)	266 (12.7)
60 (2.87)	116 (5.6)	145 (7.0)	202 (9.7)	304 (14.5)
67.5 (3.23)	131 (6.3)	163 (7.8)	227 (10.9)	342 (16.4)
75 (3.59)	146 (7.0)	182 (8.7)	252 (12.1)	380 (18.2)
82.5 (3.95)	160 (7.7)	200 (9.6)	277 (13.3)	417 (20.0)
90 (4.31)	175 (8.4)	218 (10.4)	302 (14.5)	455 (21.8)
97.5 (4.67)	189 (9.1)	236 (11.3)	328 (15.7)	493 (23.6)
X	1.94 × X	2.41 × X	3.36 × X	5.06 × X

Table Notes:

1. See Commentary 4.2 for open buildings or partially enclosed buildings.
2. Horizontal and vertical load values are calculated directly using *field of roof pressure* given in column 1.
3. Horizontal and vertical load values are calculated using External Pressure Coefficients (GC_p) of 0.97 horizontal perimeter, 1.21 horizontal corner, 1.68 vertical perimeter, and 2.53 vertical corner per ASCE 7-05 and ASCE 7-10.
4. Horizontal and vertical load values contain a *safety factor* of 2.0.

Table A3
Horizontal and Vertical Edge Pressures
Enclosed Buildings1
h* > *60 ft.

Field of Roof Pressure q_{fz} Psf (KPa)	Horizontal Load psf (KPa)		Vertical Load Psf (KPa)	
	Perimeter P_{hp}	Corner P_{hc}	Perimeter P_{vp}	Corner P_{vc}
30 (1.44)	41 (2.0)	75 (3.6)	94 (4.5)	128 (6.1)
37.5 (1.80)	51 (2.4)	94 (4.5)	118 (5.6)	161 (7.7)
45 (2.15)	61 (2.9)	113 (5.4)	141 (6.8)	193 (9.2)
52.5 (2.51)	71 (3.4)	131 (6.3)	165 (7.9)	225 (10.8)
60 (2.87)	82 (3.9)	150 (7.2)	188 (9.0)	257 (12.3)
67.5 (3.23)	92 (4.4)	169 (8.1)	212 (10.1)	289 (13.8)
75 (3.59)	102 (4.9)	188 (9.0)	236 (11.3)	321 (15.4)
82.5 (3.95)	112 (5.4)	206 (9.9)	259 (12.4)	353 (16.9)
90 (4.31)	122 (5.9)	225 (10.8)	283 (13.5)	385 (18.4)
97.5 (4.67)	133 (6.3)	244 (11.7)	306 (14.7)	417 (20.0)
105 (5.03)	143 (6.8)	263 (12.6)	330 (15.8)	449 (21.5)
112.5 (5.39)	153 (7.3)	281 (13.5)	353 (16.9)	482 (23.1)
120 (5.75)	163 (7.8)	300 (14.4)	377 (18.0)	514 (24.6)
127.5 (6.10)	173 (8.3)	319 (15.3)	400 (19.2)	546 (26.1)
X	1.36 × X	2.5 × X	3.14 × X	4.28 × X

Table Notes:

1. See Commentary 4.2 for open buildings or partially enclosed buildings.
2. Horizontal and vertical load values are calculated directly using *field of roof pressure* given in column 1.
3. Horizontal and vertical load values are calculated using External Pressure Coefficients (GC_p) of 0.68 horizontal perimeter, 1.25 horizontal corner, 1.57 vertical perimeter, and 2.14 vertical corner per ASCE 7-05 and ASCE 7-10.
4. Horizontal and vertical load values contain a *safety factor* of 2.0.

Table A4
RE-1 Loads - Dependently Terminated Systems
Enclosed Buildings[1]
h ≤ 60 ft.

Field of Roof Pressure q_{fz} psf (kPa)	Vertical Perimeter Pressure P_{vp} psf (kPa)	Membrane Tension lb./ft. (kg/m) Distance to first row of fasteners ft.				
		1 < r ≤ 2 (0.3 < r ≤ 0.6)	2 < r ≤ 3 (0.6 < r ≤ 0.9)	3 < r ≤ 4 (0.9 < r ≤ 1.2)	4 < r ≤ 5 (1.2 < r ≤ 0.5)	5 < r ≤ 6* (1.5 < r ≤ 1.8)
q_{fz} ≤ 30.0 (q_{fz} ≤ 1.44)	101 (4.83)	239 (356)	358 (533)	477 (710)	596 (887)	716 (1066)
30.0 < q_{fz} ≤ 37.5 (1.44 < q_{fz} ≤ 1.8)	126 (6.03)	298 (443)	447 (664)	596 (887)	745 (1109)	894 (1330)
37.5 < q_{fz} ≤ 45.0 (1.8 < q_{fz} ≤ 2.15)	151 (7.24)	358 (533)	537 (799)	716 (1066)	894 (1330)	1073 (1597)
45.0 < q_{fz} ≤ 52.5 (2.15 < q_{fz} ≤ 2.51)	176 (8.45)	417 (621)	626 (932)	835 (1243)	1042 (1552)	1251 (1863)
52.5 < q_{fz} ≤ 60.0 (2.51 < q_{fz} ≤ 2.87)	202 (9.65)	477 (710)	716 (1066)	954 (1419)	1193 (1775)	1431 (2130)
60.0 < q_{fz} ≤ 67.5 (2.87 < q_{fz} ≤ 3.23)	227 (10.9)	537 (799)	804 (1198)	1073 (1597)	1342 (1997)	1610 (2395)
67.5 < q_{fz} ≤ 75.0 (3.23 < q_{fz} ≤ 3.59)	252 (12.1)	596 (887)	894 (1330)	1193 (1775)	1490 (2218)	1789 (2661)
75.0 < q_{fz} ≤ 82.5 (3.59 < q_{fz} ≤ 3.95)	277 (13.3)	656 (976)	984 (1464)	1312 (1951)	1640 (2440)	1968 (2928)
82.5 < q_{fz} ≤ 90.0 (3.95 < q_{fz} ≤ 4.31)	302 (14.5)	716 (1066)	1073 (1597)	1431 (2130)	1789 (2661)	2146 (3194)
90.0 < q_{fz} ≤ 97.5 (4.31 < q_{fz} ≤ 4.67)	328 (15.7)	775 (1152)	1163 (1731)	1550 (2307)	1937 (2884)	2326 (3460)
97.5 < q_{fz} ≤ 105.0 (4.67 < q_{fz} ≤ 5.03)	353 (16.9)	835 (1243)	1251 (1863)	1669 (2484)	2087 (3106)	2504 (3725)
105 < q_{fz} ≤ 112.5 (5.03 < q_{fz} ≤ 5.39)	378 (18.1)	894 (1330)	1342 (1997)	1789 (2661)	2236 (3328)	2683 (3992)
112.5 < q_{fz} ≤ 120 (5.39 < q_{fz} ≤ 5.75)	403 (19.3)	954 (1419)	1431 (2130)	1907 (2839)	2384 (3548)	2861 (4258)
120 < q_{fz} ≤ 127.5 (5.75 < q_{fz} ≤ 6.11)	428 (20.5)	1013 (1509)	1521 (2263)	2027 (3016)	2534 (3770)	3040 (4525)

Table Notes:

1. See Commentary 4.2 for open buildings or partially enclosed buildings.
2. * 5 < r < 6 column to be used for ballasted systems.
3. See Commentary for the calculations used to determine entries in this table.

Table A5
RE-1 Loads—Dependently Terminated Systems
Enclosed Buildings[1]
h > 60 ft.

Field of Roof Pressure q_{fz} psf (kPa)	Vertical Perimeter Pressure P_{vp} psf (kPa)	Membrane Tension lb./ft. (kg/m)				
		Distance to first row of fasteners ft.				
		1 < r ≤ 2 (0.3 < r ≤ 0.6)	2 < r ≤ 3 (0.6 < r ≤ 0.9)	3 < r ≤ 4 (0.9 < r ≤ 1.2)	4 < r ≤ 5 (1.2 < r ≤ 0.5)	5 < r ≤ 6* (1.5 < r ≤ 1.8)
q_{fz} ≤ 30.0 (q_{fz} ≤ 1.44)	94 (4.51)	224 (333)	336 (498)	446 (664)	559 (830)	670 (997)
30.0 < q_{fz} ≤ 37.5 (1.44 < q_{fz} ≤ 1.8)	118 (5.64)	278 (415)	418 (622)	559 (830)	698 (1037)	836 (1245)
37.5 < q_{fz} ≤ 45.0 (1.8 < q_{fz} ≤ 2.15)	141 (6.77)	336 (498)	502 (747)	670 (997)	836 (1245)	1004 (1494)
45.0 < q_{fz} ≤ 52.5 (2.15 < q_{fz} ≤ 2.51)	165 (7.89)	390 (581)	586 (873)	782 (1163)	975 (1452)	1171 (1742)
52.5 < q_{fz} ≤ 60.0 (2.51 < q_{fz} ≤ 2.87)	188 (9.02)	446 (664)	670 (997)	893 (1329)	1116 (1661)	1339 (1993)
60.0 < q_{fz} ≤ 67.5 (2.87 < q_{fz} ≤ 3.23)	212 (10.2)	502 (747)	752 (1121)	1004 (1494)	1255 (1869)	1506 (2242)
67.5 < q_{fz} ≤ 75.0 (3.23 < q_{fz} ≤ 3.59)	236 (11.3)	559 (830)	836 (1245)	1116 (1661)	1395 (2075)	1674 (2491)
75.0 < q_{fz} ≤ 82.5 (3.59 < q_{fz} ≤ 3.95)	259 (12.4)	613 (914)	920 (1370)	1229 (1827)	1535 (2283)	1842 (2740)
82.5 < q_{fz} ≤ 90.0 (3.95 < q_{fz} ≤ 4.31)	283 (13.5)	670 (997)	1004 (1494)	1339 (1993)	1674 (2491)	2008 (2989)
90.0 < q_{fz} ≤ 97.5 (4.31 < q_{fz} ≤ 4.67)	306 (14.7)	725 (1078)	1088 (1620)	1451 (2159)	1813 (2698)	2176 (3238)
97.5 < q_{fz} ≤ 105.0 (4.67 < q_{fz} ≤ 5.03)	330 (15.8)	782 (1163)	1171 (1742)	1562 (2325)	1953 (2907)	2343 (3487)
105 < q_{fz} ≤ 112.5 (5.03 < q_{fz} ≤ 5.39)	353 (16.9)	836 (1245)	1255 (1869)	1674 (2491)	2093 (3114)	2511 (3735)
112.5 < q_{fz} ≤ 120 (5.39 < q_{fz} ≤ 5.75)	377 (18.0)	893 (1329)	1339 (1993)	1785 (2656)	2231 (3320)	2678 (3985)
120 < q_{fz} ≤ 127.5 (5.75 < q_{fz} ≤ 6.11)	400 (19.2)	948 (1412)	1424 (2118)	1896 (2823)	2371 (3528)	2846 (4235)

Table Notes:

1. See Commentary 4.2 for open buildings or partially enclosed buildings.
2. * 5 < r < 6 column to be used for ballasted systems.
3. See Commentary for the calculations used to determine entries in this table.

Table A6
Nailer Attachment- Fastener Loads
Enclosed Building
for *h* ≤ *60 ft.*

Field of Roof Pressure psf (kPa)	Fastener Spacing ft. (m)	Perimeter Fastener Load lb./ft. (kg/m)
30 (1.4)	2 (0.61)	101 (150)
30 (1.4)	3 (0.91)	151 (225)
30 (1.4)	4 (1.22)	202 (300)
30 (1.4)	5 (1.52)	252 (375)
30 (1.4)	6 (1.83)	302 (450)
37.5 (1.8)	2 (0.61)	126 (187)
37.5 (1.8)	3 (0.91)	189 (281)
37.5 (1.8)	4 (1.22)	252 (375)
37.5 (1.8)	5 (1.52)	315 (469)
37.5 (1.8)	6 (1.83)	378 (562)
45 (2.2)	2 (0.61)	151 (225)
45 (2.2)	3 (0.91)	227 (337)
45 (2.2)	4 (1.22)	302 (450)
45 (2.2)	5 (1.52)	378 (562)
45 (2.2)	6 (1.83)	454 (675)
52.5 (2.2)	2 (0.61)	176 (262)
52.5 (2.2)	3 (0.91)	265 (394)
52.5 (2.2)	4 (1.22)	353 (525)
52.5 (2.2)	5 (1.52)	441 (656)
52.5 (2.2)	6 (1.83)	529 (787)

Table Notes:

1. Loads are given in units of lb./ft. due to the variation in edge system widths. A *fastener* securing a *nailer* securing a 12-inch wide *coping* cap shall have a *fastener* load of 101 lb. for a 2-foot *fastener* spacing for a *field of roof pressure* of 30 psf. The same *fastener* shall have a load of 51 lb. for a 6 in. (½ ft.) wide *coping* cap (101 lb./ft. × 0.5 ft. = 51 lb.). Additional loads (field of roof *fasteners*, attachments) are excluded.
2. Values given above can be used as a design aid in lieu of *nailer* design calculations or *nailer* testing. See Section 3.9 for more information.
3. Perimeter *Fastener* Load values are based on Table A2 vertical loads with no *safety factor*.
4. *Fasteners* shall have a working load rating equal to the values shown in the table, with appropriate *safety factors* for the medium (masonry, steel, wood) to which the *nailer* is attached.
5. Loads are given for the perimeter region only. Multiply Perimeter Fastener Load values by 1.51 (Corner/ Perimeter ratio from Table A2) to determine *fastener* loads within a corner region.
6. The *nailer* should be designed by the engineer of record to withstand bending, shear, or other stresses imparted by the *wind loads* and *fastener* resistance loads, as well as *fastener* pull through.

Table A7
Nailer Attachment- Fastener Loads
Enclosed Building
h > 60 ft.

Field of Roof Pressure psf (kPa)	Fastener Spacing ft. (m)	Perimeter Fastener Load lb./ft. (kg/m)
30 (1.4)	2 (0.61)	94 (140)
30 (1.4)	3 (0.91)	141 (210)
30 (1.4)	4 (1.22)	188 (280)
30 (1.4)	5 (1.52)	236 (350)
30 (1.4)	6 (1.83)	283 (421)
37.5 (1.8)	2 (0.61)	118 (175)
37.5 (1.8)	3 (0.91)	177 (263)
37.5 (1.8)	4 (1.22)	236 (350)
37.5 (1.8)	5 (1.52)	294 (438)
37.5 (1.8)	6 (1.83)	353 (526)
45 (2.2)	2 (0.61)	141 (210)
45 (2.2)	3 (0.91)	212 (315)
45 (2.2)	4 (1.22)	283 (421)
45 (2.2)	5 (1.52)	353 (526)
45 (2.2)	6 (1.83)	424 (631)
52.5 (2.2)	2 (0.61)	165 (245)
52.5 (2.2)	3 (0.91)	247 (368)
52.5 (2.2)	4 (1.22)	330 (491)
52.5 (2.2)	5 (1.52)	412 (613)
52.5 (2.2)	6 (1.83)	495 (736)

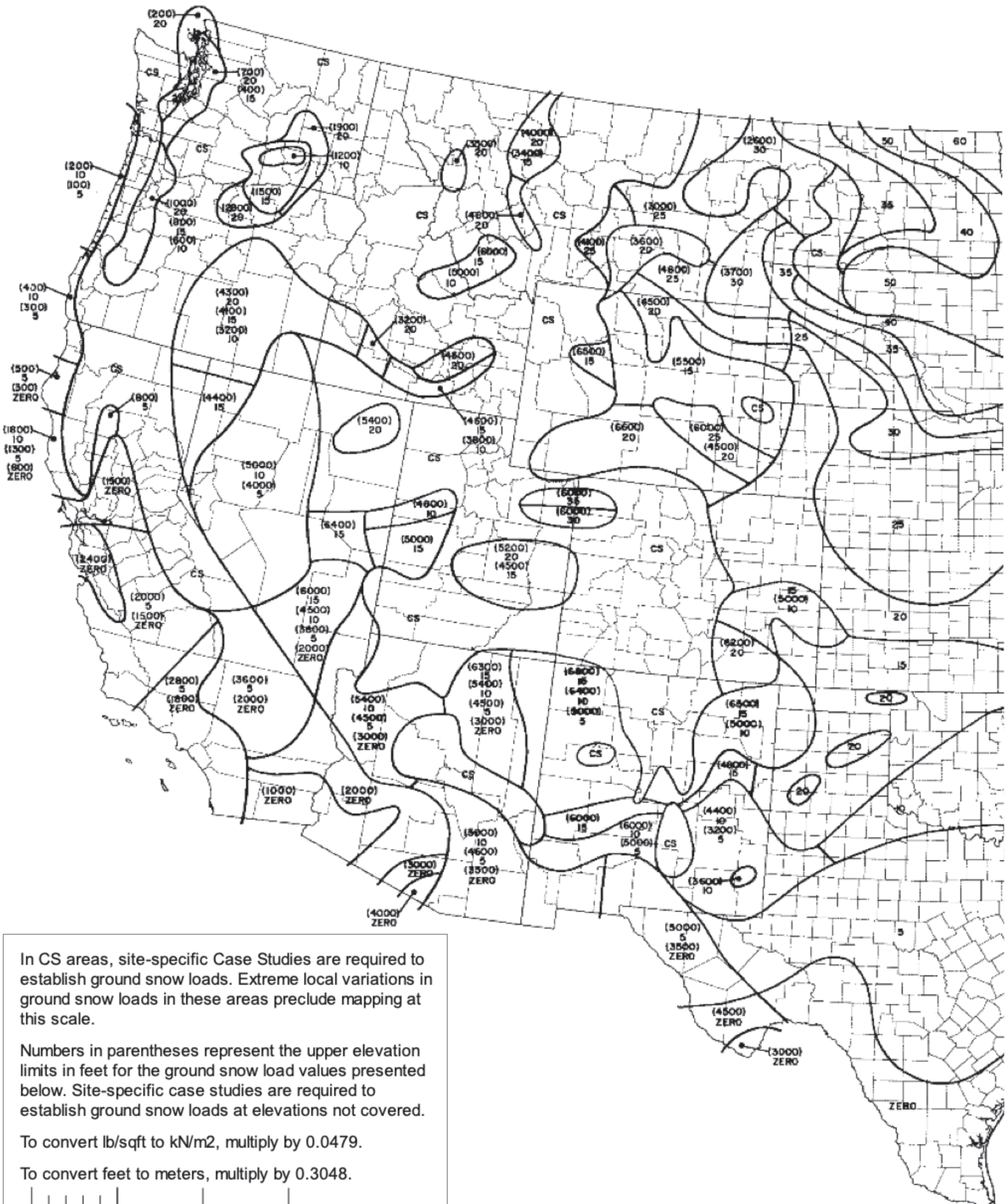
Table Notes:

1. Loads are given in units of lb./ft. due to the variation in edge system widths. A *fastener* securing a *nailer* securing a 12-inch wide *coping* cap shall have a *fastener* load of 94 lb. for a 2-foot *fastener* spacing for a *field of roof pressure* of 30 psf. The same *fastener* shall have a load of 47 lb. for a 6 in. (½ ft.) wide *coping* cap (101 lb./ft. × 0.5 ft. = 47 lb.). Additional loads (field of roof *fasteners*, attachments) are excluded.
2. Values given above can be used as a design aid in lieu of *nailer* design calculations or *nailer* testing. See Section 3.9 for more information.
3. Perimeter *Fastener* Load values are based on Table A3 vertical loads with no *safety factor*.
4. *Fasteners* shall have a working load rating equal to the values shown in the table, with appropriate *safety factors* for the medium (masonry, steel, wood) to which the *nailer* is attached.
5. Loads are given for the perimeter region only. Multiply Perimeter Fastener Load values by 1.36 (Corner/Perimeter ratio from Table A3) to determine *fastener* loads within a corner region.
6. The *nailer* should be designed by the engineer of record to withstand bending, shear, or other stresses imparted by the *wind loads* and *fastener* resistance loads, as well as *fastener* pull through.

Appendix B
Attachments

Ground Snow Loads pounds/foot²

From ASCE 7-05 and ASCE 7-10

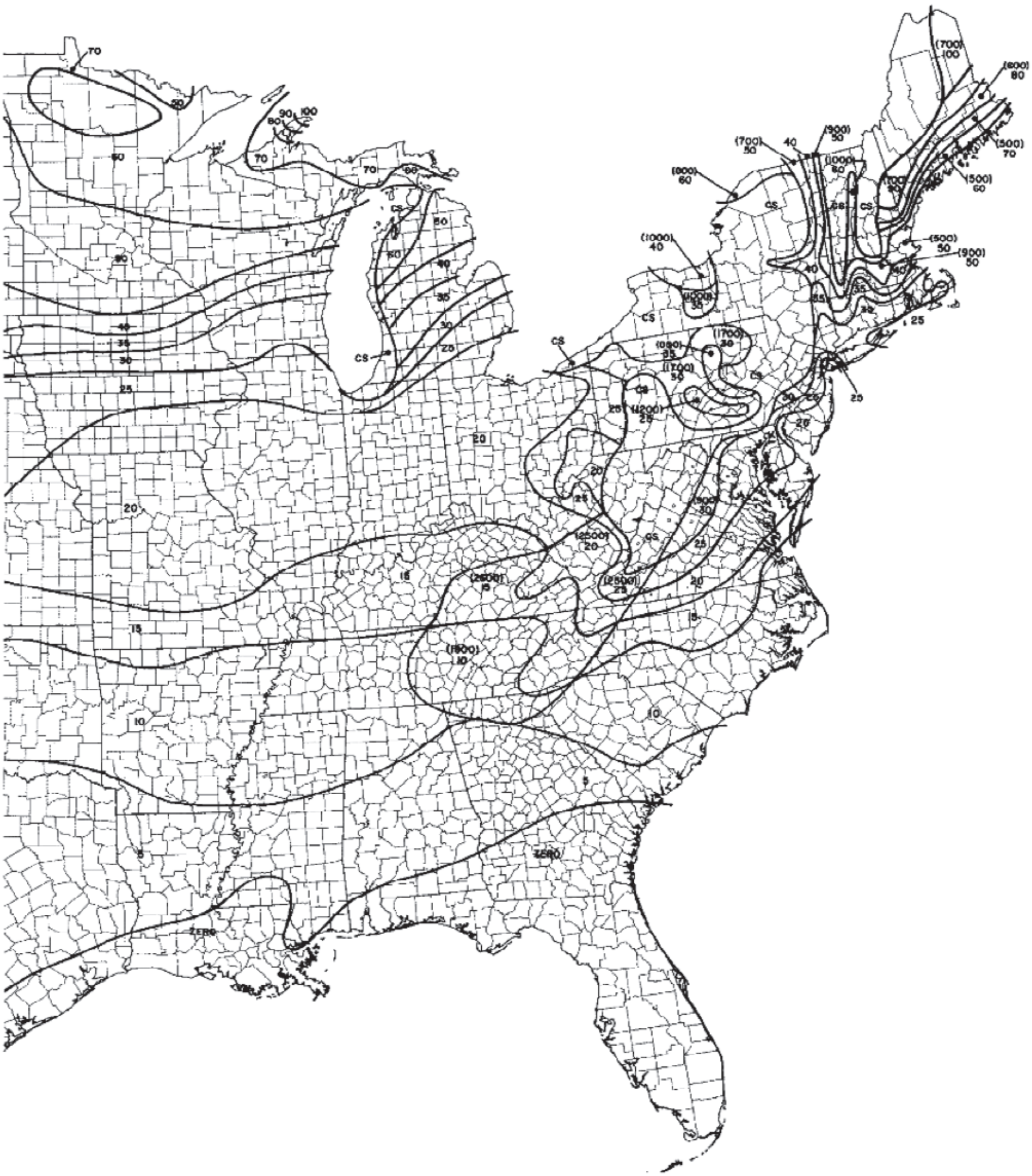


In CS areas, site-specific Case Studies are required to establish ground snow loads. Extreme local variations in ground snow loads in these areas preclude mapping at this scale.

Numbers in parentheses represent the upper elevation limits in feet for the ground snow load values presented below. Site-specific case studies are required to establish ground snow loads at elevations not covered.

To convert lb/sqft to kN/m2, multiply by 0.0479.

To convert feet to meters, multiply by 0.3048.


70
60
50
40
35
30
25
20
15
10
5
ZERO
CS
(700)
100
(800)
80
(500)
70
(500)
60
(1000)
40
(2500)
20
(2600)
15
(1900)
10

Appendix C
Commentary

This Commentary consists of explanatory and supplementary material designed to help designers, roofing contractors and local building authorities in applying the requirements of the preceding Standard.

This Commentary is intended to create an understanding of the requirements through brief explanations of the reasoning employed in arriving at these requirements.

The sections of this Commentary are numbered to correspond to sections of the Standard to which they refer. Since having supplementary material for every section of the Standard is not necessary, not all sections are referenced in this Commentary.

C1.1 Scope

This design Standard was developed for use with Built-Up (BUR), Single-Ply and Modified Bitumen roofing systems. While the Standard is intended as a reference for designers and roofing contractors, the design responsibility rests with the "designer of record."

The low slope value defined in this Standard comes from an industry accepted value of ≤ 9.5 degrees (2:12). The ASCE 7 document, used as a model for the development of this Standard, provides tables for GC_p for slopes less than or greater than 7 degrees (1.5:12) based on previous wind tunnel testing.

Roof edge systems serve aesthetic as well as performance functions for a building. Aesthetically, they provide an attractive finish and sometimes even a key feature to the exterior of a building. Of course, no matter how aesthetically pleasing, a *roof edge system* acts primarily as an effective mechanical termination and transition between the roof and other building components such as *parapet walls*, vertical walls, corners, edge flashing boards, etc.

A high-performance *roof edge system* provides many benefits. It acts as a water seal at the edge. When it is the means by which the *membrane* is attached to the building at the edge, it should also exhibit sufficient holding power to prevent the *membrane* from pulling out at the edge under design wind conditions. Furthermore, the edge device assembly itself should not come loose in a design wind. A loose edge assembly not only endangers surrounding property or persons, but it also exposes the roofing to blow-off, starting at the edge. Good design practice requires consideration of *nailer*, *roof edge system* and *membrane* securement, and selection of materials and finishes to minimize corrosion, and *metal* gauges to assure strength and *flatness*.

It is recommended that the *roof edge* designer be familiar with the ASCE 7 document and its commentary.

C2.0 Background Information

The 1980s saw a dramatic increase in the popularity of single-ply *roof systems*. With this increase, *metal* edge termination systems began receiving additional attention. Throughout the 1980s into the early 1990s a variety of organizations developed edge termination recommendations and testing criteria. These standards however were not universal, and each was focused on the specific needs or purpose of that organization. This created a challenge for design professionals in selecting the appropriate *roof edge system*, which would perform to the needs of their project.

In 1995 the Single Ply Roofing Industry (SPRI) began the process of developing a consensus *roof edge* performance standard. The goal was to create a standard that would have real-world practicality and provide unified guidance to design professionals as well as those that fabricate and install *roof edge systems*.

In 1998 the American National Standards Institute (*ANSI*) approved what was to become the ANSI/SPRI ES-1 Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems.

Today, the central role that *roof edge systems* play in protecting against *wind uplift* is gaining increasing awareness due to renewed attention of significant wind events.

C3.5 Corner Region

The angle at which the walls meet to constitute a corner is undefined here and in ASCE 7. It has been suggested that an airflow separation effect begins to take effect when walls meet at 150°. Since most walls meet at angles more acute than this, the meeting angle is not a practical consideration for this Standard.

C3.6 Importance Factor

The Importance Factor, I, accounts for the degree of hazard to human life and damage to property. The Importance Factor, I, is used to modify the wind speed and, in effect, assign different levels of risk based upon intended use of the structure. The tables are incomplete in this document; ASCE 7-05 provides additional information, and exceptions. Category I Exposure gives a 25-year mean recurrence value while Categories III and IV give 100-year mean recurrence values. Other recurrence values can be found in the Commentary of ASCE 7-05. ASCE 7-10 has separate wind maps so multiplication by an importance factor is not required.

C3.7 Membrane Termination Systems

The roof edging may be the only restraint preventing a roof blow-off. Mechanically attached *membranes* may be attached only by the *roof edge system* at the building edge. In *ballasted* systems, *ballast* may be scoured away from the edge. *Ballasted* roofs should be designed to meet ANSI/SPRI RP-4 to prevent excessive scour.

Consideration should be given to sealing the edge against air infiltration. Air infiltration may affect the loads on the roofing and the perimeter edge detail by adding a positive pressure under the roofing, thus compounding the effect of negative pressure above the roofing.

BUR and most modified bitumen *membranes* are fully adhered to roof *deck* or insulation. When they are mechanically attached they should follow the rules for all mechanically attached systems.

C3.7.1 Dependently Terminated

Ballasted Systems or systems in which the mechanically attached roof cover is secured to the *substrate* at a distance greater than 12 in. (305 mm) from the outside edge of the *nailer* are considered dependently terminated by the *roof edge system*. Dependently Terminated systems are often called Edge Flashings or *Gravel Stops*: these products or designs complete the horizontal *deck* or *membrane* plane at its transition to a vertical wall drop, typically at a 90° angle.

Normally the roofing *membrane* is restrained at the edge by means of a mechanical gripping of the roofing between *metal* members or by a bond between the roofing and edging.

Termination devices against vertical walls inboard of the *roof edge* are not considered by this Standard.

C3.7.2 Independently Terminated

Systems in which the roof cover is fully adhered to the *substrate* or a mechanically attached roof cover is secured the *substrate* at a distance less than or equal to 12 in. (305 mm) from the outside edge of the *nailer* are considered independently terminated. For these systems Tables A4 and A5 are applicable.

Copings/Caps

Copings/Caps are independently terminated systems: These are systems that cover the tops of *parapet walls*, usually with the roofing *membrane* terminated under them. Tables A2 and A3 provide loads for these systems.

C3.8 Nailer System Requirements

Resistance to blow-off depends not only upon the attachment of the *roof edge system* to the edge of the building, but also upon the integrity of the *nailer* or other *substrate* to which the edge device is attached. It is important to consider the load path from the *nailer* to the foundation of the building to assure proper *wind load* protection. The design professional or authority having jurisdiction should determine if the load path is complete and the appropriate *safety factor* is applied.

C3.8.1 Nailer Secured Systems

It is recommended that *nailers* be preservative treated wood secured to structural components of the building by corrosion resistant[1,2] means sufficient to resist a vertical load of 200 lb./ft. (300 kg/m) or the *design load*, whichever is greater. For wood *nailers* wider than 6 in. (152 mm), bolts should be staggered to avoid splitting the wood. Each wood *nailer* member should have at least two *fasteners*. A *fastener* should be located approximately 4 in. (102 mm) but not less than 3 in. (76 mm) from each end of the wood.

Additional wood members, such as cant strips and stacked *nailers* should be fastened with corrosion resistant *fasteners* having sufficient pullout resistance prior to *roof edge system* failure. These *fasteners* should be staggered, spaced at a maximum 12 in. (305 mm) on centers, and should penetrate the wood sufficiently to achieve design pullout resistance. Spacing should be on maximum 6 in. (152 mm) centers in corner regions of the building. When re-roofing, the existing *nailer* should be exposed and inspected. If it has deteriorated, it should be replaced.

The following references are provided to assist in the design of wood *nailer* systems.

- The American Forest & Paper Association's (AF&PA's) "National Design Standard for Wood Construction (NDS)"
- The American Institute of Timber Construction's (AITC), "Design Manual"
- IBC Chapter 23
- FM 1-49 wood blocking and *nailers*, Sec. 2.2—Construction and Location
- Third party *fastener* test data.

C3.8.1.1 Masonry

When embedded in masonry, anchor bolts as defined above should be bent 90 degrees at the base or have heads designed to prevent rotation and slipping out. When hollow block masonry is used at the roofline, cores and voids in the top row of blocks should be filled with concrete having a minimum density of 140-lb./cu ft. (2,243 K/m3). When embedded in lightweight aggregate hollow block, bolts should be embedded minimum 12 in. (305 mm) into concrete fill. When heavy aggregate blocks are used, bolts should be embedded minimum 8 in. (203 mm).

C3.8.1.2 Light Weight Concrete and Gypsum Decks

Anchor all roof perimeter *nailers* using *fasteners* whose size and locations meet provisions in Section 3.9 of this Standard. It is recommended that the *fasteners* be attached directly to the structure if industry approved calculations verifying the anchor attachment strength, anchor *substrate* strength, and *substrate* attachment strength, are not available.

C3.8.1.3 Nailer Attached to Steel Deck

The steel *deck* shall be designed to withstand the design forces specified under Section 4.3 of the Standard. *Nailer* attachment should provide a minimum resistance of 200-bf/ft. (300 kg/m) vertical load.

C3.8.2 Nailerless Systems

When the *roof edge system* is attached directly to masonry or steel without the use of a *nailer*, its attachment configuration should be tested to resist wind loading, using tests specified in Section 4.3 of this Standard.

C3.8.3 Re-roofing

For *nailer* security when re-roofing, the contractor should check to ensure that the *nailer* or other *substrate* is in good condition and well secured to the building. Questionable members should be removed and replaced according to the above guidelines. Note that it is much more difficult to be sure that the load path (connection of roof members ultimately to the building foundation) is secure for an existing building than it is for new construction. The roofing contractor should notify the designer if unexpected conditions or deteriorated *substrate* materials are discovered during the re-roofing process. ANSI/SPRI/FX-1 can be used to verify the resistance of *fasteners* to pull out.

C4.2 Wind Load Determination

The *Roof Edge Design Pressure*, P, has been calculated based on a conservative form of the Components and Cladding "Velocity Pressure", q_z, found in Equations in ASCE 7-05 and ASCE 7-10

GC_{pi} = Internal Pressure coefficient for Enclosed Buildings, GC_{pi} = +/-0.18, use +0.18 for worst case pressure (See ASCE 7-05 Figure 6-5 for more information).

GC_p = External Pressure Coefficient. Choose GC_{pi}, perimeter, GC_p, corner, or GC_p, roof as seen in ASCE 7-05 Figures 6-11A, 6-11B, and 6-17.

GC_p, roof = -1.0 (h < 60 ft.) for the field of roof (from ASCE 7-05 Figure 6-11B)
= -1.4 (h > 60 ft.) for the field of roof (from ASCE 7-05 Figure 6-17).

P = Roof Edge Design Pressure = 2.0 × (GC_p) × (q_{fz}), where
2.0 = Design Factor (Safety Factor) for *roof edge systems*.

GC_p = External Pressure Coefficient (see Table C-A2). Horizontal GC_p values (used for comparison to RE-2 and RE-3 Test values) and vertical GC_p values (used for comparison to RE-3 Test values) are presented for building heights less than or equal to 60 ft., or greater than 60 ft.

ASCE 7-05 does not address the horizontal component of GC_p at the actual roof edge. Therefore, the horizontal value of GC_p shown in Table 2 of this ED-1 document was taken from the value of Zone 4 of Figure 6-11A for height ≤ 60 ft. 1). Values for the horizontal GC_p term, h ≤ 60 ft. have been reduced per ASCE 7-05 Figure 6-11A. Note: for walls 60 ft. high, the horizontal GC_p can be reduced by 10% for low slope roofs (< 10%).

Vertical GC_p values are considered for vertical forces on *roof edge systems* such as *coping* (or *fascia* systems with a horizontal exposure which exceeds 4 in. in length). Values for the vertical GC_p term were chosen based on Region 2 of Figure 6-11B and 6-17 of ASCE 7-05.

To produce a representative horizontal and vertical design force for various *roof edge systems*, an effective wind area of 10 ft.^{2} was chosen for all GC_p terms (see Figure 6-11 and 6-17 of ASCE 7-05).

In this document, the GC_p term is multiplied by the *field of roof pressure* and not the velocity pressure. As such the values of GC_p shown in Table 2 were found by ensuring that the *roof edge design pressure*, P, has the same value as compared to ASCE 7-05 before a *safety factor* is applied:

Let Edge Pressure SPRI ED-1 document = Edge pressure ASCE 7-05 calculation (See ASCE 7-05 equations 6-15, 6-22, and 6-23 for calculation of the edge pressure via ASCE 7-05)

Thus, $q_{fz}\ GC_{pTable\ 2} = q_h(GC_p–GC_{pi})$

where q_h = velocity pressure evaluated at mean roof height
Knowing q_{fz} = field roof pressure
= q_h × (GC_p, roof-GC_{pi})
per ASCE 7-05 equation 6-22

Thus

$q_h \times (GC_{p,\ roof}–GC_{pi})\ GC_{Table\ 2} = q_h(GC_p–GC_{pi})$

Solve for $GC_{pTable\ 2}$

$$GC_{pTable\ 2} = \frac{GC_p–GC_{pi}}{GC_{p,\ roof}–GC_{pi}} \quad \text{(Equation C4.4-1)}$$

Where values of GC_p, and GC_{pi} in the ratio above are taken directly from ASCE 7-05.

GC_p Calculation Example: for h < 60 ft. vertical perimeter pressure, determine GC_pTable 2 value:

$$\text{Table 2 } GC_{pTable\ 2} \text{ value} = \frac{-1.8–0.18)}{-1.0–(0.18)} = 1.678\text{, round off to 1.68 and use negative sign.}$$

Thus $GC_{pTable\ 2}$ value = -1.68 (See Table 2). The negative sign is used since it is an outward pressure (consistent with ASCE 7-05).

In the ratio above:
-1.8 = Perimeter roof GC_p value from ASCE 7-05 Figure 6-11B (h < 60 ft.)
-1.0 = Field of roof GC_p ($GC_{p,\ roof}$, from ASCE 7-05 Figure 6-11B (h < 60 ft.)
0.18 = Internal Pressure Coefficient from ASCE 7-05 Figure 6-5 for an enclosed building. A positive value is used as it creates the worst-case loading (positive internal pressure).

All values shown in Table 2 are found similarly: the corner region, horizontal pressure, and roof height factors are determined from the appropriate ASCE 7-05 Figure. Upon choosing the correct GC_pTable 2 apply the *Safety Factor* and Importance Factor, as needed to Equation (1) of the SPRI ED-1 document.

Table C-A2
External Pressure Coefficient[1] (GC_p)
Partially Enclosed Building[2]

Type of Loading	Edge Location	Roof Height 60 ft. (18.3 m) or less z ≤ 60 ft. (18.3 m)	Roof Height over 60 ft. (18.3 m) z > 60 ft. (18.3 m)
Horizontal (acting outward from the building edge)	Perimeter	-0.952	-0.74
	Corner	-1.132	-1.21
Vertical (acting upward at the building edge)	Perimeter	-1.52	-1.46
	Corner	-2.16	-1.92

Table Notes:

1. Values of GC_p shown above differ from ASCE 7-05 and ASCE 7-10 values due to the incorporation of the internal pressure coefficient, GC_{pi}, and the application of GC_p to the *field of roof pressure*.
2. Per ASCE 7-05 values shown have taken into account a 10% reduction for roof slopes < 10 degrees. See ASCE 7-05 Figure 6-11A, Note 5 for more information.
3. The negative signs (–) in the External Pressure Coefficients represent vector directionality of the force acting away from the building, tending to pull materials upward or outward (horizontal) from the building.
4. Values in the table above were found by applying Equation C4-4-1 with $GC_{pi} = .55$
   See ASCE 7-05 Figure 6-6, Figure 6-11A, 6-11B, and Figure 6-17 for more information.

Open Buildings

Consult ASCE 7 to determine *roof edge* pressures for open buildings.

C4.3 Nailer Securement Load Tables

For mechanically attached or *ballasted* systems, which do NOT contain a "peel stop" within 12 in. (305 mm) of the *roof edge*, Tables A4 and A5 should be used. Values in Tables A4 and A5 were found by placing the *field of roof pressures* into Equation (1) using the vertical GC_p value for the perimeter region. However, Tables A4 and A5 do not address the horizontal loads given in Tables A2 and A3; therefore, additional engineering may be required to verify that the *nailer* attachment resists the total applied force for these specific systems.

C6.0 Edge System Resistance

Once the *design loads* have been determined, *roof edge systems* that have been tested to meet or exceed the *design loads* should be selected. International Building Code (IBC) requires that edge *metal* be tested per ANSI/SPRI ES-1 or ANSI/SPRI/FM 4435/ES-1; however, local codes and the AHJ ultimately dictate edge *metal* performance requirements.

The vertical face of an edge flashing (*gravel stop*) should be tested according to SPRI Test RE-2 and provide a strength that meets or exceeds the horizontal pressure found in Tables A2 (roof height (h) ≤ 60 ft.), and A3 (h > 60 ft.). The test should be applicable to systems with exposed horizontal components less than 4 in. (102 mm) as detailed in the RE-2 Test Method; otherwise Test RE-3 is applicable.

The vertical and horizontal faces of *copings* (and any *roof edge systems*) with a horizontal exposure which exceeds 4 in. (102 mm) in length should be tested according to Test RE-3 and provide a strength that meets or exceeds the horizontal and vertical pressures found in Tables A2 (roof height (h) > 60 ft.), and A3 (h > 60 ft.).

The edging, when used for securing dependently terminated roofing systems, should be tested according to Test RE-1 and provide a strength that meets or exceeds the *membrane* tension found in Tables A4 (roof height (h) ≤ 60 ft.), and A5 (h > 60 ft.).

C7.2 Metal Thickness

Increased *metal* thickness improves the *flatness* and reduces the “oil-can” effect of the *roof edge system*. Figure 3 was developed from NRCA, Factory Mutual, and *SMACNA* recommendations[3]. The table has been constructed to simplify its use over the Factory Mutual table and to extend the range of *fascia* widths beyond that given by *NRCA*. The required minimums do not address other important design factors such as fastening pattern and frequency, continuous *cleats* or intermittent *clips*, stiffening ribs or breaks in the edges. Tests RE-2 and RE-3 may determine that *metal* thickness need to be increased for higher *wind loads*.

C9.0 Packaging and Identification

Because IBC requires that *roof edge systems* be tested per ES-1, owners and code officials need documentation packaged with the *roof edge system* to identify that it has been tested. Follow-up programs are required for *roof edge systems* that are classified by FM, UL and other organizations.

C10.0 Installation Instructions

In order for the *roof edge system* to perform as tested it should be installed in the same manner as the tested *roof edge system*. Installation instructions are recommended to assure the proper *cleats*, *clips*, *fasteners* and other components are installed in the correct location and at the correct spacing.

Table A4 and A5 Commentary

The roof *membrane* termination (*roof edge system*, *nailer*, or other) is a key anchor point holding the *membrane* in place. During high-speed wind loading, the *roof system* can create extreme loads on the *roof edge system*.

Referring to Figure A4 for a mechanically attached system, the loading depends upon the distance, r, of the first row of *fasteners* to the edge termination. The overall shape of the *membrane* is based upon previous tests indicating that the *membrane* deformation can be well approximated by a 25-degree angle[7, 8]. Figure A5 shows a closer look at the *membrane* forces.

Figure A4—Mechanically Attached Roof Forces

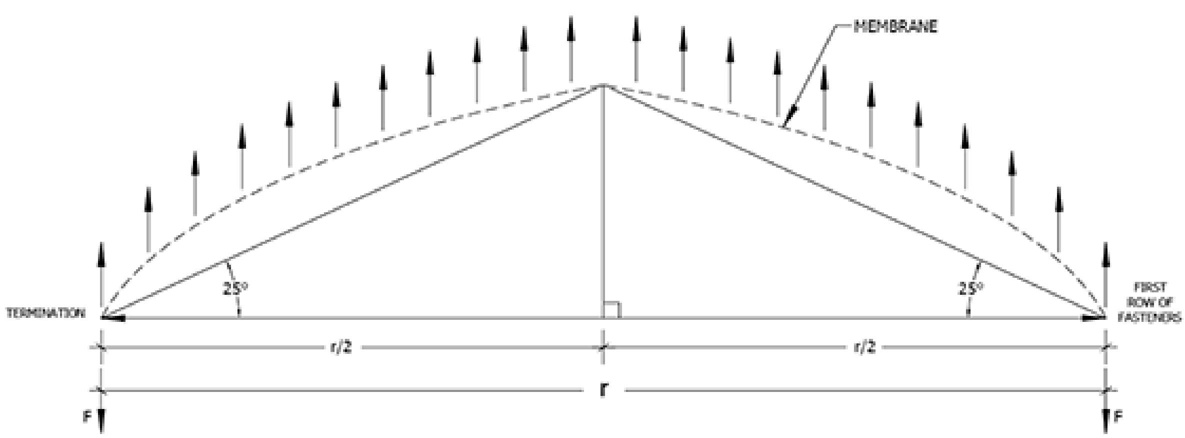
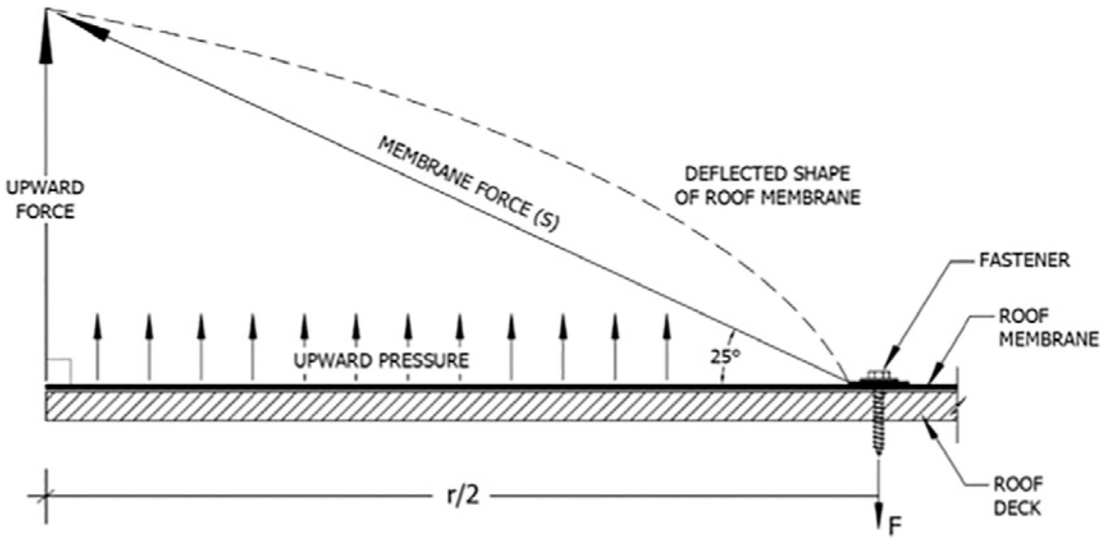


Figure A5—System of Forces, ½ of Membrane width between *Fasteners*



If an upward pressure (lb./ft.^{2}) is applied to the *membrane*, then the upward force = upward pressure x r/2 for one half of the *membrane* width r (a single *fastener* will have a force, F, to resist this load). Assuming a 25° deflected shape, then the *membrane* force, S, can be found from the equations:

$$sin25° = \frac{UpwardForce}{S}$$

$$sin25° = \frac{Upwardpressure \times \frac{r}{2}}{S}$$

Thus,

$$S = \frac{Upwardpressure \times \frac{r}{2}}{sin25°}$$

If the edge region of the roof is considered, then the upward pressure (see Figure A5) equals either the vertical perimeter pressure, P_{vp}, or the vertical corner pressure, P_{vc}. Considering the perimeter region, the perimeter pressure can be found from Section 4.2 of this document:

P_{vp} =Perimeter Pressure = SF × q_{fz} × GC_p from Equation (1) for I=1.0

The design membrane tension, at the perimeter region, can be found from:

Design membrane tension (S) = $SF \times q_{fz} \times GC_p \times \frac{\frac{r}{2}}{sin25°}$

Where GC_p = External pressure coefficient (see Section 4.2), choose either perimeter region or corner.

The equation can be simplified noting:

sin (25º) = 0.42262

1/sin (25º) = 2.37, thus:

Design membrane tension (S) = $SF \times 2.37 \times q_{fz} \times GC_p \times \frac{r}{2}$ Equation (RE1-1)

If SF = 2 is used, the equation becomes:

Design membrane tension (S) = $2.37 \times q_{fz} \times GC_p \times r$ Equation (RE1-2)

Example of Determining a Design Membrane Tension Force:

Given a 2-foot perimeter sheet, Class 135 (actual field pressure = 67.5 psf), building height = 50 ft. (see Table A5):

> S = Design membrane tension = $SF \times 2.37 \times q_{fz} \times GC_p \times \frac{r}{2}$
> Using SF = 2, the equation becomes:
> S = 2.37 × -1.68 × 67.5 psf × 2 ft. = -536 lb.

Values in Table A4 and A5 are found from the equations described above.

The precision and bias of this test measure has not been determined. In the absence of third party witness testing/verification, the ED-1 committee recommends round robin testing of standard, pre-manufactured *roof edge systems* to establish lab-to-lab variability of individual test results.

Fully Adhered Roof Systems

Fully adhered systems are assumed to apply no stress on the *roof edge system* under consideration, unless either the *metal* is loosened, or the *membrane* is in peel from the pressure differential between the exterior and interior of the system. Recent hurricane investigations have shown that both can occur.

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2. Procedure for Evaluation of Corrosion Resistance of Steel *Fasteners*, SPRI, Needham MA, 1988.
3. *NRCA* Roofing and Waterproofing Manual, National Roofing Contractors Association, Rosemont, IL, 1996, and Loss Prevention Data Sheet 1-49, Factory Mutual Research Corporation, Norwood, MA. 1985 and Architectural Sheet Metal Manual *SMACNA*, Chantilly, VA 1993.
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5. http://www.corrosion-doctors.org/Definitions/galvanic-series.htm
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