ROOFING CONTRACTORS ASSOCIATION OF HAWAII

October 3, 2017 – Honolulu, Hawaii

NRCA update on roofing industry technical issues

NRCA

Mark S. Graham
Vice President, Technical Services
National Roofing Contractors Association

1

Topics

- Building codes (IBC 2006)
- Wind design (ASCE 7-10)
- Wind warranties
- ANSI/SPRI ES-1 edge metal testing
- Technical issues
- Additional resources
- Questions (ask anytime)

2

Building codes

Roofing specific

3

Some background

- The I-Codes are "model codes" developed by the International Code Council (ICC)
- Model codes serve as the technical basis for state or local code adoption
- The code provides the minimum legal requirements for building construction…and operation
- The code is enforced by the "authority having jurisdiction" (AHJ)
- The code can also provide a basis for construction claims-related litigation

4

Who is responsible?

- The building owner
- And, everyone else involved

5

AIA General Conditions

AIA A201 – General Conditions of The Contract for Construction

Article 3 Contractor

3.2.3 The Contractor is not required to ascertain that the Contract Documents are in accordance with applicable laws, statues, ordinances, codes, rules and regulations, or lawful orders of public authorities, but the Contractor shall promptly report to the Architect any nonconformity discovered by and made known to the Contractor as a request for information in such a form as the Architect may require.

6

AIA General Conditions

AIA A201 – General Conditions of The Contract for Construction

3.2.4 …If the Contractor fails to perform the obligations of Sections 3.2.2 or 3.2.3, the Contractor shall pay the costs and damages to the Owner as would have been avoided if the Contractor had performed such obligations. If the Contractor performs those obligations, the Contractor shall not be liable to the Owner or Architect for damages …for nonconformities of the Contract Documents to… codes…

7

Code enforcement

- Code official
- Construction litigation

8

Legal considerations

"In most states, a building code violation is considered to be evidence of negligence. In some situations, a building code violation may be considered *negligence per se…"*

--Stephen M. Phillips
Hendrick, Phillips, Salzman & Flatt

9

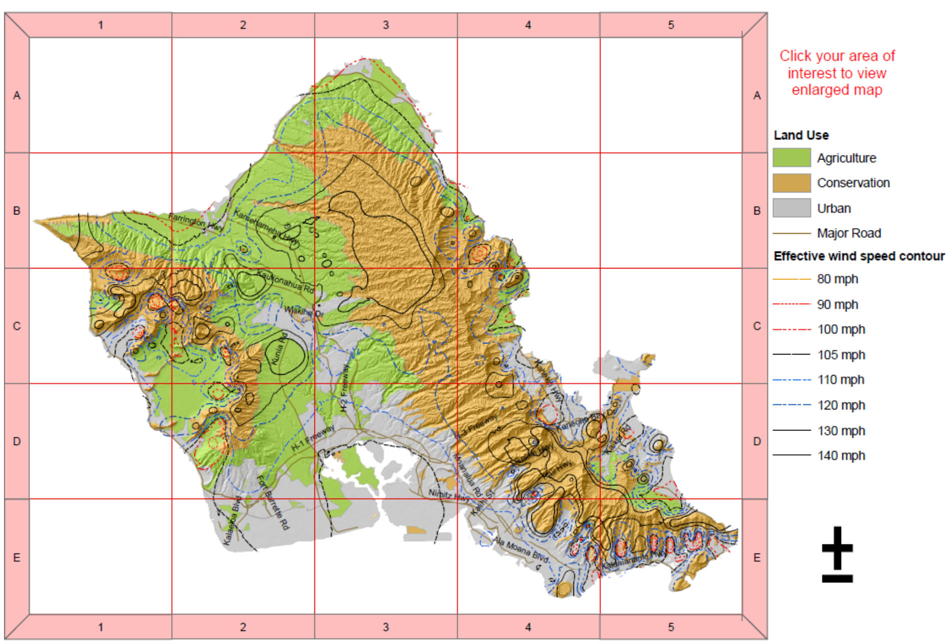
So…it's best that you know

10

Codes	State Building Code Council		Current Codes adopted by Jurisdictions				
	Currently Considering	Recently Approved	State of Hawaii	City and County of Honolulu	County of Hawaii	County of Kauai	County of Maui
Building Code	2012 IBC	2009 IBC	2006 IBC 04/04/10	2006 IBC 10/03/12	2006 IBC 03/28/12	2006 IBC 05/23/12	2006 IBC 03/19/12
Residential Code	2012 IRC	2006 IRC		2006 IRC 10/03/12	2006 IRC*	2006 IRC 05/23/12	2006 IRC 03/19/12
Electrical Code		2014 NEC	2008 NEC 04/04/10	2008 NEC 2009	2008 NEC 11/15/11	2008 NEC 12/02/09	2008 NEC 06/06/10
Plumbing Code		2012 UPC	2006 UPC 04/04/10	1997 UPC 02/14/00	2006 UPC 11/15/11	2006 UPC 10/14/13	2006 UPC 03/05/12
Energy Conservation Code	2015 IECC	2009 IECC	2006 IECC 05/13/10	2006 IECC 11/29/09	2006 IECC 10/31/10	2009 IECC 05/23/12	2006 IECC 12/20/09

Hawaii.gov Public Works Division

11



Effective Basic Wind Speed Contour for Components and Cladding for Buildings less than 60 feet tall

0 2.5 5 10 Miles

International Code Council (ICC)

INTERNATIONAL CODE COUNCIL®
People Helping People Build a Safer World™

THE I-CODES

ICC Performance Code (ICCPC)
International Building Code (IBC)
International Energy Conservation Code (IECC)
International Existing Building Code (IEBC)
International Fire Code (IFC)
International Fuel Gas Code (IFGC)
International Green Construction Code (IgCC)
International Mechanical Code (IMC)
International Plumbing Code (IPC)
International Private Sewage Disposal Code (IPSDC)
International Property Maintenance Code (IPMC)
International Residential Code (IRC)
International Swimming Pool and Spa Code (ISPSC)
International Wildland-Urban Interface Code (IWUIC)
International Zoning Code (IZC)

13

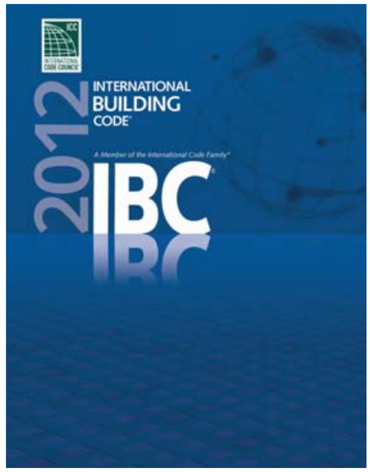
Publication cycle

- 2000 edition
- 2003 edition
- 2006 edition
- 2009 edition
- 2012 edition
- 2015 edition
- 2018 edition (just published)

Three-year code development and publication cycle

14

International Building Code, 2012 Edition (IBC 2012)



15

International Building Code, 2012 Edition

101.2 Scope. The provisions of this code shall apply to the construction, *alteration,* relocation, enlargement, replacement*,* *repair,* equipment, use and occupancy, location, maintenance, removal and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures.

> **Exception:** Detached one- and two-family *dwellings* and multiple single-family *dwellings* (townhouses) not more than three *stories* above *grade plane* in height with a separate *means of egress* and their accessory structures shall comply with the *International Residential Code.*

16

International Building Code, 2012 Edition

Specific roofing-related requirements

- Ch. 12-Interior Environment (attic ventilation)
- Ch. 13-Energy Efficiency (thermal insulation)
- Ch. 15-Roof Assemblies and Rooftop Structures
- Ch. 16-Structural Design (design loads)
- Ch. 22-Steel (structural metal panel roofing)
- Ch. 24-Glass and Glazing (skylights)
- Ch. 26-Plastic (foam plastic insulation)
- Ch. 35-Referenced Standards

17

Ch. 15-Roof Assemblies and Rooftop Structures

International Building Code, 2012 Edition

SECTION 1501

GENERAL

1501.1 Scope. The provisions of this chapter shall govern the design, materials, construction and quality of roof assemblies and rooftop structures.

18

Ch. 15-Roof Assemblies and Rooftop Structures

International Building Code, 2012 Edition

- Sec. 1501-Scope
- Sec. 1502-Defintions
- Sec. 1503-Weather Protection
- Sec. 1504-Performance Requirements (wind)
- Sec. 1505-Fire Classification
- Sec. 1506-Materials
- Sec. 1507-Requirements for Roof Coverings
- Sec. 1508-Roof Insulation
- Sec. 1509-Rooftop Structures
- Sec. 1510-Reroofing

19

Sec. 1510-Reroofing

International Building Code, 2012 Edition

1510.1 General. Materials and methods of application used for recovering or replacing an existing roof covering shall comply with the requirements of Chapter 15.

> **Exception:** Reroofing shall not be required to meet the minimum design slope requirement of one-quarter unit vertical in 12 units horizontal (2-percent slope) in Section 1507 for roofs that provide positive roof drainage.

20

Sec. 1503-Weather Protection

International Building Code, 2012 Edition

1503.6 Crickets and saddles. A cricket or saddle shall be installed on the ridge side of any chimney or penetration greater than 30 inches (762 mm) wide as measured perpendicular to the slope. Cricket or saddle coverings shall be sheet metal or of the same material as the roof covering.

> **Exception:** Unit skylights installed in accordance with Section 2405.5 and flashed in accordance with the manufacturer's instructions shall be permitted to be installed without a cricket or saddle.

AAMA/WDMA/CSA 101/I.S./A440

21

Sec. 1504-Performance Requirements

International Building Code, 2012 Edition

1504.3 Wind resistance of nonballasted roofs. Roof coverings installed on roofs in accordance with Section 1507 that are mechanically attached or adhered to the roof deck shall be designed to resist the design wind load pressures for components and cladding in accordance with Section 1609.

> **1504.3.1 Other roof systems.** Roof systems with built-up, modified bitumen, fully adhered or mechanically attached single-ply through fastened metal panel roof systems, and other types of membrane roof coverings shall also be tested in accordance with FM 4474, UL 580 or UL 1897.

22

Sec. 1504-Performance Requirements

International Building Code, 2012 Edition

1504.3.2 Metal panel roof systems. Metal panel roof systems through fastened or standing seam shall be tested in accordance with UL 580 or ASTM E 1592.

Exception: Metal roofs constructed of cold-formed steel, where the roof deck acts as the roof covering and provides both weather protection and support for structural loads, shall be permitted to be designed and tested in accordance with the applicable referenced structural design standard in Section 2210.1.

23

Sec. 1504-Performance Requirements

International Building Code, 2012 Edition

1504.4 Ballasted low-slope roof systems. Ballasted lowslope (roof slope < 2:12) single-ply roof system coverings installed in accordance with Sections 1507.12 and 1507.13 shall be designed in accordance with Section 1504.8 and ANSI/SPRI RP-4.

24

Sec. 1504-Performance Requirements

International Building Code, 2012 Edition

1504.5 Edge securement for low-slope roofs. Low-slope built-up, modified bitumen and single-ply roof system metal edge securement, except gutters, shall be designed and installed for wind loads in accordance with Chapter 16 and tested for resistance in accordance with Test Methods RE-1, RE-2 and RE-3 of ANSI/SPRI ES-1, except V_{ult} wind speed shall be determined from Figure 1609A, 1609B, or 1609C as applicable.

25

Sec. 1504-Performance Requirements

International Building Code, 2012 Edition

1504.8 Aggregate. Aggregate used as surfacing for roof coverings and aggregate, gravel or stone used as ballast shall not be used on the roof of a building located in a hurricane-prone region as defined in Section 202, or on any other building with a mean roof height exceeding that permitted by Table 1504.8 based on the exposure category and basic wind speed at the site.

[Continued…]

26

TABLE 1504.8
MAXIMUM ALLOWABLE MEAN ROOF HEIGHT PERMITTED FOR BUILDINGS WITH AGGREGATE ON THE ROOF IN AREAS OUTSIDE A HURRICANE-PRONE REGION

NOMINAL DESIGN WIND SPEED, V_{asd} (mph)[b, d]	MAXIMUM MEAN ROOF HEIGHT (ft)[a, c]		
	Exposure category		
	B	C	D
85	170	60	30
90	110	35	15
95	75	20	NP
100	55	15	NP
105	40	NP	NP
110	30	NP	NP
115	20	NP	NP
120	15	NP	NP
Greater than 120	NP	NP	NP

For SI: 1 foot = 304.8 mm; 1 mile per hour = 0.447 m/s.
a. Mean roof height as defined in ASCE 7.
b. For intermediate values of V_{asd}, the height associated with the next higher value of V_{asd} shall be used, or direct interpolation is permitted.
c. NP = gravel and stone not permitted for any roof height.
d. V_{asd} shall be determined in accordance with Section 1609.3.1.

27

Sec. 1505-Fire Classification

International Building Code, 2012 Edition

1505.1 General. Roof assemblies shall be divided into the classes defined below. Class A, B and C roof assemblies and roof coverings required to be listed by this section shall be tested in accordance with ASTM E 108 or UL 790. In addition, fire-retardant-treated wood roof coverings shall be tested in accordance with ASTM D 2898. The minimum roof coverings installed on buildings shall comply with Table 1505.1 based on the type of construction of the building.

> **Exception:** Skylights and sloped glazing that comply with Chapter 24 or Section 2610.

28

Sec. 1505-Fire Classification

International Building Code, 2012 Edition

TABLE 1505.1[a,b]
MINIMUM ROOF COVERING CLASSIFICATION FOR TYPES OF CONSTRUCTION

IA	IB	IIA	IIB	IIIA	IIIB	IV	VA	VB
B	B	B	C[c]	B	C[c]	B	B	C[c]

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2.

a. Unless otherwise required in accordance with the *International Wildland-Urban Interface Code* or due to the location of the building within a fire district in accordance with Appendix D.

b. Nonclassified roof coverings shall be permitted on buildings of Group R-3 and Group U occupancies, where there is a minimum fire-separation distance of 6 feet measured from the leading edge of the roof.

c. Buildings that are not more than two stories in height and having not more than 6,000 square feet of projected roof area and where there is a minimum 10-foot fire-separation distance from the leading edge of the roof to a lot line on all sides of the building, except for street fronts or public ways, shall be permitted to have roofs of No. 1 cedar or redwood shakes and No. 1 shingles.

29

Sec. 1505-Fire Classification

International Building Code, 2012 Edition

1505.2 Class A roof assemblies. Class A roof assemblies are those that are effective against severe fire test exposure. Class A roof assemblies and roof coverings shall be *listed* and identified as Class A by an *approved* testing agency. Class A roof assemblies shall be permitted for use in buildings or structures of all types of construction.

Exceptions:

1. Class A roof assemblies include those with coverings of brick, masonry or an exposed concrete roof deck.
2. Class A roof assemblies also include ferrous or copper shingles or sheets, metal sheets and shingles, clay or concrete roof tile or slate installed on noncombustible decks or ferrous, copper or metal sheets installed without a roof deck on noncombustible framing.
3. Class A roof assemblies include 16 oz/sq. ft. (0.0416 kg/m^2) copper sheets installed over combustible decks.

30

Sec. 1506-Materials

International Building Code, 2012 Edition

1506.1 Scope. The requirements set forth in this section shall apply to the application of roof-covering materials specified herein. Roof coverings shall be applied in accordance with this chapter and the manufacturer's installation instructions. Installation of roof coverings shall comply with the applicable provisions of Section 1507.

31

Sec. 1507-Requirements for Roof Coverings

International Building Code, 2012 Edition

- Asphalt shingles
- Clay & concrete tile
- Metal roof panels
- Metal roof shingles
- Roll roofing
- Slate shingles
- Wood shingles
- Wood shakes
- Built-up roofs
- Modified bitumen roofs
- Thermoset single-ply roofs
- Thermosplastic single-ply roofs
- SPF roofs
- Liquid-applied roofing
- Roof gardens/landscaped roofs
- Photovoltaic modules/shingles

32

Sec. 1507-Requirements for Roof Coverings

IBC 2012, Section 1507.2-Asphalt Shingles

1507.2.7 Attachment. Asphalt shingles shall have the minimum number of fasteners required by the manufacturer, but not less than four fasteners per strip shingle or two fasteners per individual shingle. Where the roof slope exceeds 21 units vertical in 12 units horizontal (21:12), shingles shall be installed as required by the manufacturer.

33

Sec. 1507-Requirements for Roof Coverings

IBC 2012, Section 1507.2-Asphalt Shingles

1507.2.7.1 Wind resistance. Asphalt shingles shall be tested in accordance with ASTM D 7158. Asphalt shingles shall meet the classification requirements of Table 1507.2.7.1(1) for the appropriate maximum basic wind speed. Asphalt shingle packaging shall bear a label to indicate compliance with ASTM D 7158 and the required classification in Table 1507.2.7.1(1).

> **Exception:** Asphalt shingles not included in the scope of ASTM D 7158 shall be tested and labeled to indicate compliance with ASTM D 3161 and the required classification in Table 1507.2.7.1(2).

34

TABLE 1507.2.7.1(1)
CLASSIFICATION OF ASPHALT
ROOF SHINGLES PER ASTM D 7158[a]

NOMINAL DESIGN WIND SPEED, V_{asd}[b], (mph)	CLASSIFICATION REQUIREMENT
85	D, G or H
90	D, G or H
100	G or H
110	G or H
120	G or H
130	H
140	H
150	H

For SI: 1 foot = 304.8 mm; 1 mph = 0.447 m/s.

a. The standard calculations contained in ASTM D 7158 assume exposure category B or C and building height of 60 feet or less. Additional calculations are required for conditions outside of these assumptions.

b. V_{asd} shall be determined in accordance with Section 1609.3.1.

35

Sec. 1507-Requirements for Roof Coverings

International Building Code, 2012 Edition

1507.2.8.1 High wind attachment. Underlayment applied in areas subject to high winds [V_{asd} greater than 110 mph (49 m/s) as determined in accordance with Section 1609.3.1] shall be applied with corrosion-resistant fasteners in accordance with the manufacturer's instructions. Fasteners are to be applied along the overlap at a maximum spacing of 36 inches (914 mm) on center… [Continued…]

V_{asd} is taken from Table 1609.3.1 using V_{ult}

36

Underlayment installed where V_{asd}, in accordance with Section 1609.3.1, equals or exceeds 120 mph (54 m/s) shall comply with ASTM D 226 Type II, ASTM D 4869 Type IV, or ASTM D 6757. The underlayment shall be attached in a grid pattern of 12 inches (305 mm) between side laps with a 6-inch (152 mm) spacing at the side laps. Underlayment shall be applied in accordance with Section 1507.2.8 except all laps shall be a minimum of 4 inches (102 mm). Underlayment shall be attached using metal or plastic cap nails with a head diameter of not less than 1 inch (25 mm) with a thickness of at least 32-gauge [0.0134 inch (0.34 mm)] sheet metal. The cap nail shank shall be a minimum of 12 gauge [0.105 inch (2.67 mm)] with a length to penetrate through the roof sheathing or a minimum of 3/4 inch (19.1 mm) into the roof sheathing.

Exception: As an alternative, adhered underlayment complying with ASTM D 1970 shall be permitted.

37

SPF roof systems

IBC 2012, Section 1507.14.3--Application

1507.14.3 Application. Foamed-in-place roof insulation shall be installed in accordance with the manufacturer's instructions. A liquid-applied protective coating that complies with Table 1507.14.3 shall be applied no less than 2 hours nor more than 72 hours following the application of the foam.

TABLE 1507.14.3

PROTECTIVE COATING MATERIAL STANDARDS

MATERIAL	STANDARD
Acrylic coating	ASTM D 6083
Silicone coating	ASTM D 6694
Moisture-cured polyurethane coating	ASTM D 6947

38

Liquid-applied Roofing

IBC 2012, Section 1507.15--Liquid-applied Roofing

1507.15 Liquid-applied roofing. The installation of liquid-applied roofing shall comply with the provisions of this section.

1507.15.1 Slope. Liquid-applied roofing shall have a design slope of a minimum of one-fourth unit vertical in 12 units horizontal (2-percent slope).

1507.15.2 Material standards. Liquid-applied roofing shall comply with ASTM C 836, ASTM C 957, ASTM D 1227 or ASTM D 3468, ASTM D 6083, ASTM D 6694 or ASTM D 6947.

39

Vegetative Roofs

IBC 2012, Section 1507.16--Roof Gardens and Landscaped Roofs

1507.16 Roof gardens and landscaped roofs. Roof gardens and landscaped roofs shall comply with the requirements of this chapter and Sections 1607.12.3 and 1607.12.3.1 and the *International Fire Code.*

1507.16.1 Structural fire resistance. The structural frame and roof construction supporting the load imposed upon the roof by the roof gardens or landscaped roofs shall comply with the requirements of Table 601.

40

Sec. 1510-Reroofing

International Building Code, 2012 Edition

1510.1 General. Materials and methods of application used for recovering or replacing an existing roof covering shall comply with the requirements of Chapter 15.

Exception: Reroofing shall not be required to meet the minimum design slope requirement of one-quarter unit vertical in 12 units horizontal (2-percent slope) in Section 1507 for roofs that provide positive roof drainage.

41

Sec. 1510-Reroofing

International Building Code, 2012 Edition

1510.3 Recovering versus replacement. New roof coverings shall not be installed without first removing all existing layers of roof coverings down to the roof deck where any of the following conditions occur:

1. Where the existing roof or roof covering is water soaked or has deteriorated to the point that the existing roof or roof covering is not adequate as a base for additional roofing.
2. Where the existing roof covering is wood shake, slate, clay, cement or asbestos-cement tile.
3. Where the existing roof has two or more applications of any type of roof covering.

Exceptions:…

42

Alternate approval

IBC 2012, Sec. 104.11

104.11 Alternative materials, design and methods of construction and equipment. The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

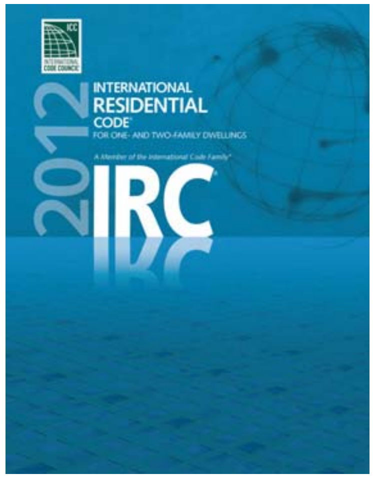
43

104.11.1 Research reports. Supporting data, where necessary to assist in the approval of materials or assemblies not specifically provided for in this code, shall consist of valid research reports from approved sources.

104.11.2 Tests. Whenever there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternative materials or methods, the building official shall have the authority to require tests as evidence of compliance to be made at no expense to the jurisdiction. Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the building official shall approve the testing procedures. Tests shall be performed by an approved agency. Reports of such tests shall be retained by the building official for the period required for retention of public records.

44

International Residential Code, 2012 Edition (IRC 2012)



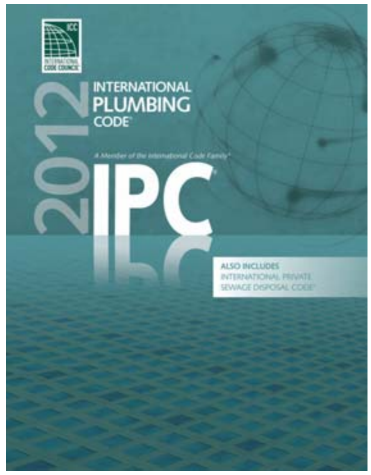
45

International Residential Code, 2012 Edition

- Chapter 9-Roof Assemblies
- Similar to IBC 2012, Chapter 15
- Required fire classification by local ordinance
- More prescriptive-based language

46

International Plumbing Code, 2012 Edition **(IPC 2012)**



47

International Plumbing Code, 2012 Edition

Roof drain, drain piping, scupper, gutter and downspout sizing is dictated by the *International Plumbing Code.*

IPC Chapter 11-Storm Drainage

48

International Fire Code, 2012 Edition **(IFC 2012)**

49

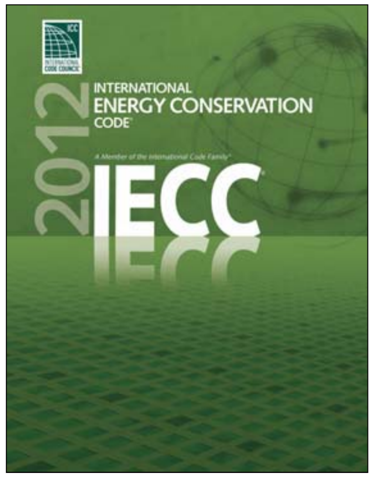
International Fire Code, 2012 Edition

Fire safety during roofing operations and rooftop PV and vegetative roof systems are dictated by the *International Fire Code.*

IFC Sec. 303-Kettles (e.g., ≥ 20 ft.)
IFC Sec. 3317-Safegauarding Roofing Operations
IFC Sec. 605.11-Solar Photovoltaic Power Systems
IFC Sec. 317-Rooftop Gardens and Landscaped Roofs

50

International Energy Conservation Code, 2012 Edition (IECC 2012)



51

Format of IECC 2012

IECC – Commercial

Ch. 1[CE]: Scope and Admin.
Ch. 2[CE]: Definitions
Ch. 3[CE]: General Req.
Ch. 4[CE]: Commercial Energy Efficiency
Ch. 5[CE]: Referenced Stds.
Index

IECC – Residential

Ch. 1[RE]: Scope and Admin.
Ch. 2[RE]: Definitions
Ch. 3[RE]: General Req.
Ch. 4[RE]: Residential Energy Efficiency
Ch. 5[RE]: Referenced Stds.
Index

52

Commercial vs. Residential

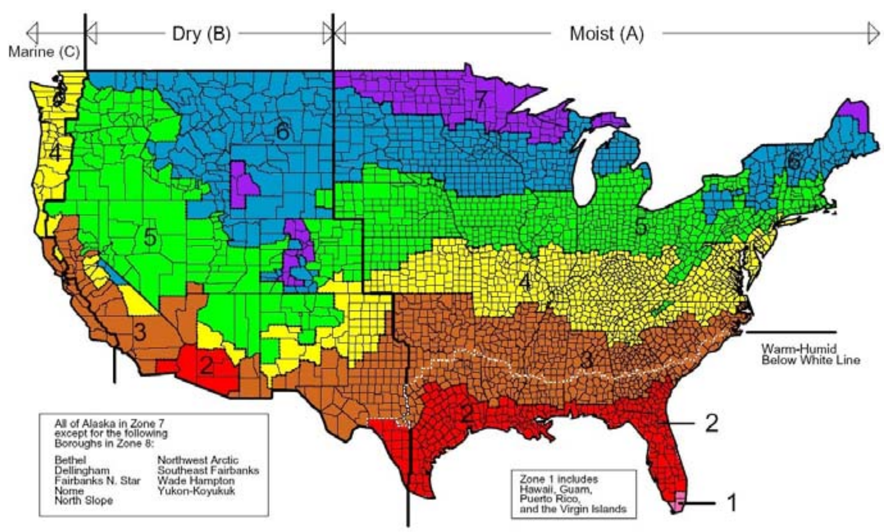
- Commercial unless Residential
- R202-General Definitions:

  Residential Building. For this code, includes detached one- and two-family dwellings and multiple single-family dwellings (townhouses) as well as Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane

53

Climate zones

IECC 2012, Section C301 and Sec. R301—Climate Zones



54

IECC – Residential Provisions

55

Ch. 4[RE]—Residential Energy Efficiency

International Energy Conservation Code, 2012 Edition

- Sec. R401—General
- Sec. R402—Building Thermal Envelope
- Sec. R403—Systems
- Sec. R404—Electrical Power and Lighting Systems
- Sec. R405—Simulated Performance Alternative

56

Roofing-specific adaptation of Table R402.1

International Energy Conservation Code, 2012 Edition

Insulation and Fenestration Requirements by Component[a]	
Climate zone	**Ceiling R-value**
1	30
2	38
3	
4	49
5	
6	
7	
8	

[a] R-values are minimums. …
[Other footnotes omitted for clarity]

57

IECC – Commercial Provisions

58

Ch. 4[CE]—Commercial Energy Efficiency

International Energy Conservation Code, 2012 Edition

- Sec. C401—General
- Sec. C402—Building Envelope Requirements
- Sec. C403—Building Mechanical Systems
- Sec. C404—Service Water Heating
- Sec. C405—Electrical Power and Lighting Systems
- Sec. C406—Additional Efficiency Package Options
- Sec. C407—Total Building Performance

59

Ch. 4—Commercial Energy Efficiency

International Energy Conservation Code, 2012 Edition

C401.2 Application. Commercial buildings shall comply with one of the following:

1. The requirements of ANSI/ASHRAE/IESNA 90.1
2. The requirements of Sections C402, C403, C404 and C405. In addition, commercial buildings shall comply with either Section C406.2, C406.3 or C406.4
3. The requirements of Section C407, C402.4, C403.2, C404, C405.2, C405.3, C405.4, C405.6 and C405.7. The building energy cost shall be equal to or less than 85 percent of the standard reference design building.

[Continued…]

60

C401.2.1 Application to existing buildings. Additions, alterations and repairs to existing buildings shall comply with one of the following:

1. Sections C402, C403, C404 and C405; or
2. ANSI/ASHRAE/IESNA 90.1

61

Minimum thermal insulation requirements

IECC 2009, Section C402.2—Specific insulation Requirements (Prescriptive)

C402.2 Specific insulation requirements (Prescriptive). Opaque assemblies shall comply with Table C402.2. Where two or more layers of continuous insulation board are used in a construction assembly, the continuous insulation boards shall be installed in accordance with Section C303.2. If the continuous insulation board manufacturer's installation instructions do not address installation of two or more layers, the edge joints between each layer of continuous insulation boards shall be staggered.

62

C402.2.1 Roof assembly. The minimum thermal resistance (*R-value)* of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table C402.2, based on construction materials used in the roof assembly. Skylight curbs shall be insulated to the level of roofs with insulation entirely above deck or R-5, whichever is less.

Exceptions:

1. Continuously insulated roof assemblies where the thickness of insulation varies 1 inch (25 mm) or less and where the area-weighted *U-factor is* equivalent to the same assembly with the *R-value* specified in Table C402.2.
2. Unit skylight curbs included as a component of an NFRC 100 rated assembly shall not be required to be insulated.

Insulation installed on a suspended ceiling with removable ceiling tiles shall not be considered part of the minimum thermal resistance of the roof insulation.

63

Roofing-specific adaptation of Table C402.2

International Energy Conservation Code, 2012 Edition

<table>
<tr><th colspan="4">Opaque Thermal Envelope Assembly Requirements</th></tr>
<tr><th rowspan="2">Climate zone</th><th colspan="3">Roof assembly configuration</th></tr>
<tr><th>Insulation entirely above deck</th><th>Metal buildings (with R-5 thermal blocks)</th><th>Attic and other</th></tr>
<tr><td>1</td><td rowspan="3">R-20ci</td><td rowspan="5">R-19 + R-11 LS</td><td rowspan="5">R-38</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td rowspan="2">R-25 ci</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td><td>R-30ci</td><td>R-25 + R-11 LS</td><td rowspan="3">R-49</td></tr>
<tr><td>7</td><td rowspan="2">R-35ci</td><td rowspan="2">R-30 + R-11 LS</td></tr>
<tr><td>8</td></tr>
<tr><td colspan="4">ci = Continuous insulation
LS = Liner system (a continuous membrane installed below the purlins and uninterrupted by framing members; uncompressed, faced insulation rests on top of the membrane between the purlins)</td></tr>
</table>

64

Comparison of IECC's various editions

Commercial Buildings (Insulation component R-value-based method)

<table>
<tr><th>Climate Zone</th><th>IECC 2006</th><th>IECC 2009</th><th>IECC 2012*</th><th>IECC 2015*</th></tr>
<tr><td>1</td><td rowspan="4">R-15 ci</td><td>R-15 ci</td><td rowspan="3">R-20 ci</td><td>R-20 ci</td></tr>
<tr><td>2</td><td rowspan="5">R-20ci</td><td rowspan="2">R-25 ci</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td rowspan="3">R-25 ci</td><td rowspan="3">R-30 ci</td></tr>
<tr><td>5</td><td rowspan="2">R-20 ci</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td><td rowspan="2">R-25 ci</td><td rowspan="2">R-25 ci</td><td rowspan="2">R-30 ci</td><td rowspan="2">R-35 ci</td></tr>
<tr><td>8</td></tr>
</table>

* Applies to roof replacement projects
ci = continuous insulation

65

R-value determination

IECC 2012, Section C303.1.4-Insulation Product Rating

C303.14 Insulation product rating. The thermal resistance (R-value) of insulation shall be determined in accordance with the U.S. Federal Trade commission R-value rule (CFR Title 16, Part 460) in units of h x ft^2 x °F/Btu at a mean temperature of 75°F (24°C).

What about tapered insulation?

66

Tapered insulation

International Energy Conservation Code, 2012 Edition

C402.2.1 Roof assembly. The minimum thermal resistance (R-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table C402.2, based on construction materials used in the roof assembly. Skylight curbs shall be insulated to the level of roofs with insulation entirely above deck or R-5, whichever is less.

Exceptions:

1. Continuously insulated roof assemblies where the thickness of insulation varies 1 inch (25 mm) or less and where the area-weighted *U-factor is* equivalent to the same assembly with the *R-value* specified in Table C402.2.
2. …

IECC Commentary indicates Exception 1 applies to tapered insulation systems.

67

2012 IECC Code and Commentary

Tapered insulation

"…The exception to this section permits a roof that is "continuously insulated" to have areas that do not meet the required *R*-values, provided that the area-weighted values are equivalent to the specified insulation values. This type of insulation referred to as tapered insulation is where the roof insulation varies to provide slope for drainage…."

[continued…]

68

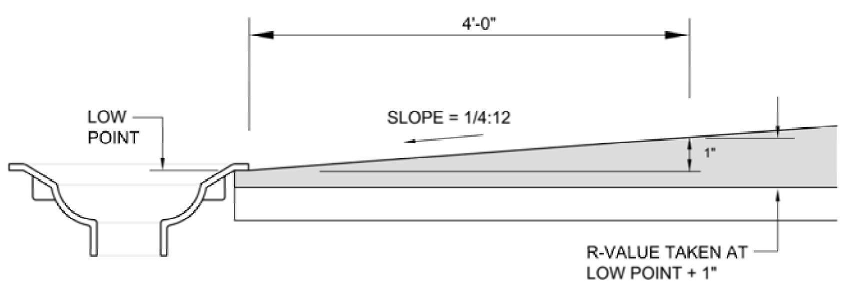
2012 IECC Code and Commentary

Tapered insulation

"…This 1-inch (25 mm) limitation does not prevent the provisions from being applied to roofs that have a greater variation; it simply does not allow the additional thickness to be factored into the average insulation values. Where the variation exceeds 1 inch (25 mm), it would be permissible to go to the thinnest spot and measure the *R*-value at that point (for the example call this Point "a"). Then go to a point that is 1 inch (25 mm) thicker than Point "a" and measure the *R*-value there (for the example, call this Point "b"). The remaining portions of the roof that are thicker than the additional 1-inch (25 mm) portion (Point "b") would simply be assumed to have the same *R*-value that Point "b" had. All portions of the roof that meet or exceed the Point "b" *R*-value would simply use the Point "b" *R*-value when determining the area weighted *U*-factor for the roof. "

69

Graphically depicted…



70

Solar reflectance and thermal emittance

IECC 2012, Section C402.2.1.1

C402.2.1.1 Roof solar reflectance and thermal emittance. Low-sloped roofs, with a slope less than 2 units vertical in 12 horizontal, directly above cooled *conditioned spaces* in Climate Zones 1, 2, and 3 shall comply with one or more of the options in Table C402.2.1.1.

Exceptions: The following roofs and portions of roofs are exempt from the requirements in Table C402.2.1.1:

1. Portions of roofs that include or are covered by:
   - 1.1 Photovoltaic systems or components.
   - 1.2 Solar air or water heating systems or components.
   - 1.3 Roof gardens or landscaped roofs.
   - 1.4 Above-roof decks or walkways.
   - 1.5 Skylights.
   - 1.6 HVAC systems, components, and other opaque objects mounted above…

[Continued…]

71

TABLE C402.2.1.1

MINIMUM ROOF REFLECTANCE AND EMITTANCE OPTIONS[a]

Three-year aged solar reflectance[b] of 0.55 and three-year aged thermal emittance of 0.75
Initial solar reflectance[b] of 0.70 and initial thermal emittance[c] of 0.75
Three-year-aged solar reflectance index[d] of 64
Initial solar reflectance index[d] of 82

[Footnotes omitted for clarity]

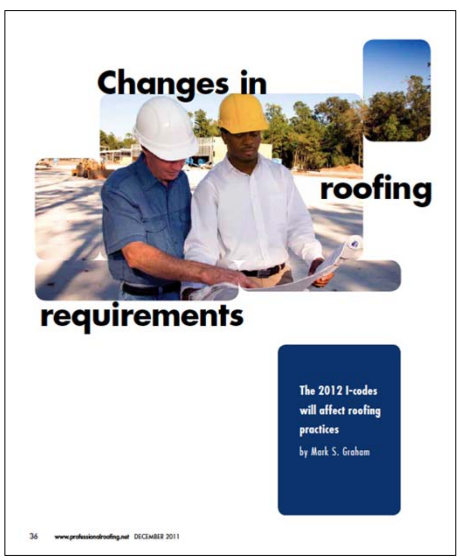
72

In summary

- Be knowledgeable of applicable codes
- Watch for state/local modifications
- Comply with the applicable codes
- Building/Residential Code
- Plumbing Code
- Fire Code
- Energy Code

73

Professional Roofing, December 2011

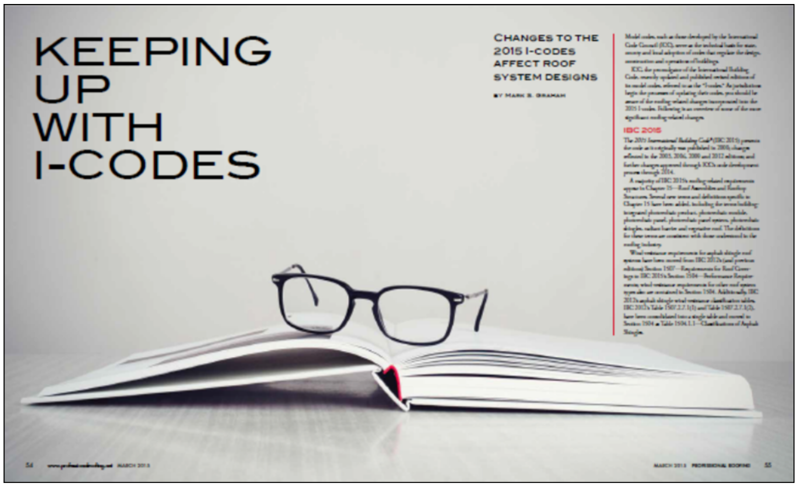


2009 I-codes

74

***Professional Roofing*, March 2015**

Pages 54-60

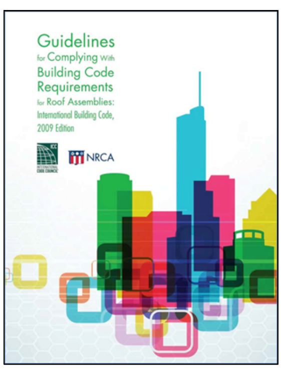


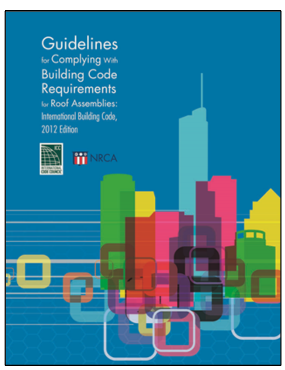
2012 I-codes

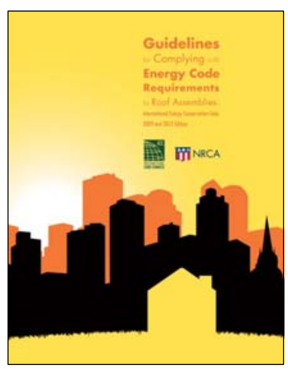
75

NRCA code manuals

shop.nrca.net or (866) ASK-NRCA







76

Consider joining ICC

ICC INTERNATIONAL CODE COUNCIL®
People Helping People Build a Safer World™

Membership categories:

- Corporate member: $400 (complete collection)
- Building safety professional member: $150 (1 code)

http://www.iccsafe.org/Membership/Pages/join.aspx

77

Wind design

Roof systems

78

Reference documents – "the acronyms"

Wind design

American Society of Civil Engineers (ASCE)

- ASCE 7, "Minimum Design Loads for Buildings and Other Structures"

International Code Council (ICC):

- *International Building Code* (IBC)

FM Global:

- Loss Prevention Data Sheet 1-28, "Design Wind Loads"
- Loss Prevention Data Sheet 1-29, "Roof Deck Securement and Above-deck Roof Components"

79

Reference documents -- continued

Wind design

FM Approvals (a subsidiary of FM Global)

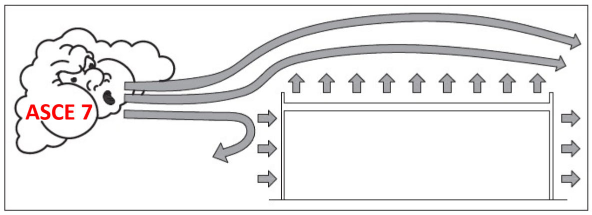
- Approval classifications: 1-60, 1-90, 1-120, etc.
- RoofNav (www.roofnav.com)

Underwriters Laboratories (UL):

- Fire classifications: Class A, Class B and Class C
- Wind classifications: Class 30, Class 60, Class 90
- Impact (hail) classifications: Class I to IV
- Online certifications directory (www.ul.com)

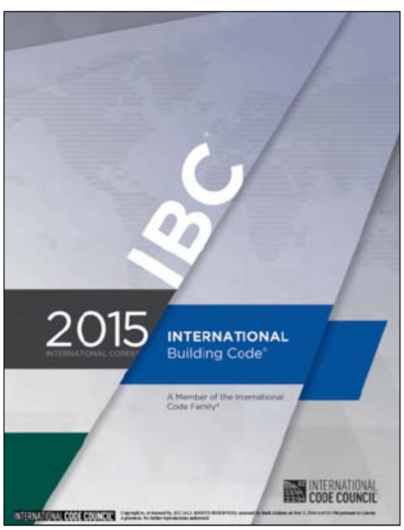
80

The fundamental concept



Wind creates pressures/forces
on building elements

81



The Code establishes minimum requirements for building construction (and reroofing)

IBC 2015:

- Ch. 15-Roof Assemblies
  - Sec. 1511-Reroofing
- Ch. 16-Structural Design
  - Sec. 1609-Wind Loads

82

SECTION 1504
PERFORMANCE REQUIREMENTS

1504.1 Wind resistance of roofs. Roof decks and roof coverings shall be designed for wind loads in accordance with Chapter 16 and Sections 1504.2, 1504.3 and 1504.4.

1504.3 Wind resistance of nonballasted roofs. Roof coverings installed on roofs in accordance with Section 1507 that are mechanically attached or adhered to the roof deck shall be designed to resist the design wind load pressures for components and cladding in accordance with Section 1609.

1504.3.1 Other roof systems. Built-up, modified bitumen, fully adhered or mechanically attached single-ply roof systems, metal panel roof systems applied to a solid or closely fitted deck and other types of membrane roof coverings shall be tested in accordance with FM 4474, UL 580 or UL 1897.

1504.5 Edge securement for low-slope roofs. Low-slope built-up, modified bitumen and single-ply roof system metal edge securement, except gutters, shall be designed and installed for wind loads in accordance with Chapter 16 and tested for resistance in accordance with Test Methods RE-1, RE-2 and RE-3 of ANSI/SPRI ES-1, except V_{ult} wind speed shall be determined from Figure 1609A, 1609B, or 1609C as applicable.

83

1609.5 Roof systems. Roof systems shall be designed and constructed in accordance with Sections 1609.5.1 through 1609.5.3, as applicable.

1609.5.1 Roof deck. The roof deck shall be designed to withstand the wind pressures determined in accordance with ASCE 7.

1609.5.2 Roof coverings. Roof coverings shall comply with Section 1609.5.1.

Exception: Rigid tile roof coverings that are air permeable and installed over a roof deck complying with Section 1609.5.1 are permitted to be designed in accordance with Section 1609.5.3.

Asphalt shingles installed over a roof deck complying with Section 1609.5.1 shall comply with the wind-resistance requirements of Section 1504.1.1.

1609.5.3 Rigid tile. Wind loads on rigid tile roof coverings shall be determined in accordance with the following equation:

$$M_a = q_h C_L b L L_a [1.0 - GC_p] \quad \textbf{(Equation 16-34)}$$

84

SECTION 1603
CONSTRUCTION DOCUMENTS

1603.1 General. *Construction documents* shall show the size, section and relative locations of structural members with floor levels, column centers and offsets dimensioned. The design loads and other information pertinent to the structural design required by Sections 1603.1.1 through 1603.1.8 shall be indicated on the *construction documents*.

1603.1.4 Wind design data. The following information related to wind loads shall be shown, regardless of whether wind loads govern the design of the lateral force-resisting system of the structure:

1. Ultimate design wind speed, V_{ult}, (3-second gust), miles per hour (km/hr) and nominal design wind speed, V_{asd}, as determined in accordance with Section 1609.3.1.
2. *Risk category*.
3. Wind exposure. Applicable wind direction if more than one wind exposure is utilized.
4. Applicable internal pressure coefficient.
5. Design wind pressures to be used for exterior component and cladding materials not specifically designed by the *registered design professional* responsible for the design of the structure, psf (kN/m^2).

85

Fundamental premise

Wind resistance ≥ Design wind load

FM or UL rating ≥ ASCE 7

86

ASCE 7-10, "Minimum Design Loads for buildings and Other Structures"

87

Fundamental pressure equation

ASCE 7-10, Equation 30.3-1

$$q_h = 0.00256\ (K_z)\ (K_{zt})\ (K_d)\ (V^2)$$

Where:

- K_d = wind directionality factor
- K_z = velocity pressure exposure coefficient
- K_{zt} = topographic factor
- V = wind speed (mph)
- q_h = velocity pressure (psf)

88

ASCE 7-10

Wind loads

- Ch. 26: Wind loads: General Requirements
- Ch. 30: Wind loads – Components & Cladding
  - Part 1: Low-rise buildings (h ≤ 60 ft.)
  - Part 2: Low-rise buildings (h ≤ 60 ft.) (Simplified)
  - Part 3: Buildings with h > 60 ft.
  - Part 4: Buildings with h ≤ 160 ft. (Simplified)
  - Part 5: Open buildings
  - Part 6: Building apprutenances and rooftop structures and equipment
- Ch. 31: Wind Tunnel Procedure

89

Design parameters

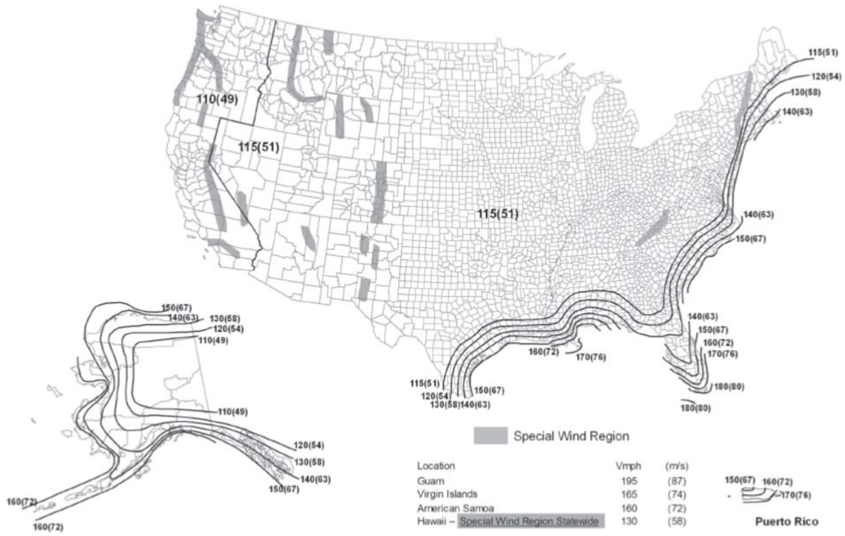
For the "Simplified procedures" (Part 2 and Part 4)

- Mean roof height (h)
- Enclosed building
- Wind-borne debris region (hurricane coastline)
- Regular-shaped building
- Topographical factor (K_{zt})
- Risk Category (Occupancy Category II most common)
- Basic wind speed (map)
- Exposure Category (Exposure C most common)
- Effective wind area (assume 10 ft^2)
- Wind zones (GC_p)

90

Basic wind speed

ASCE 7-10, Occupancy Category II Buildings



91

Pressure coefficients (GC_p)

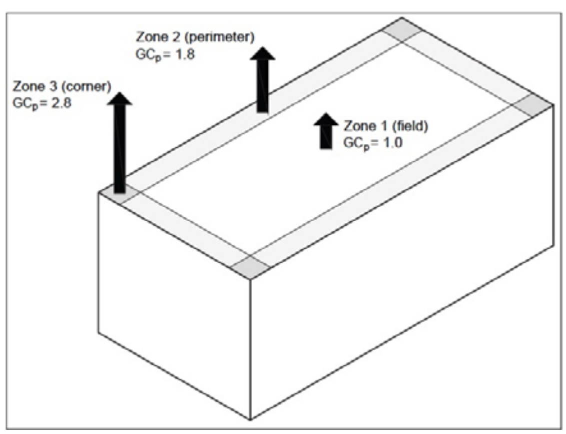


Illustration based upon ASCE 7-10, Fig. 30.4-2A (θ ≤ 7°); Effective wind area = 10 ft^2

92

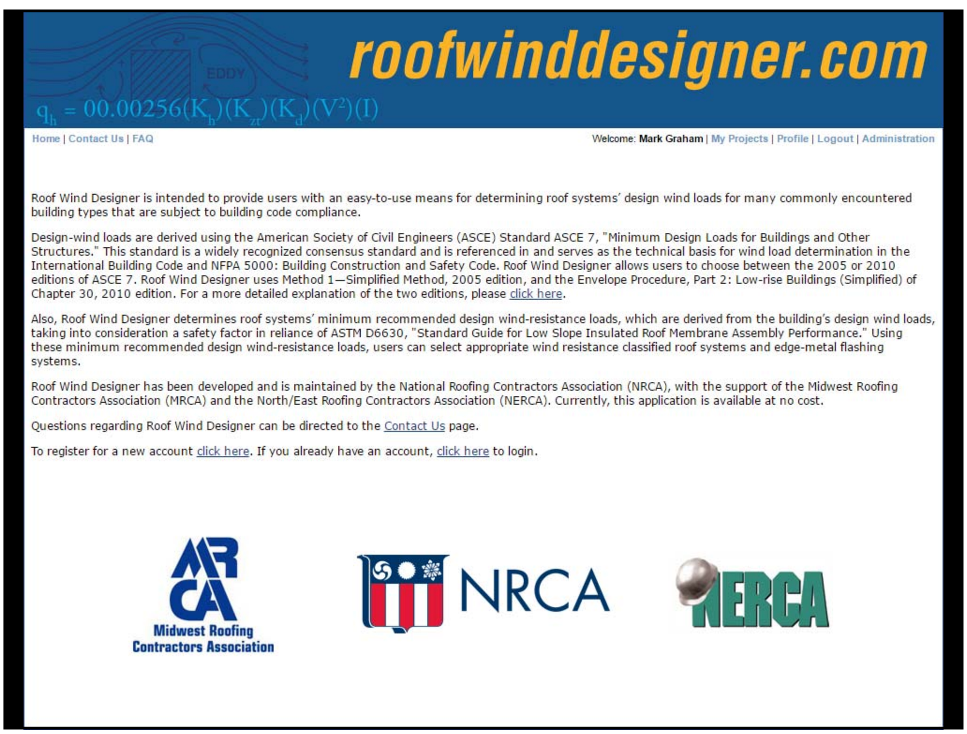
ASCE 7-10

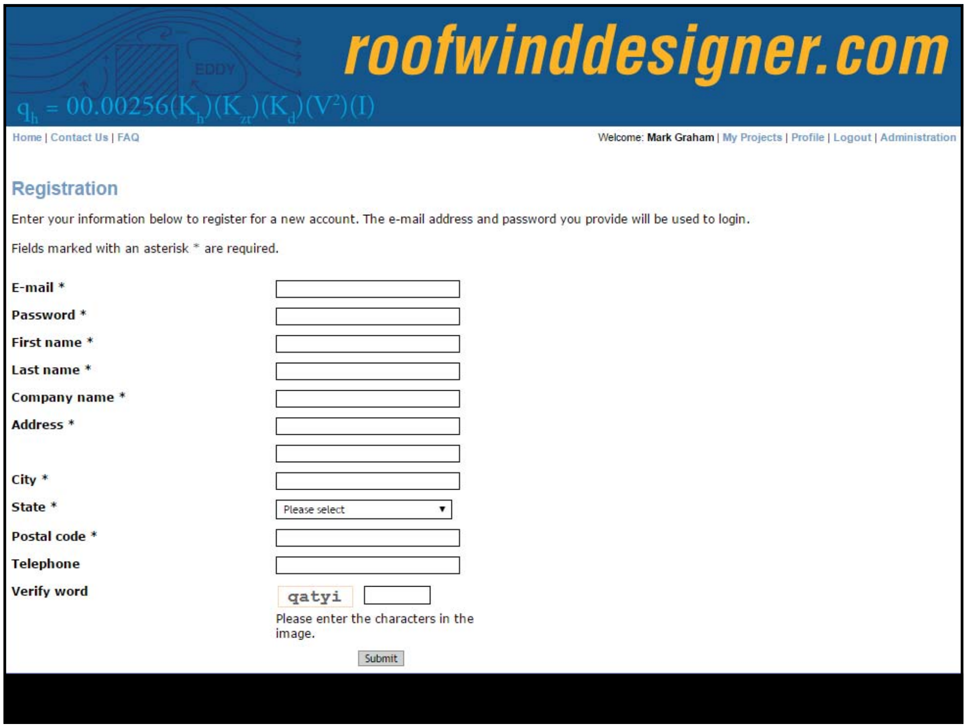
Strength design method vs. Allowable stress method

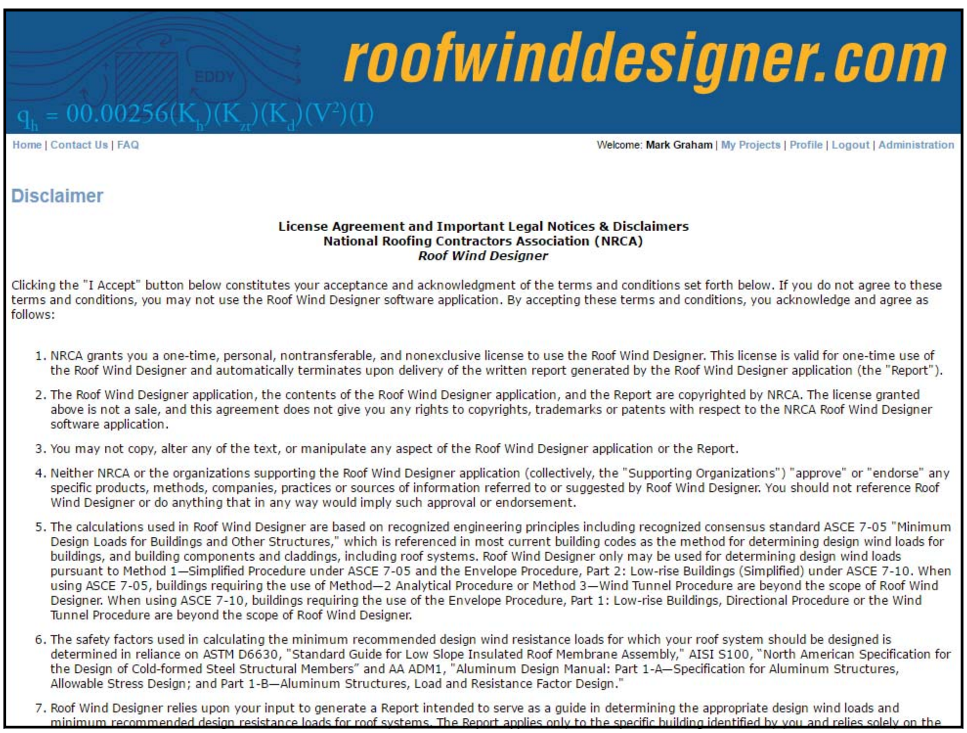
- ASCE 7-10 is based upon the strength design method
  - Increased wind speeds on map
  - Load factor of 1.6
- ASCE 7-10 allows for conversion of allowable stress design (ASD) method:

  ASD value = Strength design value x 0.6
- ASCE 7-05 and previous editions were based upon the ASD method

93





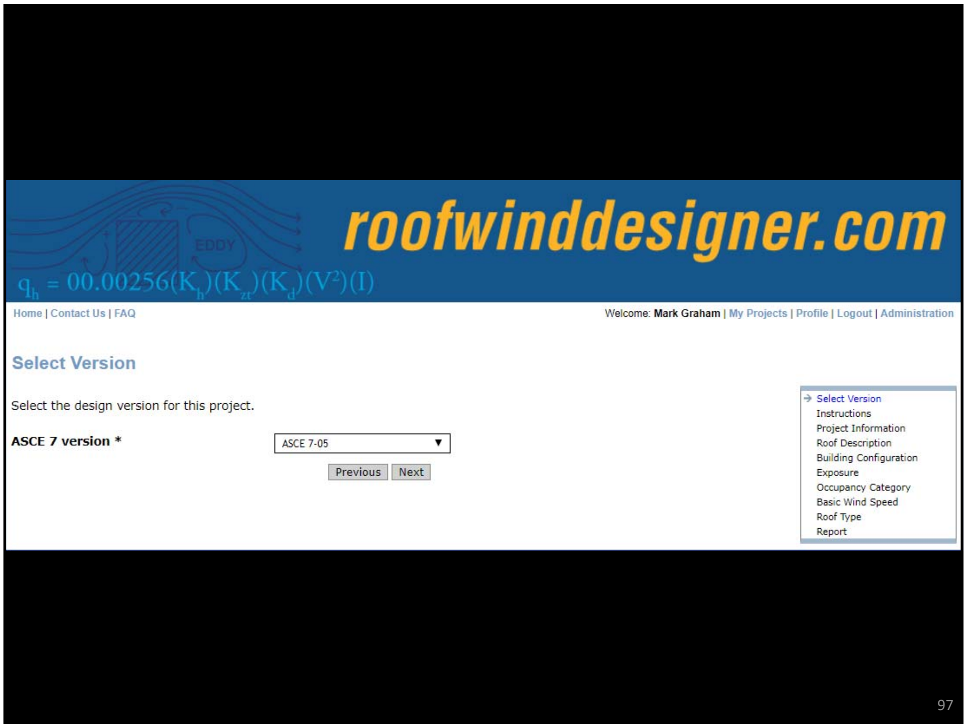


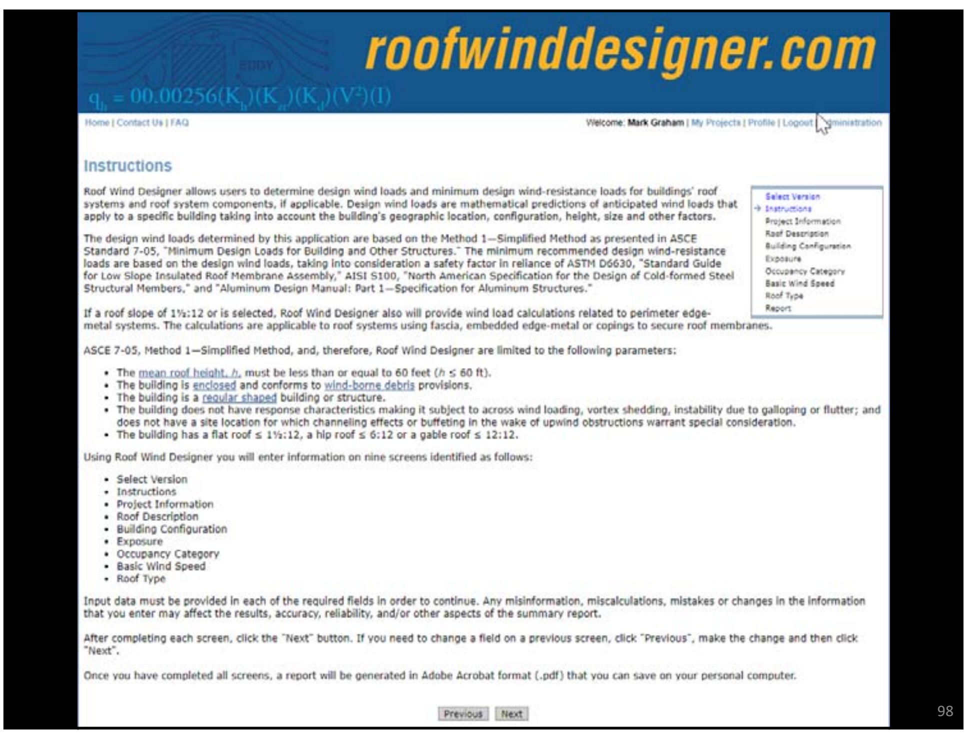
Disclaimer

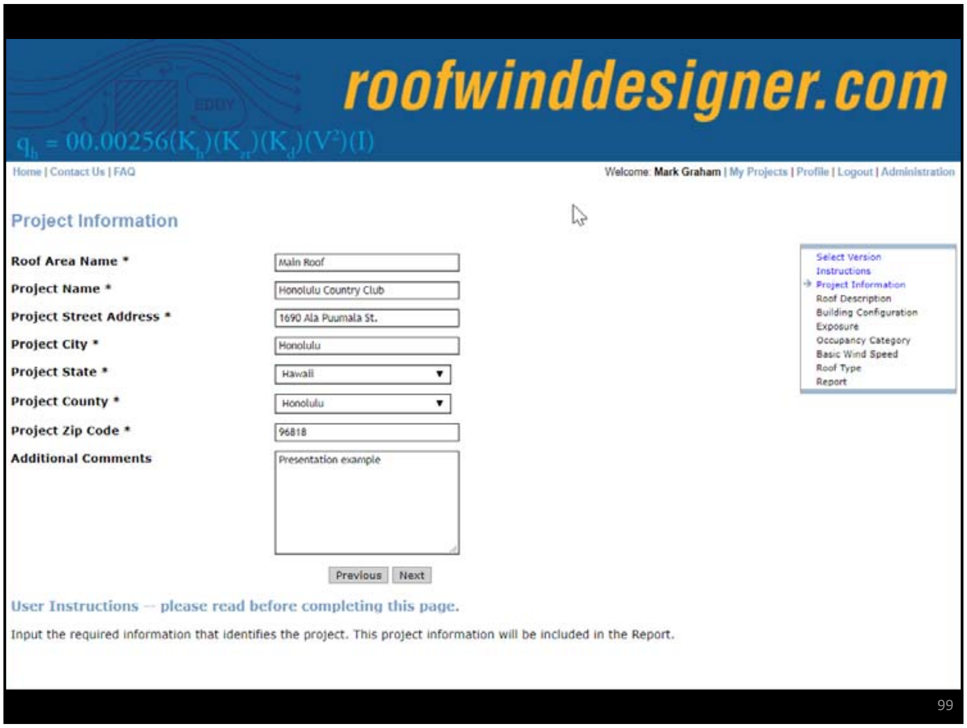
License Agreement and Important Legal Notices & Disclaimers
National Roofing Contractors Association (NRCA)
Roof Wind Designer

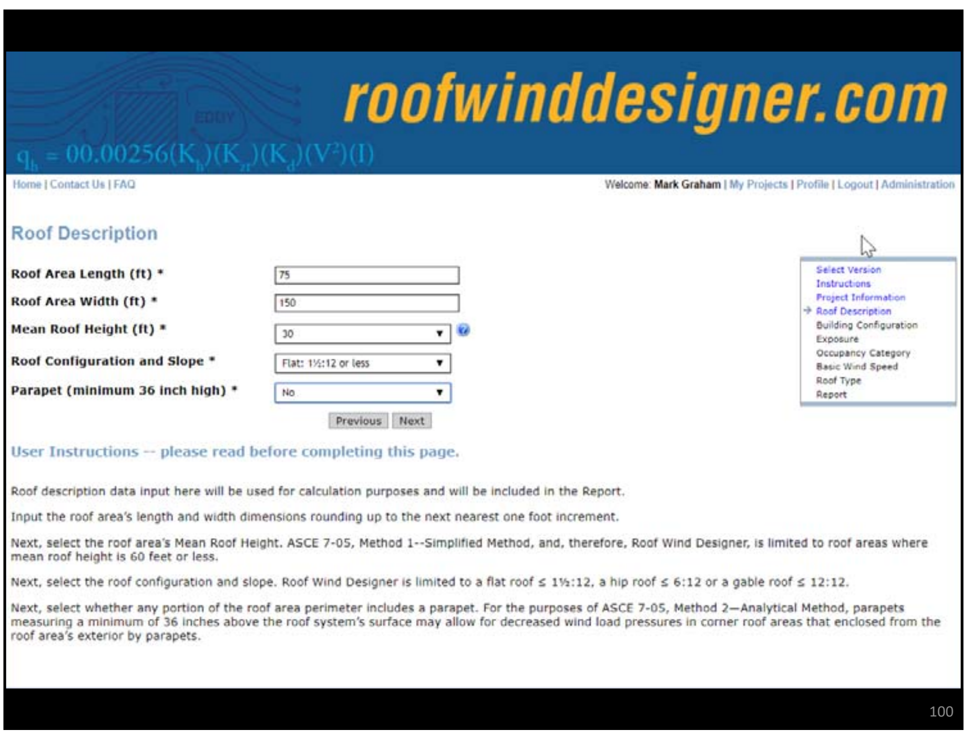
Clicking the "I Accept" button below constitutes your acceptance and acknowledgment of the terms and conditions set forth below. If you do not agree to these terms and conditions, you may not use the Roof Wind Designer software application. By accepting these terms and conditions, you acknowledge and agree as follows:

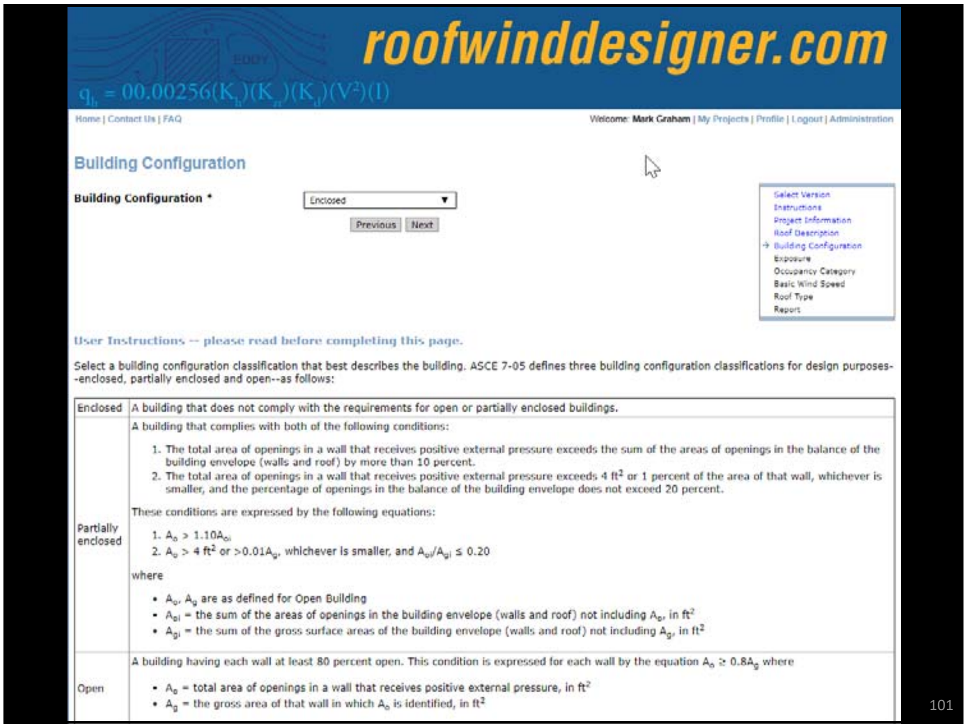
1. NRCA grants you a one-time, personal, nontransferable, and nonexclusive license to use the Roof Wind Designer. This license is valid for one-time use of the Roof Wind Designer and automatically terminates upon delivery of the written report generated by the Roof Wind Designer application (the "Report").
2. The Roof Wind Designer application, the contents of the Roof Wind Designer application, and the Report are copyrighted by NRCA. The license granted above is not a sale, and this agreement does not give you any rights to copyrights, trademarks or patents with respect to the NRCA Roof Wind Designer software application.
3. You may not copy, alter any of the text, or manipulate any aspect of the Roof Wind Designer application or the Report.
4. Neither NRCA or the organizations supporting the Roof Wind Designer application (collectively, the "Supporting Organizations") "approve" or "endorse" any specific products, methods, companies, practices or sources of information referred to or suggested by Roof Wind Designer. You should not reference Roof Wind Designer or do anything that in any way would imply such approval or endorsement.
5. The calculations used in Roof Wind Designer are based on recognized engineering principles including recognized consensus standard ASCE 7-05 "Minimum Design Loads for Buildings and Other Structures," which is referenced in most current building codes as the method for determining design wind loads for buildings, and building components and claddings, including roof systems. Roof Wind Designer only may be used for determining design wind loads pursuant to Method 1—Simplified Procedure under ASCE 7-05 and the Envelope Procedure, Part 2: Low-rise Buildings (Simplified) under ASCE 7-10. When using ASCE 7-05, buildings requiring the use of Method—2 Analytical Procedure or Method 3—Wind Tunnel Procedure are beyond the scope of Roof Wind Designer. When using ASCE 7-10, buildings requiring the use of the Envelope Procedure, Part 1: Low-rise Buildings, Directional Procedure or the Wind Tunnel Procedure are beyond the scope of Roof Wind Designer.
6. The safety factors used in calculating the minimum recommended design wind resistance loads for which your roof system should be designed is determined in reliance on ASTM D6630, "Standard Guide for Low Slope Insulated Roof Membrane Assembly," AISI S100, "North American Specification for the Design of Cold-formed Steel Structural Members" and AA ADM1, "Aluminum Design Manual: Part 1-A—Specification for Aluminum Structures, Allowable Stress Design; and Part 1-B—Aluminum Structures, Load and Resistance Factor Design."
7. Roof Wind Designer relies upon your input to generate a Report intended to serve as a guide in determining the appropriate design wind loads and minimum recommended design resistance loads for roof systems. The Report applies only to the specific building identified by you and relies solely on the

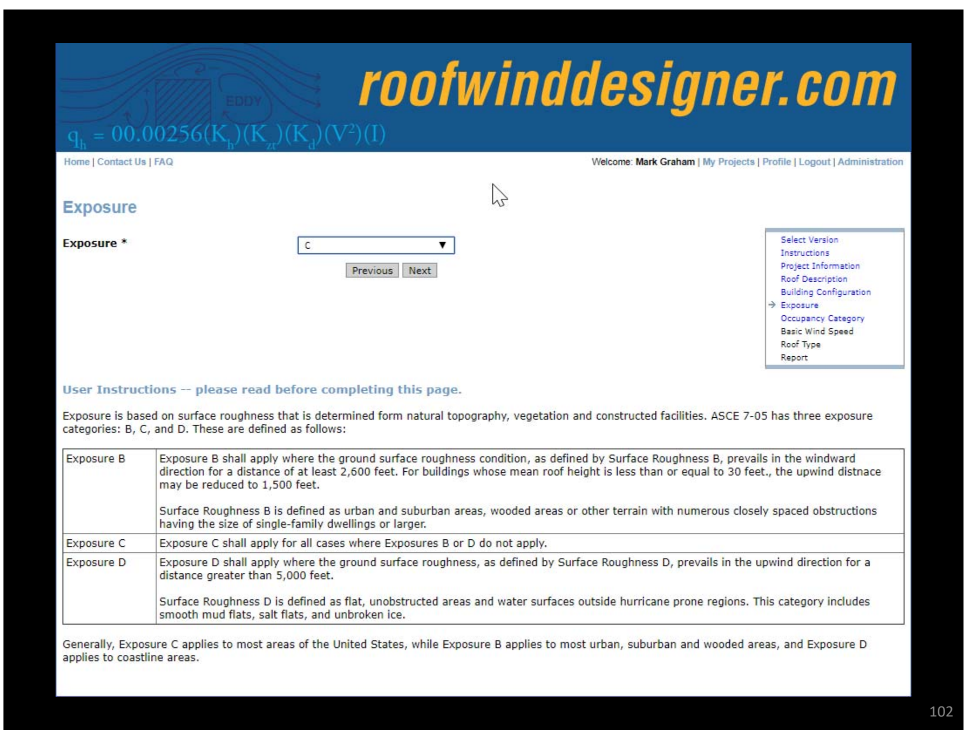

roofwinddesigner.com
qh = 00.00256(Kh)(Kzt)(Kd)(V2)(I)
Home | Contact Us | FAQ
Welcome: Mark Graham | My Projects | Profile | Logout | Administration
Select Version
Select the design version for this project.
ASCE 7 version *
ASCE 7-05
Previous
Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
97

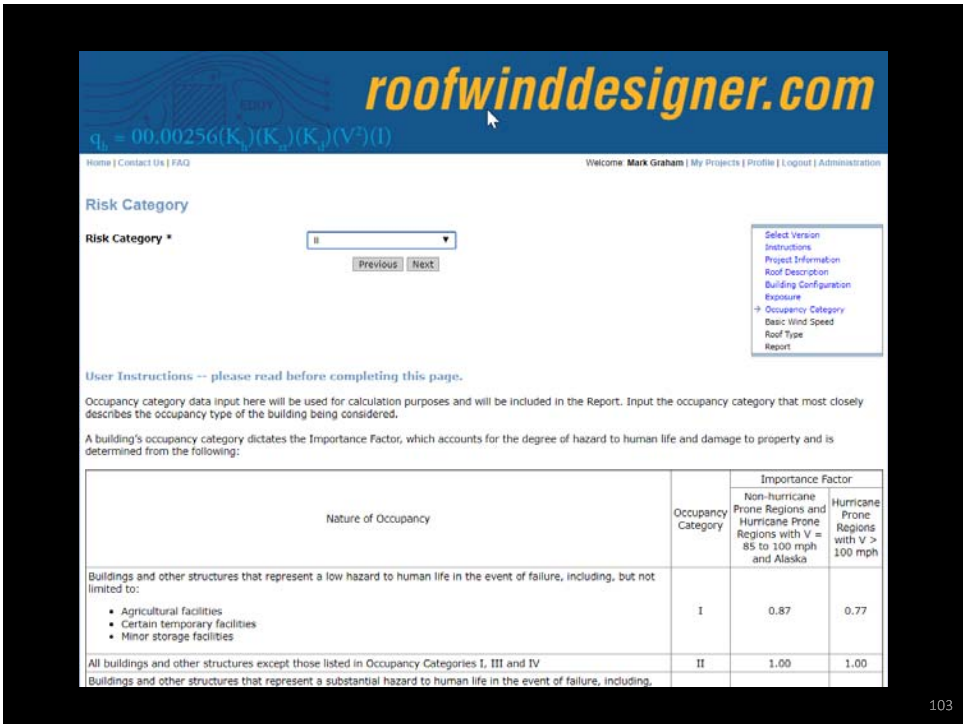

roofwinddesigner.com
qh = 00.00256(Kh)(Kzt)(Kd)(V2)(I)
Home | Contact Us | FAQ
Welcome: Mark Graham | My Projects | Profile | Logout | Administration
Instructions
Roof Wind Designer allows users to determine design wind loads and minimum design wind-resistance loads for buildings' roof systems and roof system components, if applicable. Design wind loads are mathematical predictions of anticipated wind loads that apply to a specific building taking into account the building's geographic location, configuration, height, size and other factors.
The design wind loads determined by this application are based on the Method 1—Simplified Method as presented in ASCE Standard 7-05, "Minimum Design Loads for Building and Other Structures." The minimum recommended design wind-resistance loads are based on the design wind loads, taking into consideration a safety factor in reliance of ASTM D6630, "Standard Guide for Low Slope Insulated Roof Membrane Assembly," AISI S100, "North American Specification for the Design of Cold-formed Steel Structural Members," and "Aluminum Design Manual: Part 1—Specification for Aluminum Structures."
If a roof slope of 1½:12 or is selected, Roof Wind Designer also will provide wind load calculations related to perimeter edge-metal systems. The calculations are applicable to roof systems using fascia, embedded edge-metal or copings to secure roof membranes.
ASCE 7-05, Method 1—Simplified Method, and, therefore, Roof Wind Designer are limited to the following parameters:
• The mean roof height, h, must be less than or equal to 60 feet (h ≤ 60 ft).
• The building is enclosed and conforms to wind-borne debris provisions.
• The building is a regular shaped building or structure.
• The building does not have response characteristics making it subject to across wind loading, vortex shedding, instability due to galloping or flutter; and does not have a site location for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration.
• The building has a flat roof ≤ 1½:12, a hip roof ≤ 6:12 or a gable roof ≤ 12:12.
Using Roof Wind Designer you will enter information on nine screens identified as follows:
• Select Version
• Instructions
• Project Information
• Roof Description
• Building Configuration
• Exposure
• Occupancy Category
• Basic Wind Speed
• Roof Type
Input data must be provided in each of the required fields in order to continue. Any misinformation, miscalculations, mistakes or changes in the information that you enter may affect the results, accuracy, reliability, and/or other aspects of the summary report.
After completing each screen, click the "Next" button. If you need to change a field on a previous screen, click "Previous", make the change and then click "Next".
Once you have completed all screens, a report will be generated in Adobe Acrobat format (.pdf) that you can save on your personal computer.
Previous
Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
98

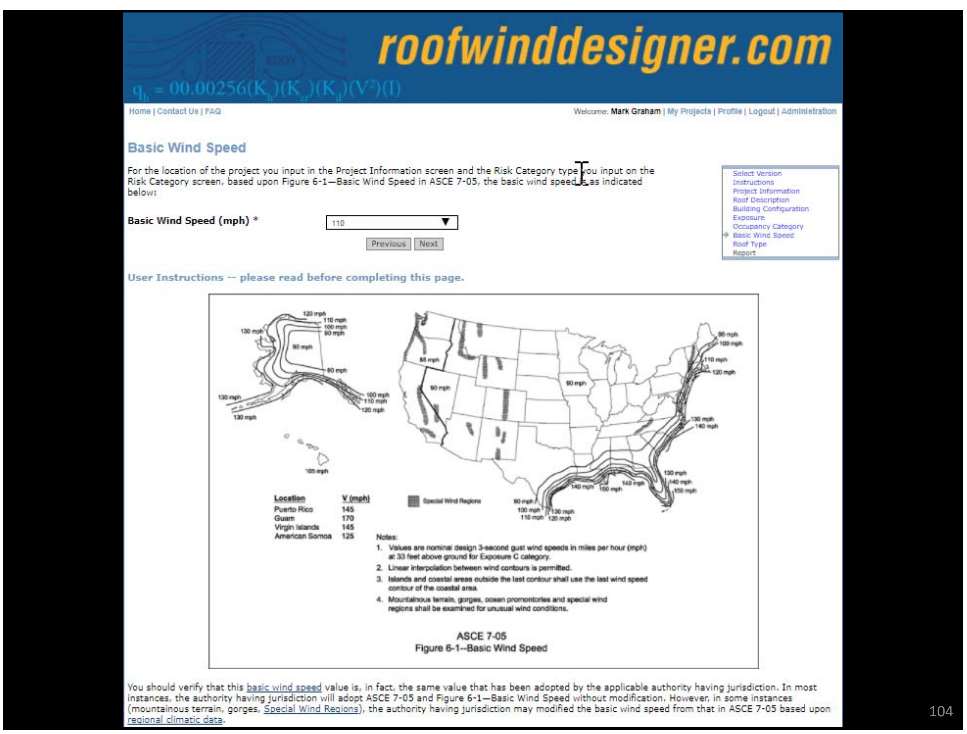

roofwinddesigner.com
q_h = 00.00256(K_z)(K_zt)(K_d)(V²)(I)
Home | Contact Us | FAQ
Welcome: Mark Graham | My Projects | Profile | Logout | Administration
Project Information
Roof Area Name *
Main Roof
Project Name *
Honolulu Country Club
Project Street Address *
1690 Ala Puumala St.
Project City *
Honolulu
Project State *
Hawaii
Project County *
Honolulu
Project Zip Code *
96818
Additional Comments
Presentation example
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
Previous
Next
User Instructions -- please read before completing this page.
Input the required information that identifies the project. This project information will be included in the Report.
99


roofwinddesigner.com
q_h = 00.00256(K_z)(K_zt)(K_d)(V²)(I)
Home | Contact Us | FAQ
Welcome: Mark Graham | My Projects | Profile | Logout | Administration
Roof Description
Roof Area Length (ft) *
75
Roof Area Width (ft) *
150
Mean Roof Height (ft) *
30
Roof Configuration and Slope *
Flat: 1½:12 or less
Parapet (minimum 36 inch high) *
No
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
Previous
Next
User Instructions -- please read before completing this page.
Roof description data input here will be used for calculation purposes and will be included in the Report.
Input the roof area's length and width dimensions rounding up to the next nearest one foot increment.
Next, select the roof area's Mean Roof Height. ASCE 7-05, Method 1--Simplified Method, and, therefore, Roof Wind Designer, is limited to roof areas where mean roof height is 60 feet or less.
Next, select the roof configuration and slope. Roof Wind Designer is limited to a flat roof ≤ 1½:12, a hip roof ≤ 6:12 or a gable roof ≤ 12:12.
Next, select whether any portion of the roof area perimeter includes a parapet. For the purposes of ASCE 7-05, Method 2—Analytical Method, parapets measuring a minimum of 36 inches above the roof system's surface may allow for decreased wind load pressures in corner roof areas that enclosed from the roof area's exterior by parapets.
100

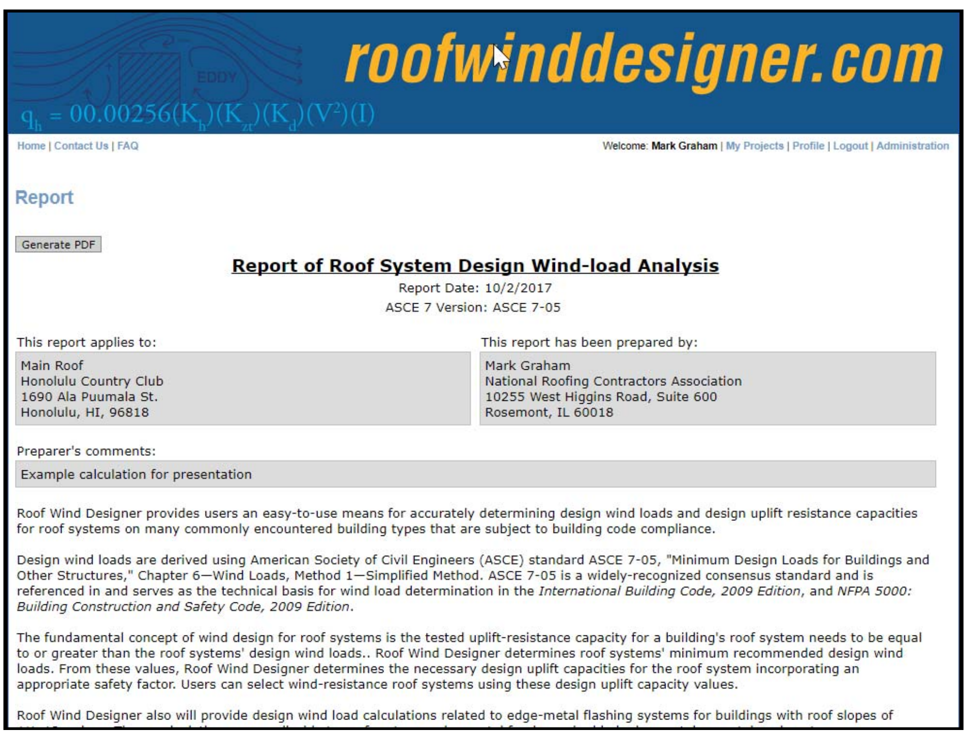

roofwinddesigner.com
$q_h = 00.00256(K_h)(K_{zt})(K_d)(V^2)(I)$
Home | Contact Us | FAQ
Welcome: Mark Graham | My Projects | Profile | Logout | Administration
Building Configuration
Building Configuration *
Enclosed
Previous
Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
User Instructions -- please read before completing this page.
Select a building configuration classification that best describes the building. ASCE 7-05 defines three building configuration classifications for design purposes--enclosed, partially enclosed and open--as follows:
Enclosed
A building that does not comply with the requirements for open or partially enclosed buildings.
Partially enclosed
A building that complies with both of the following conditions:
1. The total area of openings in a wall that receives positive external pressure exceeds the sum of the areas of openings in the balance of the building envelope (walls and roof) by more than 10 percent.
2. The total area of openings in a wall that receives positive external pressure exceeds 4 ft² or 1 percent of the area of that wall, whichever is smaller, and the percentage of openings in the balance of the building envelope does not exceed 20 percent.
These conditions are expressed by the following equations:
1. $A_o > 1.10A_{oi}$
2. $A_o >$ 4 ft² or $>0.01A_g$, whichever is smaller, and $A_{oi}/A_{gi} \leq 0.20$
where
• A_o, A_g are as defined for Open Building
• A_{oi} = the sum of the areas of openings in the building envelope (walls and roof) not including A_o, in ft²
• A_{gi} = the sum of the gross surface areas of the building envelope (walls and roof) not including A_g, in ft²
Open
A building having each wall at least 80 percent open. This condition is expressed for each wall by the equation $A_o \geq 0.8A_g$ where
• A_o = total area of openings in a wall that receives positive external pressure, in ft²
• A_g = the gross area of that wall in which A_o is identified, in ft²
101


roofwinddesigner.com
$q_h = 00.00256(K_h)(K_{zt})(K_d)(V^2)(I)$
Home | Contact Us | FAQ
Welcome: Mark Graham | My Projects | Profile | Logout | Administration
Exposure
Exposure *
C
Previous
Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
User Instructions -- please read before completing this page.
Exposure is based on surface roughness that is determined form natural topography, vegetation and constructed facilities. ASCE 7-05 has three exposure categories: B, C, and D. These are defined as follows:
Exposure B
Exposure B shall apply where the ground surface roughness condition, as defined by Surface Roughness B, prevails in the windward direction for a distance of at least 2,600 feet. For buildings whose mean roof height is less than or equal to 30 feet., the upwind distnace may be reduced to 1,500 feet.
Surface Roughness B is defined as urban and suburban areas, wooded areas or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger.
Exposure C
Exposure C shall apply for all cases where Exposures B or D do not apply.
Exposure D
Exposure D shall apply where the ground surface roughness, as defined by Surface Roughness D, prevails in the upwind direction for a distance greater than 5,000 feet.
Surface Roughness D is defined as flat, unobstructed areas and water surfaces outside hurricane prone regions. This category includes smooth mud flats, salt flats, and unbroken ice.
Generally, Exposure C applies to most areas of the United States, while Exposure B applies to most urban, suburban and wooded areas, and Exposure D applies to coastline areas.
102


roofwinddesigner.com
q_h = 00.00256(K_h)(K_{zt})(K_d)(V^2)(I)
Home | Contact Us | FAQ
Welcome: Mark Graham | My Projects | Profile | Logout | Administration
Risk Category
Risk Category *
II
Previous Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
User Instructions -- please read before completing this page.
Occupancy category data input here will be used for calculation purposes and will be included in the Report. Input the occupancy category that most closely describes the occupancy type of the building being considered.
A building's occupancy category dictates the Importance Factor, which accounts for the degree of hazard to human life and damage to property and is determined from the following:
Nature of Occupancy
Occupancy Category
Importance Factor
Non-hurricane Prone Regions and Hurricane Prone Regions with V = 85 to 100 mph and Alaska
Hurricane Prone Regions with 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 Occupancy 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,
103


roofwinddesigner.com
q_h = 00.00256(K_h)(K_{zt})(K_d)(V^2)(I)
Home | Contact Us | FAQ
Welcome: Mark Graham | My Projects | Profile | Logout | Administration
Basic Wind Speed
For the location of the project you input in the Project Information screen and the Risk Category type you input on the Risk Category screen, based upon Figure 6-1—Basic Wind Speed in ASCE 7-05, the basic wind speed is as indicated below:
Basic Wind Speed (mph) *
110
Previous Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
User Instructions -- please read before completing this page.
Notes:
2. Linear interpolation between wind contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories and special wind regions shall be examined for unusual wind conditions.
ASCE 7-05
Figure 6-1--Basic Wind Speed
You should verify that this basic wind speed value is, in fact, the same value that has been adopted by the applicable authority having jurisdiction. In most instances, the authority having jurisdiction will adopt ASCE 7-05 and Figure 6-1—Basic Wind Speed without modification. However, in some instances (mountainous terrain, gorges, Special Wind Regions), the authority having jurisdiction may modified the basic wind speed from that in ASCE 7-05 based upon regional climatic data.
104


roofwinddesigner.com
Home | Contact Us | FAQ
Welcome: Mark Graham | My Projects | Profile | Logout | Administration
Roof Type
Roof Deck Type *
Structural Concrete
Roof Covering Type *
TPO
Previous
Next
Select Version
Instructions
Project Information
Roof Description
Building Configuration
Exposure
Occupancy Category
Basic Wind Speed
Roof Type
Report
105


roofwinddesigner.com
Home | Contact Us | FAQ
Welcome: Mark Graham | My Projects | Profile | Logout | Administration
Report
Generate PDF
Report of Roof System Design Wind-load Analysis
Report Date: 10/2/2017
ASCE 7 Version: ASCE 7-05
This report applies to:
Main Roof
Honolulu Country Club
1690 Ala Puumala St.
Honolulu, HI, 96818
This report has been prepared by:
Mark Graham
National Roofing Contractors Association
10255 West Higgins Road, Suite 600
Rosemont, IL 60018
Preparer's comments:
Example calculation for presentation
Roof Wind Designer provides users an easy-to-use means for accurately determining design wind loads and design uplift resistance capacities for roof systems on many commonly encountered building types that are subject to building code compliance.
Design wind loads are derived using American Society of Civil Engineers (ASCE) standard ASCE 7-05, "Minimum Design Loads for Buildings and Other Structures," Chapter 6—Wind Loads, Method 1—Simplified Method. ASCE 7-05 is a widely-recognized consensus standard and is referenced in and serves as the technical basis for wind load determination in the International Building Code, 2009 Edition, and NFPA 5000: Building Construction and Safety Code, 2009 Edition.
The fundamental concept of wind design for roof systems is the tested uplift-resistance capacity for a building's roof system needs to be equal to or greater than the roof systems' design wind loads.. Roof Wind Designer determines roof systems' minimum recommended design wind loads. From these values, Roof Wind Designer determines the necessary design uplift capacities for the roof system incorporating an appropriate safety factor. Users can select wind-resistance roof systems using these design uplift capacity values.
Roof Wind Designer also will provide design wind load calculations related to edge-metal flashing systems for buildings with roof slopes of

Wind Design for Roof Systems

Design Wind Loads

ASCE 7-05 specifies wind design procedures for buildings and organizes them into two categories: main wind force-resisting systems, and component and cladding elements. Main wind force-resisting systems are the structural elements assigned to provide the support and stability for the overall building. Components and

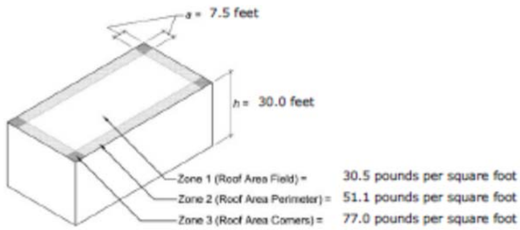
For the roof area described by this report, the design wind loads determined using ASCE 7-05, Method 1—Simplified Method, are as follows:

Zone 1 (roof area field):	30.5 pounds per square foot
Zone 2 (roof area perimeter):	51.1 pounds per square foot
Zone 3 (roof area corners):	77.0 pounds per square foot

Also, the calculated "a" dimension is as follows:

a = 7.5 feet

Graphically, these values are depicted as follows:



and construction of the building, including the roof system, and any normally anticipated deterioration of the materials' physical properties because of aging.
The equation to determine required design uplift-resistance capacity is:

Design uplift-resistance capacity = Design wind load x Safety factor

For membrane roof systems, Roof Wind Designer determines roof systems' minimum recommended design uplift-resistance capacities, using a safety factor defined in ASTM D6630, "Standard Guide for Low Slope Insulated Roof Membrane Assembly Performance." This recognized consensus standard indicates design uplift-resistance loads shall have a minimum 2.0 safety factor from the design wind uplift loads determined using ASCE 7.

Honolulu Country Club - Page 3 of 9

107

Back to the fundamental premise

Wind resistance ≥ Design wind load

FM 1-60 ≥ 30.5 psf

or

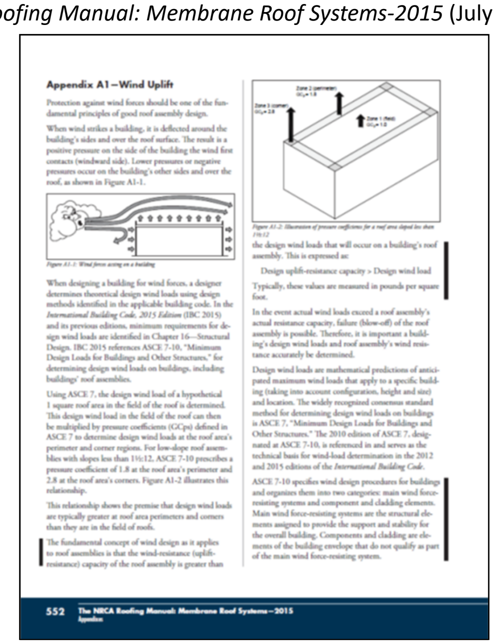
UL Class 60

108

109

Additional references

The NRCA Roofing Manual: Membrane Roof Systems-2015 (July 2016 Update)



Appendix A1—Wind Uplift

Protection against wind forces should be one of the fundamental principles of good roof assembly design.

When wind strikes a building, it is deflected around the building's sides and over the roof surface. The result is a positive pressure on the side of the building the wind first contacts (windward side). Lower pressures or negative pressures occur on the building's other sides and over the roof, as shown in Figure A1-1.

Figure A1-1: Wind forces acting on a building

When designing a building for wind forces, a designer determines theoretical design wind loads using design methods identified in the applicable building code. In the *International Building Code, 2015 Edition* (IBC 2015) and its previous editions, minimum requirements for design wind loads are identified in Chapter 16—Structural Design. IBC 2015 references ASCE 7-10, "Minimum Design Loads for Buildings and Other Structures," for determining design wind loads on buildings, including buildings' roof assemblies.

Using ASCE 7, the design wind load of a hypothetical 1 square roof area in the field of the roof is determined. This design wind load in the field of the roof can then be multiplied by pressure coefficients (GCps) defined in ASCE 7 to determine design wind loads at the roof area's perimeter and corner regions. For low-slope roof assemblies with slopes less than 1½:12, ASCE 7-10 prescribes a pressure coefficient of 1.8 at the roof area's perimeter and 2.8 at the roof area's corners. Figure A1-2 illustrates this relationship.

This relationship shows the premise that design wind loads are typically greater at roof area perimeters and corners than they are in the field of roofs.

The fundamental concept of wind design as it applies to roof assemblies is that the wind-resistance (uplift-resistance) capacity of the roof assembly is greater than the design wind loads that will occur on a building's roof assembly. This is expressed as:

Design uplift-resistance capacity > Design wind load

Typically, these values are measured in pounds per square foot.

Figure A1-2: Illustration of pressure coefficients for a roof area sloped less than 1½:12

In the event actual wind loads exceed a roof assembly's actual resistance capacity, failure (blow-off) of the roof assembly is possible. Therefore, it is important a building's design wind loads and roof assembly's wind resistance accurately be determined.

Design wind loads are mathematical predictions of anticipated maximum wind loads that apply to a specific building (taking into account configuration, height and size) and location. The widely recognized consensus standard method for determining design wind loads on buildings is ASCE 7, "Minimum Design Loads for Buildings and Other Structures." The 2010 edition of ASCE 7, designated at ASCE 7-10, is referenced in and serves as the technical basis for wind-load determination in the 2012 and 2015 editions of the *International Building Code*.

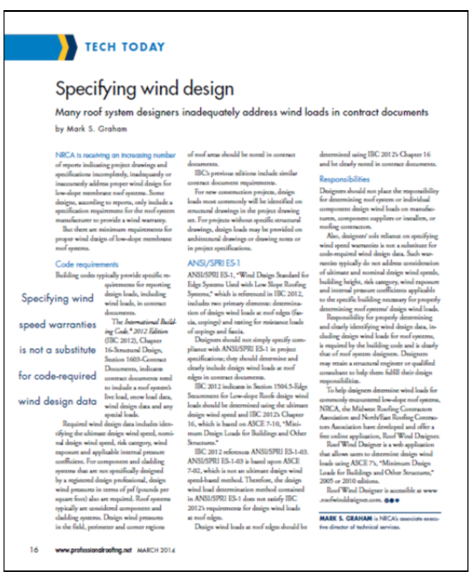
ASCE 7-10 specifies wind design procedures for buildings and organizes them into two categories: main wind force-resisting systems and component and cladding elements. Main wind force-resisting systems are the structural elements assigned to provide the support and stability for the overall building. Components and cladding are elements of the building envelope that do not qualify as part of the main wind force-resisting system.

552 **The NRCA Roofing Manual: Membrane Roof Systems—2015**

110

Wind warrantees

111



Professional Roofing

March 2014

112

ANSI/SPRI ES-1

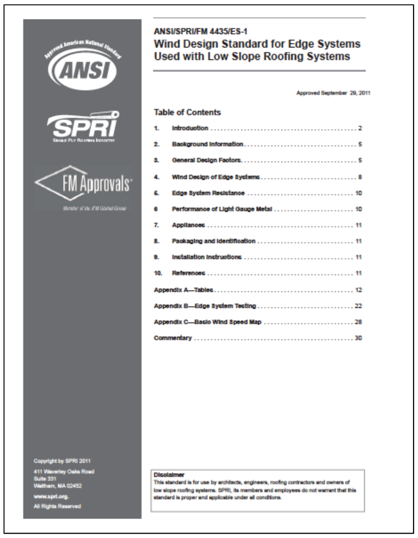
113

Sec. 1504-Performance Requirements

International Building Code, 2012 Edition

1504.5 Edge securement for low-slope roofs. Low-slope built-up, modified bitumen and single-ply roof system metal edge securement, except gutters, shall be designed and installed for wind loads in accordance with Chapter 16 and tested for resistance in accordance with Test Methods RE-1, RE-2 and RE-3 of ANSI/SPRI ES-1, except V_{ult} wind speed shall be determined from Figure 1609A, 1609B, or 1609C as applicable.

ANSI/SPRI/FM 4435/ES-1, 2011 Edition



ANSI/SPRI/FM 4435/ES-1
Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems

Approved September 29, 2011

Table of Contents

Disclaimer
This standard is for use by architects, engineers, roofing contractors and owners of low slope roofing systems. SPRI, its members and employees do not warrant that this standard is proper and applicable under all conditions.

- Design wind loads
- Tested resistance:
  - RE-1
  - RE-2
  - RE-3
- Prescriptive requirements
- Appendixes
- Commentary

115

Tested resistance

ANSI/SPRI FM 4435/ES-1, 2011 Edition

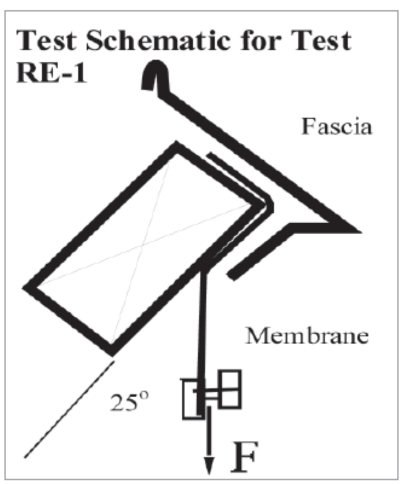


Figure RE1.1

116

Tested resistance

ANSI/SPRI FM 4435/ES-1, 2011 Edition

Fascia Blow-Off Test Set Schematic

(Force at Failure x Face Area = Blowoff Resistnace)

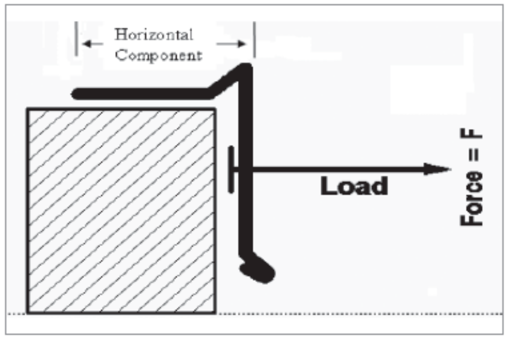


Figure RE2.1

117

Tested resistance

ANSI/SPRI FM 4435/ES-1, 2011 Edition

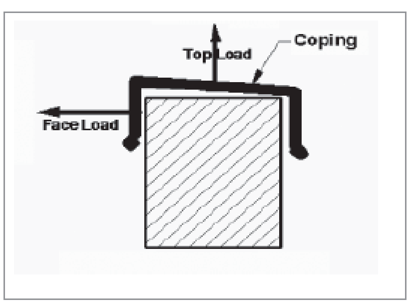


Figure RE3.1
RE3 Test—Face Leg Pull

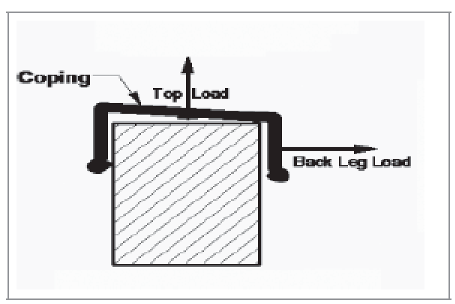


Figure RE3.2
RE3 Test—Back Leg Pull

118

Wind Load Design for Perimeter Edge Metal

The International Building Code references standard ANSI/SPRI ES-1, "Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems." This code requirement is applicable to roof slopes less than 2:12. Because a roof slope of 1½:12 was selected for this project, this report also contains design load calculations related to edge-metal system design.

ANSI/SPRI ES-1 includes two primary elements: determination of design wind loads at roof edges (perimeter edge metal) and testing for resistance loads of perimeter edge metal. However, IBC does not adopt ANSI/SPRI ES-1 in its entirety. It requires low-slope metal edge securement be designed and installed using IBC's Chapter 16—Structural Design and tested for resistance in accordance with ANSI/SPRI ES-1's Test RE-1, "Test Method for Dependently Terminated Roof Membrane Systems," RE-2, "Test Method for Dependently or Independently Terminated Edge Systems," and Test RE-3, "Test for Copings," as applicable.

The fundamental concept of wind design as it applies to perimeter edge-metal systems is that the tested wind-resistance (uplift-resistance) capacity of perimeter edge-metal system should be greater than or equal to the design resistance loads that will act upon the perimeter edge-metal system. Design wind-resistance loads are derived from a building's design wind loads, taking into consideration an appropriate safety factor. Roof Wind Designer determines roof systems' minimum recommended design wind-resistance loads. Using these minimum recommended design wind-resistance loads, users can select appropriate wind resistance perimeter edge-metal systems.

Wind-resistance capacities of edge-metal flashing systems are determined by testing in accordance with the test methods in ANSI/SPRI ES-1. Once design wind loads and minimum recommended design wind-resistance capacities (including a safety factor) for an edge-metal flashing system are determined, designers can select appropriate wind-resistant edge-metal flashing systems that have tested capacities equal to or greater than the minimum recommended design wind resistances.

Design Wind Loads Using ASCE 7

IBC Chapter 16—Structural Design of IBC uses ASCE 7 as the basis for determining design wind loads; therefore, NRCA recommends using ASCE 7 for design wind load calculations instead of ANSI/SPRI ES-1.

ASCE 7 identifies a vertical surface as a "roof zone" and a horizontal surface as a "wall zone." As previously mentioned, Zones 1 through 3 are associated with roof areas. For wall areas, ASCE 7-05 identifies two primary areas of differing horizontal wind loads: perimeter and corners. These areas are designated as Zones 4 and 5, respectively. The dimension that defines the distance of the perimeter and corner zones is the same distance "a" used with defining Zones 1 through 3 for roof areas.

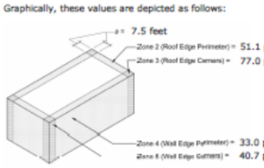
For the zones defined by this report, the design wind loads determined using ASCE 7-05, Method 1—Simplified Method, are as follows:

Zone 2 (roof edge perimeter, vertical load direction):	51.1 pounds per square foot
Zone 3 (roof edge corners, vertical load direction):	77.0 pounds per square foot
Zone 4 (wall edge perimeter, horizontal load direction):	33.0 pounds per square foot
Zone 5 (wall edge corners, horizontal load direction):	40.7 pounds per square foot

Also, the calculated "a" dimension is as follows:

a = 7.5 feet

Graphically, these values are depicted as follows:



Minimum Recommended Design Wind-resistance Capacities

NRCA recommends designers include an appropriate safety factor in their design wind-resistance calculations for perimeter edge-metal flashings. NRCA suggests a minimum safety factor of 2.0 be applied to steel or aluminum edge-metal flashings. This is consistent with the minimum safety factor recommended in ANSI/SPRI ES-1's design wind load calculations section.

The equation to determine required design wind-resistance load is:

Design wind-resistance capacity = [Design wind load] x [Safety factor of 2.0]

Taking into consideration the design wind-uplift loads, the minimum recommended design wind-resistance loads for the specific roof and wall areas described in this report are as follows:

Zone 2 (roof edge perimeter, vertical load direction):	102.2 pounds per square foot
Zone 3 (roof edge corners, vertical load direction):	154.0 pounds per square foot
Zone 4 (wall edge perimeter, horizontal load direction):	66.1 pounds per square foot
Zone 5 (wall edge corners, horizontal load direction):	81.5 pounds per square foot

Tested Resistance Load Capacities of Perimeter Edge Metal

Using the minimum recommended design wind-resistance values, a user can select an appropriately wind-resistant perimeter edge metal. The tested wind-resistance load capacity—commonly referred to as "load capacity"—of the perimeter edge metal should be greater than the minimum recommended design wind-resistance capacities for the perimeter edge-metal system to be considered appropriately wind-resistant.

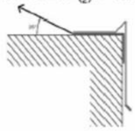
Tested wind-resistance capacities of edge-metal flashing systems are determined by testing. IBC requires the testing be done in accordance with the RE-1, RE-2 and RE-3 test methods contained in ANSI/SPRI ES-1 as applicable to the specific roof perimeter edge metal configuration. These three test methods are:

- Test RE-1, "Test Method for Dependently Terminated Roof Membrane Systems."
- Test RE-2, "Test Method for Dependently or Independently Terminated Edge Systems."
- Test RE-3, "Test for Copings."

The following images illustrate how to apply the design wind-resistance capacities (including a safety factor) for fascia, embedded edge metal and copings based on RE-1, RE-2 and RE-3:

Force at Perimeter = $\left(\frac{r}{2}\right) \times$ 242.2 pounds per square foot

Force at Corners = $\left(\frac{r}{2}\right) \times$ 365.0 pounds per square foot



where:

r = horizontal distance to first row of fasteners from edge of roof system

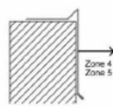
or

r = 6 feet, for ballasted roof systems

RE-1, "Test Method for Dependently Terminated Roof Membrane Systems."

Note: The resultant forces indicated on the figure need to be further adjusted, depending on row spacing of the membrane fasteners or if the roof system is ballasted.

RE-1 tests an edge metal system's ability to restrain a membrane force from billowing. This test method is only applicable to ballasted and mechanically attached membrane systems that do not contain a "peel stop" within 12 inches of the roof edge. RE-1 is not applicable to adhered roof membranes.

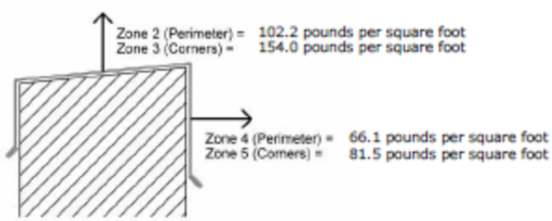


RE-2, "Test Method for Dependently or Independently Terminated Roof Membrane Systems."

RE-2 tests resistances to horizontal (outward from building face) loads for gravel stops or fascias.

Honolulu Country Club - Page 7 of 9

121



RE-3, "Test for Copings."

RE-3 tests copings' resistances to outward (horizontal) and upward (vertical) pressures.

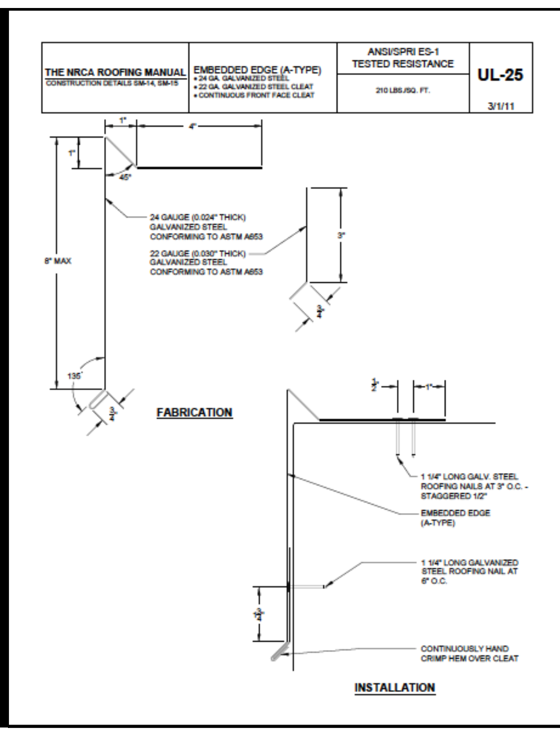
Honolulu Country Club - Page 8 of 9

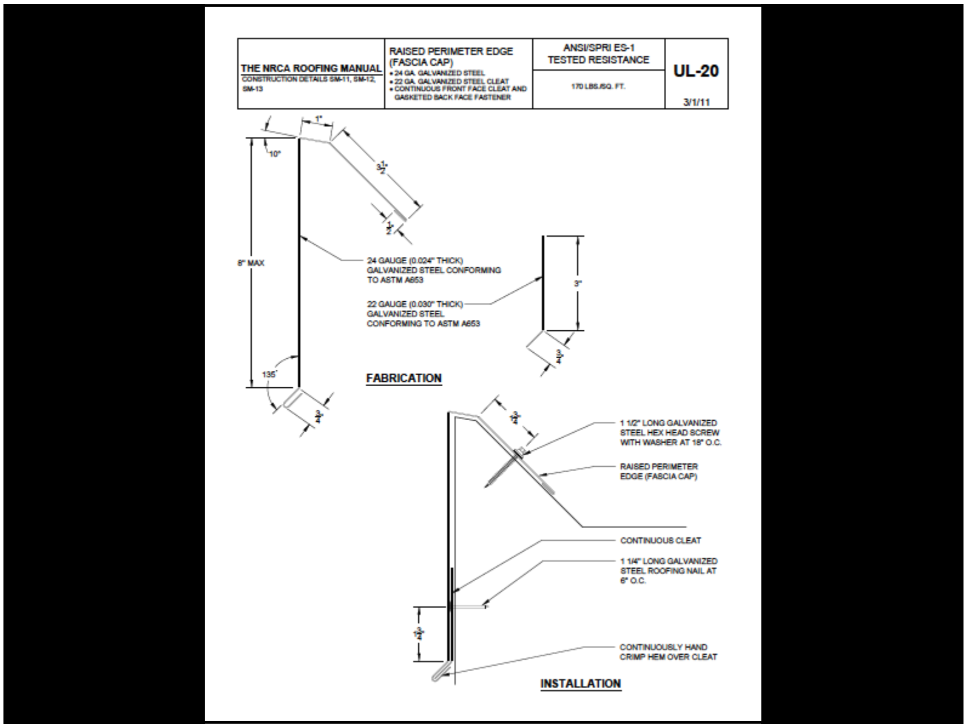
122

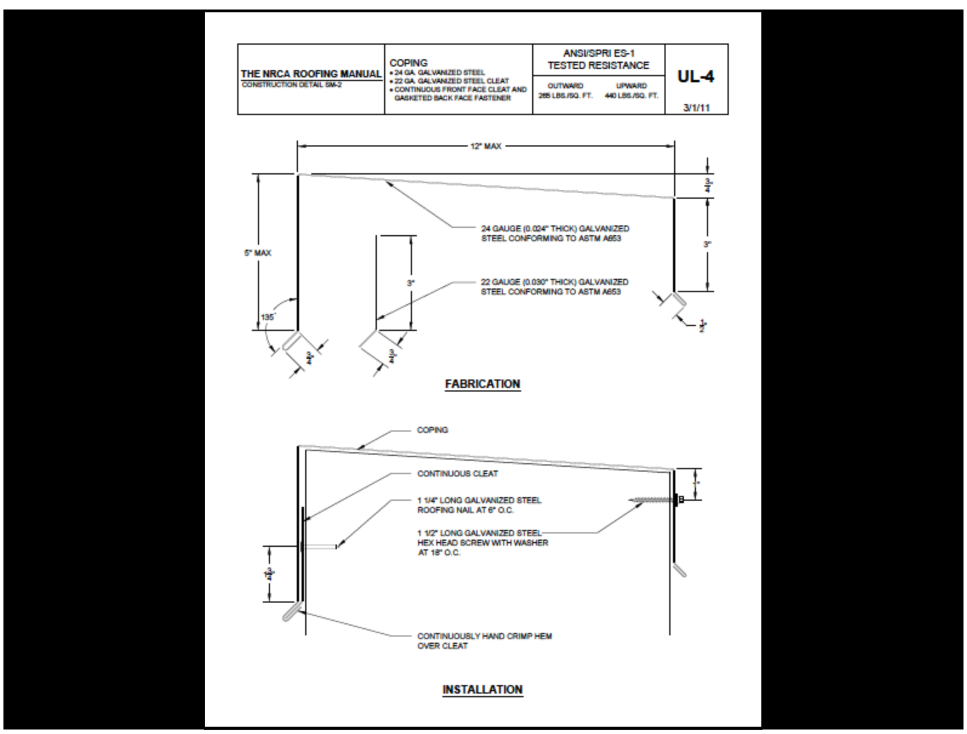
NRCA's shop-fabricated edge metal testing

www.nrca.net

123




THE NRCA ROOFING MANUAL
CONSTRUCTION DETAILS SM-11, SM-12, SM-13
RAISED PERIMETER EDGE (FASCIA CAP)
• 24 GA. GALVANIZED STEEL
• 22 GA. GALVANIZED STEEL CLEAT
• CONTINUOUS FRONT FACE CLEAT AND GASKETED BACK FACE FASTENER
ANSI/SPRI ES-1 TESTED RESISTANCE
170 LBS./SQ. FT.
UL-20
3/1/11
1"
10°
8" MAX
135°
24 GAUGE (0.024" THICK) GALVANIZED STEEL CONFORMING TO ASTM A653
22 GAUGE (0.030" THICK) GALVANIZED STEEL CONFORMING TO ASTM A653
3"
FABRICATION
1 1/2" LONG GALVANIZED STEEL HEX HEAD SCREW WITH WASHER AT 18" O.C.
RAISED PERIMETER EDGE (FASCIA CAP)
CONTINUOUS CLEAT
1 1/4" LONG GALVANIZED STEEL ROOFING NAIL AT 6" O.C.
CONTINUOUSLY HAND CRIMP HEM OVER CLEAT
INSTALLATION


THE NRCA ROOFING MANUAL
CONSTRUCTION DETAIL SM-2
COPING
• 24 GA. GALVANIZED STEEL
• 22 GA. GALVANIZED STEEL CLEAT
• CONTINUOUS FRONT FACE CLEAT AND GASKETED BACK FACE FASTENER
ANSI/SPRI ES-1 TESTED RESISTANCE
OUTWARD 265 LBS./SQ. FT.
UPWARD 440 LBS./SQ. FT.
UL-4
3/1/11
12" MAX
5" MAX
135°
3"
24 GAUGE (0.024" THICK) GALVANIZED STEEL CONFORMING TO ASTM A653
22 GAUGE (0.030" THICK) GALVANIZED STEEL CONFORMING TO ASTM A653
FABRICATION
COPING
CONTINUOUS CLEAT
1 1/4" LONG GALVANIZED STEEL ROOFING NAIL AT 6" O.C.
1 1/2" LONG GALVANIZED STEEL HEX HEAD SCREW WITH WASHER AT 18" O.C.
CONTINUOUSLY HAND CRIMP HEM OVER CLEAT
INSTALLATION

NRCA's shop-fabricated edge metal testing

- NRCA has third-party certifications:
  - UL
  - Intertek Testing Services, N.A.
- Contractors included in NRCA's third-party certification program are listed on NRCA's website: www.nrca.net
- If interested, contact me for more information.

127

Hawaii contractors

Included in NRCA's UL ANSI/SPRI ES-1 certification

Hi-Tec Roofing Inc.

Honolulu, Hawaii

128

Technical issues

129


2

All of these are problems relating to moisture in concrete roof decks…

Concrete mix design

- Aggregate:
  - Large aggregate
  - Fine (small) aggregate
- Portland cement
- Water
- Admixtures:
  - Fly ash
  - Air entrainment
  - Curing compounds
  - Etc.

Concrete Aggregates

60-80% of Concrete Mix Design

- Normal-weight aggregates (stone):
  - Dense
  - Absorb about 2% by weight
- Light-weight aggregates (expanded shale):
  - Porous
  - Absorbs from 5 - 25% by weight

Lightweight structural concrete inherently contains more moisture

When is it OK to roof?

Historical guidelines

- After 28 days
- Application of hot bitumen
- Plastic film test
  - ASTM D4263, "Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method"

These are not appropriate for current generations of concrete mixes

Concrete Floors and Moisture, 2nd Edition

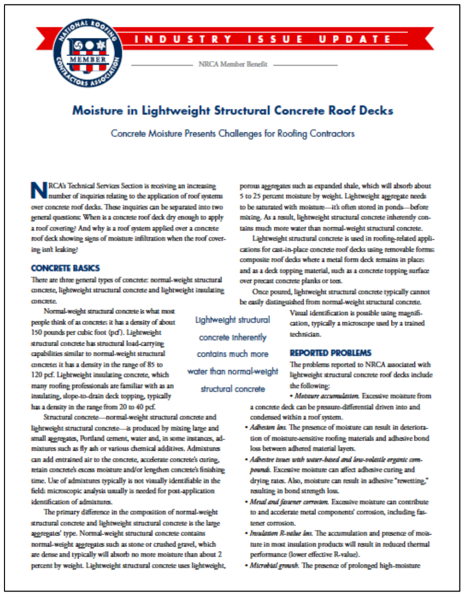
Howard M. Kanare, CTL Group

75% internal RH can be achieved:

- Normal weight structural concrete
  - Less than 90 days
- Lightweight structural concrete
  - Almost 6 months

These values are based upon "protected" concrete, without re-wetting

NRCA Industry Issue Update, August 2013



INDUSTRY ISSUE UPDATE

NRCA Member Benefit

Moisture in Lightweight Structural Concrete Roof Decks

Concrete Moisture Presents Challenges for Roofing Contractors

NRCA's Technical Services Section is receiving an increasing number of inquiries relating to the application of roof systems over concrete roof decks. These inquiries can be separated into two general questions: When is a concrete roof deck dry enough to apply a roof covering? And why is a roof system applied over a concrete roof deck showing signs of moisture infiltration when the roof covering isn't leaking?

CONCRETE BASICS

There are three general types of concrete: normal-weight structural concrete, lightweight structural concrete and lightweight insulating concrete.

Normal-weight structural concrete is what most people think of as concrete; it has a density of about 150 pounds per cubic foot (pcf). Lightweight structural concrete has structural load-carrying capabilities similar to normal-weight structural concretes it has a density in the range of 85 to 120 pcf. Lightweight insulating concrete, which many roofing professionals are familiar with as an insulating, slope-to-drain deck topping, typically has a density in the range from 20 to 40 pcf.

Structural concrete—normal-weight structural concrete and lightweight structural concrete—is produced by mixing large and small aggregates, Portland cement, water and, in some instances, admixtures such as fly ash or various chemical additives. Admixtures can add entrained air to the concrete, accelerate concrete's curing, retain concrete's excess moisture and/or lengthen concrete's finishing time. Use of admixtures typically is not visually identifiable in the field; microscopic analysis usually is needed for post-application identification of admixtures.

The primary difference in the composition of normal-weight structural concrete and lightweight structural concrete is the large aggregates' type. Normal-weight structural concrete contains normal-weight aggregates such as stone or crushed gravel, which are dense and typically will absorb no more moisture than about 2 percent by weight. Lightweight structural concrete uses lightweight, porous aggregates such as expanded shale, which will absorb about 5 to 25 percent moisture by weight. Lightweight aggregate needs to be saturated with moisture—it's often stored in ponds—before mixing. As a result, lightweight structural concrete inherently contains much more water than normal-weight structural concrete.

Lightweight structural concrete is used in roofing-related applications for cast-in-place concrete roof decks using removable forms; composite roof decks where a metal form deck remains in place; and as a deck topping material, such as a concrete topping surface over precast concrete planks or tees.

Once poured, lightweight structural concrete typically cannot be easily distinguished from normal-weight structural concrete. Visual identification is possible using magnification, typically a microscope used by a trained technician.

Lightweight structural concrete inherently contains much more water than normal-weight structural concrete

REPORTED PROBLEMS

The problems reported to NRCA associated with lightweight structural concrete roof decks include the following:

- *Moisture accumulation.* Excessive moisture from a concrete deck can be pressure-differential driven into and condensed within a roof system.
- *Adhesion loss.* The presence of moisture can result in deterioration of moisture-sensitive roofing materials and adhesive bond loss between adhered material layers.
- *Adhesive issues with water-based and low-volatile organic compounds.* Excessive moisture can affect adhesive curing and drying rates. Also, moisture can result in adhesive "rewetting," resulting in bond strength loss.
- *Metal and fastener corrosion.* Excessive moisture can contribute to and accelerate metal components' corrosion, including fastener corrosion.
- *Insulation R-value loss.* The accumulation and presence of moisture in most insulation products will result in reduced thermal performance (lower effective R-value).
- *Microbial growth.* The presence of prolonged high-moisture

Moisture on concrete roof decks

Professional Roofing,
Sept. 2017

140

"Fully" adhered

TECH TODAY

The fully adhered misnomer

Terminology can create unrealistic expectations within the roofing industry

by Mark S. Graham

The term "fully adhered" is used by some manufacturers and specifiers to identify adhered single-ply membrane roof system configurations or refer to the adhesion of rigid board insulation to underlying substrates. But this terminology can create application and performance expectations that are unrealistic and likely cannot be achieved.

NRCA recommends the term "fully adhered" be avoided

Definitions

When considering the term "fully adhered," it is important to realize it is not specifically defined by the U.S. roofing industry.

The industry's consensus-based terminology standard, ASTM D1079, "Standard Terminology Relating to Roofing and Waterproofing," does not include terms or definitions for fully adhered, adhered or adhesion.

Similarly, the glossary contained in the appendix of *The NRCA Roofing Manual: Architectural Metal Flashing, Condensation and Air Leakage Control, and Reroofing—2014* does not contain a specific definition for the term fully adhered. The manual defines "adhere" as: "To cause two surfaces to be held together by the combined strength of the molecular forces and the mechanical interlocking achieved between adhesive and the bonded surface … ."

Merriam-Webster defines adhere (and its derivatives adhered and adhering) as "to hold fast or stick by or as if by gluing, suction, grasping, or fusing." Similarly, the term "fully" is defined as "in a full manner or degree: completely."

Although not specifically defined, the implication of fully adhered is 100 percent adhesion between two surfaces or materials.

Realistic expectations

Experienced roofing industry professionals realize the expectation of complete adhesion between two surfaces such as a single-ply membrane and underlying rigid board insulation is unrealistic and likely cannot be achieved in field applications.

Taken at its most literal sense, complete adhesion between a single-ply membrane and a rigid board insulation substrate is impossible because there will not be membrane adhesion at the insulation boards' joints.

Also, thickness variability in insulation boards and its effect on adhesion needs to be considered. For example, the U.S. product standard for polyisocyanurate insulation, ASTM C1289, "Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board," permits a board thickness tolerance of ±¹⁄₁₆-inch and crushing and depressions up to ¼ of an inch in depth on up to 10 percent of a polyisocyanurate insulation board's surface area. Because reinforced single-ply membranes tend to lay relatively flat, having an adhered membrane application readily conform to and remain completely adhered to the recognized irregularities in insulation boards is unlikely.

Irregular, nonsmooth roof deck surfaces create similar situations. Because board-type insulation is relatively rigid, it generally will not readily conform to irregularities in roof deck substrates. Individual rigid boards tend to rest on the high points in a roof deck's finished surface and span the low points.

As a result, rigid board insulation seldom is completely adhered to roof deck substrates. It generally is adhered at the relative high points in the roof deck's surface and may be partially or marginally adhered and even unadhered at the relative low points. Specifying smaller insulation board sizes (4 by 4 feet instead of 4 by 8 feet) generally is suggested to minimize rigid insulation boards from spanning substrate low-point irregularities.

In practice

The concept of lacking 100 percent, complete adhesion between two adhered surfaces is not new to the roofing industry; it has long been recognized in the application of built-up roof membranes where voids between plies can occur. To address this, NRCA's *Quality Control Guidelines for the Application of Built-up Roofing* indicates interply moppings are intended to be continuous; however, voids of limited size are permitted provided overlapping voids do not occur between two or more plies. NRCA has maintained this position since the late 1970s, and it has become well-accepted by the roofing industry.

As it applies to adhering rigid board insulation in continuously applied adhesive applications, actual adhesion rates of about 60 to 90 percent are common (even less in some specific instances) in successfully performing adhered roof systems.

On this basis, NRCA recommends the term "fully adhered" be avoided and suggests the term "adhered" for field applications because it is more realistic.

MARK S. GRAHAM is NRCA's vice president of technical services.

12 www.professionalroofing.net JANUARY 2017

Professional Roofing,
January 2017

141

Polyisocyanurate insulation

Knit line, thickness and dimensional stability concerns

Professional Roofing
February 2016
www.professionalroofing.net

Knit lines

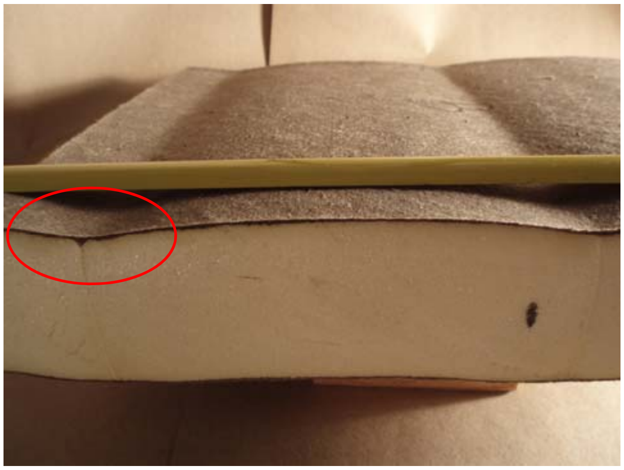
Knit lines -- continued

Photo from manufacturer's product literature

Thickness and knit lines

As delivered by manufacturer.

Knit lines -- continued



After conditioning: 158 ± 4 F and 97 ± 3% RH for 7 days

"NRCA recommends the use of a suitable cover board layer over polyisocyanurate insulation before the installation of roof membrane."

-The NRCA Roofing Manual: Membrane Roof Systems-2015

Additional interim recommendations

Polyiso. knit line, thickness and dimensional stability concerns

- Measure polyiso. thickness upon delivery
- Look for knit lines and board unevenness
- Contact manufacturer and NRCA if you see any issues

Thickness variations in polyio. insulation

RESEARCH+TECH

Not quite measuring up

Polyisocyanurate insulation thicknesses seem to vary

by Mark S. Graham

NRCA has received a limited number of reports of faced, rigid board polyisocyanurate insulation with thicknesses less than what was specified and indicated on the insulation's package labeling being delivered from manufacturers to distributors and job sites. Following is information about those reports, as well as information about recognized allowable thickness tolerances and NRCA's recommendations to roofing contractors for monitoring this situation.

Reports

NRCA has received reports of new, uninstalled polyisocyanurate insulation being received directly from polyisocyanurate insulation manufacturers with thicknesses notably less than nominal dimensions. Reports have been received from the East Coast to the Rocky Mountains and as far north as Wisconsin and south to Texas.

Reports have been received about various specified nominal thicknesses of polyisocyanurate insulation; however, the problems appear to be more common with thicker polyisocyanurate insulation products than thinner ones. For example, NRCA has received multiple reports of 3½-inch nominal thickness polyisocyanurate insulation measuring

24 www.professionalroofing.net JULY 2017

Professional Roofing,
July 2017

Thickness variations

Polyisocyanurate insulation

- Measured thicknesses notably less than nominal
- Reports from throughout the U.S.
- More common with thicker product
  - For example, 3.5 inch (nominal) measures less than 3¼-inch thick
- Most reports specific to one manufacturer
  - Multiple plants from the one manufacturer
  - Limited reports from other manufacturers

3.5 inch (nominal)

2.0 inch (nominal)

Allowable tolerances

ASTM C1289 (Polyisocyanurate insulation)

8. Dimensions

8.1 *Dimensional Tolerances*—The length and width tolerances shall not exceed ±¼ in. (6.4 mm), the thickness tolerance shall not exceed ⅛ in. (3.2 mm), and the thickness of any two boards shall not differ more than ⅛ in. (3.2 mm) when measured in accordance with Test Method C303.

8.3 *Edge Trueness in the x/y Direction*—Unless otherwise specified, the thermal insulation board shall be furnished with straight edges and edges shall not deviate more than 1/32 in./ft (2.6 mm/m) when examined in accordance with Practice C550.

8.4 *Shiplap Edges*—When specified, the insulation board shall be fabricated with shiplap edges along its longest dimensions.

8.4.1 The nominal depth of each shiplap shall be the sum of its thickest facer dimension plus one half the thickness of its core foam dimension.

8.4.2 For boards 2 in. (50.8 mm) or greater in nominal thickness, the width of the shiplap shall be 1 in. (25.4 mm). For boards less than 2 in. (50.8 mm) in thickness, the nominal width of the shiplap shall be one half the thickness of the faced board product.

8.5 *Face Trueness*—The thermal insulation boards shall not depart from absolute flatness more than ⅛ in./ft (10 mm/m) of length or width when examined in accordance with Practice C550.

8.6 *Available Sizes*—The thermal insulation boards are normally supplied in sizes of 4 by 4 ft (1.22 by 1.22 m), and 4 by 8 ft (1.22 by 2.44 m) for use in roofing applications. For sheathing applications the thermal insulation boards are normally supplied in sizes of 4 by 8 ft (1.22 by 2.44 m), 4 by 9 ft

8.7 *Crushings and Depressions*—The thermal insulation boards shall have no crushed or depressed areas on any surface exceeding ⅛ in. (3.2 mm) in depth on more than 10 % of the total surface area.

The issues…

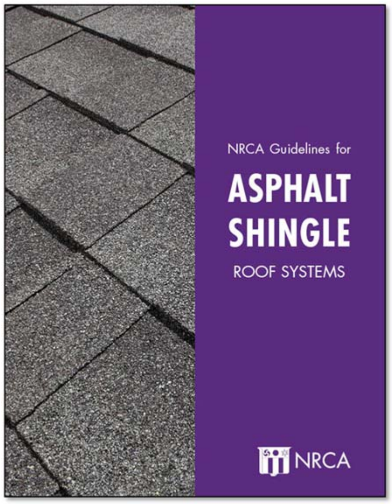
Thickness variations in polyiso. insulation

- Most physical properties are thickness related
- R-value loss:
  - R-value decreases about 0.7 per ⅛-inch thickness loss (assuming an LTTR of 5.6 per inch)
- Insulation thickness does not match established wood blocking heights

NRCA's recommendations

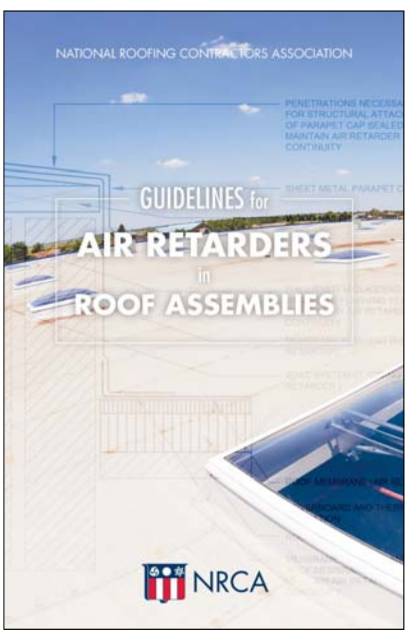
Thickness variations in polyio. insulation

- Distributors and contractors should measure board edge thicknesses upon delivery, preferably while the insulation still is on the truck
- Contact the manufacturer or distributor if thicknesses are less (or more) than specified
- Also contact NRCA Technical Services



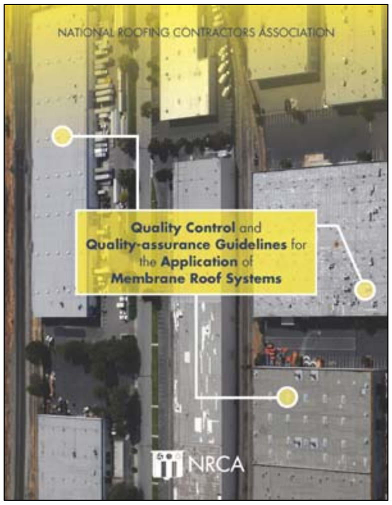
Link

NRCA Guidelines for Asphalt Shingle Roof Systems

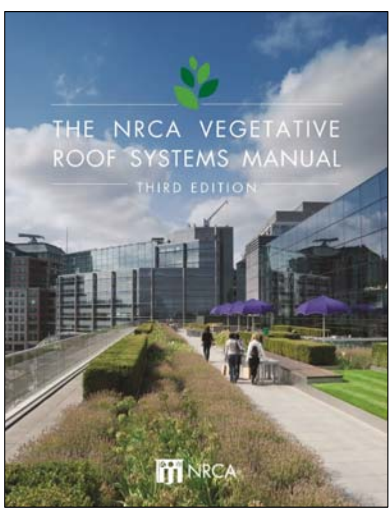


Guidelines for Air Retarders in Roof Assemblies

- Ch. 1: IECC and ASHRAE
- Ch. 2: Industry research
- Ch. 3: Recommendations



Quality Control and Quality-assurance Guidelines for the Application of Membrane Roof Systems



The NRCA Vegetative Roof Systems Manual

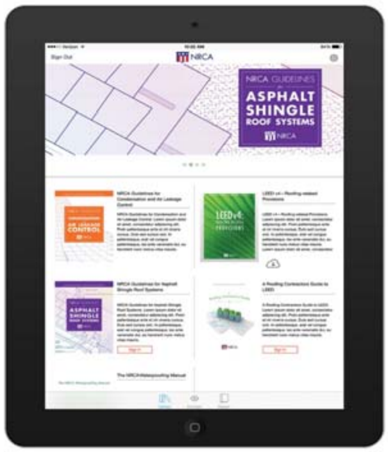
The NRCA Roofing Manual - 2017

Manual online

www.nrca.net

- Available to all NRCA member registered users (multiple users per member company)
- “Members only” section, click on “My account”, the “Electronic file”
- View, download and print

NRCA App



- NRCA App available on the Apple Store and Google Play Store for tablets
- iPhone App also available
- Register within App as being an NRCA member
- The NRCA Roofing Manual is viewable to NRCA members
- Favorite and send pages features

NRCA

Mark S. Graham
Vice President, Technical Services
National Roofing Contractors Association
10255 West Higgins Road, 600
Rosemont, Illinois 60018-5607

(847) 299-9070
mgraham@nrca.net
www.nrca.net

Twitter: @MarkGrahamNRCA
Personal website: www.MarkGrahamNRCA.com