Wind Design: Roof and Flashing

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Wind Uplift Design

- ✓ All building envelope components must be designed to withstand the forces of wind.
- ✓ Proper design of the roof and perimeter flashing is often miss understood and not properly completed on many buildings.
- ✓ What can this lead to?

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Typical Media Photo

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Mt. Washington – Vancouver Island

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BC Place Stadium

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Warehouse in Surrey

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St. Paul's Hospital

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Maurice Richard Arena - Montreal

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Apartment Building North of Sydney

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Typical Wind Failure

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Typical Wind Failure

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Wind Uplift Performance

- ✓ Proper construction to withstand wind uplift forces is still not fully understood within the industry
- ✓ A roof can fail through the forces of the wind acting on the roof membrane surface.
- ✓ Many of the roof membranes we use today can withstand the forces of wind within BC fairly easily if designed properly.
- ✓ A typical detail that is overlooked when designing a roof is the perimeter flashing attachment.

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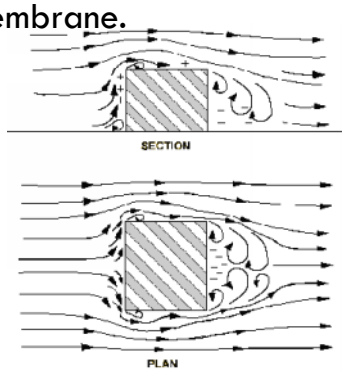
Wind Uplift Performance

✓ Improperly secured perimeter flashing is the leading cause of roof failures through wind uplift.

✓ Once the flashings are bent or torn off the wind can act directly on the edge of the membrane.



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Wind Uplift Performance

✓ So how do the codes deal with this?

- Part 5 – Environmental Separation
  - Construction conforming to a design that resists the loads of wind up-lift imposed on roofing and associated components.
- Schedule B
  - 1.18 Roofing and Flashings
  - 1.22 Integration of BE components
  - 1.06 Structural Capacity of Architectural Components?

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Wind Uplift Performance

- ✓ Section 4.1.7 of the BCBC provides direction on calculations to be completed and refers to the NBC 2005 Structural Commentary
- ✓ This calculation provides an unfactored wind uplift design pressure for the Corner, Perimeter, and Field
- ✓ Some of the factors often overlooked:
  - Are there overhangs?
  - Wind and door sizes and openings
  - Tributary area

Wind Uplift Performance

- ✓ The calculation within the BCBC is based on wind data taken from weather stations across the country
- ✓ The reference wind speeds / velocity pressures is based on an averaged hour.

FM, What is FM?

- ✓ FM Global, formally Factory Mutual, is an international full building insurance company.
- ✓ Due to a number of insurable claims, FM took it upon themselves to develop requirements that must be met for them to be able to insure a building. These requirements are based on claims made as well as testing of actual assemblies.
- ✓ This is a voluntary requirement and is not codified.

FM 1-90 or 1-60 Ratings

✓ So what does it mean when you spec a roof to meet FM 1-90?

- The prefix 1 means that the roof system has passed the FM requirement for Calorimeter Testing. (Fire Resistance Testing)
- The second number is the field uplift pressure.
- The Canadian method of determining uplift pressures is different and cannot be used to determine the design pressure for use with FM systems.

FM 1-90 or 1-60 Ratings

✓ A Roof System that has a FM 1-90 rating means that the roof membrane assembly is rated at 90 psf.

✓ Assembly includes:

- Membrane
- Insulation
- Air / Vapour barrier
- Overlay boards
- Substrate

Wind Uplift Performance

✓ The calculation within the FM requirements is based on wind data taken from weather stations across the USA

✓ The reference wind speeds / velocity pressures is based on a 3 second gust rather than an averaged hour.

FMG Requirements

✓ To determine what FM rating is required for a particular project a calculation must be performed.

- https://roofnav.fmglobal.com

✓ By referencing the FM 1-90 requirement you may unintentionally specify something else like:

- Steel Deck Gauge
- Nailer Attachment
- Steel Weld Sizes and Patterns

FMG Requirements

✓ What does the Designer, Roofer, General Contractor, or Inspector need to know?

- By specifying these requirements you may unintentionally contradict another part of the project documents
- There is more to the requirements then just membrane selections and uplift ratings
- Something that is "buried" in the roofing specification may impact the forming contractor or steel welders
- Possible extra costs during construction?

CSA Standards for Wind Uplift?

- ✓ CSA standards are currently being developed to encompass all aspects of roofing.
- ✓ The CSA A123.21 Wind Uplift Standard is being completed in phases.
- ✓ This standard is different than American standards as in is based on dynamic pressure differential rather than static pressure.
- ✓ Currently the completed phase include:
  - mechanically attached roofing systems,
  - adhesively applied roofing systems.

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CSA A123.21 - 10

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Wind Uplift Performance

- ✓ There is currently no standard for the design of flashings for wind uplift in Canada.
- ✓ What Standards are in-place to aid with designing flashing components?
  - ANSI/SPRI ES-1 - http://www.spri.org/
  - FMG Data Sheet 1-49 - http://www.fmglobal.com/default.aspx
- ✓ Both documents are based on tested flashing assemblies
- ✓ The FM requirement is intended to only be used on FM insured buildings. It is not referenced in any building codes or industry standards and therefore is a voluntary standard.

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Wind Uplift Performance

- ✓ BCBC Appendix A
- ✓ A-5.6.2.1
  - Roof Flashings guidelines
    - Roofing Specifications, Canadian Roofing Contractors Association
    - Architectural Sheet Metal Manual – SMACNA
    - Roofing and Waterproofing Manual, National Roofing Contractors Association

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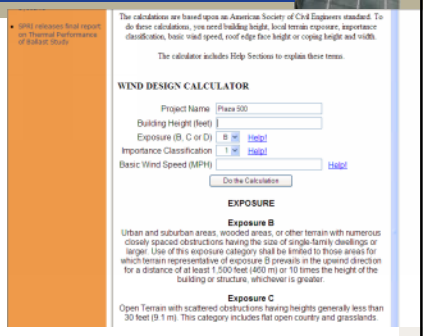
ANSI / SPRI ES-1 Calculation

PROJECT DATA

Project Name	Plaza 500
Building Height (feet)	190
Exposure (A, B, C or D)	B
Importance Classification	2
Basic Wind Speed (MPH)	90



RESULTS

Design pressure is the pressure that a product must be tested to withstand (using test method RE-2 or RE-3), measured in pounds per square foot.

Design Pressure Horizontal (outward pressure) 22 psf

Design Pressure Vertical (upward pressure) 57 psf

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ANSI / SPRI ES-1 Calculation

✓ Why can't I use the calculation in the Canadian Code?

- The Canadian code provides a calculation of surfaces of the building. On roofs it will provide an uplift pressure in the field, perimeter, and corners.
- This doesn't accurately depict the pressures on flashings as the forces are dynamically acting on the flashing from two different surfaces.

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ANSI / SPRI ES-1

- ✓ So what do these numbers mean?
  - Well these are un-factored design loads.
- ✓ What is the next step?
  - Have the project flashings tested.
- ✓ NRCA has several tested details which their accredited members can use for projects.

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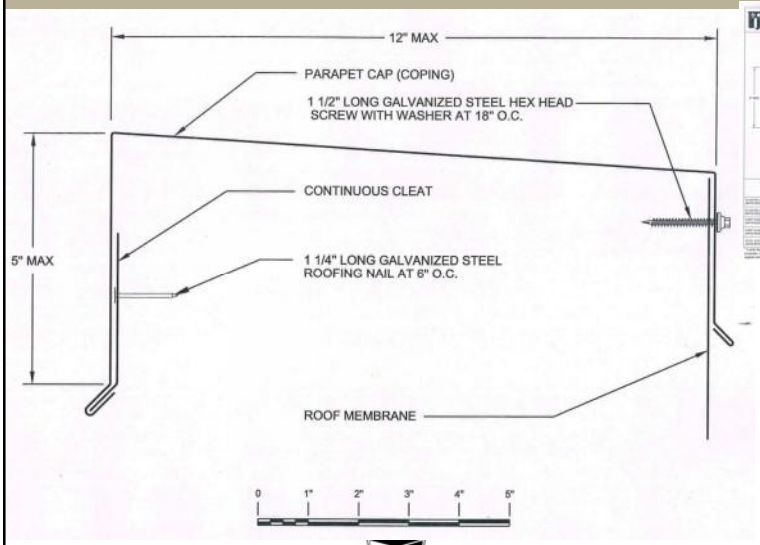
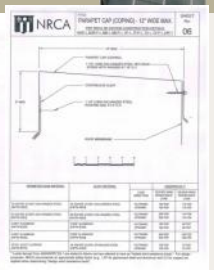
ANSI / SPRI ES-1 – NRCA Details





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ANSI / SPRI ES-1 – NRCA Details

PERIMETER EDGE MATERIAL	CLEAT MATERIAL		ANSI/SPRI ES-1*	
		LOAD DIRECTION	TESTED WIND RESISTANCE LOAD	DESIGN WIND RESISTANCE LOAD
24 GAUGE (0.024") GALVANIZED STEEL [ASTM A653]	22 GAUGE (0.030") GALVANIZED STEEL [ASTM A653]	OUTWARD UPWARD	190 PSF 190 PSF	114 PSF 114 PSF
22 GAUGE (0.030") GALVANIZED STEEL [ASTM A653]	20 GAUGE (0.036") GALVANIZED STEEL [ASTM A653]	OUTWARD UPWARD	290 PSF 290 PSF	174 PSF 174 PSF
0.040" ALUMINUM [ASTM B209]	0.040" ALUMINUM [ASTM B209]	OUTWARD UPWARD	160 PSF 160 PSF	96 PSF 96 PSF
0.050" ALUMINUM [ASTM B209]	0.050" ALUMINUM [ASTM B209]	OUTWARD UPWARD	300 PSF 300 PSF	180 PSF 180 PSF
20 OZ. (0.027") COPPER [ASTM B370]	24 GAUGE (0.024") STAINLESS STEEL [ASTM A240]	OUTWARD UPWARD	150 PSF 150 PSF	75 PSF 75 PSF

* Loads derived from ANSI/SPRI ES-1 are tested to failure and are referred to here as "tested wind resistance loads." For design purposes, NRCA recommends an appropriate safety factor (e.g., 1.67 for galvanized steel and aluminum and 2.0 for copper) be applied when determining "design wind resistance loads".

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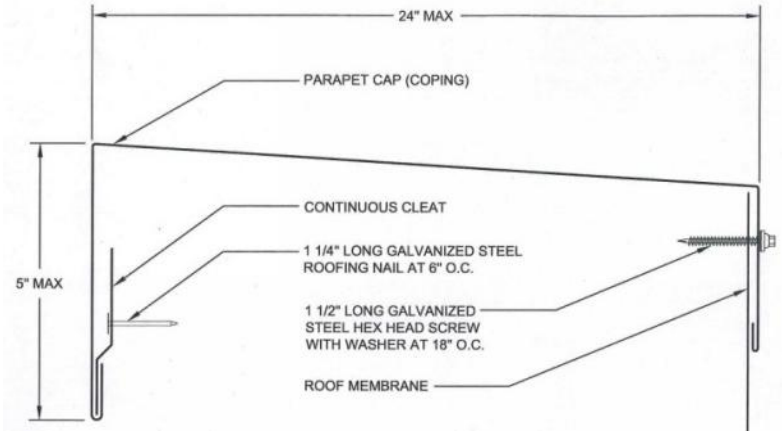

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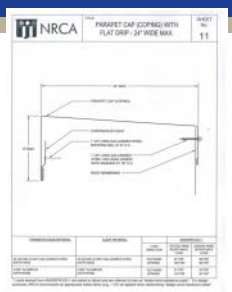
ANSI / SPRI ES-1 – NRCA Details



PERIMETER EDGE MATERIAL	CLEAT MATERIAL		ANSI/SPRI ES-1*	
		LOAD DIRECTION	TESTED WIND RESISTANCE LOAD	DESIGN WIND RESISTANCE LOAD
24 GAUGE (0.024") GALVANIZED STEEL [ASTM A653]	22 GAUGE (0.030") GALVANIZED STEEL [ASTM A653]	OUTWARD UPWARD	97 PSF 160 PSF	58 PSF 96 PSF
0.050" ALUMINUM [ASTM B209]	0.063" ALUMINUM [ASTM B209]	OUTWARD UPWARD	91 PSF 150 PSF	54 PSF 90 PSF

* Loads derived from ANSI/SPRI ES-1 are tested to failure and are referred to here as "tested wind resistance loads." For design purposes, NRCA recommends an appropriate safety factor (e.g., 1.67) be applied when determining "design wind resistance loads".

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RCABC Flashing Standards

- ✓ RCABC has developed flashing attachment standards for use by RCABC members.
- ✓ These standards are based on SMACNA (Sheet Metal and Air Conditioning Contractors` National Association) details with some changes to meet BC's specific requirements.
- ✓ SMACNA details are also tested to meet the ANSI/SPRI ES-1Standard
- ✓ These flashing attachment details are meant for typical details and thus cannot be used for unique or custom flashing profiles.
- ✓ Wind ratings for RCABC details are not provided

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Where is the CSA?

- ✓ Although the CSA A123.21 – 10 standard includes testing for roofing it does not yet include perimeter flashings.
- ✓ Currently the committee is at the test apparatus stage – meaning a test method is still being developed.
- ✓ Three different models of testing are currently being pursued:
  - Full system
  - Specific parapet
  - Modeling Verification

Conclusion

- ✓ Wind Design: Roofing and Flashings
  - Ensure that any design is reviewed, use any available standards to unsure due diligence is exercised.
  - Follow-up in construction to ensure that the contractor understood and has provided what was designed.

Wind Performance

✓ Remember, when it comes to wind design, just because it has worked for hundreds of years doesn't mean it can't fail in a second.

QUESTIONS?