Wind Uplift for Roofing Systems

Understanding wind uplift standard

Canadian Roofing Expo

April 16 2025

Agenda

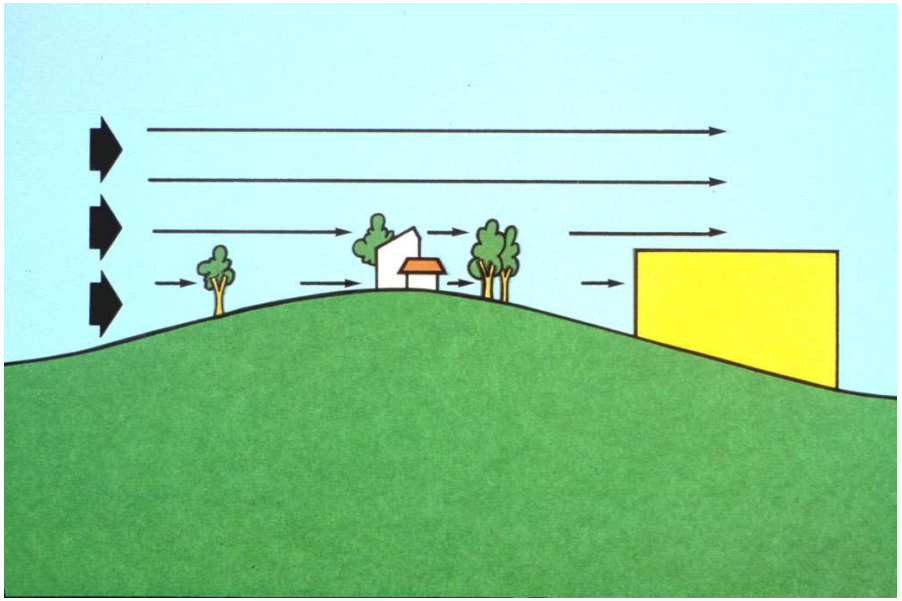
- Introduction
- Wind and Building Interactions
- Test methods – wind uplift
- Wind uplift standards
- Wind loads – NBCC
- Roles and responsibilities
- Conclusion

Introduction

- What is a roof?
  - environmental separation
  - waterproofing cover on a building
  - structural element of a building enclosure
- exposed to environmental loads; wind, rain, snow
- critical to performance - must be designed to resist these loads

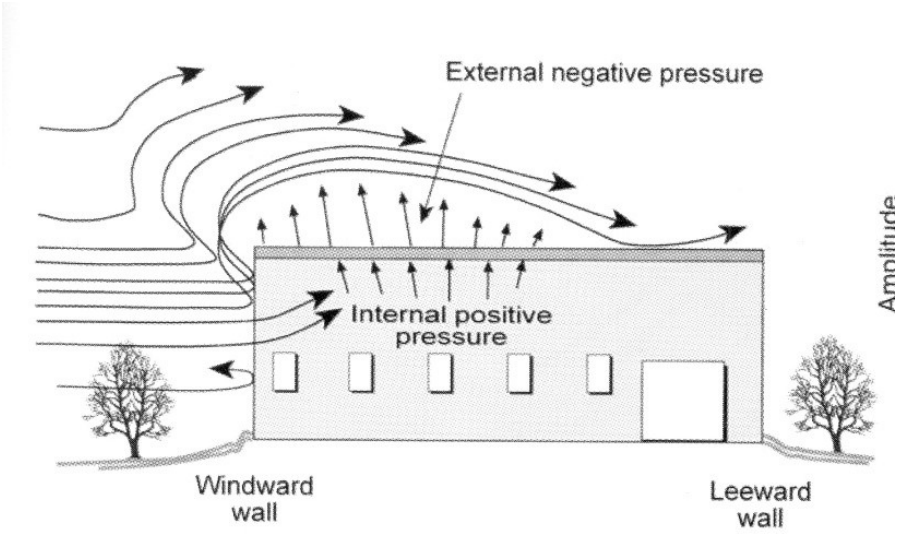
Wind and Building Interactions

- Factors affecting wind on a building
  - Geographical location, climatic conditions
  - Topography
    - Roughness of terrain
  - Building shape, size, enclosures



Wind and Building Interactions

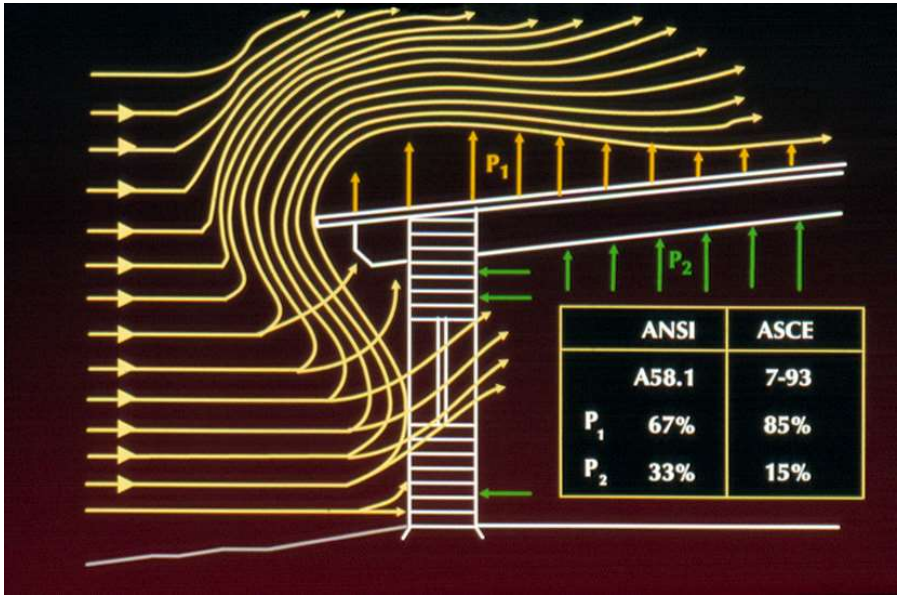
- Wind interacting on a building, both positive and negative (suction) pressures occur simultaneously
- Wind uplift – negative pressure



Wind and Building Interactions

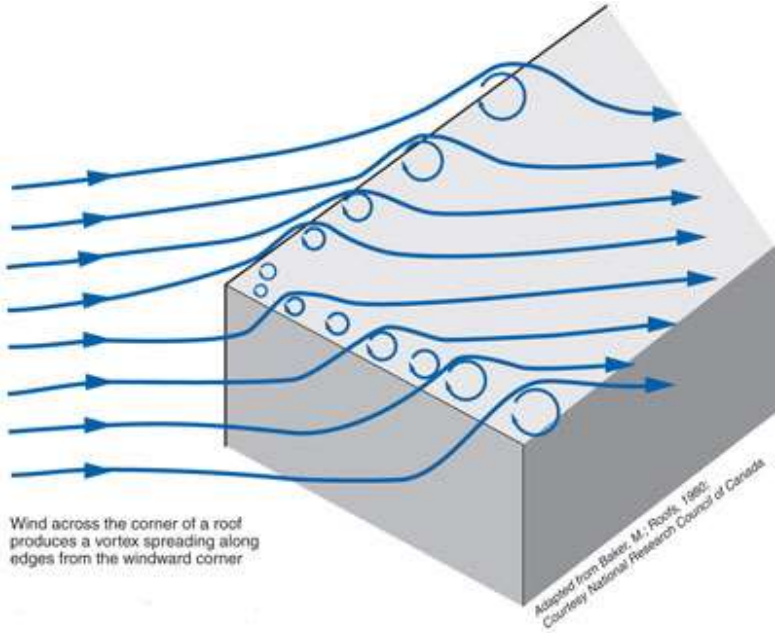
Building shape influences wind pressures

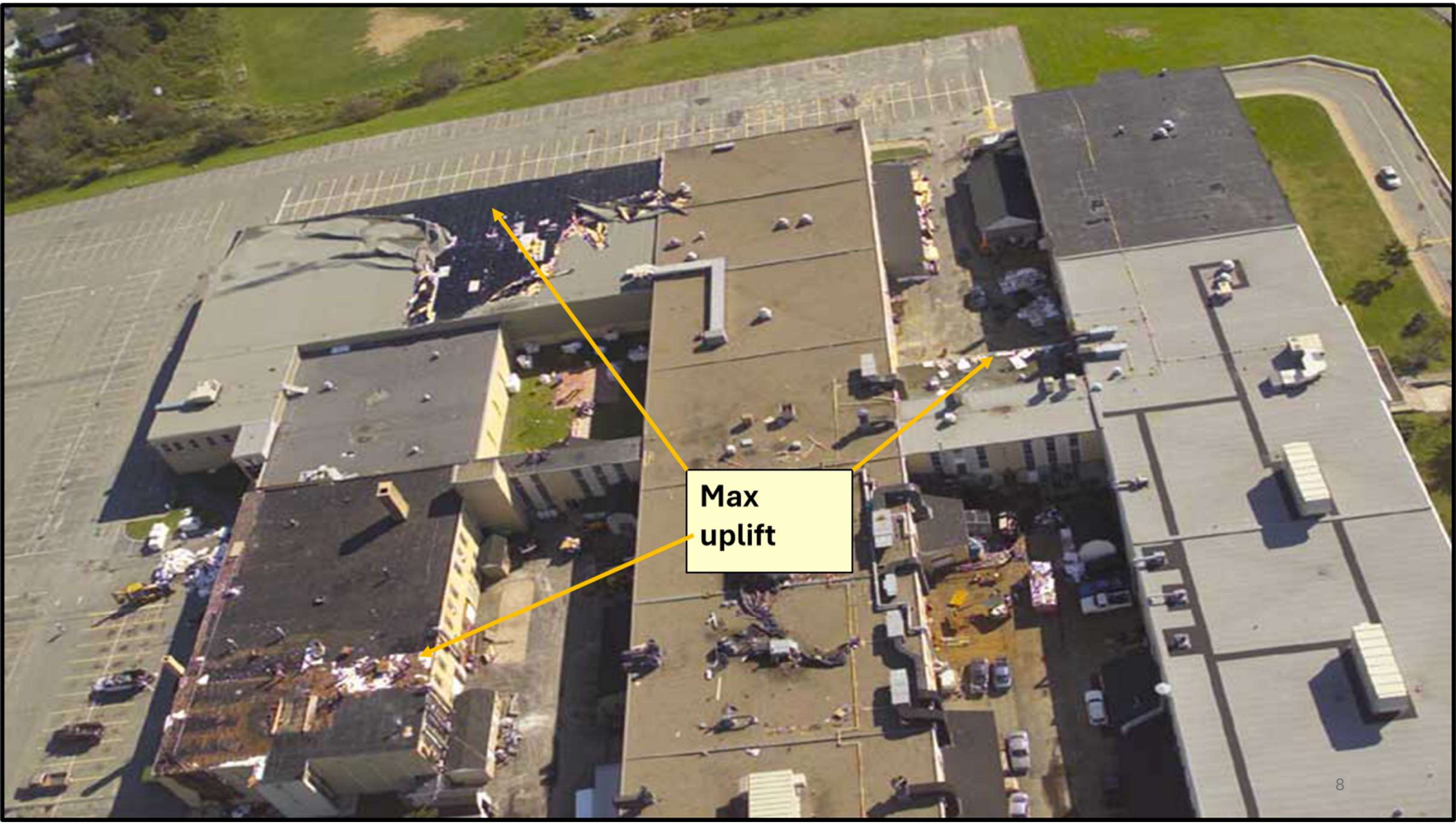
- Uplift loads on low slope roofs are larger than on gable or hip roofs
- Steeper the roof the lower the uplift loads
- Roof overhangs can increase loads at corners and perimeters
- Building irregularities (chimneys, stairwells) can cause turbulence and increase wind loads



Wind and Building Interactions

- Highest uplift pressures at corners, followed by perimeter and field
- Highest pressure at 45° angle
- Aerodynamic influences are accounted for by use of pressure coefficients



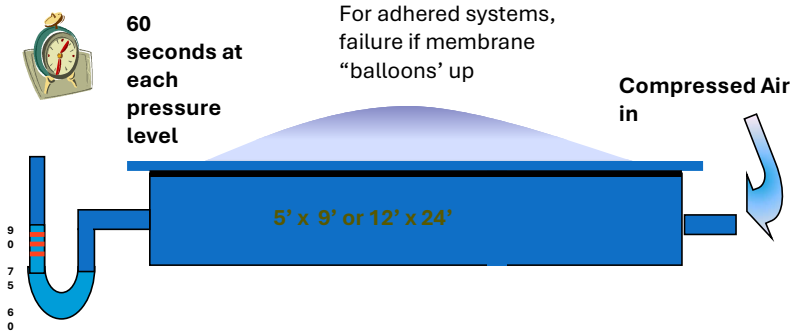

Max
uplift

Test methods – Wind uplift

- **Wind uplift test methods**
  - Static
    - FM 4474 - FM insured buildings
  - Dynamic
    - CSA A123.21 (conventional), CSA A123.24 (vegetative) - NBCC
- Ensure roof integrity, maintain performance and serviceability

Static Testing – FM

FM 4474 *Evaluating the Simulated Wind Uplift Resistance of Roof Assemblies Using Static Positive and/or Negative Differential Pressures*



5' x 9' adequate for adhered systems

12' x 24' for mechanically fastened systems

Static Testing – FM

- Simulates sustained, consistent pressure
- Does not consider variations in wind speed or pressure
- Do not test for roof fatigue

- Development of dynamic testing - NRC

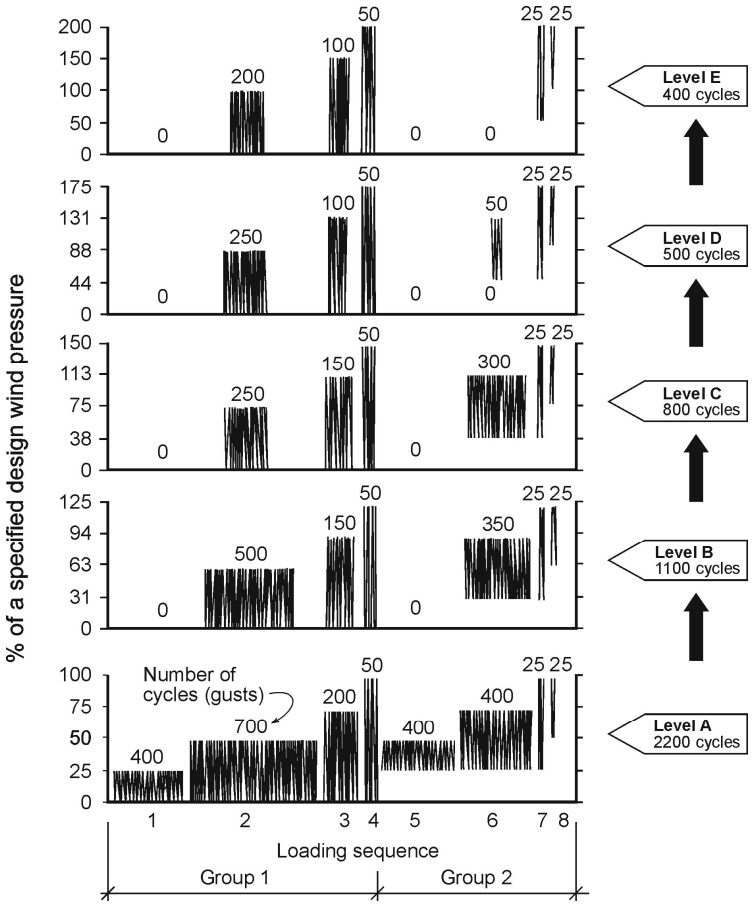
Dynamic Testing

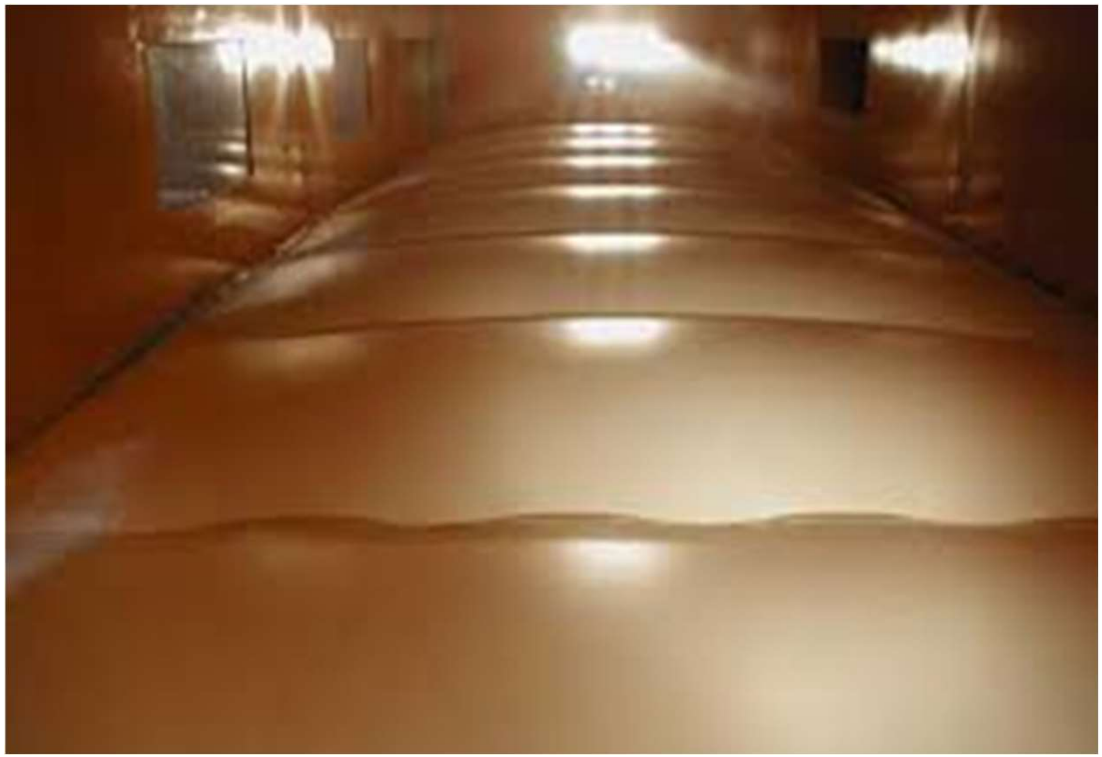
- Special Interest Group on Dynamic Evaluation of Roofing Systems **(SIGDERS)**
  - Created 1994
  - Industry-based consortium
- Goal
  - mimic real wind effects
  - achieve failure modes observed under real conditions
  - allow for variation in roof design
  - conform to Canadian code requirements

SIGDERS CSA A123.21 Test Apparatus

- capable of producing a maximum suction of 10 kPa (200 psf) over the roof assembly

SIGDERS Dynamic Load Cycle





Dynamic Testing

- Dynamic Load Cycles
  - Exerted on a test specimen in a pressure chamber
  - Simulate real-world wind events (wind gusts)
- Testing Procedure
  - Five rating levels with varying gusts
  - 5000 load cycles
- Wind Uplift Rating
  - Indicates exposure to prescribed pressure levels without failure
- **Development of CSA standard *A123.21 Standard test method for dynamic wind uplift resistance of membrane roof system***

Wind uplift Standards

CSA A123.21 Standard test method for the dynamic wind uplift resistance of membrane roofing systems

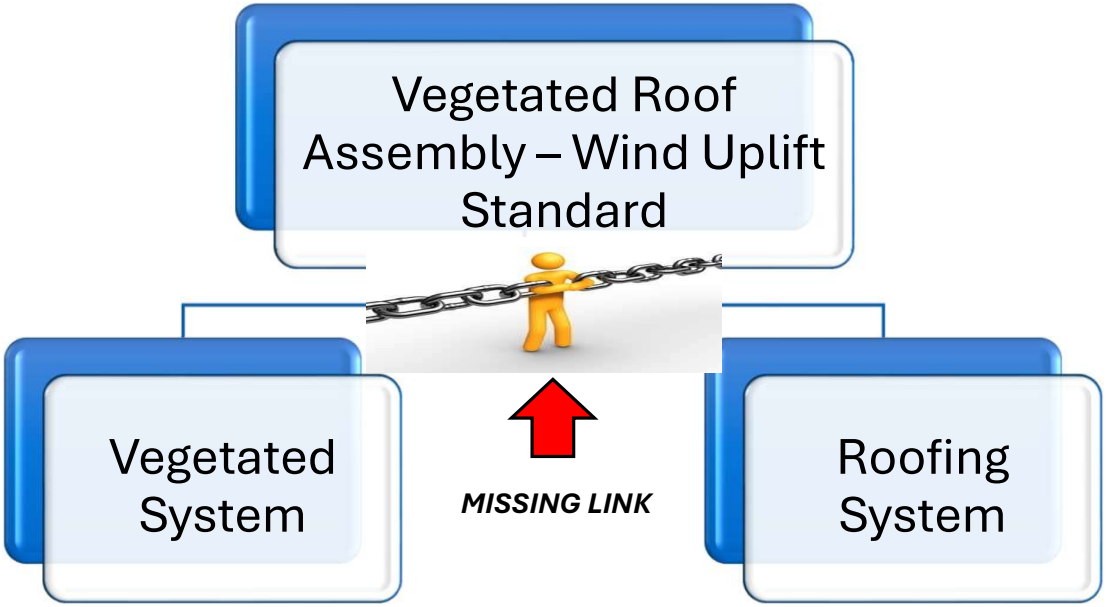
- first edition in 2004
- revisions 2010, 2014, 2020

- **Test standard – test method for conformance of roof system**
  - MARS (mechanically attached roof system)
  - PARS (partially attached roof system)
  - AARS (adhesive applied roof system)

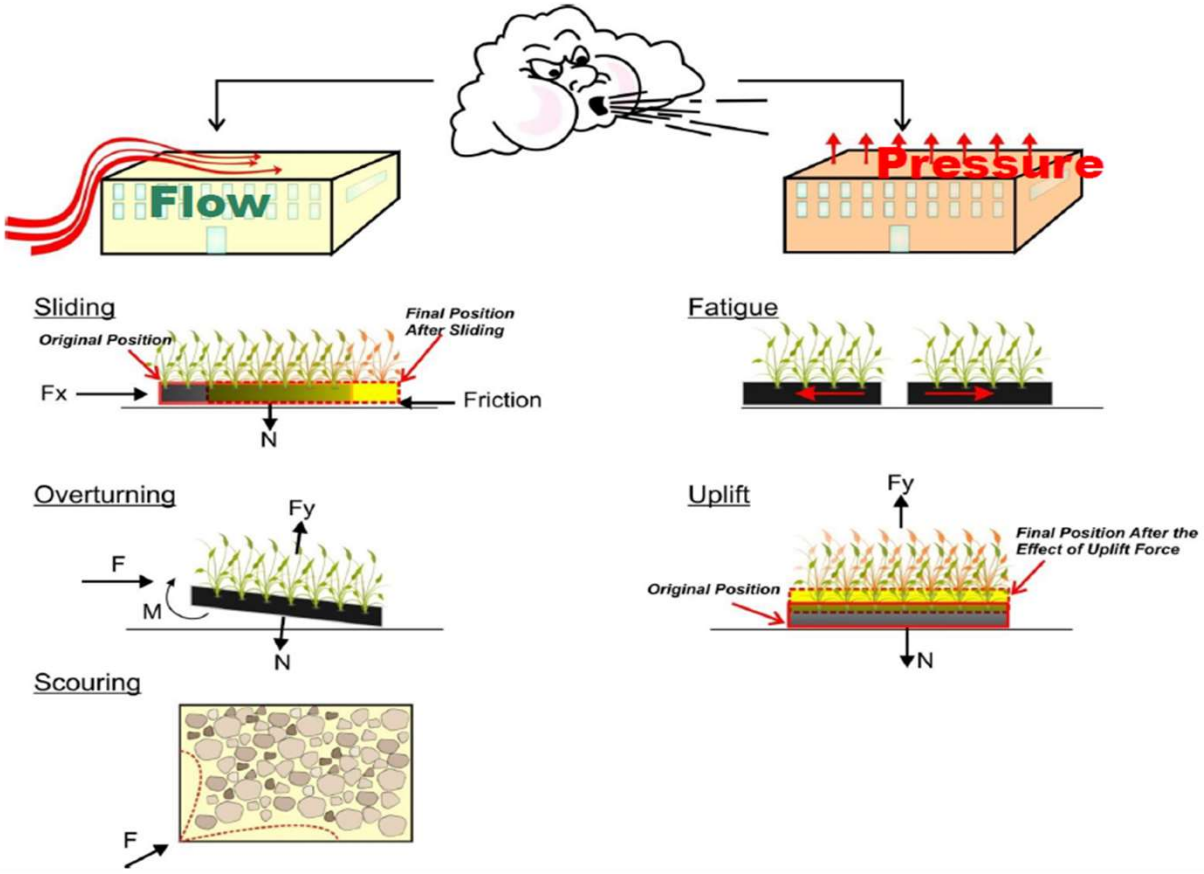
Wind uplift standards

- Roof systems outside scope of CSA A123.21
  - Vegetative roofs (CSA A123.24)
  - PMRA (inverted roof systems)
  - Ballast/pavers (loose-laid)

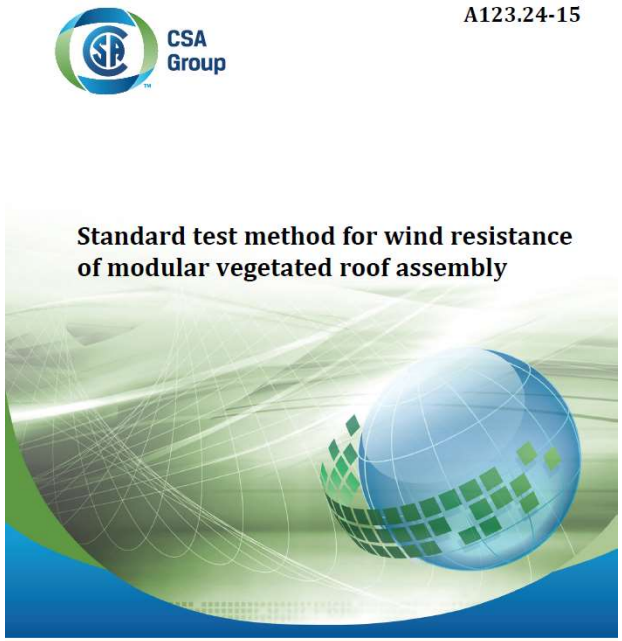
Vegetated Roof Assemblies (VRA)

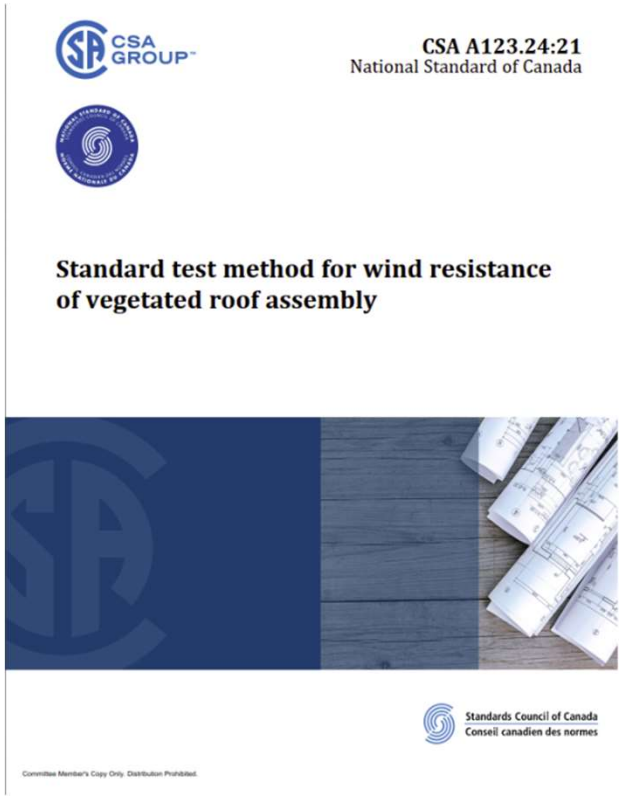


VRA – Wind Effects

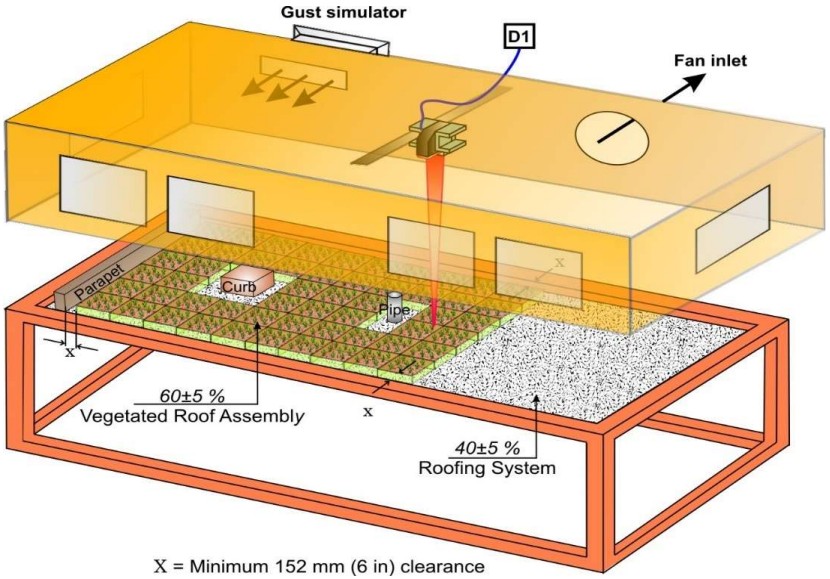


CSA Standard A123.24





Test Specimen – wind uplift



VRA – Wind Testing – wind flow resistance

Wind Flow Test: CSA 123.24

VRA Wind standard

- ***CSA 123.24 Standard Test Method for Wind Resistance of Vegetated Roof Assembly***
  - To be reference in NBCC 2025
  - Test method to determine the wind uplift resistance of a VRA (not material standard)
  - 1st edition in 2015 - Applicable to modular vegetated roof assemblies
  - 2nd edition in 2021 – Applicable to modular and built-in place vegetated roof assemblies

Wind Loads- NBCC

NATIONAL BUILDING CODE OF CANADA **Volume 1 (2015)**

5.2.2.1 **Division B**

5.2.2. Structural Loads and Design Procedures

5.2.2.2. Determination of Wind Load

4) Except as provided in Sentence (5), the wind uplift resistance of membrane roof assemblies shall be determined in accordance with the requirements of CAN/CSA-A123.21, "Dynamic Wind Uplift Resistance of Membrane-Roofing Systems." (See Note A-5.2.2.2.(4).)

A-5.2.2.2.(4) **Membrane Roofing Systems.**

The test method described in CAN/CSA-A123.21, "Dynamic Wind Uplift Resistance of Membrane-Roofing Systems," applies only to membrane roofing systems whose components' resistance to wind uplift is achieved by fasteners or adhesives. It does not apply to roofing systems that use ballast, such as gravel or pavers, to secure the membrane against wind uplift.

Wind Loads - NBCC

- Minimum Design Wind Loads
  - NBCC Division B, Part 4 deals exclusively with structural design
  - Including calculation of wind loads (Subsection 4.1.7.)

Wind Loads

- Reference wind speeds are one-hour averages of wind speeds representative of the 10 m height in flat open terrain (Exposure A)
- Tabulated for major Canadian cities in the Appendix C of the NBCC (no wind speed maps)

Wind Loads - NBCC

Wind Loads – subsection 4.1.7

Three different procedures for determining Wind Load calculations are referenced in the NBCC:

1. Static Procedure
2. Dynamic procedure
3. Experimental Procedure

Wind load - NBCC

Design considerations:

- Climate
- Building features/dimensions
- Desired reliability (building importance)
- Parapet/Edge/coping flashings

Wind Uplift Design

- Wind loads calculations
  - NBCC (Part 4)
  - Wind-RCI *

* reflects latest NBCC requirements

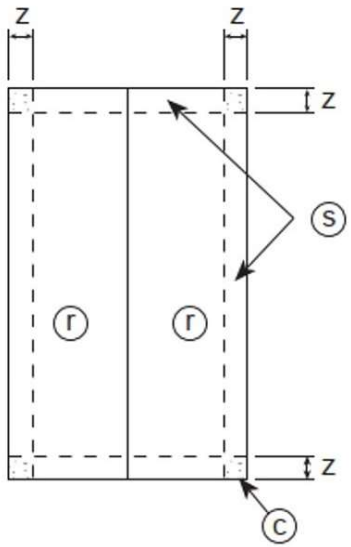
https://nrc.canada.ca/en/research-development/products-services/software-applications/wind-roof-calculators-internet-wind-rci

Wind Loads

- Wind loads – 4.1.7
  - Wind load diagram showing different zones and factored wind loads

Factored wind loads for roof cladding

Roof area	Wind load
End zone width, Z	3.6 m
Corner ⓒ	-2.8 kPa
Edge ⓢ	-1.8 kPa
Field ⓡ	-1.4 kPa

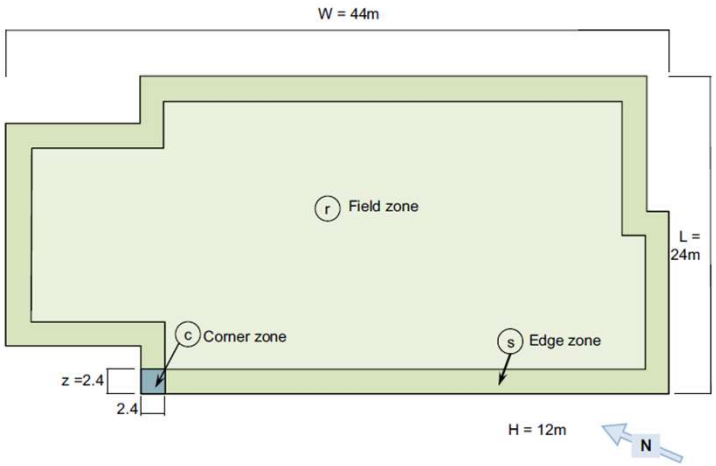


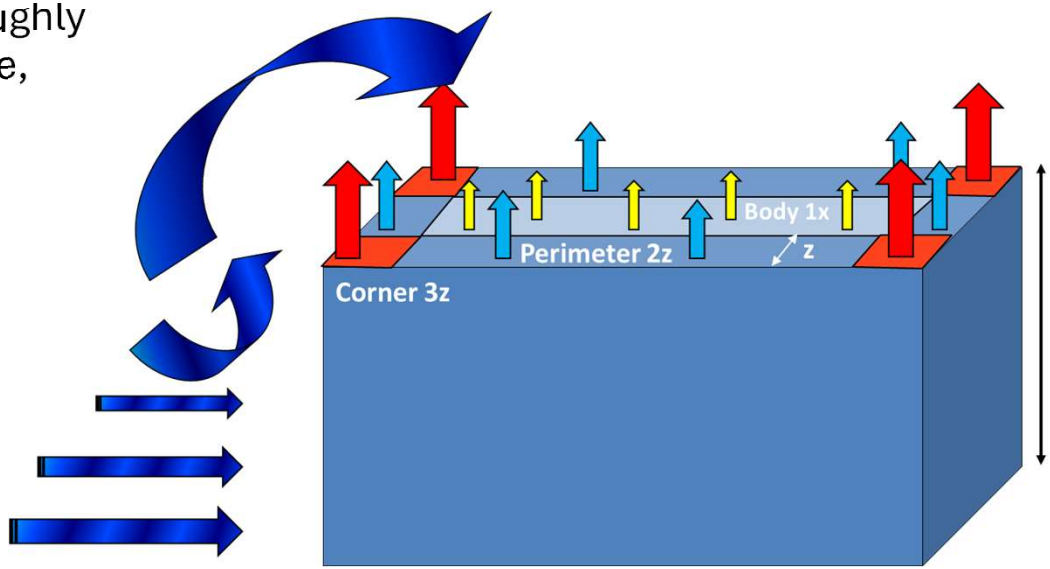
(NBCC Figure 4.1.7.6.-C)

Wind loads

Roof Zones

- Pressure coefficients are used to adjust the basic uplift pressure. Corners have roughly 3x the basic pressure, perimeters twice, and the field (interior) zone .





Wind loads

Wind loads

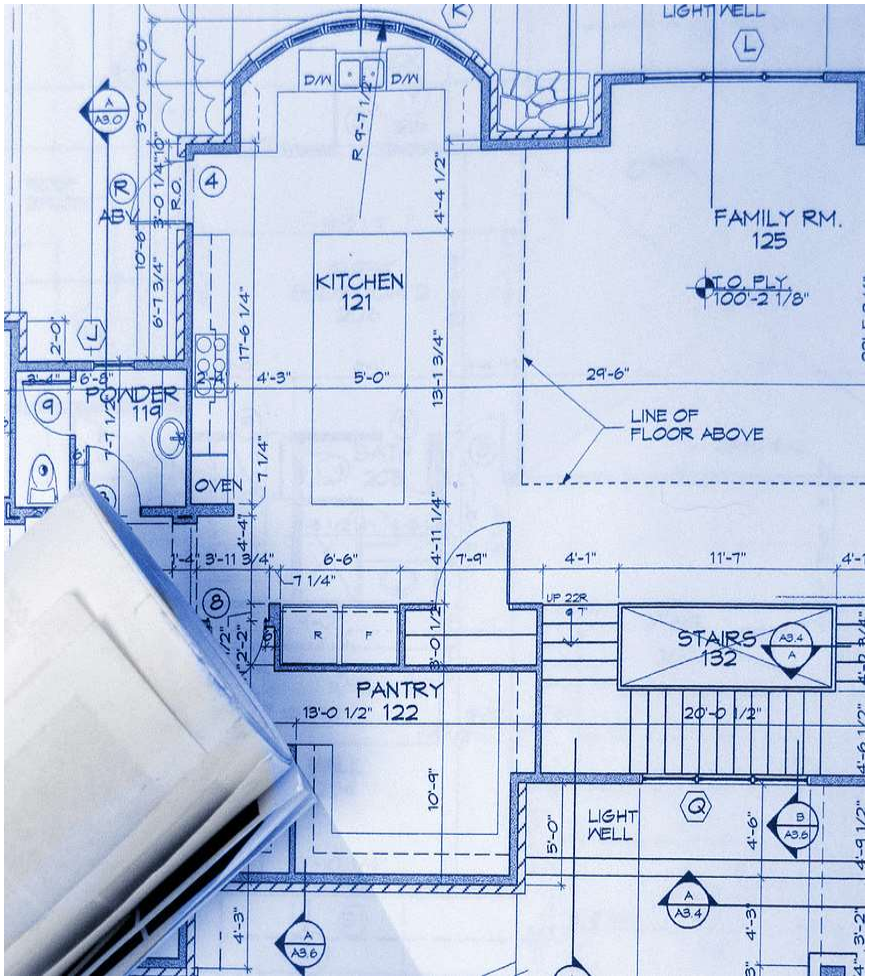
- must be less than tested uplift resistance of roof system
- verify with manufacturer test reports

Project stakeholders – Roles and responsibilities

Designer

Roofing contractor

Manufacturer



Designer's Role

- **must** determine wind loads specific to building parameters
  - NBCC Division C Article 2.2.1.2 Structural Design

    1) For design carried out in accordance with Part 4 Division B, the designer shall be a professional engineer or architect skilled in the work concerned
  - Wind loads obtained for three distinct zones of the roof: field, edge, and corner
    - Higher wind load is attributed to the corner zone, followed by the edge and field zones
  - Wind-RCI is a free web-based calculator for calculating wind loads on buildings with simple geometry
- Designer to include wind loads for each roof zone in the specification and on drawings
- Specify roof systems that meet or exceed required wind loads

Manufacturer's Role

Roofing assemblies to be tested to demonstrate wind uplift resistance

- Testing in accordance with CSA A123.21 test procedures
- Reports issued by accredited testing laboratories

Single test report may include multiple resistance values for variations

- Variations include acceptable substitute materials, different fastener spacing, gauge, adhesive ribbon spacing, etc.

Test reports may be available from multiple sources

- Roofing membrane manufacturers, Central Roof Reference, Wind-RCI website, roofing contractor associations (ex. RCABC, ARCA)

Contractor's Role

- Responsible for installing a roofing system as per:
  - Wind loads / dimensions of different zones demarcated on structural drawings, and roof system(s) **provided by designer**
  - CSA A123.21 test reports **from manufacturers** showing uplift resistance results/materials and installation procedures
- **When/what questions to ask??**
- Clarify with designer

Wind design - challenges

- No wind loads → request wind loads/zones demarcated on structural drawings
- Unclear specifications → request clarification **in writing**
- Material substitution → must meet material criteria in CSA A123.21 standard (request approval)

Wind design – downloading responsibilities

Downloading of design responsibilities to roofing contractors or manufacturer

- Requiring roofing contractors to provide calculations for wind loads & dimensions of zones/fastening patterns
  - Requiring contractors to select a roof system that meet specifications
- Contractors are not design professionals and are advised to require the appropriate information from the designer of record in order to install the specified system

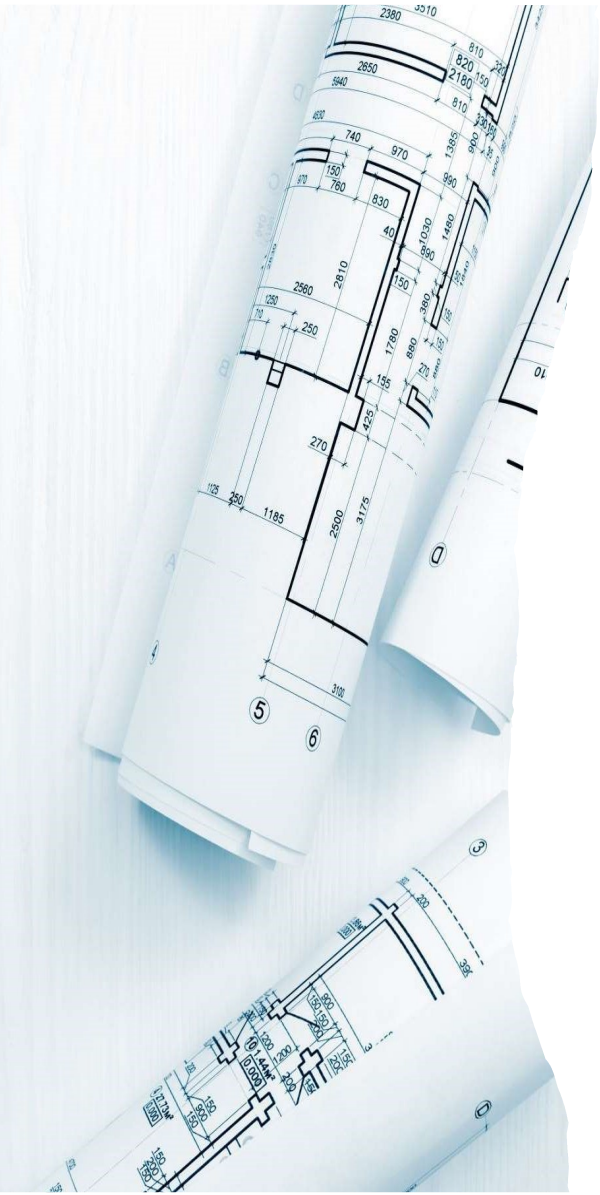
CRCA Application Policy
Test Standard CSA A123.21

"Roofing contractors should not bear the responsibility of determining wind loads and/or the proper roof system design to meet or exceed those wind loads."

- Design authority
  - responsible for required wind loads and a roof system design that meet or exceed the require loads
  - provide design drawings and specifications, associated with these calculations

City of Vancouver Building By-Law

- "structural drawings and related documents [are] submitted with the application to build" they **shall** indicate "all effects and loads, other than dead loads, used for the design and construction of the structural members and exterior cladding, **including the roof assembly**."
- "Examples of information that should be shown on architectural drawings…
  - **the dimensions of the field, edge and corner zones of the roof, and load values for each affected area of a wall and roof assembly**
- **loads must be conveyed in a meaningful manner on design drawings so that trades (roofers) know what to do with them**
- **Design authority carries responsibility for the design**



Conclusion

- **CSA A123.21 – test standard not a material standard**
- Tested wind uplift resistance of a roof assembly (CSA A123.21) **must meet or exceed** design wind load (NBCC)
- Clear specifications and drawings
  - registered professional (i.e., structural engineer or architect) must calculate wind loads for roofs
  - wind loads (all zones & dimensions) must be conveyed on design drawings
  - specify tested roof assemblies
- Tested roof assemblies **installed** as per manufacturer instructions

QUESTIONS / COMMENTS

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