NOT IN KANSAS ANYMORE:

Designing Low-slope Roofs for Wind Uplift Resistance

November 14, 2018

RCABC ROOFING CONTRACTORS ASSOCIATION OF BRITISH COLUMBIA | RoofStar GUARANTEED. BETTER.

www.rcabc.org

Not in Kansas Anymore

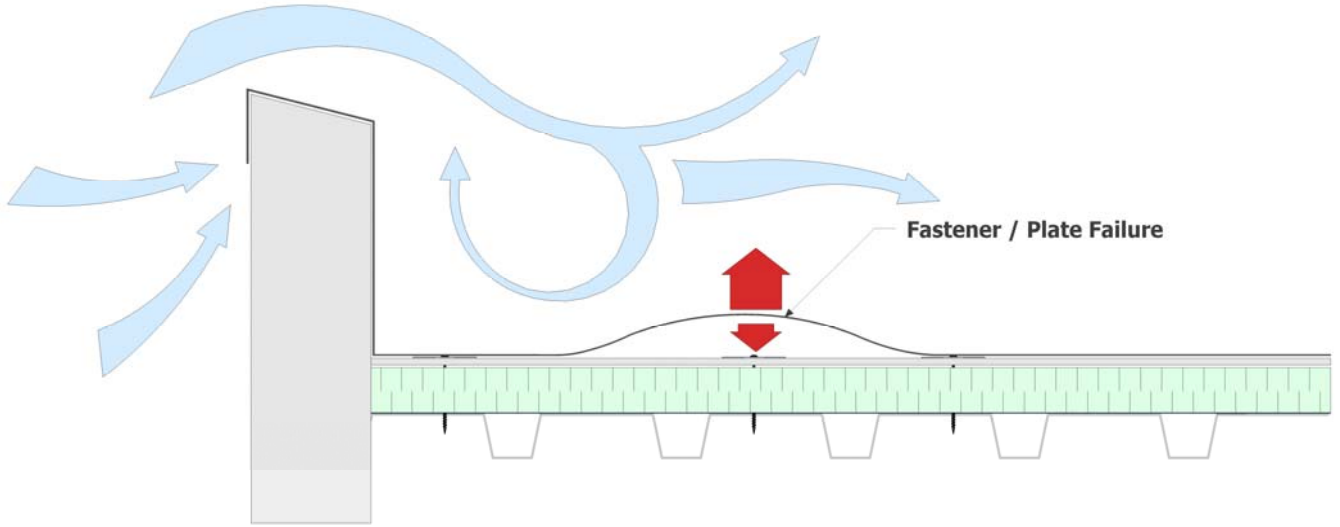
- Why wind matters
- Code requirements
- Designing low-slope roofs to resist wind

Why Wind Matters

Plow winds, blowing 70 km/h, derailed this train near Waldeck, SK (2014)

Why wind matters

- Wind effect is often misunderstood



Why wind matters

- Wind effect is often misunderstood
  - Wind does not have to get underneath an object to wreak havoc

Why wind matters

- Wind effect is often misunderstood
  - Wind does not have to get underneath an object to wreak havoc
  - Wind strength is exponentially stronger than wind speed

Why wind matters

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- Wind power is often underestimated

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- ‘Flat’ (low-sloped) roofs are susceptible to damage

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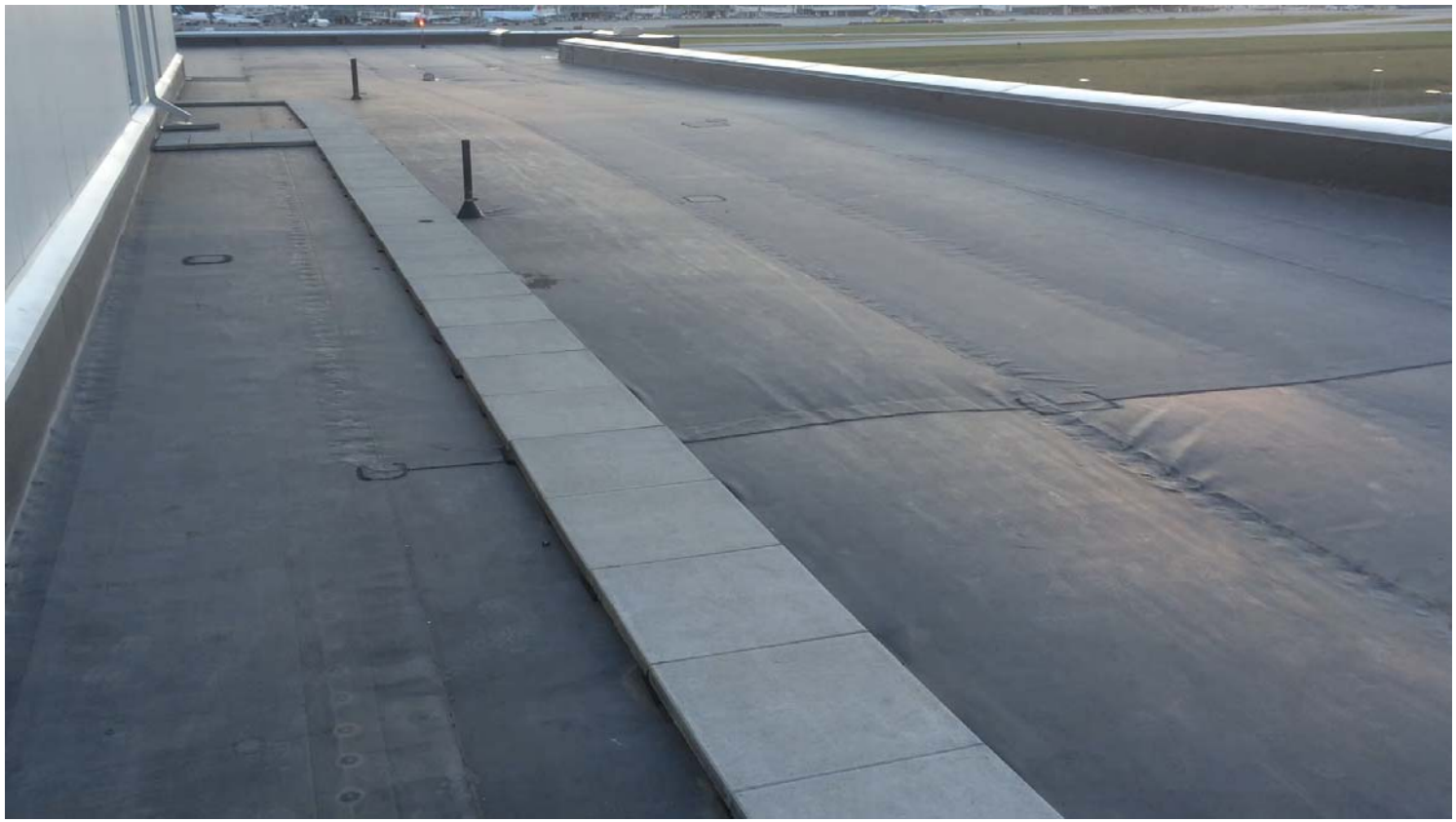
- Wind effect is often misunderstood
- Wind power is often underestimated
- ‘Flat’ (low-sloped) roofs are susceptible to damage
- Light winds can generate significant damage

Why wind matters



Code Requirements

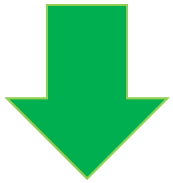
Code Requirements

- ✓ Roofing Practices Manual
  (*RoofStar Guarantee Standards*)
- ✓ British Columbia Building Code (2018)
- ✓ National Building Code (2015)

Code Requirements

IRC

(Institute for Research in Construction)

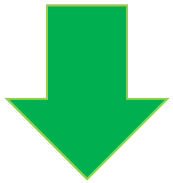


SIGDERS

(Special Interest Group for the Dynamic Evaluation of Roofing Systems)

Code Requirements

SIGDERS



CAN/CSA A123.21

(Standard test method for the dynamic wind uplift resistance of membrane-roofing systems)

Code Requirements

- BCBC (2018) aligns with the NBCC

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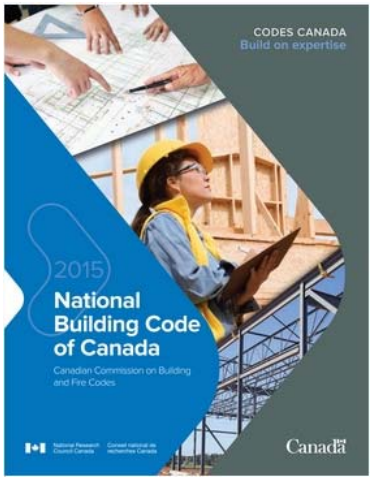

Code Requirements

- BCBC (2018) aligns with the NBCC
  - Design Authority responsible to calculate Specified Wind Loads

Code Requirements

4.1.7. Wind Load

4.1.7.1. Specified Wind Load

1) The specified wind loads for a building and its components shall be determined using the Static, Dynamic or Wind Tunnel Procedure as stated in Sentences (2) to (5).

2) For the design of ***buildings*** that are not dynamically sensitive, as defined in Sentence 4.1.7.2.(1), one of the following procedures shall be used to determine the specified wind loads:

a) the Static Procedure described in Article 4.1.7.3.,

b) the Dynamic Procedure described in Article 4.1.7.8., or

c) the Wind Tunnel Procedure described in Article 4.1.7.12.

3) For the design of ***buildings*** that are dynamically sensitive, as defined in Sentence 4.1.7.2.(2), one of the following procedures shall be used to determine the specified wind loads:

a) the Dynamic Procedure described in Article 4.1.7.8., or

b) the Wind Tunnel Procedure described in Article 4.1.7.12.

4) For the design of ***buildings*** that may be subject to wake buffeting or channelling effects from nearby ***buildings***, or that are very dynamically sensitive, as defined in Sentence 4.1.7.2.(3), the Wind Tunnel Procedure described in Article 4.1.7.12., shall be used to determine the specified wind loads.

5) For the design of cladding and secondary structural members, one of the following procedures shall be used to determine the specified wind loads:

a) the Static Procedure described in Article 4.1.7.3., or

b) the Wind Tunnel Procedure described in Article 4.1.7.12.

6) Computational fluid dynamics shall not be used to determine the specified wind loads for a ***building*** and its components. (See Note A-4.1.7.1.(6).)

Code Requirements

5.2.2.2. Determination of Wind Load

(See Note A-5.2.2.2.)

1) This Article applies to the determination of wind load to be used in the design of materials, comp assemblies, including their connections, that separate dissimilar environments or are exposed to the exteri these are

a) subject to wind load, and

b) required to be designed to resist wind load.

2) Except as provided in Sentence (3), the wind load referred to in Sentence (1) shall be 100% of the specified wind load determined in accordance with Article 4.1.7.1.

3) Where it can be shown by test or analysis that a material, component, assembly or connection referred to in Sentence (1) will be subject to less than 100% of the specified wind load, the wind load referred to in Sentence (1) shall be not less than the load determined by test or analysis.

4) Except as provided in Sentence (5), the wind uplift resistance of membrane roofing 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).)

5) Membrane roofing assemblies with proven past performance for the anticipated wind loads need not comply with Sentence (4). (See Note A-5.1.4.1.(5).)

5.2.2.3. Design Procedures

1) Structural design shall be carried out in accordance with Subsection 4.1.3. and other applicable requirements in Part 4.

Code Requirements

- BCBC (2018) aligns with the NBCC
  - Design Authority responsible to calculate Specified Wind Loads
  - Roof systems must securely attach to the structure and resist Specified Wind Loads

Code Requirements

A-5.2.2.2.(4) Membrane Roofing Systems. Wind loads for membrane roofing systems must be calculated in accordance with Part 4. The tested uplift resistance and factored load should satisfy the requirements of the Commentary entitled Limit States Design in the "User's Guide – NBC 2015, Structural Commentaries (Part 4 of Division B)."

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 ballasts, such as gravel or pavers, to secure the membrane against wind uplift.

In the case of membrane roofing systems in which the waterproof membrane is attached to the structural deck using mechanical fasteners, the wind-induced forces and the roofing system's response are time- and space-dependent and, thus, dynamic in nature. Further information on the design and evaluation of such systems can be found in "A Guide for the Wind Design of Mechanically Attached Flexible Membrane Roofs," published by NRC.

The wind uplift resistance obtained from the test method in CAN/CSA-A123.21 is limited to configurations with specific fastener or adhesive patterns. To extrapolate the test data to non-tested configurations, refer to ANSI/SPRI WD-1, "Wind Design Standard Practice for Roofing Assemblies," for a rational calculation procedure. However, in using this extrapolation procedure, wind loads should be calculated in accordance with the BCBC. NRC's guide for wind design referenced above provides further guidance and examples of wind load calculations.

Code Requirements

- BCBC (2018) aligns with the NBCC
  - Design Authority responsible to calculate Specified Wind Loads
  - Roof systems must securely attach to the structure and resist Specified Wind Loads
  - Design Authorities may rely upon
    - *Tested Assemblies*

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    - Assemblies with *Proven Past Performance*
    - *Engineered Assemblies*

Code Requirements

- RoofStar Guarantee Standards
  - Adopted NBCC (2015) requirements since April 2017

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  - Adopted NBCC (2015) requirements since April 2017
  - Require compliance with BCBC
  - Provide Design Authorities with access to library of Tested Assembly reports
  - Complete guidance in the RPM:
    - 3 SECURING the ROOF ASSEMBLY

Code Requirements

FM Global 

- Cannot be used to comply with BCBC

Code Requirements

FM Global

- Insurance risk-management focused standards

Code Requirements

FM Global

- Incorporate a proprietary test method for wind-resistance
  - Static rate of pressure
  - One cycle for 60 seconds

Code Requirements

BC Building Code

- Focused on
  - Occupant comfort
  - Energy efficiency
  - Public safety
  - Accessibility
  - Liveability

Code Requirements

BC Building Code

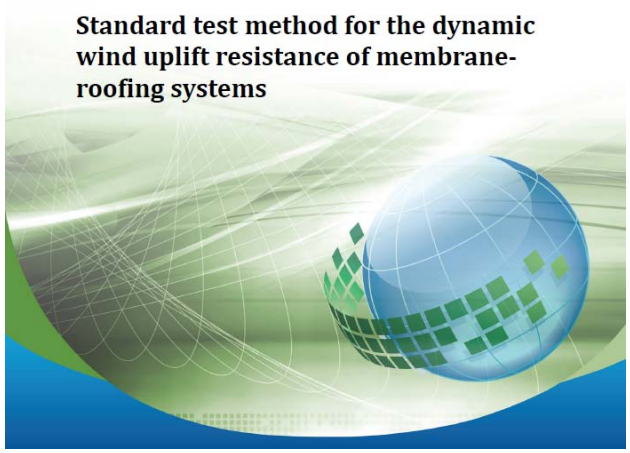
- Incorporates a test method for wind-resistance (CSA A123.21)
  - dynamic (cycling) rate of pressure
  - up to five hours

Code Requirements

FM Global ≠

CSA Group

A123.21-14



Code Requirements

FM Global 

The so-called “FM 1-90”

- focuses on Class 1 fire-resistant roofs

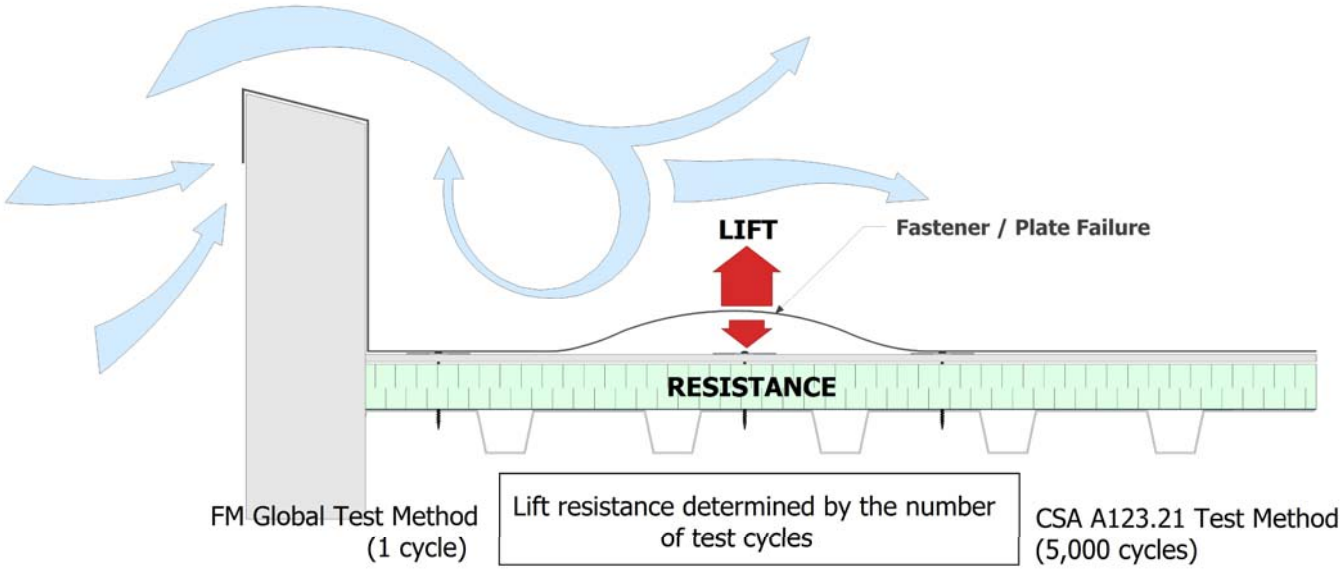
Code Requirements

FM Global 

The so-called “FM 1-90”

- focuses on Class 1 fire-resistant roofs
- establishes a minimum wind resistance of 90 lb/sf (static pressure; 60 seconds)

Code Requirements



Code Requirements

The Dynamic Roof Testing Facility, Drummondville, QC

Code Requirements

Sample Tested Assembly report

NEMO | etc.
353 Christian Street, Unit #13
Oxford, CT 06478
(203) 262-9245

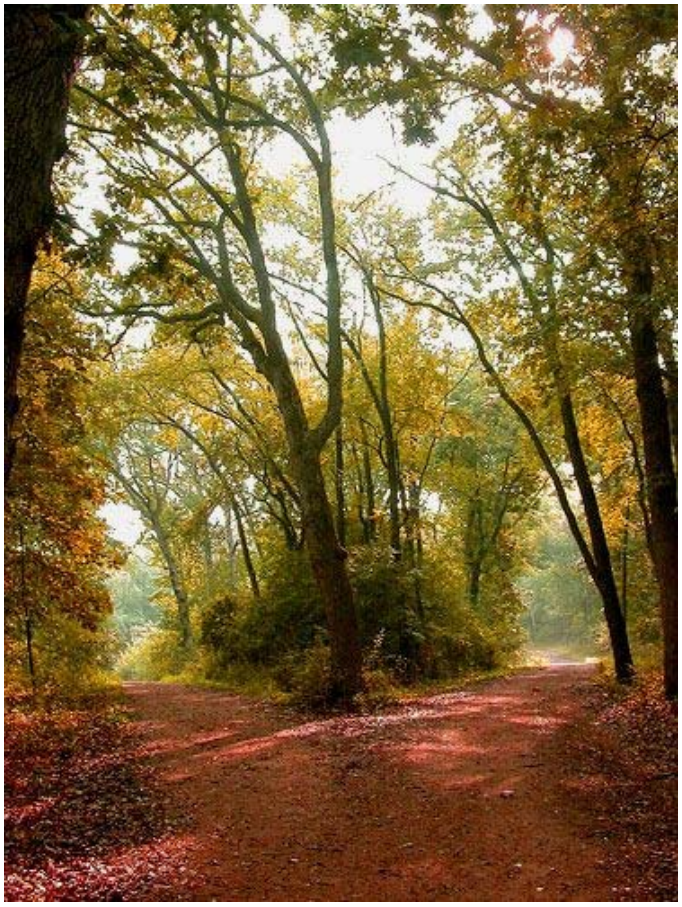
ENGINEER EVALUATE TEST CONSULT CERTIFY

ROOF SYSTEM ASSESSMENT REPORT DYNAMIC UPLIFT RESISTANCE PER CSA A123.21			
CLIENT:	SAMPLE	TEST DATE:	2016-08-23
DOCUMENT NO.	SAMPLE	PUBLICATION DATE:	2018-02-26
TEST PANEL NO.	SAMPLE	REVISION NO.	R0
SYSTEM TYPE:	SAMPLE	REEVALUATION DATE:	2021-02-26

PARTIALLY ADHERED ROOFING SYSTEM (PARS) SUMMARY		
PERFORMANCE⇨	PASSING PRESSURE	WIND UPLIFT RESISTANCE (with SF of 1.5)
	4.6 kPa (96 psf)	3.1 kPa (64 psf)

Choosing a Design Path:

Roofs that resist wind uplift



Designing roofs to resist wind uplift

- Three steps:

Designing roofs to resist wind uplift

- Three steps:
  - STEP 1: Calculate Specified Wind Loads

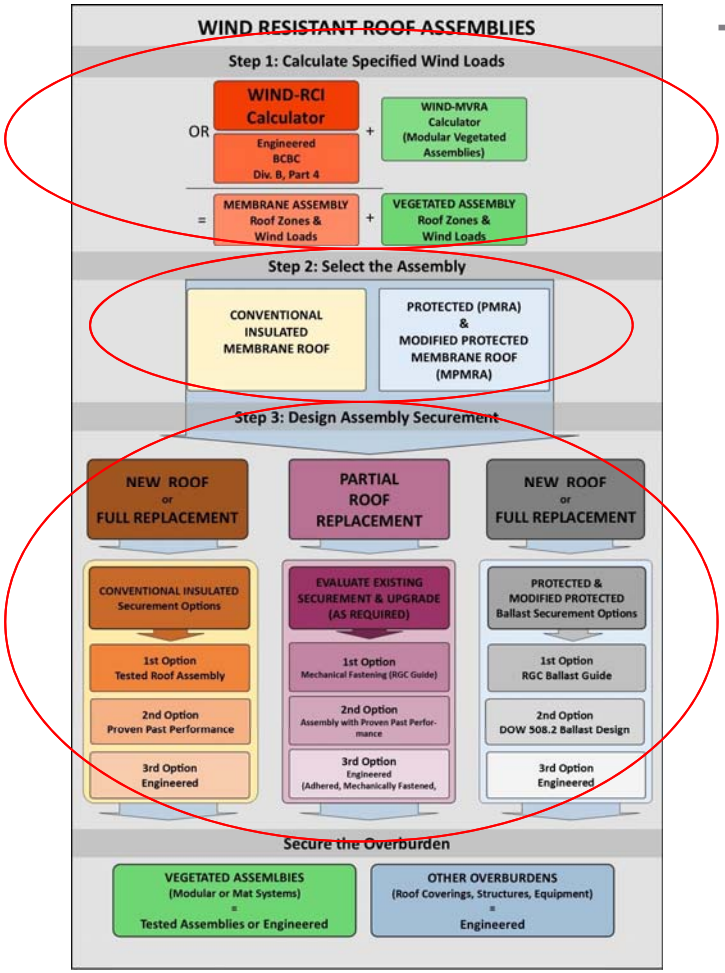
Designing roofs to resist wind uplift

- Three steps:
  - STEP 1: Calculate Specified Wind Loads
  - STEP 2: Choose the roof assembly type

Designing roofs to resist wind uplift

- Three steps:
  - STEP 1: Calculate Specified Wind Loads
  - STEP 2: Choose the roof assembly type
  - STEP 3: Design assembly securement

Designing roofs to resist wind uplift



The Design Path

Step 1

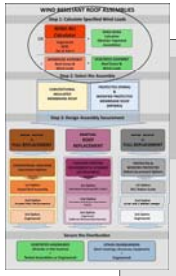
Step 2

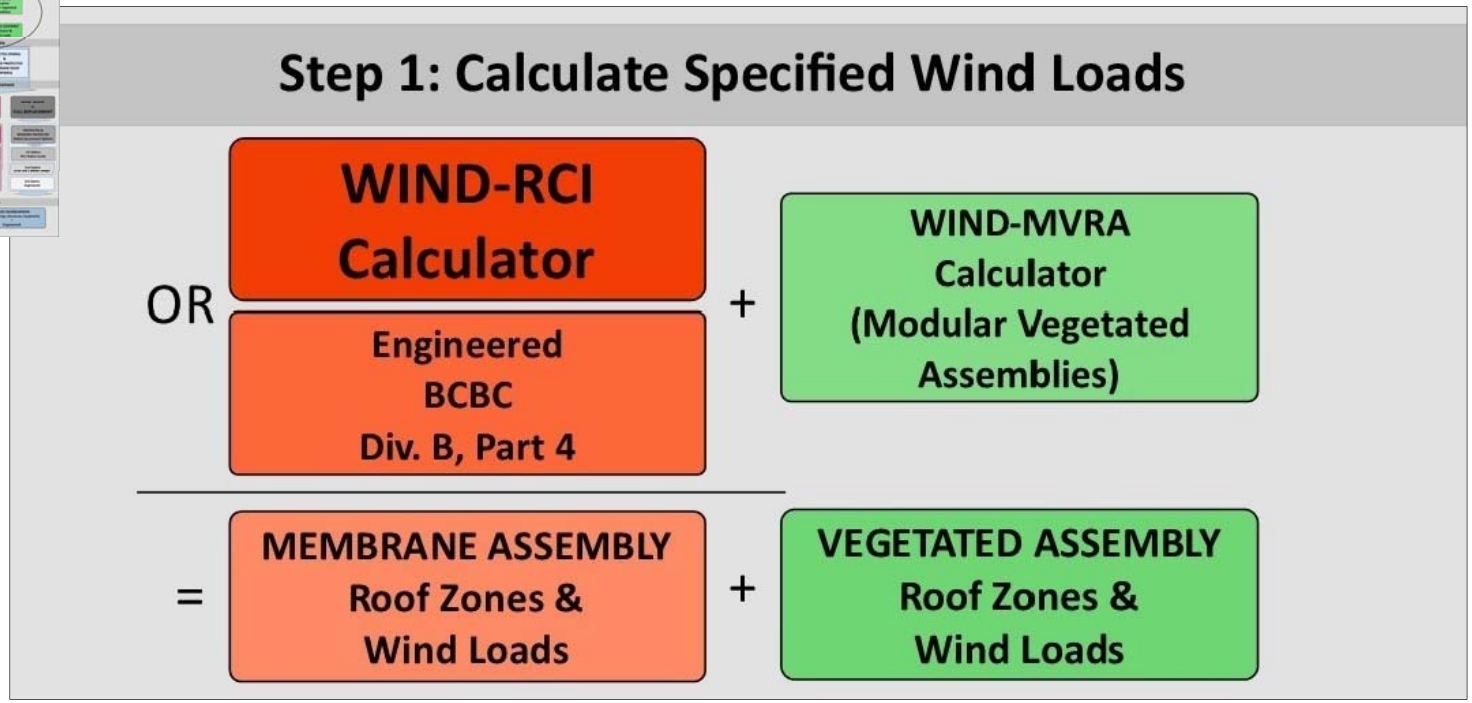
Step 3

Securing overburden

Designing roofs to resist wind uplift

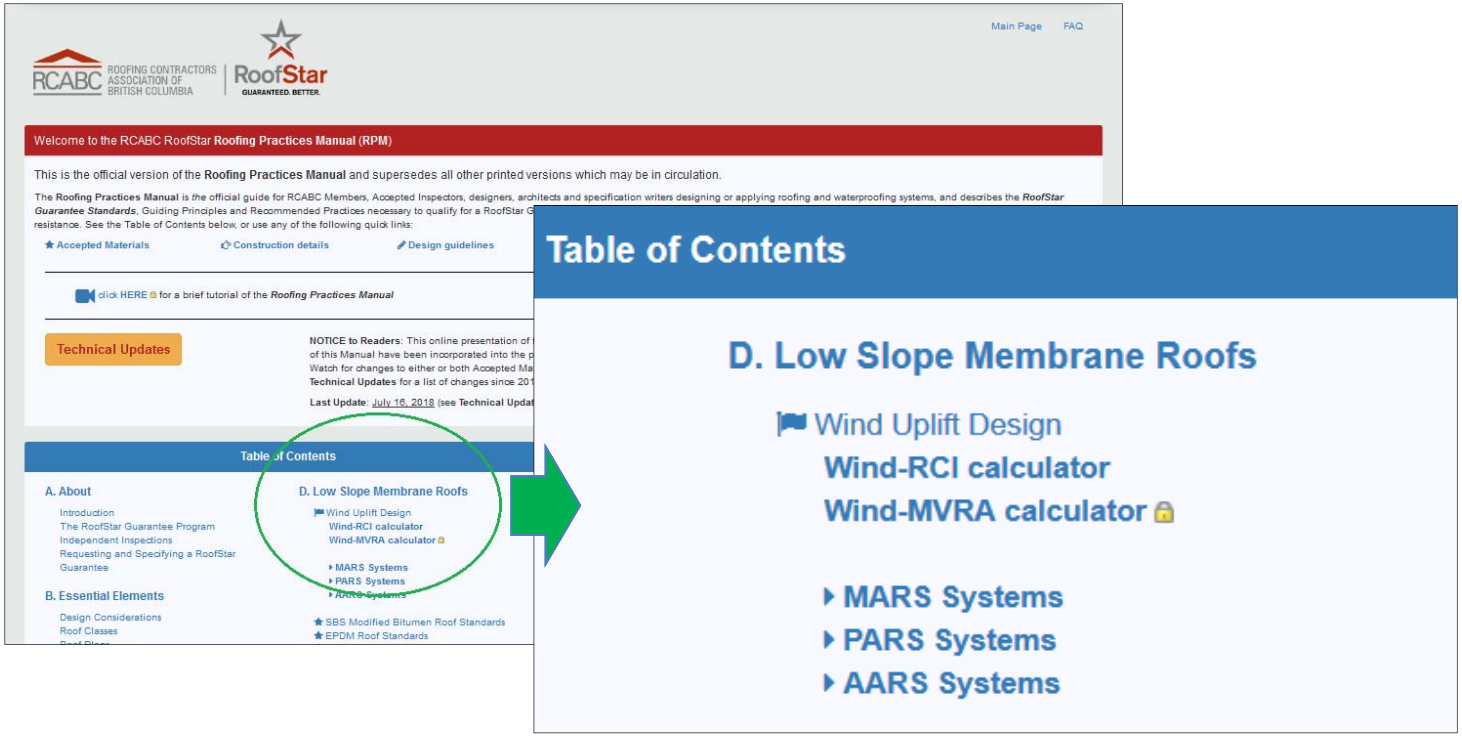
STEP 1: Calculate Specified Wind Loads





Designing roofs to resist wind uplift

Wind-RCI online calculator



Designing roofs to resist wind uplift

Wind-RCI Report

Building parameters

Building location: Vancouver Region, Burnaby (Simon Fraser Univ.), British Columbia

Building geometry:

- High Rise
- Height (reference height): 70 ft (21 m)
- Width (smaller plan dimension): 70 ft (21 m)
- Length: 150 ft (46 m)
- Does the building have parapet higher than 3.28 ft(1m): No

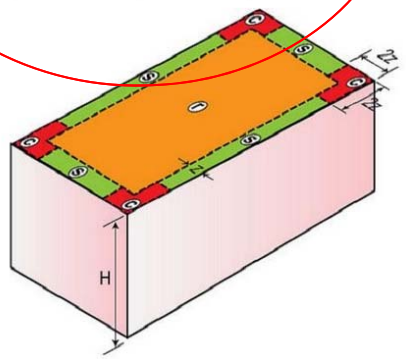
Building exposure: Open

Building openings: Category 1

Building importance: Normal

Wind loads for roof cladding

Roof area	Wind load
End zone width, Z	15 ft (4.6 m)
Corner, ©	-92 psf (-4.4 kPa)
Edge, Ⓢ	-60 psf (-2.9 kPa)
Field, ⓡ	-40 psf (-1.9 kPa)



(Conversion Unit: 1 ft = 0.3048 m, 1 psf = 47.88 Pa, 1lb/ft^2 = 4.8824 kg/m^2)

Designing roofs to resist wind uplift

Wind-RCI Report

Wind loads for roof cladding

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End zone width, Z	15 ft (4.6 m)
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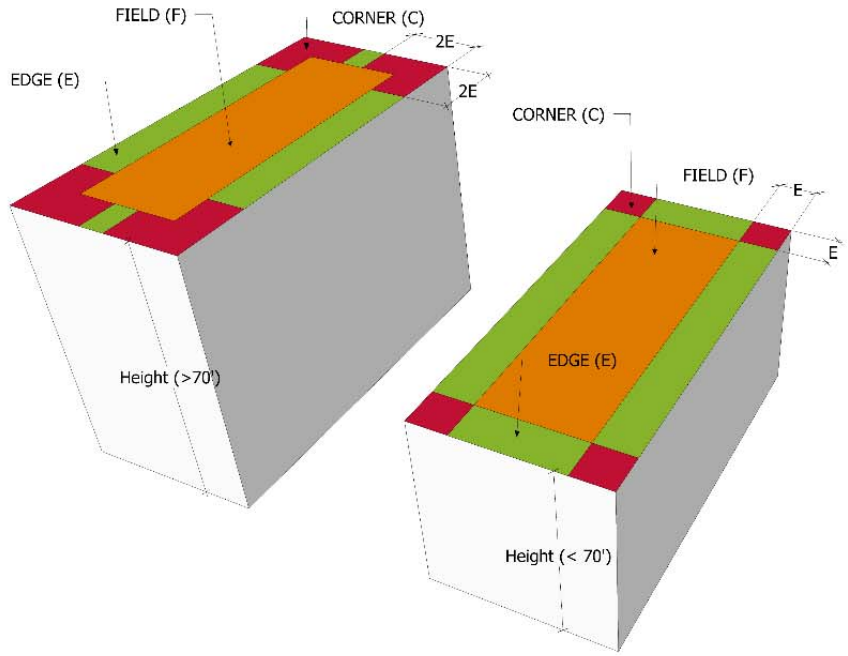
Designing roofs to resist wind uplift

Roof Zones



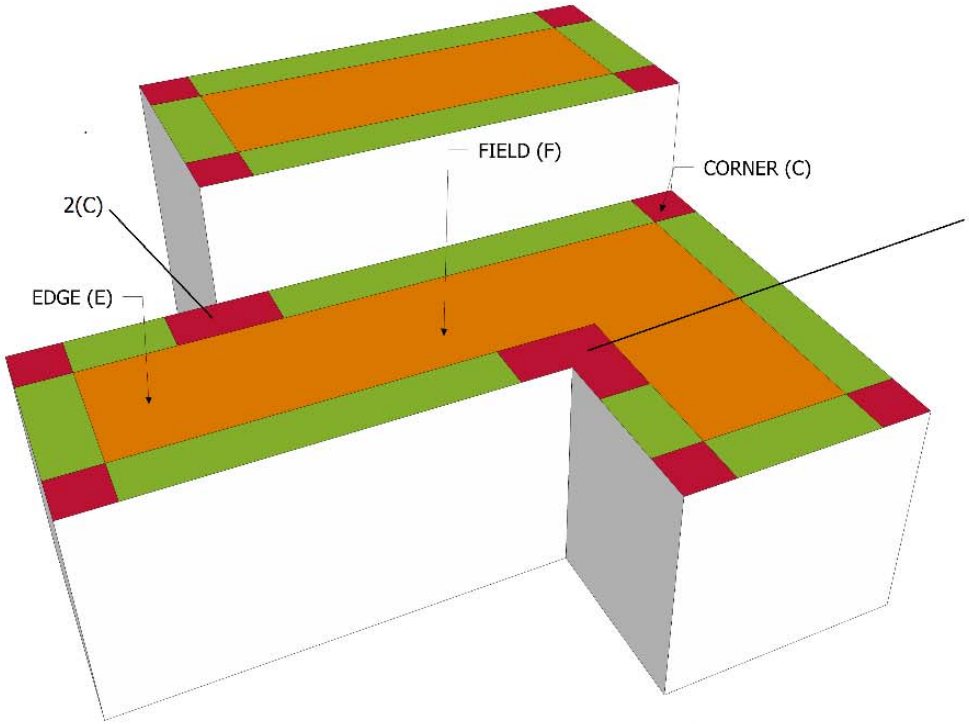
Three roof zones:
- Field
- Edge
- Corners

The Corner dimensions are always a function of the Edge width.

When structures exceed 21.3 m (70') in height, Corners double in size (2E).

Designing roofs to resist wind uplift

Roof Zones for Multiple Levels

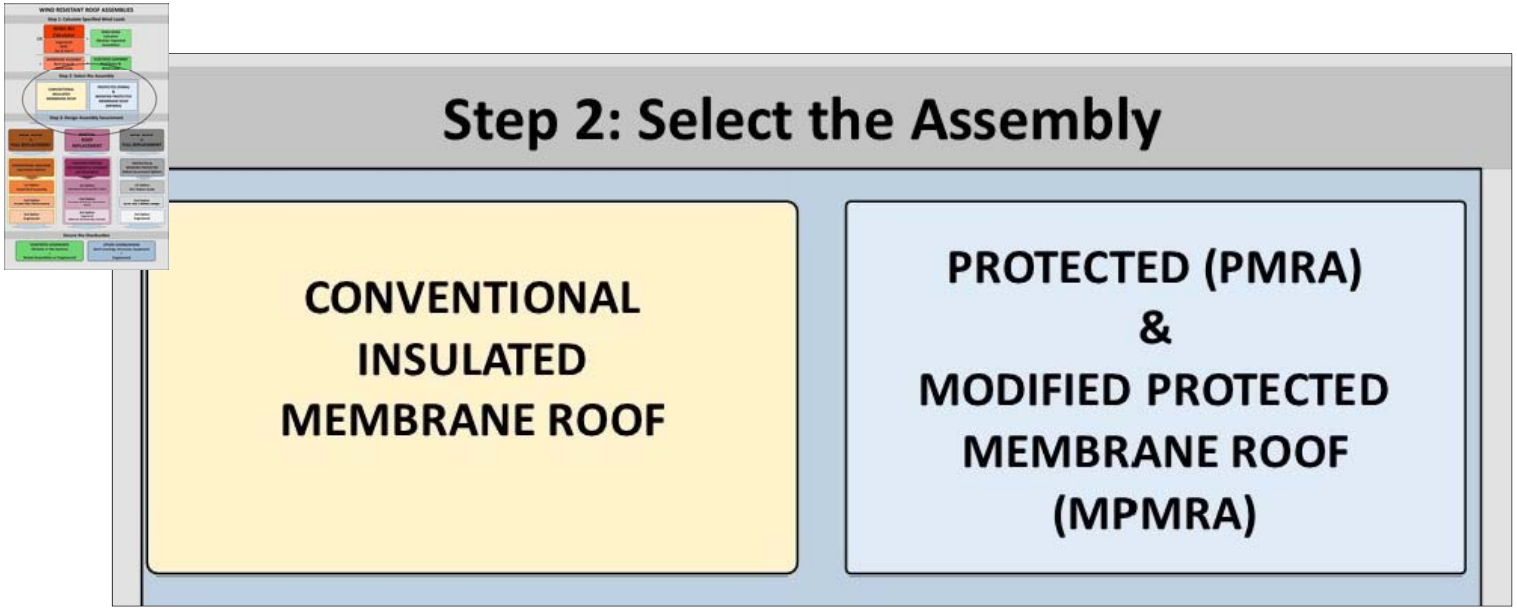


Inside corners should be regarded as vulnerable roof zones and doubled in length along both legs of the roof area.

Note that the Field (F) zone is contiguous across the full roof area

Designing roofs to resist wind uplift

STEP 2: Choose an Assembly Type



Designing roofs to resist wind uplift

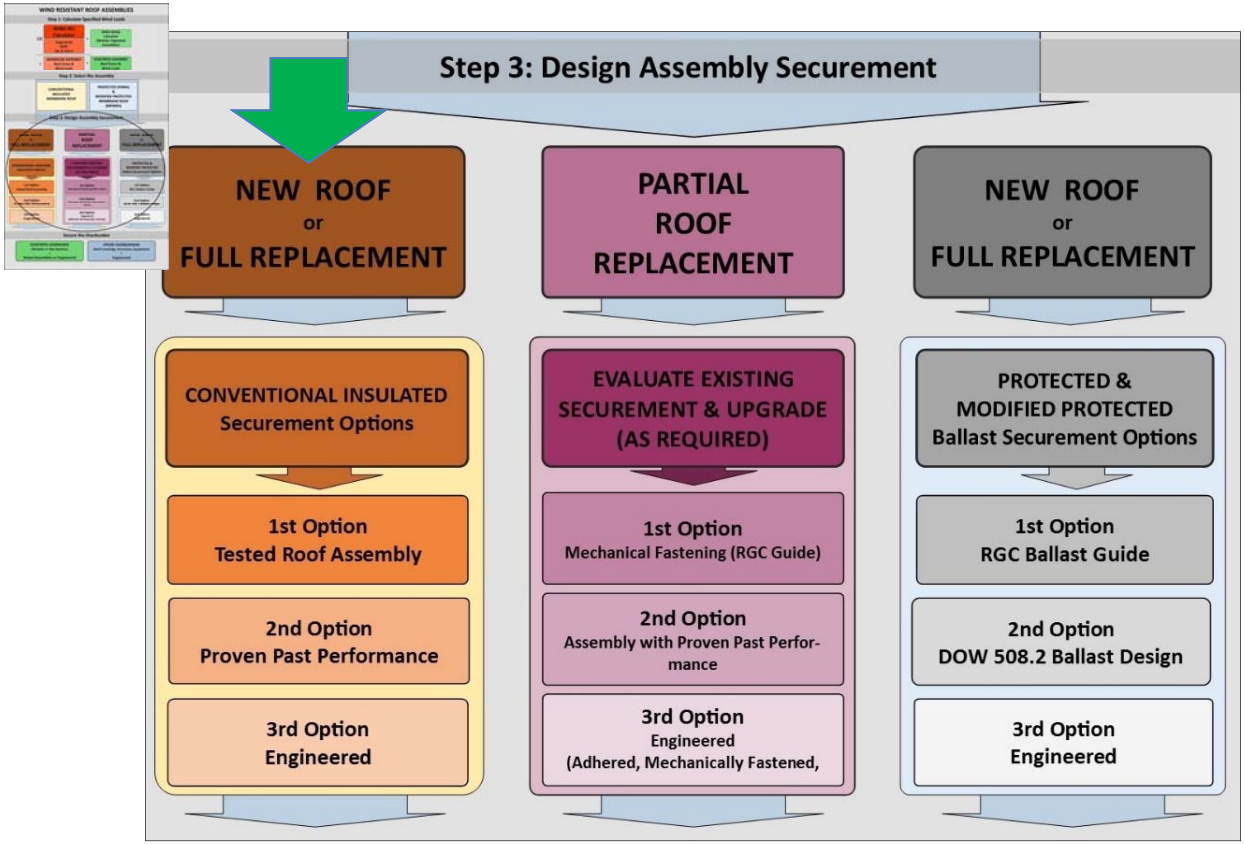
Conventionally Insulated

Designing roofs to resist wind uplift

Protected or Modified Protected

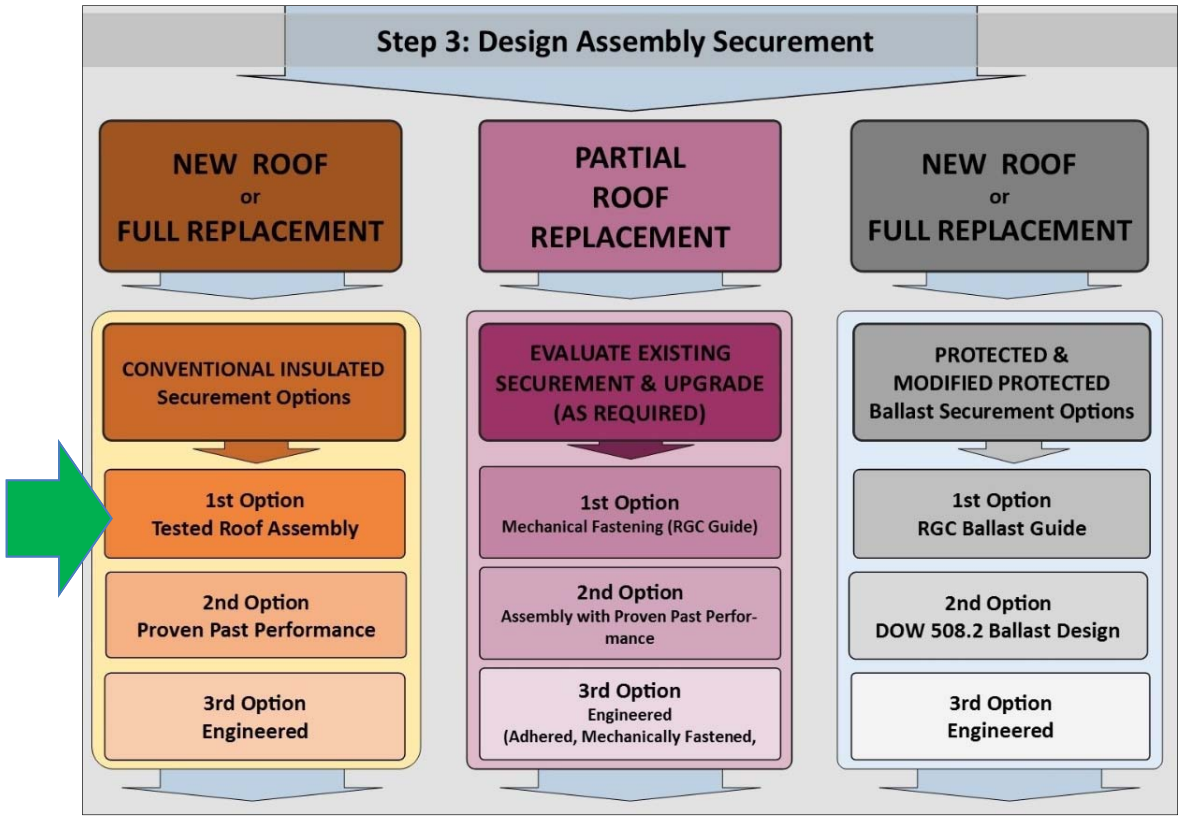
Designing roofs to resist wind uplift

STEP 3: Design Roof Securement



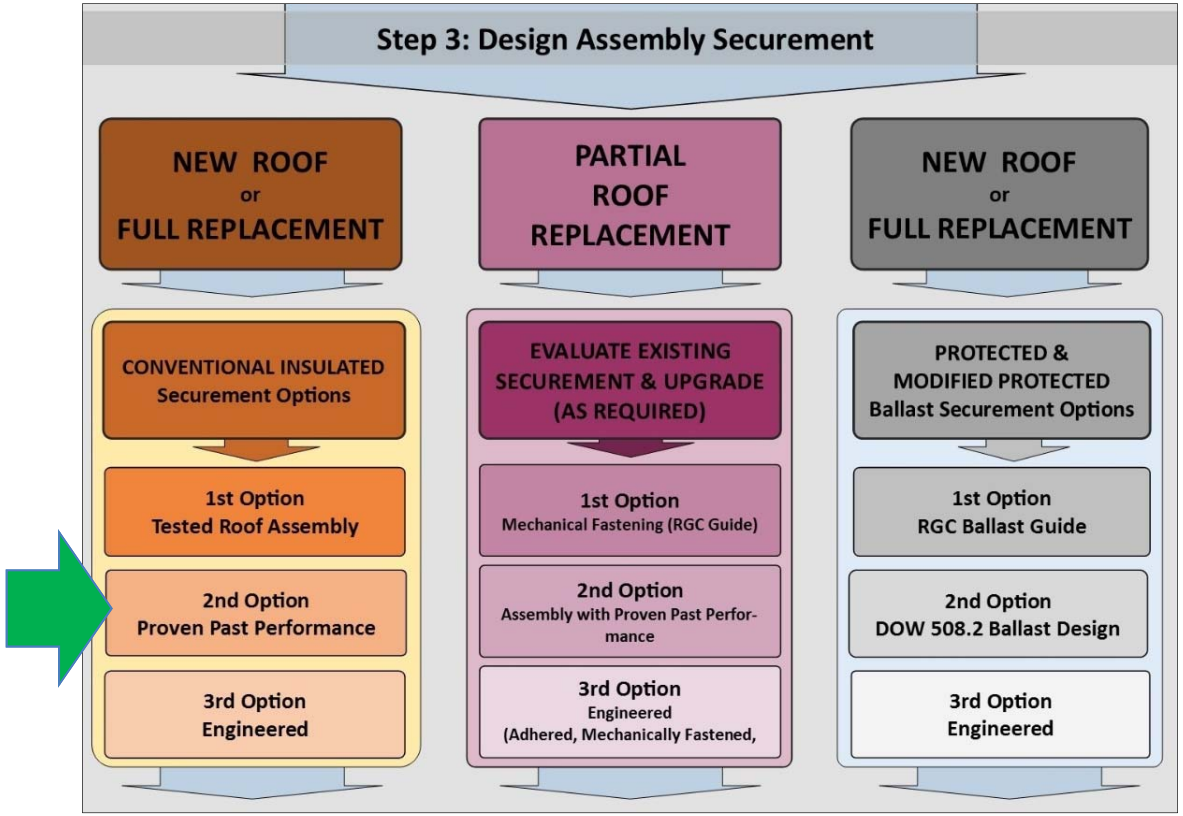
Designing roofs to resist wind uplift

Option 1:Tested Assembly



Designing roofs to resist wind uplift

Option 2: System with Proven Performance



Designing roofs to resist wind uplift

Option 2: Proven Past Performance

- An acceptable alternative to Tested Assembly

Designing roofs to resist wind uplift

Option 2: Proven Past Performance

- An acceptable alternative to Tested Assembly
- Use RoofStar Accepted Materials

Designing roofs to resist wind uplift

Option 2: Proven Past Performance

- An acceptable alternative to Tested Assembly
- Use RoofStar Accepted Materials
- System has a proven track record of wind uplift resistance

Designing roofs to resist wind uplift

Option 2: Proven Past Performance

- An acceptable alternative to Tested Assembly
- Use RoofStar Accepted Materials
- System has a proven track record of wind uplift resistance
  - For at least as long as the expected life of the roof assembly

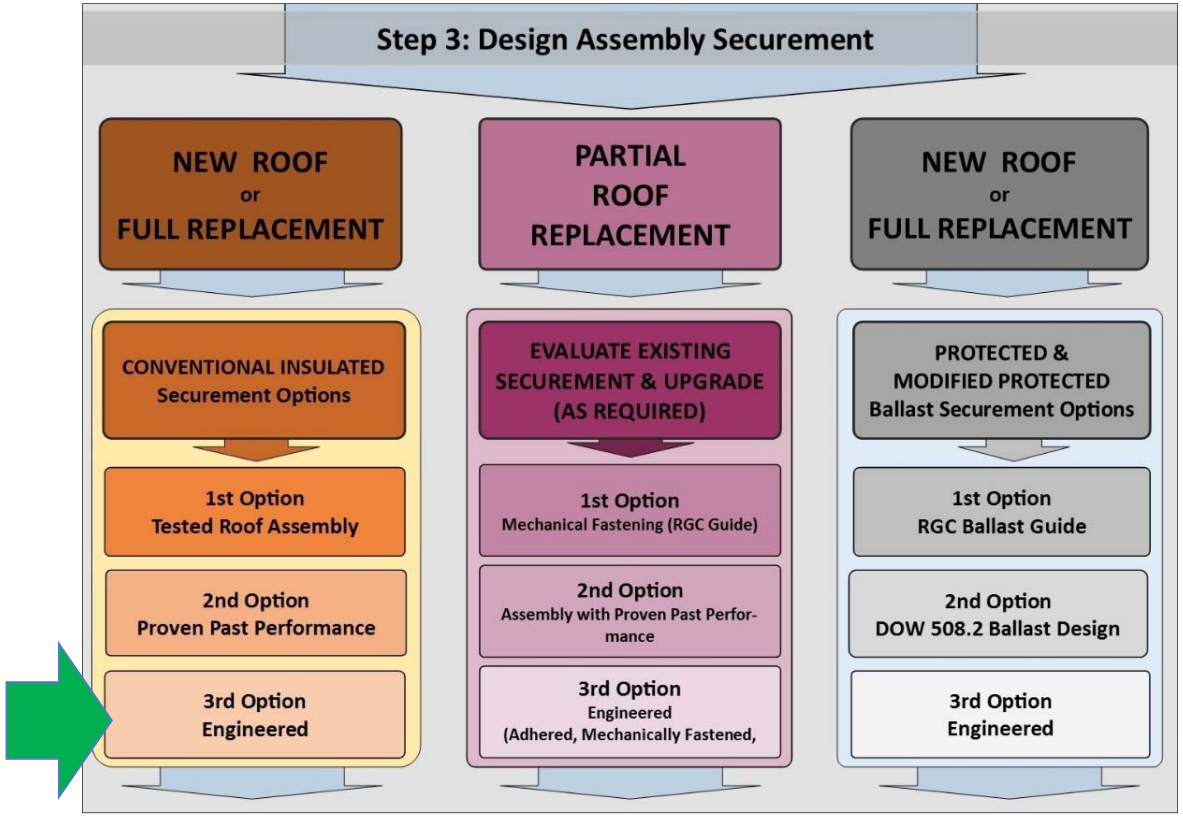
Designing roofs to resist wind uplift

Option 2: Proven Past Performance

- An acceptable alternative to Tested Assembly
- Use RoofStar Accepted Materials
- System has a proven track record of wind uplift resistance
  - For at least as long as the expected life of the roof assembly
  - For buildings, and in conditions, that are reasonably representative of the Project

Designing roofs to resist wind uplift

Option 3: Engineered Securement



Designing roofs to resist wind uplift

Option 3: Custom-engineered Securement

- Another acceptable option

Designing roofs to resist wind uplift

Option 3: Custom-engineered Securement

- Another acceptable option
- Applicable to buildings that don't conform to the Wind-RCI modeling parameters

Designing roofs to resist wind uplift

Option 3: Custom-engineered Securement

- Another acceptable option
- Applicable to buildings that don't conform to the Wind-RCI modeling parameters
- Useful when a Tested Assembly or an assembly with Proven Past Performance isn't available

Designing roofs to resist wind uplift

Option 1:Tested Assembly

Building parameters

Building location: Vancouver Region, Burnaby (Simon Fraser Univ.), British Columbia

Building geometry:

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Designing roofs to resist wind uplift

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Designing roofs to resist wind uplift

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Designing Roofs to Resist Wind Uplift

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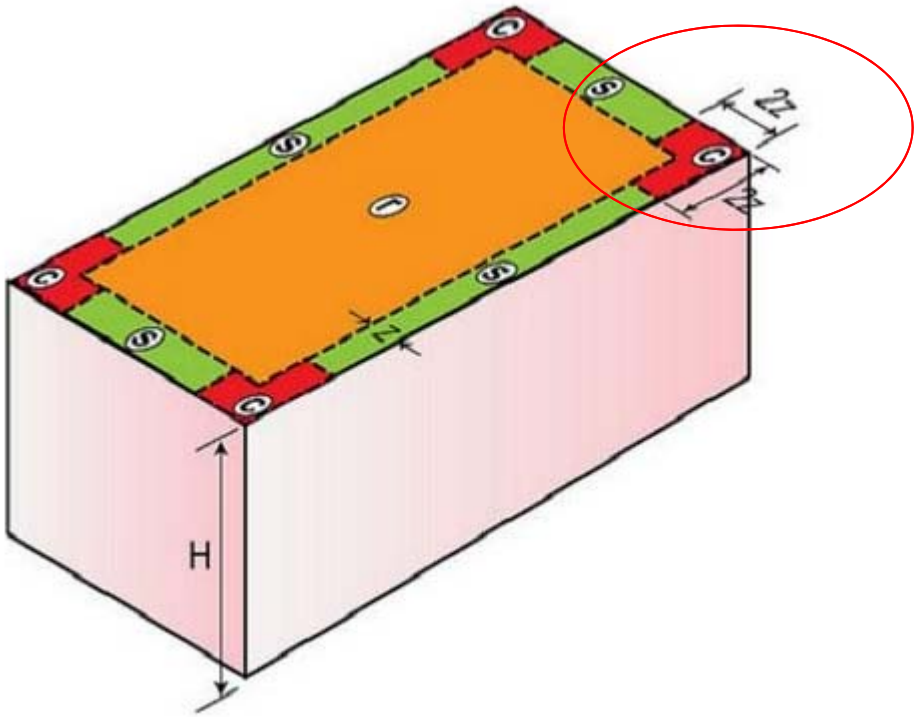
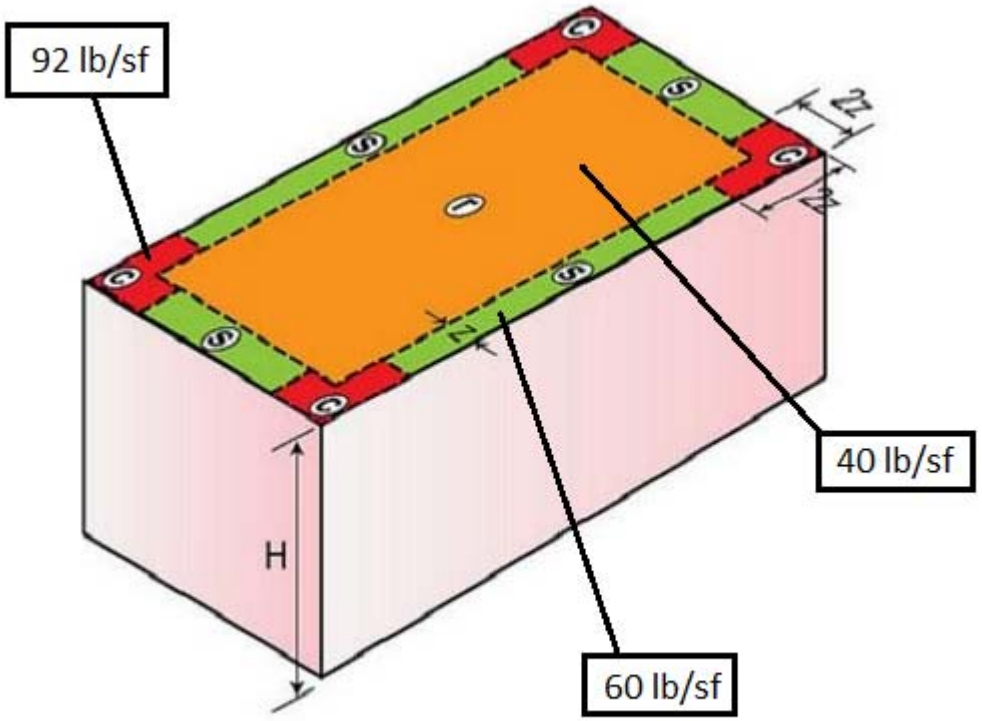


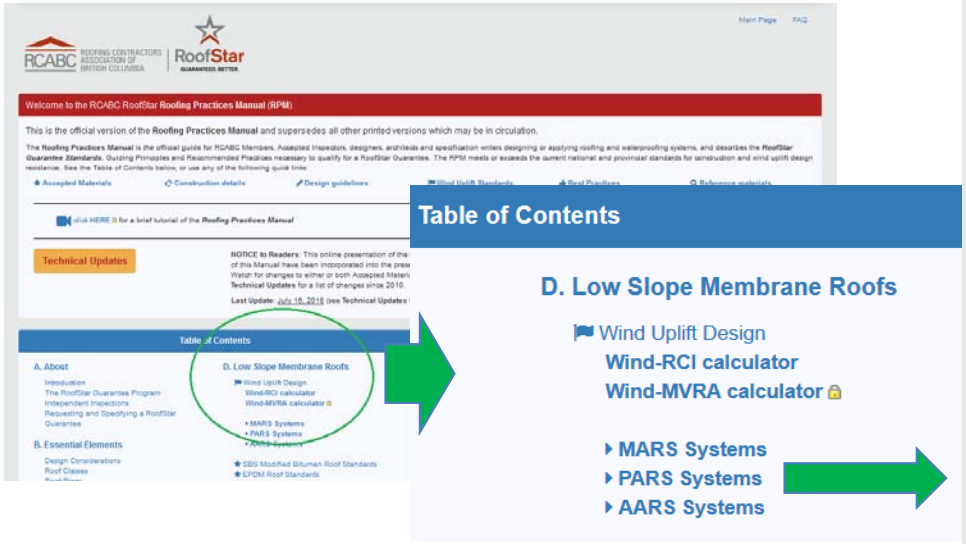
Designing Roofs to Resist Wind Uplift

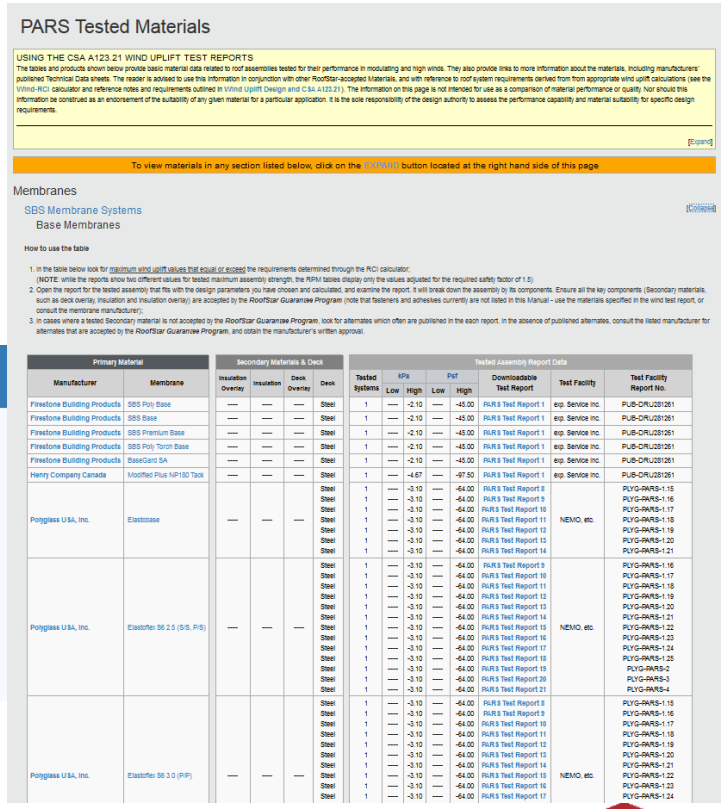
Option 1:Tested Assembly



Designing Roofs to Resist Wind Uplift

Option 1:Tested Assembly





Designing Roofs to Resist Wind Uplift

Option 1:Tested Assembly

					Steel	1	——	-3.10	——	-64.00	PARS Test Report 6		PLYG-PARS-1.13
					Steel	1	——	-3.10	——	-64.00	PARS Test Report 7		PLYG-PARS-1.14
MANUFACTURER	PRODUCT	——	——	——	Steel	1	——	-2.23	——	-46.67	PARS Test Report 3	Intertek	E9988.03-109-44
					Steel	1	——	-3.35	——	-70.00	PARS Test Report 4	Intertek	E9988.05-109-44
					Steel	1	——	-2.87	——	-60.00	PARS Test Report 5	Intertek	E9988.06-109-44
					Steel	1	——	-2.90	——	-60.00	PARS Test Report 8	exp. Service Inc.	SIPZ-DRS-00215482-01-5100
MANUFACTURER	PRODUCT	——	——	——	Plywood	1	——	-1.40	——	-30.00	PARS Test Report 2	Intertek	E998.02-109-44
					Steel	1	——	-1.80	——	-37.00	PARS Test Report 6	exp. Service Inc.	SIPZ-DRS-00221706-02-5100
					Steel	1	——	-2.86	——	-60.00	PARS Test Report 7	exp. Service Inc.	SIPZ-DRS-00221706-01-5100
					Steel	1	——	-1.46	——	-30.00	PARS Test Report 9	exp. Service Inc.	SIPZ-DRS-00221706-03-5100
MANUFACTURER	PRODUCT	——	——	——	Steel	1	——	-1.90	——	-40.00	PARS Test Report 1	Intertek	E9988.01-109-44
MANUFACTURER	PRODUCT	——	——	——	Steel	1	——	-2.90	——	-60.00	PARS Test Report 2		PUB-DRU293332
					Steel	4	-1.40	-3.40	-30.00	-70.00	PARS Test Report 3	exp. Service Inc.	PUB-DRU304337
					Steel	3	-2.10	-5.00	-45.00	-105.00	PARS Test Report 5		PUB-DRU293389
MANUFACTURER	PRODUCT	——	——	——	Steel	3	-1.40	-2.80	-30.00	-58.00	PARS Test Report 1	exp. Service Inc.	PUB-DRU305544
MANUFACTURER	PRODUCT	——	——	——	Steel	1	——	-2.90	——	-60.00	PARS Test Report 2	exp. Service Inc.	PUB-DRU293332
					Steel	4	-1.40	-3.40	-30.00	-70.00	PARS Test Report 3		PUB-DRU304337
MANUFACTURER	PRODUCT	——	——	——	Steel	1	——	-2.90	——	-60.00	PARS Test Report 2		PUB-DRU293332
					Steel	4	-1.40	-3.40	-30.00	-70.00	PARS Test Report 3	exp. Service Inc.	PUB-DRU304337
					Steel	3	-2.10	-5.00	-45.00	-105.00	PARS Test Report 5		PUB-DRU293389
MANUFACTURER	PRODUCT	——	——	——	Steel	1	——	-2.90	——	-60.00	PARS Test Report 2		PUB-DRU293332
					Steel	4	-1.40	-3.40	-30.00	-70.00	PARS Test Report 3	exp. Service Inc.	PUB-DRU304337
					Steel	3	-2.10	-5.00	-45.00	-105.00	PARS Test Report 5		PUB-DRU293389

Designing Roofs to Resist Wind Uplift

Option 1:Tested Assembly

					Steel	1	----	-3.10	----	-64.00	PARS Test Report 6		PLYG-PARS-1.13
					Steel	1	----	-3.10	----	-64.00	PARS Test Report 7		PLYG-PARS-1.14
MANUFACTURER	PRODUCT	----	----	----	Steel	1	----	-2.23	----	-46.67	PARS Test Report 3	Intertek	E9988.03-109-44
					Steel	1	----	-3.35	----	-70.00	PARS Test Report 4	Intertek	E9988.05-109-44
					Steel	1	----	-2.87	----	-60.00	PARS Test Report 5	Intertek	E9988.06-109-44
					Steel	1	----	-2.90	----	-60.00	PARS Test Report 8	exp. Service Inc.	SIPZ-DRS-00215482-01-5100
MANUFACTURER	PRODUCT	----	----	----	Plywood	1	----	-1.40	----	-30.00	PARS Test Report 2	Intertek	E998.02-109-44
					Steel	1	----	-1.80	----	-37.00	PARS Test Report 6	exp. Service Inc.	SIPZ-DRS-00221706-02-5100
					Steel	1	----	-2.86	----	-60.00	PARS Test Report 7	exp. Service Inc.	SIPZ-DRS-00221706-01-5100
					Steel	1	----	-1.46	----	-30.00	PARS Test Report 9	exp. Service Inc.	SIPZ-DRS-00221706-03-5100
MANUFACTURER	PRODUCT	----	----	----	Steel	1	----	-1.90	----	-40.00	PARS Test Report 1	Intertek	E9988.01-109-44
MANUFACTURER	PRODUCT	----	----	----	Steel	1	----	-2.90	----	-60.00	PARS Test Report 2		PUB-DRU293332
					Steel	4	-1.40	-3.40	-30.00	-70.00	PARS Test Report 3	exp. Service Inc.	PUB-DRU304337
					Steel	3	-2.10	-5.00	-45.00	-105.00	PARS Test Report 5		PUB-DRU293389
MANUFACTURER	PRODUCT	----	----	----	Steel	3	-1.40	-2.80	-30.00	-58.00	PARS Test Report 1	exp. Service Inc.	PUB-DRU305544
MANUFACTURER	PRODUCT	----	----	----	Steel	1	----	-2.90	----	-60.00	PARS Test Report 2	exp. Service Inc.	PUB-DRU293332
					Steel	4	-1.40	-3.40	-30.00	-70.00	PARS Test Report 3		PUB-DRU304337
MANUFACTURER	PRODUCT	----	----	----	Steel	1	----	-2.90	----	-60.00	PARS Test Report 2		PUB-DRU293332
					Steel	4	-1.40	-3.40	-30.00	-70.00	PARS Test Report 3	exp. Service Inc.	PUB-DRU304337
					Steel	3	-2.10	-5.00	-45.00	-105.00	PARS Test Report 5		PUB-DRU293389
MANUFACTURER	PRODUCT	----	----	----	Steel	1	----	-2.90	----	-60.00	PARS Test Report 2		PUB-DRU293332
					Steel	4	-1.40	-3.40	-30.00	-70.00	PARS Test Report 3	exp. Service Inc.	PUB-DRU304337
					Steel	3	-2.10	-5.00	-45.00	-105.00	PARS Test Report 5		PUB-DRU293389

Designing Roofs to Resist Wind Uplift

Option 1:Tested Assembly

1 Tested System	----	-2.90	----	-60.00	Steel	PARS Test Report 2
4 Tested Systems	-1.40	-3.40	-30.00	-70.00	Steel	PARS Test Report 3
3 Tested Systems	-2.10	-5.00	-45.00	-105.00	Steel	PARS Test Report 5

Designing Roofs to Resist Wind Uplift

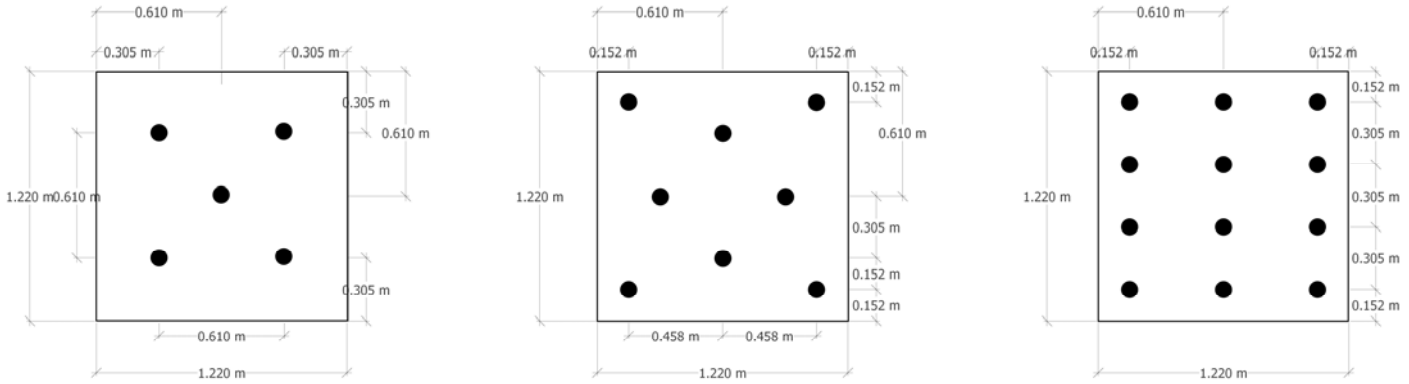
Option 1:Tested Assembly

- Dynamic Uplift Resistance (DUR)as per CSA A123.21:

Description	Test observation reading	With SF of 1.5
System A	-3.2 kPa (-67 psf)	**-2.1 kPa(-45 psf)**
System B	-5.4 kPa (-112 psf)	**-3.6 kPa (-75 psf)**
System C	-7.5 kPa (-157 psf)	**-5.0 kPa (-105 psf)**

Designing Roofs to Resist Wind Uplift

Option 1:Tested Assembly



Fastening patterns from a published Tested Assembly report, illustrating three securement systems

Designing Roofs to Resist Wind Uplift

What about partial roof replacements?

Designing Roofs to Resist Wind Uplift

What about partial roof replacements?

- The Design Authority still must calculate Specified Wind Loads

Designing Roofs to Resist Wind Uplift

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Designing Roofs to Resist Wind Uplift

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- The Design Authority still must calculate Specified Wind Loads
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  - Use proven fastener numbers and patterns in the RPM

Designing Roofs to Resist Wind Uplift

What about partial roof replacements?

- The Design Authority still must calculate Specified Wind Loads
- Mechanical fastening is always the best approach
  - Use proven fastener numbers and patterns in the RPM
  - When mechanical fastening is not an option,
    - custom-engineer the roof securement, or
    - use a system with *Proven Past Performance*

Designing Roofs to Resist Wind Uplift

And how about Protected roofs?

Designing Roofs to Resist Wind Uplift

And how about Protected roofs?

- Calculate *Specified Wind Loads*

Designing Roofs to Resist Wind Uplift

And how about Protected roofs?

- Calculate *Specified Wind Loads*
- Consult ballast guides for appropriate ballast coverings:
  - RGC Ballast Guide
  - DOW 508.2 Ballast Design Guide
  - Custom-engineered securement

Summary

- Why wind matters

Summary

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  - An underestimated, underappreciated force of nature

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  - Capable of damaging or destroying entire roofs

Summary

- Why wind matters
  - An underestimated, underappreciated force of nature
  - Capable of damaging or destroying entire roofs
  - Can render a building unsafe and vulnerable to water

Summary

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Summary

- Why wind matters
- Code requirements

Summary

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  - BCBC now requires roofs designed and built to resist Specified Wind Loads

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Summary

- Why wind matters
- Code requirements
  - BCBC now requires roofs designed and built to resist Specified Wind Loads
  - FM Global standards don’t apply and cannot be used to comply with BCBC
  - RCABC’s RPM provides guidance for complying with BCBC

Summary

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- Code requirements
- Designing roofs to resist wind

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  - 3 pathways to success:

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    - ✓ STEP 1: Calculate Specified Wind Loads

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Summary

- Why wind matters
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- Designing roofs to resist wind
  - 3 pathways to success:
    - ✓ STEP 1: Calculate Specified Wind Loads
    - ✓ STEP 2: Choose path based on type of roof
    - ✓ STEP 3: Design the roof securement using a:
      - – Tested Assembly
      - – Assembly with Proven Past Performance
      - – Custom-engineered assembly

Thank you. Any Questions?

RCABC ROOFING CONTRACTORS ASSOCIATION OF BRITISH COLUMBIA

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