I have a feeling we're not in Kansas anymore, Toto (Part 3)

Designing low-slope roofs for wind uplift resistance

In Part 1 of this article, we examined the nature and power of wind and negative pressure loads on roof surfaces, and reviewed code requirements for roof design. In Part 2, we broke down the BCBC and NBCC requirements into three steps and looked at ways to effectively design a wind-resistant roof.

Photo credit: Tony Delessio

In this third of three parts, we describe how the Design Authority can effectively specify wind-resistance requirements for a roof project, and briefly talk about the responsibilities of the roofing contractor.

Incorporating wind resistant roof design in project specifications

A good specification clearly expresses the nature, scope, general design and details of the building project, and articulates a well-rounded understanding of the responsibilities borne both by the *Design Authority* and by contractors who put it all together. To ensure a roof is wind-resistant, designers and contractors have different and complementary roles and responsibilities.

Article **5.2.2.2.** (BCBC) states that "…the wind load…shall be 100% of the specified wind load [for the roof]…" By *specified wind load*, the BCBC means the negative pressure wind exerts on the roof (Div. B, 4.1.7.1 Specified Wind Load). The Design Authority is ideally positioned to do this – determine the negative wind loads for each of three roof zones, and then clearly list those values in the construction specifications as criteria for selecting a Tested Assembly or an acceptable alternative.

There are two fundamental approaches to specifying the application of the BCBC (or NBCC) and ***RoofStar Guarantee Standards***:

a) Specifying the *actual roof assembly* and listing the component materials (what we'll call the **prescriptive** approach)
b) Specifying the *type of assembly* but leaving the selection of a Tested Assembly or even an assembly with Proven Past Performance to the contractor (the **descriptive** approach)

The ***prescriptive approach*** is really the traditional method of specification writing. In this approach, the Specification lists the materials to be used, perhaps together with approved alternates (commonly done). The *Design Authority* must include the following in the project specification:

1. List the Specified Wind Loads for the roof
2. Provide details of the Roof Securement Design, either by
    a) Identification of a specific Tested Assembly that matches the listed materials, or
    b) A clearly described assembly with "Proven Past Performance", supported by design calculations and clear fastening patterns and descriptions. These proven assemblies are

typically offered by manufacturers who are confident the assembly will meet the Specified Wind Load calculations for the roof (also a provision in the NBCC)

c) Description and details of a specific securement system designed by an engineer to meet or exceed the wind load calculations using ANSI/SPRI WD-1.

In the ***descriptive approach***, the *Design Authority* may elect to specify only the wind load requirements, roof system, and attachment methodology (MARS, PARS or AARS), and leave the selection of securement to either an engineer or the roofing contractor. In any event, securement details, inclusive of clear fastening patterns and descriptions, should be submitted to the Design Authority for review and approval.

Certainly, a Specification need not be wide open for interpretation by the contractor and could include some parameters, such as restrictions on the type or brand of membrane and insulation.

Blending the prescriptive and descriptive approaches will prove problematic. The best specifications offer one approach or the other, but not both.

Square pegs and round holes

Sometimes, the Tested Assembly approach won't work. For example, it sometimes is the case that not every material component in a Tested Assembly also is accepted for use in the ***RoofStar Guarantee Program***[1]. Switching out materials changes the Tested Assembly into a 'non-tested' assembly (BCBC, Div. B, Note A-5.2.2.2(4), paragraph four, **Membrane Roofing Systems**). When that happens, what is the *Design Authority* to do?

It also happens that some roof decks have not been tested with roof systems, or that some materials haven't yet been tested as part of an assembly. And, of course, the Wind-RCI calculator is limited to buildings up to 150 feet in height, which presents the designer with challenges for these 'non-conforming' structures. How might the designer handle this challenge?

Let's take a brief look at each of these issues, and what can be done to satisfy the requirements of the ***RoofStar Guarantee Program*** and the intent of both the BCBC and NBCC.

Switching material components in a Tested Assembly

Thankfully, many Tested Assemblies list various alternates for material components, even for membranes. This means that the *Design Authority* or Contractor is likely to find a Tested Assembly that uses material components which are tested to meet the CAN/CSA A123.21 Standard, and which are accepted for use in the ***RoofStar Guarantee Program.***

Unfortunately, not all Tested Assemblies make these kinds of provisions. Consequently, when a material component in a Tested Assembly must be switched out for one that is accepted by the ***RoofStar Guarantee Program***, and the replacement component material is not listed in the Tested Assembly report as an acceptable alternate, the assembly ceases to be "tested" and must now be considered 'non-tested'. To some readers, it may seem that the risk is small when swapping one material component for another, particularly in a MARS or PARS assembly (for example, switching brands of the same type of

[1] The RoofStar Guarantee Program relies upon select materials that have been submitted by manufacturers, approved for use in the Program by a Technical Committee and the Board of Directors, and are independently backed by a Material Performance Bond.

Polyisocyanurate insulation). However, the adhesion of one layer to another in an adhesive-bonded assembly may be material-specific, simply because the chemical bond between an adhesive and the face of a material component can be peculiar to that material and isn't necessarily a trait shared with others. In other words, don't count on one material to behave the same as another, even if they are bonded in the assembly using the same adhesive and methods.

Under these circumstances, the *Design Authority* may choose one of the following options, to meet the requirements for a Guarantee:

a) Ask the membrane manufacturer for written assurance that a substituted material will achieve the same results as the Tested Assembly, and include that written assurance with the Tender Package. The assembly and the test is, after all, theirs and they will know if a substitution is permissible.
b) Switch Tested Assemblies, or switch to a different *kind* of system, i.e. from AARS to PARS, and then locate a Tested Assembly that works for you. A lot depends on what kind of supporting deck you have to work with, but often test reports will tell the reader if the tested system will work on alternative supporting decks.
c) Use an assembly with 'Proven Past Performance'.
d) Have a qualified professional engineer design the roof assembly and its securement for you.

The NRC is currently reviewing protocols for material substitutions, and while they have not offered written guidance on the subject, the RPM will be updated as soon as further information is available.

What to do with 'Non-Conforming' buildings

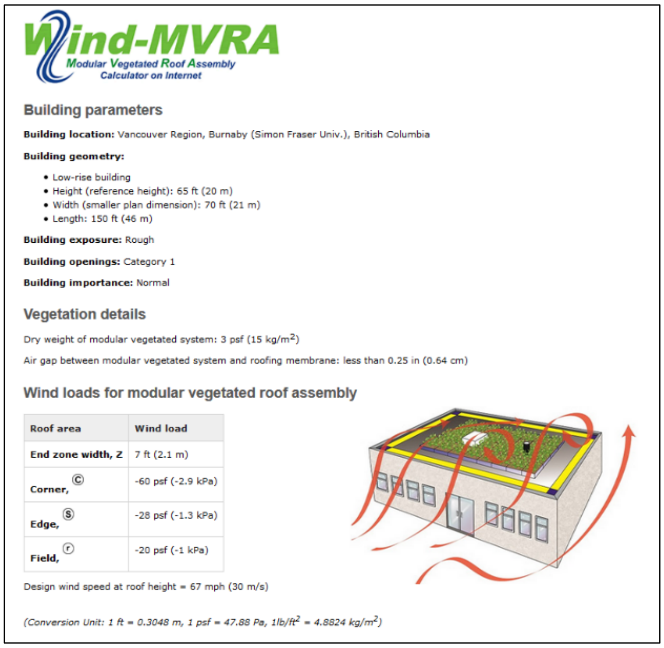
Buildings that the Wind-RCI calculator is not configured for are called 'non-conforming' in the ***RoofStar Guarantee Standards***. These typically are high-rise complexes taller than 150 feet. Unfortunately, there are no easy tools like the Wind-RCI calculator to make this job any easier; wind loads and fastener or adhesive patterns must be determined through independent engineering. Look to the BCBC and NBCC for design criteria, formulas and tables with wind load data. You may also need to consult the **Canadian Wind Energy Atlas**, an online resource that provides mean wind speed and energy data for every region, filterable by elevation above the surface.

Ballast, overburdens and vegetated assemblies

Roofs that are designed to be held in place with ballast, or that support a wearing or growing surface, require different methods of securement, depending on the type of roof. For example, a vegetated assembly can be installed on a conventionally insulated roof or a Modified Protected Membrane roof. The insulated roof itself will have to be designed to withstand the Specified Wind Loads for the structure, but the vegetated roof assembly that literally lies on top also will have to be designed to withstand wind. The Specified Wind Loads for modular vegetated assemblies – that is, assemblies comprised of interlocking trays or adjacent mats of growing plants – must be calculated using the Wind-MVRA calculator. The *Design Authority* will then need to work with that data to design the set-backs for the assembly, so that it is assembled far enough away from roof edges to ensure it remains in place when winds blow.

Vegetated assemblies that are not modular should be custom-engineered for their securement. If wind can scour river rock from a roof, wind can also move or remove both vegetation and growing media. An engineer will be able to assist the *Design Authority* in determining the best way to install vegetation on these projects, and even make decisions about the finer details, such as how to secure trees in planters.

Ballasted roofs present other challenges. PMRAs are designed so that gravel or paver ballast holds down the drainage layers, insulation and filter material. For a generic, conservative approach to gravel ballast sizing and volume, refer to the guide in the **Roofing Practices Manual**. Otherwise, look to proprietary



guides such as the DOW Chemical TECH SOLUTIONS 508.2 Ballast Design Guide, which offers an approach based on building geometry and ballast characteristics.

For other types of overburdens, there is no template the *Design Authority* can turn to, to ensure the 'stuff' on the roof stays where it's installed. A qualified engineer will be able to assist with the appropriate calculations and necessary methods for securement.

Installing the Roof

Once the design is complete, the roofing contractor is obligated to install the specified roof system and its securement design. Project specifications need to provide enough detail for the contractor to work with, including copies of test reports and fastener or adhesive pattern diagrams.

It's tempting to think that any fastener, plate or adhesive type will work, but contractors must strictly adhere to the ***RoofStar Guarantee Standards*** or to the specific requirements published in a Tested Assembly, mandated by the manufacturer of an assembly with Proven Past Performance, or detailed in an engineering specification (whichever is greater). Screw-type fastener pull-out strength increases with fastener size, which is why membranes are secured with #14 fasteners while the other roof components are normally fastened with #12 screws. Mixing these up, and using unspecified or untested adhesives, could make the difference between success and disaster.

Finally, while this article is primarily focused on conventionally insulated roofs, application standards and proper training make all the difference between a roof that stays where it's built, and one that ends up on the ground. The ***RoofStar Guarantee Standards*** provide clear guidelines for Best Practices that make our Guarantee outstanding in its field. See the entire manual at www.rcabc.org.

Not in Kansas anymore, Dorothy: looking ahead

Our climate is changing. A 2017 report produced by Metro Vancouver indicates significant climate and local weather pattern change over the next three decades, affecting mean seasonal temperatures, wind and rainfall. Similar changes are anticipated for other regions of British Columbia, and we are witnessing considerable climate shifts across the province.

We already know that wind events are stronger than they were one or two decades ago, even if their frequency seems no different. Knowing this, the NRC is already reviewing its work behind CAN/CSA A123.21, and may recommend significant revisions to the Standard for future iterations of the NBCC, including revised safety factors. We anticipate parallel changes to the British Columbia Building Code.

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

Designing a roof to meet the demands of the future is what we are about. Our ***RoofStar Guarantee Standards*** are as dynamic as the climate we live with. Watch for further changes to our Guarantee Standards as we work with the NRC to develop new, improved wind resistance standards to ensure roofs stay where they're built.

We've authored the book on great roofing design and construction standards. Learn more about our ***RoofStar Guarantee Program*** at http://www.rcabc.org/, or visit our Roofing Practices Manual at rpm.rcabc.org/.

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