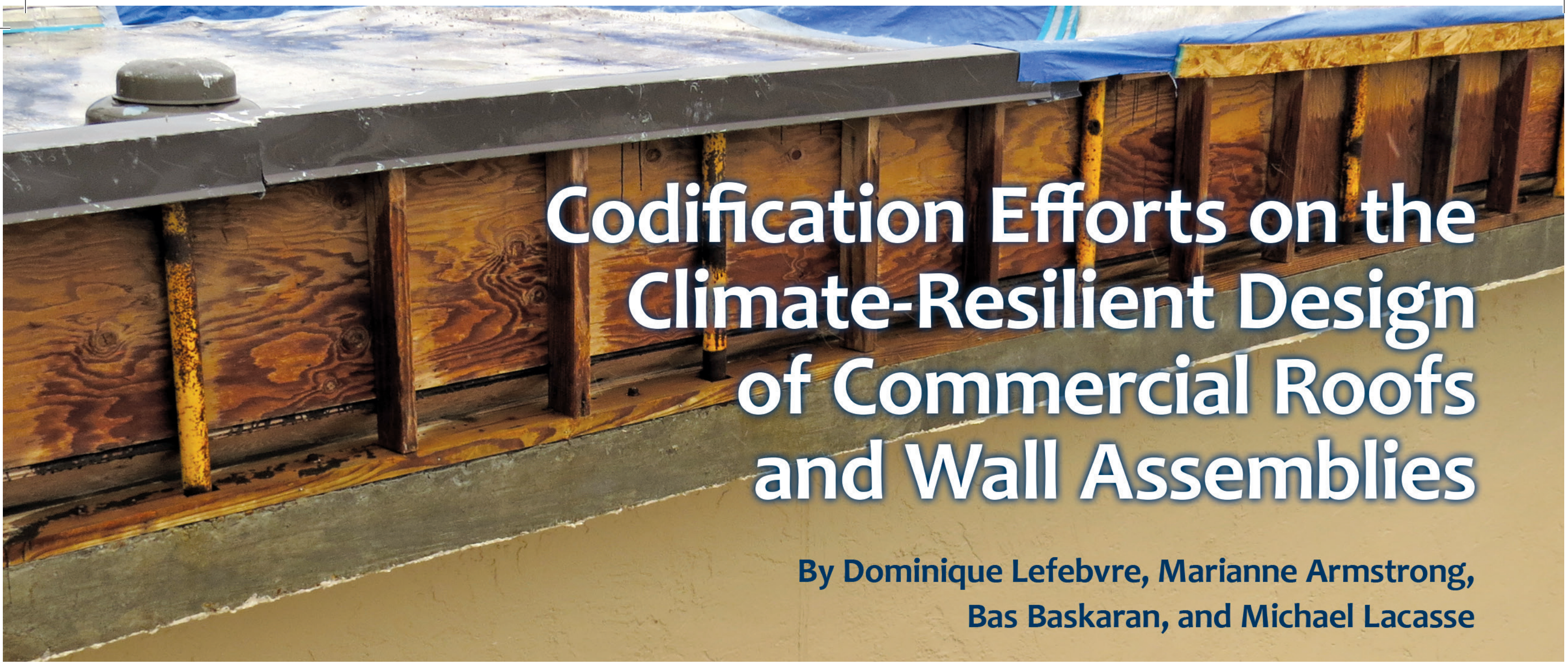

Codification Efforts on the Climate-Resilient Design of Commercial Roofs and Wall Assemblies

By Dominique Lefebvre, Marianne Armstrong, Bas Baskaran, and Michael Lacasse

ABSTRACT

This article highlights recent Canadian advancements towards codification efforts on the climate-resilient design of commercial roofs and wall assemblies. The roofing advancements on climate resilience have led to the drafting of a new standard—CSA A123.26, *Performance Requirements for Climate Resilience of Low Slope Membrane Roofing Systems*. The wall assembly research has led to the conversion of CSA S478-95 (R2007), *Guideline on Durability in Buildings* to CSA S478-19, *Standard for the Durability of Buildings*. The intent is to include the two standards (CSA A123.26 and CSA S478-19) into the National Building Code of Canada to provide essential tools to the industry on how to adapt to the changing climate and how to ensure resilience and durability.

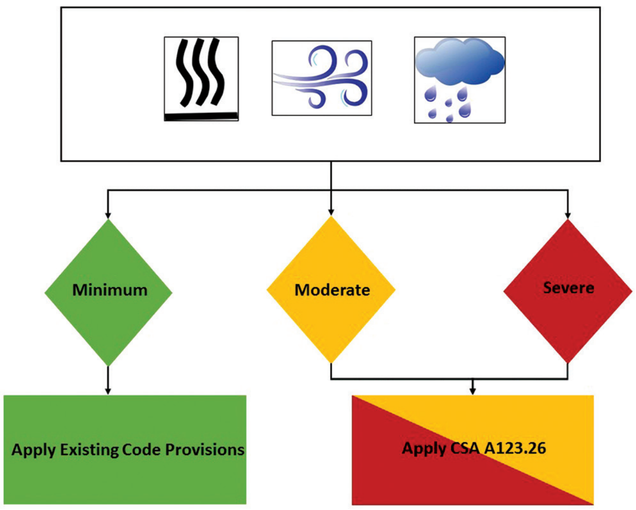

Figure 1 – Framework for standard under development for climate adaptation of low-slope membrane roofing systems (LSMRSs).

INTRODUCTION

Climate projections show past, current, and future greenhouse gas (GHG) emissions will influence the climate for decades.[1] Designs can no longer be based on the assumption that the past climate represents the future conditions wherein the new and existing buildings are expected to perform. As such, it is the collective responsibility of the industry (designers/manufacturers/installers) to adapt for the extreme events in designs, rehabilitation measures, and regulations.

To begin to address this challenge, the National Research Council of Canada (NRC) is working with numerous government, university, and industry partners to increase the resilience of Canadian buildings and infrastructure to climate change and extreme events under the Climate-Resilient Buildings and Core Public Infrastructure Initiative (CRBCPI). CRBCPI aims to integrate climate resilience into design guides, codes, and related material standards which will be the basis for future buildings and rehabilitation work in Canada, and is funded by Infrastructure Canada under the Pan-Canadian Framework (PCF) on Clean Growth and Climate Change.

As part of this initiative, work is underway to better understand the future climate of Canada to enable designs and retrofits based on future projections rather than historical data. Efforts are also being applied to understand the aging and performance of building enclosures in a changing climate, and ultimately increase the resilience of our building enclosures to ensure the expected level of performance is achieved for years to come.

CLIMATE-RESILIENT DESIGN OF COMMERCIAL ROOFS

The National Building Code of Canada (NBCC)[2] and the National Energy Code of Canada for Buildings (NECB)[3] provide minimum building requirements based on geographical location. However, even when the minimum requirements are implemented or exceeded, there are still failures that occur throughout the country. With the changing climate, there are harsh weather events that highly impact a building's resilience—its ability to recover from disturbances and adapt to climatic fluctuations. As such, coastal areas and regions across the country with harsh weather patterns require additional protection beyond the minimum requirements of the codes.

To implement an industry-wide solution for roofing, the NRC is currently developing a performance-based standard for inclusion in the NBCC. CSA A123.26[4] is under development through the Canadian Standards Association (CSA) and is intended to be used by building designers, building owners, building code officials, product manufacturers, and installers. The objective of CSA A123.26 is to provide additional requirements to the NBCC and NECB for climate adaptation in specified climatic zones for respective climatic loads. As such, the standard will include maps that divide Canada into three zones—minimum, moderate, and severe—for each of the critical weather elements, including hail, precipitation, temperature, and wind speed. Zones classified as minimum by the standard, for a particular element, will not require additional measures beyond the code requirements, although the methodologies for moderate and severe zones can equally be applied to minimum zones for good measure. However, zones classified as moderate and severe for a particular element will require additional measures to ensure climate resilience, as shown in *Figure 1*.

Figure 2 – Canadian East Coast roof failure during a Category 2 hurricane.

With existing provisions, failures continue to occur as a result of extreme weather events. *Figure 2* shows an example of a roof failure that occurred when the resistance of an interface was less than the induced wind forces, leaving the building vulnerable during a Category 2 hurricane on the Canadian East Coast. Several Roofing Industry Committee on Weather Issues (RICOWI) wind investigations clearly concluded that one of the major points of failure during extreme wind events was the edge system, which can result from poor roof edge attachment (*Figure 3*). The many failures that have been recorded and examined in the field indicate that the industry is in need of guidance on how to increase the ability of roofs to withstand the loads imposed on them under all climatic conditions to surpass the current requirements of building codes, especially in high-risk areas.

Figure 4 provides an example of the division of three Canadian provinces into minimum, moderate, and severe zones based on their wind events. CSA A123.26 proposes the following:

- The wind uplift design shall be in accordance with the loading requirements of *Figure 4* for moderate and severe zones.
- When the designer of responsibility determines there is a possibility of adverse effects on the wind performance of the low-slope membrane roofing system (LSMRS), the system shall be evaluated in accordance with CAN/CSA-A123.21, *Standard Test Method for the Dynamic Wind Uplift Resistance of Membrane-Roofing Systems*[5] on a test specimen that includes the penetrations.
- LSMRSs with modular vegetative roof assemblies shall be evaluated in accordance with CAN/CSA-A123.24, *Standard Test Method for Wind Resistance of Modular Vegetated Roof Assembly*.[6]

Figure 3 – Poor roof edge attachment—a major cause of failure during extreme wind events.

- Wind uplift performance of the installed LSMRS shall be verified according to *Guidelines for Commissioning and Certifying the Resiliency of Roofs Subjected to Extreme Weather Events* (under development by NRC).

Similar provisions are proposed in the draft CSA A123.26 for thermal and rainwater precipitation with their respective maps. A major requirement suggested for the thermal performance is minimizing thermal bridging and the exposure of fastener metal plates above the membrane. Thermal bridging results in significant energy losses and highly impacts the roof's thermal barrier, as shown in *Figure 5*. Measures should be taken to reduce energy losses at fastener and penetration locations.

In regard to precipitation, the draft of CSA A123.26 has under discussion requirements for rain (namely, rainwater resistance and tightness, and rainwater control) as follows and which are applicable to moderate and severe zones:

RAINWATER RESISTANCE AND TIGHTNESS

- The rainwater requirements shall be designed based on the rain load specifications for the number of drains, size of drains, and rainwater leaders.
- The LSMRS shall be evaluated according to ASTM D8052/D8052M, *Standard Test Method for Quantification of Air Leakage in Low-Sloped Membrane Roof Assemblies*,[7] since if it can be certified that the roof assembly is airtight, then it is equally considered rainwater tight.
- Field evaluations shall be performed according to *Guidelines for Commissioning and Certifying the Resiliency of Roofs Subjected to Extreme Weather Events* (under development by NRC).

RAINWATER CONTROL

- The designed drainage roof slope shall be a minimum of 2%.
- Secondary drains and scuppers shall be installed where appropriate.
- Base flashings shall be installed to have a minimum height of 304 mm (12 in.) where parapets are installed as a continuation of the exterior wall.
- A minimum height of 203 mm (8 in.) above the roof surface shall be maintained for fire walls, interior drainage, base flashings at curbs, transitions, and changes in plane in

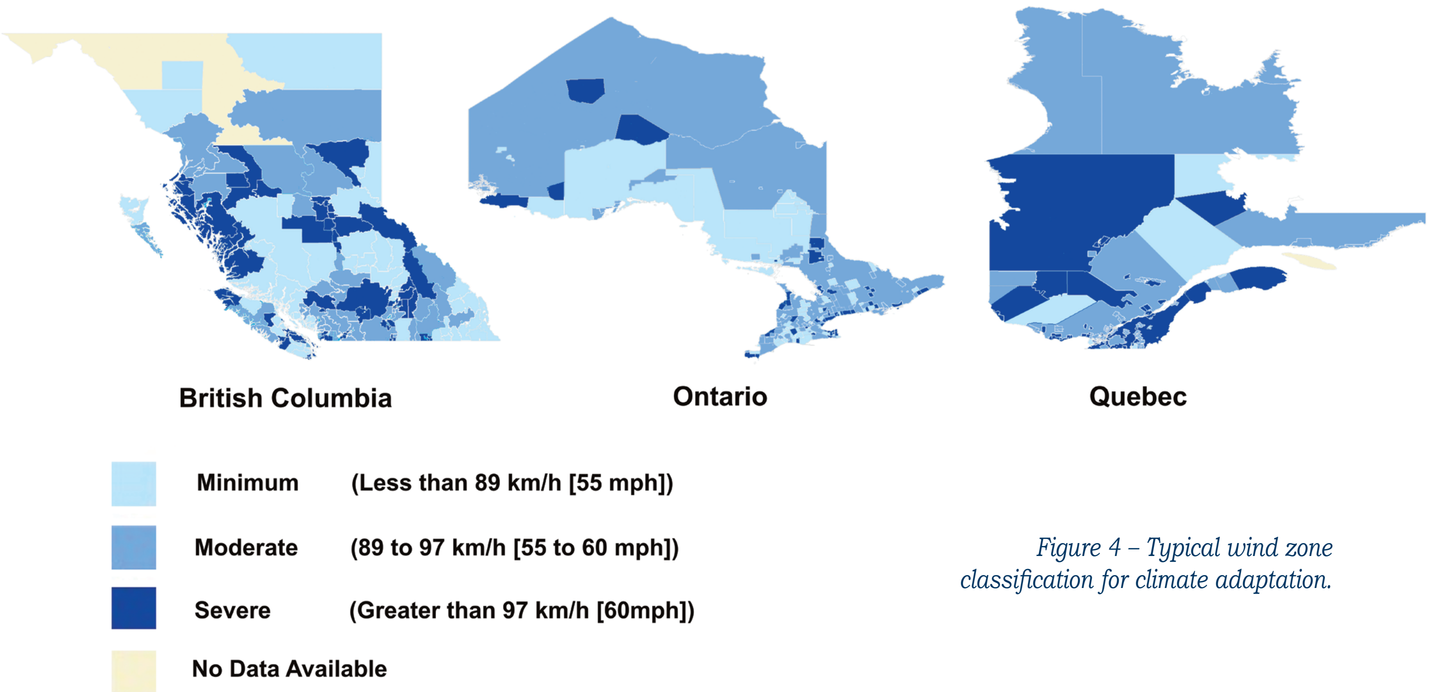

Figure 4 – Typical wind zone classification for climate adaptation.

Figure 5 – Thermal bridging on snow-covered roofs from rooftop penetrations and fasteners.

the interior field of the roof.

- Skylights on LSMRS shall be installed with a minimum height of 304 mm (12 in.) above roof membrane level.

CSA A123.26 provides the industry with three important elements for climate adaptation: design, resistance estimation, and field installation. The coherence of these three elements is critical to ensure the durability and resilience of a roof assembly, as detailed in previous work and confirmed through industry consultations.[8,9] The design element specifies the loading requirements with which a specific attribute should be in accordance. The resistance estimation provides a reference to existing laboratory test methods that can evaluate the resistance of the particular attribute. The standard also provides a field method that can be used to verify the field installation. The field evaluations ensure that the designed roof assembly was properly installed in the field and has the required resistance to withstand the climatic loads. Various case studies were presented at the recent IIBEC conference on how to achieve the "sweet spot" when all elements are in coherence.[8] Note that the "sweet spot" addresses durable roofing and not the capability of a roof to recover rapidly if extreme weather events cause damage.

RESILIENCE OF BUILDING FAÇADES AND WALL ASSEMBLIES

CSA S478-19, *Standard for the Durability of Buildings*, is the second edition of CSA S478.[10] It supersedes the first edition, published in 1995 under the title *Guideline on Durability in Buildings*. The first edition of CSA S478 was issued as a guidance document. The second edition has been developed as a standard to be referenced in the NBCC. This standard provides requirements for designers to create durable buildings. It is based on the impact on buildings and building elements of known action effects and requires that designers consider those effects and the repair or replacement procedures required to maintain durability throughout a specified design service life.

Annexes have been included to provide general guidance on environmental and other design factors that impact the durability of a building, a building material, and/or a building component. These annexes provide a framework within which the design service life of a building or a building element can be determined and specified. The standard carries forward from its first edition as a guideline with emphasis on the need to consider both initial and long-term costs, maintenance, and replaceability in the selection of materials (concrete, wood, and metals) and components. In Annex E, the revised standard introduces the issue of climate change and its potential effect on buildings and building elements. To assist the designers in the interim, for example, specifications are suggested for the selection of products, given climate change effects (*Table 1*). It is anticipated that designers will need to factor into their designs the environmental loads and action effects resulting from climate change. As information regarding the environmental data factoring in climate change becomes available, it will be incorporated into the standard.

NRC also published a guideline on the design for durability of building enclosures.[11] This document can be used for new wall systems or for assessing the durability of retrofits. The types of building enclosures that are addressed in this document include, but are not limited to:

1. Whole, or in part, institutional, commercial, and industrial (ICI) buildings and multiple urban residential buildings
2. Whole, or in part, housing and small buildings

Hygrothermal modeling is used to evaluate the short- and long-term thermal and moisture performance behavior of building enclosures. A hygrothermal model is a mathematical representation of the equations that govern the heat, air, and moisture transfer that occurs in components of a user-defined configuration of a specific building enclosure assembly subjected to heat and moisture loads. Hygrothermal modeling is a useful tool that can provide a means of estimating what temperature and moisture conditions prevail in given components of an enclosure assembly when it is subjected to simulated conditions of climate on the exterior of the assembly and indoor conditions on the interior.

In CSA S478-19, the standards to be consulted are specified for:

- Designing for durability of building elements within the building enclosure
- Undertaking hygrothermal simulations
- Ensuring that material properties used as input to the hygrothermal model are consistent with requirements for calculating the

Climate Change Effects	Environmental Agents	Suggested Specifications for the Selection of Products and Methods of Installation
Increase in global warming	Higher temperatures and broader overall range of both annual and diurnal temperature change	Dimensionally stable products having a lower coefficient of thermal expansion, thus providing a reduced overall dilation
		Products having enhanced elasticity and resistant to repeated movement cycles (e.g., when considering jointing and sealing products)
	Accelerated aging process due to more prolonged periods of higher temperature and exposure to higher levels of UVB radiation	Products of proven and heightened resistance to heat aging and UV radiation for components directly exposed to solar radiation and exterior environment (e.g., for roofing and cladding products; IG units; plastic fenestration components; polymer-based waterproofing and sheathing membranes; jointing and sealing products; and paints and coatings for cladding and similar exposed components)
Increase in wind-driven rain loads	Environmental conditions within wall assemblies and window and door frames and in installation openings under conditions of higher average temperature and humidity, together with increased incidence of liquid moisture in more prolonged contact with components	More robust design approaches that enhance drainage of water from surfaces and minimize the likelihood of retention of water in interstitial spaces (e.g., for wall assemblies, window design and installation)
		Products that are dimensionally stable when wetted and having enhanced resistance to hydrolysis; i.e., degradation from contact with warm liquid water (e.g., for insulation products used to ensure continuity of thermal resistance at wall–window and wall–door interfaces; polymer-based waterproofing and sheathing membranes; jointing and sealing products)
		Metal product components having enhanced resistance to corrosion after being wetted (e.g., for roofing, cladding, window frames, window ties, brick ties)

Table 1 – Suggested specifications for the selection of products, given climate change effects (Source: Table 1. CSA S478:19 Durability in buildings. © 2019 Canadian Standards Association. Reprinted with permission).[10]

non-steady-state transfer of heat, air, and moisture through building structures
- Identifying boundary conditions to which the enclosure is subjected on the exterior as well as the interior of the assembly

CONCLUSION

What does the codification of resilience standards mean for the industry?

- **Designers –** Designers will now have a tool to design building enclosures that have the required climate durability based on the geographical location of a particular building.
- **Owners –** Owners will have assurance that additional measures are being taken to ensure climate resilience and durability of their buildings.
- **Manufacturers –** Manufacturers will have confidence that their materials will be integrated in a way that promotes resilience.
- **Installers –** Installers will be provided with improved practices for installation to ensure that the buildings can withstand climatic events.
- **Coherence in the Industry –** The industry will collectively be proactive in responding to climate adaptations to ensure resilient and durable buildings throughout the country.

NRC is seeking input from the roofing community in enhancing the CSA A123.26 standard under development. Participation is needed from designers, consultants, manufacturers, and associations to ensure that the standard results in a harmonized document applicable to the roofing community.

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Dominique Lefebvre is a research officer at the National Research Council of Canada (NRC), where she evaluates the interfaces of various roofing materials and develops tools for climate adaptation. At present, she is developing the performance requirements of cover boards for the creation of a harmonized standard. She has authored or co-authored numerous research articles and was the recipient of several awards during her graduate and undergraduate studies at the University of Ottawa.

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Michael A. Lacasse

Michael A. Lacasse is a senior research officer and team leader for the Façades Systems and Products Group in the Construction Research Center of the NRC, having over 25 years' experience as a building engineer. He has been active in various ASTM, CSA, and CIB technical committees related to performance of enclosures and the durability and service life prediction of materials and components. Prior to working at the NRC, Dr. Lacasse worked both in private industry and government construction agencies.

NRCA Supports H.R. 1740 on Immigration Visas

House Bill H.R. 1740, called the Workforce for an Expanding Economy Act, was introduced to Congress in March and is being strongly supported by the National Roofing Contractors Association (NRCA). In May, NRCA's then Board Chair Nick Sabino (also an Industry member of IIBEC), testified before the House Committee on Small Business at a hearing to discuss the need for immigration reform. He explained that the current labor shortage negatively affects the roofing industry's supply chain, slowing down construction. He quoted Bureau of Labor Statistics (BLS) projections that employment demand for roofing professionals will increase by 11% by 2026 and opined that this demand cannot be met by native-born workers alone.

H.R. 1740 would establish a two-track system matching employers with temporary workers and providing more visas in times of economic strength. Sabino also urged Congress to provide a permanent solution for individuals working under temporary protected status who have demonstrated track records so that they may eventually acquire legal permanent resident status. To watch a video of the hearing, including Sabino's testimony, visit https://www.youtube.com/watch?v=2eYDNGz5_Bc&feature=youtu.be.

On May 3, the bill was referred to the Subcommittee on Immigration and Citizenship.