NBC 2015 SUBSECTION 5.9.3 OTHER FENESTRATION ASSEMBLIES: THE INTENT BEHIND THE NEW CODE PROVISIONS

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ABSTRACT

In Canada, the design, construction and installation of glazing systems has been partially regulated through standards and building Codes for decades. Most Code-referenced standards addressed factory assembled windows, doors or skylights installed singly or ganged in openings in exterior walls and roofs. As punch windows evolved into floor-to-ceiling, window wall systems, they moved beyond the scope of the referenced window standards. Canadian standards for glazing systems intended for non-residential construction, such as curtain wall, sloped glazing, and storefront were never codified, and the new glazed architectural structures systems being introduced from other countries are not strictly covered by standards or Codes. Prescriptive or performance requirements in CNBC that were meant to regulate other exterior wall assemblies weren't sufficient to address some aspects of these systems and more sophisticated structural glass, cable supported and other modern systems.

Architects, designers, commissioning authorities and agents, and authorities having jurisdiction have haphazardly turned to standards developed in other countries in an attempt to standardize use, but with limited success, and often inconsistent results. The building science industry has had to rely on evolving, unregulated "reasonable engineering practice" for adequate performance.

This shortcoming in regulation has been addressed in the 2015 National Building Code of Canada. A new category of "Other Fenestration Assembly" has been introduced into Division B, Part 5 Environmental Separation to address window wall, curtain wall, storefront, and glazed architectural structures. Requirements are included to address resistance to structural and environmental loads, air leakage, water penetration, heat transfer, and condensation resistance. Guidance notes in Appendix A describe background, intent and definitions.

This paper presents a summary of the new requirements and supporting guidance, identify departures from standards commonly used and give useful background information. This paper will be of interest to architects and engineers, manufacturers and installers, and authorities having jurisdiction.

NBC 2015 AND OTHER FENESTRATION ASSEMBLIES

What is this about?

The National Building Code of Canada ("NBC") is a model code that identifies expected minimum standards of performance for all functions that are to occur within a base building design. This includes life safety, occupant health, and resistance to deterioration that would endanger life. As part of the NBC's format,

guidelines identified as "Objectives" have been developed, coupled with Functional Statements. The combination of Objective and Functional Statement is used to justify the identified minimum performance expectation. No provision within the NBC can exist without an accompanying Objective and Functional Statement from the collection that are identified within Division A.

Prior to the 2015 National Building Code's (NBC) release the expected minimum performance requirements for glazing systems was covered under the Code in one of two ways;

1) Under 2010 NBC Division B 5.10 for windows and doors covered under the scope of AAMA/WDMA/CSA 101/I.S.2/A440 North American Fenestration Standard ("NAFS"), or

2) Under 2010 NBC Sub-sections 5.1 through 5.5, with performance requirements that we effectively left to the expertise of the designer to determine suitability for the design.

The North American Fenestration Standard scope only includes for windows (all type of operators and fixed), doors (sliding and hinged), skylights (modular manufactured units or roof windows) and tubular daylight devices.

Systems outside the NAFS scope, like curtain wall and window wall, defaulted to the second approach above. Each of Sub-Sections 5.1 to 5.5 provide high level instruction on performance but have little guidance on what was considered acceptable minimum performance, as related to specific Objectives and Functional Statements for these systems. These Sub-Sections also have no specific reference to the appropriate standards for assessing consistent performance identified within the regulation.

At the same time the Code was vague on specific guidance, the design and construction of new residential, institutional, and commercial facilities under the auspices of NBC, Division B, Part 3 (and therefore Part 5) was going through a significant and sustained period of growth. New glazing assembly designs and systems were being introduced and incorporated into the design landscape without clear understanding of how they should perform in the various climate zones within Canada.

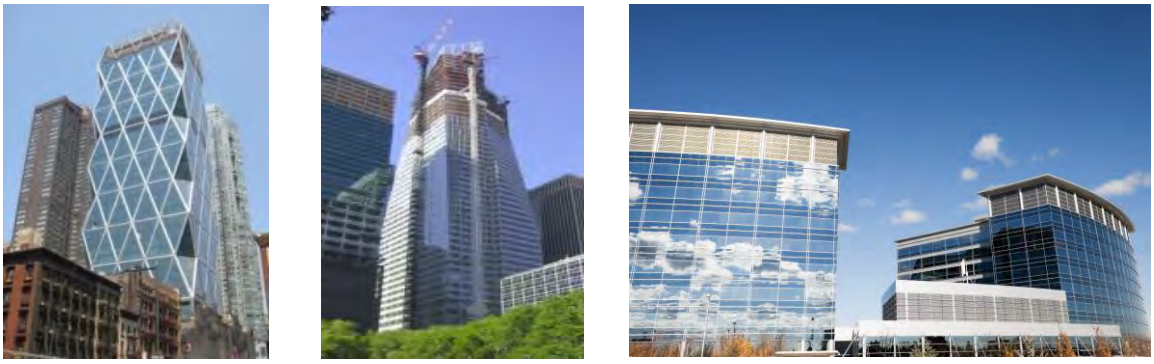


Figure 1: Photos of example buildings with special glazing systems

Designers were left to interpret the intent of 2010 NBC Sub-sections 5.1 to 5.5 and create performance criteria for these systems. In some cases, specialized technical design support was brought in to contribute towards these decisions on performance, but often the designers left the decisions on performance to the manufacturer's sales and internal testing reports. Depending upon the source of the systems, data may have been reported in any number of formats, from DIN, to ISO, to various consensus and non-consensus industry organizations test methodologies, e.g., AAMA, ASTM, CGSB, CSA, and other agencies. It was not unusual

to find incorrect performance criterial references for these systems relating back to standards that were not written for these systems, e.g., A440 air, water and structural performance criteria applied to curtain wall or window wall systems.

Experience shows, that there has been an increasing rate of large-scale failures for these systems with corresponding increased concerns in the design, construction and insurance industries. With the increased use of these systems, in both residential (e.g. mid. to high rise condominium) and commercial buildings, the Standing Committee on Environmental Separation felt that these products need to be reviewed and possibly addressed in Part 5 of the code.

It was recognized that the primary missing guidance in the Code related to;

1) Curtain wall systems

2) Window wall systems

3) Storefront systems

What the Code Commission did

In 2010 the Canadian Commission on Building and Fire Codes struck a Task Group under the Standing Committee for Environmental Separation (NBC Division B Part 5) to tackle the missing guidance on these glazing systems. The Mandate for this Task Group was:

1) Mandate

A Task Group of the Standing Committee on Environmental Separation will:

a) develop a preliminary description of the term window wall for reference for other activities under this Task and for possible inclusion in Appendix A of Part 5.

b) review relevant window wall and/or curtain wall requirements as well as related industry documents on their design, manufacture, use and installation,

c) determine whether the current building code requirements properly address window walls and/or curtain walls and,

i) if changes to the current requirements (criteria) are not considered necessary, report to the responsible Standing Committee

ii) if changes to the current requirements (criteria) are considered appropriate but there is insufficient information to support requests for changes, identify the areas where information is needed and report to the responsible Standing Committee

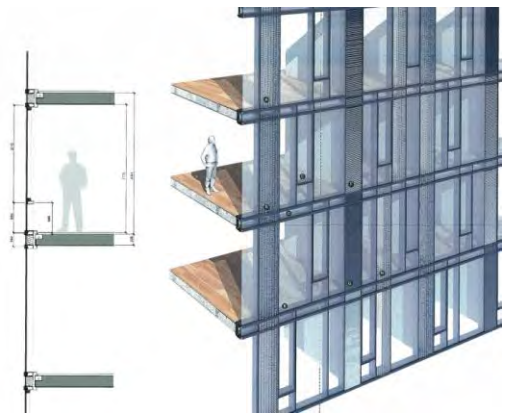
iii) if changes to the current requirements are considered appropriate and there is sufficient information to support changes, develop proposed changes and recommend those changes to the responsible Standing Committee.

Task Group First Undertaking

One of the first tasks undertaken was the identification and development of specific terminology of each of; window wall, curtain wall, storefront fenestration, glazed architectural structures. Research on existing definitions of each of these systems was conducted and then adjustments were made to capture the essence of each system as it is typically used in Canadian construction. From NBC A.5.9.5.1.(1) Terminology for Other Fenestration Assemblies stands as follows;

Curtain Wall

A curtain wall is considered to be a continuous wall cladding assembly (which may include fenestration and opaque portions) that is hung away from the edge of the primary floor structure. Curtain wall assemblies do not generally support vertical loads other than their own weight. Anchorage is typically provided by anchors that connect back to the floor structure. Curtain wall assemblies can be either "stick built" meaning each main unit is assembled on-site, or a "unitized" system, meaning factory-assembled main units are installed and connected together on-site.



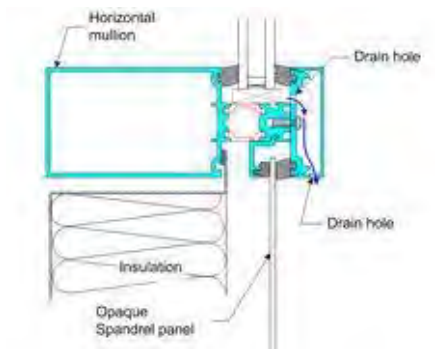


Figure 2: Curtain wall

Window Wall

A window wall is considered to be a wall cladding assembly (which may include fenestration and opaque portions) that spans from the top of a primary floor structure to the underside of the next higher primary floor structure. Window wall assemblies do not generally support vertical loads other than their own weight. Primary provision for anchorage occurs at head and sill connections with the adjoining floor structure. Window wall assemblies may include separate or integral floor edge covers.

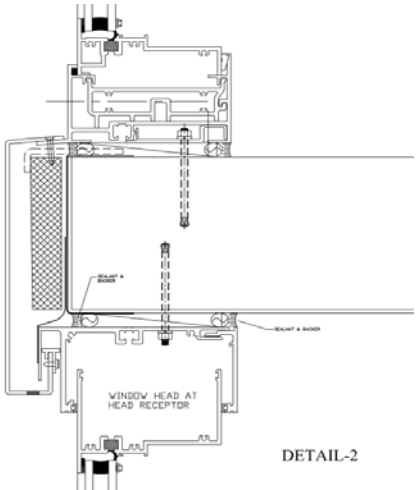


Figure 3 Window wall

Storefront

A storefront is considered to be a non-residential assembly (which may include fenestration and opaque portions) consisting of one or more elements that could include doors, windows and curtain wall framing. Storefronts do not generally support vertical loads other than their own weight. Storefront profiles are typically narrow, rectilinear framing members that hold a combination of pocket glazing and applied glazing stops to securely retain the infills. Vertical framing members typically span the height of one floor or are retained within a structural punched opening.

Storefront assemblies are designed/selected to take into account the anticipated service and exposure conditions, which may be different than those for other portions of the building.

Figure 4 Storefront

Glazed Architectural Structures

Glazed architectural structures are considered glazing assemblies that are supported in a non-traditional manner, such as corner-clamped, point-supported, linear-supported, and edge-clamped glazing. Structural support systems can include, but are not limited to, tension cables, tension rods, steel and glass. Glazed architectural structures do not generally support vertical loads other than their own weight. These assemblies are designed/selected to take into account the anticipated service and exposure conditions, which may be different than those for other portions of the building.

Skylights that are not covered by AAMA/WDMA/CSA 101/I.S.2/A440, "NAFS — North American Fenestration Standard/Specification for Windows, Doors, and Skylights," are considered glazed architectural structures.

Figure 5: Glazed Architectural Structures

These systems are common across Canada in all building types and occupancies.

The Code Requirements

NBC 2015 performance and testing requirements for 'other fenestration systems" are set out in Division B, Part 5 Environmental Separation, Subsection 5.9.3. These requirements are described following with commentary, to provide to potential users of such systems in Canada some insight regarding current design capabilities of Canadian industry and how designs may change in the next few years as the NBC 2015 is adopted or adapted across Canada.

1) **Structural and Environmental Loads**

Article 5.9.3.2.: no specific requirements are included for structural design. Instead, reference is made to Article 5.1.4.1 which sets out generic requirements for all building envelope materials, components and assemblies. However, in the non-mandatory Appendix A for Article 5.9.3.2, ASTM E330 is identified as the 'applicable' test method. That is the same test method required by previous Canadian window standards and currently by NAFS for windows, doors and skylights. Canadian manufacturers of Other Fenestration Assemblies systems should be able to furnish test reports to this standard. Appendix A also identifies AAMA 501 Methods of Tests for Exterior Walls, AAMA 501.4 Recommended Static Testing Method for Evaluating Curtain Wall and Storefront Systems Subjected to Wind Induced Interstory Drift and AAMA 501.6 Recommended Dynamic Test Method for Determining the Seismic Drift Causing Glass Fallout from a Wall System as other test methods that can be used to assess structural performance. It is important to note that currently, many Canadian window wall systems are not tested to these AAMA standards comparatively to the large number of curtain wall systems that have been tested to these AAMA standards.

2) **Heat Transfer**

Article 5.9.3.3: reference is made to Section 5.3. which sets out generic requirements for heat transfer for all building envelope materials, components and assemblies (Sentence 5.9.3.3.(1)) Metal-framed fenestration assemblies are also required to incorporate a thermal break to minimize condensation (Sentence 5.9.3.3.(2)). The accompanying discussion in Appendix A recommends compliance to CSA-A440.2, Fenestration Energy Performance which in turn references procedures developed by the National Fenestration Rating Council (NFRC) for simulation or physical testing to determine U-factor (NFRC 100 Procedure for Determining Fenestration U-Factors and NFRC 200 Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence, respectively). Two

physical test methods are identified for assessing condensation resistance: the "Temperature Index" method in CSA-A440.2 or measuring room-side surface temperatures during one of the cold cycles of AAMA 501.5 Test Method for Thermal Cycling of Exterior Walls. The 'Temperature Index' method is unique to the Canadian window industry with fixed indoor ambient air temperature of +20 +/- 1°C (68 +/- 2°F, approximately) and an outdoor ambient air temperature of -30 +/- 1°C (-22 +/- 2°F, approximately). Results are not directly comparable to methods for measuring condensation resistance in the USA, such as NFRC 500 Procedure for Determining Fenestration Product Condensation Resistance Values.

Therefore, results for condensation tests for Canadian fenestration systems should be reviewed carefully to ensure they are using an acceptable method suitable for the Canadian climate and specific to the performance expectation.

3) Air Leakage

Article 5.9.3.4: reference is made to Section 5.4. for generic requirements that apply to all building envelope materials, components and assemblies (Sentence 5.9.3.4. (1)). A specific requirement is made for testing to ASTM E 283 Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen with specified maximum allowable air leakage rates (Sentence 5.9.3.4.(2)). For fixed glazed and opaque portions the maximum allowable air leakage rate is 0.2 l/s/m^2 (0.039 cfm/ft^2) at a pressure difference of 75 Pa (1.57 psf) which is consistent with Canadian minimum requirements for air leakage rate in AAMA/WDMA/CSA 101/I.S.2/A440, NAFS — "North American Fenestration Standard/Specification for windows, doors, and skylights", for fixed windows. For operable portions the maximum allowable air leakage rate is 1.5 l/s/m^2 (0.30 cfm/ft^2) at 75 Pa (1.57 psf) which is the same as required under NAFS for R, LC and CW performance classes. There is no requirement in the NBC 2015 for testing at a 300 Pa (6.27 psf) air pressure differential as required by NAFS for the AW performance class or under AAMA 501 in buildings in which greater control of indoor air quality and/or humidity is required. However, the authors are aware of Canadian manufacturers who test their products to such levels.

Furthermore, in the non-mandatory Appendix A for Article 5.9.3.4. (2), ASTM E783 "Field Measurement of Air Leakage Through Installed Window and Doors" is identified as the "applicable" test method when in-situ air leakage tests are to be performed.

4) Water Penetration

Article 5.9.3.5: reference is made to Section 5.6. for generic requirements applicable to all envelope systems of buildings. Lab testing is also required to ASTM E 331 Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference as in the USA for fenestration systems, or to ASTM E 547 Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference which is required in Canada for window systems. Regardless of the test method, the test pressure is determined in accordance with CSA-A440S1, the Canadian Supplement to NAFS, using the Driving Rain Wind Pressure (DRWP). Water penetration resistance of windows in Canada is not based on a fraction of the wind load

(Design Pressure) as in the USA but instead on wind pressures measured during rainfall at specific locations across Canada (typically airports), for a 1/10 return period probability, modified for terrain condition (open or rough) and building height. The authors have worked with Canadian fenestration systems manufacturers who have tested systems to AAMA 501 at 300 Pa and 600 Pa (6.24 psf and 720 psf) pressure differentials so such systems are available.

Appendix A also identifies AAMA 501.1 Standard Test Method for Water Penetration of Windows, Curtain Walls and Doors Using Dynamic Pressure as a test method that can be used to evaluate the performance of "other fenestration assemblies". The reference to AAMA 501.1 is significant because it recognizes that Canadian window walls systems are similar in some respects to unitized curtain wall systems, often installed at similar building heights (50 stories or more) and therefore, subjected to dynamic wind forces. Typically, in the past Canadian window walls were tested to static cyclic pressure differentials only (ASTM E 331 and E 547) which may not adequately duplicate service conditions when installed on very tall buildings. The authors have worked with several manufacturers of Canadian window wall and curtain wall systems who have tested to AAMA 501.1.

Furthermore, in the non-mandatory Appendix A for Article 5.9.3.5. 2), ASTM E1105 "Field Determination of Water Penetration of Installed Exterior Window, Skylights, Doors and Curtain Walls by Uniform or Cyclic Static Air Pressure Difference" is identified as the "applicable" test method when in-situ water penetration resistance tests are to be performed.

CONCLUSION

Expected Impacts of the Changes and Discussion

These new requirements and recommendations in the NBC 2015 will be used as a basis for professionals to specify Other Fenestration Assemblies and Products minimum performance requirements, which will improve the uniformity of the available test results and performance expectations.

As previously mentioned, the application of these new requirements aims at reducing system failures related to criteria such as condensation, air leakages, water penetration, structural load, etc. It will also help design professionals reduce the occurrence of incorrect and/or non-applicable standards and their specification.

In addition, the Appendix A clearly identifies and differentiates the standard procedures to be followed for both laboratory testing and in-situ testing. This improvement will reduce the confusion with regards to the proper procedure applicable to each situation.

REFERENCES

2015 National Building Code of Canada

AAMA/WDMA/CSA 101/I.S.2/A440, "NAFS — North American Fenestration Standard/Specification for Windows, Doors, and Skylights"

AAMA 501.1 "Standard Test Method for Water Penetration of Windows, Curtain Walls and Doors Using Dynamic Pressure"

AAMA 501.4 "Recommended Static Testing Method for Evaluating Curtain Wall and Storefront Systems Subjected to Wind Induced Interstory Drift"

AAMA 501.5 "Test Method for Thermal Cycling of Exterior Walls"

AAMA 501.6 "Recommended Dynamic Test Method for Determining the Seismic Drift Causing Glass Fallout from a Wall System"

ASTM E 283 "Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen"

ASTM E 331 "Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference"

ASTM E 547 "Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference"

ASTM E783 "Field Measurement of Air Leakage Through Installed Window and Doors"

ASTM E1105 "Field Determination of Water Penetration of Installed Exterior Window, Skylights, Doors and Curtain Walls by Uniform or Cyclic Static Air Pressure Difference"

CSA-A440.2, "Fenestration Energy Performance"

CSA-A440S1, "Canadian Supplement to NAFS"

NFRC 100 "Procedure for Determining Fenestration U-Factors"

NFRC 200 "Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence"

NFRC 500 "Procedure for Determining Fenestration Product Condensation Resistance Values"

AUTHORS

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