Alberta Building Envelope Council South

LINKING ARCHITECTS, BUILDERS, ENGINEERS, CONTRACTORS AND SUPPLIERS

NAFS Testing and Ratings for non-Part 9 projects

February 28, 2018 for ABEC South

Prepared by Dave Goldsmith P.Eng, Ply Gem

Ply Gem®
BUILDING PRODUCTS

DAVE GOLDSMITH, P. ENG

SR DESIGN ENGINEER
PLY GEM BUILDING PRODUCTS

Dave has 27 years' experience in fenestration design and manufacturing and is responsible for regulatory/code compliance and intergovernmental affairs at Ply Gem.

He volunteers on the CSA Technical Committee on Performance Standards for Windows, Fenestration Canada's Technical Services Committee, the NAFS Joint Document Management Group, the AAMA Document Management Committee, and is on the Board of Directors for FenBC.

Through this work he has contributed to recent efforts to improve the NAFS and A440S1 standards and the way they are being adopted, interpreted and enforced in BC, Alberta and elsewhere.

What are the Code Requirements for products within the scope of NAFS in non-Part 9 buildings?

5.10.2.3. Structural Loads, Air Leakage and Water Penetration

1) Windows, doors, skylights and their components shall be designed and constructed in accordance with

a) Article 5.1.4.1. (Resistance to Loads and Deterioration), Section 5.4. (Air Leakage) and Section5.6. (Precipitation), or

b) Article 5.10.2.2., where they are covered in the scope of the standards listed in Sentence 5.10.2.2.(1)

5.10.2.2. Applicable Standards

(See Appendix A.)

1) Windows, doors and skylights shall conform to the requirements in

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

b) CSA A440S1, "Canadian Supplement to AAMA/WDMA/CSA 101/I.S.2/A440, NAFS – North American Fenestration Standard/Specification for Windows, Doors, and Skylights."

AAMA/WDMA/CSA 101/I.S.2/A440 - NAFS

North American Fenestration Standard/Specification for windows, doors and skylights.

A Harmonized standard created by the three active North American Fenestration Standards writing organizations.

- This was done to reduce the regulatory/testing burden for manufacturers in a free trade environment.
- The CSA A440-00 standard needed updating and improvement particularly regarding test sizes, mullions and labeling.
- Funding for codes and standards development in Canada can be notoriously difficult to come by, so it made sense to team up.
- Each organization had their own requirements. There wound up being something in there for everyone, and some compromises.

The Performance Class concept was central to AAMA 101:

0.2.1 Performance classes

It is important to note that although general suggestions for use are specified in Items (a) to (d), product selection is always based on the performance requirements of the particular project and not solely on these suggestions. The following descriptions can be used as a general guide in helping to determine which class is likely best suited for a particular application:

a) R: commonly used in one- and two-family dwellings.

b) LC: commonly used in low-rise and mid-rise multi-family dwellings and other buildings where larger sizes and higher loading requirements are expected.

c) CW: commonly used in low-rise and mid-rise buildings where larger sizes, higher loading requirements, limits on deflection, and heavy use are expected.

d) AW: commonly used in high-rise and mid-rise buildings to meet increased loading requirements and limits on deflection, and in buildings where frequent and extreme use of the fenestration products is expected.

There are Gateway performance rating and size requirements to enter each Class:

Table 1
Gateway requirements
(See Clauses 0.2.1, 0.2.6.1, 4.2.1, 4.4.2.3, 4.4.3.2–4.4.3.4, 5.3.3.1, 5.3.4.2, and 5.3.4.3.)

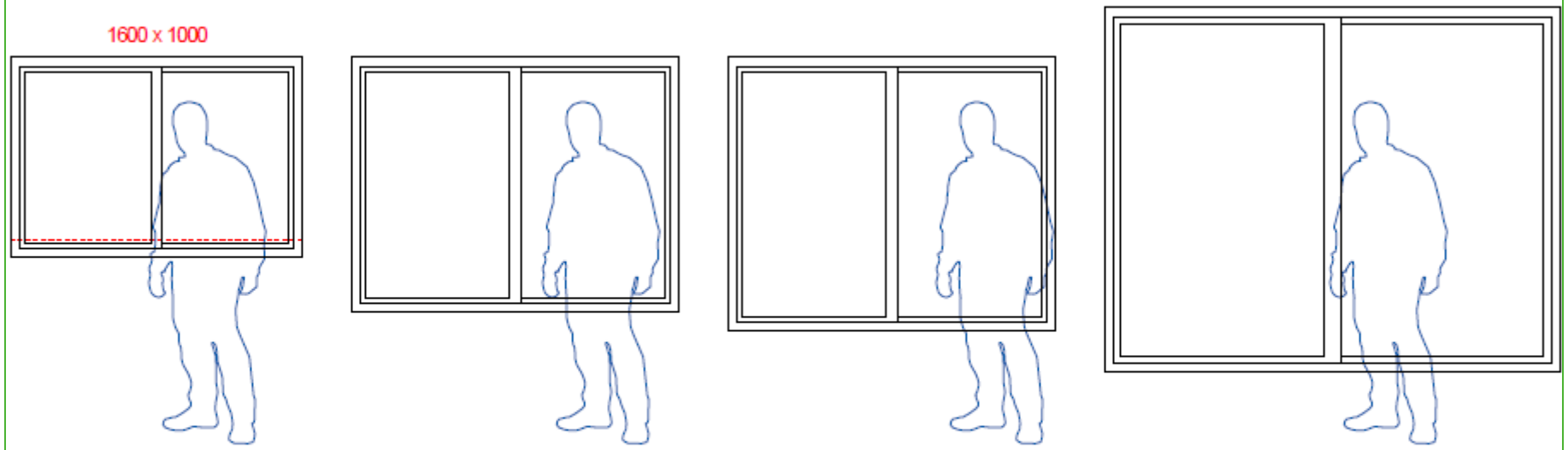
Product performance class	Minimum performance grade (PG)	Minimum design pressure (DP), Pa (psf)	Minimum structural test pressure (STP), Pa (psf)	Minimum water resistance test pressure, Pa (psf)
Windows and doors				
R	15	720 (15.0)	1080 (22.5)	140 (2.90)
LC	25	1200 (25.0)	1800 (37.5)	180 (3.75)
CW	30	1440 (30.0)	2160 (45.0)	220 (4.50)
AW	40	1920 (40.0)	2880 (60.0)	390 (8.00)

What about deflection at design pressure?

5.3.4.2 Uniform load deflection test at design pressure (DP)
For CW and AW specimens only, no member shall deflect more than *L*/175, where *L* is the length of the unsupported span. Deflection of R and LC specimen members shall be measured and recorded in the test report, but shall not be limited by this Standard/Specification.

AAMA Performance Class example for Sliding Windows:

R	LC	CW	AW
PG 15	PG 25	PG30	PG40
1600 x 1100	1800 x 1400	1800 x 1500	2500 x 2000



Min DP: 720 Pa	Min DP: 1200 Pa	Min DP: 1440 Pa	Min DP: 1920 Pa
Defl: Report Only	Defl: Report Only	Defl: L/175	Defl: L/175
Min Struct: 1080 Pa	Min Struct: 1800 Pa	Min Struct: 2160 Pa	Min Struct: 2880 Pa
Min Water Test: 140 Pa (15% DP)	Min Water Test: 180 Pa (15% DP)	Min Water Test: 220 Pa (15% DP)	Min Water Test: 390 Pa (20% DP)
Air Leakage: 1.5 L/s*m2 @ 75Pa	Air Leakage: 1.5 L/s*m2 @ 75Pa	Air Leakage: 1.5 L/s*m2 @ 75Pa	Air Leakage: 1.5 L/s*m2 @ 300 Pa

No L/175 deflection limit for R and LC – ??????

From the Glass Standard ASTM E-1300:

5. Significance and Use

5.1 This practice is used to determine the load resistance of specified glass types and constructions exposed to uniform lateral loads.

5.2 Use of this practice assumes:

5.2.1 The glass is free of edge damage and is properly glazed,

5.2.2 The glass has not been subjected to abuse,

5.2.3 The surface condition of the glass is typical of glass that has been in service for several years, and is weaker than freshly manufactured glass due to minor abrasions on exposed surfaces,

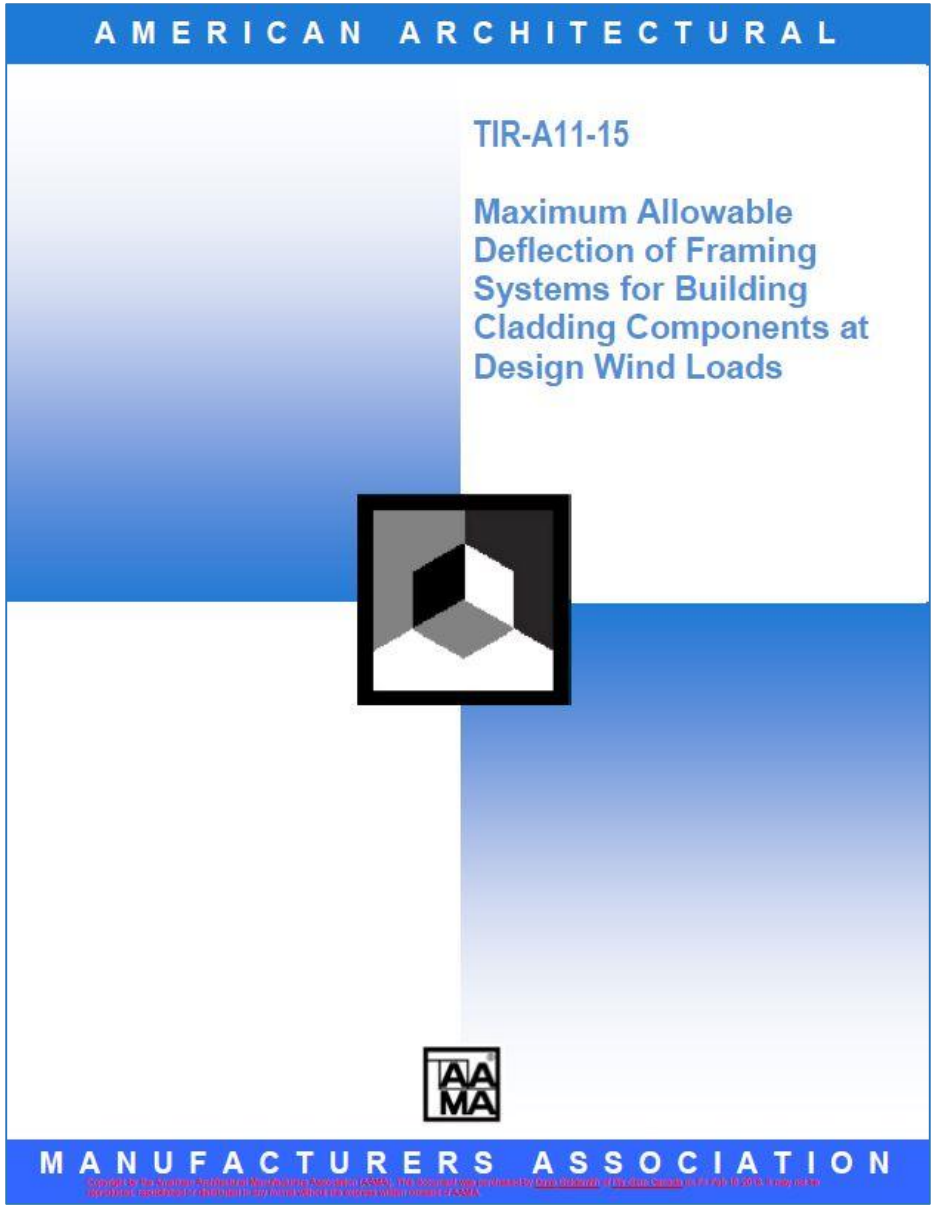
5.2.4 The glass edge support system is sufficiently stiff to limit the lateral deflections of the supported glass edges to no more than 1⁄175 of their lengths. The specified design load shall be used for this calculation.

5.2.5 The center of glass deflection will not result in loss of edge support.

6.15 If the calculated load resistance is greater than or equal to the specified design load, then the glass types and thicknesses are acceptable for a breakage probability of less than, or equal to, 8 in 1000.

CAN/CGSB 12.20 M89 is based on the same principles.

Why else should you limit deflection?



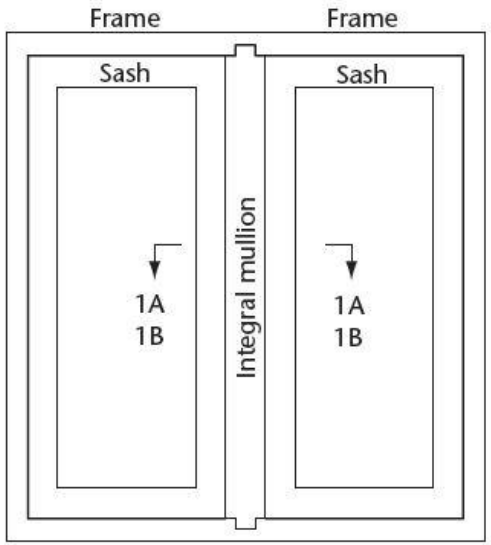
Deflections of framing members are limited in order to:

- Provide adequate support for the materials being retained by the framing members;
- Maintain weatherability of the installed product;
- Prevent damage to adjacent construction
- Provide a "psychologically acceptable" comfort level for occupants.

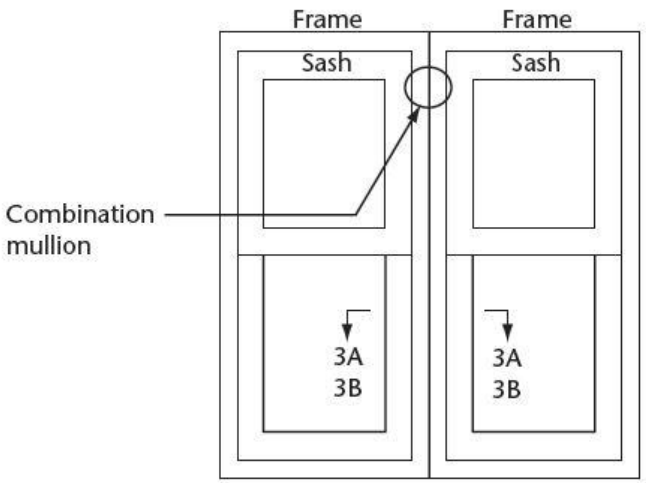
A partial list of current building codes and standards addressing deflection limits on cladding members supporting glazing:

3.1 ASTM E 1300
3.2 2012 International Building Code, Section 2403.3, "Framing"

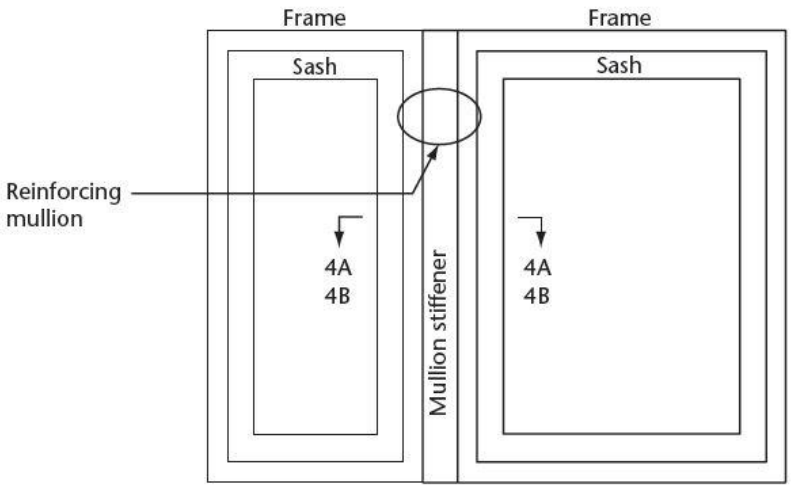
What “framing members” are we talking about? Primarily Mullions:



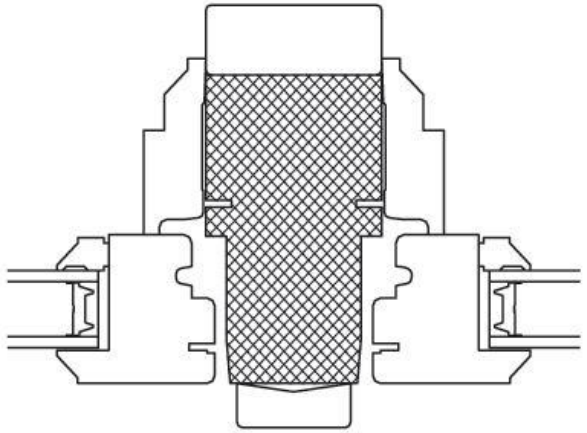
Elevation 1 — Integral mullion casement



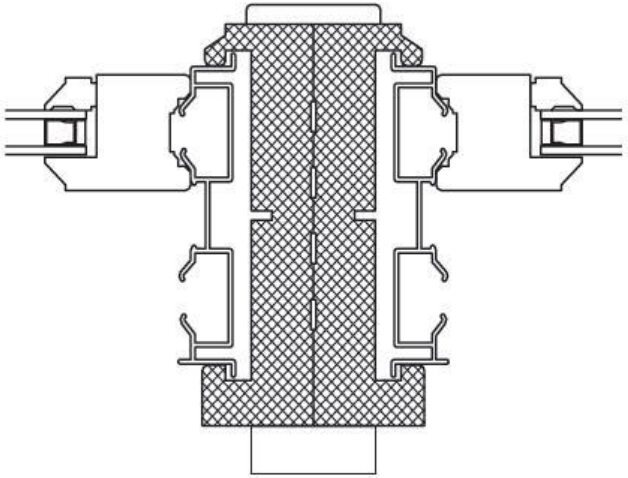
Elevation 3 — Combination mullion hung window



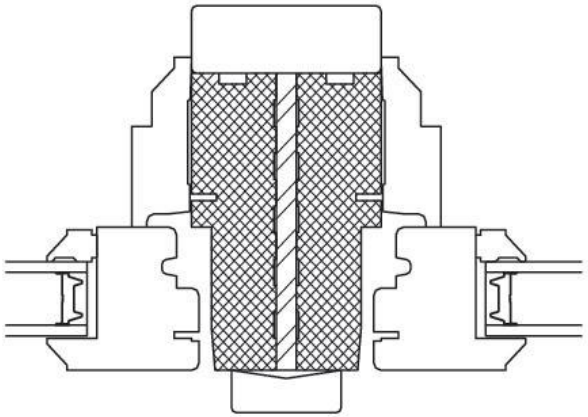
Elevation 4 — Reinforcing mullion casement & fixed



Section 1A



Section 3A



Section 4A

What about Mullions?

- A440-00 had deflection limits for mullions but gave very little guidance on testing products with mullions.
- NAFS deals with mullions comprehensively and there is a lot of guidance given In standards such as AAMA 450 – but there is *no deflection limit* for R and LC products.
- Neither NAFS, nor A440S1 *Canadian Supplement to NAFS*, has mullion labeling requirements.
- Fenestration Canada has published a document *Voluntary NAFS Labeling Guidelines for Products with Mullions*, but it has not caught on.

IRC 2006 - 2018

R612.11 Mullions. Mullions shall be tested by an *approved* testing laboratory in accordance with AAMA 450, or be engineered in accordance with accepted engineering practice. Mullions tested as stand-alone units or qualified by engineering shall use performance criteria cited in Sections R612.11.1, R612.11.2 and R612.11.3. Mullions qualified by an actual test of an entire assembly shall comply with Sections R612.11.1 and R612.11.3.

R612.11.1 Load transfer. Mullions shall be designed to transfer the design pressure loads applied by the window and door assemblies to the rough opening substrate.

R612.11.2 Deflection. Mullions shall be capable of resisting the design pressure loads applied by the window and door assemblies to be supported without deflecting more than $L/175$, where L is the span of the mullion in inches.

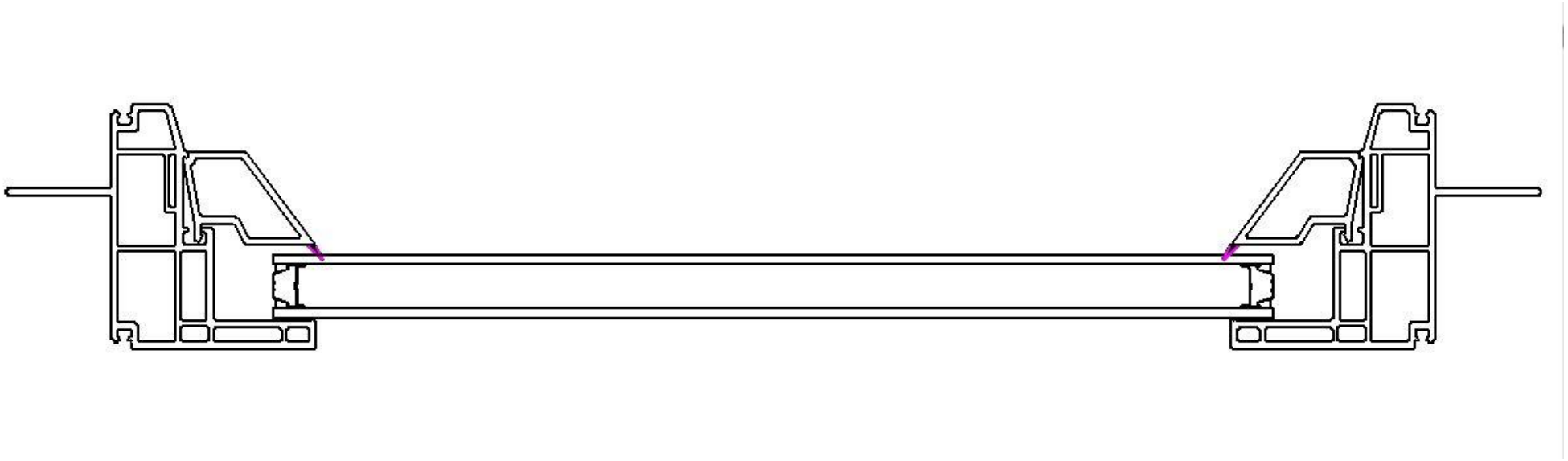
R612.11.3 Structural safety factor. Mullions shall be capable of resisting a load of 1.5 times the design pressure loads applied by the window and door assemblies to be supported without exceeding the appropriate material stress levels. If tested by an *approved* laboratory, the 1.5 times the design pressure load shall be sustained for 10 seconds, and the permanent deformation shall not exceed 0.4 percent of the mullion span after the 1.5 times design pressure load is removed.

INDIVIDUAL UNIT PERFORMANCE vs MULLION PERFORMANCE

- How does the performance of individual units compare with the performance of units with factory mullions?

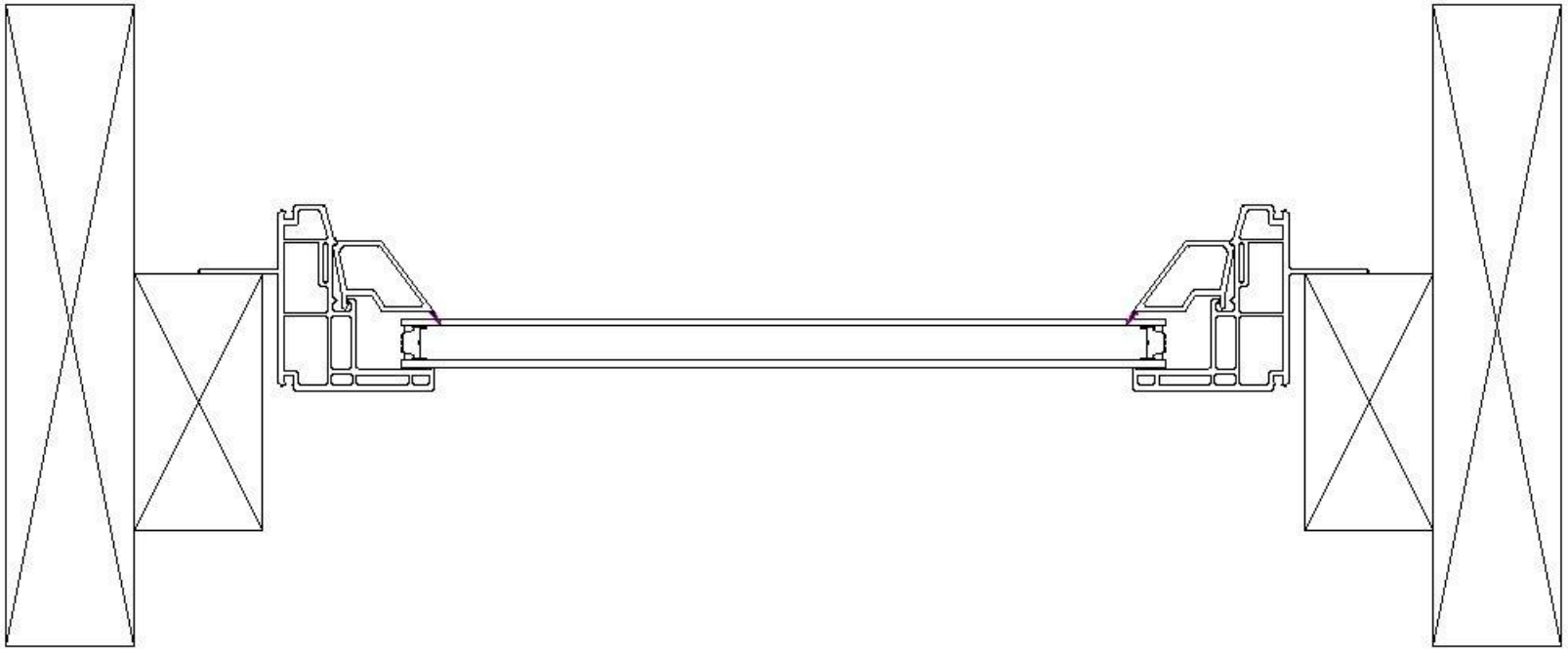
- Ply Gem tested a 2m x 2m direct-set glazed unit and achieved a DP of 75 pounds per. square foot (3600 Pa).

In cross-section the unit design looks like this:

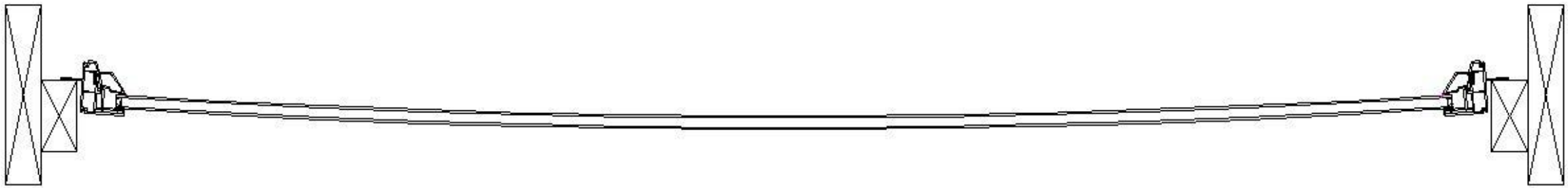


Not much to look at. Hard to believe a simple, unreinforced vinyl window can withstand that kind of force.

Mounted into a test buck:



Drawn to scale at a blow-out pressure of 5400 Pa:



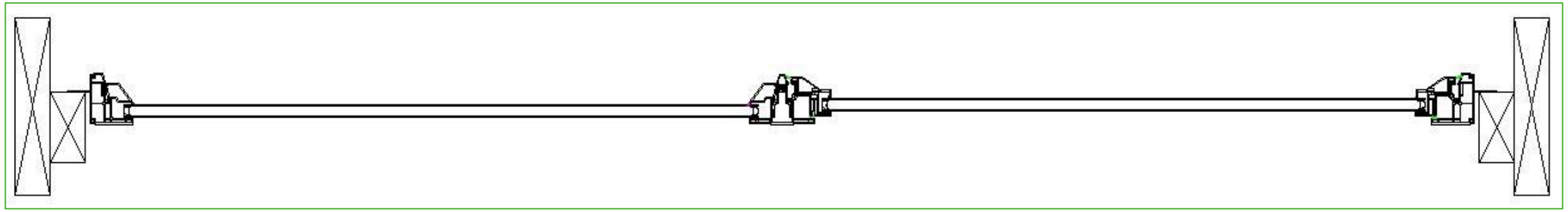
- To achieve a DP of 75 Psf (3600 Pa), the unit survived a 150% blow-out pressure of $5400N/m^2 \times 4m^2 = 21{,}600$ N.
- That is equivalent to 2200kg, or 4850lb!
- The center of glass deflection was 30mm and the glass was at 500% of design capacity.
- This is clearly more of a test of the strength of the window installation to the test buck, and the glazing sealants, than of the strength of the window framing system.

What does NAFS say about installation?

"These tests are used to evaluate the performance of the fenestration product only and are not intended to test the performance of the installation, particularly the perimeter sealants between the fixture and the test specimen and the anchoring of the test assembly to the test fixture . . . . Evaluation of actual field installation details is not part of this Standard/ Specification"

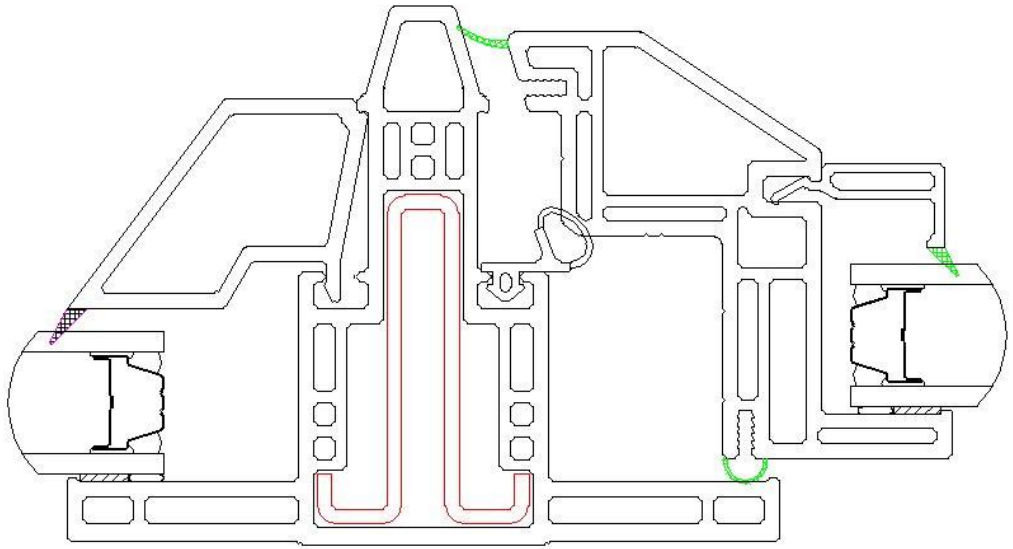
- In other words, NAFS test results do not accurately reflect the performance of the product as typically installed.

Suppose we tested a large two-lite unit with an integral mullion:



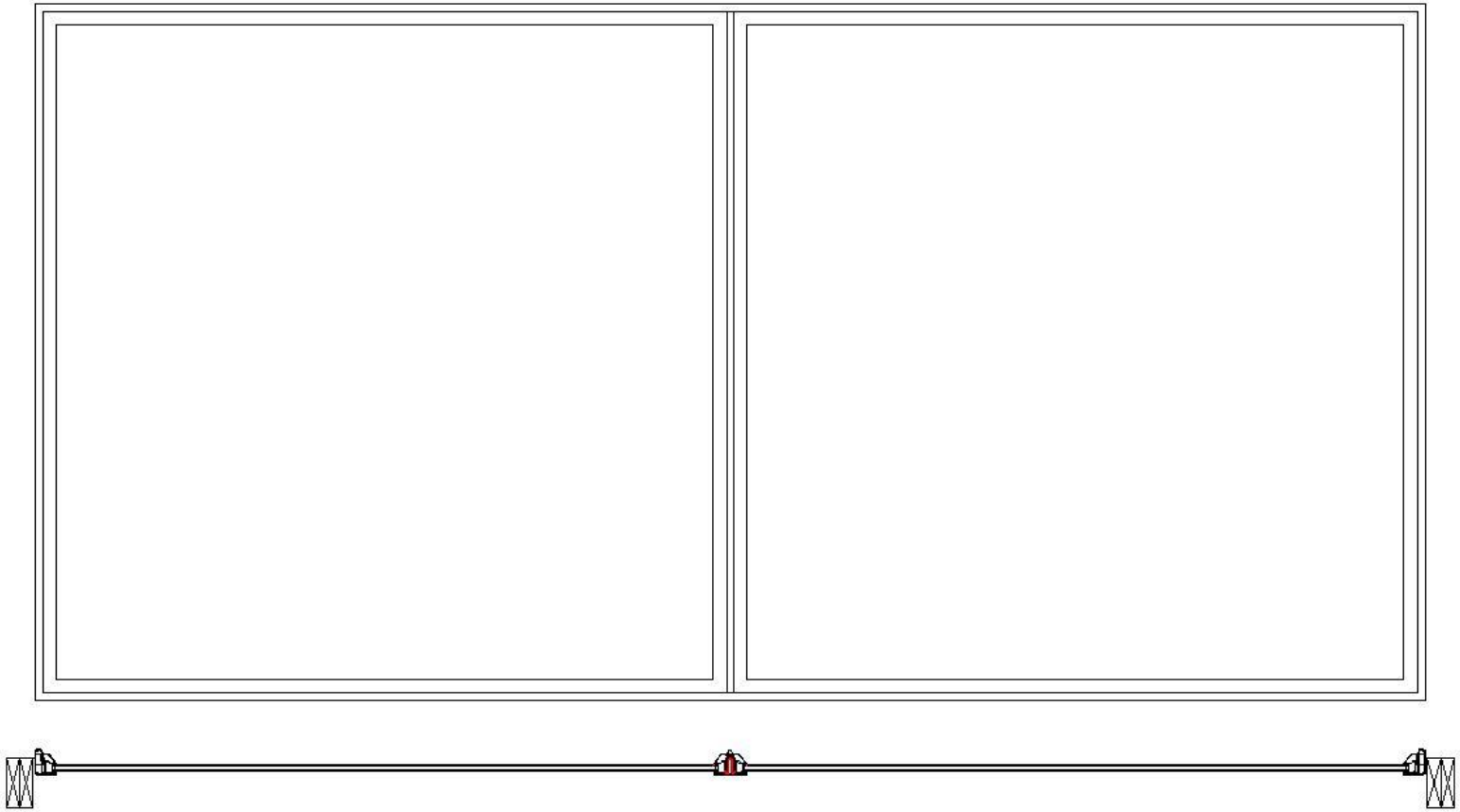
Can anyone spot a component that is potentially weak in bending?

The vinyl mullion:



- We can reinforce it with steel, as shown in this cross-section.
- But the depth of the reinforcement is limited, and the flexural rigidity is strongly dependent on depth.
- There is a limit to the potential strength of standard residential window mullions, even using steel reinforcement. It's never going to be as strong as a perimeter frame component mounted to a test buck or a wall.

For example, if Ply Gem actually allowed two 2m x 2m units to be ordered with an integral mullion for a 4m wide x 2m unit:



- Based on a deflection calculation, the pressure at which the mullion would be deflecting L/175 (2000mm/175) = 11.43mm would be under 10Psf (9.8Psf).

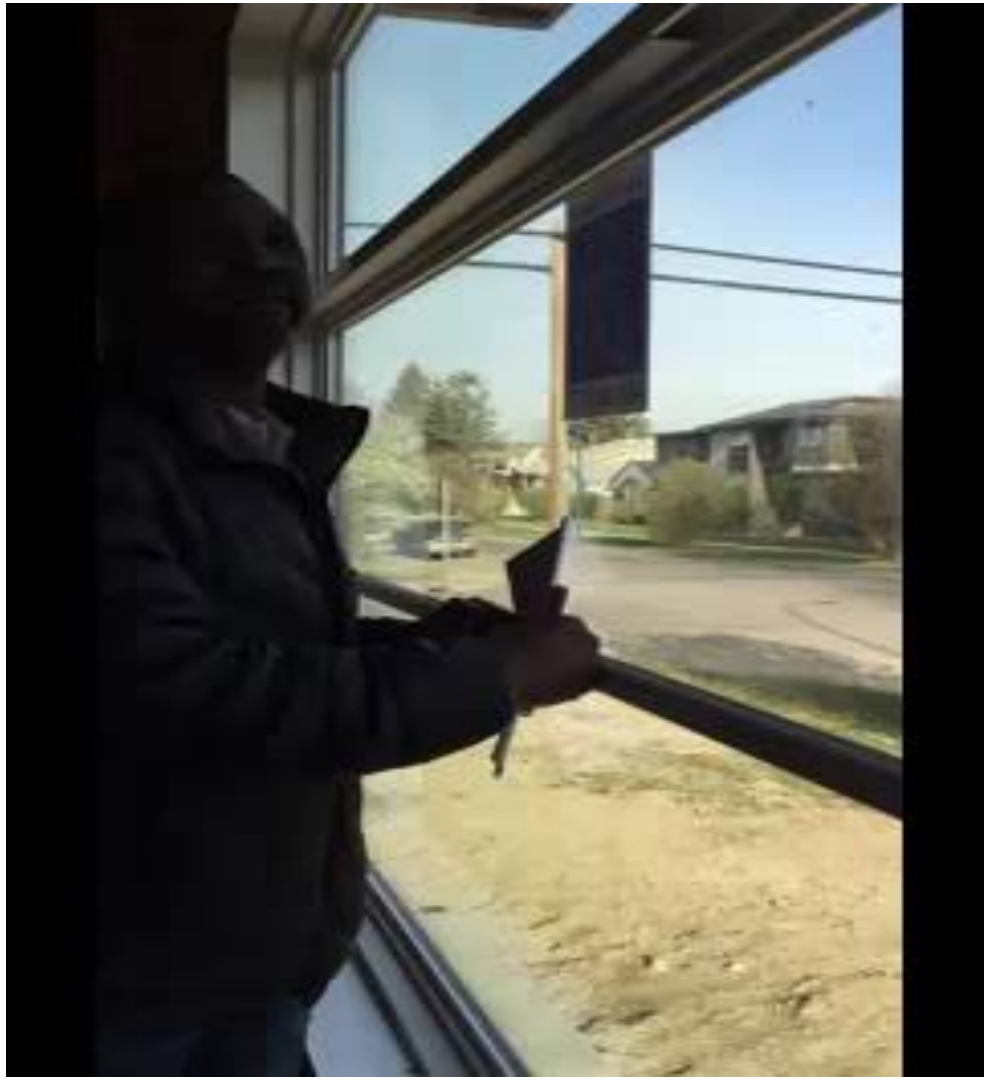
What is a NAFS Label Worth (by itself)?

Points to consider:

- There is no Conformity Assessment language in the code.
- Product Certification is not a code requirement.

Therefore, a NAFS label may be nothing more than a *Manufacturers self-declaration of compliance.*

Part 9 High Jinks:



- This is an infill in Calgary where the homeowner acted as her own General Contractor and sought out the cheapest windows.
- Multiple issues - frame corners had cracked and separated, the mullions were un-reinforced vinyl.
- She wound up buying the whole house package over again from Ply Gem.
- She wanted something in writing from the City of Calgary saying the windows were not code compliant so she could attempt to recover her funds in court.
- The City considered the windows to be code complaint purely on the basis of having NAFS labels – even though it was self-evident they were faulty and did not meet code intent. “If they have labels they meet code”.

How many of you have seen things like this?
Unreinforced vinyl windows in large sizes claiming high NAFS ratings (PG45).

What's that going to look like in a test lab?

Four lite at 16 psf (picture courtesy of Energi)

The minimum structural test pressure (STP = 150% blow-out test pressure) for the minimum NAFS rating of PG15 is 22.5 psf.

These units are actually PG = 0 based on the requirement that the residual deflection not be in excess of 0.4% of span after application of the STP.

Six lite at 20 psf (picture courtesy of CLEB)

What about glass strength?

4.3.6. Glass

4.3.6.1. Design Basis for Glass

1) Glass used in *buildings* shall be designed in conformance with CAN/CGSB-12.20-M, "Structural Design of Glass for Buildings."

Manufacturers default glass thickness schedules are usually based on tables in the Appendix of the code that relate to glass in **Part 9** buildings:

A-9.6.1.3.(1) Maximum Glass Area. Tables A-9.6.1.3.(1)A. to A-9.6.1.3.(1)F. may be used to select glass thickness for windows subject to the following conditions:

- The building has an essentially uniform distribution of paths for air leakage, including operable openings, but no large openings that would permit wind gusts to rapidly enter the building, e.g., loading or garage doors.
- The building has a height from grade to the uppermost roof of 12 m or less, and is located in a built-up area, no less than 120 m away from the boundary between this area and open terrain. (Where this criterion is not met, see Tables A-9.6.1.3.(1)D. to A-9.6.1.3.(1)F., which apply to buildings located on open terrain.)
- The building is not in an exceptionally exposed location such as a hilltop.

Asking again: What are the Code Requirements for products within the scope of NAFS in non-Part 9 buildings?

Given that:

- Manufacturers are not including the mullion ratings in their NAFS labels.
- They do not have to limit the mullion deflection at design pressure to L/175 for Class R and LC products.
- Some companies may not be properly testing their mullions at all!
- Installation and anchorage is not addressed by NAFS test reports.
- Residential window manufacturers default glass thickness schedules are based on Part 9 assumptions.

Just NAFS compliance as demonstrated by NAFS labels? NO.

So how do we ensure full code compliance under Parts 3, 4, and 5 of the code when specifying products that are within the scope of NAFS?

Professional Design and Review

Under Part 4 setting the Specified Wind Load, determining the required glass strength/thickness under CAN/CGSB-12.20M, and doing structural analysis are all considered engineering functions requiring **Professional Design and Review**.

The part of the building code that deals with this is **Section 2.4 Professional Design and Review** under Part 2 *Administrative Provisions*. 2.4.2.1 (5) says:

> **5)** For *buildings* other than those described in Sentences (3) and (4), the *building* plans and specifications must be imprinted with seals and stamps of both
> a) a *registered architectural professional* in the case of architectural design, and
> b) one or more *registered engineering professionals* qualified to engage in the appropriate combination of those branches of engineering that are applicable to *building* design and construction in the case of engineering design.

Appendix B – Schedules of Professional Involvement

B-2.4.3. Schedules of Professional Involvement. The Schedules are intended to clearly define the relationship between the owner of the building and the required professionals. They are also needed to show how the various professional disciplines will be coordinated. The coordination relates to both the design and site review of all aspects of the building.

The following Schedules are provided on the following pages:

- **Schedule A-1** Letter of Commitment by the Owner and Coordinating Registered Professional(1)
- **Schedule A-2** Confirmation of Commitment by Owner and by Registered Professional of Record(1)
- **Schedule B-1** Letter of Commitment by the Registered Professional of Record(2)
- **Schedule B-2** Summary of Design and Field Review Requirements(2)
- **Schedule C-1** Assurance of Compliance Coordinating Registered Professional(3)
- **Schedule C-2** Assurance of Professional Field Review and Compliance(3)

---

(1) Schedules A-1 and A-2 should be in place at the inception of the project before the issuance of a development or building permit. These help establish a dialogue early in the project.

(2) Schedules B-1 and B-2 should be attached to the drawings and specifications submitted for a building permit.

(3) Schedules C-1 and C-2 should be submitted at the conclusion of the project.

From Schedule B-2:

1.14 Structural capacity of architectural components; including anchorage and seismic restraint
1.16 Review of all applicable shop drawings

Shop Drawing and Configuration Review Process

1. Ply Gem does a ***Configuration Review***, which is an internal-only structural review in order to ensure that we are quoting products with adequate structural capacity at point of bidding, before any 3rd party processes.
2. After we have won the contract Ply Gem creates ***Window and Door Shop Drawings***.
3. The Shop Drawings are reviewed, signed and sealed by a 3rd party engineering consultant, with any required modifications captured (but the point of the Configuration Review is to avoid this and quote accurately up front).
4. The consultant does Field Reviews to ensure the product is being supplied and installed per. the Shop Drawings.
5. The customer is billed for our Shop Drawings and the 3rd party consulting services.

This process only covers the structural capacity of the window assemblies and their installation. The air/water resistance properties of the products (separate from the installation) are still covered under our NAFS testing and labeling, as referenced in **Part 5, 5.10.2.2** ***Applicable Standards***.

The 3rd party structural engineers do not design, review or verify any materials relating to building envelope, waterproofing, finishes or other materials. These aspects are typically reviewed by a Building Envelope Consultant, which is a separate process that takes place without our involvement.

PROJECT INFORMATION

PROJECT NAME:	Sterling Terrace (10 Storey High-rise)	DATE:	15-Feb-18
ADDRESS	2323 Hamilton Street, Regina, SK	BY:	ES
CLIENT	Plygem Windows	PROJECT NO:	1052-13986
WIND LOAD, q50:	0.49 kPa		

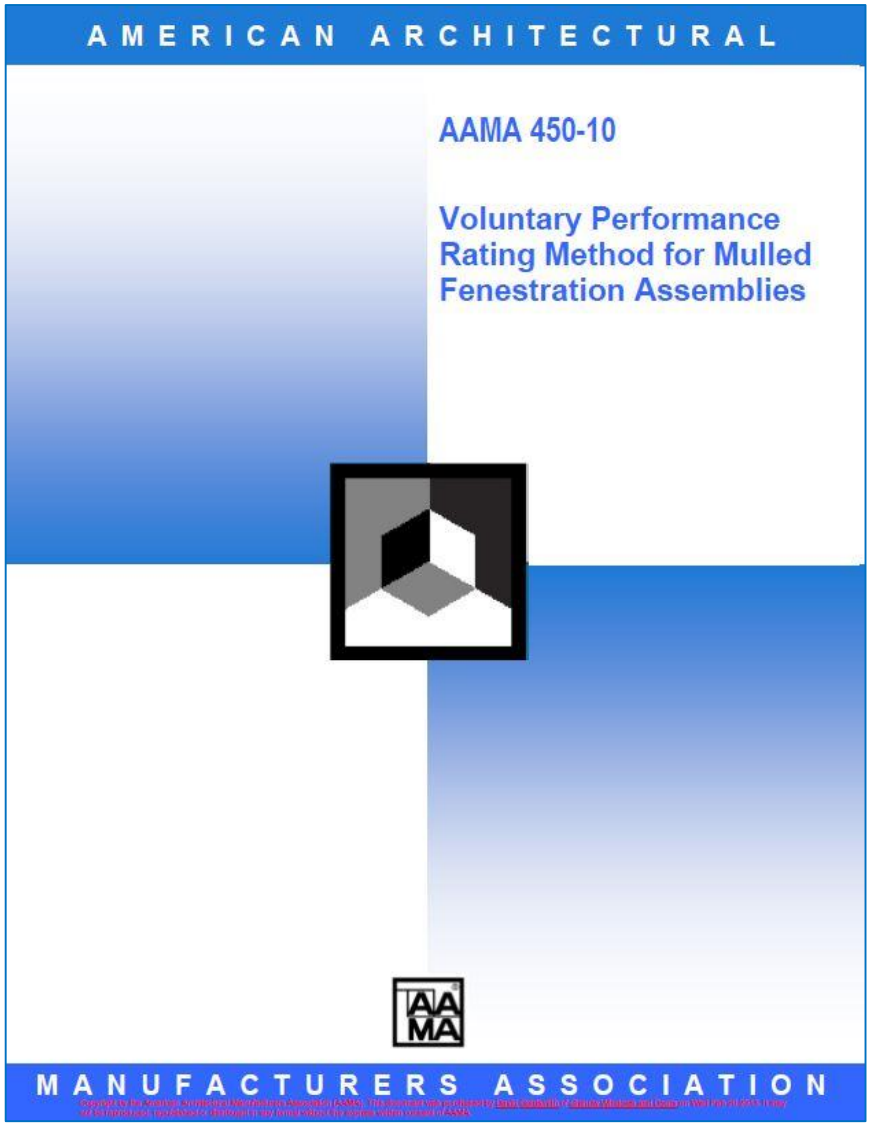
IMPORT. CATEGORY:	Normal	IMPORT. FACTOR (ULS):	1.00
TYPE OF TERRAIN:	Rough	IMPORT. FACTOR (SLS):	0.75
CODE:	NBC 2015	PROJECT ON A HILL?:	No

Check	Floor	Height (m)	External Exposure Factor	True Ext. Exposure Factor	Corner or Non-corner	STRESS Net Wind ULS (psf)	DEFLECT. Net Wind SLS (psf)
NON-CORNER PRESSURES (UNFACTORED)*							
1	Level 1,2	6.00	0.569	0.700	Non-corner	22.56	16.92
2	Level 3,4	12.00	0.700	0.700	Non-corner	22.56	16.92
3	Level 5,6	20.00	0.816	0.816	Non-corner	25.23	18.92
4	Level 7-9	30.00	0.921	0.921	Non-corner	28.10	21.08
5	Level 10	31.00	0.931	0.931	Non-corner	28.38	21.29
CORNER PRESSURES (UNFACTORED)*							
1	Level 1,2	6.00	0.569	0.700	Corner	27.93	20.95
2	Level 3,4	12.00	0.700	0.700	Corner	27.93	20.95
3	Level 5,6	20.00	0.816	0.816	Corner	31.49	23.62
4	Level 7-9	30.00	0.921	0.921	Corner	35.18	26.38
5	Level 10	31.00	0.931	0.931	Corner	35.52	26.64

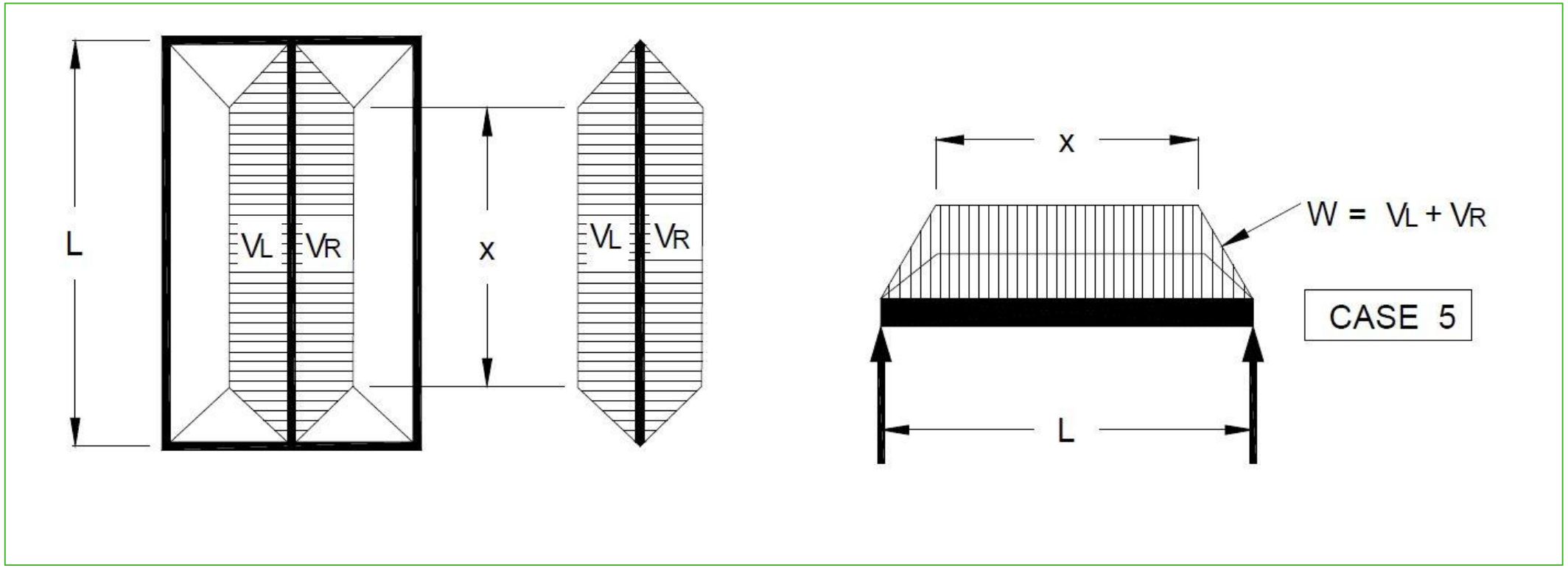
- Can be as simple as setting a single wind load value for the entire project
- Or can be done on a floor-by-floor basis with corner and non-corner pressures

Ply Gem BUILDING PRODUCTS

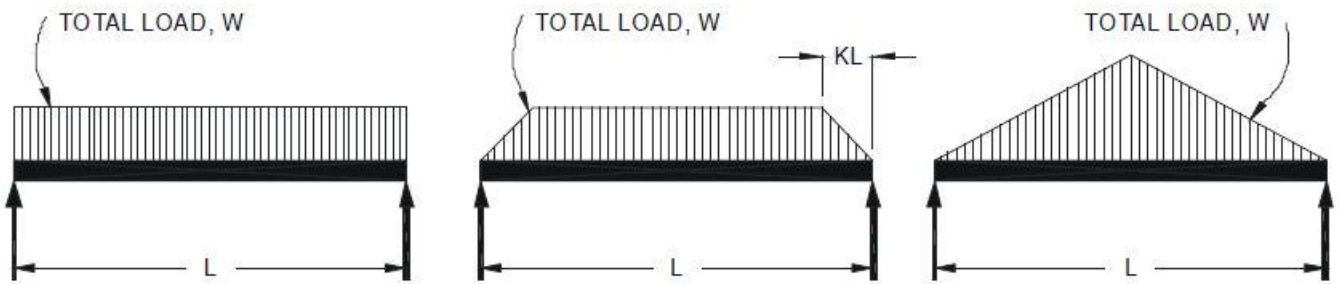
The NAFS Referenced Standard for Mullion Structural Analysis is AAMA 450:



In AAMA 450 the wind loads are assumed to be transferred to intermediate members in windows in the same way as slab loads are transferred to beams in civil engineering – by trapezoidal loading.



Formulae are provided giving the deflection based on the load shape and amount:



UNIFORM LOAD

$$M\ max. = \frac{WL}{8}$$

$$D\ max. = \frac{5WL^3}{384EI}$$

TRAPEZOIDAL LOAD

(SEE TABLE BELOW)

TRIANGULAR LOAD

$$M\ max. = \frac{WL}{6}$$

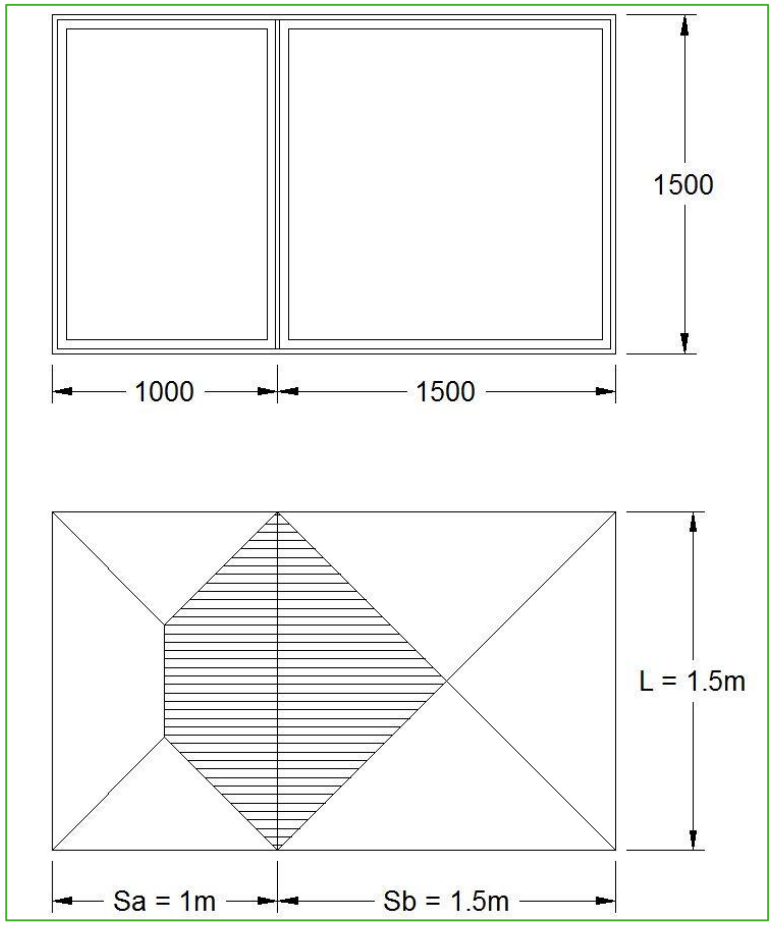
$$D\ max. = \frac{WL^3}{60EI}$$

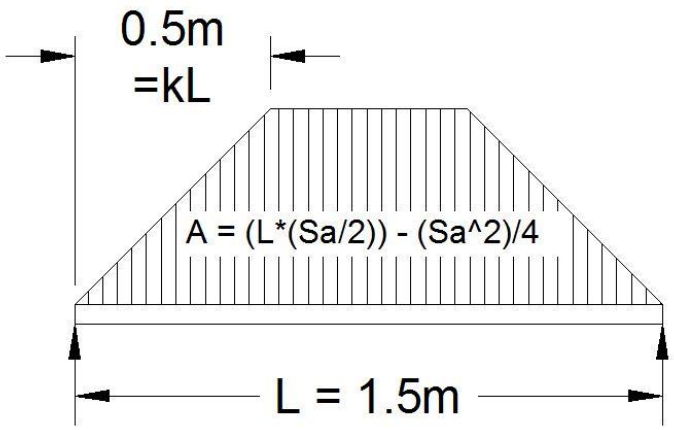
DEFLECTION AND MOMENT COEFFICIENTS FOR TRAPEZOIDAL LOAD ON SIMPLE BEAM

	K = 0	K = 0.1	K = 0.2	K = 0.3	K = 0.4	K = 0.5
M max.	$\frac{WL}{8.00}$	$\frac{WL}{7.30}$	$\frac{WL}{6.76}$	$\frac{WL}{6.36}$	$\frac{WL}{6.10}$	$\frac{WL}{6.00}$
D max.	$\frac{WL^3}{76.8\ EI}$	$\frac{WL^3}{70.2\ EI}$	$\frac{WL^3}{65.6\ EI}$	$\frac{WL^3}{62.4\ EI}$	$\frac{WL^3}{60.6\ EI}$	$\frac{WL^3}{60.0\ EI}$

Example AAMA 450 manual calculation

What is the Design Pressure at which the intermediate member deflects L/175?

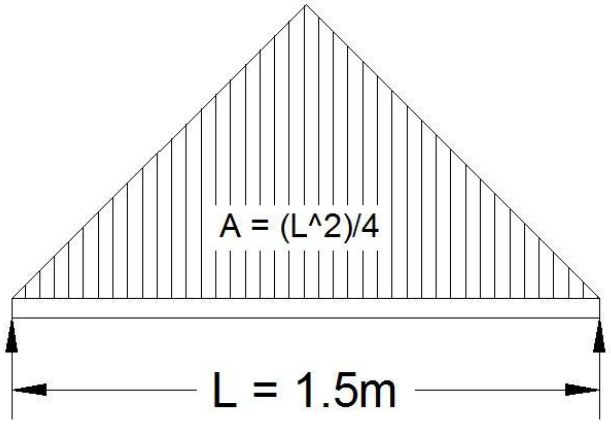




Load A

$$Def(A) = \frac{W * L^3}{62.4EI}$$

k = 0.3



Load B

$$Def(B) = \frac{W * L^3}{60EI}$$

k = 0.5

Solution:

- 1606 Pa
- At 1606 Pa this product can claim a NAFS rating of PG30.

Performance class and optional performance grade (PG)				Design pressure (DP)	
R	LC	CW	AW	Pa	(psf)
20	—	—	—	960	(20.00)
25	—	—	—	1 200	(25.00)
30	30	—	—	1 440	(30.00)
35	35	35	—	1 680	(35.00)
40	40	40	—	1 920	(40.00)

Total defection at the Design Pressure is the deflection due to Load A plus Load B.

$$Def = Def(A) + Def(B)$$

$$Def = \frac{Wa * L^3}{62.4EI} + \frac{Wb * L^3}{60EI}$$

Load W is equal to the DP times the Area, and the deflection limit is L/175:

$$Wa = DP * Aa;\ Wb = DP * Ab;\ Def = \frac{L}{175}$$

Subbing these values in:

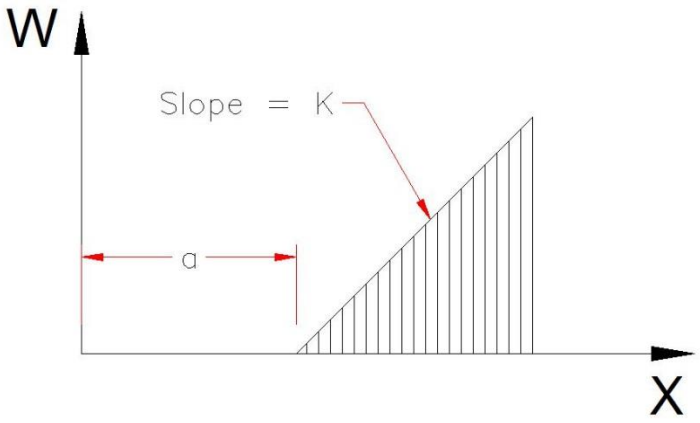
$$\frac{L}{175} = \frac{DP * Aa * L^3}{62.4EI} + \frac{DP * Ab * L^3}{60EI}$$

Solving for DP:

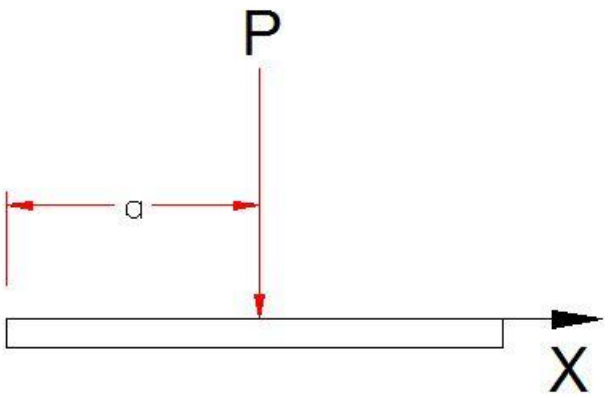
$$DP = \frac{\frac{L}{175}}{\frac{Aa * L^3}{62.4EI} + \frac{Ab * L^3}{60EI}}$$

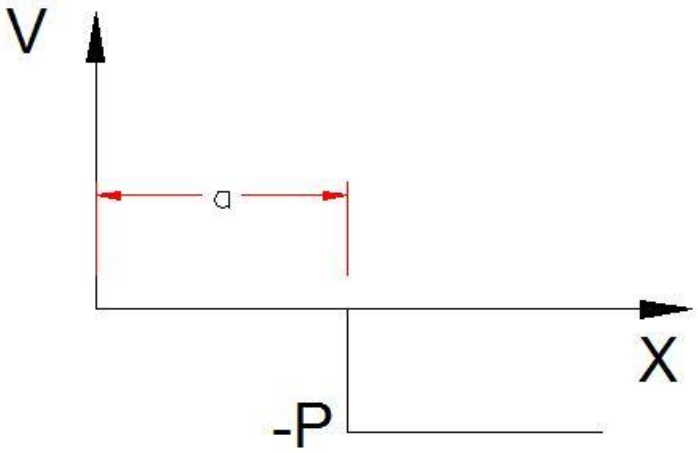
$$DP = \frac{.008571}{\frac{0.5 * 3.375}{686400} + \frac{0.5625 * 3.375}{660000}} = 1606\ Pa$$

Doing these types of calculations manually can be time consuming and error prone. We can easily program computers to automate the process.



$$f(x) = \frac{k}{n!}\langle X - a\rangle^n$$

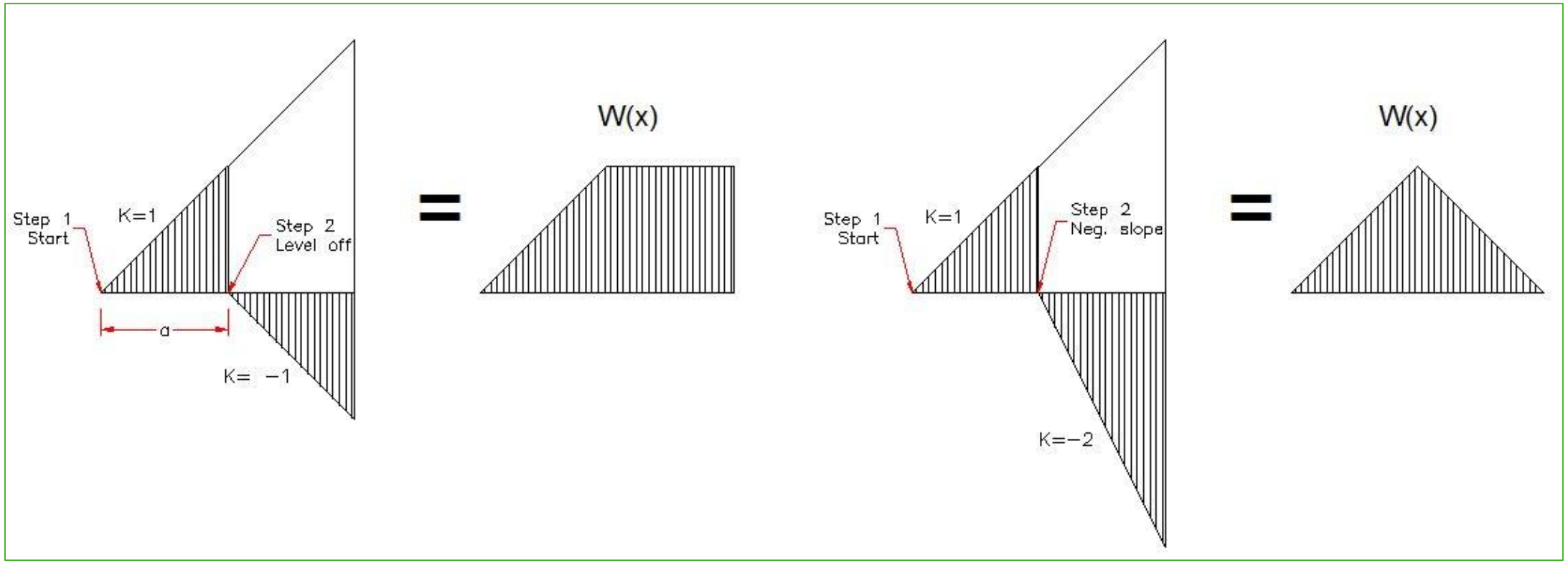




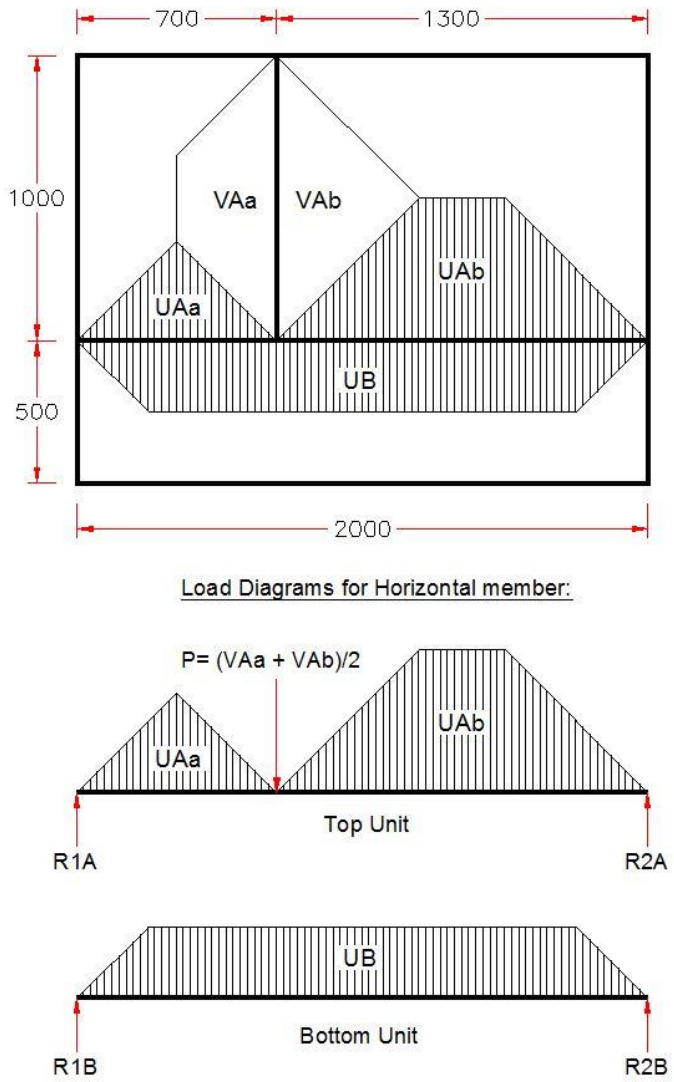
For any value of n≥2

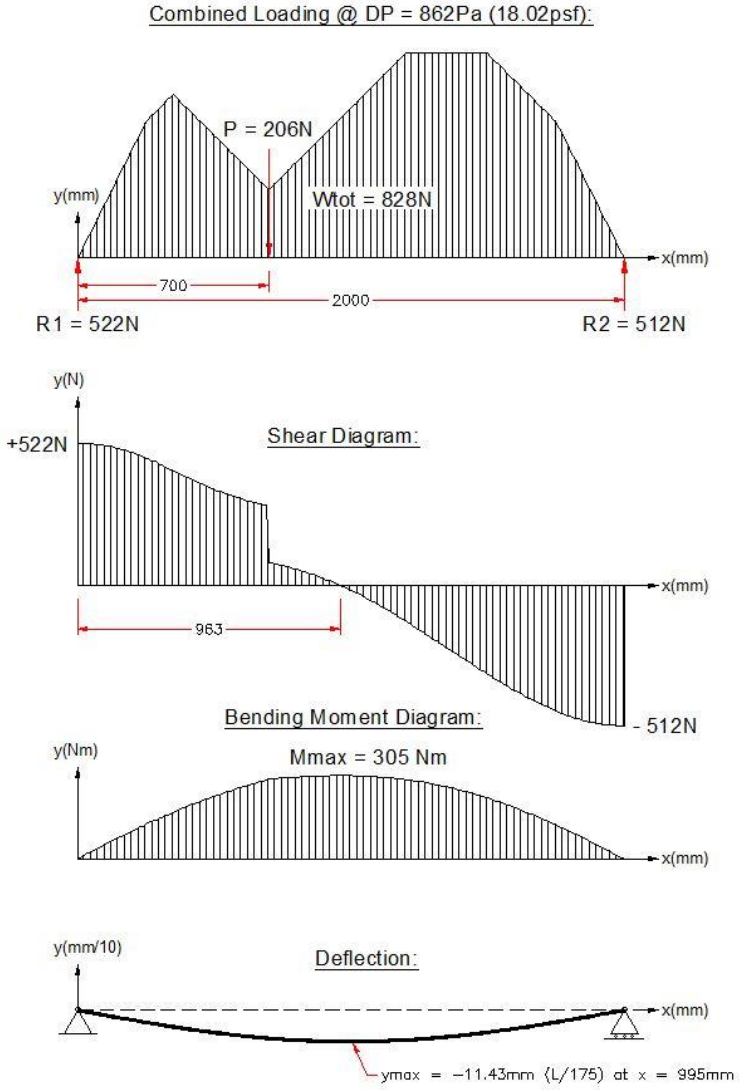
$$f(x) = \frac{-P}{(n-2)!}\langle X - a\rangle^{n-2}$$

Adding these functions to one another you can create a function for the loading at any point on the beam.



Then the software can calculate the shear, bending moment and deflection by integrating the functions, simply by increasing the value of the exponent n in the step function.





$$f(x) = \frac{k}{n!}\langle X - a\rangle^{n}$$

$$f(x) = \frac{-P}{(n-2)!}\langle X - a\rangle^{n-2}$$

Automated Mullion Analysis

Ply Gem has this functionality built into our new AccuQuote order entry system in order to ensure a minimum level of compliance of the mullions for all products we configure, using the deflection limit of L/175 at PG15.

- This is not a Part 9 Code requirement or a NAFS requirement, it is something we do for a minimum level of assurance regarding the mullion strength and deflection.
- It is on top of NAFS laboratory test reports that rate the mullions at higher pressures based on blow-out testing with a residual deflection criteria.

On non-Part 9 projects we would use the design pressure specified for the project by the Architect or Engineering consultant as our design target during the quotation process.

- This is not the official professional design and review required by code
  - It is just an internal process to help us avoid costly changes later.
  - Professional Design and Review needs to be done by a 3rd party with liability insurance.
- The AAMA 450 calculations are repeated by the 3rd party structural engineering consultant, using the same methods, before signing off on the shop drawing or noting any required changes.

What Else is Covered by a Shop Drawing Review?

1. Glass thickness to meet specified wind load requirements based on CAN/CGSB 12.20-M89
   - Can use GD 2012 Software distributed by IGMA

2. Fastener schedule / window installation details
   - Are head retainers required to accommodate interstorey drift (Yes).

3. Occupant safety (fall protection) – sash limit devices on operable windows where required

4. Safety glass where required

5. Guard Load requirements for glazing that are little understood in Alberta.

2. Fastener Schedule, Head retainers:

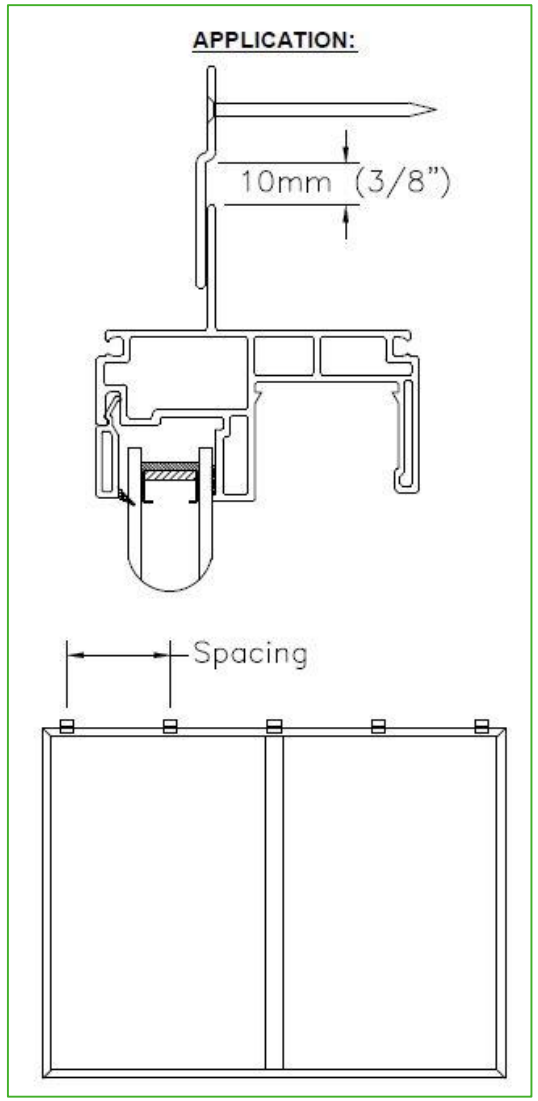
Fastener Spacing:

Fasteners: #11 GA FH x 2-1/2" LG galvanized roofing nails
(To be filled in by structural engineer prior to stamping drawings)

Type	Head Retainer	Jambs	Sills
Windows	12 " O.C.	12 " O.C.	12 " O.C.
Patio Doors	6 " O.C.	12 " O.C.	6 " O.C.
Swing Doors	12" O.C.	12" O.C.	12 " O.C.

4. Allowable horizontal interstorey drift: Maximum $\frac{3}{8}$"

5. Allowable differential vertical deflection between floors: Maximum $\frac{3}{8}$"



3. Sash limit devices:

3.3.4.8. Protection of Openable Windows

1) Except as provided in Sentence (2), openable windows in *suites* of *residential occupancy* shall be protected by

a) a *guard* with a minimum height of 1 070 mm constructed in accordance with Article 3.3.1.18., or

b) a mechanism capable of controlling the free swinging or sliding of the openable part of the window so as to limit any clear unobstructed opening to not more than 100 mm measured either vertically or horizontally where the other dimension is greater than 380 mm.

2) Windows need not be protected in accordance with Sentence (1) where

a) the only opening having greater dimensions than those allowed by Clause (1)(b) is located higher than 1 070 mm above the finished floor, or

b) the bottom edge of the openable portion of the window is located less than 1 800 mm above the floor or ground on the other side of the window.

4. Safety Glazing requirements:

1. Doors – 3.3.1.19 (2)
   - Glass in doors must be laminated or tempered safety glass
   - A no-brainer, all manufacturers do this as a default
2. Door sidelites – 3.3.1.19 (5) says must conform to 9.6.1.4
   - Glass in doors and sidelites that could be mistaken for doors must be laminated or tempered safety glass
   - Some jurisdictions require all sidelite glazing to be safety glass, therefore Ply Gem tempers all sidelite glass.
3. Glass used in shower and bathtub enclosures shall be laminated or tempered safety glass - 3.7.2.5, 9.31.2.4

5. Windows that are required to meet guard loads:

3.3.1.19.

6) A window in a public area that extends to less than 1000mm above the floor and is located above the second storey in a building of residential occupancy, shall be protected by a barrier or railing to not less than 1070mm above the floor, or the window shall be non-openable and designed to withstand the lateral design loads for balcony guards required by Article 4.1.5.14.

3.3.4.7. Stairs, Ramps, Landings, Handrails and Guards for Dwelling Units

1) Except as required in Article 3.3.4.8., stairs, ramps, landings, handrails and *guards* within a *dwelling unit* shall conform to the appropriate requirements in Section 9.8. and Sentences 9.8.8.1.(4) to (6).

From 9.8.8.1:

7) Except as provided in Sentence (8), glazing installed over *stairs*, ramps and landings that extends to less than 1 070 mm above the surface of the treads, ramp or landing shall be

a) protected by *guards*, in accordance with this Subsection, or
b) non-openable and designed to withstand the specified lateral loads for balcony *guards* as provided in Article 4.1.5.14.

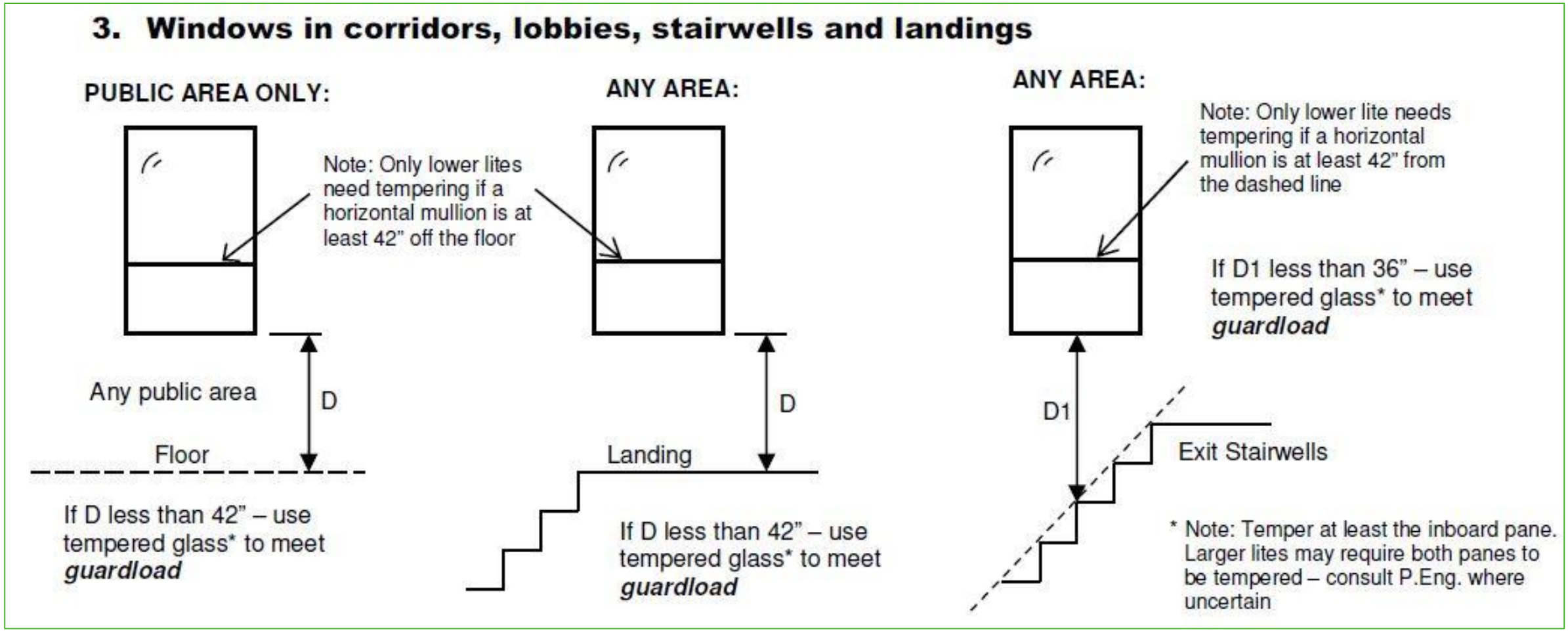
8) In *dwelling units*, glazing installed over *stairs*, ramps and landings that extends to less than 900 mm above the surface of the treads, ramp or landing shall be

a) protected by *guards*, in accordance with this Subsection, or
b) non-openable and designed to withstand the specified lateral loads for balcony *guards* as provided in Article 4.1.5.14.

9) Glazing installed in public areas that extends to less than 1 m from the floor and is located above the second *storey* in *buildings* of *residential occupancy* shall be

a) protected by *guards* in accordance with this Subsection, or
b) non-openable and designed to withstand the specified lateral loads for balcony *guards* as provided in Article 4.1.5.14.

A picture is worth a thousand words:



Windows in exterior walls that are required to Act as a Guard:

3.3.1.18. Guards

1) Except as provided in Sentence (4) and Article 3.3.2.9., a *guard* not less than 1 070 mm high shall be provided

a) around any roof to which access is provided for purposes other than maintenance,

b) at openings into smoke shafts referred to in Subsection 3.2.6. that are less than 1 070 mm above the floor, and

c) at each raised floor, *mezzanine*, balcony, gallery, interior or exterior vehicular ramp, and at other locations where the difference in level is more than 600 mm.

4.1.5.16. Loads on Walls Acting As Guards

1) Where the floor elevation on one side of a wall, including a wall around a shaft, is more than 600 mm higher than the elevation of the floor or ground on the other side, the wall shall be designed to resist the appropriate lateral design loads prescribed elsewhere in this Section or 0.5 kPa, whichever produces the more critical effect.

BC BUILDING CODE INTERPRETATION COMMITTEE

A joint committee with members representing

AIBC, APEGBC, BOABC, POABC

File No: 06-0078r **INTERPRETATION** **Page 1 of 2**

Interpretation Date:	February 15, 2011 (***Revised September 28, 2011***)
Building Code Edition:	BC Building Code 2006
Subject:	Structural Loads on Exterior Glazing within Dwelling Units
Keywords:	Structural Loads, Guards, Exterior Glazing, Dwelling Units
Building Code Reference(s):	3.3.1.18.(1)(c), 3.3.1.19.(6), ***3.3.4.7.(1)***, 4.1.5.15., 4.1.5.17.(1), ***9.8.8.2.(4)***

Question:

In a Part 3 building, are exterior windows in non-public areas of residential and other occupancies required to be structurally designed to resist guard loading when the windows extend lower than 1000 mm above finished floor level and the floor level is more than 600 mm above adjacent ground level?

Interpretation:

Yes

Clause 3.3.1.18.(1)(c) requires that a guard be provided ***whenever the difference in floor elevation exceeds*** 600 mm.

Sentence 4.1.5.17.(1) requires that a wall act as a guard when the floor elevation on one side of the wall is more than 600 mm above the floor or ground elevation on the other side of the wall.

If a window is located within a wall, the window is considered part of the wall.

The required design load for this wall is either the guard loading described in Article 4.1.5.15. or 0.5 kPa, whichever produces the more critical effect. When an exterior wall contains windows that extend lower than 1000 mm above finished floor level, ***and such window is not protected by a guard***, the window would be subject to these loads.

Although Sentence 3.3.1.19.(6) only applies to windows in public areas that extend to less than 1000 mm above the floor level, Sentence 4.1.5.17.(1) applies to walls in both public and private areas.

R. J. Light, Committee Chair

What is the Guard Height?

From CSA-A500-16 *Building Guards*:

Table 4.1
Minimum guard height, H_G
(See Clauses 4.1.9.1 and 5.5.1.7.)

Location		Minimum height of the guard H_G, mm
Residential (per *NBC* Articles 3.3.4.7. and 9.8.8.3.)	Within dwelling units	900
	Exterior guards not more than 1800 mm above ground level	
	Flights of stairs, except exit stairs	
	All other residential guards	1070
Exterior stairs and landings more than 10 m above ground level (per *NBC* Articles 3.4.6.6. and A-9.8.8.1.)		1500
Fire escapes (per *NBC* Article 3.4.7.6.)		920
All other guards (per *NBC* Articles 3.3.5.4. and 3.3.1.18.)		1070

What are the Guard Loads?

4.1.5.14. Loads on Guards

(See Appendix A.)

1) The minimum specified horizontal load applied inward or outward at the minimum required height of every required *guard* shall be

a) 3.0 kN/m for open viewing stands without fixed seats and for *means of egress* in grandstands, stadia, bleachers and arenas,

b) a concentrated load of 1.0 kN applied at any point for access ways to equipment platforms, contiguous stairs and similar areas where the gathering of many people is improbable, and

c) 0.75 kN/m or a concentrated load of 1.0 kN applied at any point, whichever governs for locations other than those described in Clauses (a) and (b).

2) Individual elements within the *guard*, including solid panels and pickets, shall be designed for a load of 0.5 kN applied over an area of 100 mm by 100 mm located at any point in the element or elements so as to produce the most critical effect.

What does all this mean:

If there is a drop on the other side, and the sill of a window is below the Guard Height, the window is required to act as a guard.

- GH = 900mm = 36” within a dwelling unit
- GH = 1070mm = 42” in corridors and public spaces

Individual elements within the guard (such as glazing) shall be designed to resist a load of 0.5kN over an area of 100 x 100mn (4”x4”)

- This requires the glass to be ***tempered in***, with some exceptions:
  - Lites less than 0.46m^2 (5 ft^2) can resist the load without tempering.
  - Lites ≤ 500mm in either width or height are also exempt.
  - If there is a horizontal mullion at the guardrail height or within 150mm (6”) from the guardrail height, only the bottom lite(s) need to be tempered.

Is this just a BC thing?

These requirements are also described in the ***Glazing Systems Specifications Manual:***

- Originally published by the *Glazing Contractor's Association of BC* (Now FenBC)
- Also adopted by:
  - The *Provincial Glaziers Association of Alberta*
  - And in Ontario by
    - The *Glass and Architectural Glass and Metal Contractors Association* (AGMCA)
    - The Ontario Glass and Metal Association (OGMA)
    - The Canadian Glass Association (CGA)

From the Glazing Systems Specifications Manual:

(D) LOW LEVEL WINDOW GLAZING
IN BUILDINGS OF RESIDENTIAL AND OTHER OCCUPANCY

This section is applicable to windows in non-public areas of residential and other buildings located above the ground floor or where the floor elevation on the inside of the window is more than 0.6 m (24") higher than on the outside of the window. If the window is not protected with a guard it is considered to be a wall that is acting as a guard[19], therefore it must comply with Sentences 3.3.1.17.(1) and 4.1.10.3.(1) of the Building Code. These locations are not considered to be hazardous but a minimum level of safety is still recommended if the glass would be accidentally hit by children or adults.

The Ontario Building Code states the following:

> The entire wall shall also comply with the requirements of articles 4.1.10.1 and 4.1.10.2 as well as the live loads specified elsewhere in part 4 of the OBC [Ontario Building Code]. This requirement is applicable to interior and exterior walls. It is applicable regardless of the construction of the wall; ie. gypsum board, **glass**, masonry, precast concrete.

Glass in windows wider than 500 mm (20") where the bottom exposed edge of glass is less than 760 mm (30") above the standing or walking surface shall be designed to withstand a 0.5 kN point load. However, if the glass area in such a window is less than 0.46 m2 (5 sqft) in ***residential buildings*** or less than 0.84 m2 (9 sqft) in ***other buildings***, and the height of the glass is less than 500 mm (20"), it is considered adequate[20].

Dave Goldsmith | Dave.Goldsmith@plygem.com

Senior Design Engineer

D: 587-320-3898 | T: 866-214-7913 x 265

7140 40th Street S.E., Calgary AB