FENESTRATION CANADA

Glass strength design under NBC 2015/2020 and use of CSA A440S1 to determine Part 9 glass design pressures for use with CAN/CGSB-12.20-M or ASTM E1300

Date: 2022-11-03

EXECUTIVE SUMMARY

The 2015 NBC made two significant changes affecting calculation of wind loads for glass design. The first was to reduce the factored hourly wind pressure by 25% when designing glass to CAN/CGSB-12.20-M. The second was to allow the use of ASTM E1300 for glass design. Both changes were accomplished by the introduction of a ”wind load adjustment factor” in Article 4.3.6.1.[1]

This bulletin describes the changes to the design basis for glass introduced in the 2015 NBC and present in the 2020 edition. It also describes how serviceability limit states (SLS) wind pressures determined using CSA A440S1 to determine design pressures for selecting NAFS Performance Grades can be converted to ultimate limit states (ULS) pressures for glass design by using the appropriate importance factors.

Referenced document versions

This document applies to buildings constructed under the 2015 and 2020 editions of the NBC. The relevant standard versions are presented below.

Standard	2015 NBC	2020 NBC
CSA A440S1	CSA A440S1-17, Canadian Supplement to AAMA/WDMA/CSA 101/I.S.2/A440-11, North American Fenestration Standard/Specification for Windows, Doors, and Skylights	CSA A440S1:19, Canadian Supplement to AAMA/WDMA/CSA 101/I.S.2/A440-17, North American Fenestration Standard/Specification for windows, doors, and skylights
ASTM E1300	ASTM E 1300-12ae1, Determining Load Resistance of Glass in Buildings	ASTM E1300-16, Standard Practice for Determining Load Resistance of Glass in Buildings
CAN/CGSB-12.20-M	CAN/CGSB-12.20-M89, Structural Design of Glass for Buildings	

Change to the “design basis” for glass

NBC 2015 Article 4.3.6.1 allows glass to be designed to CAN/CGSB-12.20-M or ASTM E1300. Section 68 of the 2015 NBC User’s Guide Structural Commentary I presents the rationale for allowing use of ASTM

[1] The wording of Article 4.3.6.1 is the same in the 2015 and 2020 editions of the NBC.

E1300 to be used for glass strength design in addition to CAN/CGSB-12.20-M and asserts that both standards ". . . are worth referencing as they each address some applications the other does not." [2]

Specifically, Section 68 describes two factors that are to be applied to the 1/50 hourly wind pressure (HWP) in NBC 2015 Div. B Appendix C Table C-2 to determine a factored load that can be used to calculate the specified wind load used for glass strength design under ASTM E1300 or CAN/CGSB-12.20-M.

The first factor to be applied is a Load Factor, the second is an Adjustment Factor.

Load Factor. NBC Table 4.1.3.2.-A [3] provides load factor combinations for ULS design. The environmental 1/50 HWP represented by the letter **W** is assigned a Load Factor of 1.4. The Load Factor increases the 1/50 HWP by 40% for the purposes of designing to a material's *ultimate load capacity before failure* and is in effect a 140% "safety factor" applied to the historic environmental wind pressure data. (See principal-load factor 1.4W in Case 4 of Table 4.1.3.2.-A where W refers to a variable wind load.)

Wind Load Adjustment Factor. The wind load adjustment factor was introduced in Article 4.3.6.1 of NBC 2015 specifically to allow the use of ASTM E1300 for glass strength design.

> **4.3.6.1. Design Basis for Glass**
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> **1)** Glass used in *buildings* shall be designed in conformance with
> a) CAN/CGSB-12.20-M, "Structural Design of Glass for Buildings," using an adjustment factor on the wind load, W, of not less than 0.75, or
> b) ASTM E 1300, "Determining Load Resistance of Glass in Buildings," using an adjustment factor on the wind load, W, of not less than 1.0.
>
> (See Note A-4.3.6.1.(1).)

The adjustment factor for CAN/CGSB-12.20-M is 0.75, which means it *reduces* the factored 1/50 HWP by 25%. The 2015 NBC User's Guide Structural Commentary I Section 68 explains this was done ". . . to make the overall level of reliability similar to the one achieved in 1989 using CAN/CGSB-12.20-M . . ." when 1/10 HWP values were used for wind load design. (The change to use of a 1/50 HWP return period in the 2005 code had the result of making glass design more conservative than was the case in 1989 when CAN/CGSB-12.20-M was published.)

The adjustment factor for ASTM E1300 is 1.0. According to Section 68 of Structural Commentary I, glass strength calculations using ASTM E1300 with an adjustment factor of 1.0 produce very similar results to calculations using CAN/CGSB-12.20-M with an adjustment factor of 0.75.

[2] Structural Commentaries (User's Guide – NBC 2015: Part 4 of Division B).
[3] The Load Combinations in NBC Table 4.1.3.2.-A are the same in the 2015 and 2020 editions of the NBC.

The two factors are used to determine the factored wind load for use in calculating the specified wind pressure:

Design Standard	Factored wind load
CAN/CGSB-12.20-M	1/50 HWP x 1.4 x 0.75
ASTM E1300	1/50 HWP x 1.4 x 1.0

These factored loads are used with the formula for calculating the specified wind load *p* in NBC Article 4.1.7.3. On large buildings, the Static Procedure, Dynamic Procedure, or Wind Tunnel procedures are used to design glass for resistance to wind loading.

The preceding discussion of Load Factor and Wind Load Adjustment Factor applies to fenestration glass design in all buildings. The following section is addressed to non-professionals that need to determine the appropriate wind load for glass design on Part 9 buildings where registered professionals are not ordinarily employed for this purpose.

Determining ULS glass design pressure using the CSA A440S1 SLS specified wind load

For Part 9 buildings, static procedure calculations are commonly used to determine the wind load for glass strength design. A simplified version of the formula in NBC Article 4.1.7.3 [4] is presented in Clause 4.2.2 of CSA A440S1, where it is used to determine a conservative *specified wind load* (*p*) used to evaluate the in-service deflection behaviour of fenestration framing members in buildings situated on level terrain with a slope no greater than 1:10. Tables 2 – 5 of CSA A440S1 contain tabular values computed with the simplified formula, and the Fenestration Canada online Performance Grade Calculator computes level terrain values using the same calculations.

In principle, the CSA A440S1 specified wind load can be used to determine a factored wind load for glass strength design using CAN/CGSB-12.20-M or ASTM E1300 with the use of the appropriate Importance Factor in addition to the Load Factor and Wind Load Adjustment Factor previously discussed.

The importance factors for wind load are presented in NBC Table 4.1.7.3 [5], and reproduced below.

Table 4.1.7.3.
Importance Factor for Wind Load, I_W
Forming Part of Sentences 4.1.7.3.(1) and 4.1.7.8.(4)

Importance Category	Importance Factor, I_W	
	ULS	SLS
Low	0.8	0.75
Normal	1	0.75
High	1.15	0.75
Post-disaster	1.25	0.75

[4] The wording of Article 4.1.7.3 is the same in the 2015 and 2020 editions of the NBC.
[5] The Importance Factors in Table 4.1.7.3 are the same in the 2015 and 2020 editions of the NBC. The NBC 2020 table is presented here.

The specified wind load calculation uses an importance factor of 0.75 which is appropriate for determining the SLS wind pressure for buildings of normal importance. Glass however must be designed to the ULS wind load used to evaluate failure and which requires the importance factor for Normal buildings to be 1.0. Consequently, the A440S1 specified wind load *p* must be factored by 1.0/0.75 to *correct the importance factor* before applying the wind load and adjustment factors.

ULS Importance Factor Correction: multiply the specified wind load by 1.0/0.75.

Calculation formula and example

The factors required to convert a CSA A440S1 SLS specified wind load *p* for in-service deflection analysis to a ULS design pressure for glass failure analysis using CAN/CGSB-12.20-M and ASTM E1300 are presented below.

ULS glass design pressure:

p × ULS Importance Factor Correction (1.0/0.75) × Load Factor (1.4) × Adjustment Factor (0.75 or 1.0)

Where *p* is the CSA A440S1 Clause 4.2.2 specified wind load or the design pressure value from the Fenestration Canada Performance Calculator.

Examples:

Design standard	Calculation	Example
CAN/CGSB-12.20-M	A440S1 DP x 1.0/0.75 x 1.4 x 0.75	20 psf x 1.0/0.75 x 1.4 x 0.75 = 28.0 psf
ASTM E1300	A440S1 DP x 1.0/0.75 x 1.4 x 1.0	20 psf x 1.0/0.75 x 1.4 x 1.0 = 37.3 psf