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Proposed Change 1898

Code Reference(s):	**NBC20 Div.B 4.1.8.1. (first printing)**
Subject:	Earthquake Design
Title:	Revisions to Article 4.1.8.1. (Simplified Method)
Description:	The proposed change revises Article 4.1.8.1. by adjusting the triggers that determine the locations where the simplified method for seismic design applies and modifying the approach for determining the design spectral acceleration.

This change could potentially affect the following topic areas:

- ☐ Division A
- ☐ Division C
- ☐ Building operations
- ☐ Small Buildings
- ☐ Fire Protection
- ☐ Accessibility
- ☐ Building Envelope
- ☐ Heating, Ventilating and Air Conditioning
- ☑ Division B
- ☑ Design and Construction
- ☐ Housing
- ☑ Large Buildings
- ☐ Occupant safety in use
- ☑ Structural Requirements
- ☐ Energy Efficiency
- ☐ Plumbing
- ☐ Construction and Demolition Sites

Problem

Article 4.1.8.1. of Division B of the NBC was introduced in the 2015 edition to provide a simplified method for the seismic design of buildings in localities where the seismic hazard is low. Due to the general increase in the seismic hazard values for the NBC 2020, the number of localities in the country where this method is permitted to be used for seismic design in compliance with the NBC has shrunk considerably.

In general, designers and enforcement professionals in localities where the simplified method was previously permitted are not familiar with the full (detailed) seismic design requirements. Therefore, the inability to use the simplified method presents a significant hardship for them.

Justification

The reduction in the number of localities where the simplified method can be used presents a hardship for Code users who have relied on this method since it was introduced in the NBC 2015 to satisfy seismic design requirements in localities where the seismic hazard is low. The use of the simplified method by designers in such localities ensured that buildings were designed for estimated earthquake loads without designers having to navigate the complexity of the seismic provisions in the rest of the Subsection 4.1.8.

However, the number of localities where this method is permitted be used has decreased significantly with the NBC 2020 seismic hazard values. If nothing is done, Code users in some localities where the simplified method was previously permitted will have to apply the full seismic design requirements. For localities with relatively low seismic hazard, this is an avoidable hardship. To mitigate this hardship, the proposed change increases the values of the hazard thresholds to expand the application of the simplified design method to match, to the extent possible, its application with the NBC 2015 seismic hazard values. It also harmonizes the determination of the values of the thresholds with the definitions in Article 4.1.8.2. to improve consistency between the simplified and full design methods.

PROPOSED CHANGE

[4.1.8.1.] 4.1.8.1. Analysis

[1] 1) Except as permitted in Sentence (2), the deflections and specified loading due to earthquake motions shall be determined according to the requirements of Articles 4.1.8.2. to 4.1.8.23.

[2] 2) Where I_E~~F_s~~$S_a(0.2,X_{450S})$ and $I_E S_a(0.5,X_S)$ are less than 0.2 and I_E~~F_s~~S_a(~~2~~1.0,X_{450S}) ~~are~~is less than ~~0.16 and 0.03 respectively~~0.1, the deflections and specified loading due to earthquake motions are permitted to be determined in accordance with Sentences (3) to (15), where

[a] a) I_E is the earthquake importance factor and has a value of 0.8, 1.0, 1.3 and 1.5 for *buildings* in the Low, Normal, High and Post-disaster Importance Categories respectively,

[b] b) ~~F_s is the site coefficient based on the average $\bar{N}_{60}$ or $\bar{s}_u$, as defined in Article 4.1.8.2., for the top 30 m of *soil* below the footings, *pile* caps, or mat *foundations* and has a value of~~

[i] i) ~~1.0 for *rock* sites or when $\bar{N}_{60} > 50$ or $\bar{s}_u > 100$ kPa,~~

[ii] ii) ~~1.6 when $15 \leq \bar{N}_{60} \leq 50$ or 50 kPa $\leq \bar{s}_u \leq 100$ kPa, and~~

[iii] iii) ~~2.8 for all other cases, and~~

[c] c) $S_a(T,X_{450S})$ is the 5%-damped spectral acceleration ~~value~~ , expressed as a ratio to gravitational acceleration, at period T for

site designation X_{450S}, as defined in ~~Article 4.1.8.2.~~Clause (d), determined in accordance with Subsection 1.1.3. and corresponding to a 2% probability of exceedance in 50 years, and

[d] --) X_S is the site designation in terms of Site Class, where S is the Site Class determined using the average $\overline{N}_{60}$ or $\overline{s}_u$, as defined in Article 4.1.8.2., for the top 30 m of *soil* and has a value of

[i] i) X_C for *rock* sites or where $\overline{N}_{60} > 50$ or $\overline{s}_u > 100$ kPa,

[ii] ii) X_D where $15 < \overline{N}_{60} \leq 50$ or 50 kPa $\leq \overline{s}_u \leq 100$ kPa, and

[iii] iii) X_E for all other cases.

[3] 3) The structure shall have a clearly defined

[a] a) seismic force resisting system (SFRS) to resist the earthquake loads and their effects, and

[b] b) load path (or paths) that will transfer the inertial forces generated in an earthquake to the supporting ground.

[4] 4) An unreinforced masonry SFRS shall not be permitted where

[a] a) I_E is greater than 1.0, or

[b] b) the height above *grade* is greater than or equal to 30 m.

[5] 5) The height above *grade* of an SFRS designed in accordance with CSA S136, "North American Specification for the Design of Cold-Formed Steel Structural Members (using the Appendix B provisions applicable to Canada)", shall be less than 15 m.

[6] 6) Earthquake forces shall be assumed to act horizontally and independently about any two orthogonal axes.

[7] 7) The specified lateral earthquake force, V_s, at the base of the structure in the direction under consideration shall be calculated as follows:

$$V_s = F_s S_a\left(T_s, X_{450}\right) I_E W \Big/ R_s$$

$$V_s = S\left(T_s\right) I_E W \Big/ R_S$$

where

$S_a(T_s, X_{450})$ = ~~value of $S_a(T_s, X_{450})$~~design spectral acceleration at period T_s, determined ~~by~~as follows, using linear interpolation for intermediate values of T_s~~between the values of $S_a(0.2, X_{450})$, $S_a(0.5, X_{450})$ and $S_a(1.0, X_{450})$~~, $= S_a(0.2, X_{450S})$ or $S_a(0.5, X_S)$, whichever is greater, for $T_s \leq 0.2$ s, ~~and~~
$= S_a(0.5, X_S)$ for $T_s = 0.5$ s, and
$= S_a(1.0, X_{450S})$ for $T_s \geq 1.0$ s,

W = sum of W_i over the height of the *building*, where W_i is defined in Article 4.1.8.2., and

R_S = 1.5, except $R_S = 1.0$ for structures where the *storey*

strength is less than that in the *storey* above and for an unreinforced masonry SFRS,

where

$S_a(0.2,X_S)$, $S_a(0.5,X_S)$, $S_a(1.0,X_S)$ = 5%-damped spectral acceleration values at periods of 0.2 s, 0.5 s and 1.0 s, respectively, for site designation X_S, determined in accordance with Subsection 1.1.3. and corresponding to a 2% probability of exceedance in 50 years, and

T_s = fundamental lateral period of vibration of the *building*, as defined in Article 4.1.8.2.,
= $0.085(h_n)^{3/4}$ for steel moment frames,
= $0.075(h_n)^{3/4}$ for concrete moment frames,
= $0.1N$ for other moment frames,
= $0.025h_n$ for braced frames, and
= $0.05(h_n)^{3/4}$ for shear walls and other structures,

where

h_n = height, in m, above the base to level n, as defined in Article 4.1.8.2., and

N = total number of *storeys* above exterior *grade* to level n, as defined in Article 4.1.8.2.,

except that, in cases where $R_s = 1.5$, V_s need not be greater than ~~F_s~~$S_a(0.5,X_{450S})I_EW/R_s$.

[8] 8) The specified lateral earthquake force, V_s, shall be distributed over the height of the *building* in accordance with the following formula:

$$F_x = \frac{V_s W_x h_x}{\sum_{i=1}^{n} W_i h_i}$$

where

F_x = force applied through the centre of mass at level x,

W_x, W_i = portion of W that is located at or is assigned to level x or i respectively, and

h_x, h_i = height, in m, above the base to level x or i respectively, as defined in Article 4.1.8.2.

[9] 9) Accidental torsional effects applied concurrently with F_x shall be considered by applying torsional moments about the vertical axis at each level for each of the following cases considered separately:

[a] a) $+0.1D_{nx}F_x$, and

[b] b) $-0.1D_{nx}F_x$.

[10] 10) Deflections obtained from a linear analysis shall include the effects of torsion and be multiplied by R_s/I_E to get realistic values of expected

deflections.

[11] **11)** The deflections referred to in Sentence (10) shall be used to calculate the largest inter*storey* deflection, which shall not exceed

[a] a) $0.01h_s$ for *post-disaster buildings*,

[b] b) $0.02h_s$ for High Importance Category *buildings*, and

[c] c) $0.025h_s$ for all other *buildings*,

where h_s is the inter*storey* height as defined in Article 4.1.8.2.

[12] **12)** When earthquake forces are calculated using R_s = 1.5, the following elements in the SFRS shall have their design forces due to earthquake effects increased by 33%:

[a] a) diaphragms and their chords, connections, struts and collectors,

[b] b) tie downs in wood or drywall shear walls,

[c] c) connections and anchor bolts in steel- and wood-braced frames,

[d] d) connections in precast concrete, and

[e] e) connections in steel moment frames.

[13] **13)** Except as provided in Sentence (14), where cantilever parapet walls, other cantilever walls, exterior ornamentation and appendages, towers, chimneys or penthouses are connected to or form part of a *building*, they shall be designed, along with their connections, for a lateral force, V_{sp}, distributed according to the distribution of mass of the element and acting in the lateral direction that results in the most critical loading for design using the following equation:

$$V_{sp} = 0.9S_a\left(0.2, X_{450}\right)F_s I_E W_p$$

$$V_{sp} = 0.9S_a\left(0.2, X_s\right)I_E W_p$$

where

W_p = weight of a portion of a structure as defined in Article 4.1.8.2.

[14] **14)** The value of V_{sp} shall be doubled for unreinforced masonry elements.

[15] **15)** Structures designed in accordance with this Article need not comply with the seismic requirements stated in the applicable design standard referenced in Section 4.3.

Impact analysis

The proposed change is expected to have a positive impact as it would alleviate a hardship for Code users in localities with relatively low seismic hazard where the simplified method is no longer permitted under the NBC 2020 due to an increase in the estimated values of seismic hazard.

The proposed change would provide relief for designers and enforcement professionals in such localities, as it reinstates the simplified method as a means of compliance with NBC in these localities.

Enforcement implications

The proposed change would have positive implications for enforcement, as it addresses the hardship resulting from the change of practice in the NBC 2020 for localities with relatively low seismic hazard.

The continued ability to use the simplified method for seismic design in localities with relatively low seismic hazard, where compliance with the full seismic design requirements would otherwise be required, would provide relief for enforcement professionals, as it would allow authorities having jurisdiction to use existing methods and resources without the need for additional training.

Who is affected

Owners, designers, contractors and enforcement professionals dealing with the seismic design of buildings in low-seismic-hazard localities covered under Article 4.1.8.1.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[4.1.8.1.] 4.1.8.1. ([1] 1) no attributions

[4.1.8.1.] 4.1.8.1. ([2] 2) no attributions

[4.1.8.1.] 4.1.8.1. ([2] 2) ([a] a) [F20-OS2.1]

[4.1.8.1.] 4.1.8.1. ([2] 2) ([a] a) [F20-OP2.1,OP2.3] [F22-OP2.4]

[4.1.8.1.] 4.1.8.1. ([2] 2) ([b] b) [F20-OS2.1]

[4.1.8.1.] 4.1.8.1. ([2] 2) ([b] b) [F20-OP2.1] [F22-OP2.4]

[4.1.8.1.] 4.1.8.1. ([2] 2) ([c] c)

[4.1.8.1.] 4.1.8.1. ([3] 3) [F20-OS2.1]

[4.1.8.1.] 4.1.8.1. ([3] 3) [F20-OP2.1,OP2.4]

[4.1.8.1.] 4.1.8.1. ([4] 4) [F20-OS2.1]

[4.1.8.1.] 4.1.8.1. ([4] 4) [F20-OP2.1] [F22-OP2.4]

[4.1.8.1.] 4.1.8.1. ([5] 5) [F20-OS2.1]

[4.1.8.1.] 4.1.8.1. ([5] 5) [F20-OP2.1] [F22-OP2.4]

[4.1.8.1.] 4.1.8.1. ([6] 6) [F20-OS2.1]

[4.1.8.1.] 4.1.8.1. ([6] 6) [F20-OP2.1] [F22-OP2.4]

[4.1.8.1.] 4.1.8.1. ([7] 7) [F20-OS2.1]

[4.1.8.1.] 4.1.8.1. ([7] 7) [F20-OP2.1] [F22-OP2.4]

[4.1.8.1.] 4.1.8.1. ([8] 8) [F20-OS2.1]

[4.1.8.1.] 4.1.8.1. ([8] 8) [F20-OP2.1] [F22-OP2.4]

[4.1.8.1.] 4.1.8.1. ([9] 9) [F20-OS2.1]

[4.1.8.1.] 4.1.8.1. ([9] 9) [F20-OP2.1] [F22-OP2.4]

[4.1.8.1.] 4.1.8.1. ([10] 10) [F20-OS2.1]

[4.1.8.1.] 4.1.8.1. ([10] 10) [F20-OP2.1] [F22-OP2.4]

[4.1.8.1.] 4.1.8.1. ([11] 11) [F20-OS2.1]

[4.1.8.1.] 4.1.8.1. ([11] 11) [F20-OP2.1] [F22-OP2.4]

[4.1.8.1.] 4.1.8.1. ([12] 12) [F20-OS2.1]

[4.1.8.1.] 4.1.8.1. ([12] 12) [F20-OP2.1] [F22-OP2.4]

[4.1.8.1.] 4.1.8.1. ([13] 13) [F20-OS2.1]

[4.1.8.1.] 4.1.8.1. ([13] 13) [F20-OP2.3] [F22-OP2.3,OP2.4]

[4.1.8.1.] 4.1.8.1. ([14] 14) [F20-OS2.1]

[4.1.8.1.] 4.1.8.1. ([14] 14) [F20-OP2.3] [F22-OP2.3,OP2.4]

[4.1.8.1.] 4.1.8.1. ([15] 15) no attributions