Submit a comment

Proposed Change 1895

Code Reference(s):	**NBC20 Div.B 4.1.8.1. (first printing)**
Subject:	Earthquake Design — Site Properties
Title:	Datum for the Determination of $\bar{N}_{60}$ and $\bar{s}_u$ in Article 4.1.8.1.
Description:	The proposed change revises the datum used for the determination of $\bar{N}_{60}$ and $\bar{s}_u$ in Article 4.1.8.1. to make it consistent with that used in the rest of Subsection 4.1.8.

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

Currently, the specified datum for the determination of $\bar{N}_{60}$ and $\bar{s}_u$ is described differently in Clause 4.1.8.1.(2)(b) and in other parts of Subsection 4.1.8. of Division B of the NBC.

This inconsistency is a source of confusion and could lead to the incorrect and inadequate design of buildings, which could increase the risk to life safety and the risk of injury beyond the risk levels that are currently acceptable in the NBC for a design-level earthquake event.

Justification

The inconsistency in the specified datum to be used for the determination of $\bar{N}_{60}$ and $\bar{s}_u$ in Article 4.1.8.1. and in the rest of Subsection 4.1.8. must be addressed to ensure the consistent and correct application of the NBC requirements for earthquake design. The proposed change removes the inconsistency and harmonizes the specified datum throughout Subsection 4.1.8.

This proposed change would eliminate confusion and prevent errors in the application of the Code requirements, thus, preventing any increase in the risk to life safety and the risk of injury beyond the risk levels currently acceptable in the NBC.

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 $I_E F_s S_a(0.2,X_{450})$ and $I_E F_s S_a(2.0,X_{450})$ are less than 0.16 and 0.03 respectively, 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 $15 \le \bar{N}_{60} \le 50$ or 50 kPa $\le \bar{s}_u \le 100$ kPa, and

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

[c] c) $S_a(T,X_{450})$ is the 5%-damped spectral acceleration value at period T for site designation X_{450}, as defined in Article 4.1.8.2., determined in accordance with Subsection 1.1.3. and corresponding to a 2% probability of exceedance in 50 years.

[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:

$$V_s = S_a\left(T_s,X_s\right)I_E W \Big/ R_S$$

where

$S_a(T_s,X_{450})$ = value of $S_a(T_s,X_{450})$ determined by linear interpolation between the values of $S_a(0.2,X_{450})$, $S_a(0.5,X_{450})$ and $S_a(1.0,X_{450})$,
= $S_a(0.2,X_{450})$ for $T_s \leq 0.2$ s, and
= $S_a(1.0,X_{450})$ 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

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 $F_s S_a(0.5,X_{450})I_E W/R_s$.

[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:

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

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 addresses an inconsistency in Subsection 4.1.8. by providing a harmonized specification of the datum to be used for the determination of $\bar{N}_{60}$ and $\bar{s}_u$. As a result, it would have a positive impact on Code users.

Since the proposed change does not involve a change to requirements, it should not result in any additional costs.

Enforcement implications

The proposed change would have positive implications for enforcement, as it would reduce inconsistency within Subsection 4.1.8. and facilitate error-free compliance with the NBC requirements regarding the determination of site properties.

Who is affected

Owners, designers, contractors and enforcement professionals dealing with the seismic design of buildings in low-seismicity locations that are 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