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## Proposed Change 1896

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<b>Code Reference(s):</b>	<b>NBC20 Div.B 4.1.8.4. (first printing)</b>
Subject:	Earthquake Design — Site Properties
Title:	Clarification of the Scope of Article 4.1.8.4.
Description:	This proposed change adds an explanatory Note clarifying that the provisions of Article 4.1.8.4. may not apply to sites with certain ground profiles.

This change could potentially affect the following topic areas:

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|--|---|
| <input type="checkbox"/> Division A                                | <input checked="" type="checkbox"/> Division B              |
| <input type="checkbox"/> Division C                                | <input checked="" type="checkbox"/> Design and Construction |
| <input type="checkbox"/> Building operations                       | <input type="checkbox"/> Housing                            |
| <input type="checkbox"/> Small Buildings                           | <input checked="" type="checkbox"/> Large Buildings         |
| <input type="checkbox"/> Fire Protection                           | <input type="checkbox"/> Occupant safety in use             |
| <input type="checkbox"/> Accessibility                             | <input checked="" type="checkbox"/> Structural Requirements |
| <input type="checkbox"/> Building Envelope                         | <input type="checkbox"/> Energy Efficiency                  |
| <input type="checkbox"/> Heating, Ventilating and Air Conditioning | <input type="checkbox"/> Plumbing                           |
|  | <input type="checkbox"/> Construction and Demolition Sites  |

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### Problem

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The requirements of Article 4.1.8.4. of Division B of the NBC may not apply to ground profiles that differ significantly from the generic ground profiles assumed in the models that underpin the NBC provisions. Therefore, the estimation of seismic hazard in accordance with Article 4.1.8.4. may not be appropriate for sites with such non-conforming ground profiles.

The NBC does not currently alert Code users to this important precondition for the application of the requirements of Article 4.1.8.4. The application of these requirements to sites with non-conforming ground profiles may lead to incorrect and inadequate design, which may 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.

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## Justification

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A wide range of ground profiles are found on construction sites. The models used to generate the estimated seismic hazard values for the NBC are based on generic ground profiles. Therefore, these estimates are not valid for sites with ground profiles that are significantly different from the generic profiles, such as sites with ground profiles having strong impedance contrast and sites above deep sedimentary basins. Use of the NBC provisions to calculate the seismic hazard for such sites would be inappropriate and may lead to incorrect results. Code users must be alerted to the limitations in the scope of Article 4.1.8.4.

Since it is not possible to codify all variations of ground profiles, an explanatory Note is proposed to inform Code users that certain ground profiles are not covered by the NBC. This information will prevent any increase (beyond the currently acceptable level in the NBC) in the risk to life safety and the risk of injury from the application of Code requirements to non-conforming ground profiles. A few examples of non-conforming ground profiles are provided in the Note. Additional guidance is proposed to be included in the Commentary entitled Design for Seismic Effects in the "Structural Commentaries (User's Guide – NBC 2025: Part 4 of Division B)."

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## PROPOSED CHANGE

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### **[4.1.8.4.] 4.1.8.4. Site Properties**

#### **(See Note 4.1.8.4.)**

- [1] 1)** For site designation X, as determined in accordance with Sentence (2) or (3), the peak ground acceleration,  $PGA(X)$ , the peak ground velocity,  $PGV(X)$ , and the 5%-damped spectral acceleration values,  $S_a(T,X)$ , at periods T of 0.2 s, 0.5 s, 1.0 s, 2.0 s, 5.0 s and 10.0 s shall
- [a] a) except as provided in Sentence (4), be determined in accordance with Subsection 1.1.3., and
  - [b] b) except as provided in Article 4.1.8.23., correspond to a 2% probability of exceedance in 50 years.
- [2] 2)** Except as provided in Sentence (3), the site designation referred to in Sentence (1) shall be determined using the average shear wave velocity,  $V_{s30}$ , calculated from in situ measurements of shear wave velocity, as follows:
- [a] a) for the ground profiles described in Table 4.1.8.4.-A, the site designation shall be determined in accordance with the Table, and
  - [b] b) for all other ground profiles, the site designation shall be  $X_V$ , where V is the value of  $V_{s30}$ .
- (See Note A-4.1.8.4.(2) and (3).)

**Table [4.1.8.4.-A] 4.1.8.4.-A**  
**Exceptions for Site Designation Using  $V_{s30}$  Calculated from In Situ**  
**Measurements**  
**Forming Part of Sentence [4.1.8.4.] 4.1.8.4.([2] 2)**

Ground Profile Characteristics		Site Designation
Average Shear Wave Velocity in Top 30 m, $V_{s30}$ , Calculated from In Situ Measurements, in m/s	Additional Characteristics	
$V_{s30} > 760$	Ground profile contains more than 3 m of softer materials between <i>rock</i> and the underside of footing or mat foundations	$X_{760}$
$V_{s30} > 140$	Ground profile contains more than 3 m of <i>soil</i> with all the following characteristics: <ul style="list-style-type: none"> <li>• plasticity index, <math>PI &gt; 20</math>,</li> <li>• moisture content, <math>w \geq 40\%</math>, and</li> <li>• undrained shear strength, <math>s_u &lt; 25</math> kPa</li> </ul>	$X_E$
$V_{s30} > 140$	Ground profile contains <ul style="list-style-type: none"> <li>• liquefiable <i>soil</i>, quick and highly sensitive clay, collapsible weakly cemented <i>soil</i>, or other <i>soil</i> susceptible to failure or collapse under seismic loading,</li> <li>• more than 3 m of peat and/or highly organic clay,</li> <li>• more than 8 m of highly plastic <i>soil</i> (with <math>PI &gt; 75</math>), or</li> <li>• more than 30 m of soft to medium-stiff clay</li> </ul>	$X_F$
$V_{s30} \leq 140$	n/a	$X_F$

**[3] 3)** Where  $V_{s30}$  calculated from in situ measurements is not available, the site designation referred to in Sentence (1) shall be  $X_S$ , where S is the Site Class determined using the energy-corrected average standard penetration resistance,  $N_{60}$ , or the average undrained shear strength,  $\bar{s}_u$ , in accordance with Table 4.1.8.4.-B,  $N_{60}$  and  $\bar{s}_u$  being calculated based on rational analysis. (See Notes A-4.1.8.4.(3) and A-4.1.8.4.(2) and (3).)

**Table [4.1.8.4.-B] 4.1.8.4.-B**  
**Site Classes, S, for Site Designation X<sub>S</sub>**  
**Forming Part of Sentence [4.1.8.4.] 4.1.8.4.([3] 3)**

Site Class, S	Ground Profile	Ground Profile Characteristics		
		Average Shear Wave Velocity in Top 30 m, $V_{s30}$ , in m/s <sup>(1)</sup>	Average Standard Penetration Resistance in Top 30 m, $\bar{N}_{60}$ , in Blows per 0.3 m	Average Undrained Shear Strength in Top 30 m, $\bar{s}_u$ , in kPa
A	Hard rock <sup>(2)</sup>	$V_{s30} > 1\ 500$	n/a	n/a
B	Rock <sup>(2)</sup>	$760 < V_{s30} \leq 1\ 500$	n/a	n/a
C	Very dense soil and soft rock	$360 < V_{s30} \leq 760$	$\bar{N}_{60} > 50$	$\bar{s}_u > 100$
D	Stiff soil	$180 < V_{s30} \leq 360$	$15 < \bar{N}_{60} \leq 50$	$50 < \bar{s}_u \leq 100$
E	Soft soil	$140 < V_{s30} \leq 180$	$10 < \bar{N}_{60} \leq 15$	$40 < \bar{s}_u \leq 50$
		Any ground profile other than Site Class F that contains more than 3 m of soil with all the following characteristics: <ul style="list-style-type: none"> <li>• plasticity index, <math>PI &gt; 20</math>,</li> <li>• moisture content, <math>w \geq 40\%</math>, and</li> <li>• undrained shear strength, <math>s_u &lt; 25</math> kPa</li> </ul>		
F	Other soils <sup>(3)</sup>	$V_{s30} \leq 140$	$\bar{N}_{60} \leq 10$	$\bar{s}_u \leq 40$
		Any ground profile that contains <ul style="list-style-type: none"> <li>• liquefiable soil, quick and highly sensitive clay, collapsible weakly cemented soil, or other soil susceptible to failure or collapse under seismic loading,</li> <li>• more than 3 m of peat and/or highly organic clay,</li> <li>• more than 8 m of highly plastic soil (with <math>PI &gt; 75</math>), or</li> <li>• more than 30 m of soft to medium-stiff clay</li> </ul>		

**Notes to Table [4.1.8.4.-B] 4.1.8.4.-B:**

- (1) See Note A-4.1.8.4.(2) and (3).

- (2) Site designations  $X_A$  and  $X_B$ , corresponding to Site Classes A and B, are not to be used in cases where the ground profile contains more than 3 m of softer materials between *rock* and the underside of footing or mat *foundations*. The appropriate site designation for such cases is  $X_{760}$ .
- (3) Site-specific geotechnical evaluation is required.

- [4] 4)** Site-specific geotechnical evaluation is required to determine the values of  $PGA(X_F)$ ,  $PGV(X_F)$  and  $S_a(T, X_F)$  for site designation  $X_F$ .
- [5] 5)** Where structures on liquefiable *soils* have a fundamental lateral period,  $T_a$ , of 0.5 s or less, the site designation  $X$  and the corresponding values of  $S_a(T, X)$  and  $PGA(X)$  are permitted to be determined in accordance with Sentence (1) by assuming that the *soils* are not liquefiable.
- [6] 6)** The design spectral acceleration,  $S(T)$ , shall be determined in accordance with Table 4.1.8.4.-C, using log-log or linear interpolation for intermediate values of  $T$ . (See Note A-4.1.8.4.(6).)

**Table [4.1.8.4.-C] 4.1.8.4.-C**  
**Design Spectral Acceleration**  
**Forming Part of Sentence [4.1.8.4.] 4.1.8.4.([6] 6)**

Period, $T$ , in s	Design Spectral Acceleration, $S(T)$
$\leq 0.2$	$S_a(0.2, X)$ or $S_a(0.5, X)$ , whichever is greater
0.5	$S_a(0.5, X)$
1.0	$S_a(1.0, X)$
2.0	$S_a(2.0, X)$
5.0	$S_a(5.0, X)$
10.0	$S_a(10.0, X)$

- [7] 7)** Where required for the application of a standard referenced in this Subsection, the acceleration-based site coefficient,  $F_a$ , for site designation  $X$  shall be taken as  $S(0.2)/S_a(0.2, X_{450})$  and the velocity-based site coefficient,  $F_v$ , for site designation  $X$  shall be taken as  $S(1.0)/S_a(1.0, X_{450})$ .

**Note A-4.1.8.4. Site Properties.**

The provisions of Article 4.1.8.4. may not be sufficient for determining the seismic hazard values for sites with ground profiles that differ significantly from the ground profiles implicit in the ground motion models (GMMs) used to establish the NBC seismic

hazard values. A few examples of such sites are sites with ground profiles having strong impedance contrast, sites above deep sedimentary basins, sites near active faults, sloping bedrock sites, sites with ground profiles that are highly variable across the building footprint, and sites with ground improvements.

Information on the ground profiles used in the GMMs, as well as general guidance for sites with ground profiles that differ from those used in the GMMs, can be found in the Commentary entitled Design for Seismic Effects in the "Structural Commentaries (User's Guide – NBC 2020: Part 4 of Division B)".

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## Impact analysis

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The proposed change is a clarification and does not add any new requirements. The impact would be neutral in terms of cost and positive in terms of facilitating the correct application of the Code.

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## Enforcement implications

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The proposed change is a clarification of the scope of Article 4.1.8.4. It would help enforcement staff to properly understand the requirements of this Article and their application. No difficulties are expected to result from the proposed change.

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## Who is affected

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Owners, designers, engineers, contractors and enforcement professionals dealing with geotechnical aspects of the design of buildings for earthquake loads.

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## OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

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**[4.1.8.4.]** 4.1.8.4. (**[1]** 1) [F20-OS2.1]

**[4.1.8.4.]** 4.1.8.4. (**[1]** 1) [F20-OP2.1] [F22-OP2.4]

**[4.1.8.4.]** 4.1.8.4. (**[2]** 2) [F20-OS2.1]

**[4.1.8.4.]** 4.1.8.4. (**[2]** 2) [F20-OP2.1] [F22-OP2.4]

**[4.1.8.4.]** 4.1.8.4. (**[3]** 3) no attributions

**[4.1.8.4.]** 4.1.8.4. (**[4]** 4) [F20-OS2.1]

**[4.1.8.4.]** 4.1.8.4. (**[4]** 4) [F20-OP2.1] [F22-OP2.4]

[4.1.8.4.] 4.1.8.4. ([5] 5) no attributions

[4.1.8.4.] 4.1.8.4. ([6] 6) [F20-OS2.1]

[4.1.8.4.] 4.1.8.4. ([6] 6) [F20-OP2.1] [F22-OP2.4]

[4.1.8.4.] 4.1.8.4. ([7] 7) no attributions