

[Submit a comment](#)

Proposed Change 1897

Code Reference(s):	NBC20 Div.B 4.1.8.4. (first printing)
Subject:	Earthquake Design — Site Properties
Title:	Clarification of the Permission for Liquefiable Soils
Description:	The proposed change adds an explanatory Note clarifying the scope of the permission stated in Sentence 4.1.8.4.(5) for structures built on liquefiable soils.

This change could potentially affect the following topic areas:

- | | |
|--|---|
| <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 checked="" type="checkbox"/> Small Buildings | <input checked="" type="checkbox"/> Large Buildings |
| <input type="checkbox"/> Fire Protection | <input checked="" 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 |

Problem

The NBC provides a relaxation for the determination of spectral acceleration values for short-period structures on liquefiable soils. However, this relaxation could be incorrectly interpreted to bypass the requirement for checking the potential for liquefaction and its effect on the structure. A failure to check for this ground failure hazard could result in unsafe structures that carry a risk to life safety and a risk of injury that are above the risk levels currently acceptable in the NBC for a design-level earthquake event.

Justification

The relaxation provided in Sentence 4.1.8.4.(5) of Division B of the NBC for buildings on liquefiable soils has the potential to be misinterpreted. Misinterpretation and incorrect application of this relaxation may lead to geotechnical and structural failure, as well as an unacceptable risk of injury to the occupants and an unacceptable risk of

damage to the building or loss of its use. The limited scope of this relaxation must be clearly expressed in the Code to prevent unsafe designs resulting from misinterpretation.

The proposed change clarifies the intent of the Code, by modifying Sentence 4.1.8.4.(5) and adding an explanatory Note, to prevent the potential misinterpretation of this Sentence, which could lead to inaccurate and unsafe building designs.

PROPOSED CHANGE

[4.1.8.4.] 4.1.8.4. Site Properties

- [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"> • plasticity index, $PI > 20$, • moisture content, $w \geq 40\%$, and • undrained shear strength, $s_u < 25$ kPa 	X_E
$V_{s30} > 140$	Ground profile contains <ul style="list-style-type: none"> • 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, • more than 3 m of peat and/or highly organic clay, • more than 8 m of highly plastic <i>soil</i> (with $PI > 75$), or • more than 30 m of soft to medium-stiff clay 	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_S
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 ⁽¹⁾	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 ⁽²⁾	$V_{s30} > 1\ 500$	n/a	n/a
B	Rock ⁽²⁾	$760 < V_{s30} \leq 1\ 500$	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"> • plasticity index, $PI > 20$, • moisture content, $w \geq 40\%$, and • undrained shear strength, $s_u < 25$ kPa 		
F	Other soils ⁽³⁾	$V_{s30} \leq 140$	$\bar{N}_{60} \leq 10$	$\bar{s}_u \leq 40$
		Any ground profile that contains <ul style="list-style-type: none"> • liquefiable soil, quick and highly sensitive clay, collapsible weakly cemented soil, or other soil susceptible to failure or collapse under seismic loading, • more than 3 m of peat and/or highly organic clay, • more than 8 m of highly plastic soil (with $PI > 75$), or • more than 30 m of soft to medium-stiff clay 		

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~~ based on the pre-liquefaction soils characteristics ~~are not liquefiable.~~ (See Note 4.1.8.4.(5).)
- [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, $S(T)$
≤ 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.(5) Scope of the Permission for Structures on Liquefiable Soils.

The permission to use the pre-liquefaction soil characteristics, as stated in Sentence 4.1.8.4.(5), only applies for the purpose of determining the site designation, X , and the

corresponding values of $S_a(T,X)$ and $PGA(X)$. The potential for liquefaction of the soil and its consequences still need to be evaluated in accordance with Sentence 4.1.8.16.(10).

Impact analysis

The proposed change addresses the potential misinterpretation of Sentence 4.1.8.4.(5) by revising the Sentence and adding an explanatory Note clarifying its intent. The proposed change would have a positive impact, as it would remove the ambiguity in the requirement and, thereby, prevent inaccurate designs. The proposed change would not have a cost implication, as it is a clarification of an existing requirement.

Enforcement implications

The proposed change clarifies an existing requirement. As a result, it would alleviate the potential difficulties for enforcement officials arising from the ambiguity in this requirement. Awareness of the revised requirement would need to be raised, but no difficulty is expected to be encountered in checking compliance and no special testing is anticipated to be necessary.

Who is affected

Owners, designers, contractors and enforcement professionals dealing with the construction of low- or medium-rise buildings on liquefiable soils.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[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