cable, regardless of whether other materials, standards, or resources outside of this Code would provide a different definition.

R1.5.4 — Dictionaries and other reference materials commonly used by licensed design professionals may be used to help determine the meaning of words or terms that are not defined in this Code.

1.5.5 — Unless stated otherwise, the following words or terms in this Code shall be interpreted as specified here:

(a) The words “must” and “shall” are mandatory;

(b) Words used in the present tense shall include the future;

(c) Words used in the singular shall include the plural, and plural words shall include the singular;

(d) “And” indicates that all of the connected items, conditions, requirements, or events shall apply;

(e) “Or” indicates that the connected items, conditions, requirements, or events shall apply singularly or in any combination as determined by the licensed design professional.

R1.5.5(a) — The substance or context of certain provisions in this Code may indicate that they are mandatory even if the words “must” or “shall” are not used.

1.5.6 — In any case in which one or more provisions of this Code are declared by a court or tribunal to be invalid, that ruling shall not affect the validity of the remaining provisions of this Code, which are severable. The ruling of a court or tribunal shall be effective only in that court’s jurisdiction and shall not affect the content or interpretation of this Code in other jurisdictions.

R1.5.6 — Though not binding, rulings by a court or tribunal may be considered for their persuasive value in other jurisdictions.

1.6 — Role of the licensed design professional

1.6.1 — All references in this Code to the “licensed design professional” shall be understood to mean persons who are licensed to practice structural design in the jurisdiction where this Code is being used. The licensed design professional for a project is responsible for and in charge of the structural design.

R1.6.1 — The licensed design professional is often a professional engineer. The minimum requirements in this Code do not replace exercising sound professional judgment or the licensed design professional’s knowledge of the specific factors surrounding a project, its design, the project site, and other specific or unusual circumstances to the project.

1.7 — Contract documents and project records

1.7.1 — Contract document

1.7.1.1 — Contract documents issued for construction shall bear the seal of a licensed design professional and shall include the specified compressive strength of the concrete, the thickness of the
Precast chimney shell is defined as a shell constructed wholly from precast reinforced concrete sections, assembled one on top of another, to form a freestanding, self-supporting cantilever. "1.1d"

CHAPTER 3—REFERENCES

3.1—Scope<7.1>

3.1.1—The standards listed in this chapter are cited in the Code.

3.2—ASTM International

3.2.1—ASTM A615/A615M-05a Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

ASTM A706/A706M-05a Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement

ASTM A996/A996M-05a Standard Specification for Rail Steel and Axle-Steel Deformed Bars for Concrete Reinforcement

ASTM C33-03 Standard Specification for Concrete Aggregates

ASTM C150-04 Standard Specification for Portland Cement

ASTM C309-03 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

ASTM C595-03 Standard Specification for Blended Hydraulic Cement

3.3—American Concrete Institute

3.3.1—ACI 318-02Building Code Requirements for Structural Concrete

3.4—ASCE

3.4.1—ASCE/SEI 7-02Minimum Design Loads for Buildings and Other Structures

3.5—Federal Aviation Administration

3.5.1—AC70-74G-1KObstruction Marking and Lighting

3.6—Underwriters Laboratories

3.6.1—UL 96AInstallation Requirements for Lighting Protection Systems

CHAPTER 4—STRUCTURAL SYSTEM REQUIREMENTS

4.1—Scope

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CHIMNEY AND STACK INSPECTION GUIDELINES
5.2.4.4 — All cementitious materials specified in this chapter and the combinations of these materials shall be included in calculating the w/cm of the concrete mixture.

5.2.5 — Aggregates<2.3>

5.2.5.1 Concrete aggregates shall be in accordance with ACI 318.<2.3.1>

5.2.5.2 The maximum size of coarse aggregate shall not exceed 1/8 of the narrowest dimension between inside and outside forms or 1/2 the minimum clear distance between reinforcing bars.<2.3.2>

R2.3.2 This requirement differs from the ACI 318 because most walls are 8 in. thick, and 3/4 or 1 in. aggregate works best with 8 ft forms.

5.3 — Concrete properties

5.3.1 Specified compressive strength

5.3.1.1 — The value of $f'_c$ shall be at least 3000 psi.<3.2>5.3.1.2 — Unless otherwise specified, $f'_c$ shall be based on 28-day tests. If other than 28 days, test age for $f'_c$ shall be indicated in the contract documents.

5.3.2 Thermal coefficient of expansion

5.3.2.1 — Thermal coefficient of expansion of concrete and of reinforcing steel, $\alpha_{ct}$, shall be permitted to be taken as 0.0000065 per °F.

5.3.3 Modulus of elasticity

5.3.3.1 — The value of $E_c$ shall be in accordance with ACI 318.

5.3.4 Modulus of rupture

5.3.4.1 — The value of $f$ shall be in accordance with ACI 318.

5.3.5 Lightweight concrete

5.3.5.1 — The value of modification factor, $A$, shall be in accordance with ACI 318.

5.3.6 Concrete durability

5.3.6.1 — Concrete properties for durability shall be in accordance with ACI 318.

5.4 — Concrete proportioning and acceptance

5.4.1 Concrete mixture proportioning shall be in accordance with ACI 318.

5.4.2 Evaluation and acceptance of concrete shall be in accordance with ACI 318.
The moment due to the maximum allowable misalignment in Section 3.8.1.1 and vertical acceleration together with the static moment due to misalignment is negligible compared with the moments due to wind lateral earthquake effects.

For circular chimneys, the earthquake forces can be assumed to act in any one direction only. For noncircular chimneys, the design earthquake forces are computed as the SRSS combination of the responses to earthquake motions acting in any two orthogonal directions.

### 7.5.3 General procedure

7.5.3.1 The mapped maximum considered earthquake spectral response acceleration at short periods, $S_0$, and $S_1$ at 1 second, shall be obtained from Fig. 9.4.1.1(a) through 9.4.1.1(j) of ASCE 7.

7.5.3.2 The site class shall be determined from Table 9.4.1.2 of ASCE 7.

7.5.3.3 Soil properties are not known in sufficient detail to determine the site class. Class D shall be used.

7.5.3.4 The acceleration-based site coefficient $F_a$ shall be obtained from Table 9.4.1.2.4(a) of ASCE 7.

7.5.3.5 The velocity-based site coefficient $F_v$ shall be obtained from Table 9.4.1.2.4(b) of ASCE 7.

7.5.3.6 The maximum considered earthquake spectral response acceleration for short periods, $S_{DS}$, and $S_{DI}$ at 1 second, adjusted for site class effects, shall be calculated by:

$$ S_{DS} = F_a S_0 <eq. 4-33> $$

$$ S_{DI} = F_v S_1 <eq. 4-34> $$

7.5.3.7 The design earthquake spectral response acceleration at short periods, $S_{DS}$, and $S_{DI}$ at 1 second, shall be determined as:

$$ S_{DS} = (2/3)S_{DS} <eq. 4-35> $$

$$ S_{DI} = (2/3)S_{DI} <eq. 4-36> $$

7.5.3.8 The design response spectrum curve shall be in accordance with (a), (b), or (c): 

(a) For a chimney with fundamental period, $T_a$, less than $T_w$, the design spectral response acceleration, $S_a$, shall be calculated by:

$$ S_a = S_{DS}(0.4 + 0.67/T_a) <eq. 4-37> $$

where

$$ T_w = 0.2S_{DI}/S_{DS} <eq. 4-40> $$

(b) For a chimney with fundamental period, $T_a$, at least $T_w$ and not exceeding $T_s$, the design spectral response acceleration, $S_a$, shall be calculated by:

$$ S_a = S_{DS} <eq. 4-38> $$

where

$$ T_s = S_{DS}/S_{DS} <eq. 4-41> $$

(c) For a chimney with fundamental period, $T_a$, exceeding $T_s$, the design spectral response acceleration, $S_a$, shall be calculated by:

$$ S_a = S_{DS}/T_s <eq. 4-39> $$

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Does THIS AND 7.5.4 AND 7.5.5 BELONG IN CHAPTER 8?
7.5 Site-specific procedure
7.5.4.1 A site-specific response spectrum shall provide the maximum considered earthquake spectral response acceleration, \( S_{ad} \), at any period according to the site-specific procedures of Section 9.4.1.3 of ACI 318-05.

7.5.4.2 The design earthquake spectral response acceleration at any period, \( S_d \), shall be calculated by:
\[
S_d = \frac{2}{3} S_{ad} \quad \text{eq. 4-42}
\]

7.5.4.3 The value of \( S_d \) from Eq. (4-42) shall be at least 80% of the \( S_d \) determined by the general procedure of Section 4.3.2.1 for any period.

When a site-specific spectrum is provided, 80% of the map-generated values, at any period, are required to be used as a minimum as permitted by ACI 318-05.

7.5.5.1.2 A linear time-history analysis shall conform to Section 9.5.7 of ACI 318-05, except as indicated in Section 7.5.5.3.

7.5.5.3 It shall not be required that the seismic base shear be scaled to the minimum values set forth in the ACI 318-05, Eq. 9.5.7.3.

7.5.5.4 A nonlinear time-history analysis shall conform to Section 9.5.8 of ACI 318-05.

7.5.6 Soil-structure interaction—
7.5.6.1 The effects of seismic interaction between a chimney and soil can be ignored and a fixed base condition assumed.

7.5.6.2 If a soil-structure interaction assessment is performed, it is permitted to follow the procedure given in Section 9.5.9 of ACI 318-05.

7.5.7 Lateral displacements—Service level displacements shall be determined by scaling the total displacements calculated by the general procedure or the site-specific procedure by the factor \( R/L \).

7.5.7.1 Total displacements are the modal displacements combined by the SRSS method or the CP method.

7.5.7.2 Clearance, \( \Delta \), between the chimney shell and the liner shall be at least:
\[
\Delta = \frac{(R_y + R_x)}{2} \quad \text{eq. 7.5.7.2}
\]

Clearance should be maintained between the chimney shell and the liner. Computation of lateral displacements for each structure should take into account the magnification of elastic deflections due to yielding. Typical values for \( R_x \) are 1.25 for brick liners and 3 for steel liners.

7.5.8 P-\( \Delta \) effect—The P-\( \Delta \) effect between vertical loads and seismic lateral deflections shall be considered for chimneys with assigned Seismic Design Categories D, E, or F.

CHAPTER 8—ANALYSIS

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8.3.3 Second mode

8.3.3.1 Across-wind response in the second mode shall be considered if the critical wind speed \( V_{cr2} \), as computed by Eq. (4-25), is between 0.50 and 1.30 \( V(z_0) \), where \( V(z_0) \) is the mean hourly wind speed at \((5/6)h\).<4.2.3.3a>

\[
V_{cr2} = \frac{5d(u)}{T_2}
\]
< eq. 4-25>

where second mode period, \( T_2 \), shall be calculated by dynamic analysis.<4.2.3.3b>

8.3.3.2 For preliminary design second mode period, \( T_2 \), in seconds per cycle, for an unlined shell shall be permitted to be approximated by:<4.2.3.3b>

\[
T_2 = 0.82 \frac{h^2}{d(b) \sqrt{\frac{\rho \epsilon f}{E'}}} \sqrt{\frac{d(b)}{\rho \epsilon f}}^{0.09} \left(\frac{d(b)}{d(h)}\right)^{0.22}
\]
< eq. 4-26>

8.3.3.3 The effect of a shell-supported liner on the period of the second mode shall be considered.<4.2.3.3c>

8.3.3.4 Across-wind response in the second mode shall be calculated by a method based on the modal characteristics of the chimney.<4.2.3.3c>

8.3.4 Grouped chimneys—

If two chimneys, specified to be identical, are in close proximity, the across-wind load shall be increased to account for the potential increase in vortex-induced motions.<4.2.3.4a>

In such cases, the lift coefficient \( C_l \) in Eq. (4-11) shall be modified as follows.<4.2.3.4b>

a. If \( s/d(z_0) > 12.75 \), \( C_l \) is unaltered; and<4.2.3.4c>

b. If \( s/d(z_0) < 12.75 \), \( C_l \) shall be multiplied by \( 0.26 - 0.015s/d(z_0) \).<4.2.3.4d>

For chimneys that are specified not to be identical and for specified to be identical chimneys where \( s/d(z_0) < 3 \), the value of \( C_l \) shall be established by reference to model tests or observations or test reports of similar arrangements.<4.2.3.4e>

8.4.2.3.4 Interactions between closely spaced cylindrical objects have been studied in considerable detail, but virtually all of the test results are for subcritical values of Reynolds numbers, and their applicability to chimneys is highly questionable. Even with the scale effects introduced by the inequality of
The increase in the loads near the tip is consistent with observations (Okamoto and Yagita 1973) that the drag coefficient increases significantly in this region.

CHAPTER 9—Chimney Design

9.1 Scope

9.1.1—The provisions of this chapter shall apply for design of chimneys including cast-in-place and precast, circular and non-circular.

9.1.2—If a provision only applies to a specific type of chimney, the chimney type is identified in the provision or section heading.

9.1.3—Structural plain concrete chimneys shall not be permitted.

9.2 General<4.1>

9.2.1—Materials

9.2.1.1—Concrete material properties for design shall conform to Chapter 5.

9.2.1.2—Steel reinforcement properties for design shall conform to Chapter 6.

9.2.2—Connections

9.2.2.1—For cast-in-place chimneys, connections shall satisfy the force transfer requirements of 7.2.

9.2.2.2—For precast chimneys, connections shall satisfy the force transfer requirements of 7.2.

9.2.2.3—Strength and detailing of chimney connections to foundations shall be in accordance with 3.7.4.

9.2.3—Stability

...add text as needed

9.2.4—The chimney shell shall be designed for the effects of gravity, temperature, wind, and earthquake forces in accordance with ACI 318, except as stated otherwise.<4.1.1>

9.2.5—Reinforced concrete chimneys shall be designed to resist the wind forces in both the along-wind and across-wind directions.<4.2.1a>

9.2.6—The hollow circular cross section shall be designed to resist the loads caused by the circumferential pressure distribution.<4.2.1b>

9.2.7—Shell and liner interaction—A chimney shell that supports lining loads shall comply with the requirements of this standard with the lining in place.<4.1.4a>

9.2.8—Design for temporary construction loads—Temporary construction access openings shall be designed as permanent openings.<4.1.5>

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AND GROUP EFFECT?