Building Code Requirements for Masonry Structures (2011)

CHAPTER 2
ALLOWABLE STRESS DESIGN OF MASONRY

CODE

2.1 — General

2.1.1 Scope
This chapter provides requirements for allowable stress design of masonry. Masonry design in accordance with this chapter shall comply with the requirements of Chapter 1, Sections 2.1.2 through 2.1.7, and either Section 2.2 or 2.3.

2.1.2 Load combinations
When the legally adopted building code does not provide allowable stress load combinations, structures and members shall be designed to resist the combinations of load specified by the building official.

2.1.3 Design strength

2.1.3.1 Project drawings shall show the specified compressive strength of masonry, f'_m, for each part of the structure.

2.1.3.2 Each portion of the structure shall be designed based on the specified compressive strength of masonry, f'_m, for that part of the work.

2.1.3.3 Computed stresses shall not exceed the allowable stress requirements of this Chapter.

2.1.4 Anchor bolts embedded in grout
2.1.4.1 Design requirements — Anchor bolts shall be designed using either the provisions of Section 2.1.4.2 or, for headed and bent-bar anchor bolts, by the

COMMENTARY

2.1 — General

2.1.1 Scope
Historically, a one-third increase in allowable stress has been permitted for load combinations that include wind or seismic loads. The origin and the reason for the one-third stress increase are unclear [2.1]. From a structural reliability standpoint, the one-third stress increase is a poor way to handle load combination effects. Therefore, the one-third stress increase is no longer permitted in this Code. The allowable stresses of this Chapter should not be increased by one-third for wind and load combinations.

2.1.2 Load combinations
When there is no legally adopted building code or the legally adopted building code does not have allowable stress load combinations, possible sources of allowable stress load combinations are ASCE 7 [2.2] and IBC [2.3].

2.1.3 Design strength
The structural adequacy of masonry construction requires that the compressive strength of masonry equal or exceed the specified strength. The specified compressive strength f'_m on which design is based for each part of the structure must be shown on the project drawings.

The 1995, 1999, 2002, and 2005 editions of the Code contained provisions to permit use of strength-level load combinations in allowable stress design, to compensate for lack of service-level load combinations in previously referenced load standards. This procedure, which enabled the calculation of 'pseudo-strengths' on the basis of allowable stresses, is no longer included in the Code because recent editions of ASCE 7 include both service-level and strength-level load combinations. The 2005 edition of the Code provides guidance for using strength-level load combinations whenever the legally adopted building code does not provide service-level load combinations.

2.1.4 Anchor bolts embedded in grout
Allowable Stress Design anchor bolt provisions were obtained by calibrating corresponding Strength Design provisions to produce similar results. See Code

Code Requirements for Steel Construction, AISC 14th ed.

CHAPTER B

DESIGN REQUIREMENTS

The general requirements for the analysis and design of steel structures that are applicable to all chapters of the specification are given in this chapter.

The chapter is organized as follows:

B1. General Provisions
B2. Loads and Load Combinations
B3. Design Basis
B4. Classification of Sections for Local Buckling
B5. Fabrication, Erection and Quality Control
B6. Evaluation of Existing Structures

B1. GENERAL PROVISIONS

The design of members and *connections* shall be consistent with the intended behavior of the framing system and the assumptions made in the *structural analysis*. Unless restricted by the *applicable building code, lateral load* resistance and *stability* may be provided by any combination of members and connections.

B2. LOADS AND LOAD COMBINATIONS

The loads and load combinations shall be as stipulated by the *applicable building code*. In the absence of a building code, the loads and load combinations shall be those stipulated in SEI/ASCE 7. For design purposes, the *nominal loads* shall be taken as the *loads* stipulated by the applicable building code.

User Note: For LRFD designs, the load combinations in SEI/ASCE 7, Section 2.3 apply. For ASD designs, the load combinations in SEI/ASCE 7, Section 2.4 apply.

B3. DESIGN BASIS

Designs shall be made according to the provisions for *Load and Resistance Factor Design* (LRFD) or to the provisions for *Allowable Strength Design* (ASD).

1. Required Strength

The *required strength* of structural members and *connections* shall be determined by *structural analysis* for the appropriate load combinations as stipulated in Section B2.

Design by *elastic, inelastic or plastic analysis* is permitted. Provisions for inelastic and plastic analysis are as stipulated in Appendix 1, Inelastic Analysis and Design. The provisions for moment redistribution in continuous beams in Appendix 1, Section 1.3 are permitted for elastic analysis only.

2. Limit States

Design shall be based on the principle that no applicable strength or serviceability *limit state* shall be exceeded when the structure is subjected to all appropriate load combinations.

3. Design for Strength Using Load and Resistance Factor Design (LRFD)

Design according to the provisions for *Load and Resistance Factor Design* (LRFD) satisfies the requirements of this Specification when the *design strength* of each *structural component* equals or exceeds the *required strength* determined on the basis of the *LRFD load combinations*. All provisions of this Specification, except for those in Section B3.4, shall apply.

Design shall be performed in accordance with Equation B3-1:

$$R_u \le \phi R_n \qquad \text{(B3-1)}$$

where

R_u = required strength (LRFD)
R_n = nominal strength, specified in Chapters B through K
ϕ = resistance factor, specified in Chapters B through K
ϕR_n = design strength

4. Design for Strength Using Allowable Strength Design (ASD)

Design according to the provisions for *Allowable Strength Design* (ASD) satisfies the requirements of this Specification when the *allowable strength* of each *structural component* equals or exceeds the *required strength* determined on the basis of the *ASD load combinations*. All provisions of this Specification, except those of Section B3.3, shall apply.

Design shall be performed in accordance with Equation B3-2:

$$R_a \le R_n / \Omega \qquad \text{(B3-2)}$$

where

R_a = required strength (ASD)
R_n = nominal strength, specified in Chapters B through K
Ω = safety factor, specified in Chapters B through K
R_n / Ω = allowable strength

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CHAPTER 9 — STRENGTH AND SERVICEABILITY REQUIREMENTS

CODE

9.1 — General

9.1.1 — Structures and structural members shall be designed to have design strengths at all sections at least equal to the required strengths calculated for the factored loads and forces in such combinations as are stipulated in this Code.

9.1.2 — Members also shall meet all other requirements of this Code to ensure adequate performance at service load levels.

9.1.3 — Design of structures and structural members using the load factor combinations and strength reduction factors of Appendix C shall be permitted. Use of load factor combinations from this chapter in conjunction with strength reduction factors of Appendix C shall not be permitted.

9.2 — Required strength

9.2.1 — Required strength U shall be at least equal to the effects of factored loads in Eq. (9-1) through (9-7). The effect of one or more loads not acting simultaneously shall be investigated.

$$U = 1.4D \qquad (9\text{-}1)$$

$$U = 1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R) \qquad (9\text{-}2)$$

$$U = 1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (1.0L \text{ or } 0.5W) \qquad (9\text{-}3)$$

$$U = 1.2D + 1.0W + 1.0L + 0.5(L_r \text{ or } S \text{ or } R) \qquad (9\text{-}4)$$

$$U = 1.2D + 1.0E + 1.0L + 0.2S \qquad (9\text{-}5)$$

COMMENTARY

R9.1 — General

In the 2002 Code, the factored load combinations and strength reduction factors of the 1999 Code were revised and moved to Appendix C. The 1999 combinations were replaced with those of SEI/ASCE 7-02.[9.1] The strength reduction factors were replaced with those of the 1999 Appendix C, except that the factor for flexure was increased. In the 2011 Code, the factored load combinations were revised for consistency with ASCE/SEI 7-10.[9.2]

The changes were made to further unify the design profession on one set of load factors and combinations, and to facilitate the proportioning of concrete building structures that include members of materials other than concrete. When used with the strength reduction factors in 9.3, the designs for gravity loads will be comparable to those obtained using the strength reduction and load factors of the 1999 and earlier Codes. For combinations with lateral loads, some designs will be different, but the results of either set of load factors are considered acceptable.

Chapter 9 defines the basic strength and serviceability conditions for proportioning structural concrete members.

The basic requirement for strength design may be expressed as follows:

Design Strength ≥ Required Strength

$$\phi \, (\text{Nominal Strength}) \geq U$$

In the strength design procedure, the margin of safety is provided by multiplying the service load by a load factor and the nominal strength by a strength reduction factor.

R9.2 — Required strength

The required strength U is expressed in terms of factored loads, or related internal moments and forces. Factored loads are the loads specified in the general building code multiplied by appropriate load factors.

The factor assigned to each load is influenced by the degree of accuracy to which the load effect usually can be calculated and the variation that might be expected in the load during the lifetime of the structure. Dead loads, because they are more accurately determined and less variable, are assigned a lower load factor than live loads. Load factors also account for variability in the structural analysis used to compute moments and shears.

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CODE

$$U = 0.9D + 1.0W \qquad (9\text{-}6)$$

$$U = 0.9D + 1.0E \qquad (9\text{-}7)$$

except as follows:

(a) The load factor on the live load L in Eq. (9-3) to (9-5) shall be permitted to be reduced to 0.5 except for garages, areas occupied as places of public assembly, and all areas where L is greater than 100 lb/ft^2.

(b) Where W is based on service-level wind loads, $1.6W$ shall be used in place of $1.0W$ in Eq. (9-4) and (9-6), and $0.8W$ shall be used in place of $0.5W$ in Eq. (9-3).

(c) Where E is based on service-level forces, $1.4E$ shall be used in place of $1.0E$ in Eq. (9-5) and (9-7).

COMMENTARY

The Code gives load factors for specific combinations of loads. In assigning factors to combinations of loading, some consideration is given to the probability of simultaneous occurrence. While most of the usual combinations of loadings are included, it should not be assumed that all cases are covered.

Due regard is to be given to sign in determining U for combinations of loadings, as one type of loading may produce effects of opposite sense to that produced by another type. The load combinations with $0.9D$ are specifically included for the case where a higher dead load reduces the effects of other loads. The loading case may also be critical for tension-controlled column sections. In such a case, a reduction in axial load and an increase in moment may result in a critical load combination.

Consideration should be given to various combinations of loading to determine the most critical design condition. This is particularly true when strength is dependent on more than one load effect, such as strength for combined flexure and axial load or shear strength in members with axial load.

If unusual circumstances require greater reliance on the strength of particular members than encountered in usual practice, some reduction in the stipulated strength reduction factors ϕ or increase in the stipulated load factors may be appropriate for such members.

In 2011, the Code removed the weight of soil and other fill materials as part of the definition of H. Consistent with ASCE/SEI 7-10, the weight of these materials is part of dead load, D. The load factors for D are appropriate provided the unit weight and thickness of earth or other fill materials are well controlled. If the weight of earth stabilizes the structure, a load factor of zero may be appropriate.

R9.2.1(a) — The load modification factor of 9.2.1(a) is different than the live load reductions based on the loaded area that may be allowed in the legally adopted general building code. The live load reduction, based on loaded area, adjusts the nominal live load (L_0 in ASCE/SEI 7) to L. The live load reduction as specified in the legally adopted general building code can be used in combination with the 0.5 load factor specified in 9.2.1(a).

R9.2.1(b) — ASCE/SEI 7-10 has converted wind loads to strength level, and reduced the wind load factor to 1.0. ACI 318 requires use of the previous load factor for wind loads, 1.6, when service-level wind loads are used. For serviceability checks, the commentary to Appendix C of ASCE/SEI 7-10 provides service-level wind loads, W_a.

R9.2.1(c) — In 1993, ASCE 7[9.3] converted earthquake forces to strength level, and reduced the earthquake load factor to 1.0. Model building codes[9.4-9.6] followed. ACI 318 requires use of the previous load factor for earthquake effects, approximately 1.4, when service-level earthquake effects are used.