
FOUNDATION DESIGN AND DETAILING: 2022 CBC

Disciplines: Structural**History:** Issued 01/03/24 Under 2022 CBC

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PURPOSE

This Interpretation of Regulations (IR) clarifies code requirements relating to the design and detailing of foundations on projects under DSA jurisdiction.

SCOPE

This IR applies to the design of new foundation elements, including both shallow and deep foundation systems. It addresses minimum reinforcement and detailing requirements, some of which apply generally to foundation elements and others that are specific to foundation elements supporting the seismic force resisting system (SFRS).

BACKGROUND

Most prescriptive design and detailing requirements for foundation elements are given in the American Concrete Institute (ACI) Standard: Building Code Requirements for Structural Concrete (ACI 318) as adopted by the California Building Code (CBC). The CBC also contains foundation design and detailing requirements, both in Chapter 18A and as modifications to ACI 318 in Chapter 19A. In addition to these, some requirements specific to SFRS foundations are found in the American Society of Civil Engineers Standard 7: Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE 7). The varied locations of these requirements warrant clarification and guidance to facilitate their proper application.

1. MINIMUM REINFORCEMENT**1.1 Footings Designed for Direct Bearing**

Shallow footings can be designed and proportioned to transfer loads from the building structure to the subgrade (i.e., soil or rock) through direct bearing. Footings of this type shall be provided with minimum reinforcement meeting the requirements for shrinkage and temperature reinforcement per ACI 318 Section 24.4.3.

1.1.1 The minimum reinforcement ratio requirement of ACI 318 Section 24.4.3.2 applies to the combination of top and bottom bars and separately in each orthogonal direction.

1.1.2 Continuous concentric shallow footings supporting light framed bearing walls meeting the following dimensional limits may be prescriptively categorized as designed for direct bearing.

1.1.2.1 Footing width does not extend horizontally beyond the face of the wall a dimension greater than its depth.

1.1.2.2 Dimension of each wall opening (i.e., door openings or similar) does not exceed two times the footing depth.

1.1.3 Bearing wall footings with widths extending beyond the face of the wall a dimension greater than their depth shall be provided with transverse flexural reinforcement complying with Section 1.2.5 below.

FOUNDATION DESIGN AND DETAILING: 2022 CBC**1.2 Foundation Elements Subject to One-Way Flexure**

Footings, grade beams, pile caps, and other foundation elements subject to one-way flexure shall comply with ACI 318 minimum reinforcement requirements as amended by the CBC and summarized in this section.

1.2.1 Foundation elements shall be provided with minimum flexural reinforcement complying with ACI 318 Section 9.6.1.

1.2.2 The minimum reinforcement ratio requirement of ACI 318 Section 9.6.1.2 applies to the bars on the tension face only.

1.2.3 In accordance with CBC Section 1905A.1.3, ACI 318 Section 9.6.1.3 cannot be applied unless one or more of the following conditions occurs:

1.2.3.1 The foundation element does not resist seismic loads.

1.2.3.2 The foundation supports a one-story wood-frame or light steel building per CBC Section 1905A.1.3, Exception #1.

1.2.3.3 The foundation element is designed for load combinations including the seismic overstrength factor per CBC Section 1905A.1.3, Exception #2.

1.2.4 The spacing of flexural reinforcement shall not exceed the requirements of ACI 318 Section 24.3.2.

1.2.5 Foundation elements with a width-to-depth ratio greater than 2, shall be provided with minimum flexural reinforcement in the transverse direction complying with ACI 318 Section 8.6.1.1. Transverse reinforcement consisting of hoops with horizontal legs continuous across the full width of the grade beam or footing may be used to satisfy the minimum flexural reinforcement requirement.

1.2.6 Foundation elements with depths exceeding 36 inches shall be provided with longitudinal skin reinforcement per ACI 318 Section 9.7.2.3.

1.3 Foundation Elements Subject to Two-Way Flexure

Footings, mat slabs, pile caps, and other foundation elements subject to two-way flexure shall comply with ACI 318 minimum reinforcement requirements as summarized in this section.

1.3.1 Foundation elements of uniform thickness shall be provided with minimum flexural reinforcement complying with ACI 318 Section 8.6.1.

1.3.2 The minimum reinforcement ratio requirement of ACI 318 Section 8.6.1.1 applies to the bars on the tension face only.

1.3.3 In isolated spread footings subject to uplift in which the top bars are required solely to support the weight of the footing and the soil and slab on top of the footing, the area of top bar reinforcement provided need not exceed 133 percent of that required by analysis.

1.3.4 Flexural reinforcement in two-way isolated shallow footings with a rectangular plan shall be distributed in accordance with ACI 318 Section 13.3.3.3, including a banded layout in the short direction.

1.4 Drilled Pier Foundation Elements with Embedded Poles

Drilled piers or caissons with embedded steel poles shall be provided with the minimum reinforcement required by *Bulletin (BU) 09-06: Minimum Reinforcement of Concrete Piers and Caissons Embedded with Steel Poles*.

FOUNDATION DESIGN AND DETAILING: 2022 CBC**2. DETAILING****2.1 General Requirements**

2.1.1 Per CBC Sections 1809A.15 and 1810A.3.12, grade beams designed for load combinations including the seismic overstrength factor need not comply with the ductile detailing requirements of ACI 318 Section 18.13.3.1.

2.1.2 The transverse reinforcement of SFRC concrete columns and boundary elements shall extend into the foundation element when required per ACI 318 Section 18.13.2.4.

2.2 Inelastic Grade Beams

When the foundation design is based on inelastic foundation behavior in accordance with ASCE 7 Section 12.13.1.1, Exception #2 as added by CBC Section 1617A.1.15, the detailing requirements of this section apply. Refer to Section 2.2 of *IR 18-3: Foundation Analysis and Design Forces* for structural analysis requirements necessary to invoke Exception #2.

2.2.1 Per ACI 318 Section 18.13.3.1, grade beams shall comply ACI 318 Section 18.6.

2.2.2 Grade beam dimensions shall comply with ACI 318 Section 18.6.2.1.

2.2.3 Grade beam longitudinal reinforcement shall comply with ACI 318 Section 18.6.3.

2.2.4 Grade beam transverse reinforcement shall comply with ACI 318 Sections 18.6.4 and 18.6.5.

2.2.5 Column to grade beam joints shall comply with the transverse reinforcement requirements of ACI 318 Section 18.8.3. When a steel column is embedded in the grade beam, the transverse confinement reinforcement shall be provided outside the column core per ACI 318 Section 18.8.3.3. For additional information, see *IR 18-4: Superstructure to Foundation Connection*.

2.3 Deep Foundation Elements

Deep foundation elements shall be designed and detailed to comply with the requirements of CBC Chapter 18A and ACI 318 Chapter 13 and Section 18.13.

2.3.1 Precast concrete piles shall be designed and detailed in accordance with ACI 318 Sections 18.13.5.1 through 18.13.5.6 and Section 18.13.5.10.

2.3.2 Cast-in-place deep foundation elements (i.e., drilled piers, augered piles, etc.) shall be designed and detailed in accordance with CBC Section 1810A.3.9 and ACI 318 Sections 18.13.5.1 through 18.13.5.6 and Table 18.13.5.7.1. Drilled piers supporting certain structure types with lesser loads and ductility demand may use the simplified transverse reinforcement requirements given in the following pre-check design criteria documents:

2.3.2.1 *IR PC-1: Pre-Check (PC) Design Criteria for Freestanding Signs, Scoreboards, and Ball Walls*, Section 5.4.3.

2.3.2.2 *IR PC-4: Pre-Check (PC) Design Criteria for Open Fabric Shade Structures*, Section 5.4.5.

2.3.2.3 *IR PC-7: Pre-Check (PC) Design Criteria for Steel Cantilevered Canopy Structures*, Section 5.4.5.

2.3.3 When a deep foundation element uses a spiral for transverse reinforcement, it shall comply with ACI 318 Section 25.7.3, except that Section 25.7.3.3 does not apply.

2.3.4 Splices in deep foundation elements shall be designed and detailed to comply with CBC Section 1810A.3.6.

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2.3.5 The connection of deep foundation elements to pile caps shall be designed and detailed to comply with CBC Section 1810A.3.11.

REFERENCES:

2022 California Code of Regulations (CCR) Title 24

Part 2: California Building Code (CBC), Sections 1617A.1.15, 1809A.15, 1810A.3.6, 1810A.3.9, 1810A.3.11
1810A.3.12, 1905A.1.3.

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