ACI 332-14

An ACI Standard

Residential Code Requirements for Structural Concrete (ACI 332-14) and Commentary

Reported by ACI Committee 332

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Residential Code Requirements for Structural Concrete and Commentary

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Reported by ACI Committee 332

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This code covers the design and construction of cast-in-place concrete for one- and two-family dwellings and multiple single-family dwellings (townhouses), and their accessory structures. Among the subjects covered are the design and construction requirements for plain and reinforced concrete footings; foundation walls; slabs-on-ground; and requirements for concrete, reinforcement, forms, and other related materials. The quality and testing of materials discussed in this document are covered by reference to the appropriate ASTM standards.

This code is written to allow for reference by adoption in a general building code without changing its language. Background details or suggestions for carrying out the requirements or intent of the code are provided in the commentary. The commentary discusses some of the considerations of the committee in developing the code with emphasis given to the explanation of provisions that may be unfamiliar to code users or where significant departure exists from other concrete codes. Commentary provisions begin with an "R." Relevant resource documents are provided for the user desiring more detailed study of individual issues.

Keywords: admixtures; aggregates; air entrainment; backfill; calcium chloride; cover; curing; flexural strength; footings; formwork (construction); joints; loads (forces); mixture proportioning; slab-on-ground; slabs; sulfates exposure; structural analysis; welded-wire reinforcement.

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ACI 332-14 was adopted January 21, 2014 and published February 2014.

PREFACE

The commentary of this code discusses some of the considerations of Committee 332 in developing the provisions contained herein. Explanation of the departure of this code from ACI 318 is emphasized. Comments on specific provisions are made under the corresponding chapter and section numbers of this code.

The commentary is not intended to provide a complete historical background concerning the development of this code, nor is it intended to provide a detailed résumé of the studies and research data reviewed by the committee in formulating this document.

This code is meant to be used as part of a legally adopted building code and, as such, must differ in form and substance from documents that provide detailed specifications, recommended practice, or complete design procedures.

This code is intended to cover all residential structures that fall within the scope of the International Residential Code (IRC-2012). Requirements more stringent than the code provisions may be desirable for large, complex, or irregular structures; high-hazard areas; and other unusual construction. This code cannot replace sound engineering knowledge, experience, and judgment.

A building code states only the minimum requirements necessary to provide for public health and safety; this code is based on this principle. For any structure, the owner or the designer may require the quality of materials and construction to be higher than the minimum requirements necessary to protect the public as stated herein. Lower standards, however, are not permitted. The commentary directs attention to other documents that provide suggestions for carrying out the requirements and intent of this code.

This code has no legal status unless adopted by government bodies having authority to regulate building design and construction. Where this code has not been adopted, it may serve as a reference to good practice even though it has no legal status.

This code provides a means of establishing minimum standards for acceptance of designs and construction by legally appointed building officials or their designated representatives. This document is not intended for use in settling disputes between the owner; engineer; architect; contractor; or their agents, subcontractors, material suppliers, or testing agencies. Therefore, this code cannot define the contract responsibility of each of the parties in construction. General references requiring compliance with this code in the project specifications should be avoided because the contractor is rarely in a position to accept responsibility for design details or construction requirements that depend on detailed knowledge of the design. Design-build construction contractors, however, typically combine the design and construction responsibility. Generally, the drawings, specifications, and contract documents should contain all the necessary requirements to ensure compliance with the code. In part, this can be accomplished by reference to specific code sections in the project specifications. Other ACI publications, such as ACI 301, are written specifically for use as contract documents for construction. Testing and certification programs should be provided for the individual parties involved with the execution of work performed in accordance with this code.

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CODE

CHAPTER 1—GENERAL

1.1—Scope

1.1.1 This code, when legally adopted as part of a general building code, provides minimum requirements for design and construction of residential concrete elements. In areas without a legally adopted building code and lack of a project specification, this code defines minimum acceptable standards of design and construction practice.

1.1.2 This code supplements the general building code and governs matters pertaining to design and construction of cast-in-place concrete construction for one- and two-family dwellings and multiple single-family dwellings (townhouses), and their accessory structures, except wherever this code conflicts with requirements in the legally adopted general building code.

1.1.3 Where this code conflicts with requirements contained in other standards referenced in this code, this code shall govern.

1.1.4 This code is limited to design and construction of concrete footings, including thickened slab footings, wall footings, and isolated footings; concrete basement or foundation walls constructed with removable forms or with flat insulating concrete forms; and concrete slabs-on-ground.

1.1.5 Where the scope of this code and the scope of ACI 318 coincide, design in accordance with ACI 318 shall be permitted for all buildings and structures, and all parts thereof, within the scope of this code.

1.1.6 This code does not govern design and construction of insulating concrete form walls with a waffle or screen configuration; precast wall elements; above-grade concrete walls; deep foundation systems, such as piles, drilled piers, or caissons; and elevated concrete slabs.

1.1.7 This code does not govern the design and application of systems for surface drainage, waterproofing, dampproofing, or the ventilation of radon gases.

1.1.8 When a building or structure contains elements that exceed the limits of this code or otherwise do not conform to this code, these elements shall be designed in accordance with ACI 318.

1.1.9 Where permitted by the statutes of the jurisdiction where the project is to be constructed, construction documents for residences designed by the provisions of this code need not be prepared by a licensed design professional. Where required by the statutes of the jurisdiction where the

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R1—GENERAL

R1.1—Scope

R1.1.1 The user of this code should consult the applicable general building code for all applied loads to determine the applicable values for design requirements. In the absence of a governing code, the user should consider the use of ASCE/SEI 7 to determine applicable loads.

R1.1.3 The International Residential Code (IRC-2012) references this code. Where the design of an element is initiated with this code from reference by the IRC-2012, the entire design of the element must be completed using the provisions of this code.

R1.1.4 The design and construction requirements for footings, foundation walls, and slabs-on-ground are included in this code, together with requirements for concrete, reinforcement, forms, and other related materials.

R1.1.6 Provisions for application of precast wall elements are found in IRC-2012. The provisions for above-grade concrete walls are currently available in IRC-2012 based on PCA 100.

R1.1.7 Guidance on the type and application of systems for drainage, waterproofing, dampproofing, and radon gas ventilation are commonly found in the general building code.

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project is to be constructed, a licensed design professional shall prepare the construction documents for residences.

1.1.10 This code is intended to state only minimum requirements necessary to provide for public health and safety for the design of residences that fall within the scope of the IRC-2012. The owner or the licensed design professional may require the quality of materials and construction to be higher than the minimum requirements stated in the code.

1.1.11 All references to minimum and maximum dimensions or values in the code refer to those dimensions or values as specified.

1.1.12 This code is not intended to define contractual responsibilities between all the parties involved in a project, nor is it intended to settle disputes regarding contractual responsibilities.

1.1.13 The commentary text, tables, figures, or illustrations shall not be used to interpret the code in a way that conflicts with the plain meaning of the code text, or to create ambiguity within the code that would not otherwise exist.

1.1.14 The English version in U.S. customary units is the official version of the code. In case of conflict between the official version and versions with SI units or in different languages, the official version governs.

1.2—Alternative systems

Sponsors of any system of design or construction or an alternative material to be applied within the scope of this code, the adequacy of which has been shown by successful use, analysis, or test, but which does not conform to or is not covered by this code, shall have the right to present the data on which their design is based to the building official or to a board of examiners appointed by the building official. This board shall have authority to investigate the data so submitted, to require tests, and to formulate rules governing design and construction of such systems to meet the intent of this code. These rules, if approved by the building official and promulgated, shall be of the same force and effect as the provisions of this code.

1.3—Footings and foundation walls

The design and construction of concrete footings and foundation walls shall be in accordance with the provisions of Chapters 7 and 8, respectively.

1.3.1 *Seismic design*—The seismic risk level of a region, or seismic performance or design category of a structure, shall be regulated by the legally adopted general building code, of which this code forms a part, or determined by local authority.

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R1.2—Alternative systems

New methods of design, materials, and uses of materials should undergo a period of development before being specifically covered in a code. Hence, good systems or components might be excluded from use by implication if means were not available to obtain acceptance. For systems considered under this section, specific tests, load factors, deflection limits, and other pertinent requirements should be set by the board of examiners and should be consistent with the intent of this document.

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1.3.2 *Design for expansive soils*—Concrete design for expansive soils shall be in accordance with the provisions of Chapter 9.

1.4—Drawings and specifications

All designs for cast-in-place concrete construction not covered by the design provisions or prescriptive tables of this code shall require the seal of a licensed design professional.

1.5—Inspection

The construction of all concrete elements covered by this code shall be inspected as required by the legally adopted general building code.

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CHAPTER 2—NOTATION AND DEFINITIONS

R2—NOTATION AND DEFINITIONS

2.1—Notation

d_b = diameter of steel reinforcing bar, in.
f_c' = specified compressive strength of concrete, psi
f_y = specified minimum yield strength, psi
M_n = nominal moment strength at section, in.-lb
S = elastic section modulus of cross section, in.^{3}

2.2—Definitions

R2.2—Definitions

ACI provides a comprehensive list of definitions through an online resource, "ACI Concrete Terminology," http://concrete.org/Tools/ConcreteTerminology.aspx. Definitions provided herein complement that resource.

flat insulating concrete forms—insulating concrete forming system that produces a solid concrete wall of uniform thickness.

general residential code—code adopted in each jurisdiction; when adopted, this code supplements and forms part of the general residential code.

insulating concrete forms—concrete forming system using stay-in-place forms of rigid foam plastic insulation, a hybrid of cement and foam insulation, a hybrid of cement and wood chips, or other insulating material for constructing cast-in-place concrete walls.

macrofiber—fiber with an equivalent diameter greater than or equal to 0.012 in. (0.3 mm) for use in concrete.

plain concrete—structural concrete with no reinforcement or with less reinforcement than the minimum amount specified in ACI 318, except as modified in 8.2 of this code.

reentrant corner—an internal or inside corner where a concrete element turns or wraps around on itself, creating an inside corner flanked by two outside corners or lengths of concrete.

reinforced concrete—structural concrete reinforced with no less than the minimum amount of prestressing steel or nonprestressed reinforcement as specified by ACI 318, except as modified in 8.2 of this code.

seismic design category—classification assigned to a structure based on its occupancy category and the severity of the design earthquake ground motion at the site, as defined by the legally adopted general building code.

slump flow—measure of the unconfined flow potential of freshly mixed self-consolidating concrete or grout. The value is equal to the average of two perpendicular diameters of the material measured to the nearest 1/4 in., but reported to the nearest 1/2 in. after it is released from a slump cone and stops flowing.

townhouse—single-family dwelling unit constructed in a group of three or more attached units in which each unit extends from foundation to roof and with open space on at least two sides.

unbalanced backfill height—difference between the heights of the finished grade on each side of a wall.

unbalanced backfill height—where an interior concrete slab is provided, the unbalanced backfill should be measured from the exterior finished grade level to the top of the interior concrete slab.

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wall height—distance from the top of the lower floor framing or slab to the bottom of the upper floor framing or slab.

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CHAPTER 3—REFERENCED STANDARDS

American Concrete Institute

ACI 301-10—Specifications for Structural Concrete

ACI 318-11—Building Code Requirements for Structural Concrete and Commentary

ASTM International

ASTM A416/A416M-12—Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete

ASTM A615/A615M-12—Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

ASTM A706/A706M-09b—Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement

ASTM A996/A996M-09b—Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement

ASTM A1064/A1064M-12—Standard Specification for Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

ASTM C33/C33M-13—Standard Specification for Concrete Aggregates

ASTM C94/C94M-13—Standard Specification for Ready-Mixed Concrete

ASTM C150/C150M-12—Standard Specification for Portland Cement

ASTM C260/C260M-10—Standard Specification for Air-Entraining Admixtures for Concrete

ASTM C330/C330M-09—Standard Specification for Lightweight Aggregates for Structural Concrete

ASTM C494/C494M-13—Standard Specification for Chemical Admixtures for Concrete

ASTM C595/C595M-13—Standard Specification for Blended Hydraulic Cements

ASTM C618-12—Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

ASTM C685/C685M-11—Standard Specification for Concrete Made By Volumetric Batching and Continuous Mixing

ASTM C845/845M-12—Standard Specification for Expansive Hydraulic Cement

ASTM C989/C989M-12—Standard Specification for Slag Cement for Use in Concrete and Mortars

ASTM C1012/C1012M-13—Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution

ASTM C1017/C1017M-07—Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete

ASTM C1116/C1116M-10—Standard Specification for Fiber-Reinforced Concrete

ASTM C1157/C1157M-11—Standard Performance Specification for Hydraulic Cement

ASTM C1218/C1218M-99(2008)—Standard Test Method for Water-Soluble Chloride in Mortar and Concrete

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ASTM C1240-12—Standard Specification for Silica Fume Used in Cementitious Mixtures

ASTM C1579-13—Standard Test Method for Evaluating Plastic Shrinkage Cracking of Restrained Fiber Reinforced Concrete (Using a Steel Form Insert)

ASTM C1580-09—Standard Test Method for Water-Soluble Sulfate in Soil

ASTM C1602/C1602M-12—Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

ASTM D98-05—Standard Specification for Calcium Chloride

ASTM D422-63(2007)—Standard Test Method for Particle-Size Analysis of Soils

ASTM D516-11—Standard Test Method for Sulfate Ion in Water

ASTM D4130-08—Standard Test Method for Sulfate Ion in Brackish Water, Seawater, and Brines

ASTM D4318-10—Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D4829-11—Standard Test Method for Expansion Index of Soils

International Code Council

IRC-2012—International Residential Code for One- and Two-Family Dwellings

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CHAPTER 4—MATERIALS

4.1—Concrete

4.1.1 *Cementitious material*

4.1.1.1 Cement shall conform to ASTM C150/C150M, C595/C595M, or C1157/C1157M.

4.1.1.2 Fly ash and natural pozzolans shall conform to ASTM C618.

4.1.1.3 Slag cement shall conform to ASTM C989/C989M.

4.1.1.4 Silica fume shall conform to ASTM C1240.

4.1.2 *Aggregates*—Aggregates shall conform to ASTM C33/C33M or C330/C330M.

4.1.3 *Water*—Water used as mixing water in producing concrete shall conform to ASTM C1602/C1602M.

4.1.4 *Admixtures*

4.1.4.1 Air-entraining admixtures shall conform to ASTM C260/C260M.

4.1.4.2 Chemical admixtures shall conform to ASTM C494/C494M, except that admixtures for flowing concrete shall conform to ASTM C1017/C1017M.

4.1.4.3 Calcium chloride shall conform to ASTM D98.

4.2—Reinforcement

4.2.1 *Deformed reinforcement*—Deformed steel reinforcing bars shall conform to ASTM A615/A615M, A706/A706M, or A996/A996M. The yield strength of reinforcement shall be at least 40,000 psi.

4.2.2 *Welded wire reinforcement*

4.2.2.1 Welded plain wire reinforcement, designated by the letter W, shall conform to ASTM A1064/A1064M.

4.2.2.2 Welded deformed wire reinforcement, designated by the letter D, shall conform to ASTM A1064/A1064M.

4.2.3 *Prestressing steel*—Prestressing steel strand shall conform to ASTM A416/A416M.

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R4—MATERIALS

R4.2—Reinforcement

R4.2.1 Refer to Table R4.2.1 for properties of bars.

Table R4.2.1—Steel reinforcing bar information

Bar size, no.	Nominal diameter, in.	Nominal area, in.^{2}	Nominal weight, lb/ft	Development length ($30d_b$), in.
3	0.375	0.11	0.376	11.25
4	0.500	0.20	0.668	15.00
5	0.625	0.31	1.043	18.75
6	0.750	0.44	1.502	22.50

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4.2.4 *Surface conditions of reinforcement*—At the time concrete is placed, deformed bar and welded wire reinforcement shall be free of materials deleterious to development of bond strength between the reinforcement and the concrete.

4.2.5 *Fiber reinforcement*—Synthetic macrofiber and synthetic microfiber shall conform to ASTM C1116/C1116M.

4.3—Formwork

4.3.1 Forms shall result in a final structure that conforms to shapes, lines, and dimensions of the members as required by the design drawings and specifications.

4.3.2 Forms shall provide a consistent surface and sufficiently tight joints to prevent the leakage of concrete or mortar beyond the specified deviance for surface finish or that can be cleaned from the exposed concrete surface.

4.3.3 Forms shall be braced or tied together to maintain position and shape.

4.3.4 Forms and their supports shall be designed so as not to damage the previously placed structure.

4.3.5 Design of formwork shall include consideration of the following factors:

(a) Rate and method of placing concrete

(b) Construction loads, including vertical, horizontal, and impact loads

(c) Form requirements for construction of arches, blockouts, ledges, floor decks, or similar elements

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R4.2.4 Common surface contaminants such as concrete splatter, rust, form oil, or other release agents have been found not to be deleterious to bond (Taber et al. 2002; Suprenant and Malisch 1998).

R4.3—Formwork

R4.3.1 Refer to ACI 347 and ACI SP-4 for guidance on design and construction of formwork.

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CHAPTER 5—CONCRETE REQUIREMENTS

5.1—General requirements

5.1.1 The value of f_c' shall be the greatest of the values required in this chapter for durability or for structural strength requirements. Concrete mixtures shall be proportioned to achieve the strength and to comply with the slump, air content, and cementitious materials limitations in this chapter.

5.2—Exposure categories and classes

5.2.1 Exposure classes shall be assigned to concrete elements based on the severity of the anticipated exposure for each category according to Table 5.2.1 or as determined by the local building official.

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R5—CONCRETE REQUIREMENTS

R5.1—General requirements

R5.1.1 The specifier can require a higher specified strength than indicated in this code. The concrete supplier proportions concrete mixtures to achieve an average strength higher than the specified strength. The purchaser may request documentation demonstrating that the concrete being supplied will achieve the strength requirements. ACI 301 provides guidance for proportioning mixtures to meet specified compressive strength. If strength verification is required, cylinders taken by an ACI Certified Field Technician or technician certified by an equivalent program during time of placement should be tested according ASTM C39/C39M. The concrete strength is considered satisfactory as long as averages of any three consecutive strength tests remain above the specified f_c' and no individual strength test falls below the specified f_c' by more than 500 psi.

R5.2—Exposure categories and classes

R5.2.1 For Exposure Category RF, Exposure Class RF0 should be assigned to interiors and to footings, foundations, and basement walls submerged in the ground. Concrete deteriorates when exposed to freezing-and-thawing cycles when any portion of the member is in a critically saturated condition during freezing weather. Basement and foundation walls that extend above grade less than 12 in. are unlikely to be saturated and could generally be assigned Exposure Class RF0. Exposure Class RF1 or RF2 should be assigned to vertical concrete members where excessive accumulation of ice and snow is not anticipated. Examples include above-grade footings, walls, and columns. Exposure Class RF2 should be assigned to elevated or on-grade horizontal concrete members that have a likelihood for prolonged contact with water to achieve a saturation state. Examples include concrete roofs, patios, or other slabs where it is anticipated that deicing chemicals will not be used. Exposure Class RF3 should be assigned to the same type of members as in Exposure Class RF2 but where the application of deicing chemicals is anticipated. Examples include driveways, curbs, steps, stairs, and porches.

Exposure Category RS should be based on a measurement or knowledge of the concentration of soluble sulfates in soil or water that will be in contact with the relevant concrete member. The referenced standards should be used to measure the sulfate concentrations. Other methods can provide different results compared with the methods referenced. Where the predominant soil sulfates are in the form of gypsum, the measured sulfate content will be higher and these criteria will be conservative. In these cases, it is preferable that a test that has a history of successful use in the geographic area of the project be permitted and approved by the local building official. Even though concentration of soluble sulfates in seawater will be high, members exposed to seawater should be assigned to Exposure Class RS1.

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Exposure Category RC is only applicable to concrete members with structural reinforcement and not to plain concrete. The corrosion of the small amount of reinforcement used as temperature and shrinkage steel in plain concrete members does not represent a problem whereby the structural safety of the member will be compromised.

The user of this document is encouraged to develop a table to assign exposure classes for each concrete element on a project as shown in Table R5.2.1.

Table 5.2.1—Exposure categories and classes

Category	Severity	Class	Condition	
RF freezing and thawing	Not applicable	RF0	Concrete not exposed to freezing-and-thawing cycles	
	Moderate	RF1	Concrete exposed to moisture but not likely to be in a saturated condition when exposed to freezing-and-thawing cycles	
	Severe	RF2	Concrete exposed to moisture and with the potential of being in a saturated condition when exposed to freezing-and-thawing cycles	
	Very severe	RF3	Concrete exposed to moisture and application of deicing chemicals with the potential of being saturated when exposed to freezing-and-thawing cycles	
RS sulfate			Water-soluble sulfate (SO_4) in soil, percent by mass*	Dissolved sulfate (SO_4) in water, ppm†
	Not applicable	RS0	$SO_4 < 0.10$	$SO_4 < 150$
	Moderate	RS1	$0.10 \le SO_4 < 0.20$	$150 \le SO_4 < 1500$ Seawater
	Severe	RS2	$0.20 \le SO_4 \le 2.00$	$1500 \le SO_4 \le 10{,}000$
	very severe	RS3	$SO_4 > 2.00$	$SO_4 > 10{,}000$
RC‡ corrosion protection of reinforcement	Not applicable	RC0	Concrete dry or protected from moisture	
	Moderate	RC1	Concrete containing structural steel reinforcement and exposed to moisture but not to external sources of chlorides	
	Severe	RC2	Concrete containing structural steel reinforcement and exposed to moisture and an external source of chlorides from deicing chemicals, salt, brackish water, seawater, or spray from these sources	

*Percent sulfate by mass in soil shall be determined by ASTM C1580.

†Concentration of dissolved sulfates in water in ppm shall be determined by ASTM D516 or ASTM D4130.

‡Exposure Category RC applies to concrete members designed with reinforcing steel to resist loads. Does not apply to members with minimum steel reinforcement used for control of cracking due to temperature and shrinkage or to steel fiber-reinforced concrete.

Table R5.2.1—Assigned exposure classes for concrete elements

Concrete element*	Exposure class		
	RF freezing and thawing	RS sulfate	RC corrosion protection of reinforcement
Footings, foundations, and basement walls not exposed to weather	RF# †	RS# †	RC# †
Basement slabs and interior slabs-on-ground	RF# †	RS# †	RC# †
Footings, foundations, basement walls, and exterior walls exposed to weather	RF# †	RS# †	RC# †
Driveways, curbs, walks, patios, porches, steps, stairs, and unheated garage floors exposed to weather.	RF# †	RS# †	RC# †

*Depending on the project and or exposure conditions, fewer or additional concrete elements may need to be defined for purposes of assigning exposure classes.

†For each concrete element, the corresponding exposure classifications should be placed in the appropriate cell and compared to determine the most restrictive requirements for concrete per 5.3.2.

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5.3—Requirements for concrete mixtures

5.3.1 *Coarse aggregate size*—The nominal maximum size of coarse aggregate shall not exceed the smallest of (a), (b), and (c):

(a) 1/5 of the minimum wall thickness

(b) 1/3 of the cross-sectional dimension of a member

(c) 3/4 of the specified minimum clear spacing between reinforcing bars or clear cover

5.3.2 Based on the exposure classes assigned from 5.2.1, concrete mixtures shall comply with the most restrictive requirements according to Table 5.3.2.

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R5.3—Requirements for concrete mixtures

R5.3.1 These limitations do not apply if workability and consolidation methods facilitate the placement of concrete without honeycombs or voids.

R5.3.2 Concrete durability is improved by the introduction of air entrainment for resistance to freezing and thawing, the use of a *w*/*cm* less than 0.45 to reduce the permeability of concrete to water and deleterious chemicals, and proper curing (refer to 6.5). The requirements in Table 5.3.2 do not include a limit on *w*/*cm*, but specified compressive strength levels are indicated that provide reasonable assurance of achieving a low *w*/*cm*. Tests can verify compressive strength of concrete, but it is difficult to accurately determine the w/cm of concrete delivered to a project. Use of supplementary cementitious materials such as fly ash and slag cement, also reduces the permeability of concrete and improves its durability. Section 6.5 emphasizes the importance of properly curing concrete for the conditions described in Table 5.3.2.

The type and performance of water-reducing admixtures are selected based on the intended application and include both high-range water-reducing admixtures (HRWRAs) and mid-range water-reducing admixtures (MRWRAs). HRWRAs and MRWRAs result in large to moderate water reductions, respectively, in mixtures while maintaining greater flowability without causing undue set retardation or increased air entrainment. When using HRWRAs conforming to ASTM C494/C494M or C1017/C1017M, the specified maximum slump may be increased from those listed in Table 5.3.2, provided the concrete mixture does not segregate during placement. Specify a slump of 9 in. if necessary. If slump verification is required, slump testing should be in accordance with ASTM C143/C143M. A traditional slump limit is not appropriate for self-consolidated (SCC) concrete, where the consistency of the concrete is measured in terms of slump flow in accordance with ASTM C1611/C1611M. Slump flow in the range of 24 to 28 in. is generally used for residential concrete. Refer to ACI 237R for additional information.

For Exposure Class RS3, it is permitted to use cementitious materials in concrete mixtures that have a good service record in similar exposure conditions. When typical concrete mixtures used in the region have had good service history that exceeds approximately 5 years, testing mixtures in accordance with 5.4.2 to establish the additional quantity of pozzolans and slag cement is not necessary. The MS and HS designations for blended cements complying with ASTM C595/C595M and ASTM C1157/C1157M are tested to comply with the requirements of Table 5.4.2.

Calcium chloride is a common and effective chemical admixture used to accelerate the setting time and rate of strength gain in cold weather construction. Its use is not

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permitted for members assigned with Exposure Classes RS2 and RS3 because of the potential for reducing the sulfate resistance of concrete. Its use may also be restricted for members with structural reinforcement assigned to Exposure Category RC. The limits for are stated in terms of chloride ions. When there is no other source of chlorides in the concrete ingredients, the limit on calcium chloride is approximately double the chloride ion limit (a 1 percent chloride ion limit is roughly equivalent to 2 percent calcium chloride). When calcium chloride use is restricted, non-chloride-based accelerating admixtures may be used for the same purpose.

Table 5.3.2—Exposure categories and classes

Exposure class	Maximum slump*	Minimum f_c', psi	Additional minimum requirements			
			Air content			Limits on cementitious materials
RF0	6	2500	N/A			N/A
RF1	5	3000	Table 5.4.1			N/A
RF2	5	3500	Table 5.4.1			N/A
RF3	4	4000	Table 5.4.1			Table 5.4.2
			Cementitious materials†—types			Calcium chloride admixture
			ASTM C150/C150M	ASTM C595/C595M	ASTM C1157/C1157M	
RS0	6	2500	No type restriction	No type restriction	No type restriction	No restriction
RS1	6	2500	II	IP(MS), IS (<70) (MS)	MS	No restriction
RS2	5	3000	V‡	IP (HS) IS (<70) (HS)	HS	Not permitted
RS3	5	3000	V + pozzolan or slag§	IP (HS) + pozzolan or slag§ or IS (<70) (HS) + pozzolan or slag cement§	HS + pozzolan or slag cement§	Not permitted
			Maximum water-soluble chloride ion (Cl^-) content in concrete, percent by weight of cement‖ in reinforced concrete			
RC0	6	2500	1.00			
RC1	6	2500	0.30			
RC2	4	4000	0.15			

*Maximum specified slump shall have a tolerance for purposes of field testing and acceptance of ±1.5 in. for specified slump greater than 4 in. and ±1 in. for specified slump 4 in. or less. Specified slumps shall be permitted to be increased to a maximum of 9 in. by using mid-range water-reducing admixtures (MRWRAs) or high-range water-reducing admixtures (HRWRAs). When self-consolidating concrete (SCC) is used, no maximum slump is specified; however, specified slump flow shall be between 24 and 28 in. with a tolerance of ±2.5 in.

†Alternative combinations of cementitious materials of those listed in Table 5.4.2 shall be permitted when tested for sulfate resistance and meeting the criteria in 5.5.1.

‡Other available types of cement such as Type III or Type I are permitted in Exposure Classes RS1 or RS2 if the C_3A contents are less than 8 or 5 percent, respectively.

§The amount of the specific source of the pozzolan or slag to be used shall not be less than the amount that has been determined by service record to improve sulfate resistance when used in concrete containing Type V cement. Alternatively, the amount of the specific source of the pozzolan or slag to be used shall not be less than the amount tested in accordance with ASTM C1012/C1012M and meeting the criteria in 5.5.1.

‖Water-soluble chloride ion content that is contributed from the ingredients including water, aggregates, cementitious materials, and admixtures shall be determined on the concrete mixture by ASTM C1218/C1218M between 28 and 42 days.

5.4—Additional requirements for freezing-and-thawing exposure

5.4.1 Normalweight and lightweight concrete subject to Exposure Category RF shall be air entrained with a total air content as indicated in Table 5.4.1. Tolerance on air content as delivered shall be ±1.5 percent. For f_c' greater than 5000 psi, reduction of air content indicated in Table 5.4.1 by 1.0 percent shall be permitted.

R5.4—Additional requirements for freezing-and-thawing exposure

R5.4.1 Air-entrained concrete is essential for durability of concrete exposed to freezing-and-thawing cycles. A lower air content is required for members assigned an Exposure Class RF1 because of the reduced likelihood that these members will be in a saturated condition when exposed to freezing and thawing. Higher air contents than indicated in Table 5.4.1 will reduce strength and will not improve dura-

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Table 5.4.1—Total air content for concrete assigned to exposure category RF

Nominal maximum aggregate size, in.*	Total air content, percent	
	Exposure Class RF1	Exposure Classes RF2 and FR3
3/8	6	7.5
1/2	5.5	7
3/4	5	6
1	4.5	6
1-1/2	4.5	5.5
2†	4	5
3†	3.5	4.5

*Refer to ASTM C33/C33M for tolerance on oversized aggregate for various nominal maximum size designations.

†Tolerance on air content of ±1.5 percent shall be permissible.

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bility. If verification of air entrainment is specified, testing should be performed by certified technicians and in accordance with ASTM C231/C231M or C173/C173M, as appropriate. If concrete fails to meet the required air entrainment at the lower end of the tolerance, steps should be taken to increase the air content.

5.4.2 The quantity of pozzolans, including fly ash and silica fume, and slag in concrete subject to Exposure Class RF3 shall not exceed the limits in Table 5.4.2.

Table 5.4.2—Requirements for concrete subject to exposure class RF3

Cementitious materials	Maximum percent of total cementitious materials by weight*
Fly ash or other pozzolans conforming to ASTM C618	25
Slag conforming to ASTM C989/C989M	50
Silica fume conforming to ASTM C1240	10
Total of fly ash, silica fume, slag, and other pozzolans	50†
Total of fly ash, silica fume, slag, and other pozzolans	35†

*The total cementitious material also includes ASTM C150/C150M, C595/C595M, C845/C845M, and C1157/C1157M cement.

The maximum percentages above shall include:

(a) Fly ash or other pozzolans in Type IP blended cement, ASTM C595/C595M, or ASTM C1157/C1157M

(b) Slag used in the manufacture of an IS blended cement, ASTM C595/C595M, or ASTM C1157/C1157M

(c) ASTM C1240 silica fume present in a blended cement

†Fly ash or other pozzolans and silica fume shall constitute no more than 25 and 10 percent, respectively, of the total weight of the cementitious materials.

R5.4.2 Table 5.4.2 establishes limitations on the amount of fly ash, other pozzolans, silica fume, and slag cement that can be included in concrete members assigned to Exposure Category RF3. The quantity of these materials includes those in blended cements (ASTM C595/C595M and C1157/C1157M) and/or separately added when batching concrete. Exceeding these limitations may increase the potential for surface scaling. These limits on supplementary cementitious materials should not be applied to concrete members that are not assigned to Exposure Class RF3.

5.5—Alternative cementitious materials for sulfate exposure

5.5.1 Alternative combinations of cementitious materials to those listed in Table 5.3.2 shall be permitted when tested for sulfate resistance and meeting the criteria in Table 5.5.1.

R5.5—Alternative cementitious materials for sulfate exposure

R5.5.1 Testing required to qualify cementitious materials in Table 5.5.1 takes considerable time and may not be possible with typical project schedules. It is permitted to use concrete mixtures with good service records in these regions. The expansion criteria for Exposure Classes RS1 and RS2 are the same as those for the MS and HS designa-

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Table 5.5.1—Requirements for establishing suitability of cementitious materials combinations exposed to water-soluble sulfate

Exposure class	Maximum expansion when tested using ASTM C1012/C1012M		
	At 6 months	At 12 months	At 18 months
RS1	0.10 percent	—	—
RS2	0.05 percent	0.10 percent*	—
RS3	—	—	0.10 percent

*The 12-month expansion limit applies only when the measured expansion exceeds the 6-month maximum expansion limit.

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tions, respectively, for cements manufactured in accordance with ASTM C595/C595M and C1157/C1157M. Therefore, these blended cements may be an option in these exposure conditions.

5.6—Concrete cover

R5.6—Concrete cover

5.6.1 Concrete cover shall have a tolerance of ±3/8 in.

5.6.2 Concrete cover for slabs-on-ground shall be in accordance with 10.6.1.

5.6.3 Clear cover to reinforcement in concrete footings and walls shall be in accordance with 5.6.4 through 5.6.7.

5.6.4 Cover to reinforcement for concrete cast against earth shall be at least 3 in.

R5.6.4 In some instances, it is advantageous or necessary for one or more sides of the formed concrete placement to consist of an excavated earth surface. This section refers to these instances where the placing operation results in the concrete directly contacting the earth.

5.6.5 Cover to reinforcement for concrete not exposed to earth or weather shall be at least 3/4 in.

5.6.6 Cover to reinforcement, with a size not larger than a No. 5 bar or W31 or D31 wire, for concrete exposed to earth or weather shall be at least 1-1/2 in.

5.6.7 Cover to reinforcement, with a size not smaller than a No. 6 bar, for concrete exposed to earth or weather shall be at least 2 in.

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CHAPTER 6—CONCRETE PRODUCTION AND PLACEMENT

6.1—Concrete

6.1.1 Ready mixed concrete shall be ordered, batched, mixed, and transported in accordance with ASTM C94/C94M.

6.1.2 Concrete produced by volumetric batching and continuous mixing shall be batched and mixed in accordance with ASTM C685/C685M.

6.2—Placement

6.2.1 Specified concrete properties in accordance with 5.3.2 and 5.4.1 shall be provided at point of delivery.

6.2.2 Concrete shall be placed by methods that maintain the properties specified in Chapter 5.

6.2.3 Concrete that is partially hardened or contaminated by foreign materials shall not be placed.

6.2.4 Areas prepared for the placement of concrete shall be free of debris and contaminants. Confined footing areas shall also be free of water.

6.2.5 Concrete shall be consolidated by suitable means during placement and shall be worked around embedded items and reinforcement and into corners of the forms.

6.3—Form removal

Forms shall be removed in a manner that does not impair safety and serviceability of the structure. Concrete exposed by form removal shall have sufficient strength not to be damaged by the removal operation.

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R6—CONCRETE PRODUCTION AND PLACEMENT

R6.1—Concrete

R6.1.1 The user should refer to ACI 304R for additional recommendations for the measuring, mixing, transporting, and placing of concrete.

R6.1.2 The user should refer to ACI 304.6R for additional recommendations for volumetric batching and the continuous mixing of concrete.

R6.2—Placement

R6.2.1 Normally, concrete discharge is completed within 90 minutes after the introduction of water to cement. Experience has shown that the 90-minute discharge time can be exceeded while maintaining the specified concrete properties during placing operations.

ASTM C94/C94M allows for the one-time addition of water at the job site up to the allowable maximum *w*/*cm*. Alternatively, the addition of a high-range water-reducing admixture (HRWRA) or mid-range water-reducing admixture (MRWRA) at the job site may be used to increase the slump of flowing concrete when it falls below the desired slump. After an HRWRA or MRWRA is added to the concrete at the site to achieve flowable concrete, do not add water to the concrete.

R6.2.4 Refer to 6.6 for the placement of concrete on frozen material. If the footing form permits water to exit, the hydraulic pressure of the concrete placement is sufficient to displace the water from the formed areas and prevent segregation.

R6.2.5 Recommendations for consolidation of residential concrete are given in detail in ACI 332.1R, and for all forms of concrete in ACI 309R. Usually, self-consolidating concrete (SCC) and concrete with slump greater than 7 in. due to HRWRA are not vibrated; however, minimal vibration may be required to minimize surface defects. Care must be taken to avoid segregation of the concrete due to over vibration.

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6.4—Finishing

Surface defects that expose reinforcement shall be repaired. Surface defects greater than 50 in.^{2} with depths greater than 0.5 in. shall be repaired.

6.5—Curing

After placement, concrete shall be protected to maintain proper moisture and temperature. Protection shall ensure that excessive water evaporation does not impair required strength or serviceability of the element. Sections 6.6 and 6.7 shall be followed in cold and hot weather conditions, respectively.

6.6—Cold weather

6.6.1 During anticipated ambient temperature conditions of 35°F or less, concrete shall be maintained above a frozen state until a concrete compressive strength of 500 psi has been reached.

6.6.2 Concrete materials, reinforcement, forms, and any earth with which concrete is to come in contact shall be free from ice, snow, and frost.

6.6.3 Frozen materials or materials containing ice shall not be used.

6.7—Hot weather

6.7.1 During hot weather, attention shall be given to ingredients, production methods, handling, delivering, placing, protection, and curing of concrete to prevent excessive concrete temperatures or water evaporation that could impair required strength or serviceability of the member or structure.

6.7.2 Use of synthetic macrofibers, synthetic microfibers, or both, is permitted at a dosage rate based on manufacturer's data to reduce plastic shrinkage cracking by a minimum of 40 percent when measured in accordance with ASTM C1579.

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R6.4—Finishing

Refer to ACI 332.1R for repair guidelines.

R6.5—Curing

The objectives of curing are to reduce the loss of moisture from concrete and, when needed, to supply additional moisture and maintain a favorable concrete temperature for a sufficient period of time to allow the concrete to reach initial critical strengths. Common methods include wet burlap, polyethylene sheets, blankets, foggers, and curing compounds. References to these methods and other curing techniques can be found in ACI 332.1R and 308R.

R6.6—Cold weather

R6.6.1 Concrete that is frozen before achieving a compressive strength of 500 psi will not achieve the compressive strength that it would have had it been protected. A maturity curve for a particular mixture, available from the concrete supplier, can be used to determine when the compressive strength of the concrete mixture can be expected to reach 500 psi. Further information demonstrating the effectiveness of maturity testing as an accurate prediction method for early-age in-place strength and mixture performance can be obtained from the Concrete Foundations Association (2004). Refer to ACI 306R for further information regarding cold-weather concrete practices.

R6.7—Hot weather

R6.7.1 Refer to ACI 305R for information on hot-weather concreting practices.

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CHAPTER 7—FOOTINGS

7.1—General

Isolated and continuous wall footings shall be designed by using the prescriptive tables in this chapter in accordance with 7.2. The construction of isolated footings and wall footings shall be in accordance with 7.3.

7.2—Design

For footings designed by this code, the attributes listed in Table 7.2 shall not be exceeded.

7.2.1 *Wall footings*

7.2.1.1 Wall footing width shall be at least the greater of the applicable dimensions specified in Tables 7.2.1.1a through 7.2.1.1h or the supported wall thickness plus 4 in. Tables 7.2.1.1a through 7.2.1.1h are based on the following conditions:

(a) Maximum attic load, 20 psf
(b) Maximum second and third floor live load, 30 psf each
(c) Maximum foundation wall dead load, 125 psf (10 in. wall)
(d) Maximum floor dead load, 15 psf
(e) Maximum interior wall dead load, 15 psf (wood framing)
(f) Maximum first floor live load, 40 psf
(g) Maximum roof and ceiling dead load, 20 psf
(h) Maximum floor to floor height, 10 ft
(i) Maximum foundation wall height, 10 ft
(j) Maximum roof overhang, 2 ft
(k) Minimum f_c', 2500 psi
(l) Minimum f_y, 60,000 psi

7.2.1.1.1 *Construction requirements*—Continuous footings shall be at least 9.5 in. wide, with the wall centered on the footing.

7.2.1.2 Minimum depth of the footing shall be 6 in. The maximum projection of an unreinforced footing beyond the wall face shall not exceed the thickness of the footing unless transverse reinforcement is provided.

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R7—FOOTINGS

R7.1—General

Footings are provided under columns, also called piers, and walls when calculations show that omitting the footing will result in soil pressures that exceed the allowable soil-bearing pressures. Footings are also provided to facilitate the placement of forms. Soil-bearing pressures can be referenced in the general building code or obtained by conducting a geotechnical investigation where fill or otherwise unusual soil conditions are encountered.

R7.2—Design

R7.2.1.1 Footing widths need to project a minimum of 2 in. on each side of the wall to support the forming system. The footing width projection is measured from the face of the concrete wall to the edge of the footing. The values in Tables 7.2.1.1a through 7.2.1.1h are consistent with light frame wood construction roof and floor with second and third floors used for sleeping areas.

R7.2.1.1.1 The minimum footing width of 9.5 in. is determined by the minimum wall thickness permissible by this code of 5.5 in. as specified in 8.2.1.2 and the minimum extension beyond the wall thickness as specified in 7.2.1.1.

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Table 7.2—Specified maximum attributes for prescriptive design of footings

Attribute		Maximum limitation
General	Plan dimension	60 ft
	Ground snow load	70 lb/ft^2
Foundations	Equivalent fluid density of soil	100 lb/ft^3 (refer to Chapter 8)
	Presumptive soil-bearing value	1500 to 4000 lb/ft^2 (refer to 7.2.1.1)
Walls	Unsupported wall height, per story	10 ft
	Unbalanced backfill height	9 ft
Floor loads	Floor dead load	15 lb/ft^2
	First-floor live load	40 lb/ft^2
	Second- and third-floor live loads	30 lb/ft^2
Roof loads	Roof and ceiling dead load	15 lb/ft^2
	Roof snow load	70 lb/ft^2
	Attic live load	20 lb/ft^2
Maximum clear span	Floor span (unsupported)	32 ft
	Beam span (unsupported)	16 ft
	Roof span (unsupported)	40 ft

Table 7.2.1.1a—Minimum exterior footing width for clear span and interior supported footing*

Wall deal load† = 15 psf		One-story/slab				One-story with basement				Two-story with basement				Three-story with basement			
Soil bearing capacity, psf	Maximum span, ft	Roof live load, psf				Roof live load, psf				Roof live load, psf				Roof live load, psf			
		20	30	50	70	20	30	50	70	20	30	50	70	20	30	50	70
1500	16	9.5	9.5	9.5	9.5	18	19	20	21	21	22	24	25	25	26	27	28
	24	9.5	9.5	10	11	21	22	24	26	26	27	29	30	30	32	33	35
	32	9.5	10	12	14	24	25	28	30	30	31	34	36	36	37	40	42
2000	16	9.5	9.5	9.5	9.5	14	14	15	16	17	17	18	19	19	20	21	21
	24	9.5	9.5	9.5	9.5	16	17	18	19	20	20	22	23	23	24	25	26
	32	9.5	9.5	9.5	11	18	19	21	22	23	24	25	27	27	28	30	31
3000	16	9.5	9.5	9.5	9.5	9.5	10	10	11	11	11	12	13	13	13	14	14
	24	9.5	9.5	9.5	9.5	11	11	12	13	13	14	15	15	16	16	17	18
	32	9.5	9.5	9.5	9.5	12	13	14	15	15	16	17	18	18	19	20	21
4000	16	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	10	10	10	11	11
	24	9.5	9.5	9.5	9.5	9.5	9.5	9.5	10	10	10	11	12	12	12	13	13
	32	9.5	9.5	9.5	9.5	9.5	10	11	11	12	12	13	14	14	14	15	16

*This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.

†Wall dead load: light frame wood construction only.

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Table 7.2.1.1b—Minimum exterior footing width for clear span and interior supported footing*

Wall dead load† = 45 psf		One-story/slab				One-story with basement				Two-story with basement				Three-story with basement			
Soil bearing capacity, psf	Maximum span, ft	Roof live load, psf				Roof live load, psf				Roof live load, psf				Roof live load, psf			
		20	30	50	70	20	30	50	70	20	30	50	70	20	30	50	70
1500	16	9.5	9.5	10	11	21	21	22	24	27	27	28	30	33	33	34	36
	24	9.5	10	12	14	24	25	26	28	31	32	33	35	38	39	41	42
	32	11	12	14	16	27	28	30	32	35	36	38	41	44	45	47	27
2000	16	9.5	9.5	9.5	9.5	16	16	17	18	20	21	21	22	25	25	26	17
	24	9.5	9.5	9.5	10	18	19	20	21	23	24	25	26	29	29	31	32
	32	9.5	9.5	11	12	20	21	23	24	26	27	29	31	33	34	35	37
3000	16	9.5	9.5	9.5	9.5	11	11	11	12	14	14	14	15	17	17	17	18
	24	9.5	9.5	9.5	9.5	12	13	13	14	16	16	17	18	19	20	21	21
	32	9.5	9.5	9.5	9.5	14	14	15	16	18	18	19	21	22	23	24	25
4000	16	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	10	11	11	11	13	13	13	13
	24	9.5	9.5	9.5	9.5	9.5	9.5	10	10	12	12	13	13	15	15	15	16
	32	9.5	9.5	9.5	9.5	10	11	12	12	13	14	15	15	17	17	18	19

*This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.

†Wall dead load: light frame wood construction with brick veneer above the foundation.

Table 7.2.1.1c—Minimum exterior footing width for clear span and interior supported footing*

Wall dead load† = 100 psf		One-story/slab				One-story with basement				Two-story with basement				Three-story with basement			
Soil bearing capacity, psf	Maximum span, ft	Roof live load, psf				Roof live load, psf				Roof live load, psf				Roof live load, psf			
		20	30	50	70	20	30	50	70	20	30	50	70	20	30	50	70
1500	16	12	13	14	15	25	26	27	28	35	36	37	38	46	46	48	49
	24	14	15	16	18	28	29	31	32	40	41	42	44	51	52	54	56
	32	15	16	19	21	31	32	34	37	44	45	47	49	57	58	60	62
2000	16	9.5	10	11	12	19	19	20	21	27	27	28	29	35	35	36	37
	24	10	11	12	14	21	22	23	24	30	31	32	33	39	39	41	42
	32	12	12	14	16	23	24	26	28	33	34	36	37	43	44	45	47
3000	16	9.5	9.5	9.5	9.5	13	13	14	14	18	18	19	19	23	23	24	25
	24	9.5	9.5	9.5	9.5	14	15	16	16	20	21	21	22	26	26	27	28
	32	9.5	9.5	10	11	16	16	17	19	22	23	24	25	29	29	30	31
4000	16	9.5	9.5	9.5	9.5	10	10	10	11	14	14	14	15	17	18	28	19
	24	9.5	9.5	9.5	9.5	11	11	12	12	15	15	16	17	20	20	20	21
	32	9.5	9.5	9.5	9.5	12	12	13	14	17	17	18	19	22	22	23	24

*This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.

†Wall dead load: 8 in. grout-filled concrete masonry unit above the foundation wall.

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Table 7.2.1.1d—Minimum interior footing width for clear span and interior supported footing*

Wall dead load† = 15 psf		One-story/slab				One-story with basement				Two-story with basement				Three-story with basement			
Soil bearing capacity, psf	Maximum span, ft	Roof live load, psf				Roof live load, psf				Roof live load, psf				Roof live load, psf			
		20	30	50	70	20	30	50	70	20	30	50	70	20	30	50	70
1500	16	9.5	9.5	9.5	9.5	9.5	9.5	10	11	13	13	14	15	16	17	18	19
	24	9.5	9.5	9.5	10	12	13	14	16	17	17	19	20	22	22	24	25
	32	9.5	9.5	11	13	15	16	18	20	21	22	24	26	27	28	30	32
2000	16	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	10	10	11	11	12	13	13	14
	24	9.5	9.5	9.5	9.5	9.5	10	11	12	13	13	14	15	16	17	18	19
	32	9.5	9.5	9.5	10	11	12	14	15	16	17	18	19	20	21	22	24
3000	16	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
	24	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	10	10	11	11	12	13
	32	9.5	9.5	9.5	9.5	9.5	9.5	9.5	10	11	11	12	13	14	14	15	16
4000	16	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
	24	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	10
	32	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	10	10	11	11	12

*This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.

†Wall dead load: light frame wood construction only.

Table 7.2.1.1e—Minimum interior footing width for clear span and interior supported footing*

Wall dead load† = 45 psf		One-story/slab				One-story with basement				Two-story with basement				Three-story with basement			
Soil bearing capacity, psf	Maximum span, ft	Roof live load, psf				Roof live load, psf				Roof live load, psf				Roof live load, psf			
		20	30	50	70	20	30	50	70	20	30	50	70	20	30	50	70
1500	16	9.5	9.5	9.5	10	14	14	15	16	20	20	21	22	26	26	27	28
	24	9.5	10	11	12	17	17	19	20	24	25	26	28	31	32	33	35
	32	10	11	13	15	20	21	23	25	28	29	31	33	37	28	39	41
2000	16	9.5	9.5	9.5	9.5	10	11	11	12	15	15	16	17	19	20	20	21
	24	9.5	9.5	9.5	9.5	13	13	14	15	18	19	20	21	23	24	25	26
	32	9.5	9.5	10	12	15	16	17	19	21	22	23	25	28	28	30	31
3000	16	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	10	10	11	11	13	13	14	14
	24	9.5	9.5	9.5	9.5	9.5	9.5	10	10	12	13	13	14	16	16	17	18
	32	9.5	9.5	9.5	9.5	10	11	12	13	14	15	16	17	19	19	20	21
4000	16	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	10	10	10	11
	24	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	10	10	11	12	12	13	13
	32	9.5	9.5	9.5	9.5	9.5	9.5	9.5	10	11	11	12	13	14	14	15	16

*This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.

†Wall dead load: light frame wood construction with brick veneer above the foundation.

CODE COMMENTARY

Table 7.2.1.1f—Minimum interior footing width for clear span and interior supported footing*

Wall dead load† = 100 psf		One-story/slab				One-story with basement				Two-story with basement				Three-story with basement			
Soil bearing capacity, psf	Maximum span, ft	Roof live load, psf				Roof live load, psf				Roof live load, psf				Roof live load, psf			
		20	30	50	70	20	30	50	70	20	30	50	70	20	30	50	70
1500	16	12	12	13	14	23	23	24	25	33	33	34	35	43	44	45	46
	24	13	14	15	17	26	26	28	29	37	38	39	41	49	49	51	52
	32	15	16	18	20	29	30	31	33	41	42	44	46	54	55	57	59
2000	16	9.5	9.5	10	11	17	17	18	19	25	25	26	27	33	33	34	34
	24	10	11	12	13	19	20	21	22	28	29	30	31	37	37	38	39
	32	11	12	13	15	22	22	24	25	31	32	33	35	41	41	43	44
3000	16	9.5	9.5	9.5	9.5	11	12	12	13	17	17	17	18	22	22	23	23
	24	9.5	9.5	9.5	9.5	13	13	14	15	19	19	20	21	25	25	26	26
	32	9.5	9.5	9.5	10	15	15	16	17	21	21	22	23	27	28	29	30
4000	16	9.5	9.5	9.5	9.5	9.5	9.5	9.5	10	13	13	13	14	17	17	17	17
	24	9.5	9.5	9.5	9.5	10	10	11	11	14	14	15	16	19	19	19	20
	32	9.5	9.5	9.5	9.5	11	11	12	13	16	16	17	18	21	21	22	22

*This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.

†Wall dead load: 8 in. grout-filled concrete masonry unit above the foundation wall.

CODE **COMMENTARY**

Table 7.2.1.1g—Minimum interior footing area with single span*†

		Soil bearing capacity, psf															
		1500				2000				3000				4000			
		Maximum roof load: live load or snow load, psf															
		20 and below	21 to 30	31 to 50	51 to 70	20 and below	21 to 30	31 to 50	51 to 70	20 and below	21 to 30	31 to 50	51 to 70	20 and below	21 to 30	31 to 50	51 to 70
Footing supporting roof only																	
Plain‡	L	2’-4”	2’-6”	2’-9”	3’-1”	2’-0”	2’-2”	2’-5”	2’-8”	1’-8”	1’-10”	2’-0”	2’-2”	1’-5”	1’-6”	1’-9”	1’-11”
	W	2’-4”	2’-6”	2’-9”	3’-1”	2’-0”	2’-2”	2’-5”	2’-8”	1’-8”	1’-10”	2’-0”	2’-2”	1’-5”	1’-6”	1’-9”	1’-11”
	D	1’-2”	1’-3”	1’-5”	1’-7”	1’-0”	1’-1”	1’-3”	1’-4”	1’-5”	1’-5”	1’-0”	1’-1”	1’-0”	1’-3”	0’-11”	1’-6”
Reinforced	L	2’-4”	2’-6”	2’-9”	3’-1”	2’-0”	2’-2”	2’-5”	2’-8”	1’-8”	1’-10”	2’-0”	2’-2”	1’-5”	1’-6”	1’-9”	1’-11”
	W	2’-4”	2’-6”	2’-9”	3’-1”	2’-0”	2’-2”	2’-5”	2’-8”	1’-8”	1’-10”	2’-0”	2’-2”	1’-5”	1’-6”	1’-9”	1’-11”
	D	0’-8”	0’-9”	0’-9”	0-’10”	0’-8”	0’-9”	0’-9”	0’-10”	0’-8”	0’-9”	0’-9”	0’-9”	0’-8”	0’-8”	0’-9”	0’-9”
	R§‖	(2)-#3	(2)-#3	(3)-#3	(3)-#3	(2)-#3	(2)-#3	(2)-#3	(2)-#4	(2)-#3	(2)-#3	(2)-#3	(3)-#3	(2)-#3	(2)-#3	(2)-#3	(2)-#3
Footing supporting roof and single floor																	
Plain‡	L	3’-2”	3’-4”	3’-7”	3’-9”	2’-9”	2’-11”	3’-1”	3’-3”	2’-3”	2’-5”	2’-6”	2’-8”	1’-11”	2’-1”	2’-2”	2’-4”
	W	3’-2”	3’-4”	3’-7”	3’-9”	2’-9”	2’-11”	3’-1”	3’-3”	2’-3”	2’-5”	2’-6”	2’-8”	1’-11”	2’-1”	2’-2”	2’-4”
	D	1’-7”	1’-8”	1’-10”	1’-11”	1’-5”	1’-6”	1’-7”	1’-8”	1’-2”	1’-3”	1’-3”	1’-4”	1’-0”	1’-1”	1’-1”	1’-2”
Reinforced	L	3’-2”	3’-4”	3’-7”	3’-9”	2’-9”	2’-11”	3’-1”	3’-3”	2’-3”	2’-5”	2’-6”	2’-8”	1’-11”	2’-1”	2’-2”	2’-4”
	W	3’-2”	3’-4”	3’-7”	3’-9”	2’-9”	2’-11”	3’-1”	3’-3”	2’-3”	2’-5”	2’-6”	2’-8”	1’-11”	2’-1”	2’-2”	2’-4”
	D	0’-10”	0’-10”	0’-10”	0’-9”	0’-9”	0’-10”	0’-10”	0’-10”	0’-9”	0’-10”	0’-10”	1’-0”	0’-9”	0’-10”	0-10”	0’-10”
	R§‖	(2)-#4	(2)-#4	(3)-#4	(3)-#4	(3)-#3	(2)-#4	(2)-#4	(3)-#4	(3)-#3	(3)-#3	(3)-#3	(2)-#4	(2)-#3	(2)-#3	(2)-#3	(2)-#4
Footing supporting roof and two floors																	
Plain‡	L	4’-0”	4’-2”	4’-4”	4’-6”	3’-6”	3’-7”	3’-9”	3’-11”	2’-10”	2’-11”	3’-1”	3’-3”	2’-6”	2’-7”	2’-8”	2’-9”
	W	4’-0”	4’-2”	4’-4”	4’-6”	3’-6”	3’-7”	3’-9”	3’-11”	2’-10”	2’-11”	3’-1”	3’-3”	2’-6”	2’-7”	2’-8”	2’-9”
	D	1’-0”	2’-2”	2’-2”	2’-3”	1’-9”	1’-10”	1’-11”	2’-0”	1’-5”	1’-6”	1’-7”	1’-8”	1’-3”	1’-4”	1’-4”	1’-5”
Reinforced	L	4’-0”	4’-2”	4’-4”	4’-6”	3’-6”	3’-7”	3’-9”	3’-11”	2’-10”	2’-11”	3’-1”	3’-3”	2’-6”	2’-7”	2’-8”	2’-9”
	W	4’-0”	4’-2”	4’-4”	4’-6”	3’-6”	3’-7”	3’-9”	3’-11”	2’-10”	2’-11”	3’-1”	3’-3”	2’-6”	2’-7”	2’-8”	2’-9”
	D	1’-0”	1’-0”	1’-0”	1’-0”	0’-10”	1’-0”	1’-0”	1’-0”	1’-0”	1’-0”	1’-0”	1’-0”	1’-0”	1’-0”	1’-0”	1’-0”
	R§‖	(3)-#4	(3)-#4	(3)-#4	(3)-#4	(3)-#4	(3)-#4	(3)-#4	(3)-#4	(2)-#4	(2)-#4	(2)-#4	(3)-#4	(2)-#4	(2)-#4	(2)-#4	(2)-#4

*This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.

†Maximum tributary area = 320 ft^2.

‡The term “plain” refers to concrete where no structural reinforcement is required.

§R refers to minimum steel reinforcement.

‖Minimum reinforcement cover is 3 in.

CODE **COMMENTARY**

Table 7.2.1.1h—Minimum interior footing area with multiple spans*†

		Soil bearing capacity, psf															
		1500				2000				3000				4000			
		Maximum roof load: live load or snow load, psf															
		20 and below	21 to 30	31 to 50	51 to 70	20 and below	21 to 30	31 to 50	51 to 70	20 and below	21 to 30	31 to 50	51 to 70	20 and below	21 to 30	31 to 50	51 to 70
Footing supporting roof only																	
Plain‡	L	3’-4”	3’-6”	4’-0”	4’-4”	2’-10”	3’-1”	3’-4”	3’-9”	2’-4”	2’-6”	2’-9”	3’-1”	2’-0”	2’-2”	2’-5”	2’-8”
	W	3’-4”	3’-6”	4’-0”	4’-4”	2’-10”	3’-1”	3’-4”	3’-9”	2’-4”	2’-6”	2’-9”	3’-1”	2’-0”	2’-2”	2’-5”	2’-8”
	D	1’-8”	1’-9”	2’-0”	2’-2”	1’-6”	1’-7”	1’-8”	1’-11”	1’-2”	1’-3”	1’-5”	1’-7”	1’-0”	1’-1”	1’-3”	1’-4”
Reinforced	L	3’-4”	3’-6”	4’-0”	4’-4”	2’-10”	3’-1”	3’-4”	3’-9”	2’-4”	2’-6”	2’-9”	3’-1”	2’-0”	2’-2”	2’-5”	2’-8”
	W	3’-4”	3’-6”	4’-0”	4’-4”	2’-10”	3’-1”	3’-4”	3’-9”	2’-4”	2’-6”	2’-9”	3’-1”	2’-0”	2’-2”	2’-5”	2’-8”
	D	0’-10”	0’-10”	1’-0”	1’-0”	0’-10”	0’-10”	1’-0”	1’-0”	0’-10”	0’-10”	1’-0”	1’-0”	0’-10”	0’-10”	1’-0”	1’-0”
	R§‖	(2)-#4	(2)-#4	(3)-#4	(4)-#4	(2)-#4	(2)-#4	(2)-#4	(3)-#4	(2)-#4	(3)-#3	(2)-#4	(3)-#4	(2)-#3	(3)-#3	(3)-#4	(2)-#4
Footing Supporting roof and single floor																	
Plain‡	L	4’-9”	4’-11”	5’-3”	5’-5”	4’-1”	4’-3”	4’-6”	4’-10”	3’-4”	3’-6”	3’-8”	3’-11”	2’-11”	3’-0”	3’-3”	3’-5”
	W	4’-9”	4’-11”	5’-3”	5’-5”	4’-1”	4’-3”	4’-6”	4’-10”	3’-4”	3’-6”	3’-8”	3’-11”	2’-11”	3’-0”	3’-3”	3’-5”
	D	2’-6”	2’-6”	2’-8”	2’-9”	2’-1”	2’-2”	2’-3”	2’-2”	1’-8”	1’-9”	1’-10”	2’-0”	1’-6”	1’-6”	1’-8”	1’-9”
Reinforced	L	4’-9”	4’-11”	5’-3”	5’-5”	4’-1”	4’-3”	4’-6”	4’-10”	3’-4”	3’-6”	3’-8”	3’-11”	2’-11”	3’-0”	3’-3”	3’-5”
	W	4’-9”	4’-11”	5’-3”	5’-5”	4’-1”	4’-3”	4’-6”	4’-10”	3’-4”	3’-6”	3’-8”	3’-11”	2’-11”	3’-0”	3’-3”	3’-5”
	D	1’-0”	1’-0”	1’-2”	1’-2”	1’-0”	1’-0”	1’-2”	1’-2”	1’-0”	1’-0”	1’-2”	1’-0”	1’-0”	1’-0”	1’-2”	1’-2”
	R§‖	(3)-#5	(3)-#5	(3)-#5	(3)-#5	(2)-#5	(2)-#5	(3)-#5	(3)-#5	(3)-#4	(3)-#4	(3)-#4	(4)-#4	(3)-#4	(3)-#4	(3)-#4	(3)-#4
Footing supporting roof and two floors																	
Plain‡	L	5’-8”	5’-10”	6’-1”	6’-5”	4’-11”	5’-1”	5’-3”	5’-6”	4’-0”	4’-2”	4’-4”	4’-6”	3’-6”	3’-7”	3’-9”	3’-11”
	W	5’-8”	5’-10”	6’-1”	6’-5”	4’-11”	5’-1”	5’-3”	5’-6”	4’-0”	4’-2”	4’-4”	4’-6”	3’-6”	3’-7”	3’-9”	3’-11”
	D	2’-10”	2’-11”	3’-1”	3’-3”	2’-6”	2’-7”	2’-8”	2’-9”	2’-0”	2’-1”	2’-2”	2’-3”	2’-9”	2’-10”	1’-11”	2’-0”
Reinforced	L	5’-8”	5’-10”	6’-1”	6’-5”	4’-11”	5’-1”	5’-3”	5’-6”	4’-0”	4’-2”	4’-4”	4’-6”	3’-6”	3’-7”	3’-9”	3’-11”
	W	5’-8”	5’-10”	6’-1”	6’-5”	4’-11”	5’-1”	5’-3”	5’-6”	4’-0”	4’-2”	4’-4”	4’-6”	3’-6”	3’-7”	3’-9”	3’-11”
	D	1’-2”	1’-2”	1’-2”	1’-2”	1’-2”	1’-2”	1’-2”	1’-2”	1’-2”	1’-2”	1’-2”	1’-2”	1’-2”	1’-2”	1’-2”	1’-2”
	R§‖	(5)-#4	(4)-#5	(4)-#5	(5)-#5	(3)-#5	(3)-#5	(4)-#5	(4)-#5	(3)-#4	(3)-#5	(3)-#5	(4)-#5	(3)-#4	(3)-#4	(4)-#4	(3)-#5

*This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.

†Maximum tributary area = 640 ft^2

‡The term “plain” refers to concrete where no structural reinforcement is required.

§R refers to minimum steel reinforcement

‖Minimum reinforcement cover is 3 in.