ACI 332M-10

(metric)

Residential Code Requirements for Structural Concrete (ACI 332M-10) and Commentary

An ACI Standard

Reported by ACI Committee 332

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Residential Code Requirements for Structural Concrete and Commentary

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Residential Code Requirements for Structural Concrete (ACI 332M-10) and Commentary

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Reported by ACI Committee 332

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The "Residential Code Requirements for Structural Concrete" cover 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, and 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.

The 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," such as "R.1.1.1," and commentary text is shown in italics.

Relevant resource documents are cited for the user desiring more detailed study of individual issues.

Keywords: admixtures; aggregates; air entrainment; anchorage (structural); backfill; building codes; calcium chloride; cements; cold weather construction; compressive strength; concrete construction; concrete construction joints; concretes; contraction joints; cover; curing; flexural strength; floors; footings; formwork (construction); foundation walls; foundations; hot weather construction; inspection; loads (forces); materials; mixing; mixture proportioning; placing; plain concrete; reinforced concrete; reinforcing steels; residential; serviceability; specifications; slab-on-ground; slabs; sulfates exposure; strength; structural analysis; structural concrete; structural design; walls; water; welded wire reinforcement.

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ACI 332M-10 supersedes 332-08, became effective May 18, 2010, and was published August 2010.

INTRODUCTION

The commentary of ACI 332M-10 discusses some of the considerations of Committee 332 in developing the provisions contained in "Residential Code Requirements for Structural Concrete (ACI 332M-10)," hereinafter called the "Code." Explanation of the departure of this Code from ACI 318M is emphasized. Comments on specific provisions are made under the corresponding chapter and section numbers of the Code.

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

However, references to some research data are provided for those who wish to study the background material in depth. The 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.

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

A building code states only the minimum requirements necessary to provide for public health and safety. The 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 in the Code. However, lower standards are not permitted. The commentary directs attention to other documents that provide suggestions for carrying out the requirements and intent of the Code. However, those documents and the commentary are not a part of the Code.

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

The Code provides a means of establishing minimum standards for acceptance of designs and construction by legally appointed building officials or their designated representatives. The Code and commentary are not intended for use in settling disputes between the owner, engineer, architect, contractor, or their agents, subcontractors, material suppliers, or testing agencies. Therefore, the Code cannot define the contract responsibility of each of the parties in construction. General references requiring compliance with the 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 301M, 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.

ACI 332.1R is a companion document to the Code that provides practical information about the quality construction of residential concrete elements conforming to this Code. ACI 332.1R provides detailed information on systems for production, placement, finishing, and testing residential concrete along with considerations for such issues as insulation, hot and cold weather precautions, curing, and forming. ACI 332.1R does not provide any further mandatory requirements

but suggests ways of working within the scope of the Code to deliver the highest quality residential concrete.

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, this Code defines minimum acceptable standards of design and construction practice.

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.*

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.

R1.1.3 *The IRC references this Code. Where the design of an element is initiated with this Code from reference by the IRC, the entire design of the element must be completed using the provisions of this Code.*

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.

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.*

1.1.5 Where the scope of this Code and the scope of ACI 318M coincide, design in accordance with ACI 318M 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.

R1.1.6 *Provisions for application of precast wall elements are found in the International Residential Code (IRC) and other publications. The provisions for above-grade concrete walls are currently available in the 2009 IRC based on the PCA 100 Standard or directly found in the PCA 100 Standard.*

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

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.*

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 318M.

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 project is to be constructed, a Licensed Design Professional shall prepare the construction documents for residences.

1.1.10 The 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 International Residential Code (IRC). 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 The Code is not intended to define contractual responsibilities between all the parties involved in a project, nor is the Code intended to settle disputes regarding contractual responsibilities.

1.1.12 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.

1.1.13 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 or by 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.

R1.2 *New methods of design, new materials, and new 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.*

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.

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.

CHAPTER 2—NOTATION AND DEFINITIONS

2.1—Notation

d_b	=	diameter of steel reinforcing bar, mm
f'_c	=	specified compressive strength of concrete, MPa
f_y	=	specified minimum yield strength, MPa
M_n	=	nominal moment strength at section, N·mm
S	=	elastic section modulus of cross section, mm^3

2.2—Definitions

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

admixture—a material other than water, aggregates, and cementitious materials used as an ingredient of a cementitious mixture to modify its freshly mixed, setting, or hardened properties and that is added to the batch before or during its mixing.

admixture, water-reducing—an admixture that either increases slump of freshly mixed mortar or concrete without increasing water content or maintains slump with a reduced amount of water, the effect being due to factors other than air entrainment.

air entrainment—the incorporation of air in the form of microscopic bubbles (typically smaller than 1 mm) during the mixing of either concrete or mortar.

allowable bearing capacity—the maximum pressure to which a soil or other material should be subjected to guard against shear failure or excessive settlement.

blast-furnace slag—the nonmetallic product consisting essentially of silicates and aluminosilicates of calcium and other bases that develops in a molten condition simultaneously with iron in a blast furnace.

1. **blast-furnace slag, air-cooled**—the material resulting from solidification of molten blast-furnace slag under atmospheric conditions; subsequent cooling may be accelerated by application of water to the solidified surface;

2. **blast-furnace slag, expanded**—the low-density, cellular material obtained by controlled processing of molten blast-furnace slag with water, or water and other agents, such as steam, compressed air, or both;

3. **blast-furnace slag, granulated**—the glassy, granular material formed when molten blast-furnace slag is rapidly chilled, as by immersion in water; and

4. **blast-furnace slag, ground-granulated**—obsolete term; see **cement, slag**.

bulkhead—a partition in formwork blocking fresh concrete from a section of the form, or a partition closing a section of the form, such as at a construction joint.

cement, hydraulic—a binding material that sets and hardens by chemical reaction with water and is capable of doing so underwater. For example, portland cement and slag cement are hydraulic cements.

cement, portland—a hydraulic cement produced by pulverizing clinker formed by heating a mixture, usually of limestone and clay, 760 to 870°C. Calcium sulfate is usually ground with the clinker to control set.

cement, slag—granulated blast-furnace slag that has been finely ground and that is hydraulic cement.

compound, curing—a liquid that can be applied as a coating to the surface of newly placed concrete to retard the loss of water and, in the case of pigmented compounds, to reflect heat so as to provide an opportunity for the concrete to develop its properties in a favorable temperature and moisture environment.

concrete, flowing—a cohesive concrete mixture with a slump greater than 190 mm.

concrete, plain—structural concrete with no reinforcement or with less reinforcement than the minimum amount specified in ACI 318M, except as modified in Section 7.2 of this Code.

concrete, reinforced—structural concrete reinforced with no less than the minimum amount of prestressing steel or nonprestressed reinforcement as specified by ACI 318M, except as modified in Section 7.2 of this Code.

fin—a narrow linear projection on a formed concrete surface, resulting from mortar flowing into spaces in the formwork.

fly ash—the finely divided residue that results from the combustion of ground or powdered coal and that is transported by flue gases from the combustion zone to the particle removal system.

footing—a structural element of a foundation that transmits loads directly to the soil.

foundation—a system of structural elements that transmit loads from the structure above to the earth.

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

height, unbalanced backfill—*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.*

honeycomb—voids left in concrete due to failure of the mortar to effectively fill the spaces among coarse-aggregate particles.

insulating concrete forms (ICFs)—a 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.

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

joint—

1. a physical separation in a concrete system, whether precast or cast-in-place, including cracks if intentionally made to occur at specified locations; or

2. the region where structural members intersect.

joint, contraction—formed, sawed, or tooled groove in a concrete structure to create a weakened plane to regulate the location of cracking resulting from the dimensional change of different parts of the structure.

joint, isolation—a separation between adjoining parts of a structure that allows relative movement in three directions; usually vertical planes located to avoid formation of cracks in the structure. (See also **joint, contraction**.)

keyway—a recess or groove in one lift or placement of concrete that is filled with concrete of the next lift, giving shear strength to the joint.

Licensed Design Professional—an individual who is licensed to practice structural design as defined by the statutory requirements of the professional licensing laws of the state or jurisdiction in which the project is to be constructed and who is in responsible charge of the structural design; in other documents, also referred to as registered design professional.

load, dead—dead weight (without load factors) supported by a member, as defined by general building code of which this Code forms a part.

load, live—live load (without load factors) specified by general building code of which this Code forms a part.

load, roof—roof live load (without load factors) specified by general building code of which this Code forms a part; the specific live load applied to the structure.

material, cementitious—pozzolans and hydraulic cements. (See also **fly ash**; **silica fume**; **cement, slag**.)

reinforcement—bars, wires, strands, or other slender members that are embedded in concrete in such a manner that they and the concrete act together in resisting forces.

seismic design category (SDC)—a 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.

silica fume—very fine noncrystalline silica produced in electric arc furnaces as a by-product of the production of elemental silicon or alloys containing silicon.

slab-on-ground—a slab supported by ground, whose main purpose is to support the applied loads by bearing on the ground.

slump—a measure of consistency of freshly mixed concrete, mortar, or stucco equal to the subsidence measured to the nearest 6 mm of the molded specimen immediately after removal of the slump cone.

story—that portion of a building between the upper surface of the floor and the upper surface of the floor or the roof above.

strength—a generic term for the ability of a material to resist strain or rupture induced by external forces.

strength, concrete compressive—the measured maximum resistance of a concrete specimen to axial compressive loading; expressed as force per unit cross-sectional area.

strength, specified concrete compressive—the specified resistance of a concrete specimen to axial compressive loading used in design calculations and as a criterion for material proportioning and acceptance.

strength, yield—the engineering stress at which a material exhibits a specific limiting deviation from the proportionality of stress to strain.

subgrade—the soil prepared and compacted to support a structure or pavement system.

tie, form—a mechanical connection in tension used to prevent concrete forms from spreading due to the fluid pressure of fresh concrete.

townhouse—a 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.

wall, load-bearing—a wall designed and built to carry superimposed vertical or in-plane shear loads, or both.

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

water-cementitious material ratio—the ratio of the mass of water, excluding that absorbed by the aggregate, to the mass of cementitious material in a mixture, stated as a decimal.

water-cementitious material ratio—*abbreviated as* w/cm.

CHAPTER 3—REFERENCED STANDARDS

American Concrete Institute

301M-05	Specifications for Structural Concrete
318M-08	Building Code Requirements for Structural Concrete and Commentary

ASTM International

A82M-07	Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
A185M-07	Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
A416M-06	Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
A496M-07	Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
A497M-07	Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
A615M-09b	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
A706M-09b	Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement

A996M-09b	Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
C33M-08	Standard Specification for Concrete Aggregates
C94M-09a	Standard Specification for Ready-Mixed Concrete
C150M-09	Standard Specification for Portland Cement
C173M-10	Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
C231M-09b	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
C260-06	Standard Specification for Air-Entraining Admixtures for Concrete
C330M-09	Standard Specification for Lightweight Aggregates for Structural Concrete
C494-10	Standard Specification for Chemical Admixtures for Concrete
C595-10	Standard Specification for Blended Hydraulic Cements
C618-08a	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C685M-10	Standard Specification for Concrete Made By Volumetric Batching and Continuous Mixing
C989-09a	Standard Specification for Slag Cement for Use in Concrete and Mortars
C1017M-07	Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
C1157M-10	Standard Performance Specification for Hydraulic Cement
C1240-05	Standard Specification for Silica Fume Used in Cementitious Mixtures
C1602M-06	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
D98-05	Standard Specification for Calcium Chloride
D422-63(2007)	Standard Test Method for Particle-Size Analysis of Soils
D4318-10	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D4829-08a	Standard Test Method for Expansion Index of Soils

International Code Council

IRC 2009	International Residential Code for One- and Two-Family Dwellings

Portland Cement Association

PCA 100-2007	Prescriptive Design of Exterior Concrete Walls for One- and Two-Family Dwellings

The above publications may be obtained from these organizations:

American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
www.concrete.org

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428
www.astm.org

International Code Council
500 New Jersey Avenue, NW
6th Floor, Washington, DC 20001
www.iccsafe.org

Portland Cement Association
5420 Old Orchard Road
Skokie, IL 60077
www.cement.org

CHAPTER 4—MATERIALS

4.1—Concrete

Materials used in residential concrete shall conform to the requirements of Sections 4.1.1 through 4.1.4.

4.1.1 *Cementitious material*

4.1.1.1 Cement shall conform to ASTM C150M, C595M, or 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.

4.1.1.4 Silica fume shall conform to ASTM C1240.

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

4.1.3 *Water*

4.1.3.1 Water used as mixing water in producing concrete shall conform to ASTM C1602M.

4.1.4 *Admixtures*

4.1.4.1 Air-entraining admixtures shall conform to ASTM C260.

4.1.4.2 Chemical admixtures shall conform to ASTM C494M. Admixtures for flowing concrete shall conform to 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 A615M, A706M, or A996M. The specified yield strength of reinforcement shall not be less than 280 MPa.

R4.2.1 *Refer to Table R4.1.*

4.2.2 *Welded wire reinforcement*

4.2.2.1 Welded plain wire reinforcement, designated by the letter W, shall conform to ASTM A82M and ASTM A185M.

4.2.2.2 Welded deformed wire reinforcement, designated by the letter D, shall conform to ASTM A496M and A497M.

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

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.

Table R4.1—Steel reinforcement bar information

Bar size, no.	Nominal diameter, mm	Nominal area, mm^2	Nominal mass, kg/m	$30d_b$, mm
10	9.5	71	0.560	290
13	13	130	0.994	390
16	16	200	1.552	480
19	19	285	2.235	570

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 1996).*

4.3—Formwork

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.

R4.3 *Refer to ACI 347 and ACI SP-4 for guidance on design and construction of formwork.*

4.3.1 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.

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

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

4.3.4 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; and

(c) Form requirements for construction of arches, block-outs, ledges, floor decks, or similar elements.

CHAPTER 5—CONCRETE REQUIREMENTS

5.1—General requirements

Concrete shall meet the requirements of Sections 5.2, 5.3, and 5.4.

5.2—Concrete properties

Concrete strength, slump, and air entrainment shall conform to Tables 5.1 and 5.2 based on negligible, moderate, or severe exposures to freezing and thawing, as defined in (a) through (c) or as determined by the local building official.

(a) A "severe" classification is where weather conditions encourage or require the use of deicing chemicals or where there is potential for a continuous presence of moisture during frequent cycles of freezing and thawing.

(b) A "moderate" classification is where the weather conditions occasionally expose concrete in the presence of moisture to freezing and thawing, but where deicing chemicals are not generally used.

(c) A "negligible" classification is where weather conditions rarely expose concrete in the presence of moisture to freezing and thawing.

R5.2 *In some cases, the local building official will designate the exposure condition to use. 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 improve the permeability of concrete to water and deleterious chemicals, and proper curing; refer to Section 6.5. The requirements in Table 5.1 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. Section 6.4 emphasizes the importance of curing concrete for the conditions described in Table 5.1. Concrete work considered as Type 2, in addition to foundation walls, includes yard walls, retaining walls, and other vertical concrete elements not exposed to saturation or deicing salts.*

Table 5.1—Minimum specified compressive strength (f'_c, MPa) at 28 days and maximum specified slump of concrete

Type or location of concrete construction	Exposure to freezing and thawing			Maximum slump, mm*
	Negligible	Moderate	Severe	
Type 1: Footings and interior slabs-on-ground, not including garage floor slabs	17	17	17	150
Type 2: Foundation walls and other concrete work, except as noted in Type 3	17	21	21	150
Type 3: Driveways, curbs, walk-ways, ramps, patios, porches, steps, and stairs exposed to weather, and garage floor slabs	17	24	31	125

*Specified maximum slumps shall be permitted to be increased by 230 mm 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, slump flow shall be between 600 and 700 mm.

Table 5.2—Air content for Type 3 concrete under moderate or severe exposure to freezing and thawing

Nominal specified maximum aggregate size, mm	Air content, % (tolerance ±1.5%)	
	Moderate	Severe
9.5	6.0	7.5
12.5	5.5	7.0
19	5.0	6.0
25	4.5	6.0
37.5	4.5	5.5

5.2.1 *Strength*—The specified minimum 28-day compressive strength f'_c shall be selected from Table 5.1.

R5.2.1 *The concrete supplier has the responsibility for providing concrete with the compressive strength specified by the purchaser. The purchaser may request documentation demonstrating that the concrete being supplied will have a high probability of meeting the strength specified. ACI 301M, Section 4.2.3 provides guidance for proportioning mixtures to meet specified compressive strength and documentation to demonstrate that the concrete will have a high probability of meeting the strength specified. The concrete supplier should provide delivery ticket information in accordance with ASTM C94M, Section 13.1. If strength verification is required, cylinders taken by an ACI Certified Field Technician*

during time of placement should be tested in accordance with ASTM C39M. Maturity software can provide an accurate prediction of the compressive strength attained based on the information provided by the concrete producer and the temperature profile of the concrete during the hydration process. Later, if the concrete compressive strength is in question, nondestructive field tests and core samples in accordance with ASTM C42M can verify the in-place strength. 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 3.5 MPa.*

5.2.2 *Slump*—The specified maximum design slump of concrete shall be selected from Table 5.1.

R5.2.2 *The type and performance of water-reducing admixtures are selected based on the intended application and include both HRWRA and MRWRA. Water-reducing admixtures result in large to moderate water reductions in mixtures while maintaining greater flowability without causing undue set retardation or air entrainment. When using HRWRAs conforming to ASTM C494M or C1017M, the specified maximum slump may be increased from that listed in Table 5.1 provided the aggregates in the concrete do not segregate from the paste in the resulting mixture. Specify a maximum of 230 mm if necessary. If slump verification is required, slump testing should be in accordance with ASTM C143M. A traditional slump limit is not appropriate for SCC concrete, where the consistency of the concrete is measured in terms of slump flow in accordance with ASTM C1611M. Generally, slump flow in the range of 600 to 700 mm is used for residential concrete. Refer to ACI 237R.*

5.2.3 *Air entrainment*—Concrete in regions of moderate or severe weathering probability and exposed to weather shall be air entrained in accordance with Table 5.2.

R5.2.3 *An important aspect of air entrainment is the uniform distribution of air bubbles to provide resistance to damage due to freezing and thawing. When the construction documents require verification of air entrainment, the contractor should provide testing in accordance with ASTM C231M or ASTM C173M as appropriate on the first batch of concrete delivered to the site. If concrete fails to meet the air-entrainment requirements, steps should be taken to correct the air content on the first batch and on future batches. Additional tests should then be taken to verify that the air content is within tolerances.*

In previous versions of this Code, Table 5.2 included reference to a Type 2 concrete. Table 5.1 now limits reference to vertical walls in Type 2 and eliminates exposure to deicing salts. Therefore, Type 2 requirements for air-entrainment have been eliminated.

5.2.4 *Coarse aggregate size*—The nominal maximum size of coarse aggregate shall not exceed the smaller of the following:

(a) 1/5 of the minimum wall thickness;

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

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

R5.2.4 *These limitations do not apply if workability and consolidation methods facilitate the placement of concrete without honeycombs or voids.*

5.2.5 *Concrete sulfate exposure*

5.2.5.1 Concrete that is in direct contact with native soils containing water-soluble sulfates as determined according to Section 5.2.5.2 shall conform to Sections 5.2.5.1.1 through 5.2.5.1.3:

5.2.5.1.1 For sulfate concentrations greater than or equal to 0.1% but less than 0.2% by weight, concrete shall be made with ASTM C150M Type II cement, or an ASTM C595M or C1157M hydraulic cement meeting moderate sulfate-resistant hydraulic cement (MS) designation.

5.2.5.1.2 For sulfate concentrations equal to or greater than 0.2% by weight, concrete shall be made with ASTM C150M Type V cement or an ASTM C595M or C1157M hydraulic cement meeting high sulfate-resistant hydraulic cement (HS) designation and shall have a specified minimum compressive strength of 21 MPa at 28 days or greater as required in Table 5.1.

5.2.5.1.3 Alternative combinations of cements and supplementary cementitious materials shall be permitted with acceptable service record or test results. The materials shall comply with Section 4.1.1 of this Code.

R5.2.5.1.3 *For information regarding proportioning of concrete exposed to elevated sulfate levels, refer to ACI 201.2R.*

5.2.5.2 Concentrations of water-soluble soil sulfates shall be determined by a test method or historical data accepted by the local building official.

R5.2.5.2 *Tests for soil sulfates can yield different results for the same soil sample, depending primarily on the specified test extraction ratio, which is the weight of water divided by the weight of soil. This is particularly true where the predominant soil sulfates are in the form of gypsum. Thus, it is preferable that the test has a history of successful use in the geographic area of the project, and be recognized and approved by the local building official. Test methods may include the USBR method 1973; California DOT Test 417; and ASTM C1580.*

5.3—Concrete cover

Clear cover for reinforcement in all concrete elements shall not be less than required by Sections 5.3.1, 5.3.2, and 5.3.3. The requirements shall not apply to slabs-on-ground, except for thickened slab footings. Concrete cover for slabs-on-ground shall be in accordance with Section 10.6.1. Concrete cover shall have a tolerance of –10 mm.

5.3.1 Concrete cast against earth: 75 mm.

R5.3.1 *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.*

5.3.2 Concrete exposed to earth or weather:

(a) No. 16 bar W31 or D31 wire and smaller: 40 mm; and

(b) No. 19 and larger: 50 mm.

5.3.3 Concrete not exposed to earth or weather: 20 mm.

5.4—Calcium chloride

5.4.1 Where reinforced concrete is dry or protected from moisture in service, or for plain concrete in all service conditions, calcium chloride added to the mixture shall not exceed 2.0% by weight of cementitious materials. For reinforced concrete subject to other service conditions, calcium chloride added to the mixture shall not exceed 0.50% by weight of cementitious materials.

R5.4.1 *These values are based on the chloride ion amounts present in calcium chloride as an admixture, not chloride ion content by weight. For additional information on the effects of chlorides on the corrosion of reinforcing steel, refer to ACI 201.2R and 222R. Gaynor (1999) gives guidance on calculating the percentage of calcium chloride content. The molecular ratio of $CaCl_2$ used in ACI 332M to Cl^- used in ACI 318M is approximately 2:1. Limits in ACI 332M expressed on the basis of $CaCl_2$ would be approximately twice the equivalent values in ACI 318M expressed on the basis of Cl^-. Another difference is that ACI 318M expresses limits as a percentage of the weight of cement whereas ACI 332M expresses it based on cementitious materials. ACI 332M is more restrictive than ACI 318M when invoking limits for plain concrete and establishes limits equivalent to 0.15% Cl^- on plain concrete that is not dry in service and for all reinforced concrete regardless of service condition, but the actual restriction is based on common product availability in the residential industry.*

The use of calcium chloride for these applications in cold weather construction is common and has not been a concern for life safety or corrosion-related failures of these types of concrete members.

5.4.2 Calcium chloride as an admixture, or admixtures containing intentionally added chloride ions, shall not be used in concrete containing prestressing steel, aluminum, or dissimilar metals.

R5.4.2 *This requirement also applies to concrete, grouts, or both, in direct contact with post-tensioning steel.*

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 C94M.

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

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

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

6.2—Placement

6.2.1 Specified concrete properties in accordance with Sections 5.2.2 and 5.2.3 shall be provided at point of delivery.

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 C94M allows for the one-time addition of water at the job site up to the allowable maximum w/cm. *Alternatively, the addition of an HRWRA or a 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.*

6.2.2 Concrete shall be placed into position by methods that maintain the properties specified in Sections 5.2.2 and 5.2.3.

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. Such areas shall also be free of water in excess of an amount present in the bottom of footings that will be displaced by the concrete during placement.

R6.2.4 *Refer to Section 6.6 for the placement of concrete on frozen material.*

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.

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 and concrete with slump greater than 175 mm due to HRWRA is not vibrated; however, minimal vibration may be required to minimize surface defects.*

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 removal operation.

6.4—Finishing

Surface defects that expose reinforcement shall be repaired. Surface defects greater than .03 m^2 with depths greater than 13 mm shall be repaired.

R6.4 *Refer to ACI 332.1R for repair guidelines.*

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.

R6.5 *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.*

6.6—Cold weather

6.6.1 During anticipated ambient temperature conditions of 2°C or less, concrete temperature shall be maintained above a frozen state until a concrete compressive strength of 3.5 MPa has been reached.

R6.6.1 *Concrete that is frozen before achieving a compressive strength of 3.5 MPa will not achieve the compressive strength that it would have otherwise. 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 3.5 MPa. 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 (CFA) in the Cold-Weather Research Report. Refer to ACI 306R for further information regarding cold-weather concrete practices.*

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

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.

R6.7 *Hot weather conditions can impair the ultimate concrete compressive strength or serviceability of the concrete element if appropriate hot-weather concreting practices are not followed. Refer to ACI 305R for information on hot-weather concreting practices.*

CHAPTER 7—FOOTINGS

7.1—General

The design and construction of isolated footings and wall footings shall be in accordance with Sections 7.2 and 7.3.

R7.1 *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.*

7.2—Design

For footings designed by this Code, the attributes listed in Table 7.1 shall not be exceeded.

7.2.1 *Wall footings*

7.2.1.1 Wall footing width shall not be less than the applicable dimensions specified in Table 7.2 or the supported wall thickness plus 100 mm, whichever is greater.

R7.2.1.1 *Footing widths need to project a minimum of 50 mm on each side of the wall to support the forming system. The footing width projection is measured from the face of the concrete to the edge of the footing.*

Table 7.1—Specified maximum values for prescriptive tables in Chapter 7

Attribute		Maximum limitation
General	Plan dimension	18 m
	Ground snow load	3.4 kN/m^2
Foundations	Equivalent fluid density of soil	1600 kg/m^3. Refer to Appendix A
	Presumptive soil-bearing value	71.8 to 191.5 kN/m^2. Refer to Tables 7.2 and 7.3
Walls	Unsupported wall height, per story	3 m
	Unbalanced backfill height	2.7 m
Floor loads	Floor dead load	0.7 kN/m^2
	First-floor live load	1.9 kN/m^2
	Second- and third-floor live loads	1.4 kN/m^2
Roof loads	Roof and ceiling dead load	0.7 kN/m^2
	Roof snow load	3.4 kN/m^2
	Attic live load	1.0 kN/m^2
Maximum clear span	Floor clear span (unsupported)	9.8 m
	Roof clear span (unsupported)	12.2 m

7.2.1.2 Wall footing thickness shall not be less than the greater of 150 mm or half the footing width minus the supported wall thickness.

7.2.2 *Isolated footings*—Isolated footing dimensions shall not be less than the applicable dimensions specified in Table 7.3.

R7.2.2 *The tributary area supported by an isolated footing is shown in Fig. R7.1. Isolated footings are also called pier or column footings.*

7.2.3 *Footing surfaces*—The bottom surface of footings shall not exceed a slope of 1 vertical in 10 horizontal. The top surface of footings shall be level within the tolerances specified.

R7.2.3 *Common tolerances for residential concrete can be found in ACI 332.1R.*

7.2.4 *Footings not continuously supported*—Footings that are not continuously supported shall be constructed in accordance with Section 7.2.4.1, 7.2.4.2, or 7.2.4.3.

R7.2.4 *Conditions where wall footings are not continuously supported are commonly found around sanitary or water pipes where poorly compacted soil settles below the bottom surface of the footing. The backfill should be compacted by tamping to the level of the bottom surface of the footings to obtain adequate bearing and minimize the likelihood of detrimental settlement.*

7.2.4.1 Where an unsupported wall footing section does not exceed a 900 mm span, a minimum of two No. 13 reinforcing bars shall be placed in the bottom of the footing and extend at least 450 mm into the supported sections on both sides. Reinforcing bars shall have a specified minimum cover of 75 mm from the sides and bottom of the footing.

7.2.4.2 Trenches under footings shall be backfilled to prevent movement of the adjacent soil and compacted to match the adjacent soil conditions.

Table 7.2—Minimum specified width of wall footings, mm*†

	No. of stories above grade‡	Allowable soil-bearing capacity, lb/ft^2					
		70	95	120	145	170	190
Conventional wood frame construction (above grade)	One-story	400	300	250	200	175	150
	Two-story	480	380	300	250	200	175
	Three-story	560	430	350	280	250	230
100 mm brick veneer over wood frame; 200 mm hollow concrete masonry unit (above grade)	One-story	480	380	300	250	200	175
	Two-story	635	480	380	330	280	250
	Three-story	790	580	480	400	330	300
200 mm grouted concrete masonry unit	One-story	560	430	330	280	250	230
	Two-story	790	580	480	400	330	300
	Three-story	1000	750	600	500	430	380

*Specified minimum concrete strength f_c' shall be 17 MPa.

†Footing widths less than 300 mm are restricted to walls that meet all of the following criteria: a) 1.2 m or less in height; b) Seismic Design Category C or less; and c) wall footings that support garages, porches, or single-story roof loads.

‡Table includes foundation (for example, a one-story includes the story above grade and a foundation).

Table 7.3—Minimum specified size and reinforcement for isolated footings, mm*†‡

Tributary area	Allowable soil-bearing capacity, ft^2 kN/m^2					
	70	95	120	145	170	190
Footing supporting roof load‡	900 x 900 x 200 mm with 3 No. 13 each way	750 x 750 x 200 mm with 3 No. 13 each way	750 x 750 x 200 mm with 3 No. 13 each way	600 x 600 x 200 mm with 3 No. 13 each way	600 x 600 x 200 mm with 3 No. 13 each way	600 x 600 x 200 mm with 3 No. 13 each way
Footing supporting roof and one floor‡	1200 x 1200 x 250 mm with 3 No. 13 each way	1200 x 1200 x 250 mm with 3 No. 13 each way	900 x 900 x 250 mm with 3 No. 13 each way	900 x 900 x 250 mm with 3 No. 13 each way	750 x 750 x 250 mm with 3 No. 13 each way	750 x 750 x 250 mm with 3 No. 13 each way
Footing supporting roof and two floors‡	1500 x 1500 x 300 mm with 4 No. 16 each way	1500 x 1500 x 300 mm with 4 No. 16 each way	1200 x 1200 x 300 mm with 4 No. 16 each way	1200 x 1200 x 300 mm with 4 No. 16 each way	1000 x 1000 x 300 mm with 4 No. 16 each way	900 x 900 x 300 mm with 4 No. 16 each way

*Specified minimum concrete strength f_c' shall be 17 MPa.
†Specified minimum yield strength f_y shall be 275 MPa.
‡Maximum tributary area is 6.1 x 9.8 m (based on loads prescribed in Table 7.1).

7.2.4.3 Unsupported wall footing spans exceeding 900 mm are beyond the scope of this Code.

7.2.5 *Discontinuous wall footings*—A wall footing shall be permitted to be discontinuous at an abrupt elevation change according to Section 7.2.5.1 or 7.2.5.2.

R7.2.5 *Abrupt elevation changes, commonly called steps, occur in locations such as walkout basements, grade changes, and transitions to garage foundations. At such locations, the wall spans the horizontal discontinuity of the footing. Refer to Fig. R7.2.*

7.2.5.1 A maximum horizontal discontinuity of 1.2 m shall be permitted by this Code and conform to the reinforcement requirements of Section 8.2.9.

7.2.5.2 Horizontal footing discontinuities greater than 1.2 m are beyond the scope of this Code.

7.2.6 *Foundation anchorage in Seismic Design Categories (SDCs) C, D_0, D_1, and D_2*—The following requirements shall apply to wood light-frame structures in SDC D_0, D_1, and D_2 and wood light-frame townhouses in SDC C as defined by Section 1.3.1 of this Code:

(a) Plate washers that are a minimum of 5 x 50 x 50 mm shall be provided for all anchor bolts between the sill plate and the nut. Properly sized cut washers shall be permitted for anchor bolts in wall lines not containing braced wall panels;

(b) Interior braced wall plates shall have anchor bolts spaced at not more than 1.8 m on center and located within 300 mm of the ends of each plate section when supported on a continuous foundation;

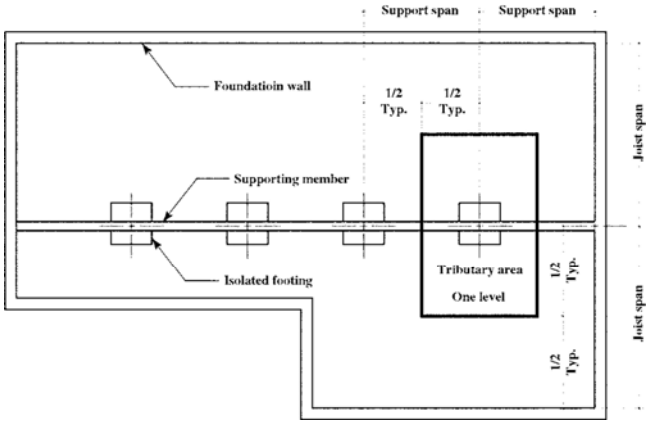

Fig. R7.1—Tributary area for isolated footing.

(c) Interior bearing wall sole plates shall have anchor bolts spaced at not more than 1.8 m on center and located within 300 mm of the ends of each plate section when supported on a continuous foundation; and

(d) The specified maximum anchor bolt spacing shall be 1.2 m for buildings over two stories in height.

7.2.7 *Longitudinal reinforcement in continuous footings in SDC D_0, D_1, and D_2*

7.2.7.1 *Continuous footings with stem walls*—Footings with stem walls shall contain one longitudinal No. 13 bar

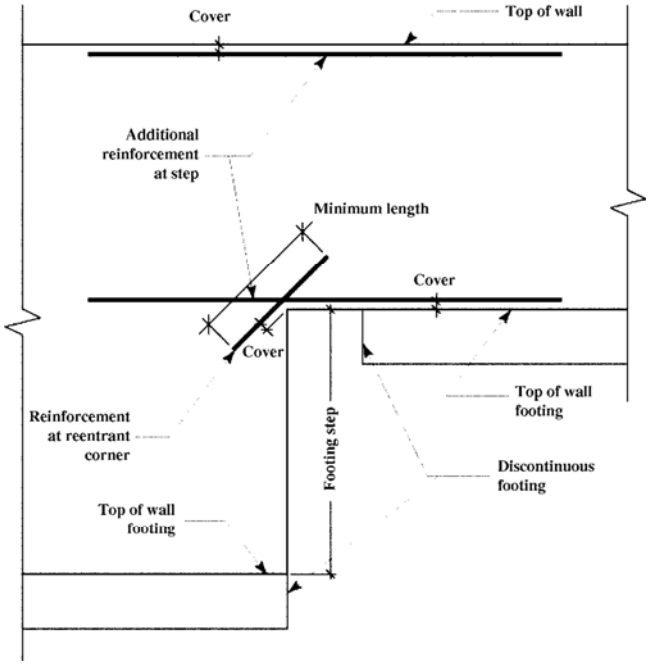

Fig. R7.2—Discontinuous wall footing and additional wall reinforcement.

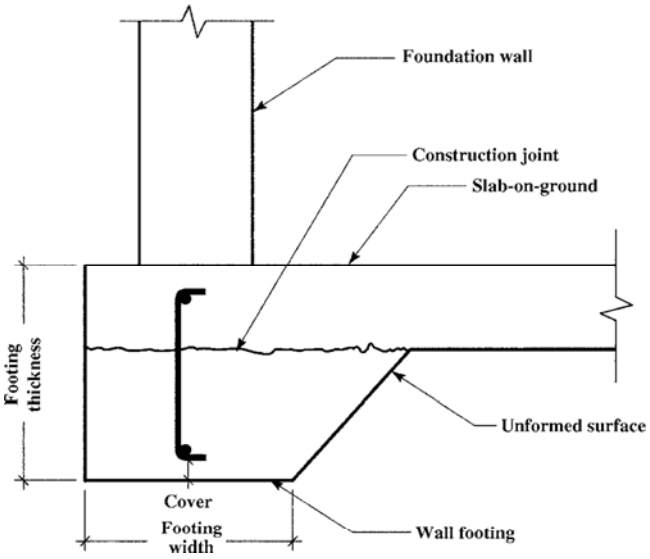

Fig. R7.3—Thickened slab footing with horizontal construction joint.

within 300 mm of the top of the stem wall and one longitudinal No. 13 bar located 75 to 100 mm from the bottom of the footing.

7.2.7.2 *Slabs-on-ground with turned-down footings*

(a) If a horizontal construction joint exists between the slab thickness and the footing thickness, reinforcement shall consist of a minimum of one longitudinal No. 13 bar placed near the top and bottom, and No. 10 or larger vertical bars at a maximum spacing of 1.2 m on center passing through the joint. Vertical bars shall have 75 mm cover at bottom and sides, and shall engage the top and bottom longitudinal bars with standard hooks at each end. Standard hooks shall conform to ACI 318M, Section 12.5.

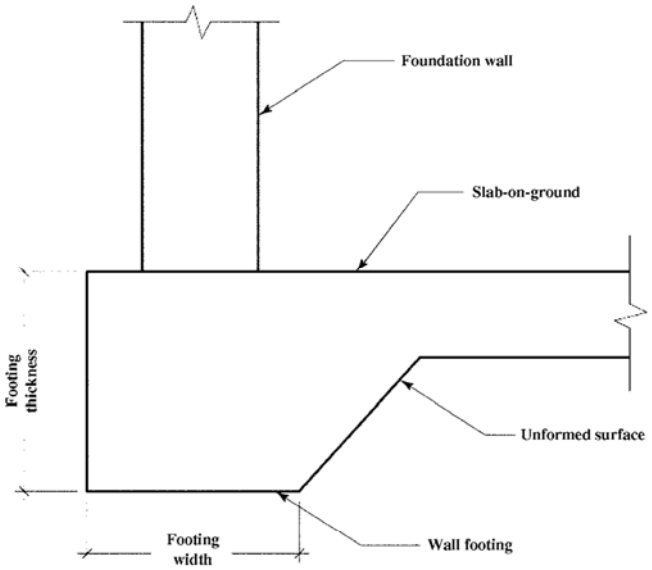

Fig. R7.4—Exterior unformed thickened slab footing.

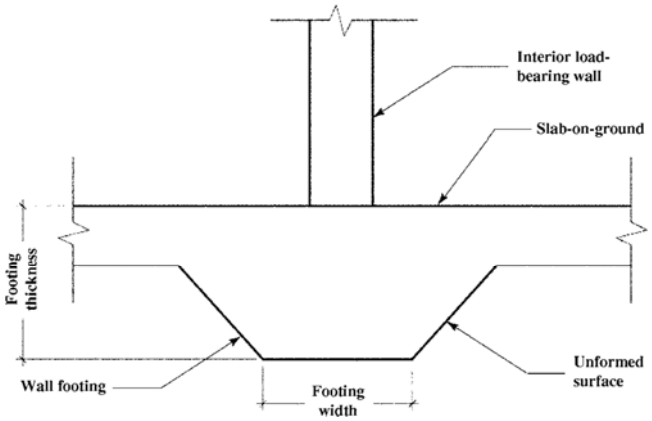

Fig. R7.5—Interior unformed thickened slab footing.

(b) If the slab and footing are cast monolithically, the footing shall be reinforced by one of the following:

1) A minimum of two longitudinal No. 13 bars, one located at the top, and one located at the bottom of the footing;
2) A minimum of two longitudinal No. 13 bars located in the middle third of the footing depth; and
3) A minimum of one longitudinal No. 16 bar located in the middle third of the footing depth.

R7.2.7.2 *Refer to Fig. R7.3.*

7.3—Construction

7.3.1 *Unformed footings*—The excavations for unformed footings shall remain stable before and during concrete placement.

R7.3.1 *Unformed footings are used frequently where frost depth is shallow or for interior load-bearing walls. Footings may be placed integrally with the floor slab. Refer to Fig. R7.4 for exterior unformed footings in slabs-on-ground. Refer to Fig. R7.5 for interior unformed footings in slabs-on-ground.*

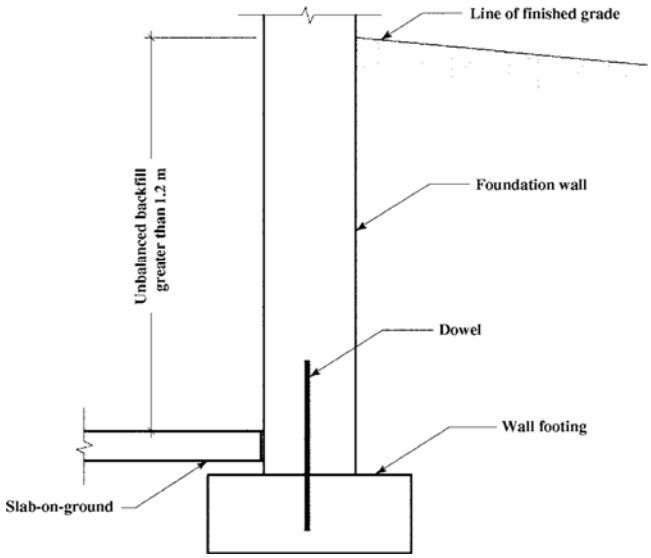

Fig. R7.6—Wall-to-footing joint with dowel.

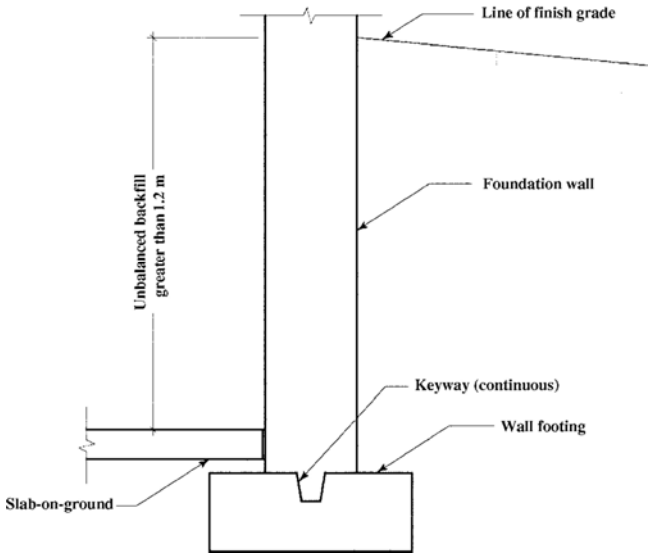

Fig. R7.7—Wall-to-footing joint with keyway.

7.3.2 *Formed footings*—Side forms shall be secured to maintain dimensions and alignment before and during concrete placement.

7.3.3 *Finishing*—Top surfaces of the footing shall be struck off level or prepared for keyway or dowel connection as required in Section 7.3.4.

7.3.4 *Wall-to-footing joint*—All wall-to-footing connections shall be in accordance with Table 7.4.

7.3.4.1 A No. 13 dowel shall extend at least $36d_b$ into the wall and 150 mm into the footing at a maximum of 600 mm on-center along the footing. To facilitate positioning before concrete placement, vertical dowels are permitted to be driven into the grade in the bottom of the footing.

R7.3.4.1 *Refer to Fig. R7.6.*

7.3.4.2 A continuous keyway shall be formed in the footing located within the middle third of the wall. The keyway shall be a specified minimum of 40 mm deep and 40 mm wide at the top.

R7.3.4.2 *Refer to Fig. R7.7.*

Table 7.4—Required wall-to-footing joint designs

SDC	Height of unbalanced backfill	Acceptable joint
A, B, C	≤ 1.2 m	Clean construction joint*
	> 1.2 m	7.3.4.1 or 7.3.4.2
D_0, D_1, D_2, E	All	7.3.4.1

*Clean construction joint refers to the interface between footing and foundation wall with no debris and with no tooled surface characteristics; refer to Fig. R7.4.

CHAPTER 8—FOUNDATION WALLS

8.1—General

8.1.1 Provisions of this chapter shall apply to foundation walls of buildings within the scope of this Code.

8.1.2 Lateral support is required at the top and bottom of the wall. Wall-to-footing joints that comply with Section 7.3.4 have satisfied the bottom lateral support requirement. The connection of the lateral support system to the top of the wall shall comply with Section 8.2.5.1. The design of top lateral support is beyond the scope of this Code.

R8.1.2 *Refer to Section 8.2 for the design of foundation walls.*

8.1.3 Walls with a required thickness greater than 300 mm are beyond the scope of this Code.

R8.1.3 *The Code allows wall sections with thickness greater than 300 mm for nonstructural purposes, such as ease of forming.*

8.1.4 Wall thickness shall not be less than the specified minimum required by Section 8.2.1.2, except as permitted by Section 8.2.4.

8.1.5 Walls with an unsupported wall height greater than 30 m are beyond the scope of this Code.

R8.1.5 *Unsupported wall heights greater than 30 m require design considerations that are not covered by the tables and equations of this Code.*

8.1.6 The determination of equivalent fluid pressure of the backfill against the foundation wall is beyond the scope of this Code.

R8.1.6 *The user may consult ASCE/SEI 7, a geotechnical engineer, or the Building Code to obtain the equivalent fluid pressure of backfill.*

8.2—Design

Foundation walls shall be designed by using the prescriptive tables in Appendix A or by wall provisions of this chapter. Foundation wall design shall be based on analyzing the wall as a simply supported vertical flexural member with the top and bottom laterally supported. Walls shall be designed as plain concrete conforming to Section 8.2.1, reinforced concrete conforming to Section 8.2.2, or conforming to Section 8.2.3. All wall provisions of ACI 318M not specifically modified or excluded by this chapter shall apply to the design and analysis of foundation walls.

R8.2 *ACI 318M, Section 14.3, Eq. (22-2), and Section 22.6.6 are modified or excluded in Chapter 8 of this Code. ACI 318M, Section 14.3 requires minimum wall reinforcement; Eq. (22-2) limits the tensile strength of plain concrete walls subject to*

flexure; and Section 22.6.6 provides various limits for foundation walls. In Chapter 8 of this Code, the minimum reinforcement requirements are less than those required in ACI 318M, Section 14.3, the tensile strength limit is higher than in Eq. (22-2), and some other wall requirements are less restrictive than those required in ACI 318M, Section 22.6.6, based on an extensive history of adequate performance of plain concrete foundation walls.

8.2.1 *Plain concrete design*

8.2.1.1 Foundation walls that meet the requirements of Section 8.2.1.2 shall be permitted to be designed using Eq. (8-1)

$$M_n = 0.625\lambda\sqrt{f'_c}\,S_m \qquad (8\text{-}1)$$

R8.2.1.1 *In ACI 318M, Chapter 22, the nominal moment strength at a section,* M_n*, of plain concrete is* $0.42\lambda\sqrt{f'_c}\,S_m$*. This is less than the cracking moment* M_{cr}*, which is based on the default value for the modulus of rupture of concrete,* $0.625\sqrt{f'_c}$*. The modulus of rupture was used to compute* M_n *of plain concrete. This change is based on an extensive history of satisfactory performance of plain concrete foundation walls. The* M_n *of* $0.42\lambda\sqrt{f'_c}\,S_m$ *still applies to foundation walls constructed by methods that do not have a significant history of satisfactory performance in the housing industry.*

This provision only applies to the use of Eq. (8-1). The other design provisions of the related section in ACI 318M should be satisfied as well; in particular, the load combinations of Section 9.2 and the strength reduction factors of Section 9.3.5 should be used.

8.2.1.2 Foundation walls designed by Section 8.2.1.1 shall satisfy the following conditions:

(a) The specified minimum uniform wall thickness is 190 mm, except a specified minimum thickness of 140 mm shall be permitted where the wall height does not exceed 1.2 m and the unbalanced backfill does not exceed 600 mm; and

(b) The requirements of Sections 8.2.3 through 8.2.10.

R8.2.1.2 *A specified minimum thickness of 190 mm for plain concrete foundation walls is required to use Eq. (8-1) in flexural strength computations.*

8.2.1.3 Plain concrete walls located in Seismic Design Categories D_0, D_1, and D_2 shall comply with the following:

(a) Plain concrete walls supporting more than 1.2 m of unbalanced backfill or exceeding 2.4 m in height shall be constructed in accordance with Tables A.1 through A.10. Where Tables A.1 through A.10 permit plain concrete walls, not less than No. 13 vertical bars at a spacing not exceeding 1.2 m shall be provided; and

(b) Minimum thickness for plain concrete walls shall be 190 mm, but 150 mm shall be permitted when the maximum height is 1.4 m.

R8.2.1.3 *Walls that have an unsupported height in excess of 3 m are beyond the scope of this Code as defined in the general assumptions for Section 8.2.3.*

8.2.2 *Reinforced concrete design*

8.2.2.1 Foundation walls that meet the requirements of Section 8.2.2.2 shall be permitted to be designed using the provisions of ACI 318M with modifications (a) and (b):

(a) Section 14.3 is excluded; and

(b) Section 22.6.6 is excluded.

8.2.2.2 Foundation wall vertical reinforcement shall comply with Section 8.2.1.2 and (a) through (h):

(a) Minimum area of vertical wall reinforcement shall be 140 mm^2 per linear meter of wall;

(b) Specified maximum vertical wall reinforcement spacing shall be 1.2 m;

(c) Minimum vertical wall reinforcement spacing shall be 0.5 times the wall thickness;

(d) Vertical reinforcement shall be placed in one layer, unless shown otherwise on the construction documents;

(e) Vertical reinforcement shall be placed with a concrete cover from the tension face in accordance with Section 5.3, unless shown otherwise on the construction documents;

(f) Vertical reinforcement shall be placed closer to the tension face of the wall and secured to the horizontal reinforcement where vertical and horizontal reinforcement intersect;

(g) Reinforcement lap length shall not be less than 600 mm; and

(h) Reinforcement shall conform to Section 4.2.1 or 4.2.2.

R8.2.2.2 *The minimum area of vertical wall reinforcement amounts to No. 13 bars at 900 mm on center. This minimum reinforcement and the maximum bar spacing of 1.2 m correspond to the extensive history of satisfactory performance. The tension face of the wall refers to the face that is opposite the side on which lateral loading (soil) is applied. Refer to Fig. R8.1.*

8.2.3 *Wall design tables*—It shall be permitted to construct foundation walls using the design information found in Appendix A and Tables A.1 through A.10, which satisfies Sections 8.2.1 and 8.2.2.

8.2.4 *Reduction of wall thickness*—The thickness of the top of a foundation wall shall be permitted to be reduced. The height of the reduced thickness section shall not exceed 600 mm. The reduced thickness section shall comply with (a) and (b):

(a) Reduced wall thickness shall not be less than 90 mm; and

(b) Where the reduced wall thickness is 100 mm or less, a minimum of one vertical No. 13 reinforcing bar at 600 mm on center shall be placed at the tension face. This bar shall extend at least 300 mm into the full thickness section, and full height into the reduced thickness section. Concrete cover shall be maintained in accordance with Section 5.3.

R8.2.4 *The reduction of wall thickness is a common detail to accommodate brick veneer. Refer to Fig. R8.2.*

8.2.5 *Lateral restraint*—The equivalent fluid pressure of the backfill shall be determined, but in no case shall be taken as less than 1.44 kN/m^2. The foundation walls shall be restrained top and bottom against lateral movement. The top and bottom restraint for the foundation wall shall be in place before the introduction of backfill against the foundation wall. Temporary lateral restraint shall be permitted.

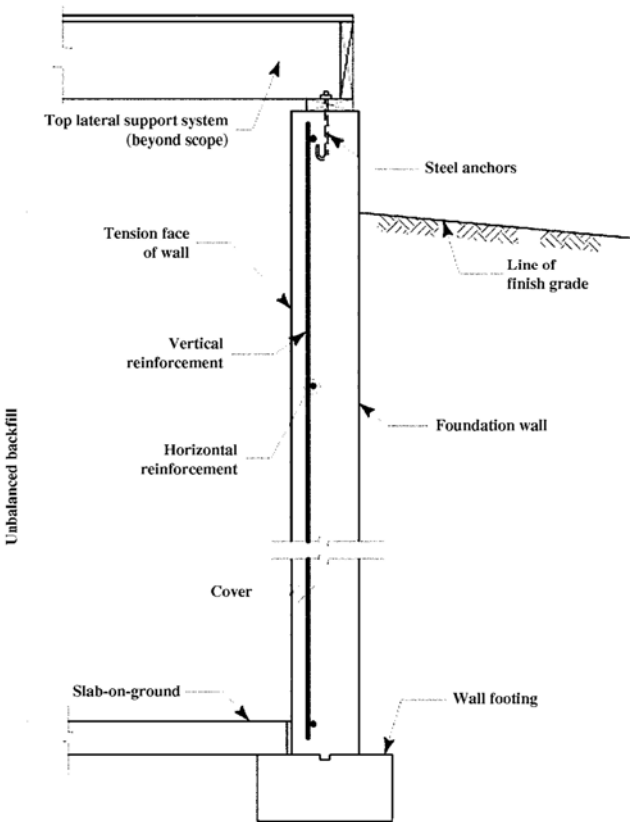

Fig. R8.1—Reinforced concrete foundation wall.

R8.2.5 *A properly detailed connection between the wall and the interior slab or a wall-to-footing joint conforming to Section 7.3.4 should provide bracing to the wall bottom. Values for equivalent fluid pressure can be determined by using ASCE/SEI 7, the general building code, or geotechnical reports obtained locally.*

8.2.5.1 *Connection to lateral support system at top of wall*—A positive connection by means of steel anchors shall be required between the top of the wall and the lateral bracing system. The spacing and size of the anchors that transmit the lateral force due to earth pressures to the lateral bracing system shall conform to (a) through (e):

(a) The minimum diameter of anchors shall be 13 mm;

(b) The specified minimum embedment depth of anchors shall be 150 mm;

(c) The specified maximum spacing of the anchors shall be 1.8 m;

(d) A minimum of one anchor shall be located within 300 mm of each change of wall direction, height, or termination; and

(e) A minimum of one anchor shall be located within 300 mm of each side of each door or window opening.

R8.2.5.1 *When appropriate, the connection to the lateral support system should be reviewed by a Licensed Design Professional—for example, conditions with high soil pressures or tall walls, such as 2 kN/m^2 soil pressure or a 3 m wall height.*

8.2.6 *Minimum specified reinforcement size*—The specified minimum bar size for wall reinforcement shall be No. 13.

8.2.7 *Lintel beams*

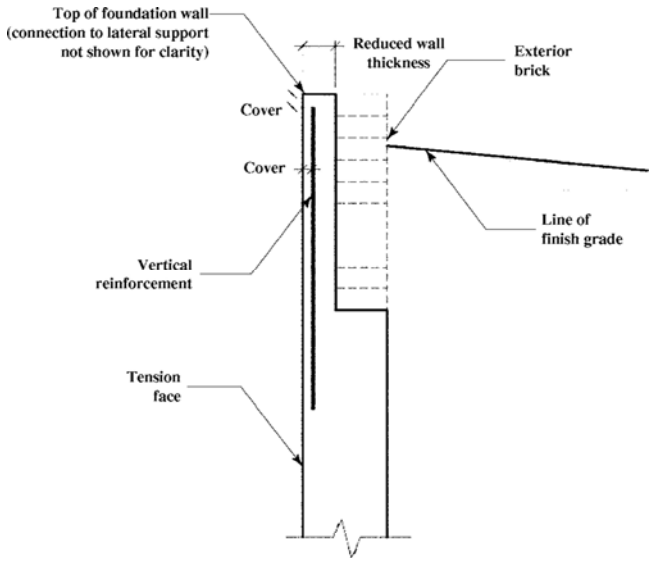

Fig. R8.2—Reduction of wall thickness.

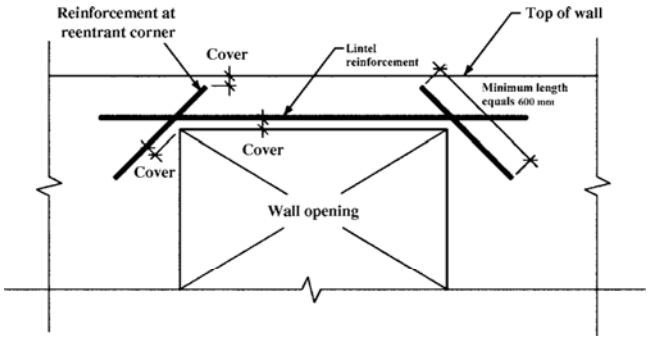

Fig. R8.3—Lintel beam reinforcement.

8.2.7.1 Lintel beams that conform to the empirical requirements given in (a) through (d) shall be permitted:

(a) Lintel beam depth shall be not less than 200 mm;

(b) Lintel beam span shall not exceed 1 m; and

(c) A minimum of two continuous, bottom No. 13 bars shall extend at least 600 mm into the wall at each end. Concrete cover shall be maintained in accordance with Section 5.3.

R8.2.7.1 *Refer to Fig. R8.3.*

8.2.8 *Horizontal reinforcement*—For both reinforced and plain concrete walls, horizontal reinforcement shall be provided in accordance with (a) through (f). For Seismic Design Categories D_0, D_1, and D_2, the provisions of (g) shall apply:

(a) Where walls exceed 1.8 m in height, a minimum of three continuous, horizontal reinforcing bars shall be provided;

(b) Where walls exceed 2.4 m in height, a minimum of four continuous, horizontal reinforcing bars shall be provided;

(c) For all wall heights, a minimum of one horizontal bar shall be located within the top 600 mm and a minimum of

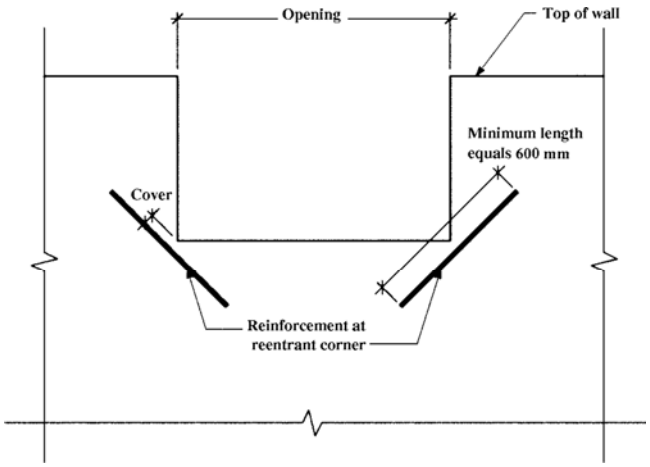

Fig. 8.4—Reentrant corner reinforcement.

one in the bottom 600 mm. The remaining required bars shall be spaced over the height of the wall as equally as practical;

(d) The horizontal reinforcement shall be secured as close as practical to the tension face of the wall, but behind vertical reinforcement where present;

(e) Reinforcement lap length shall not be less than 600 mm; and

(f) At corners, horizontal reinforcement shall extend around corners and lap reinforcement a specified minimum of $30d_b$.

(g) Two No. 13 horizontal bars shall be located in the upper 300 m of the wall.

R8.2.8 *Horizontal wall reinforcement is placed to reduce cracking that can result from restraint against volume changes due to shrinkage and temperature change. The serviceability requirements of residential concrete allow for crack development. The tension face is the inside face of a wall, assuming backfill is applied to the outside face. Refer to Table R4.1 for common reinforcing bar values including* $30d_b$.

8.2.9 *Additional wall reinforcement*—At discontinuous wall footings, where wall footing elevation change is greater than twice the footing thickness, place a minimum of two No. 13 horizontal reinforcing bars, one at the top and the other at the bottom of the wall, in addition to other required wall reinforcement. These bars shall extend at each end at least 900 mm into the wall portion supported directly by the top and bottom wall footings. The bars shall be placed in the middle third of the wall thickness. Concrete cover shall be maintained in accordance with Section 5.3.

R8.2.9 *This reinforcement is placed to restrain cracking. The Code requires reinforcement to be provided in both plain and reinforced foundation walls. Refer to Fig. R7.2.*

8.2.10 *Reentrant corners*—Where a wall opening, or an abrupt elevation change greater than 200 mm in top or bottom of wall, creates a reentrant corner, at least one No. 13 reinforcing bar, 600 mm long, shall be placed diagonally as close as practical to the reentrant corner.

R8.2.10 *This reinforcement is placed to limit the width of wall cracks caused by a reentrant corner such as is formed by a window or a door. Refer to Fig. R8.4.*

8.3—Construction

8.3.1 *Forms*—Foundation wall forms shall be stable during placement of concrete and shall result in a structure that conforms to the shapes, lines, and dimensions required by the design drawings and specifications. Blockouts, inserts, bulkheads, embedded items, and reinforcement shall be installed in the forms in such a manner that their final dimensions, alignments, and elevations are maintained within the tolerances specified.

R8.3.1 *Bulkheads form the edge of a construction joint and are used at the end of a placement when an interruption is planned or anticipated. Common tolerances for residential concrete can be found in ACI 332.1R.*

8.3.2 *Construction joints*—The joint surface shall be clean and wetted and standing water removed from the forms immediately before concrete is placed.

R8.3.2 *Construction joints may be required where there is an interruption in the placement of concrete.*

8.3.2.1 Construction joints shall be oriented vertically in plain concrete walls. Horizontal or vertical construction joints are permitted in reinforced concrete walls.

8.3.2.2 For vertical construction joints, a minimum of three horizontal reinforcing bars, equally spaced, shall extend through construction joints, with a specified minimum length of 600 mm on each side of the joint.

8.3.2.3 Construction joints shall be sealed in a manner to prevent seepage of water, paste, or mortar through the joint.

R8.3.2.3 *External waterproofing and internal waterstops are methods commonly used to provide watertight construction joints.*

8.3.3 *Surface irregularities*—Fins or projections of concrete greater than 13 mm shall be removed after stripping forms. Surface areas where voids in the concrete placement expose the reinforcement shall be repaired.

R8.3.3 *It is important to remove fins or other projections from the exterior wall surface to prevent interference with dampproofing and waterproofing systems. It is also important to remove fins or other projections from the interior wall surface to prevent interference with interior finish systems where the wall surface encloses occupied space.*

CHAPTER 9—DESIGN FOR EXPANSIVE SOILS

9.1—General

9.1.1 The design of footings and foundations for buildings and structures founded on expansive soil shall conform to Section 9.3.1 or 9.3.2.

9.1.2 Where expansive soil is removed to a depth that ensures constant moisture content in the remaining soil, or when the soil is stabilized in accordance with the general building code, the design of footings and foundations for buildings and structures need not conform to Sections 9.3.1 and 9.3.2.

9.1.3 Fill material shall comply with the general building code and shall not contain expansive soils.

9.2—Expansive soil classification

Soils shall be considered expansive when tests for item (a) are found positive or when soils tested comply with items (b), (c), and (d):

(a) Expansion Index (EI) greater than 20, determined in accordance with ASTM D4829;

(b) Plasticity Index (PI) of 15 or greater, determined in accordance with ASTM D4318;

(c) More than 10% of the soil particles pass a No. 200 sieve, determined in accordance with ASTM D422; and

(d) More than 10% of the soil particles are less than 5 micrometers in size, determined in accordance with ASTM D422.

9.3—Design

9.3.1 *Footings and foundations*—Footings or foundations placed on or within the moisture active zone of expansive soils shall be designed to resist differential volume changes and to prevent damage to the supported structure.

Foundations extending into or penetrating expansive soils shall be designed to prevent uplift of the supported structure and to resist forces exerted on the foundation due to soil volume changes or shall be isolated from the expansive soil.

R9.3.1 *For limits on deflection and cracking of the supported structure, refer to the general building code.*

9.3.2 *Slab-on-ground foundations*—Slab-on-ground, mat, or raft foundations on expansive soils shall be designed using moments, shears, and deflections derived from an analysis that accounts for the combined action of the deformed shape of the soil support, the plate or stiffened plate action of the slab, as well as both edge lift and edge drop conditions.

R9.3.2 *Guidance on the requirements for post-tensioned slabs-on-ground can be found in the Post-Tensioning Institute's (PTI) DC10.1-08. The provisions for slabs-on-ground that are not on expansive soils are in Chapter 10 of this Code.*

CHAPTER 10—SLABS-ON-GROUND

10.1—Design

Slabs-on-ground shall be designed considering the anticipated loads and the soil or fill bearing capacity supporting the slab. Chapter 10 shall apply to slabs-on-ground that are:

(a) Subjected to loads resulting from pedestrians or vehicles with a passenger capacity of nine or less and conforming to the values listed in Tables 5.1 and 5.2; and

(b) Constructed on soils not classified as expansive by the general building code.

Slabs-on-ground not conforming to (a) are beyond the scope of this Code and those not conforming to (b) shall be designed according to Section 9.3.2.

R10.1 *These provisions apply to slabs placed on ground where the loads do not exceed those expected because of pedestrian traffic and passenger vehicles. Any slab placed on soil not suitable to support the imposed loads, located over voids, or otherwise not continuously supported should be designed and constructed as a structural slab. In addition, refer to the general building code for applicable requirements concerning vapor retarder, granular base drainage, waterproofing, and damp-proofing requirements.*

Table 10.1—Specified maximum contraction joint spacing for slab-on-ground without steel reinforcement

Slab thickness *h*, mm	Specified maximum size aggregate less than 20 mm	Specified maximum size aggregate 20 mm and larger
90	2.4 m	3.0 m
110	3.0 m	4.0 m
140	3.7 m	4.6 m

10.2—Support

Slabs-on-ground shall be continuously supported on undisturbed soil or with fill and base as described in Sections 10.2.1 and 10.2.2.

10.2.1 *Fill*—The fill shall be compacted to provide uniform support of the slab and shall not contain deleterious quantities of organic or foreign material. Fill depths shall not exceed 600 mm for clean sand or gravel and 200 mm for suitable soils, unless approved by the local building official.

10.2.2 *Base*—A 100 mm thick base course consisting of clean graded sand, gravel, crushed stone, crushed slag, or recycled crushed concrete passing a 50 mm sieve shall be placed on the prepared subgrade when the slab is below grade.

10.3—Forms

Forms for slabs-on-ground shall be braced to maintain horizontal and vertical alignment with sufficient strength to resist concrete pressure and applied loads from mechanical placing and finishing equipment.

10.4—Thickness

The specified minimum thickness of slabs-on-ground shall be 90 mm.

R10.4 *Interior bearing walls on slabs-on-ground may require thickened slab footings for load distribution. Refer to Fig. R7.4 for unformed thickened slab footings.*

10.5—Joints

10.5.1 *Construction joints*—Formed construction joints shall be provided when concrete placing operations are interrupted long enough for previously placed concrete to set.

10.5.2 *Contraction joints*—Contraction joints shall conform to (a) through (e). Alternatively, an isolation joint conforming to Section 10.5.3 is an acceptable contraction joint.

(a) Joints shall be formed, sawed, or tooled;

(b) Joint spacing shall not exceed the limits of Table 10.1 unless the slab is reinforced in accordance with Section 10.6.2;

(c) Slab sections defined by contraction joints shall have an aspect ratio no greater than 1.5;

(d) Joint depth shall be a specified minimum of 1/4 the slab thickness for formed or tooled joints, or dry-cut sawed joints in hardened concrete; and

(e) Joint depth shall be a specified minimum of 25 mm for slab depths up to 230 mm for early-entry sawed joints.

R10.5.2 *Contraction joints are required because concrete shrinkage (shortening) occurs at a ratio of approximately 16 mm for each 30 m based on empirical data.*

Interior bearing walls should not bear directly on slabs-on-ground without considering the location of the contraction joint relative to the bearing wall. Also, the floor finish (such as carpeting or tile) manufacturer instructions should be consulted to determine the ability of the floor finish to span the contraction joint. Spacing joints in accordance with Table 10.1 may not eliminate all random cracks in concrete slabs. Experience has shown that the use of an early-entry concrete saw just after final set, or a conventional saw, tends to limit crack development to the sawed joint. Refer to ACI 302.1R for more information on limiting slab-on-ground cracking.

10.5.3 *Isolation joints*—Isolation joints shall extend the full depth of the slab. Where vehicular traffic crosses isolation joints, slab thickness shall be increased at least 25% at the joint and tapered back to specified thickness over a distance not less than 300 mm from the joint.

R10.5.3 *Usually, isolation joints use at least 20 mm thick pre-molded joint filler. Isolation joints are provided where:*

(a) Slab edges are adjacent to other slabs-on-ground or walls; and

(b) Rigid elements penetrate the slabs-on-ground.

Isolation joints are formed at the rigid element penetrations by wrapping the element with a compressible filler material.

10.6—Reinforcement

10.6.1 *Steel reinforcement*—Reinforcement shall consist of deformed bars or welded wire reinforcement conforming to Sections 4.2.1 or 4.2.2 and shall be placed and maintained in the upper 2/3 of the slab depth with a specified minimum cover of 20 mm for interior conditions and 40 mm for exterior conditions. Reinforcement shall be supported in a manner that maintains its position during concrete placement.

10.6.2 *Minimum steel reinforcement based on joint spacing*—For crack-width control, provide contraction joints in accordance with Section 10.5.2, or a minimum area of reinforcement in both directions. The specified minimum area of reinforcement shall be equal to 0.5% times the slab cross-sectional area for joint spacing exceeding 100h, where h is the slab thickness. For joint spacing between 24h and 100h, the specified minimum area of reinforcement shall be determined by a linear interpolation from 0.1% at 24h to 0.5% at 100h.

APPENDIX A—PRESCRIPTIVE TABLES FOR FOUNDATION WALLS

A.1

Tables A.1 through A.10 are based on the conditions found in Sections A.1.1 thru A.1.3.

A.1.1 *General assumptions*

(a) Simply supported vertical flexural member;

(b) Top and bottom laterally supported;

(c) Axial force neglected;

(d) Self-weight neglected;

(e) No deflection limits considered because wall thickness and loading limits are specified;

(f) The only loading considered is the equivalent fluid pressure of soil (use 30, 45, 60, and 100 kN/m^2);

(g) Maximum unsupported wall height is 2.4, 2.7, and 3 m, with maximum unbalanced backfill height of 2.1, 2.4, and 3 m, respectively;

(h) Range of specified concrete compressive strength f'_c considered is 17 to 31 MPa;

(i) Yield strength of reinforcement, f_y, is 280 or 420 MPa; and

(j) The building shall not be assigned to Seismic Design Category D, E, or F, as defined in Section 1.3.1.

A.1.2 *Modified ACI 318M provisions*—ACI 318M design criteria provisions are modified or excluded as follows:

(a) Eq. (22-2) modified to $M_n = 0.625\lambda \sqrt{f'_c}\, S_m$;

(b) Section 22.6.6 excluded; and

(c) Section 14.3 excluded.

A.1.3 *Construction requirements*:

(a) Specified minimum actual wall thickness: 190, 240, and 290 mm;

(b) Concrete cover to vertical reinforcement: 20 mm;

(c) Walls constructed with removable forms;

(d) Specified maximum vertical reinforcement spacing: 1.2 m;

(e) Specified minimum vertical reinforcement spacing: 1/2 of wall thickness; and

(f) One layer of vertical reinforcement placed at the tensile face, maintaining concrete cover in accordance with Item (b) of construction requirements.

Table A.1—Vertical reinforcing bar spacing for concrete basement walls

Unsupported wall height, m	f_c' = 17 MPa f_y = 280 MPa		Specified maximum equivalent fluid pressure of soil, kN/m^2/m											
			4.5			7.0			9.5			15.5		
	Unbalanced backfill, m	Reinforcing bar	Specified minimum wall thickness, mm.			Specified minimum wall thickness, mm			Specified minimum wall thickness, mm			Specified minimum wall thickness, mm		
			190	240	290	190	240	290	190	240	290	190	240	290
2.50	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	305	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	465	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	655	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	365	Plain	Plain	215	285	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	560	Plain	Plain	330	440	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	785	Plain	Plain	465	620	Plain
2.75	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	435	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	670	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	345	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	280	370	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	430	565	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	600	800	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	440	Plain	Plain	330	Plain	Plain	195	260	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	675	Plain	Plain	505	Plain	Plain	300	395	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	950	Plain	Plain	710	Plain	Plain	425	560	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	330	Plain	Plain	245	325	Plain	155	195	240
		No. 16 @ ... mm	Plain	Plain	Plain	505	Plain	Plain	375	500	Plain	245	300	370
		No. 19 @ ... mm	Plain	Plain	Plain	710	Plain	Plain	530	700	Plain	350	415	520
3.00	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	415	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	635	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	895	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	440	Plain	Plain	260	345	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	675	Plain	Plain	400	530	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	950	Plain	Plain	565	750	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	405	Plain	Plain	305	Plain	Plain	180	240	295
		No. 16 @ ... mm	Plain	Plain	Plain	625	Plain	Plain	465	Plain	Plain	275	365	455
		No. 19 @ ... mm	Plain	Plain	Plain	875	Plain	Plain	655	Plain	Plain	385	515	645
	2.50	No. 13 @ ... mm	450	Plain	Plain	300	Plain	Plain	225	295	Plain	155	175	220
		No. 16 @ ... mm	695	Plain	Plain	460	Plain	Plain	345	455	Plain	245	270	335
		No. 19 @ ... mm	975	Plain	Plain	645	Plain	Plain	480	640	Plain	350	380	475
	2.75	No. 13 @ ... mm	350	Plain	Plain	230	305	Plain	175	230	285	135	135	170
		No. 16 @ ... mm	540	Plain	Plain	355	470	Plain	265	350	440	205	210	260
		No. 19 @ ... mm	755	Plain	Plain	500	665	Plain	370	495	620	290	295	370

Notes:
1. The term “plain” refers to concrete where no vertical reinforcement is required other than reinforcement consistent with Section 8.2.10 and where horizontal reinforcement is required in accordance with Sections 8.2.8 and 8.2.9 of this Code.
2. This table is applicable to walls of specified height, unbalanced backfill height, equivalent fluid pressure of soil, concrete strength, and the yield strength of reinforcement.
3. This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.
4. Values in this table are derived in accordance with ACI 318M and Section 8.2 of this Code.

Table A.2—Vertical reinforcing bar spacing for concrete basement walls

Unsupported wall height, m	f_c' = 17 MPa f_y = 420 MPa Unbalanced backfill, m	Reinforcing bar	Specified maximum equivalent fluid pressure of soil, kN/m^2/m 4.5 Specified minimum wall thickness, mm.			7.0 Specified minimum wall thickness, mm			9.5 Specified minimum wall thickness, mm			15.5 Specified minimum wall thickness, mm		
			190	240	290	190	240	290	190	240	290	190	240	290
2.50	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	455	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	700	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	985	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	545	Plain	Plain	325	430	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	835	Plain	Plain	495	660	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	1175	Plain	Plain	700	925	Plain
2.75	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	655	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	1005	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	1415	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	420	555	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	645	850	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	305	1200	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	660	Plain	Plain	495	Plain	Plain	290	355	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	1015	Plain	Plain	755	Plain	Plain	450	595	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	1425	Plain	Plain	1060	Plain	Plain	630	840	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	495	Plain	Plain	370	485	Plain	235	290	360
		No. 16 @ ... mm	Plain	Plain	Plain	755	Plain	Plain	565	745	Plain	365	445	555
		No. 19 @ ... mm	Plain	Plain	Plain	1065	Plain	Plain	795	1055	Plain	525	625	780
3.00	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	620	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	955	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	1340	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	660	Plain	Plain	390	520	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	1015	Plain	Plain	600	795	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	1425	Plain	Plain	845	1125	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	610	Plain	Plain	455	Plain	Plain	270	355	445
		No. 16 @ ... mm	Plain	Plain	Plain	935	Plain	Plain	700	Plain	Plain	415	550	685
		No. 19 @ ... mm	Plain	Plain	Plain	1315	Plain	Plain	980	Plain	Plain	580	775	965
	2.50	No. 13 @ ... mm	680	Plain	Plain	450	Plain	Plain	335	445	Plain	235	265	330
		No. 16 @ ... mm	1040	Plain	Plain	690	Plain	Plain	515	680	Plain	365	405	505
		No. 19 @ ... mm	1465	Plain	Plain	970	Plain	Plain	720	960	Plain	525	570	710
	2.75	No. 13 @ ... mm	525	Plain	Plain	350	460	Plain	260	345	425	200	205	255
		No. 16 @ ... mm	810	Plain	Plain	535	710	Plain	395	530	660	310	315	390
		No. 19 @ ... mm	1135	Plain	Plain	750	995	Plain	560	745	930	435	440	550

Notes:
1. The term “plain” refers to concrete where no vertical reinforcement is required other than reinforcement consistent with Section 8.2.10 and where horizontal reinforcement is required in accordance with Sections 8.2.8 and 8.2.9 of this Code.
2. This table is applicable to walls of specified height, unbalanced backfill height, equivalent fluid pressure of soil, concrete strength, and the yield strength of reinforcement.
3. This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.
4. Values in this table are derived in accordance with ACI 318M and Section 8.2 of this Code.

Table A.3—Vertical reinforcing bar spacing for concrete basement walls

Unsupported wall height, m	f_c' = 21 MPa f_y = 280 MPa		Specified maximum equivalent fluid pressure of soil, kN/m^2/m											
			4.5			7.0			9.5			15.5		
	Unbalanced backfill, m	Reinforcing bar	Specified minimum wall thickness, mm.			Specified minimum wall thickness, mm			Specified minimum wall thickness, mm			Specified minimum wall thickness, mm		
			190	240	290	190	240	290	190	240	290	190	240	290
2.50	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	305	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	470	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	650	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	365	Plain	Plain	215	285	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	560	Plain	Plain	335	440	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	785	Plain	Plain	465	620	Plain
2.75	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	280	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	430	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	605	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	330	Plain	Plain	195	260	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	505	Plain	Plain	300	400	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	710	Plain	Plain	420	560	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	330	Plain	Plain	245	325	Plain	155	195	240
		No. 16 @ ... mm	Plain	Plain	Plain	505	Plain	Plain	380	500	Plain	245	295	370
		No. 19 @ ... mm	Plain	Plain	Plain	710	Plain	Plain	530	705	Plain	350	420	520
3.00	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	415	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	640	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	895	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	260	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	405	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	565	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	410	Plain	Plain	305	Plain	Plain	180	240	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	625	Plain	Plain	465	Plain	Plain	275	270	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	880	Plain	Plain	655	Plain	Plain	390	520	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	300	Plain	Plain	225	295	Plain	155	175	220
		No. 16 @ ... mm	Plain	Plain	Plain	460	Plain	Plain	345	455	Plain	245	270	335
		No. 19 @ ... mm	Plain	Plain	Plain	650	Plain	Plain	485	640	Plain	350	380	475
	2.75	No. 13 @ ... mm	350	Plain	Plain	235	305	Plain	175	230	285	135	135	170
		No. 16 @ ... mm	540	Plain	Plain	360	475	Plain	265	355	440	210	210	260
		No. 19 @ ... mm	760	Plain	Plain	500	665	Plain	375	500	620	295	295	370

Notes:
1. The term “plain” refers to concrete where no vertical reinforcement is required other than reinforcement consistent with Section 8.2.10 and where horizontal reinforcement is required in accordance with Sections 8.2.8 and 8.2.9 of this Code.
2. This table is applicable to walls of specified height, unbalanced backfill height, equivalent fluid pressure of soil, concrete strength, and the yield strength of reinforcement.
3. This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.
4. Values in this table are derived in accordance with ACI 318M and Section 8.2 of this Code.

Table A.4—Vertical reinforcing bar spacing for concrete basement walls

Unsupported wall height, m	f_c' = 21 MPa f_y = 420 MPa Unbalanced backfill, m	Reinforcing bar	Specified maximum equivalent fluid pressure of soil, kN/m^2/m 4.5 Specified minimum wall thickness, mm.			7.0 Specified minimum wall thickness, mm			9.5 Specified minimum wall thickness, mm			15.5 Specified minimum wall thickness, mm		
			190	240	290	190	240	290	190	240	290	190	240	290
2.50	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	455	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	700	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	985	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	545	Plain	Plain	325	430	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	840	Plain	Plain	500	660	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	1180	Plain	Plain	700	930	Plain
2.75	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	420	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	645	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	905	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	495	Plain	Plain	295	390	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	760	Plain	Plain	450	595	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	1065	Plain	Plain	635	840	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	495	Plain	Plain	370	485	Plain	235	290	360
		No. 16 @ ... mm	Plain	Plain	Plain	760	Plain	Plain	565	750	Plain	365	445	555
		No. 19 @ ... mm	Plain	Plain	Plain	1065	Plain	Plain	795	1055	Plain	525	630	785
3.00	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	625	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	955	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	1345	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	395	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	605	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	850	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	610	Plain	Plain	455	Plain	Plain	270	360	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	940	Plain	Plain	700	Plain	Plain	415	550	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	1320	Plain	Plain	985	Plain	Plain	585	775	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	450	Plain	Plain	335	445	Plain	235	265	330
		No. 16 @ ... mm	Plain	Plain	Plain	690	Plain	Plain	515	685	Plain	365	405	505
		No. 19 @ ... mm	Plain	Plain	Plain	970	Plain	Plain	725	960	Plain	525	570	715
	2.75	No. 13 @ ... mm	530	Plain	Plain	350	460	Plain	260	345	170	205	205	255
		No. 16 @ ... mm	810	Plain	Plain	535	710	Plain	400	530	260	315	315	395
		No. 19 @ ... mm	1140	Plain	Plain	755	1000	Plain	560	745	365	440	445	555

Notes:
1. The term “plain” refers to concrete where no vertical reinforcement is required other than reinforcement consistent with Section 8.2.10 and where horizontal reinforcement is required in accordance with Sections 8.2.8 and 8.2.9 of this Code.
2. This table is applicable to walls of specified height, unbalanced backfill height, equivalent fluid pressure of soil, concrete strength, and the yield strength of reinforcement.
3. This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.
4. Values in this table are derived in accordance with ACI 318M and Section 8.2 of this Code.

Table A.5—Vertical reinforcing bar spacing for concrete basement walls

Unsupported wall height, m	f_c' = 24 MPa f_y = 280 MPa		Specified maximum equivalent fluid pressure of soil, kN/m^2/m											
			4.5			7.0			9.5			15.5		
	Unbalanced backfill, m	Reinforcing bar	Specified minimum wall thickness, mm.			Specified minimum wall thickness, mm			Specified minimum wall thickness, mm			Specified minimum wall thickness, mm		
			190	240	290	190	240	290	190	240	290	190	240	290
2.50	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	305	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	470	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	660	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	365	Plain	Plain	215	285	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	560	Plain	Plain	335	440	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	785	Plain	Plain	470	620	Plain
2.75	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	280	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	430	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	605	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	330	Plain	Plain	195	260	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	505	Plain	Plain	300	400	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	710	Plain	Plain	425	560	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	330	Plain	Plain	245	Plain	Plain	160	195	240
		No. 16 @ ... mm	Plain	Plain	Plain	505	Plain	Plain	380	Plain	Plain	245	300	370
		No. 19 @ ... mm	Plain	Plain	Plain	715	Plain	Plain	530	Plain	Plain	350	420	525
3.00	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	260	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	405	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	570	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	305	Plain	Plain	180	230	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	470	Plain	Plain	280	370	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	660	Plain	Plain	390	520	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	300	Plain	Plain	225	300	Plain	155	175	220
		No. 16 @ ... mm	Plain	Plain	Plain	460	Plain	Plain	345	455	Plain	245	270	340
		No. 19 @ ... mm	Plain	Plain	Plain	650	Plain	Plain	485	640	Plain	350	380	475
	2.75	No. 13 @ ... mm	350	Plain	Plain	235	310	Plain	175	230	Plain	135	135	170
		No. 16 @ ... mm	540	Plain	Plain	360	475	Plain	265	355	Plain	210	210	260
		No. 19 @ ... mm	760	Plain	Plain	505	665	Plain	375	500	Plain	295	295	370

Notes:
1. The term “plain” refers to concrete where no vertical reinforcement is required other than reinforcement consistent with Section 8.2.10 and where horizontal reinforcement is required in accordance with Sections 8.2.8 and 8.2.9 of this Code.
2. This table is applicable to walls of specified height, unbalanced backfill height, equivalent fluid pressure of soil, concrete strength, and the yield strength of reinforcement.
3. This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.
4. Values in this table are derived in accordance with ACI 318M and Section 8.2 of this Code.

Table A.6—Vertical reinforcing bar spacing for concrete basement walls

Unsupported wall height, m	f_c' = 24 MPa f_y = 420 MPa Unbalanced backfill, m	Reinforcing bar	Specified maximum equivalent fluid pressure of soil, kN/m^2/m 4.5 Specified minimum wall thickness, mm.			7.0 Specified minimum wall thickness, mm			9.5 Specified minimum wall thickness, mm			15.5 Specified minimum wall thickness, mm		
			190	240	290	190	240	290	190	240	290	190	240	290
2.50	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	460	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	705	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	990	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	550	Plain	Plain	325	430	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	840	Plain	Plain	500	660	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	1180	Plain	Plain	705	930	Plain
2.75	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	420	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	645	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	910	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	495	Plain	Plain	295	390	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	760	Plain	Plain	450	600	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	1070	Plain	Plain	635	840	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	495	Plain	Plain	370	Plain	Plain	235	290	360
		No. 16 @ ... mm	Plain	Plain	Plain	760	Plain	Plain	570	Plain	Plain	365	445	555
		No. 19 @ ... mm	Plain	Plain	Plain	1070	Plain	Plain	800	Plain	Plain	525	630	785
3.00	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	395	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	605	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	850	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	460	Plain	Plain	270	360	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	700	Plain	Plain	420	555	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	985	Plain	Plain	585	780	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	450	Plain	Plain	335	445	Plain	235	265	330
		No. 16 @ ... mm	Plain	Plain	Plain	695	Plain	Plain	520	685	Plain	365	405	505
		No. 19 @ ... mm	Plain	Plain	Plain	975	Plain	Plain	725	965	Plain	525	575	715
	2.75	No. 13 @ ... mm	530	Plain	Plain	350	460	Plain	260	345	Plain	205	205	255
		No. 16 @ ... mm	810	Plain	Plain	540	710	Plain	400	530	Plain	315	315	395
		No. 19 @ ... mm	1140	Plain	Plain	755	1000	Plain	565	750	Plain	445	445	555

Notes:
1. The term “plain” refers to concrete where no vertical reinforcement is required other than reinforcement consistent with Section 8.2.10 and where horizontal reinforcement is required in accordance with Sections 8.2.8 and 8.2.9 of this Code.
2. This table is applicable to walls of specified height, unbalanced backfill height, equivalent fluid pressure of soil, concrete strength, and the yield strength of reinforcement.
3. This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.
4. Values in this table are derived in accordance with ACI 318M and Section 8.2 of this Code.

Table A.7—Vertical reinforcing bar spacing for concrete basement walls

Unsupported wall height, m	f_c' = 28 MPa f_y = 280 MPa		Specified maximum equivalent fluid pressure of soil, kN/m^2/m											
			4.5			7.0			9.5			15.5		
	Unbalanced backfill, m	Reinforcing bar	Specified minimum wall thickness, mm.			Specified minimum wall thickness, mm			Specified minimum wall thickness, mm			Specified minimum wall thickness, mm		
			190	240	290	190	240	290	190	240	290	190	240	290
2.50	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	305	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	470	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	660	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	220	285	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	335	440	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	470	620	Plain
2.75	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	280	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	430	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	605	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	330	Plain	Plain	195	260	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	505	Plain	Plain	300	400	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	715	Plain	Plain	425	560	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	330	Plain	Plain	245	Plain	Plain	155	195	240
		No. 16 @ ... mm	Plain	Plain	Plain	510	Plain	Plain	380	Plain	Plain	245	300	370
		No. 19 @ ... mm	Plain	Plain	Plain	715	Plain	Plain	535	Plain	Plain	350	420	525
3.00	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	260	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	405	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	570	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	305	Plain	Plain	180	240	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	470	Plain	Plain	280	370	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	660	Plain	Plain	390	520	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	300	Plain	Plain	225	Plain	Plain	155	175	220
		No. 16 @ ... mm	Plain	Plain	Plain	465	Plain	Plain	355	Plain	Plain	245	270	340
		No. 19 @ ... mm	Plain	Plain	Plain	650	Plain	Plain	485	Plain	Plain	350	380	480
	2.75	No. 13 @ ... mm	355	Plain	Plain	235	Plain	Plain	175	230	Plain	140	135	170
		No. 16 @ ... mm	540	Plain	Plain	360	Plain	Plain	270	355	Plain	210	210	260
		No. 19 @ ... mm	760	Plain	Plain	505	Plain	Plain	375	500	Plain	295	295	370

Notes:
1. The term “plain” refers to concrete where no vertical reinforcement is required other than reinforcement consistent with Section 8.2.10 and where horizontal reinforcement is required in accordance with Sections 8.2.8 and 8.2.9 of this Code.
2. This table is applicable to walls of specified height, unbalanced backfill height, equivalent fluid pressure of soil, concrete strength, and the yield strength of reinforcement.
3. This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.
4. Values in this table are derived in accordance with ACI 318M and Section 8.2 of this Code.

Table A.8—Vertical reinforcing bar spacing for concrete basement walls

	f_c' = 28 MPa		Specified maximum equivalent fluid pressure of soil, kN/m^2/m											
	f_y = 420 MPa		4.5			7.0			9.5			15.5		
			Specified minimum wall thickness, mm.			Specified minimum wall thickness, mm			Specified minimum wall thickness, mm			Specified minimum wall thickness, mm		
Unsupported wall height, m	Unbalanced backfill, m	Reinforcing bar	190	240	290	190	240	290	190	240	290	190	240	290
2.50	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	460	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	705	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	990	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	330	430	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	500	660	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	705	930	Plain
2.75	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	420	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	650	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	910	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	495	Plain	Plain	295	390	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	760	Plain	Plain	455	600	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	1070	Plain	Plain	635	845	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	495	Plain	Plain	370	Plain	Plain	235	290	360
		No. 16 @ ... mm	Plain	Plain	Plain	760	Plain	Plain	570	Plain	Plain	365	450	555
		No. 19 @ ... mm	Plain	Plain	Plain	1070	Plain	Plain	800	Plain	Plain	525	630	785
3.00	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	395	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	605	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	855	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	460	Plain	Plain	275	360	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	705	Plain	Plain	420	555	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	990	Plain	Plain	590	780	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	450	Plain	Plain	340	Plain	Plain	235	265	330
		No. 16 @ ... mm	Plain	Plain	Plain	695	Plain	Plain	520	Plain	Plain	365	410	510
		No. 19 @ ... mm	Plain	Plain	Plain	975	Plain	Plain	730	Plain	Plain	525	575	715
	2.75	No. 13 @ ... mm	530	Plain	Plain	350	Plain	Plain	260	345	Plain	205	205	255
		No. 16 @ ... mm	815	Plain	Plain	540	Plain	Plain	400	530	Plain	315	315	395
		No. 19 @ ... mm	1145	Plain	Plain	760	Plain	Plain	565	750	Plain	445	445	555

Notes:
1. The term “plain” refers to concrete where no vertical reinforcement is required other than reinforcement consistent with Section 8.2.10 and where horizontal reinforcement is required in accordance with Sections 8.2.8 and 8.2.9 of this Code.
2. This table is applicable to walls of specified height, unbalanced backfill height, equivalent fluid pressure of soil, concrete strength, and the yield strength of reinforcement.
3. This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.
4. Values in this table are derived in accordance with ACI 318M and Section 8.2 of this Code.

Table A.9—Vertical reinforcing bar spacing for concrete basement walls

Unsupported wall height, m	f_c' = 31 MPa f_y = 280 MPa		Specified maximum equivalent fluid pressure of soil, kN/m^2/m											
			4.5			7.0			9.5			15.5		
	Unbalanced backfill, m	Reinforcing bar	Specified minimum wall thickness, mm.			Specified minimum wall thickness, mm			Specified minimum wall thickness, mm			Specified minimum wall thickness, mm		
			190	240	290	190	240	290	190	240	290	190	240	290
2.50	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	305	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	470	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	660	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	220	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	335	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	470	Plain	Plain
2.75	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	280	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	430	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	610	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	330	Plain	Plain	195	260	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	510	Plain	Plain	300	400	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	715	Plain	Plain	425	565	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	330	Plain	Plain	250	Plain	Plain	155	195	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	510	Plain	Plain	380	Plain	Plain	245	300	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	715	Plain	Plain	535	Plain	Plain	350	420	Plain
3.00	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	265	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	405	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	570	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	305	Plain	Plain	180	240	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	470	Plain	Plain	280	370	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	660	Plain	Plain	395	520	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	300	Plain	Plain	225	Plain	Plain	155	175	220
		No. 16 @ ... mm	Plain	Plain	Plain	465	Plain	Plain	345	Plain	Plain	245	275	340
		No. 19 @ ... mm	Plain	Plain	Plain	650	Plain	Plain	485	Plain	Plain	350	385	480
	2.75	No. 13 @ ... mm	Plain	Plain	Plain	235	Plain	Plain	175	230	Plain	140	140	170
		No. 16 @ ... mm	Plain	Plain	Plain	360	Plain	Plain	270	355	Plain	210	210	265
		No. 19 @ ... mm	Plain	Plain	Plain	505	Plain	Plain	380	500	Plain	300	300	370

Notes:
1. The term “plain” refers to concrete where no vertical reinforcement is required other than reinforcement consistent with Section 8.2.10 and where horizontal reinforcement is required in accordance with Sections 8.2.8 and 8.2.9 of this Code.
2. This table is applicable to walls of specified height, unbalanced backfill height, equivalent fluid pressure of soil, concrete strength, and the yield strength of reinforcement.
3. This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.
4. Values in this table are derived in accordance with ACI 318M and Section 8.2 of this Code.

Table A.10—Vertical reinforcing bar spacing for concrete basement walls

Unsupported wall height, m	f_c' = 31 MPa f_y = 420 MPa Unbalanced backfill, m	Reinforcing bar	Specified maximum equivalent fluid pressure of soil, kN/m^2/m 4.5 Specified minimum wall thickness, mm.			7.0 Specified minimum wall thickness, mm			9.5 Specified minimum wall thickness, mm			15.5 Specified minimum wall thickness, mm		
			190	240	290	190	240	290	190	240	290	190	240	290
2.50	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	460	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	705	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	990	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	330	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	505	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	705	Plain	Plain
2.75	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	425	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	650	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	910	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	495	Plain	Plain	295	390	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	760	Plain	Plain	455	600	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	1070	Plain	Plain	640	845	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	495	Plain	Plain	370	Plain	Plain	235	290	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	760	Plain	Plain	570	Plain	Plain	365	450	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	1075	Plain	Plain	800	Plain	Plain	525	630	Plain
3.00	1.75	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
	2.00	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	395	Plain	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	610	Plain	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	855	Plain	Plain
	2.25	No. 13 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	460	Plain	Plain	275	360	Plain
		No. 16 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	705	Plain	Plain	420	555	Plain
		No. 19 @ ... mm	Plain	Plain	Plain	Plain	Plain	Plain	990	Plain	Plain	590	780	Plain
	2.50	No. 13 @ ... mm	Plain	Plain	Plain	455	Plain	Plain	340	Plain	Plain	235	265	330
		No. 16 @ ... mm	Plain	Plain	Plain	695	Plain	Plain	520	Plain	Plain	365	410	510
		No. 19 @ ... mm	Plain	Plain	Plain	975	Plain	Plain	730	Plain	Plain	525	575	715
	2.75	No. 13 @ ... mm	Plain	Plain	Plain	350	Plain	Plain	265	345	Plain	210	205	255
		No. 16 @ ... mm	Plain	Plain	Plain	540	Plain	Plain	405	535	Plain	320	315	395
		No. 19 @ ... mm	Plain	Plain	Plain	760	Plain	Plain	565	750	Plain	450	445	555

Notes:
1. The term “plain” refers to concrete where no vertical reinforcement is required other than reinforcement consistent with Section 8.2.10 and where horizontal reinforcement is required in accordance with Sections 8.2.8 and 8.2.9 of this Code.
2. This table is applicable to walls of specified height, unbalanced backfill height, equivalent fluid pressure of soil, concrete strength, and the yield strength of reinforcement.
3. This table is applicable only when the structure is not assigned to Seismic Design Category D, E, or F.
4. Values in this table are derived in accordance with ACI 318M and Section 8.2 of this Code.

COMMENTARY REFERENCES

Referenced standards and reports

The standards and reports listed below were the latest editions at the time this document was prepared. Because these documents are revised frequently, the reader is advised to contact the proper sponsoring group if it is desired to refer to the latest version.

American Concrete Institute

201.2R Guide to Durable Concrete
222R Protection of Metals in Concrete Against Corrosion
237R Self-Consolidating Concrete
301M Specifications for Structural Concrete
302.1R Guide for Concrete Floor and Slab Construction
304R Guide for Measuring, Mixing, Transporting, and Placing Concrete
304.6R Guide for Use of Volumetric-Measuring and Continuous-Mixing Concrete Equipment
305R Hot Weather Concreting
306R Cold Weather Concreting
308R Guide to Curing Concrete
309R Guide for Consolidation of Concrete
318M Building Code Requirements for Structural Concrete and Commentary
332.1R Guide to Residential Concrete Construction
347 Guide to Formwork for Concrete
SP-4 Formwork for Concrete

American Society of Civil Engineers

ASCE/SEI 7 Minimum Design Loads for Buildings and Other Structures

ASTM International

A416M Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
C39M Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
C42M Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
C94M Standard Specification for Ready-Mixed Concrete
C143M Standard Test Method for Slump of Hydraulic Cement Concrete
C173M Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
C231M Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
C494 Standard Specification for Chemical Admixtures for Concrete
C1017M Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
C1580 Standard Test Method for Water-Soluble Sulfate in Soil
C1611M Standard Test Method for Slump Flow of Self-Consolidating Concrete

California Department of Transportation

California Test 417 Method of Testing Soils and Waters for Sulfate Content

Concrete Foundations Association

Cold Weather Research Report for Residential Foundation Walls, 2004

Portland Cement Association

PCA 100 Prescriptive Design of Exterior Concrete Walls for One- and Two-Family Dwellings

Post-Tensioning Institute

DC10.1 Design of Post-Tensioned Slabs-on-Ground

U.S. Bureau of Reclamation

Method of Test for Determining the Quantity of Soluble Sulfate in Solid (Soil or Rock) and Water Samples, 1973

The above publications may be obtained from the following organizations:

American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
www.concrete.org

American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, VA 20191
www.asce.org

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428
www.astm.org

Concrete Foundations Association
P.O. Box 204
Mount Vernon, IA 52314
www.cfawalls.org

California Department of Transportation
Engineering Service Center
Transportation Laboratory
5900 Folsom Boulevard
Sacramento, CA 95819-4612
http://www.dot.ca.gov/hq/esc/

Portland Cement Association
5420 Old Orchard Road
Skokie, IL 60077
www.cement.org

Post-Tensioning Institute
38800 Country Club Drive
Farmington Hills, MI 48331
www.post-tensioning.org

Wire Reinforcement Institute
942 Main Street, Suite 300
Hartford, CT 06103
www.wirereinforcementinstitute.org

Cited references

Gaynor, R. D., 1999, "Calculating Chloride Percentages," *Concrete Products*, V. 102, No. 2, Feb., pp. 97-98.

Suprenant, B. A., and Malisch, W. R., 1998, "How Clean Must Rebar Be?" *Concrete Construction*, June, pp. 517-523.

Taber, L. H.; Belarbi, A.; and Richardson, D. N., 2002, "Effect of Reinforcing Bar Contamination on Steel-Concrete Bond During Concrete Construction," *Innovations in Design with Emphasis on Seismic, Wind and Environmental Loading, Quality Control*, Proceedings of the ACI Fifth International Conference, SP-209, V. M. Malhotra, ed., American Concrete Institute, Farmington Hills, MI, Sept., pp. 839-862.

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Residential Code Requirements for Structural Concrete and Commentary

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