

ACI 318M-11

**Building Code Requirements for
Structural Concrete (ACI 318M-11)**

An ACI Standard

and Commentary

Reported by ACI Committee 318



American Concrete Institute®



First Printing
September 2011

American Concrete Institute®
Advancing concrete knowledge

Building Code Requirements for Structural Concrete (ACI 318M-11) and Commentary

Copyright by the American Concrete Institute, Farmington Hills, MI. All rights reserved. This material may not be reproduced or copied, in whole or part, in any printed, mechanical, electronic, film, or other distribution and storage media, without the written consent of ACI.

The technical committees responsible for ACI committee reports and standards strive to avoid ambiguities, omissions, and errors in these documents. In spite of these efforts, the users of ACI documents occasionally find information or requirements that may be subject to more than one interpretation or may be incomplete or incorrect. Users who have suggestions for the improvement of ACI documents are requested to contact ACI via the errata website at www.concrete.org/committees/errata.asp. Proper use of this document includes periodically checking for errata for the most up-to-date revisions.

ACI committee documents are intended for the use of individuals who are competent to evaluate the significance and limitations of its content and recommendations and who will accept responsibility for the application of the material it contains. Individuals who use this publication in any way assume all risk and accept total responsibility for the application and use of this information.

All information in this publication is provided “as is” without warranty of any kind, either express or implied, including but not limited to, the implied warranties of merchantability, fitness for a particular purpose or non-infringement.

ACI and its members disclaim liability for damages of any kind, including any special, indirect, incidental, or consequential damages, including without limitation, lost revenues or lost profits, which may result from the use of this publication.

It is the responsibility of the user of this document to establish health and safety practices appropriate to the specific circumstances involved with its use. ACI does not make any representations with regard to health and safety issues and the use of this document. The user must determine the applicability of all regulatory limitations before applying the document and must comply with all applicable laws and regulations, including but not limited to, United States Occupational Safety and Health Administration (OSHA) health and safety standards.

Order information: ACI documents are available in print, by download, on CD-ROM, through electronic subscription, or reprint and may be obtained by contacting ACI.

Most ACI standards and committee reports are gathered together in the annually revised *ACI Manual of Concrete Practice* (MCP).

American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
U.S.A.

Phone: 248-848-3700

Fax: 248-848-3701

www.concrete.org

ISBN 978-0-87031-745-3

BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE (ACI 318M-11) AND COMMENTARY

REPORTED BY ACI COMMITTEE 318

ACI Committee 318
Structural Building Code

Voting Main Committee Members

Randall W. Poston
Chair

Basile G. Rabbat
Secretary

Sergio M. Alcocer
Neal S. Anderson
Florian G. Barth
Roger J. Becker
Kenneth B. Bondy
Dean A. Browning
James R. Cagley
Ned M. Cleland
W. Gene Corley
Charles W. Dolan

Anthony E. Fiorato
Catherine E. French
Robert J. Frosch
Luis E. García
Satyendra Ghosh
Harry A. Gleich
David P. Gustafson
James R. Harris
Terence C. Holland
Shyh-Jiann Hwang

James O. Jirsa
Dominic J. Kelly
Gary J. Klein
Ronald Klemencic
Cary S. Kopczynski
Colin L. Lobo
Paul F. Mlakar
Jack P. Moehle
Gustavo J. Parra-Montesinos
Julio A. Ramirez

David M. Rogowsky
David H. Sanders
Guillermo Santana
Thomas C. Schaeffer
Stephen J. Seguirant
Andrew W. Taylor
Eric M. Tolles
James K. Wight
Sharon L. Wood
Loring A. Wyllie Jr.

Voting Subcommittee Members

F. Michael Bartlett
Raul D. Bertero
Allan P. Bommer
JoAnn P. Browning
Nicholas J. Carino
Ronald A. Cook
David Darwin
Lisa R. Feldman

Kevin J. Folliard
H. R. Trey Hamilton III
R. Doug Hooton
Kenneth C. Hover
Steven H. Kosmatka
Michael E. Kreger
Jason J. Krohn
Daniel A. Kuchma

Andres Lepage
Raymond Lui
LeRoy A. Lutz
Joseph Maffei
Donald F. Meinheit
Fred Meyer
Denis Mitchell

Theodore A. Mize
Suzanne Dow Nakaki
Theodore L. Neff
Lawrence C. Novak
Viral B. Patel
Conrad Paulson
Jose A. Pincheira

Mario E. Rodriguez
Bruce W. Russell
M. Saiid Saiidi
Andrea J. Schokker
John F. Stanton
Roberto Stark
John W. Wallace

International Liaison Members

Mathias Brewer
Josef Farbiarz
Luis B. Fargier-Gabaldon

Alberto Giovambattista
Hector D. Hernandez
Angel E. Herrera

Hector Monzon-Despang
Enrique Pasquel
Patricio A. Placencia

Oscar M. Ramirez
Fernando Reboucas Stucchi
Fernando Yáñez

Consulting Members

John E. Breen
Neil M. Hawkins

H. S. Lew
James G. MacGregor

Robert F. Mast
Charles G. Salmon

BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE (ACI 318M-11) AND COMMENTARY

REPORTED BY ACI COMMITTEE 318

PREFACE

The “Building Code Requirements for Structural Concrete” (“Code”) covers the materials, design, and construction of structural concrete used in buildings and where applicable in nonbuilding structures. The Code also covers the strength evaluation of existing concrete structures.

Among the subjects covered are: contract documents; inspection; materials; durability requirements; concrete quality, mixing, and placing; formwork; embedded pipes; construction joints; reinforcement details; analysis and design; strength and serviceability; flexural and axial loads; shear and torsion; development and splices of reinforcement; slab systems; walls; footings; precast concrete; composite flexural members; prestressed concrete; shells and folded plate members; strength evaluation of existing structures; provisions for seismic design; structural plain concrete; strut-and-tie modeling in Appendix A; alternative design provisions in Appendix B; alternative load and strength reduction factors in Appendix C; and anchoring to concrete in Appendix D.

The quality and testing of materials used in construction are covered by reference to the appropriate ASTM standard specifications. Welding of reinforcement is covered by reference to the appropriate American Welding Society (AWS) standard.

Uses of the Code include adoption by reference in general building codes, and earlier editions have been widely used in this manner. The Code is written in a format that allows such reference without change to its language. Therefore, background details or suggestions for carrying out the requirements or intent of the Code portion cannot be included. The Commentary is provided for this purpose. Some of the considerations of the committee in developing the Code portion are discussed within the Commentary, with emphasis given to the explanation of new or revised provisions. Much of the research data referenced in preparing the Code is cited for the user desiring to study individual questions in greater detail. Other documents that provide suggestions for carrying out the requirements of the Code are also cited.

Keywords: admixtures; aggregates; anchorage (structural); beam-column frame; beams (supports); **building codes**; cements; cold weather construction; columns (supports); combined stress; composite construction (concrete and steel); composite construction (concrete to concrete); compressive strength; **concrete construction**; concrete slabs; **concretes**; construction joints; continuity (structural); contract documents; contraction joints; cover; curing; deep beams; deflections; earthquake-resistant structures; embedded service ducts; flexural strength; floors; folded plates; footings; formwork (construction); frames; hot weather construction; inspection; isolation joints; joints (junctions); joists; lightweight concretes; load tests (structural); loads (forces); materials; mixing; mixture proportioning; modulus of elasticity; moments; pipe columns; pipes (tubing); placing; plain concrete; precast concrete; prestressed concrete; prestressing steels; quality control; **reinforced concrete**; reinforcing steels; roofs; serviceability; shear strength; shear walls; shells (structural forms); spans; splicing; strength; strength analysis; stresses; **structural analysis**; **structural concrete**; **structural design**; structural integrity; T-beams; torsion; walls; water; welded wire reinforcement.

ACI 318M-11 was adopted as a standard of the American Concrete Institute May 24, 2011, to supersede ACI 318M-08 in accordance with the Institute’s standardization procedure and was published October 2011.

A complete U.S. Customary unit companion to ACI 318M has been developed, 318; U.S. Customary equivalents are provided only in Appendix F of this document.

ACI Committee Reports, Manuals, Guides, Standard Practices, and Commentaries are intended for guidance in planning, designing, executing, and inspecting construction. This Commentary is intended for the use of individuals who are competent to evaluate the significance and limitations of its content and recommendations, and who will accept responsibility for the application of the material it contains. The American Concrete Institute

disclaims any and all responsibility for the stated principles. The Institute shall not be liable for any loss or damage arising therefrom. Reference to this Commentary shall not be made in contract documents. If items found in this Commentary are desired by the licensed design professional to be a part of the contract documents, they shall be restated and incorporated in mandatory language.

Copyright © 2011, American Concrete Institute.

All rights reserved including rights of reproduction and use in any form or by any means, including the making of copies by any photo process, or by any electronic or mechanical device, printed or written or oral, or recording for sound or visual reproduction or for use in any knowledge or retrieval system or device, unless permission in writing is obtained from the copyright proprietors.

CONTENTS

INTRODUCTION	7
CHAPTER 1—GENERAL REQUIREMENTS	9
1.1—Scope	9
1.2—Contract documents	14
1.3—Inspection	15
1.4—Approval of special systems of design or construction	17
CHAPTER 2—NOTATION AND DEFINITIONS.....	19
2.1—Code notation	19
2.2—Definitions	29
CHAPTER 3—MATERIALS.....	43
3.1—Tests of materials	43
3.2—Cementitious materials	43
3.3—Aggregates	44
3.4—Water	44
3.5—Steel reinforcement	45
3.6—Admixtures.....	50
3.7—Storage of materials	51
3.8—Referenced standards	51
CHAPTER 4—DURABILITY REQUIREMENTS	57
4.1—General.....	57
4.2—Exposure categories and classes	57
4.3—Requirements for concrete mixtures.....	59
4.4—Additional requirements for freezing-and-thawing exposure	62
4.5—Alternative cementitious materials for sulfate exposure	63
CHAPTER 5—CONCRETE QUALITY, MIXING, AND PLACING	65
5.1—General.....	65
5.2—Selection of concrete proportions	66
5.3—Proportioning on the basis of field experience or trial mixtures, or both	66
5.4—Proportioning without field experience or trial mixtures	71
5.5—Average compressive strength reduction	71
5.6—Evaluation and acceptance of concrete.....	72
5.7—Preparation of equipment and place of deposit	77
5.8—Mixing	78
5.9—Conveying.....	78
5.10—Depositing.....	79
5.11—Curing	79
5.12—Cold weather requirements	80
5.13—Hot weather requirements	81
CHAPTER 6—FORMWORK, EMBEDMENTS, AND CONSTRUCTION JOINTS.....	83
6.1—Design of formwork.....	83
6.2—Removal of forms, shores, and reshoring.....	83
6.3—Embedments in concrete	85
6.4—Construction joints	86
CHAPTER 7—DETAILS OF REINFORCEMENT	89
7.1—Standard hooks	89
7.2—Minimum bend diameters	89
7.3—Bending	90
7.4—Surface conditions of reinforcement	90
7.5—Placing reinforcement.....	91

7.6—Spacing limits for reinforcement	92
7.7—Concrete protection for reinforcement	93
7.8—Reinforcement details for columns	96
7.9—Connections.....	97
7.10—Transverse reinforcement for compression members	98
7.11—Transverse reinforcement for flexural members	101
7.12—Shrinkage and temperature reinforcement	101
7.13—Requirements for structural integrity.....	104
CHAPTER 8—ANALYSIS AND DESIGN—GENERAL CONSIDERATIONS	107
8.1—Design methods.....	107
8.2—Loading.....	107
8.3—Methods of analysis.....	108
8.4—Redistribution of moments in continuous flexural members	109
8.5—Modulus of elasticity	111
8.6—Lightweight concrete.....	111
8.7—Stiffness.....	112
8.8—Effective stiffness to determine lateral deflections.....	112
8.9—Span length.....	113
8.10—Columns.....	114
8.11—Arrangement of live load.....	114
8.12—T-beam construction.....	115
8.13—Joist construction.....	116
8.14—Separate floor finish.....	117
CHAPTER 9—STRENGTH AND SERVICEABILITY REQUIREMENTS.....	119
9.1—General.....	119
9.2—Required strength	119
9.3—Design strength.....	122
9.4—Design strength for reinforcement	126
9.5—Control of deflections	126
CHAPTER 10—FLEXURE AND AXIAL LOADS	135
10.1—Scope.....	135
10.2—Design assumptions	135
10.3—General principles and requirements.....	137
10.4—Distance between lateral supports of flexural members	140
10.5—Minimum reinforcement of flexural members.....	140
10.6—Distribution of flexural reinforcement in beams and one-way slabs.....	141
10.7—Deep beams	143
10.8—Design dimensions for compression members	144
10.9—Limits for reinforcement of compression members.....	144
10.10—Slenderness effects in compression members	146
10.11—Axially loaded members supporting slab system.....	154
10.12—Transmission of column loads through floor system.....	154
10.13—Composite compression members	155
10.14—Bearing strength	158
CHAPTER 11—SHEAR AND TORSION	161
11.1—Shear strength.....	161
11.2—Shear strength provided by concrete for nonprestressed members.....	164
11.3—Shear strength provided by concrete for prestressed members.....	166
11.4—Shear strength provided by shear reinforcement.....	169
11.5—Design for torsion.....	174
11.6—Shear-friction	186
11.7—Deep beams	189
11.8—Provisions for brackets and corbels.....	190
11.9—Provisions for walls	194
11.10—Transfer of moments to columns	196
11.11—Provisions for slabs and footings.....	196

CHAPTER 12—DEVELOPMENT AND SPLICES OF REINFORCEMENT	209
12.1—Development of reinforcement—General	209
12.2—Development of deformed bars and deformed wire in tension	210
12.3—Development of deformed bars and deformed wire in compression	212
12.4—Development of bundled bars	213
12.5—Development of standard hooks in tension	213
12.6—Development of headed and mechanically anchored deformed bars in tension	216
12.7—Development of welded deformed wire reinforcement in tension	218
12.8—Development of welded plain wire reinforcement in tension	220
12.9—Development of prestressing strand	220
12.10—Development of flexural reinforcement—General	222
12.11—Development of positive moment reinforcement	225
12.12—Development of negative moment reinforcement	226
12.13—Development of web reinforcement	227
12.14—Splices of reinforcement—General	230
12.15—Splices of deformed bars and deformed wire in tension	231
12.16—Splices of deformed bars in compression	233
12.17—Splice requirements for columns	234
12.18—Splices of welded deformed wire reinforcement in tension	236
12.19—Splices of welded plain wire reinforcement in tension	237
 CHAPTER 13—TWO-WAY SLAB SYSTEMS	 239
13.1—Scope	239
13.2—General	240
13.3—Slab reinforcement	241
13.4—Openings in slab systems	244
13.5—Design procedures	244
13.6—Direct design method	247
13.7—Equivalent frame method	254
 CHAPTER 14—WALLS	 259
14.1—Scope	259
14.2—General	259
14.3—Minimum reinforcement	260
14.4—Walls designed as compression members	261
14.5—Empirical design method	261
14.6—Nonbearing walls	262
14.7—Walls as grade beams	262
14.8—Alternative design of slender walls	263
 CHAPTER 15—FOOTINGS	 267
15.1—Scope	267
15.2—Loads and reactions	267
15.3—Footings supporting circular or regular polygon-shaped columns or pedestals	268
15.4—Moment in footings	268
15.5—Shear in footings	269
15.6—Development of reinforcement in footings	270
15.7—Minimum footing depth	270
15.8—Transfer of force at base of column, wall, or reinforced pedestal	270
15.9—Sloped or stepped footings	272
15.10—Combined footings and mats	273
 CHAPTER 16—PRECAST CONCRETE	 275
16.1—Scope	275
16.2—General	275
16.3—Distribution of forces among members	276
16.4—Member design	276
16.5—Structural integrity	277
16.6—Connection and bearing design	279

16.7—Items embedded after concrete placement	281
16.8—Marking and identification	281
16.9—Handling.....	281
16.10—Strength evaluation of precast construction.....	281
CHAPTER 17—COMPOSITE CONCRETE FLEXURAL MEMBERS.....	283
17.1—Scope.....	283
17.2—General	283
17.3—Shoring	284
17.4—Vertical shear strength.....	284
17.5—Horizontal shear strength.....	284
17.6—Ties for horizontal shear	285
CHAPTER 18—PRESTRESSED CONCRETE	287
18.1—Scope.....	287
18.2—General	288
18.3—Design assumptions	289
18.4—Serviceability requirements—Flexural members	290
18.5—Permissible stresses in prestressing steel.....	293
18.6—Loss of prestress	293
18.7—Flexural strength	294
18.8—Limits for reinforcement of flexural members.....	296
18.9—Minimum bonded reinforcement	296
18.10—Statically indeterminate structures.....	298
18.11—Compression members—Combined flexure and axial loads.....	299
18.12—Slab systems	300
18.13—Post-tensioned tendon anchorage zones	302
18.14—Design of anchorage zones for monostrand or single 16 mm diameter bar tendons	307
18.15—Design of anchorage zones for multistrand tendons	309
18.16—Corrosion protection for unbonded tendons	309
18.17—Post-tensioning ducts	310
18.18—Grout for bonded tendons.....	310
18.19—Protection for prestressing steel	311
18.20—Application and measurement of prestressing force.....	311
18.21—Post-tensioning anchorages and couplers.....	312
18.22—External post-tensioning	313
CHAPTER 19—SHELLS AND FOLDED PLATE MEMBERS	315
19.1—Scope and definitions	315
19.2—Analysis and design.....	317
19.3—Design strength of materials	319
19.4—Shell reinforcement.....	319
19.5—Construction.....	321
CHAPTER 20—STRENGTH EVALUATION OF EXISTING STRUCTURES	323
20.1—Strength evaluation—General	323
20.2—Determination of required dimensions and material properties	324
20.3—Load test procedure.....	325
20.4—Loading criteria	326
20.5—Acceptance criteria	326
20.6—Provision for lower load rating	328
20.7—Safety.....	328
CHAPTER 21—EARTHQUAKE-RESISTANT STRUCTURES	329
21.1—General requirements	329
21.2—Ordinary moment frames.....	335
21.3—Intermediate moment frames.....	335
21.4—Intermediate precast structural walls	339
21.5—Flexural members of special moment frames.....	340

21.6—Special moment frame members subjected to bending and axial load	346
21.7—Joints of special moment frames	350
21.8—Special moment frames constructed using precast concrete	354
21.9—Special structural walls and coupling beams	356
21.10—Special structural walls constructed using precast concrete	365
21.11—Structural diaphragms and trusses	366
21.12—Foundations	371
21.13—Members not designated as part of the seismic-force-resisting system	374
CHAPTER 22—STRUCTURAL PLAIN CONCRETE	377
22.1—Scope	377
22.2—Limitations	378
22.3—Joints	378
22.4—Design method	379
22.5—Strength design	380
22.6—Walls	381
22.7—Footings	382
22.8—Pedestals	384
22.9—Precast members	384
22.10—Plain concrete in earthquake-resisting structures	384
APPENDIX A—STRUT-AND-TIE MODELS	387
A.1—Definitions	387
A.2—Strut-and-tie model design procedure	394
A.3—Strength of struts	396
A.4—Strength of ties	399
A.5—Strength of nodal zones	400
APPENDIX B—ALTERNATIVE PROVISIONS FOR REINFORCED AND PRESTRESSED CONCRETE FLEXURAL AND COMPRESSION MEMBERS	403
B.1—Scope	403
APPENDIX C—ALTERNATIVE LOAD AND STRENGTH REDUCTION FACTORS.....	411
C.9.1—Scope	411
C.9.2—Required strength	411
C.9.3—Design strength	413
APPENDIX D—ANCHORING TO CONCRETE	417
D.1—Definitions	417
D.2—Scope	421
D.3—General requirements	422
D.4—General requirements for strength of anchors	430
D.5—Design requirements for tensile loading	436
D.6—Design requirements for shear loading	450
D.7—Interaction of tensile and shear forces	461
D.8—Required edge distances, spacings, and thicknesses to preclude splitting failure	462
D.9—Installation and inspection of anchors	463
APPENDIX E—STEEL REINFORCEMENT INFORMATION	467
APPENDIX F—EQUIVALENCE BETWEEN SI-METRIC, MKS-METRIC, AND U.S. CUSTOMARY UNITS OF NONHOMOGENOUS EQUATIONS IN THE CODE	469
COMMENTARY REFERENCES	477
INDEX	497

The ACI Building Code Requirements for Structural Concrete (“Code”) and Commentary are presented in a side-by-side column format, with Code text placed in the left column and the corresponding Commentary text aligned in the right column. To further distinguish the Code from the Commentary, the Code has been printed in Helvetica, the same type face in which this paragraph is set.

This paragraph is set in Times Roman, and all portions of the text exclusive to the Commentary are printed in this type face. Commentary section numbers are preceded by an “R” to further distinguish them from Code section numbers.

Substantive changes from 318M-08 are indicated with vertical lines in the margin (editorial changes not indicated).

INTRODUCTION

This Commentary discusses some of the considerations of Committee 318 in developing the provisions contained in “Building Code Requirements for Structural Concrete (ACI 318M-11),” hereinafter called the Code or the 2011 Code. Emphasis is given to the explanation of new or revised provisions that may be unfamiliar to Code users. In addition, comments are included for some items contained in previous editions of the Code to make the present commentary independent of the previous editions. 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 provisions of the Code. However, references to some of the research data are provided for those who wish to study the background material in depth.

As the name implies, “Building Code Requirements for Structural Concrete” 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, complete design procedures, or design aids.

The Code is intended to cover all buildings of the usual types, both large and small. Requirements more stringent than the Code provisions may be desirable for 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 licensed design professional 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.

^{*}For a history of the ACI Building Code, see Kerekes, F., and Reid, H. B., Jr., “Fifty Years of Development in Building Code Requirements for Reinforced Concrete,” *ACI JOURNAL*, *Proceedings* V. 50, No. 6, Feb. 1954, p. 441. For a discussion of code philosophy, see Siess, C. P., “Research, Building Codes, and Engineering Practice,” *ACI JOURNAL*, *Proceedings* V. 56, No. 5, May 1960, p. 1105.

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 it is adopted by the government bodies having the police power 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 usual construction. General references requiring compliance with the Code in the project specifications should be avoided since the contractor is rarely in a position to accept responsibility for design details or construction requirements that depend on a detailed knowledge of the design. Design-build construction contractors, however, typically combine the design and construction responsibility. Generally, the contract documents should contain all of 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 “Specifications for Structural Concrete (ACI 301M)” are written specifically for use as contract documents for construction.

It is recommended to have testing and certification programs for the individual parties involved with the execution of work performed in accordance with this Code. Available for this purpose are the plant certification programs of the Precast/Prestressed Concrete Institute, the Post-Tensioning Institute, and the National Ready Mixed Concrete Association; the personnel certification programs of the American Concrete Institute and the Post-Tensioning Institute; and the Concrete Reinforcing Steel Institute’s Voluntary Certification Program for Fusion-Bonded Epoxy Coating Applicator Plants. In addition, “Standard Specification for Agencies Engaged in Construction Inspecting and/or Testing” (ASTM

E329-09) specifies performance requirements for inspection and testing agencies.

Design reference materials illustrating applications of the Code requirements may be found in the following documents. The design aids listed may be obtained from the sponsoring organization.

Design aids:

“ACI Design Handbook,” Publication SP-17M(09), American Concrete Institute, Farmington Hills, MI, 2009, 252 pp. (This provides tables and charts for design of eccentrically loaded columns by the Strength Design Method of the 2005 Code. Provides design aids for use in the engineering design and analysis of reinforced concrete slab systems carrying loads by two-way action. Design aids are also provided for the selection of slab thickness and for reinforcement required to control deformation and assure adequate shear and flexural strengths.)

“ACI Detailing Manual—2004,” ACI Committee 315, Publication SP-66(04), American Concrete Institute, Farmington Hills, MI, 2004, 212 pp. (Includes the standard, ACI 315-99, and report, ACI 315R-04. Provides recommended methods and standards for preparing engineering drawings, typical details, and drawings placing reinforcing steel in reinforced concrete structures. Separate sections define responsibilities of both engineer and reinforcing bar detailer.)

“Guide to Durable Concrete (ACI 201.2R-08),” ACI Committee 201, American Concrete Institute, Farmington Hills, MI, 2008, 49 pp. (This describes specific types of concrete deterioration. It contains a discussion of the mechanisms involved in deterioration and the recommended requirements for individual components of the concrete, quality considerations for concrete mixtures, construction procedures, and influences of the exposure environment.)

“Guide for the Design of Durable Parking Structures (362.1R-97 (Reapproved 2002)),” ACI Committee 362, American Concrete Institute, Farmington Hills, MI, 1997, 33 pp. (This summarizes practical information regarding design of parking structures for durability. It also includes information about design issues related to parking structure construction and maintenance.)

“CRSI Handbook,” Concrete Reinforcing Steel Institute, Schaumburg, IL, tenth edition, 2008, 777 pp. (This provides tabulated designs for structural elements and slab systems. Design examples are provided to show the basis and use of the load tables. Tabulated designs are given for beams; square, round, and rectangular columns; one-way slabs; and

one-way joist construction. The design tables for two-way slab systems include flat plates, flat slabs, and waffle slabs. The chapters on foundations provide design tables for square footings, pile caps, drilled piers (caissons), and cantilevered retaining walls. Other design aids are presented for crack control and development of reinforcement and lap splices.)

“Reinforcement Anchorages and Splices,” Concrete Reinforcing Steel Institute, Schaumburg, IL, fifth edition, 2008, 100 pp. (This provides accepted practices in splicing reinforcement. The use of lap splices, mechanical splices, and welded splices are described. Design data are presented for development and lap splicing of reinforcement.)

“Structural Welded Wire Reinforcement Manual of Standard Practice,” Wire Reinforcement Institute, Hartford, CT, eighth edition, Apr. 2006, 38 pp. (This describes welded wire reinforcement material, gives nomenclature and wire size and weight tables. Lists specifications and properties and manufacturing limitations. Book has latest code requirements as code affects welded wire. Also gives development length and splice length tables. Manual contains customary units and soft metric units.)

“Structural Welded Wire Reinforcement Detailing Manual,” Wire Reinforcement Institute, Hartford, CT, 1994, 252 pp. (The manual, in addition to including ACI 318 provisions and design aids, also includes: detailing guidance on welded wire reinforcement in one-way and two-way slabs; precast/prestressed concrete components; columns and beams; cast-in-place walls; and slabs-on-ground. In addition, there are tables to compare areas and spacings of high-strength welded wire with conventional reinforcing.)

“PCI Design Handbook—Precast and Prestressed Concrete,” Precast/Prestressed Concrete Institute, Chicago, IL, seventh edition, 2010, 804 pp. (This provides load tables for common industry products, and procedures for design and analysis of precast and prestressed elements and structures composed of these elements. Provides design aids and examples.)

“Design and Typical Details of Connections for Precast and Prestressed Concrete,” Precast/Prestressed Concrete Institute, Chicago, IL, second edition, 1988, 270 pp. (This updates available information on design of connections for both structural and architectural products, and presents a full spectrum of typical details. This provides design aids and examples.)

“Post-Tensioning Manual,” Post-Tensioning Institute, Farmington Hills, MI, sixth edition, 2006, 354 pp. (This provides comprehensive coverage of post-tensioning systems, specifications, design aids, and construction concepts.)

CHAPTER 1 — GENERAL REQUIREMENTS

CODE

1.1 — Scope

1.1.1 — This Code provides minimum requirements for design and construction of structural concrete members of any structure erected under requirements of the legally adopted general building code of which this Code forms a part. In areas without a legally adopted building code, this Code defines minimum acceptable standards for materials, design, and construction practice. This Code also covers the strength evaluation of existing concrete structures.

For structural concrete, f'_c shall not be less than 17 MPa. No maximum value of f'_c shall apply unless restricted by a specific Code provision.

COMMENTARY

R1.1 — Scope

The American Concrete Institute “**Building Code Requirements for Structural Concrete (ACI 318M-11)**,” referred to as the Code or 2011 Code, provides minimum requirements for structural concrete design or construction.

The 2011 Code revised the previous standard “**Building Code Requirements for Structural Concrete (ACI 318M-08)**.” This standard includes in one document the rules for all concrete used for structural purposes including both plain and reinforced concrete. The term “structural concrete” is used to refer to all plain or reinforced concrete used for structural purposes. This covers the spectrum of structural applications of concrete from nonreinforced concrete to concrete containing nonprestressed reinforcement, prestressing steel, or composite steel shapes, pipe, or tubing. Requirements for structural plain concrete are in Chapter 22.

Prestressed concrete is included under the definition of reinforced concrete. Provisions of the Code apply to prestressed concrete except for those that are stated to apply specifically to nonprestressed concrete.

Chapter 21 of the Code contains provisions for design and detailing of earthquake-resistant structures. See 1.1.9.

Appendix A of Codes prior to 2002 contained provisions for an alternate method of design for nonprestressed reinforced concrete members using service loads (without load factors) and permissible service load stresses. The Alternate Design Method was intended to give results that were slightly more conservative than designs by the Strength Design Method of the Code. The Alternate Design Method of the 1999 Code may be used in place of applicable sections of this Code.

Appendix A of the Code contains provisions for the design of regions near geometrical discontinuities, or abrupt changes in loadings.

Appendix B of this Code contains provisions for reinforcement limits based on $0.75\rho_b$, determination of the strength reduction factor ϕ , and moment redistribution that have been in the Code for many years, including the 1999 Code. The provisions are applicable to reinforced and prestressed concrete members. Designs made using the provisions of Appendix B are equally acceptable as those based on the body of the Code, provided the provisions of Appendix B are used in their entirety.