

ACI 318M-08

**Building Code Requirements for
Structural Concrete (ACI 318M-08)
and Commentary**

An ACI Standard

Reported by ACI Committee 318



American Concrete Institute®

Deemed to satisfy ISO 19338:2007(E)



American Concrete Institute®
Advancing concrete knowledge

Third Printing
January 2010

Building Code Requirements for Structural Concrete 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.

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

ACI 318M-08 is deemed to satisfy ISO 19338:2007(E).

ISBN 978-0-87031-283-0

BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE (ACI 318M-08) AND COMMENTARY

REPORTED BY ACI COMMITTEE 318

ACI Committee 318
Structural Building Code

James K. Wight
Chair

Basile G. Rabbat
Secretary

Sergio M. Alcocer
Florian G. Barth
Roger J. Becker
Kenneth B. Bondy
John E. Breen
James R. Cagley
Ned M. Cleland
Michael P. Collins
W. Gene Corley
Charles W. Dolan
Anthony E. Fiorato

Catherine E. French
Luis E. Garcia
S. K. Ghosh
Lawrence G. Griffis
David P. Gustafson
D. Kirk Harman
James R. Harris
Neil M. Hawkins
Terence C. Holland
Kenneth C. Hover

James O. Jirsa
Dominic J. Kelly
Gary J. Klein
Ronald Klemencic
Cary Kopczynski
H. S. Lew
Colin L. Lobo
Robert F. Mast
W. Calvin McCall
Jack P. Moehle

Myles A. Murray
Julio A. Ramirez
Thomas C. Schaeffer
Stephen J. Seguirant
Roberto Stark
Eric M. Tolles
Thomas D. Verti
Sharon L. Wood
Loring A. Wyllie, Jr.
Fernando V. Yáñez

Subcommittee Members

Neal S. Anderson
Mark A. Aschheim
F. Michael Bartlett
John F. Bonacci
JoAnn P. Browning
Nicholas J. Carino
Ronald A. Cook
Juan P. Covarrubias

David Darwin
Robert J. Frosch
Harry A. Gleich
R. Doug Hooton
L. S. Paul Johal
Michael E. Kreger
Jason J. Krohn
Daniel A. Kuchma

Andres Lepage
LeRoy A. Lutz
James G. MacGregor
Joe Maffei
Karl F. Meyer
Denis Mitchell
Vilas S. Mujumdar

Suzanne D. Nakaki
Theodore L. Neff
Andrzej S. Nowak
Gustavo J. Parra-Montesinos
Jose A. Pincheira
Randall W. Poston
Bruce W. Russell

David H. Sanders
Guillermo Santana
Andrew Scanlon
John F. Stanton
Fernando Reboucas Stucchi
Raj Valluvan
John W. Wallace

Liaison Members

Mathias Brewer
Josef Farbiarz
Rafael Adan Ferrera-Boza

Alberto Giovambattista
Hector Hernandez
Angel E. Herrera

Hector Monzon-Despang
Enrique Pasquel
Victor F. Pizano-Batlle

Patricio A. Placencia
Oscar M. Ramirez
Mario E. Rodriguez

Consulting Members

C. Raymond Hays

Richard C. Meininger

Charles G. Salmon

BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE (ACI 318M-08) 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: drawings and specifications; 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 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); contraction joints; cover; curing; deep beams; deflections; drawings; 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; specifications; splicing; strength; strength analysis; stresses; **structural analysis**; **structural concrete**; **structural design**; structural integrity; T-beams; torsion; walls; water; welded wire reinforcement.

ACI 318M-08 was adopted as a standard of the American Concrete Institute November 2007 to supersede ACI 318M-05 in accordance with the Institute’s standardization procedure and was published July 2008.

A complete U.S. Customary unit companion to ACI 318M has been developed, 318; therefore, no U.S. Customary unit equivalents are included in 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 © 2008, 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—Drawings and specifications.....	13
1.3—Inspection.....	14
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	28
CHAPTER 3—MATERIALS.....	41
3.1—Tests of materials.....	41
3.2—Cementitious materials.....	41
3.3—Aggregates.....	42
3.4—Water.....	42
3.5—Steel reinforcement.....	43
3.6—Admixtures	49
3.7—Storage of materials.....	49
3.8—Referenced standards.....	49
CHAPTER 4—DURABILITY REQUIREMENTS	55
4.1—General	55
4.2—Exposure categories and classes	55
4.3—Requirements for concrete mixtures	57
4.4—Additional requirements for freezing-and-thawing exposure.....	60
4.5—Alternative cementitious materials for sulfate exposure.....	61
CHAPTER 5—CONCRETE QUALITY, MIXING, AND PLACING	63
5.1—General	63
5.2—Selection of concrete proportions.....	64
5.3—Proportioning on the basis of field experience or trial mixtures, or both	64
5.4—Proportioning without field experience or trial mixtures.....	69
5.5—Average compressive strength reduction.....	69
5.6—Evaluation and acceptance of concrete	70
5.7—Preparation of equipment and place of deposit.....	75
5.8—Mixing.....	76
5.9—Conveying	76
5.10—Depositing	77
5.11—Curing.....	77
5.12—Cold weather requirements	78
5.13—Hot weather requirements.....	79
CHAPTER 6—FORMWORK, EMBEDMENTS, AND CONSTRUCTION JOINTS	81
6.1—Design of formwork	81
6.2—Removal of forms, shores, and reshoring	81
6.3—Embedments in concrete	83
6.4—Construction joints.....	84
CHAPTER 7—DETAILS OF REINFORCEMENT	87
7.1—Standard hooks.....	87
7.2—Minimum bend diameters.....	87
7.3—Bending.....	88
7.4—Surface conditions of reinforcement.....	88
7.5—Placing reinforcement	89

7.6—Spacing limits for reinforcement	90
7.7—Concrete protection for reinforcement	91
7.8—Reinforcement details for columns	94
7.9—Connections.....	95
7.10—Lateral reinforcement for compression members	96
7.11—Lateral reinforcement for flexural members	98
7.12—Shrinkage and temperature reinforcement	98
7.13—Requirements for structural integrity.....	100
CHAPTER 8—ANALYSIS AND DESIGN—GENERAL CONSIDERATIONS	103
8.1—Design methods.....	103
8.2—Loading.....	103
8.3—Methods of analysis.....	104
8.4—Redistribution of moments in continuous flexural members	105
8.5—Modulus of elasticity	107
8.6—Lightweight concrete.....	107
8.7—Stiffness.....	108
8.8—Effective stiffness to determine lateral deflections.....	108
8.9—Span length	109
8.10—Columns	110
8.11—Arrangement of live load.....	110
8.12—T-beam construction.....	111
8.13—Joist construction.....	112
8.14—Separate floor finish.....	113
CHAPTER 9—STRENGTH AND SERVICEABILITY REQUIREMENTS.....	115
9.1—General.....	115
9.2—Required strength	115
9.3—Design strength	117
9.4—Design strength for reinforcement	121
9.5—Control of deflections	121
CHAPTER 10—FLEXURE AND AXIAL LOADS.....	129
10.1—Scope	129
10.2—Design assumptions	129
10.3—General principles and requirements.....	131
10.4—Distance between lateral supports of flexural members.....	134
10.5—Minimum reinforcement of flexural members	134
10.6—Distribution of flexural reinforcement in beams and one-way slabs	135
10.7—Deep beams	137
10.8—Design dimensions for compression members.....	138
10.9—Limits for reinforcement of compression members.....	138
10.10—Slenderness effects in compression members.....	140
10.11—Axially loaded members supporting slab system.....	148
10.12—Transmission of column loads through floor system	148
10.13—Composite compression members	149
10.14—Bearing strength	152
CHAPTER 11—SHEAR AND TORSION	155
11.1—Shear strength.....	155
11.2—Shear strength provided by concrete for nonprestressed members.....	158
11.3—Shear strength provided by concrete for prestressed members.....	160
11.4—Shear strength provided by shear reinforcement	163
11.5—Design for torsion	168
11.6—Shear-friction	180
11.7—Deep beams	183
11.8—Provisions for brackets and corbels.....	184
11.9—Provisions for walls.....	188
11.10—Transfer of moments to columns	190
11.11—Provisions for slabs and footings.....	190

CHAPTER 12—DEVELOPMENT AND SPLICES OF REINFORCEMENT	203
12.1—Development of reinforcement—General	203
12.2—Development of deformed bars and deformed wire in tension	204
12.3—Development of deformed bars and deformed wire in compression	206
12.4—Development of bundled bars	207
12.5—Development of standard hooks in tension	207
12.6—Development of headed and mechanically anchored deformed bars in tension	210
12.7—Development of welded deformed wire reinforcement in tension	212
12.8—Development of welded plain wire reinforcement in tension	213
12.9—Development of prestressing strand	214
12.10—Development of flexural reinforcement—General	216
12.11—Development of positive moment reinforcement	218
12.12—Development of negative moment reinforcement	220
12.13—Development of web reinforcement	220
12.14—Splices of reinforcement—General	224
12.15—Splices of deformed bars and deformed wire in tension	225
12.16—Splices of deformed bars in compression	227
12.17—Splice requirements for columns	228
12.18—Splices of welded deformed wire reinforcement in tension	230
12.19—Splices of welded plain wire reinforcement in tension	231
CHAPTER 13—TWO-WAY SLAB SYSTEMS	233
13.1—Scope	233
13.2—General	234
13.3—Slab reinforcement	235
13.4—Openings in slab systems	238
13.5—Design procedures	238
13.6—Direct design method	241
13.7—Equivalent frame method	248
CHAPTER 14—WALLS	253
14.1—Scope	253
14.2—General	253
14.3—Minimum reinforcement	254
14.4—Walls designed as compression members	255
14.5—Empirical design method	255
14.6—Nonbearing walls	256
14.7—Walls as grade beams	256
14.8—Alternative design of slender walls	257
CHAPTER 15—FOOTINGS	261
15.1—Scope	261
15.2—Loads and reactions	261
15.3—Footings supporting circular or regular polygon-shaped columns or pedestals	262
15.4—Moment in footings	262
15.5—Shear in footings	263
15.6—Development of reinforcement in footings	264
15.7—Minimum footing depth	264
15.8—Transfer of force at base of column, wall, or reinforced pedestal	264
15.9—Sloped or stepped footings	266
15.10—Combined footings and mats	267
CHAPTER 16—PRECAST CONCRETE	269
16.1—Scope	269
16.2—General	269
16.3—Distribution of forces among members	270
16.4—Member design	270
16.5—Structural integrity	271
16.6—Connection and bearing design	273

16.7—Items embedded after concrete placement	275
16.8—Marking and identification	275
16.9—Handling	275
16.10—Strength evaluation of precast construction	275
CHAPTER 17—COMPOSITE CONCRETE FLEXURAL MEMBERS.....	277
17.1—Scope	277
17.2—General	277
17.3—Shoring	278
17.4—Vertical shear strength.....	278
17.5—Horizontal shear strength	278
17.6—Ties for horizontal shear	279
CHAPTER 18—PRESTRESSED CONCRETE	281
18.1—Scope	281
18.2—General	282
18.3—Design assumptions	283
18.4—Serviceability requirements—Flexural members	284
18.5—Permissible stresses in prestressing steel.....	287
18.6—Loss of prestress	287
18.7—Flexural strength.....	289
18.8—Limits for reinforcement of flexural members	290
18.9—Minimum bonded reinforcement	291
18.10—Statically indeterminate structures.....	293
18.11—Compression members—Combined flexure and axial loads.....	294
18.12—Slab systems	294
18.13—Post-tensioned tendon anchorage zones	297
18.14—Design of anchorage zones for monostrand or single 16 mm diameter bar tendons	302
18.15—Design of anchorage zones for multistrand tendons	303
18.16—Corrosion protection for unbonded tendons	304
18.17—Post-tensioning ducts	304
18.18—Grout for bonded tendons.....	304
18.19—Protection for prestressing steel	306
18.20—Application and measurement of prestressing force	306
18.21—Post-tensioning anchorages and couplers	307
18.22—External post-tensioning	308
CHAPTER 19—SHELLS AND FOLDED PLATE MEMBERS	309
19.1—Scope and definitions	309
19.2—Analysis and design.....	311
19.3—Design strength of materials.....	313
19.4—Shell reinforcement.....	313
19.5—Construction	315
CHAPTER 20—STRENGTH EVALUATION OF EXISTING STRUCTURES	317
20.1—Strength evaluation—General	317
20.2—Determination of required dimensions and material properties	318
20.3—Load test procedure.....	319
20.4—Loading criteria	320
20.5—Acceptance criteria	320
20.6—Provision for lower load rating	322
20.7—Safety	322
CHAPTER 21—EARTHQUAKE-RESISTANT STRUCTURES	323
21.1—General requirements.....	323
21.2—Ordinary moment frames.....	328
21.3—Intermediate moment frames.....	329
21.4—Intermediate precast structural walls.....	333
21.5—Flexural members of special moment frames.....	333

21.6—Special moment frame members subjected to bending and axial load	339
21.7—Joints of special moment frames.....	343
21.8—Special moment frames constructed using precast concrete.....	347
21.9—Special structural walls and coupling beams	349
21.10—Special structural walls constructed using precast concrete.....	356
21.11—Structural diaphragms and trusses	357
21.12—Foundations	362
21.13—Members not designated as part of the seismic-force-resisting system	365
CHAPTER 22—STRUCTURAL PLAIN CONCRETE	369
22.1—Scope	369
22.2—Limitations	370
22.3—Joints.....	370
22.4—Design method.....	371
22.5—Strength design.....	371
22.6—Walls	373
22.7—Footings	374
22.8—Pedestals	376
22.9—Precast members	376
22.10—Plain concrete in earthquake-resisting structures	376
APPENDIX A—STRUT-AND-TIE MODELS	379
A.1—Definitions	379
A.2—Strut-and-tie model design procedure	386
A.3—Strength of struts	388
A.4—Strength of ties.....	391
A.5—Strength of nodal zones.....	392
APPENDIX B—ALTERNATIVE PROVISIONS FOR REINFORCED AND PRESTRESSED CONCRETE FLEXURAL AND COMPRESSION MEMBERS	395
B.1—Scope.....	395
APPENDIX C—ALTERNATIVE LOAD AND STRENGTH REDUCTION FACTORS	403
C.9.1—Scope	403
C.9.2—Required strength.....	403
C.9.3—Design strength	405
APPENDIX D—ANCHORING TO CONCRETE.....	409
D.1—Definitions.....	409
D.2—Scope	411
D.3—General requirements.....	412
D.4—General requirements for strength of anchors.....	414
D.5—Design requirements for tensile loading	419
D.6—Design requirements for shear loading.....	428
D.7—Interaction of tensile and shear forces.....	436
D.8—Required edge distances, spacings, and thicknesses to preclude splitting failure	437
D.9—Installation of anchors.....	438
APPENDIX E—STEEL REINFORCEMENT INFORMATION	439
APPENDIX F—EQUIVALENCE BETWEEN SI-METRIC, MKS-METRIC, AND U.S. CUSTOMARY UNITS OF NONHOMOGENOUS EQUATIONS IN THE CODE	441
COMMENTARY REFERENCES	449
INDEX.....	467

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.

Except for Chapters 4 and 21, substantive changes from 318M-05 are indicated with vertical lines in the margin (editorial changes not indicated). Changes to the provisions of Chapters 4 and 21 are not indicated by a vertical line because the provisions were renumbered for this edition.

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-08),” hereinafter called the Code or the 2008 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.

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 drawings, specifications, and 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

*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.

Program for Fusion-Bonded Epoxy Coating Applicator Plants. In addition, “Standard Specification for Agencies Engaged in Construction Inspecting and/or Testing” (ASTM E329-06a) 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-17(97), American Concrete Institute, Farmington Hills, MI, 1997, 482 pp. (This provides tables and charts for design of eccentrically loaded columns by the Strength Design Method of the 1995 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-01),**” ACI Committee 201, American Concrete Institute, Farmington Hills, MI, 2001, 41 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, 9th Edition, 2002, 648 pp. (This provides tabulated designs for structural elements and slab systems. Design examples are provided to show the basis of 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, 4th Edition, 1997, 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, 6th Edition, Apr. 2001, 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.)

“**Strength Design of Reinforced Concrete Columns,**” Portland Cement Association, Skokie, IL, 1978, 48 pp. (This provides design tables of column strength in terms of load in kips versus moment in ft-kips for concrete strength of 5000 psi and Grade 60 reinforcement. Design examples are included. Note that the PCA design tables do not include the strength reduction factor ϕ in the tabulated values; M_u/ϕ and P_u/ϕ must be used when designing with this aid.)

“**PCI Design Handbook—Precast and Prestressed Concrete,**” Precast/Prestressed Concrete Institute, Chicago, IL, 6th Edition, 2004, 736 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, 2nd 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, Phoenix, AZ, 6th 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-08)**,” referred to as the Code or 2008 Code, provides minimum requirements for structural concrete design or construction.

The 2008 Code revised the previous standard “**Building Code Requirements for Structural Concrete (ACI 318M-05)**.” 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 1.1.8.

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.