Reinforced Concrete Design

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Fundamentals and Practical Examples

By

Sayed Mahmoud

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PREFACE

The primary objective of this book is to present subject matter related to the analysis and design of reinforced concrete (RC) structures. The book provides the fundamentals of designing different structural elements subjected to flexure, shear, and axial loads. The book also presents the elements' reinforcement details in a simple way with the aid of practical examples and two- and three-dimensional figures.

The main goal of a structural designer is to achieve design safety and economy. Although design codes are adopted to provide structural engineers with the necessary requirements to minimize the occurrence of failure, it is necessary for structural designers to thoroughly understand the fundamentals of RC design along with the provisions to achieve a safe and economical design. For this purpose, familiarity with both design skills and codified procedures for RC elements is essential to establish a solid understanding of structural elements' design fundamentals and develop a professional design practice. The Building Code Requirements for Structural Concrete (ACI 318-19) was utilized in the design procedures. The book addresses the design fundamentals of individual structural elements, including horizontal elements such as beams and slabs and vertical elements such as columns, that are exposed to flexure, shear, and axial forces. The book is intended for use by undergraduate civil and architectural engineering students studying RC design courses. Moreover, fresh graduates and practicing engineers who are interested in structural design are also targeted.

The book includes a unique chapter, which works as a guide for converting architectural drawings to structural ones. This is a fundamental step to the success of distributing and calculating the loads acting on different elements. Several examples of real architectural drawings are used to clearly demonstrate the conversion process and to emphasize some of the issues raised. One of the strengths of the book is the inclusion of a chapter devoted to load distribution and calculations, clarifying the transfer of gravity loads from slabs to supporting beams for design. The book contains abundant two- and three-dimensional figures to simplify problem explanation and analysis procedures. In addition, several practical real-life examples are provided to enable the reader to deeply understand the discussed topic. Another strength of the book is that it provides data sheets

in the Appendices that include tables for performing analysis and design and figures for typical reinforcement details of the designed elements.

Throughout the book, the presented design procedures for structural elements follow the most updated code requirements. Moreover, they provide a roadmap enabling students and practicing engineers to create their own programming codes or to implement any of the available computer tools to increase the productivity of design practice.

Presented in **Chapter 1** are the mechanical properties of the constituent materials of RC in terms of concrete and steel reinforcing. Minimum design loads for buildings and other structures following the American Standard (ASCE-7-16) are summarized in **Chapter 2**. A guide for converting architectural drawings to structural ones is presented in **Chapter 3**. Understanding load distribution and its transfer throughout different structural elements is discussed in **Chapter 4**. Approximate methods for calculating the bending moment and shear forces are covered in **Chapter 5**. General information regarding the analysis and behavior of RC elements subjected to flexure is provided in **Chapter 6**. **Chapter 7** contains the analysis and design of singly reinforced rectangular sections. Concepts of the strength design method, its design assumptions, and the procedures to calculate the nominal strength of RC elements subjected to flexure are also presented in **Chapter 7**. Load factors, load combinations, and strength reduction factors are also covered. **Chapters 8 and 9** respectively present the analysis and design of flanged and doubly reinforced sections to flexure. **Chapter 10** covers the design and details of the reinforcement of one-way slabs. The design of RC sections subjected to shear forces is provided in **Chapter 11**. The principles and design requirements of RC short columns are presented in **Chapter 12**. Additionally, the design of axially loaded short columns is presented together with the corresponding reinforcement details. The design assumptions and techniques to determine the nominal strength of RC short columns subjected to flexure, axial load, or a combination of them are covered in detail, including the method of creating Interaction Diagrams of a specific RC column section. **Chapter 13** presents the bonding, development anchorage, and splicing of reinforcing steel bars. Deflection of structural elements, including the code limits as well as the methods of calculation for both short- and long-term deflections are illustrated in **Chapter 14** following the requirements of the ACI 318-19. **Chapter 15** explains the use of the working stress design method (allowable stress design) in designing RC elements that are subjected to flexural.

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—Prof. Sayed Mahmoud