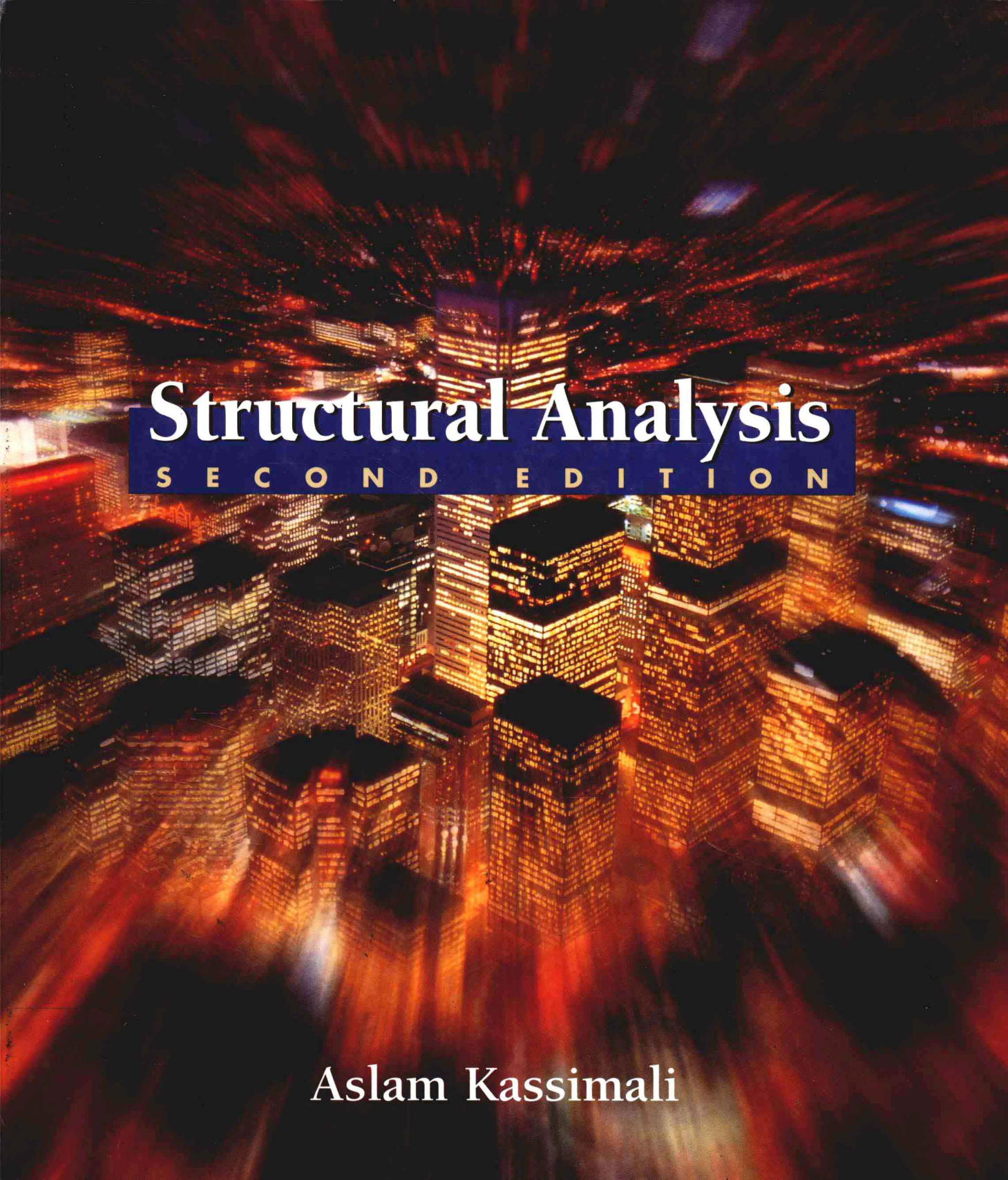
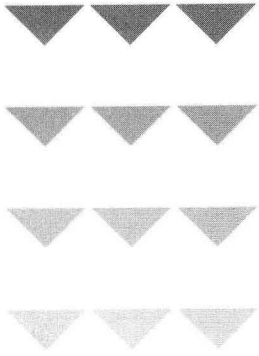

Structural Analysis
SECOND EDITION
Aslam Kassimali



STRUCTURAL ANALYSIS

SECOND EDITION

ASLAM KASSIMALI

Southern Illinois University—Carbondale

PWS Publishing
An Imprint of Brooks/Cole Publishing Company
An International Thomson Publishing Company

Pacific Grove • Albany • Belmont • Boston • Bonn • Cincinnati
Detroit • London • Madrid • Melbourne • Mexico City • New York
Paris • San Francisco • Singapore • Tokyo • Toronto • Washington

Product Development Editor: *Suzanne Jeans*
Marketing Team: *Nathan Wilbur, Margaret Parks, and Jean Thompson*
Editorial Assistant: *Major Mugrage*
Production Editor: *Tom Novack*
Interior Design: *David Abel*
Cover Design: *Roger Knox*
Cover Photo: *Al Harvey/Masterfile*
Production Management: *Interactive Composition Corporation*
Typesetting: *Interactive Composition Corporation*
Cover Printing: *Phoenix Color*
Printing and Binding: *R. R. Donnelley & Sons Co./Crawfordsville*

For more information, contact PWS Publishing at Brooks/Cole Publishing Company:

BROOKS/COLE PUBLISHING COMPANY
511 Forest Lodge Road
Pacific Grove, CA 93950
USA

International Thomson Publishing Europe
Berkshire House 168-173
High Holborn
London WC1V 7AA
England

Thomas Nelson Australia
102 Dodds Street
South Melbourne, 3205
Victoria, Australia

Nelson Canada
1120 Birchmount Road
Scarborough, Ontario
Canada M1K 5G4

International Thomson Editores
Seneca 53
Col. Polanco
11560 México, D. F. México

International Thomson Publishing GmbH
Königswinterer Strasse 418
53227 Bonn
Germany

International Thomson Publishing Asia
60 Albert Street
#15-01 Albert Complex
Singapore 189969

International Thomson Publishing Japan
Hirakawacho Kyowa Building, 3F
2-2-1 Hirakawacho
Chiyoda-ku, Tokyo 102
Japan

Printed in the United States of America

10 9 8 7 6 5 4

Library of Congress Cataloging-in-Publication Data

Kassimali, Aslam.
Structural analysis / Aslam Kassimali. —2nd ed.
p. cm. —(PWS series in civil engineering)
Includes bibliographical references and index.
ISBN 0-534-95324-7 (alk. paper)
1. Structural analysis (Engineering) I. Title. II. Series.
TA645.K37 1999
624.1'71—dc21 98–40454

STRUCTURAL ANALYSIS

THE PWS SERIES IN CIVIL ENGINEERING

Das, *Principles of Geotechnical Engineering*, Fourth Edition
Das, *Principles of Foundation Engineering*, Fourth Edition
Das, *Principles of Soil Dynamics*
Garber and Hoel, *Traffic and Highway Engineering,* Second Edition
Gere and Timoshenko, *Mechanics of Materials*, Fourth Edition
Kassimali, *Structural Analysis,* Second Edition
Miller and Cooper, *Visual Mechanics*
Oweis and Khera, *Geotechnology of Waste Management,* Second Edition
Ray, *Environmental Engineering*
Reynolds and Richards, *Unit Operations and Processes in Environmental Engineering,* Second Edition
Segui, *LRFD Steel Design,* Second Edition
Vesilind, *Introduction to Environmental Engineering*
Wolff, *Spreadsheet Applications in Geotechnical Engineering*

IN MEMORY OF *AMI*

PREFACE

The objective of this book is to develop an understanding of the basic principles of structural analysis. Emphasizing the intuitive classical approach, *Structural Analysis* covers the analysis of statically determinate and indeterminate beams, trusses, and rigid frames. It also presents an introduction to the matrix analysis of structures.

The book is divided into three parts. Part One presents a general introduction to the subject of structural engineering. It includes a chapter devoted entirely to the topic of loads because attention to this important topic is generally lacking in many civil engineering curricula. Part Two, consisting of Chapters 3 through 10, covers the analysis of statically determinate beams, trusses, and rigid frames. The chapters on deflections (Chapters 6 and 7) are placed before those on influence lines (Chapters 8 and 9), so that influence lines for deflections can be included in the latter chapters. This part also contains a chapter on the analysis of symmetric structures (Chapter 10). Part Three of the book, Chapters 11 through 17, covers the analysis of statically indeterminate structures. The format of the book is flexible to enable instructors to emphasize topics that are consistent with the goals of the course.

Each chapter of the book begins with an introductory section defining its objective and ends with a summary section outlining its salient features. An important general feature of the book is the inclusion of step-by-step procedures for analysis to enable students to make an easier transition from theory to problem solving. Numerous solved examples are provided to illustrate the application of the fundamental concepts.

A CD-ROM containing computer software for the analysis of plane frames, continuous beams, and trusses is attached to the back cover. This interactive software can be used to simulate a variety of structural and loading configurations and to determine cause versus effect relationships between loading and various structural parameters, thereby enhancing the students' understanding of the behavior of structures. A solutions manual, containing complete solutions to text exercises, is also available for the instructor.

A Note on the Revised Edition

In this second edition, the number of problems has been increased by about 33 percent (including some new design- and computer-oriented problems) to bring the total to over 500. The chapter on loads has been revised to meet the provisions of the ASCE 7-95 standard, and Appendix C rewritten to describe the new Windows® 95–based computer software, which has been upgraded to

include the effects of support settlements, temperature changes, and fabrication errors in the analysis. The new software also shows deflected shapes of structures, to enhance students' understanding of structural response due to various types of loadings. There are numerous other minor revisions, including an expanded discussion of sidesway of frames in Chapter 15, and many figures have been redrawn and rearranged to enhance clarity.

Acknowledgments

I wish to express my thanks to Suzanne Jeans of Brooks/Cole Publishing Company for her constant support and help throughout this project, and to Jonathan Plant, my editor for the first edition, for encouraging me to develop this second edition. The comments and suggestions for improvement from colleagues and students who have used the first edition are gratefully acknowledged. All of their suggestions were carefully considered, and implemented whenever possible. Thanks are also due to the following reviewers for their careful reviews of the manuscripts of the first and/or second editions, and for their constructive suggestions:

Ayo Abatan
Virginia Polytechnic Institute and State University

Riyad S. Aboutaha
Georgia Institute of Technology

Osama Abudayyeh
Western Michigan University

Thomas T. Baber
University of Virginia

Gordon B. Batson
Clarkson University

George E. Blandford
University of Kentucky

Ramon F. Borges
Penn State/Altoona College

Kenneth E. Buttry
University of Wisconsin

William F. Carroll
University of Central Florida

Malcolm A. Cutchins
Auburn University

Jack H. Emanuel
University of Missouri—Rolla

Fouad Fanous
Iowa State University

Leon Feign
Fairfield University

Robert Fleischman
University of Notre Dame

George Kostyrko
California State University

E. W. Larson
California State University/ Northridge

L. D. Lutes
Texas A&M University

Eugene B. Loverich
Northern Arizona University

David Mazurek
US Coast Guard Academy

Ahmad Namini
University of Miami

Arturo E. Schultz
North Carolina State University

Kassim Tarhini
Valparaiso University

Robert Taylor
Northeastern University

John Zachar
Milwaukee School of Engineering

C. C. Tung
North Carolina State University

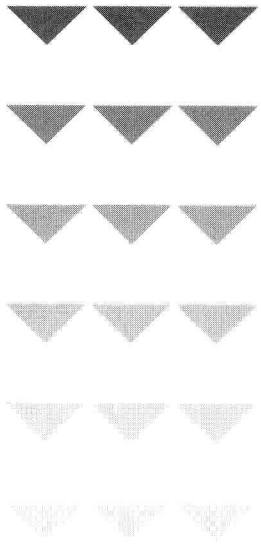
Mannocherh Zoghi
University of Dayton

Nicholas Willems
University of Kansas

Finally, I would like to express my loving appreciation to my wife, Maureen, for her constant encouragement and help in preparing this manuscript, and to my sons, Jamil and Nadim, for their enormous understanding and patience.

Aslam Kassimali

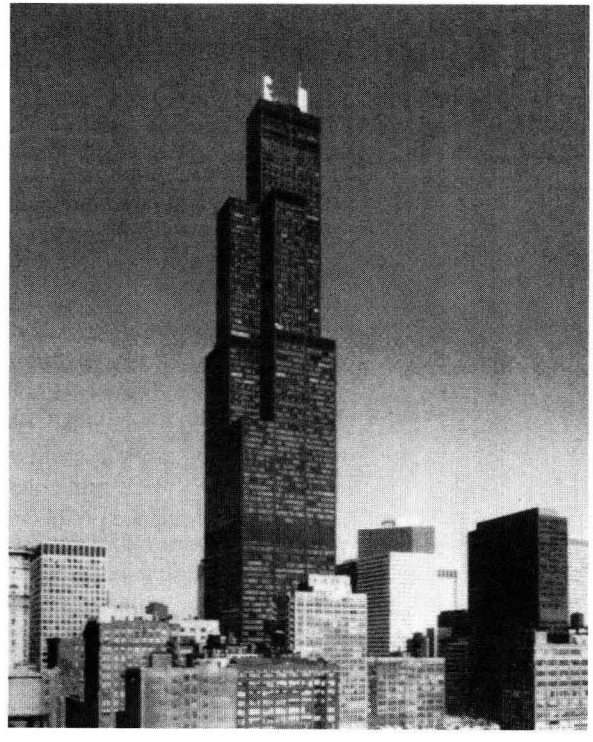
CONTENTS



PART ONE

INTRODUCTION TO STRUCTURAL ANALYSIS AND LOADS

1 INTRODUCTION TO STRUCTURAL ANALYSIS



The Sears Tower, Chicago
Photo courtesy of Bethlehem Steel Corporation