Simplified Mechanics and Strength of Materials

The Late Harry Parker, M.S.

FOURTH EDITION

JAMES AMBROSE, M.S.

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Preface

The purpose and scope of this book were stated by Professor Parker in the preface to the first edition, which is reprinted on the following pages.

The arguments for a "simplified" treatment of the basic topics of structural mechanics and strength of materials are as valid today as when Professor Parker made them in 1951. Studies and work in this field have grown increasingly sophisticated, yet the basic principles and the work required for investigation and design of most common elements of ordinary building structures are limited and elementary. This new edition retains the spirit and basic style of the original work, while offering a somewhat updated and slightly broadened treatment. Several topics have been added, including sliding friction, three-dimensional force systems, combined stresses, and rigid frames. For most of the work the mathematical treatment is limited to the use of algebra and geometry. In a few instances, however, elementary trigonometry has been used where it offers a more practical procedure.

In Professor Parker's early days of teaching both architecture and engineering students were extensively trained in drafting. The use of graphic techniques for force vector analysis was therefore popular. Sadly, the teaching of drafting has considerably declined, so that its use for analysis work is less practical. For most of the applied work in later chapters the computations are done entirely algebraically, although the development of graphic techniques has been retained in the early chapters.

I am grateful to the American Institute of Steel Construction, the National Forest Products Association, and the American Concrete Institute for their permission to reproduce and adapt materials from their publications. I am also grateful to the editors and production staff at

John Wiley and Sons for their patient and thorough work and their maintenance of high standards through the editing and production processes.

As usual, I am in debt to the many students who have passed (or not) through the courses that I have taught over the last 25 years; I have benefited selfishly from both their successes and their failures. Finally, I am grateful to my colleagues, my present students, and my family for their endurance and tolerance in the face of my absorption with this work.

JAMES AMBROSE

Westlake Village, California
June 1986

Preface to the First Edition

Since engineering design is based on the science of mechanics, it is impossible to overemphasize the importance of a thorough knowledge of this basic subject. Regardless of the particular field of engineering in which a student is interested, it is essential that he understand fully the fundamental principles that deal with the action of forces on bodies and the resulting stresses.

Each of the other volumes of this "simplified" series has, in general, dealt with the design of a particular material, structural steel, timber, and reinforced concrete. In each of these books is included only pertinent material, relating to the principles of mechanics, in the accompanying discussions and explanations. Obviously, such discussions and explanations are brief and limited in scope, and many important items are necessarily omitted. Students in engineering will find that the knowledge gained from a study of mechanics and strength of materials will enable them to understand more fully the theory of the design of structural members regardless of the material involved.

This is an elementary treatment written for those who have had limited preparation. The best books on the subject of mechanics and strength of materials make use of physics, calculus, and trigonometry. Such books are useless for many ambitious men. Consequently, this book has been prepared for the student who has not obtained a practical appreciation of mechanics or advanced mathematics. A working knowledge of algebra and arithmetic is sufficient to enable him to comprehend the mathematics involved in this volume.

This book has been written for use as a textbook in courses in mechanics and strength of materials and for use by practical men interested in mechanics and construction. Because it is elementary, the material has been arranged so that it may be used for home study. For

those who have had previous training it will serve as a refresher course in reviewing the most important of the basic principles of structural design.

One of the most important features of this book is a detailed explanation of numerous illustrative examples. In so far as possible, the examples relate to problems encountered in practice. The explanations are followed by problems to be solved by the student.

The designer of structural members must have at hand tables of allowable stresses, properties of sections, and other tables giving engineering data. Such tables are included in this book, and reference books are not required. The author is indebted to The American Concrete Institute, The American Institute of Steel Construction, The National Lumber Manufacturers Association, and the Timber Engineering Company for their kindness and cooperation in granting permission to reproduce tables and other data from their publications.

This book presents no short-cuts to a knowledge of the fundamental principles of mechanics and strength of materials. There is nothing unique in the presentation, for the discussions follow accepted present-day design procedure. It is the belief of the author, however, that a thorough understanding of the material contained herein will afford a foundation of practical information and serve as a step to further study.

HARRY PARKER

High Hollow
Southampton
Bucks County, Pennsylvania
May 1951

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Introduction

1-1. Mechanics

The science of *mechanics* concerns the actions of forces on material bodies. Most of engineering design is based on applications of the science of mechanics. *Statics* is the branch of mechanics that deals with forces in equilibrium or with bodies held motionless by the forces acting on them. *Dynamics* is the branch of mechanics that concerns bodies in motion or forces that are involved with time-dependent relationships.

1-2. Strength of Materials

When forces act on a material body, two things happen. First, internal forces that resist the effects of the external forces are set up in the body. These internal forces produce *stresses* in the material of the body. Second, the external forces produce *deformations* or changes in the shape of the body.

Strength of materials, or mechanics of materials, is the study of the properties of material bodies that enable them to resist the actions of external forces, of the stresses within the bodies, and of the deformations that result from the external forces.

1-3. Structural Mechanics

In architectural and civil engineering the related subjects of statics and strength of materials are often given the overall designation *structural mechanics* since they form the basis of structural design.

In general, an architect or engineer is confronted with two distinct types of problems, *design* and *investigation*. Design problems are problems in which the material, shape, and size of a body are to be determined in order that external forces may be resisted economically. Problems of investigation give as data the kind of material and its size and shape as well as the loads to be resisted by the body. The architect or engineer computes the magnitudes of the internal resisting forces (stresses) set up in the body in order to determine whether or not the size of the member is sufficiently large.

1-4. Units of Measurement

At the time of preparation of this edition, the building industry in the United States is still in a state of confused transition from the use of English units (feet, pounds, etc.) to the new metric-based system referred to as the SI units (for Système International). Although a complete phase-over to SI units seems inevitable, at the time of this writing the construction-materials and products suppliers in the United States are still resisting it. Consequently, the AISC Manual and most building codes and other widely used references are still in the old units. (The old system is now more appropriately called the U.S. system because England no longer uses it!) Although it results in some degree of clumsiness in the work, we have chosen to give the data and computations in this book in both units as much as is practicable. The technique is generally to perform the work in U.S. units and immediately follow it with the equivalent work in SI units enclosed in brackets [thus] for separation and identity.

Table 1-1 lists the standard units of measurement in the U.S. system with the abbreviations used in this work and a description of the type of the use in structural work. In similar form Table 1-2 gives the corresponding units in the SI system. The conversion units used in shifting from one system to the other are given in Table 1-3.

For some of the work in this book, the units of measurement are not significant. What is required in such cases is simply to find a nu-