STATICS AND STRENGTH OF MATERIALS

JENSEN AND CHENOWETH

THIRD EDITION

INTERNATIONAL STUDENT EDITION

Statics and Strength of Materials

Third Edition

by

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McGRAW-HILL KOGAKUSHA, LTD.

Tokyo Auckland Beirut Bogota Düsseldorf Johannesburg
Lisbon London Lucerne Madrid Mexico New Delhi Panama
Paris San Juan São Paulo Singapore Sydney

Library of Congress Cataloging in Publication Data

Jensen, Alfred.
Statics and strength of materials.

"Material . . . taken, unchanged, from two of the authors' previously published books. Statics . . . in book I of this volume . . . taken from part one of Applied engineering mechanics. Strength of materials . . . in book II . . . taken in its entirety from Applied strength of materials."
Includes indexes.
1. Statics. 2. Strength of materials. I. Chenoweth, Harry H., joint author. II. Title.
TA351.J4 1975 620.1'12 75-8820
ISBN 0-07-032472-7

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TOSHO PRINTING CO., LTD. TOKYO, JAPAN

Statics and Strength of Materials

By Alfred Jensen and
Harry H. Chenoweth

Applied Engineering Mechanics, Third Edition
Applied Strength of Materials, Third Edition
Statics and Strength of Materials, Third Edition

Preface

The subjects of statics and strength of materials have been arranged under one cover in this text in response to many requests from teachers at schools where the study of dynamics is not included in certain specialized curricula.

The material contained herein has been taken, unchanged, from two of the authors' previously published books. "Statics," contained in Book I of this volume, was taken from Part One of "Applied Engineering Mechanics." "Strength of Materials," contained in Book II, was taken in its entirety from "Applied Strength of Materials."

To avoid duplication of material, Chaps. 10 and 11 of "Statics" were deleted from Book I because the same material appears in Chap. 5 of Book II in slightly rearranged form. The authors recommend, however, that the material in Chap. 5, Centroids and Moments of Inertia of Areas, be taught in the statics course, as is usual, *after* completion of the study of the 10 chapters of Book I. By so doing, a better balance of quantity of material in each of the two courses will be achieved.

Virtually all the subject matter normally taught in the usual college courses in statics and strength of materials has been included in this book. However, formulas and mathematical relationships have been derived using only algebra and elementary trigonometry. The text material is based upon easily and commonly understood physical concepts and principles rather than upon the more abstract mathematical relationships which often are not so well understood. Hence, nothing more than a working knowledge of high school mathematics is required. However, for those wishing a more advanced treatment of some of the derivations, using the calculus, a number of such derivations are shown in Appendixes A to D.

The authors' primary aim has been to develop and to present the material in an easily understood manner in order to make the text suitable in content and approach both for college students in engineering and architecture, where a rigorous mathematical treatment of the subjects is not required, and for those in junior and community colleges, technical institutes, and in many industrial training and armed services programs. Further, the authors believe that this text will be a continuing aid to the many practicing engineers, architects, and engineering aides who in the past have found the earlier separate editions useful as reference texts.

During many years of teaching these subjects to community college and technical institute students, and in industrial training programs, the authors'

experience has proven to them conclusively that students learn more easily by studying the two subjects separately rather than in integrated form. Statics is essentially force analysis; that is, the determination of the *total* internal forces produced in members of a structure by externally applied loads. Statics in itself is not design of any part of a structure but is only a first step leading to design. In strength of materials these total internal forces, together with predetermined allowable unit stresses (usually pounds per square inch), are then used to determine the size of a structural member or part required to safely resist the external loads. This is design. In practice, these two steps definitely require separate solutions.

The content of Books I and II is divided into 22 chapters, each composed of several articles. Each article presents additional theory, a new concept, or a different aspect and contains one or more completely solved problems illustrating the application of some theory or concept. A number of problems then follow, carefully arranged in order of difficulty, more than one-third of which are supplied with answers. Classroom instructors may, upon request to the authors, obtain a list of answers to the remaining problems. Each chapter closes with a summary of the important points and formulas covered in the chapter. This summary affords students a quick review of the essential parts. The summary too is followed by a series of review problems and by a number of review questions carefully arranged to test the student's grasp of the subject matter.

In arranging and developing the subject matter, the authors have proceeded very gradually from the elementary problems to those more difficult, in the honest belief that, by such gradation, students learn more quickly and easily. Their experience has been that students learn more efficiently by thoroughly mastering one step at a time and later integrating the various steps and concepts into a completed whole.

The more than 1,200 problems in this text, of which 130 are solved in complete detail, together with more than 300 review questions, give students ample opportunity to test their understanding of the subject matter. Chapter 12, Book I, contains some interesting articles and many problems explaining and dealing with such varied, yet commonly encountered, engineering problems as hydrostatic pressure, buoyancy, hydrostatic loads, stability of retaining walls, flexible cables, and arches. Practical problems are used whenever possible, because they stimulate the students' interest and often lie within their personal experience or observation.

In the solution of analytical problems, mainly in statics, great emphasis is placed on the *complete* free-body diagram. Students are encouraged to develop this diagram gradually as the solution progresses until, upon completion of the problem, it shows all forces or their components. Simple arithmetical summations then prove the correctness of the solution without further computation. Analytical and graphical problems are presented side by side in order

to show their close relationship and to encourage students to use them concurrently, one as a check upon the other. Experience has shown that graphical solutions enable a student to *visualize* force analysis and that they definitely better the student's understanding of corresponding processes in analytical solutions.

In strength of materials, strong emphasis has been placed on the actual design of structural members, parts, and connections. This emphasis is of particular advantage to the many students who do not later take additional courses in design. It is also very helpful to those already employed in industry who have need for such a book for reference and self-study.

Because relatively few students have the opportunity to study separately the methods of manufacture and the properties of the various so-called "engineering" materials, a brief chapter discussing these items has been included in Book II. The subject matter of this chapter is informative rather than technical and is intended to give students only an elementary understanding of some of the most commonly used engineering materials.

Deflections of beams are determined (1) by the beam-diagram method and (2) by the moment-area method. In the beam-diagram method, two additional diagrams—the slope diagram and the deflection diagram—have been added to the load, shear, and moment diagrams to make a total of five consecutive diagrams, all of which are easily constructed by use of the two laws of beam diagrams. While this method is applicable only to a limited number of types of beams and loadings, it nevertheless has great teaching value because students understand it better than other methods and can easily construct the diagrams. More difficult problems are solved by the more complex, but excellent, moment-area method.

Special subjects, such as (1) axial stresses in members of two materials, (2) eccentrically loaded riveted joints, (3) design of laterally unsupported steel beams, (4) statically indeterminate beams, and (5) eccentrically loaded columns, have been included in the firm belief that students should not be unfamiliar with them. Any or all of these subjects may, of course, be omitted without disadvantage to the rest of the subject matter.

The new "Statics" section (Book I) retains the best of the well-tested problems found in previous editions but also provides new data for many other problems and presents more than a hundred new problems. Answers are also given in the text to many of the problems. New material in this section also includes a three-dimensional approach to space frames, V-belt theory and problems, jack screws, and a section on coriolis acceleration.

The following new materials have been added to "Strength of Materials" (Book II): (1) variation of stress with inclination of the exposing cutting plane and principal stresses and (2) prestressed beams. In addition, many problems have been changed and new problems have been added. The latest edition of the "Manual of Steel Construction" by the American Institute of Steel

Construction (AISC) has been followed where practical. Also included in Chapter 12 (Columns) in the "Strength of Materials" part are the latest formula and design procedures for the design of timber columns, recommended by the National Lumber Manufacturers Association. The older and more conservative formulas recommended by the Forest Products Laboratory are also included.

The authors are grateful to the many teachers who in the past have used their previously published books and who have so generously offered many constructive suggestions. Appreciation is also extended to the American Institute of Steel Construction for permission to reproduce from their handbook many of the tables in the Appendix.

Alfred Jensen and Harry H. Chenoweth

Contents

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Authors' Note: The material contained in Chapter 10, Centroids and Centers of Gravity, and Chapter 11, Moments of Inertia of Areas, is also found in Chapter 5 of Book II. It was deleted here to avoid duplication. See Preface, third paragraph.

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