国外大学优秀教材——土木工程系列（影印版）

钢结构

（第4版）

Applied Structural Steel Design

(Fourth Edition)

Leonard Spiegel
George F. Limbrunner

清华大学出版社

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序　言

土木工程专业是工科高等教育重要的方向，随着我国基本建设行业长期稳健发展，土木工程专业办学规模不断扩大、开设院校不断增加，对教材的要求也更加多样化和分层次化。同时，随着我国加入WTO、中国企业角逐国际工程、国外建筑企业挤入中国市场，使得土木工程专业教育对从内容到语言上能够与国际建筑业接轨的教材需求更加迫切。

鉴于这种趋势，清华大学出版社秉承在引进国外原版教材方面的领先优势，与全球高等教育出版巨擘——美国培生教育出版集团——合作，经过清华大学土木工程专业专家评审，精选出这套“国外大学优秀教材——土木工程系列（影印版）”教材。

“国外大学优秀教材——土木工程系列（影印版）”适合作为土木工程专业和相关建设类专业的原版教材，以及具有较好英文基础和专业背景、渴望了解国外相关领域知识的企业界人士学习使用。该系列第一批包括：《混凝土结构（第4版）》（Reinforced Concrete Design, 4e）和《钢结构（第4版）》（Applied Structural Steel Design,4e）。

另外，我社还出版了“国外大学优秀教材——建设管理系列（影印版）”，适合作为建设管理专业、相关经济类专业和土木工程专业使用，该系列包括：《房屋设计与施工案例分析》（Case Studies in Building Design and Construction）、《建筑工程合同（第3版）》（Construction Contracts, 3e）、《建筑工程估价（第5版）》（Estimating in Building Construction, 5e）、《建筑工程项目管理（专业版）》（Construction Project Management-Professional Edition）和《建筑施工计划与进度》（Construction Planning and Scheduling）。

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Preface

The primary objective of the fourth edition of *Applied Structural Steel Design* remains unchanged since its first edition: to furnish the reader with a basic understanding of the strength and behavior of structural steel members and their interrelationships in simple structural systems.

The emphasis of this edition remains on the analysis and design of structural steel elements in accordance with the American Institute of Steel Construction (AISC) Specification for Structural Steel Buildings—Allowable Stress Design (ASD) and the AISC Manual of Steel Construction—ASD, 9th Edition.

Allowable stress design has been the traditional design method for structural steel. A modern design method called *Load and Resistance Factor Design* (LRFD) was officially introduced in 1986 when AISC published the first edition of the Manual of Steel Construction—Load and Resistance Factor Design and the LRFD Specification for Structural Steel Buildings.

Both design methods are currently being used, and although most engineering professionals agree that LRFD will become the dominant method in the future, the traditional ASD method remains popular and practical and is still widely used. This edition is seen as a transitional text that bridges the two methods. ASD is utilized throughout the first 12 chapters. In these chapters, continual reference is made to the AISC Manual of Steel Construction—ASD, 9th edition, and its use as a ready reference and companion publication to the text is strongly recommended. The last two chapters furnish a simplified (but comprehensive) introduction to the LRFD method. Chapter 13 deals with structural members, and Chapter 14 covers basic connections.

In this fourth edition, discussions have been updated to reflect current information. Additionally, examples and homework problems reflect the greater usage of higher-strength steels, homework problems have been added, and some have been edited.

With a great amount of relevant structural steel research and literature available in various forms, it remains the intent of this book to translate this vast amount of information and data into an integrated source. It is not intended to be a comprehensive theoretical treatise of the subject, because we believe that such a document could easily obscure the fundamentals

that we strive to emphasize in engineering technology programs. In addition, we are of the opinion that adequate comprehensive books on structural steel design do exist for those who seek the theoretical background, the research studies, and more rigorous applications.

The text content has remained primarily an elementary, noncalculus, practical approach to the design and analysis of structural steel members, using numerous example problems and a step-by-step solution format. In addition, chapters on structural steel detailing of beams and columns are included in an effort to convey to the reader a feeling for the design-detailing sequence.

The book has been thoroughly tested over the years in our engineering technology programs and should serve as a valuable design guide and source for technologists, technicians, and engineering and architectural students. Additionally, it will aid engineers and architects preparing for state licensing examinations for professional registration.

As in the past, gratitude is extended to students, colleagues, and users of the book who, with their questions, helpful criticisms, suggestions, and enthusiastic encouragement, have provided input for this edition.

Thanks also to the reviewers of this edition for their suggestions and comments: Thomas Burns, University of Cincinnati; John W. Buttlewerth, Cincinnati State Technical and Community College; Sanjiv Gokhale, Purdue University; and Madan Mehta, University of Texas at Arlington.

George F. Limbrunner

Contents

Chapter 1

Introduction to Steel Structures

1-1 Steel Structures

The material steel, as we know it today, is a relatively modern human creation. Its forerunners, cast iron (which may have been invented in China as early as the fourth century B.C.) and wrought iron, were used in building and bridge construction from the mid-eighteenth century to the mid-nineteenth century. In the United States, however, the age of steel began when it was first manufactured in 1856. The first important use of steel in any major construction project was in the still-existing Eads Bridge at St. Louis, Missouri, which was begun in 1868 and completed in 1874. This was followed in 1884 by the construction of the first high-rise steel-framed building, the 10-story (later, 12-story) Home Insurance Company Building in Chicago. The rapid development of steel-framed buildings in the Chicago area at that time seems to have resulted from that city's position as the commercial center for the booming expansion of the Midwest's economy. The rapid expansion caused an increased demand for commercial building space. This demand resulted in soaring land prices that, in turn, made high-rise buildings more cost-effective.

Since those beginnings, steel has been vastly improved both in material properties and in methods and types of applications. Steel structures of note at present include the Akashi Kaikyo Bridge in Japan with a central suspension span of 1900 meters (6530 ft); a guyed radio mast in Poland with a height of 2120 ft; and the Sears Tower in Chicago, with 109 stories, which rises to 1454 ft. Each of these structures owes its notability (at least, in part) to the strength and quality of the steel of which it is made.

This is not to say that steel offers the builder an answer to all structural problems. The other major common building materials (concrete, masonry, and wood) all have their place and in many situations will offer economies that will dictate their use. But for building applications in which the ratio of strength to weight (or the strength per unit weight) must be kept high, steel offers feasible options.

Steels used in construction are generally *carbon steels,* alloys of iron and carbon. The carbon content is ordinarily less than 1% by weight. The chemical composition of the steel is varied, according to the properties desired, such as strength and corrosion resistance, by the addition of other alloying elements, such as silicon, manganese, copper, nickel, chromium, and vanadium, in very small amounts. When a steel contains a significant amount of any of such alloying elements, it is referred to as an *alloy steel.* Steel is not a renewable resource, but it can be recycled, and its primary component, iron, is plentiful.

Among the advantages of steel are uniformity of material and predictability of properties. Dimensional stability, ease of fabrication, and speed of erection are also beneficial characteristics of this building material. One may also list some disadvantages, such as susceptibility to corrosion (in most but not all steels) and loss of strength at elevated temperatures. Steel is not combustible, but it should be fireproofed to have any appreciable fire rating.

Some of the common types of steel structures are shown in Figure 1-1.