



Applied Structural Steel Design

Fourth Edition

Leonard Spiegel and George F. Limbrunner

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■ **Leonard Spiegel, P.E.**

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■ **George F. Limbrunner, P.E.**

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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

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Chapter 1

Introduction to Steel Structures

- 1-1 Steel Structures
- 1-2 Handbooks and Specifications
- 1-3 Steel Properties
- 1-4 Products Available
- 1-5 The Building Project
- 1-6 Design Considerations
- 1-7 Notation and Calculations

1-1

Steel Structures

The material steel, as we know it today, is a relatively modern human creation. Its fore-runners, 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.

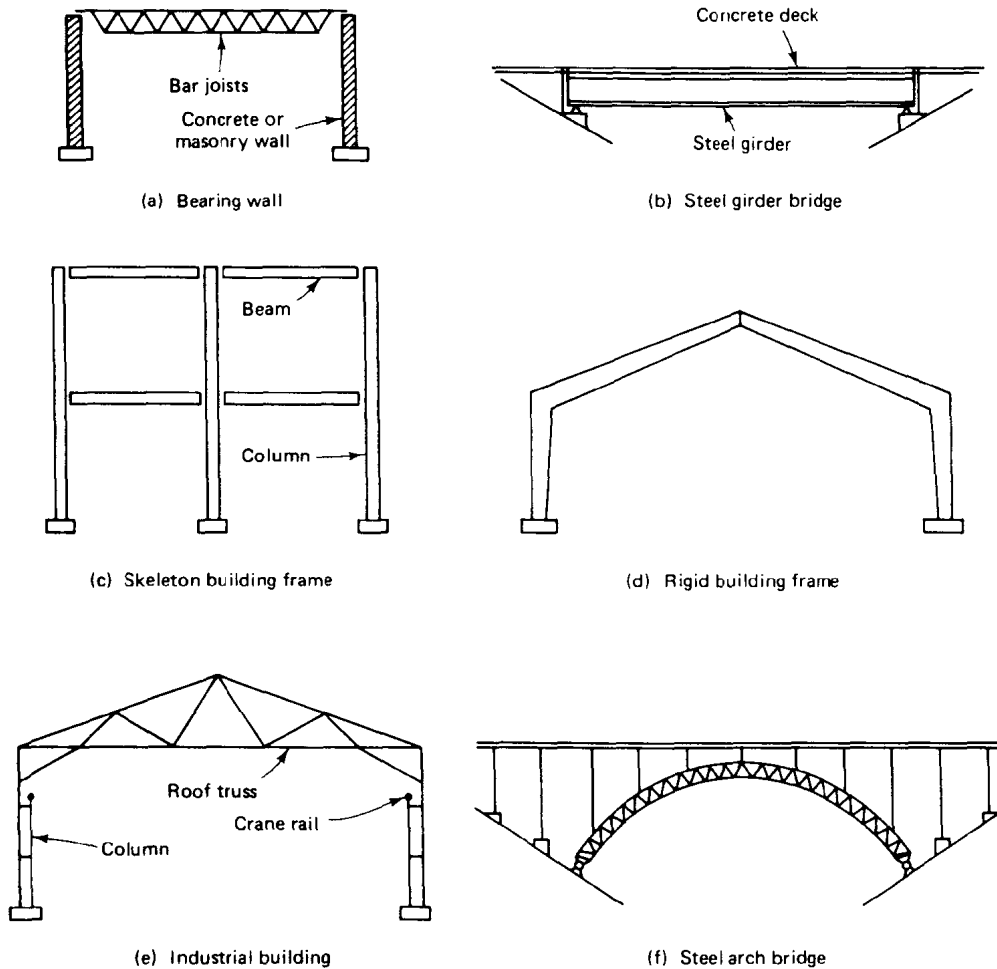


FIGURE 1-1 Types of steel structures.

1-2

Handbooks and Specifications

Structural steel is a manufactured product and is available in various grades, sizes, and shapes. The use of standard handbooks is absolutely essential to anyone working in any phase of steel construction.

The American Institute of Steel Construction (AISC) is a nonprofit trade association that represents and serves the steel construction industry. Its objective is to improve, advance,