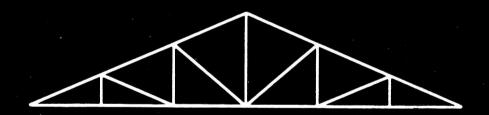
# STRUCTURAL STEEL DESIGN

Second Edition



second edition

# STRUCTURAL STEEL DESIGN

# JACK C. McCORMAC

Associate Professor of Civil Engineering Clemson University

Intext HARPER & ROW, PUBLISHERS New York Hagerstown San Francisco London STRUCTURAL STEEL DESIGN, Second Edition

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STEEL DESIGN

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# TO

my wife, Mary

and

daughters, Mary Christine and Ann Rebecca

# PREFACE TO SECOND EDITION

In 1969 the American Institute of Steel Construction, the American Association of State Highway Officials, and the American Railway Engineering Association made substantial revisions to their specifications for structural steel. This edition has been prepared with the primary objective of updating its contents to agree with these new specifications.

In addition many sections have been rewritten and additional material included. The homework problems have been almost completely changed and their number greatly increased. Based on requests from students, answers are included for approximately half of the problems.

The author is very grateful to the many persons who have taken the time to write to him concerning various phases of the text and will continue to be extremely interested in hearing from anyone regarding any part of the book. He is especially grateful to Dr. Oktay Ural, University of Missouri-Rolla, for his helpful suggestions and review of the manuscript for this edition.

Jack C. McCormac

Clemson, South Carolina May, 1971

# PREFACE TO FIRST EDITION

This book presents an elementary discussion of structural steel design. Its purpose is to set forth the fundamental theories necessary for the design of simple steel structures in such a manner as to create interest in the subject.

The design of individual members and their connections is discussed in Chapters 1 through 12. Chapters 13 through 20 treat designs for entire structures. Chapters 21 and 22 introduce the student to plastic analysis and design. A satisfactory background in the fundamentals of mechanics of materials and structural analysis is a prerequisite for this text.

It is strongly recommended that the student supplement the text by observing the actual erection of steel structures. If he develops an awareness of the details of steel construction, a large part of the purpose of this book will have been achieved, and the student will have made a long and important step toward becoming a structural designer.

Proficiency in the field of structures undoubtedly leads to many employment opportunities with appreciable economic rewards. Perhaps more important is the definite sense of accomplishment felt by the engineer in seeing the structures he has designed become reality and of service to the community.

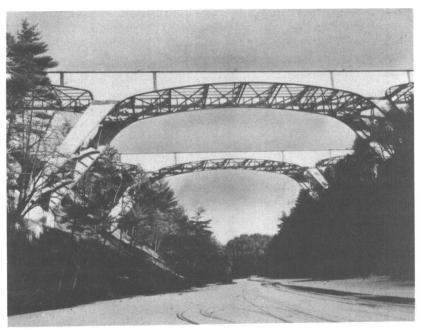
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Clemson, South Carolina May, 1965

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Jack C. McCormac



 $\begin{array}{cccc} \textbf{Mirror Lake Bridge, Wisconsin.} & \textit{(American Bridge Division,} \\ \textit{U.S. Steel Corporation.)} \end{array}$ 

# CONTENTS

chapter 1
INTRODUCTION TO STRUCTURAL STEEL DESIGN 1
Advantages of Steel as a Structural Material. Disadvantages of Steel as a Structural Material. The Structural Designer. Objectives of the Structural Designer. Factor of Safety. Failures of Engineering Structures. Specifications. Variations in Designs. Slide-Rule Computations. Charts and Tables.
chapter 2
PROPERTIES OF STRUCTURAL STEEL
Stress-Strain Relationships in Structural Steel. Elastic and Plastic Design Methods Defined. Steel Sections. Modern Structural Steels. Furnishing of Structural Steel. Design of Steel Members.
chapter 3
TENSION MEMBERS
Introduction. Allowable Tensile Stress. Net Section. Effect of Staggered Holes. Design of Tension Members. Splices for Tension Members. Design of Rods and Bars. Eye-Bar Tension Members. Problems.
chapter 4
INTRODUCTION TO COMPRESSION MEMBERS 54
General. Residual Stresses. Sections Used for Columns. Development of Column Formulas. Derivation of the Euler Formula. Revisions to Euler Formula. Problems.
xiii

chapter 5
DESIGN OF COMPRESSION MEMBERS 72
Practical Design Formulas. Straight-Line Formulas. Parabolic Formulas. Gordon-Rankine Formula. The Secant Formula. The AISC Formulas. Effective Column Lengths. Design of Columns with AISC Formulas. Lacing and Tie Plates. Base Plates for Concentrically Loaded Columns. Problems.
chapter 6
DESIGN OF BEAMS 104
Types of Beams. The Flexure Formula. Selection of Beams. Holes in Beams. Lateral Support of Beams. Design of Laterally Unsupported Beams. Design of Continuous Members. Problems.
chapter 7
DESIGN OF BEAMS (CONTINUED)
Shear. Web Crippling. Vertical Buckling of Webs. Maximum Deflections of Beams. Unsymmetrical Bending. Design of Purlins. The Shear Center. Lintels. Beam-Bearing Plates. Problems.
chapter 8
BENDING AND AXIAL STRESS
Occurrence. Calculation of Stresses. Specifications for Combined Stresses. Design for Axial Compression and Bending. AISC Requirements. Design of Beam-Columns-AISC. Combined Axial Tension and Bending. Further Discussion of Effective Lengths of Columns. Problems.
chapter 9
RIVETED CONNECTIONS

General. Inspection of Rivets. Types of Rivets. Types of Joints. Failure of Riveted Joints. Variations from Actual Stresses. Spacing and Edge Distances of Rivets. Strength of Riveted Connections—Rivets in Shear. Rivets Subjected to Eccentric Shear. Rivets Subjected to Combined Shear and Tension. Rivets in Tension. Problems.

chapter 10
BOLTED CONNECTIONS 230
Types of Bolts. Discussion of High-Strength Bolts. Advantages of High-Strength Bolts. Specifications for High-Strength Bolts. Installation of High-Strength Bolts. Shearing Resistance of Bolted Joints. Tension Loads on Bolted Joints. Prying Action. Bolts Subjected to Combined Shear and Tension. Problems.
chapter 11
WELDED CONNECTIONS
General. Advantages of Welding. Types of Welding. Welding Inspection. Classification of Welds. Welding Symbols. Butt Welds. Fillet Welds. Strength of Fillet Welds. AISC Requirements. Design of Simple Fillet Welds. Design of Fillet Welds for Truss Members. Shear and Torsion. Shear and Bending. Problems.
chapter 12
BUILDING CONNECTIONS
Selection of Type of Fastener. Types of Beam Connections. Standard Riveted or Bolted Beam Connections. Semirigid and Rigid Riveted or Bolted Connections. Types of Welded Beam Connections. Welded Web Angles. Design of Welded Seated Beam Connections. Welded Stiffened Beam Seat Connections. Welded Moment; Resistant Connections. Problems.
chapter 13
DESIGN OF STEEL BUILDINGS
Introduction. Types of Steel Frames Used for Buildings, Common Types of Floor Construction. Concrete Slabs on Open-Web Steel Joists. One-Way and Two-Way Reinforced Concrete Slabs. Composite Floors. Concrete-Pan Floors. Structural Clay Tile, Gypsum Tile, and Concrete-Block Floors. Steel-Decking Floors. Flat Slabs. Precast Concrete Floors. Types of Roof Construction. Exterior Walls and Interior Partitions. Design Live Loads (Vertical). Wind and Earthquake Loadings.
chapter 14
INTRODUCTION TO STEEL BRIDGES 344

General. Through, Deck and Halt-Through Bridges. Erection Methods for Bridges. The Beam Bridge. The Plate Girder Bridge. Truss Bridges for Medium Spans. Subdivided Truss Bridges. Continuous Bridge Trusses. Cantilever Bridges. Steel Arches. Suspension Bridges. Miscellaneous Bridge Types. Summary of Bridge Types. Comparison of High Level Bridges and Low Level Movable Bridges. Movable Bridges. Selection of Bridge Type. Spacing of Piers and Abutments. Live Loads for Highway Bridges. Live Loads for Railway Bridges.

chapter 15		
COMPOSITE	DESIGN	 372

Composite Construction. Advantages of Composite Construction. Discussion of Shoring. Effective Flange Widths. Stress Calculations for Composite Sections. Shear Transfer. Proportioning Composite Sections. Design of Encased Sections. Design of Composite Sections Using AASHO Specifications. Miscellaneous. Problems.

chapter 10					
BUILT-UP	BEAMS	AND	PLATE	GIRDERS	 407

Cover-Plated Beams. Introduction to Plate Girders. Comments on Specifications. Proportions of Plate Girders—AASHO and AREA. Cutting Off Cover Plates—AASHO, AREA, and AISC. Cover-Plate and Flange Connectors—AASHO, AREA, and AISC. Stiffeners—AASHO. Longitudinal Stiffeners—AASHO. Web Splices—AASHO, AREA, and AISC. Proportions of Webs—AISC. Proportions of Flange—AISC. Design of Stiffeners—AISC. Example Plate Girder Design—AISC. Problems.

chapter 17	
DESIGN OF ROOF TRUSSES	450

Introduction. Types of Roof Trusses. Selection of Type of Roof Truss. Spacing and Support of Roof Trusses. Estimated Weight of Roof Trusses. Discussion of Roof Truss Analysis. Example Analysis of a Roof Truss. Design of a Roof Truss. Trusses for Industrial Buildings. Roof Truss Bracing. Problems.



Introduction. Bridge Floor System. Live-Load Truss Stresses. Truss Dead Loads. Selection of Truss Members. Lateral Bracing. Bridge-Truss Deflections. End Bearings for Bridges. Problems.

chapter 19
DESIGN OF RIGID FRAMES
Introduction. Supports for Rigid Frames. Rigid-Frame Knees. Approximate Analysis of Rigid Frames. "Exact" Analysis of Rigid Frames. Preliminary Design. Final Design and Details. Plastic Design of Rigid Frames. Problems.
chapter 20
MULTISTORY BUILDINGS
Introduction. Column Splices. Discussion of Lateral Forces. Types of Lateral Bracing. Analysis of Buildings with Diagonal Wind Bracing for Lateral Forces. Moment-Resisting Joints. Analysis of Buildings with Moment-Resisting Joints for Lateral Loads. Analysis of Buildings for Gravity Loads. Design of Members.
chapter 21
PLASTIC ANALYSIS
Introduction. Theory of Plastic Analysis. The Plastic Hinge. The Plastic Modulus. Factors of Safety and Load Factors. The Collapse Mechanism. Plastic Analysis by the Equilibrium Method. The Virtual-Work Method. Location of Plastic Hinge for Uniform Loadings. Problems.
chapter 22
PLASTIC ANALYSIS AND DESIGN
Introduction to Plastic Design. AISC Requirements for Plastic Design. Continuous Beams. Plastic Analysis of Frames. Conclusion of Text. Problems.
INDEX 601

# chapter 1 INTRODUCTION TO STRUCTURAL STEEL DESIGN

### 1-1. ADVANTAGES OF STEEL AS A STRUCTURAL MATERIAL

A person traveling in the United States might quite understandably decide that steel was the perfect structural material. He would see an endless number of steel bridges, buildings, towers, and other structures—comprising, in fact, a list too lengthy to enumerate. After seeing these numerous steel structures he might be quite surprised to learn that steel was not made in the United States until 1856 and the first wide-flange beams were not rolled until 1908.

His assumption of the perfection of this metal, perhaps the most versatile of structural materials, would appear to be even more reasonable when he considered its great strength, light weight, ease of fabrication, and many other desirable properties. These and other advantages of structural steel are discussed in detail in the following paragraphs.

High Strength. The high strength of steel per unit of weight means dead loads will be small. This fact is of great importance for long-span bridges, tall buildings, and for structures having poor foundation conditions.

Uniformity. The properties of steel do not change appreciably with time as do those of a reinforced-concrete structure.

Elasticity. Steel behaves closer to design assumptions than most materials because it follows Hooke's law up to fairly high stresses. The moments of inertia of a steel structure can be definitely calculated while the values obtained for a reinforced concrete structure are rather indefinite.

Permanence. Steel frames that are properly maintained will last indefinitely. Research on some of the newer steels indicates that under certain conditions no painting maintenance whatsoever will be required.

Ductility. The property of a material by which it can withstand extensive deformation without failure under high tensile stresses is said to be its ductility. When a mild steel member is being tested in tension,

a considerable reduction in cross section and a large amount of elongation will occur at the point of failure before the actual fracture occurs. A material that does not have this property is probably hard and brittle and might break if subjected to a sudden shock.

In structural members under normal loads, high stress concentrations develop at various points. The ductile nature of the usual structural steels enables them to yield locally at those points, thus preventing premature failures. A further advantage of ductile structures is that when overloaded their large deflections give visible evidence of impending failure (sometimes jokingly referred to as "running time").

Additions to Existing Structures. Steel structures are quite well suited to having additions made to them. New bays or even entire new wings can be added to existing steel frame buildings, and steel bridges may often be widened.

Miscellaneous. Several other important advantages of structural steel are: (a) adaptation to prefabrication, (b) speed of erection, (c) weldability, (d) toughness and fatigue strength, (e) possible reuse after a structure is disassembled, and (f) scrap value even though not reusable in its existing form.

# 1-2. DISADVANTAGES OF STEEL AS A STRUCTURAL MATERIAL

In general steel has the following disadvantages:

Maintenance Costs. Most steels tend to corrode when freely exposed to air and must be periodically painted.

Fireproofing Costs. The strength of structural steel is tremendously reduced at temperatures which are commonly reached in fires. The steel frame of a building must be fireproofed to obtain an appreciable fire rating. It is to be remembered, however, that steel itself is not combustible.

Susceptibility to Buckling. The longer and slenderer compression members, the greater the danger of buckling. As previously indicated, steel has a high strength per unit weight and when used for steel columns is sometimes not economical because considerable material has to be used merely to stiffen the columns against buckling.

### 1-3. THE STRUCTURAL DESIGNER

The structural designer can take great pride in his part in the development of our country. Cities, farmlands, and industrial areas of the United States are filled with the amazing structures designed by members of his profession. But even this remarkable array of structures will be merely child's play compared to the structural endeavors of the next few