STEEL CONSTRUCTION

MANUAL

An Online Resource

AMERICAN INSTITUTE
OF
STEEL CONSTRUCTION

FIFTEENTH EDITION

CONTENTS

by

American Institute of Steel Construction

ISBN 978-1-56424-033-0

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Printed in the United States of America

This resource is based upon the
Steel Construction Manual, 15th Ed., First Printing: May 2017

DEDICATION

This edition of the *AISC Steel Construction Manual* is dedicated to Robert O. Disque, a retired AISC staff member and long-time member of the AISC Committee on Manuals. Bob, or Mr. Steel, as his friends on the Committee call him, worked closely with the Committee on Manuals, developing the 1st Edition of the LRFD *Manual of Steel Construction* and the 9th Edition ASD *Manual of Steel Construction*. After retiring from AISC in 1991, Bob continued to be involved with the Committee as a member.

He joined AISC in 1959, after working as a structural designer for firms in Philadelphia and New York. His career at AISC began as a District Engineer in Pittsburgh, where he marketed to architects and engineers by providing them with the latest technical information on structural steel. After a brief period as Assistant Chief Engineer, he was promoted to Chief Engineer in 1963 at AISC headquarters, which, at that time, was in New York City. In this capacity, Bob supervised 32 engineers throughout the country. In 1964, he launched the first AISC lecture series on steel design, educating thousands of engineers across the country on various topics related to steel design and construction.

In 1979, Bob left AISC for a brief stint as an associate professor of Civil Engineering at the University of Maine, only to return to AISC a few years later as Assistant Director of Engineering in Chicago, where AISC made its home in the early 1980s. It was at this time that he worked on the development of the two aforementioned AISC *Manuals*. In 1991, Bob retired from AISC and joined the consulting firm of Gibble, Norden, Champion and Brown in Old Saybrook, Connecticut.

Bob invented many things that today are the norm. He created the "snug tight" concept for bolted joints, in conjunction with his contemporary and fellow Manual Committee member Ted Winneberger of W&W Steel Company of Oklahoma City. He coined the term "anchor rods" to highlight that bolts are not rods; the astute reader will also note that it incorporates his initials. He advanced the use of flexible moment connections, formerly known as "Type 2 with Wind Connections," as a simplified and economical design approach based on the beneficial inelastic behavior of steel.

Bob shared his knowledge of structural steel by authoring numerous papers and the textbook, *Applied Plastic Design of Steel*. He also co-authored the textbook, *Load and Resistance Factor Design of Steel Structures*, with Louis F. Geschwindner and Reidar Bjorhovde. Of greatest importance to this Manual, however, Bob always emphasized that the Manual is not a textbook, but rather a handbook to provide design guidance and aids for practicing engineers.

For all that he has done to advance the practice of structural steel design, this Committee of friends and former colleagues is pleased to dedicate this 15th Edition *Manual* to Mr. Steel.

FOREWORD

The American Institute of Steel Construction, founded in 1921, is the nonprofit technical standards developer and trade organization for the fabricated structural steel industry in the United States. AISC is headquartered in Chicago and has a long tradition of service to the steel construction industry providing timely and reliable information.

The continuing financial support and active participation of Members in the engineering, research and development activities of the Institute make possible the publishing of this *Steel Construction Manual.* Those Members include the following: Full Members engaged in the fabrication, production and sale of structural steel; Associate Members, who include erectors, detailers, service consultants, software developers, and steel product manufacturers; Professional Members, who are structural or civil engineers and architects, including architectural and engineering educators; Affiliate Members, who include general contractors, building inspectors and code officials; and Student Members.

The Institute's objective is to make structural steel the material of choice, by being the leader in structural-steel-related technical and market-building activities, including specification and code development, research, education, technical assistance, quality certification, standardization and market development.

To accomplish this objective, the Institute publishes manuals, design guides and specifications. Best known and most widely used is the *Steel Construction Manual*, which holds a highly respected position in engineering literature. The Manual is based on the *Specification for Structural Steel Buildings* and the *Code of Standard Practice for Steel Buildings and Bridges*. Both standards are included in the Manual for easy reference.

The Institute also publishes technical information and timely articles in its *Engineering Journal*, Design Guide series, *Modern Steel Construction* magazine, and other design aids and research reports. Nearly all of the information AISC publishes is available for download from the AISC web site at **www.aisc.org**.

PREFACE

This Manual is the 15th Edition of the AISC *Steel Construction Manual*, which was first published in 1927. It replaces the 14th Edition *Manual* originally published in 2011.

The following specifications, codes and standards are printed in Part 16 of this Manual:

- 2016 AISC *Specification for Structural Steel Buildings*
- 2014 RCSC *Specification for Structural Joints Using High-Strength Bolts*
- 2016 AISC *Code of Standard Practice for Steel Buildings and Bridges*

The following resources supplement the Manual and are available on the AISC web site at **www.aisc.org:**

- AISC *Design Examples*, which illustrate the application of tables and specification provisions that are included in this Manual.
- AISC *Shapes Database V15.0 and V15.0H.*
- Background and supporting literature (references) for the AISC *Steel Construction Manual.*

The following major changes and improvements have been made in this revision:

- All tabular information and discussions are updated to comply with the 2016 *Specification for Structural Buildings*, and the standards and other documents referenced therein.
- Shape information is updated to ASTM A6/A6M-14 throughout this Manual. Larger pipe, HSS and angle sizes have also been incorporated into the dimensions and properties tables in Part 1.
- The available compressive strength tables are expanded to include 65- and 70-ksi steel for a limited number of shapes.
- In Part 6, a new design aid is included that provides the width-to-thickness slenderness limits for various steel strengths.
- In Part 6, a new design aid is included that provides the available flexural strength, available shear strength, available compressive strength, and available tensile strength for W-shapes in one table.
- In Part 9, a new interaction equation is provided for connection design based on a plastic strength approach.
- In Part 9, a new approach to designing coped beams is presented based on recent studies.

In addition, many other improvements have been made throughout this Manual.

By the AISC Committee on Manuals,

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The committee gratefully acknowledges the contributions made to this Manual by the AISC Committee on Specifications and the following individuals: W. Scott Goodrich, Heath Mitchell, William N. Scott, Marc L. Sorenson, and Sriramulu Vinnakota.

SCOPE

The specification requirements and other design recommendations and considerations summarized in this Manual apply in general to the design and construction of steel buildings and other structures.

The design of seismic force-resisting systems also must meet the requirements in the AISC *Seismic Provisions for Structural Steel Buildings*, except in the following cases for which use of the AISC *Seismic Provisions* is not required:

- Buildings and other structures in seismic design category (SDC) A
- Buildings and other structures in SDC B or C with $R = 3$ systems [steel systems not specifically detailed for seismic resistance per ASCE/SEI 7 Table 12.2-1 (ASCE, 2016)]
- Nonbuilding structures similar to buildings with $R = 1^1/_2$ braced-frame systems or $R = 1$ moment-frame systems (see ASCE/SEI 7 Table 15.4-1)
- Nonbuilding structures not similar to buildings (see ASCE/SEI 7 Table 15.4-2), which are designed to meet the requirements in other standards entirely

Conversely, use of the AISC *Seismic Provisions* is required in the following cases:

- Buildings and other structures in SDC B or C when one of the exemptions for steel seismic force-resisting systems above does not apply
- Buildings and other structures in SDC B or C that use composite seismic force-resisting systems (those containing composite steel-and-concrete members and those composed of steel members in combination with reinforced concrete members)
- Buildings in SDC D, E or F
- Nonbuilding structures in SDC D, E or F, when the exemption above does not apply

The AISC *Seismic Design Manual* provides guidance on the use of the AISC *Seismic Provisions*.

The Manual consists of seventeen parts addressing various topics related to steel building design and construction. Part 1 provides the dimensions and properties for structural products commonly used. For proper material specifications for these products, as well as general specification requirements and other design considerations, see Part 2. For the design of members, see Parts 3 through 6. For the design of connections, see Parts 7 through 15. For Specifications and Codes, see Part 16. For other miscellaneous information, see Part 17.

Tables in the Manual that present available strengths are developed using the geometric conditions indicated and the applicable limit states from the AISC *Specification for Structural Steel Buildings.* Given the nature of the tables, and the possible governing limit state for each table value, linear interpolation between tabulated values may or may not provide correct strengths.

REFERENCE

ASCE (2016), *Minimum Design Loads for Buildings and Other Structures*, including Supplement No. 1, ASCE/SEI 7-16, American Society of Civil Engineers, Reston, VA.