

1 General Design Considerations

2 Analysis

3 Systems Not Specifically Detailed for Seismic Resistance

4 Moment Frames

5 Braced Frames

6 Composite Moment Frames

7 Composite Braced Frames and Shear Walls

8 Diaphragms, Collectors and Chords

9 Provisions and Standards

10 Engineered Damping Systems

Index

SEISMIC DESIGN



MANUAL

AMERICAN INSTITUTE
OF
STEEL CONSTRUCTION

SECOND EDITION

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by

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DEDICATION



Clarkson (“Pinky”) W. Pinkham

This edition of the AISC *Seismic Design Manual* is dedicated to the memory of Clarkson W. Pinkham, a long-time member of the AISC Committee on Specifications and Task Committee 9—Seismic Design. Mr. Pinkham, or Pinky as he was affectionately known to his professional colleagues, was president and member of the Los Angeles consulting structural engineering firm, S.B. Barnes and Associates, for 62 years. He served on the AISC Committee on Specifications from the mid-1970s until the year 2000, and Task Committee 9—Seismic Design from the mid-1990s until 2010. As a member of Task Committee 9 and technical secretary for the 1997 AISC *Seismic Provisions for Structural Steel Buildings*, he was a major contributor and instrumental in the early development of that standard. Pinky was one of the first proponents of including composite systems in the AISC *Seismic Provisions* and, for the first time, this *Seismic Design Manual* includes two chapters on such systems. Pinky received the AISC Lifetime Achievement Award in 1999. Through a career that spanned more than six decades, he spent a lifetime sharing his expertise with others in the field. He was passionate about learning up until his death in 2012 at the age of 92. Pinky was generous in sharing his abundance of structural engineering experience and knowledge through committee involvement and with those who requested it on the subjects of structural steel, concrete and masonry design, cold-formed structures, and timber. By providing solutions and recommendations in this way, Pinky improved the integrity of numerous structures; in particular, their capacity to resist seismic-generated forces. He was elected president of the Structural Engineers Association of Southern California (SEAOSC) in 1971, and later served as president of the Structural Engineers Association of California (SEAOC) in 1975. He was twice given the S.B. Barnes Award for Research, and in 1994 was inducted into the SEAOC College of Fellows, the highest honor awarded by SEAOC. In 2009, the Structural Engineering Institute of the American Society of Civil Engineers awarded Pinky the Walter P. Moore, Jr., Award in recognition of his dedication to and technical expertise in the development of structural codes and standards. AISC will always remember his dedication to the development of standards related to the design and construction of structural steel and it is especially fitting that the 2nd Edition of the AISC *Seismic Design Manual* be dedicated to the memory of Clarkson W. Pinkham.

FOREWORD

The American Institute of Steel Construction, founded in 1921, is the nonprofit technical specifying and trade organization for the fabricated structural steel industry in the United States. Executive and engineering headquarters of AISC are maintained in Chicago. The Institute is supported by four classes of membership: Active 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 individuals or firms engaged in the practice of architecture or engineering, including architectural and engineering educators; and Affiliate Members, who include General Contractors, Building Inspectors and Code Officials. 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 *Seismic Design Manual*.

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, research reports, and journal articles. Nearly all of the information AISC publishes is available for download from the AISC web site at www.aisc.org.

PREFACE

This is the second edition of the AISC *Seismic Design Manual*, intended to assist designers in properly applying AISC standards and provisions in the design of steel frames to resist high-seismic loadings. This Manual is intended for use in conjunction with the AISC *Steel Construction Manual*, 14th Edition.

The following consensus standards are printed in Part 9 of this Manual:

- 2010 *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341-10)
- 2010 *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications* including Supplement No. 1 (ANSI/AISC 358-10 and ANSI/AISC 358s1-11)

The design examples contained in this Manual demonstrate an approach to design, and are not intended to suggest that the approach presented is the only approach. The committee responsible for the development of these design examples recognizes that designers have alternate approaches that work best for them and their projects. Design approaches that differ from those presented in these examples are considered viable as long as the AISC *Specification* and AISC *Seismic Provisions*, sound engineering, and project specific requirements are satisfied.

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

- More thorough and comprehensive design examples, updated for the 2010 AISC *Seismic Provisions*
- Side-by-side LRFD and ASD design methodologies for design examples
- Addition of Part 2: Analysis
- Addition of column base plate design examples
- Extended discussion in Part 8 on collector elements
- Addition of Part 10: Engineered Damping Systems
- Addition of buckling-restrained braced frame systems and examples
- Addition of new chapters on composite moment frames and composite braced frames

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SCOPE

The specification requirements and other design recommendations and considerations summarized in this Manual apply in general to the design and construction of seismic force resisting systems in steel buildings and other structures. The AISC *Seismic Design Manual* is intended to be applied in conjunction with the AISC *Steel Construction Manual*, which provides guidance on the use of the AISC *Specification for Structural Steel Buildings*.

In addition to the requirements of the AISC *Specification*, the design of seismic force resisting systems 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)
- Nonbuilding structures similar to buildings with $R = 1\frac{1}{2}$ 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 *Seismic Design Manual* consists of ten parts addressing various topics related to the design and construction of seismic force resisting systems of structural steel and structural steel acting compositely with reinforced concrete. Part 1 stipulates the specific editions of the specifications, codes and standards referenced in this Manual, and provides a discussion of general design considerations related to seismic design. Part 2 provides some guidance on structural analysis procedures employed. For the design of systems not detailed for seismic resistance, see Part 3. Parts 4 through 7 apply to the various types of seismic force resisting systems, including design examples. Part 8 discusses other systems, such as diaphragm chords and collectors, which are important in seismic design. Part 10 addresses engineering damping systems. For applicable AISC seismic standards, see Part 9.

