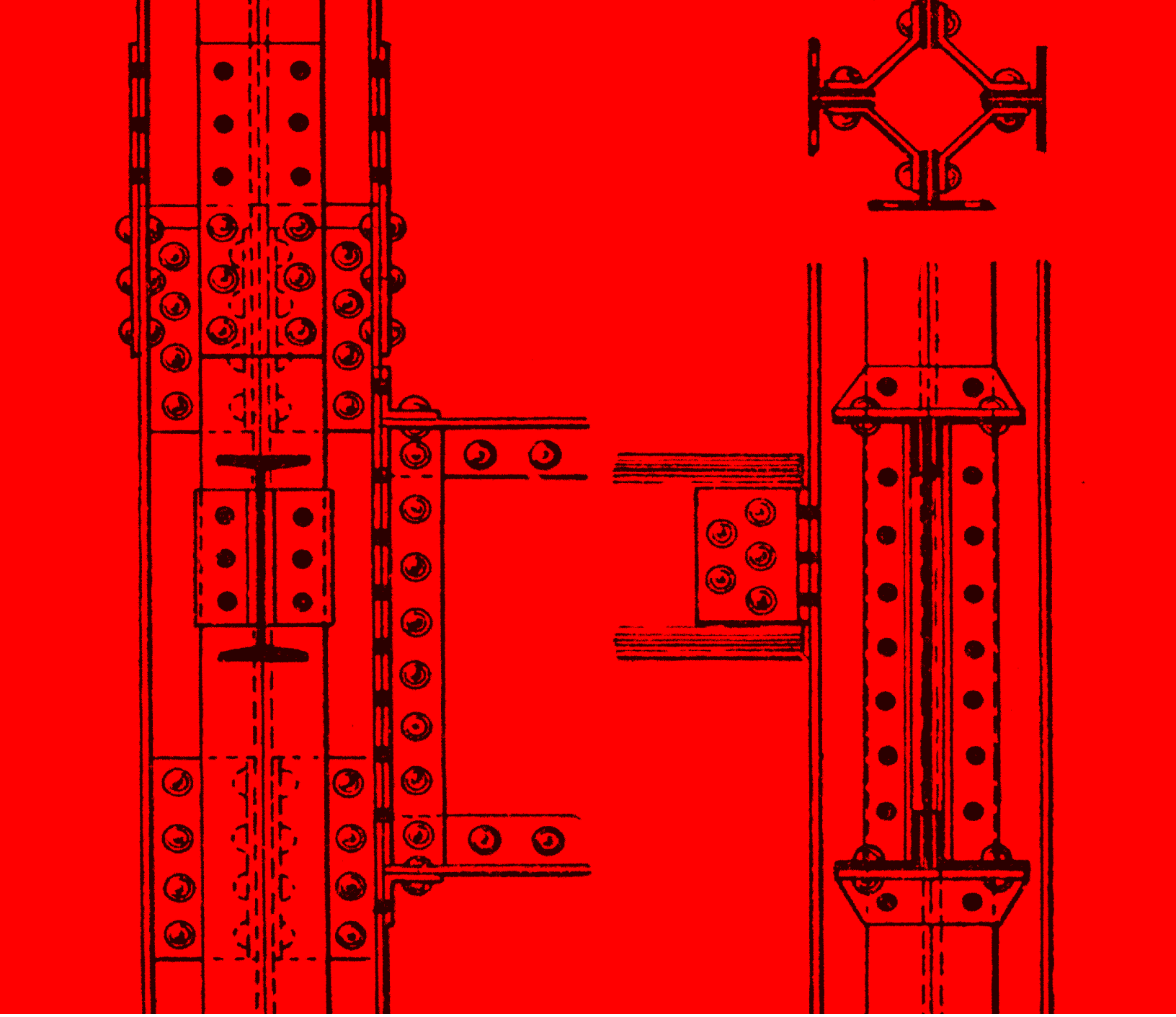

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Rehabilitation and Retrofit

Second Edition

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Rehabilitation and Retrofit

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American Institute of Steel Construction

by

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Preface

The material presented herein has been reorganized and design examples incorporated for the second edition of this Design Guide. Chapter 1 outlines considerations in the evaluation of existing structures for gravity loads and seismic loads.

Chapter 2 describes how existing structural systems can be enhanced for increased strength and stiffness. Included are gravity systems, lateral systems, connections, and certain fabrication considerations.

Chapter 3 provides an historical overview of steel-related specifications and standards, including AISC *Specification* changes beginning in 1923, AISC *Manuals* published beginning in 1927, AISC *Code of Standard Practice* from 1924 forward, RCSC *Specifications for High-Strength Bolted Joints* beginning in 1951, and a summary of design specifications for structural welding from 1934 forward. Details are given in Appendices A1 through A5.

Chapter 4 provides an historical review of the material standards published by the American Society for Testing and Materials (ASTM) for structural steel shapes and plates, steel pipe and hollow structural sections, rivets, and bolts, beginning in 1900. A review is also provided of the basic design stresses (allowable stresses, allowable strengths and design strengths) for structural steel, rivets, bolts and welds, based on AISC *Specifications* from 1923 forward.

Chapter 5 includes reference data (cross-sectional dimensions and properties) for steel shapes (wide-flange or I-shaped cross sections) that have been discontinued from 1887 to present times. Similar data are included for wrought iron cross sections, which were phased out around the year 1900.

Chapter 6 includes extensive design examples for flexural members, columns and connections.

Chapter 7 presents a summary of the contents of the References organized into three categories: General Retrofit, Retrofit Case Studies and Seismic Retrofit. An extensive list of references on rehabilitation and retrofit is given separately to conclude the text.

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Chapter 1
Evaluation of Existing Structures

1.1 INTRODUCTION

The use of ferrous metal for structural framing began with cast-iron columns and wrought iron beams. Early uses of cast iron in England in the 1770s included a small arch bridge over the river Severn at Coalbrookdale and interior structural members in St. Anne's Church in Liverpool. In the United States, cast-iron columns were introduced as balcony supports in the Chestnut Street Theater in Philadelphia in 1820. An early use of wrought iron was in the Menai Bridge in Wales in 1826. In the United States, a wrought iron frame was used in 1853 to construct the six-story Cooper Union Building. Wrought iron appears to have flourished in the United States between 1870 and 1900. Structural steel shapes became available in the 1880s and rapidly displaced cast iron and wrought iron. The ten-story Home Insurance Co. building erected in 1884 was the first to use steel framing. In this transitional structure, steel was used for the top four floors, wrought iron was used for the lower floors, and cast iron columns were used in the exterior walls. The advantages structural steel offered in strength, stiffness and economy greatly accelerated the development of tall buildings and other structures.

Evaluation of structures for potential rehabilitation can be required for many reasons. Some of the more common are as follows:

- Change in building use
- General renovation or upgrade
- Expansion, either vertical or horizontal
- Deterioration of members, such as in old timber structures
- Damage from fire or explosion
- Historic preservation
- Verification of design loadings or code requirements
- Rehabilitation or new-build decisions
- Seismic damage
- Change in seismic code requirements

Regardless of the reasons, evaluation must proceed in a carefully organized manner appropriate to the situation. Although load testing may be required in some cases, evaluation will usually rely on a structural analysis of the existing structure. All dimensions used in the evaluation (spans, column heights, member spacings, bracing locations, cross-section dimensions, thicknesses, connection details, etc.) should be determined from a field survey. Dimensions can also be obtained from project plans or drawings, where available, with field verification of critical values. The design strength of members and connections can then be determined from the provisions of the AISC *Specification for Structural Steel Buidlings* (AISC, 2016c), hereafter referred to as the AISC *Specification*.

1.2 EVALUATION METHODS

The first step in planning rehabilitation work is a careful evaluation of the existing structure. Fortunately, several references are available to help organize this process for both gravity loads and seismic loads as indicated in the following subsections. Methods of structural enhancement and rehabilitation are reviewed in Chapter 2.

1.2.1 Gravity Loads

Evaluation of the strength and stiffness of existing structures under vertical static loads (i.e., gravity loads) is treated in the 2016 AISC *Specification* Appendix 5, "Evaluation of Existing Structures." Evaluation by structural analysis and/or load tests is included. Material property considerations are also covered.

Pertinent information is also provided in AWS D1.1/D1.1M, particularly Chapter 8, "Strengthening and Repairing Existing Structures;" see the Section 7.1 reference to AWS (2015). Subjects covered include suitability of the base metal for welding, design for strengthening and repair—design process, stress analysis, fatigue history, restoration or replacement, loading during operations, existing connections, and use of existing fasteners—fatigue life enhancement, workmanship and technique, and quality.

1.2.2 Seismic Loads

For seismic rehabilitation, reference should be made to the standard ASCE/SEI 41-13 (ASCE, 2014) and to the publications of FEMA. The FEMA publications provide an excellent source of material for understanding many important aspects of building rehabilitation, particularly as related to seismic damage. The information provided therein has been used to develop ASCE/SEI 41-13 and to update the AISC *Seismic Provisions for Structural Steel Buildings* (AISC, 2016b), hereafter referred to as the AISC *Seismic Provisions*, and the building codes.

A summary of seismic references is provided in Section 7.3.

1.3 REQUIREMENTS FOR EVALUATION IN THE AISC *SPECIFICATION*

The AISC *Specification* (AISC, 2016c) provides guidance for the evaluation of existing structures in Appendix 5 and the associated Commentary. The Appendix applies to evaluation under static loads; it is not applicable to structures under seismic or moving (vibration) loads. It includes guidance on material properties, evaluation by structural analysis and load testing, and the evaluation report.