2018 IBC® SEAOC STRUCTURAL/SEISMIC DESIGN MANUAL

VOLUME 2
EXAMPLES FOR LIGHT-FRAME, TILT-UP, AND MASONRY BUILDINGS

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Publisher

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The Structural Engineers Association of California (SEAOC) is a professional association of four regional member organizations (Southern California, Northern California, San Diego, and Central California). SEAOC represents the structural engineering community in California. This document is published in keeping with SEAOC's stated mission:

> To advance the structural engineering profession; to provide the public with structures of dependable performance through the application of state-of-the-art structural engineering principles; to assist the public in obtaining professional structural engineering services; to promote natural hazard mitigation; to provide continuing education and encourage research; to provide structural engineers with the most current information and tools to improve their practice; and to maintain the honor and dignity of the profession.

Editor

International Code Council

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Suggestions for Improvement

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Errata Notification

SEAOC has made a substantial effort to ensure that the information in this document is accurate. In the event that corrections or clarifications are needed, these will be posted on the SEAOC website at **www.seaoc.org** and on the ICC website at **www.iccsafe.org**.

SEAOC, at its sole discretion, may issue written errata.

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Preface to the 2018 *IBC SEAOC Seismic/Structural Design Manual*

The *IBC SEAOC Seismic/Structural Design Manual*, throughout its many editions, has served the purpose of illustrating good seismic design and the correct application of building-code provisions. The *Manual* has bridged the gap between the discursive treatment of topics in the *SEAOC Blue Book* (*Recommended Lateral Force Requirements and Commentary*) and real-world decisions that designers face in their practice.

The examples illustrate code-compliant designs engineered to achieve good performance under severe seismic loading. In some cases simply complying with building-code requirements does not ensure good seismic response. This *Manual* takes the approach of exceeding the minimum code requirements in such cases, with discussion of the reasons for doing so.

This manual comprises four volumes:

- Volume 1: Code Application Examples
- Volume 2: Examples for Light-Frame, Tilt-Up, and Masonry Buildings
- Volume 3: Examples for Concrete Buildings
- Volume 4: Examples for Steel-Framed Buildings

In general, the provisions for developing the design base shear, distributing the base-shear-forces vertically and horizontally, checking for irregularities, etc., are illustrated in Volume 1. The other volumes contain more extensive design examples that address the requirements of the material standards (for example, ACI 318 and AISC 341) that are adopted by the IBC. Building design examples do not illustrate many of the items addressed in Volume 1 in order to permit the inclusion of less-redundant content.

Each volume has been produced by a small group of authors under the direction of a manager. The managers have assembled reviewers to ensure coordination with other SEAOC work and publications, most notably the *Blue Book*, as well as numerical accuracy.

This manual can serve as valuable tool for engineers seeking to design buildings and building components for good seismic response.

Rafael Sabelli and Katy Briggs
Project Managers

Preface to Volume 2

Volume 2 of the 2018 *IBC SEAOC Structural/Seismic Design Manual* addresses the design of light-frame, concrete tilt-up, and masonry shear wall building systems for seismic loading. These include the illustration of the design requirements for the shear walls and diaphragms, as were illustrated in previous editions, and also important interfaces with the rest of the structure.

The design examples in this volume represent a range of structural systems and seismic systems. The design of each of these systems is governed by standards developed by the American Concrete Institute (ACI) and the American Wood Council (AWC). The methods illustrated herein represent approaches consistent with the ductility expectations for each system and with the desired seismic response. In most cases there are several details or mechanisms that can be utilized to achieve the ductility and resistance required, and the author of each example has selected an appropriate option. In many cases alternatives are discussed. This *Manual* is not intended to serve as a building code or to be an exhaustive catalogue of all valid approaches and details.

This *Manual* is presented as a set of examples in which the engineer has considered the building-code requirements in conjunction with the optimal seismic response of the system. The examples follow the guidelines of the *SEAOC Blue Book* and other SEAOC recommendations. The examples are intended to aid conscientious designers in crafting designs that are likely to achieve good seismic performance consistent with expectations inherent in the requirements for the systems.

Douglas Thompson
Volume 2 Manager

Acknowledgments

Volume 2 of the 2018 *IBC SEAOC Seismic/Structural Design Manual* was written by a group of highly qualified structural engineers, chosen for their knowledge and experience with structural engineering practice and seismic design. The authors are:

Douglas S. Thompson, S.E., S.E.C.B—Volume Manager and Example 1
Doug Thompson has over 40 years of experience in designing of wood structures. He is the author of several publications in timber design including the WoodWorks publications**:** *Four-story Wood-frame Structure over Podium Slab and Five-story Wood-frame Structure over Podium Slab*. Doug has instructed license review classes in timber design for the PE and SE exams for 20 years. He is a past president of the Structural Engineers Association of Southern California and holds licenses in six states. www.stbse.com

John Lawson, S.E.—Examples 2 and 5
Professor John Lawson has provided structural engineering consulting services for over 30 years, including overseeing more than 100 million square feet of low-sloped roof and tilt-up concrete engineering. He now teaches in the Architectural Engineering department at California Polytechnic State University in San Luis Obispo. John is the recipient of the 2006 Tilt-Up Concrete Association's David L. Kelly Distinguished Engineer Award. www.arce.calpoly.edu

Michael Cochran, S.E., S.E.C.B.—Example 3
Michael Cochran is a Vice President with Thornton Tomasetti, Inc., in Los Angeles, California, with over 25 years of design experience. He has an extensive background in the design of multistory light-frame commercial and multifamily residential wood and cold-formed steel-stud buildings. He is a registered structural engineer in California, an active member of the AISC Connection Prequalification Review Panel, a past president of the Structural Engineers Association of Southern California (SEAOSC) and the Structural Engineers Association of California, and a SEAOC fellow.

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Jeff Ellis, Director of Codes and Compliance for Simpson Strong-Tie Company, Inc., has more than 28 years of experience as a professional engineer and manages the company code and compliance efforts. Additionally, he is involved in research and development and provides support for existing product lines, including technical guidance for connectors, fastening systems, and lateral-force-resisting systems. He was a practicing design engineer for commercial, residential, and forensic projects for more than nine years prior to joining Simpson at the end of 2000. He currently serves on the International Code Council Evaluation Service Board and has served as president of the Structural Engineers Association of Southern California (SEAOSC), SEAOC secretary, chairman of the AISI COFS Lateral Design Subcommittee, and president of the Cold-Formed Steel Engineers Institute (CFSEI).

Chukwuma G. Ekwueme, PhD, SE, LEED AP—Example 4
Dr. Ekwueme is a Principal with Thornton Tomasetti in Los Angeles, California. He has an extensive background in the design and analysis of a wide variety of structures, including concrete and masonry construction, steel and aluminum structures, and light-frame wood buildings. He is a registered structural engineer in California and Nevada and is an active member of the main committee, the seismic subcommittee, and the axial flexural loads and shear subcommittee of the Masonry Standards Joint Committee (MSJC).

Additionally, a number of SEAOC members and other structural engineers helped check the examples in this volume. During its development, drafts of the examples were sent to these individuals. Their help was sought in review of code interpretations as well as detailed checking of the numerical computations. The reviewers include:

James Lai, S.E.

Alan Robinson, S.E.

Tim Stafford, S.E.

Doug Thompson, S.E.

Tom VanDorpe, S.E.

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How to Use This Document

Equation numbers in the right-hand margin refer to the one of the standards (e.g., ACI 318, ASCE 7, or IBC). The default standard is given in the heading of each section of each example; equation numbers in that section refer to that standard unless another standard is explicitly cited.

Abbreviations used in the "Code Reference" column are

§ – Section T – Table

F – Figure Eq – Equation