2018 IBC® SEAOC STRUCTURAL/SEISMIC DESIGN MANUAL

VOLUME 1
CODE APPLICATION EXAMPLES

Copyright

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.

Table of Contents

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

The *IBC SEAOC Structural/Seismic 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 a 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 1

Volume 1 of the 2018 *IBC SEAOC Structural/Seismic Design Manual* addresses the application and interpretation of the seismic provisions of the 2018 *International Building Code*. More specifically, Chapter 16 of the 2018 IBC requires compliance with the provisions of ASCE/SEI 7-16 "Minimum Design Loads and Associated Criteria for Buildings and Other Structures."

ASCE 7 generally prescribes the loading and methodology to be used in the analysis of a structure or an element. In order to determine strength to resist to the load demands from ASCE 7, the IBC adopts national material design standards (such as ACI, AISC, and NDS) to be used for the design of an element of a particular material. The Volume 1 examples focus on the application of the provisions of ASCE 7, while the examples in Volumes 2, 3, and 4 focus more on the application of the material design standards. The *Manual* is not intended to serve as a building code or to be an exhaustive catalogue of all valid approaches.

Volume 1 presents 61 examples covering most of the key code provisions within ASCE 7 Chapters 2, 11, 12, 13, and 15. Of the 61 examples, 58 have been updated and revised to reflect applicable changes to codes and standards since the 2015 edition of the *Manual*, to provide additional clarification and commentary for the more complex or nuanced provisions, and to incorporate input from the SEAOC Seismology Committee and other practicing engineers regarding the latest SEAOC interpretations and recommended practices. Three new examples have been added to Volume 1; these examples cover the determination of seismic forces on nonstructural components using building accelerations, the determination of rho for core concrete shear wall building, and the design of a column that is part of the SFRS of a building and supports a mezzanine.

Whenever possible, the authors have incorporated lessons learned from actual projects into the examples. Readers are welcome to submit other conditions or provisions not addressed in this edition for consideration in future editions.

Katy Briggs
Volume Manager

Acknowledgments

Volume 1 of the 2018 *IBC SEAOC Seismic Design Manual* was written and reviewed by a group of highly qualified structural engineers, chosen for their knowledge and experience with structural engineering practice and seismic design. The authors are:

Ryan A. Kersting, S.E., Associate Principal, Buehler—2012 & 2015 Volume Manager and Author/Reviewer of Various Previous Examples
Ryan has over 20 years of experience in the analysis, design, and review of structures spanning the spectrum of conventional systems and materials. He is also frequently involved in projects that incorporate innovative structural systems, nonlinear analysis, and performance-based designs. Ryan's industry involvement includes ASCE 7 Seismic Subcommittee member, former SEAOC Seismology Committee Chair, NEHRP Advisory Committee member, 2014–15 SEAOC President, and current SEAOC Legislative Committee Chair. www.buehlerengineering.com

Kevin S. Moore, S.E., Senior Principal, Simpson Gumpertz & Heger—Author/Reviewer of Various Examples
Kevin has over 25 years of experience in the analysis, design, and evaluation of building structures spanning the spectrum of conventional systems and materials. He is a recognized leader in the use of structural steel systems, nonlinear analysis, and performance-based designs. Kevin has been very active in SEAOC, including serving as Chair of the SEAOC Structural Standards Committee, Chair of the SEAOC Seismology Committee, and leading the production of the modern iteration of the *Blue Book* in 2009. www.sgh.com

Michael Comaroto, S.E., Senior Structural Engineer, Nishkian Menninger—Author of Example 60
Michael Comaroto has 8 years of experience performing seismic design, analysis, and rehabilitation of a variety of building systems in California, including conventional and post-tensioned concrete shear wall buildings, steel BRB and moment frame systems, and conventional timber and masonry buildings.

Jennifer Gross, S.E., Associate, Degenkolb Engineers—Author of Example 59
Jennifer has more than 13 years of structural engineering experience. She has frequently worked in design and analysis, and her work spans across various sectors throughout California, Nevada, Washington, and Hawaii. She has expertise in structural analysis, seismic evaluation, and structural design, and she often reviews the work of younger engineers—which she uses as an opportunity to mentor and train. www.degenkolb.com/

Melissa Vickery, S.E., Associate, Degenkolb Engineers—Author of Example 59
Melissa brings nearly 12 years of structural engineering experience, specializing in seismic evaluation of existing structures, and new design. Her projects are in multiple sectors, namely healthcare, higher education, and the public sector. She is active in SEAONC (Northern California's SEAOC chapter) and currently serves as the Secretary for the ACEC Bay Bridge Chapter. Other past roles include the YMF Co-Chair and YMF Treasurer with SEAONC and serving on the committees for the 2020 and 2016 SEAOC Conventions. www.degenkolb.com/

The additions and revisions incorporated in the 2018 edition of Volume 1 are the result of thoughtful review from and close collaboration with the SEAOC Seismology Committee. The review, input, and assistance from the following individuals is gratefully acknowledged and appreciated.

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SEAOC would like to thank the following people for their work authoring and reviewing design examples in this book that were included in past editions and have been updated for the 2018 *International Building Code*: April Buchberger, Timothy S. Lucido, Kevin Morton, Nicolas Rodrigues, and Ali Sumer. This version of the *Structural/Seismic Design Manual* would not be possible without their time and efforts.

Production and art was provided by the International Code Council.

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Standards

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American Society of Civil Engineers. ASCE 7-16: *Minimum Design Loads and Associated Criteria for Buildings and Other Structures.* Reston, Virginia, 2017.

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Other References

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SEAOC Seismology Committee. *Recommended Lateral Force Requirements and Commentary* (Blue Book), Structural Engineers Association of California (SEAOC), Seventh Edition, Sacramento, California, 1999.

SEAOC Seismology Committee. *SEAOC Blue Book Seismic Design Recommendations*, Structural Engineers Association of California (SEAOC), First Printing, Sacramento, California, 2009. www.seaoc.org/bluebook

How to Use This Document

The examples in Volume 1 are written to illustrate the application of a specific section or provision within ASCE 7. Each example is a separate problem (or group of problems) for a unique condition chosen to best address the particular referenced code provision. Examples are stand-alone and do not rely on results from another example.

Each example contains a problem statement with a detailed listing of "given" information and a clear list of items to be determined in order to arrive at the solution. The problem is solved through a logical sequence of steps, and appropriate code references are provided in the right-hand margin of the page. Most examples include an introductory overview to the particular code provision and/or additional commentary following the solution. Readers are referred to applicable *SEAOC Blue Book* articles for additional information when appropriate.

For all examples, ASCE 7 is the default source document for the references, unless another document is specifically included in the reference. The following abbreviations are used within the references:

§—Section T—Table

F—Figure Eq—Equation