2012 IBC®

SEAOC STRUCTURAL/SEISMIC DESIGN MANUAL

VOLUME 1

CODE APPLICATION EXAMPLES

Copyright

Publisher

Structural Engineers Association of California (SEAOC)
1400 K Street, Ste. 212
Sacramento, California 95814
Telephone: (916) 447-1198; Fax: (916) 444-1501
E-mail: seaoc@seaoc.org; Web address: www.seaoc.org

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.

SEAOC Board oversight of this publication was provided by 2012 SEAOC Board President James Amundson, S.E. and Immediate Past President Doug Hohbach, S.E.

Editor

International Code Council

Disclaimer

First Printing: September 2013

Suggestions for Improvement

Comments and suggestions for improvements are welcome and should be sent to the following:

Structural Engineers Association of California (SEAOC)
Don Schinske, Executive Director
1400 K Street, Suite 212
Sacramento, California 95814
Telephone: (916) 447-1198; Fax: (916) 444-1501
E-mail: dschinske@seaoc.org

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 Web site at *www.seaoc.org* and on the ICC Web site at *www.iccsafe.org*.

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

Table of Contents

Preface to the 2012 *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.

Recent editions of the *IBC SEAOC Structural/Seismic Design Manual* have consisted of updates of previous editions, modified to address changes in the building code and referenced standards. Many of the adopted standards did not change between the 2006 edition of the *International Building Code* and the 2009 edition. The 2012 edition, which is the one used in this set of manuals, represents an extensive change of adopted standards, with many substantial changes in methodology.

Additionally, this edition has been substantially revised. New examples have been included to address new code provisions and new systems, as well as to address areas in which the codes and standards provide insufficient guidance. Important examples such as the design of base-plate anchorages for steel systems and the design of diaphragms have been added.

This expanded edition comprises five volumes:

- Volume 1: Code Application Examples
- Volume 2: Examples for Light-Frame, Tilt-Up, and Masonry Buildings
- Volume 3: Examples for Reinforced Concrete Buildings
- Volume 4: Examples for Steel-Framed Buildings
- Volume 5: Examples for Seismically Isolated Buildings and Buildings with Supplemental Damping

Previous editions have been three volumes. This expanded edition contains more types of systems for concrete buildings and steel buildings. These are no longer contained in the same volume. Volumes 3 and 4 of the 2012 edition replace Volume 3 of the 2009 edition. Additionally, we have fulfilled the long-standing goal of including examples addressing seismic isolation and supplemental damping. These examples are presented in the new Volume 5.

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 for good seismic response.

Rafael Sabelli
Project Manager

Preface to Volume 1

Volume 1 of the 2012 *IBC SEAOC Structural/Seismic Design Manual* addresses the application and interpretation of the seismic provisions of the 2012 *International Building Code*. More specifically, Chapter 16 of the 2012 IBC requires compliance with the provisions of ASCE/SEI 7-10 “Minimum Design Loads for Buildings and Other Structures," except for Chapter 14 of ASCE 7.

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, MSJC, 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 58 examples covering most of the key code provisions within ASCE 7 Chapters 11, 12, 13, and 15. Many of the examples are similar to those in previous editions but have been rewritten to more clearly present the material and have been updated to reflect changes to the code provisions and SEAOC recommendations. Additionally, new examples are included in this edition that specifically address provisions related to site-specific ground-motion procedures, combination framing detailing requirements, scaling design values in modal response spectrum analysis, and retaining walls subject to seismic earth pressures.

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.

Ryan A. Kersting
Volume Manager

Acknowledgements

Volume 1 of the 2012 *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 & Buehler Structural Engineers — Volume Manager and Author/Reviewer of Various Examples
Ryan has over 15 years of experience in the analysis, design, and review of building 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 has been very active in SEAOC, including previously serving as Chair of the SEAOC Seismology Committee, co-authoring / reviewing Blue Book articles, and serving as Chair of the 2007 SEAOC Convention. www.bbse.com

April Buchberger, S.E., Senior Structural Engineer, Clark Pacific — Author/Reviewer of Various Examples
April has 10 years of experience designing precast concrete structural systems and architectural cladding for the commercial, residential, health care, and government sectors in California. She is active in the SEAOCC (Central California) member organization of SEAOC, where she is currently serving on the Board of Directors and as Website Committee Chair. www.ClarkPacific.com

Timothy S. Lucido, S.E., Associate, Rutherford + Chekene — Author/Reviewer of Various Examples
Tim has 10 years of experience in the seismic design and evaluation of building structures with specialization in hospital design and steel-framed systems. He is a contributing member of SEAOC and SEAONC, including co-authoring the SEAOC Blue Book article "Concentrically Braced Frames." He has developed proprietary data and software analysis tools for BRB manufacturers, has given webinars on BIM 3D shop drawing review and coordination, and is a BIM leader for Rutherford + Chekene. www.ruthchek.com

Kevin Morton, S.E., Associate Principal, Hohbach-Lewin Structural Engineers — Author/Reviewer of Various Examples
Kevin has 12 years of experience designing new structures and retrofitting existing ones, with particular expertise in seismic analysis, value engineering, and precast parking structure design. He is an active member of SEAOC, having served on the state Seismology Committee for the past three years. www.hohbach-lewin.com

Nicolas Rodrigues, PE, SE, Associate, DeSimone Consulting Engineeers — Author/Reviewer of Various Examples
Nic has more than 10 years of experience in performing both code-based and performance-based designs of new highrise concrete and steel buildings in seismic zones around the world including California, Turkey, the UAE, and the Philippines. He has chaired several SEAOC committees, served on a PEER committee for the performance-based design of tall buildings, and actively participates in ACI. Nic was the responsible structural engineer for such notable projects as the 60-story Millennium Tower in San Francisco and the twisting, 42-story Emirates Pearl Hotel in Abu Dhabi. www.de-simone.com.

Ali Sumer, Ph.D., S.E., Senior Structural Engineer, State of California Office of Statewide Health Planning and Development (OSHPD) — Author/Reviewer of Various Examples
Prior to joining OSHPD, Ali worked in private industry for eight years. He has focused on projects that incorporate seismic retrofitting, innovative structural systems, nonlinear analysis techniques, performance-based designs, building collapse risk analysis, and equipment shake-table tests. www.oshpd.ca.gov

Close collaboration with the SEAOC Seismology Committee was maintained during the development of the document. The Seismology Committee has reviewed the document and provided many helpful comments and suggestions. Their assistance is gratefully acknowledged.

Production and art was provided by the International Code Council.

Cover photo credits:
Main photo: Rien van Rijthoven Architecture Photography
Inset photos: Buehler & Buehler Structural Engineers, Inc.