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SEAOC STRUCTURAL/SEISMIC DESIGN MANUAL

Volume 3: EXAMPLES FOR CONCRETE BUILDINGS

Copyright

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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 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 2015 *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 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

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 3

Volume 3 of the 2015 *IBC SEAOC Structural/Seismic Design Manual* illustrates the design requirements for reinforced concrete shear wall and moment-frame seismic systems, 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) in ACI 318. 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, nor to be an exhaustive catalogue of all valid approaches and details.

The 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 recommendations 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.

Three examples have been included in past editions of this manual and are updated in this edition: reinforced concrete shear wall, reinforced concrete shear wall with coupling beams, and reinforced concrete special moment frame. Three examples are new and are included in this edition of the manual: reinforced concrete parking garage, reinforced concrete pile foundation, and reinforced concrete diaphragms and collectors.

Jon P. Kiland
Volume 3 Manager

Acknowledgements

Volume 3 of the 2015 *IBC SEAOC Structural/Seismic 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

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With 32 years of experience in research and practice, Joe is an expert on the seismic evaluation, design, and retrofitting of structures. He has directed a range of projects, including those using innovative solutions and advanced methods of evaluation. The American Society of Civil Engineers and the American Concrete Institute have appointed Joe to committees writing structural code provisions. www.maffei-structure.com

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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:

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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