



Homebuilders' Guide to Earthquake Resistant Design and Construction

FEMA 232 - June 2006



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Homebuilders' Guide to Earthquake-Resistant Design and Construction

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**Prepared by the
Building Seismic Safety Council
for the
Federal Emergency Management Agency
of the Department of Homeland Security**

National Institute of Building Sciences
Washington, D.C.

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The opinions expressed herein regarding the requirements of the *International Residential Code* do not necessarily reflect the official opinion of the International Code Council. The building official in a jurisdiction has the authority to render interpretation of the code.

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For further information on the Building Seismic Safety Council, see the Council's website -- www.bssconline.org -- or contact the Building Seismic Safety Council, 1090 Vermont, Avenue, N.W., Suite 700, Washington, D.C. 20005; phone 202-289-7800; fax 202-289-1092; e-mail bssc@nibs.org.

In Memoriam

Edwin G. Zacher 1920-2005

The Federal Emergency Management Agency and the Building Seismic Safety Council dedicate this guide to Edwin G. Zacher in recognition of his significant contributions to the profession of structural engineering and the nation's codes and standards development efforts. The residential built environment and all those who work to create it and use it have benefited tremendously from his work.

PREFACE

The Federal Emergency Management Agency (FEMA), which is part of the Department of Homeland Security, works to reduce the ever-increasing cost that disasters inflict on the nation. Preventing losses before they occur by designing and constructing buildings and their components to withstand anticipated forces from various hazards is one of the key components of mitigation and is one of the most effective ways of reducing the cost of future disasters.

The National Earthquake Hazards Reduction Program (NEHRP) is the federal program established to address the nation's earthquake threat. NEHRP seeks to resolve two basic issues: how will earthquakes affect us and how do we best apply our resources to reduce their impact on our nation. The program was established by Congress under the Earthquake Hazards Reduction Act of 1977 (Public Law 95-124) and was the result of years of examination of the earthquake hazard and possible mitigation measures. Under the NEHRP, FEMA is responsible for supporting program implementation activities, including the development, publication, and dissemination of technical design and construction guidance documents.

Generally, there has not been much technical guidance addressing residential buildings unless they are located in areas of high seismicity or exceed a certain size or height. This is because most residential buildings were thought to perform fairly well in earthquakes due to their low mass and simple construction. While buildings may not normally experience catastrophic collapse, they can still suffer significant amounts of damage, rendering them uninhabitable. This is especially true when construction techniques are less than adequate. What is particularly important from FEMA's point of view is that, given the sheer number of this type of building, even minor damage represents a significant loss potential and temporary housing demand that will need to be addressed after an earthquake by all levels of government.

After the San Fernando earthquake in 1971, a study of residential buildings and the damage they suffered was conducted by a team of experts under funding from the Department of Housing and Urban Development (HUD) and the National Science Foundation (NSF). HUD utilized these data to develop a non-engineering document entitled *Home Builder's Guide to Earthquake Design*. This manual, originally published in 1980, provided easy-to-follow information to the average homebuilder on steps for reducing potential earthquake damage. In July 1992 it was reprinted as a joint FEMA-HUD document, also known as FEMA 232. The manual was subsequently updated for FEMA and the revised publication, *Home Builders Guide to Seismic Resistant Construction* (FEMA 232), was published in August 1998.

Since that time, there have been several significant changes that needed to be incorporated into this document to keep it current. The first and most important change was the completion of the FEMA-funded Consortium of Universities for Research in Earthquake Engineering (CUREE)-Caltech Woodframe Project. This project was funded using FEMA Hazard Mitigation Grant Program funds available after the Northridge earthquake and was designed to address the unexpected amount of damage suffered by wood frame residential structures. Similar to the successful FEMA/SAC Steel Moment Frame Buildings Project, this effort combined academic research and testing of wood frame buildings and components with the development of

engineering-based design guidance for future construction. The project yielded some interesting findings that needed to be captured in a guidance document.

A second change was the development and publication of the 2000 *International Residential Code (IRC)* by the International Code Council. This model residential building code replaced the Council of American Building Officials (CABO) *One- and Two-Family Dwelling Code*, which did not adequately address earthquake loads. The *IRC* reflects on the *NEHRP Recommended Provisions* and is intended to adequately address the earthquake hazard.

This publication presents seismic design and construction guidance for one- and two-family houses in a manner that can be utilized by homebuilders, knowledgeable homeowners, and other non-engineers. It incorporates and references the prescriptive provisions of the 2003 *International Residential Code* as well as the results of the FEMA-funded CUREE-Caltech Woodframe Project. The manual includes prescriptive building detail plans based on state-of-the-art earthquake-resistant design for use by homebuilders and others in the construction of a non-engineered residential structure. Further, the manual also uses the results of recent loss investigations as well as current research and analysis results to identify a number of specific **above-code** measures for improved earthquake performance along with their associated costs. A typical modern house is used to illustrate the application and benefits of **above-code** measures. This manual replaces the *Home Builders Guide to Seismic Resistant Construction* (FEMA 232) published by FEMA in August 1998 as well as earlier FEMA and HUD versions.

Finally, FEMA wishes to express its deepest gratitude for the significant efforts of primary authors J. Daniel Dolan, Kelly Cobeen, and James Russell; the members of the Project Team; the many reviewers and workshop attendees; and the BSSC Board of Direction and staff. Their dedication and hard work made this document possible.

Department of Homeland Security/Federal Emergency Management Agency

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J. Daniel Dolan, PhD, PE, Professor, Washington State University, Wood Materials and Engineering Laboratory, Pullman (team leader)

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James E. Russell, Building Codes Consultant, Concord, California

Special thanks also go to Gerald Jones, retired building official, and Douglas Smits, the chief building official of Charleston, South Carolina, who served with me and the writers on the committee overseeing this project.

The BSSC also is grateful to those who participated in a workshop discussion (Appendix F) of an early draft of this guide and willingly shared their experiences with respect to earthquake-resistant home building. Special thanks go to those individuals who reviewed and commented on subsequent drafts of this document; their input has made this a much more useful guide.

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Finally the BSSC is grateful to Michael Mahoney, FEMA project officer, for his insight and ongoing support, to the International Code Council for their work in reviewing and disseminating this guide, and to the National Association of Home Builders for their assistance in disseminating this guide.

Jim. W. Sealy
Chairman, BSSC Board of Direction

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