Builders Guide to Earthquake Resistant Building Design

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PDH: 5

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Chapter 1
INTRODUCTION

1.1 BACKGROUND

After the 1971 earthquake in San Fernando, California, a study of residential buildings and the types of damage they suffered was conducted by a team of experts with funding from the Department of Housing and Urban Development (HUD) and the National Science Foundation (NSF). Subsequently, HUD utilized the results of that study to develop a nonengineering guidance document entitled *Home Builder's Course to Earthquake Design*. This manual was originally published in June 1980 to provide homebuilders with easy-to-follow guidance for reducing potential earthquake damage.

In July 1992, the Federal Emergency Management Agency (FEMA) reissued the HUD manual with some updated material as a joint FEMA/HUD publication identified as FEMA 232. By the mid-1990s, it was apparent that this publication was in need of updating, especially to take into account some of the early findings from the 1994 Northridge earthquake. This update was prepared for FEMA by SOHA Engineers and was published by FEMA in August 1998 as the *Home Builders Course to Seismic Resistant Construction*, again as FEMA 232.

Since that time, significant events have occurred warranting another updating of the course. First was completion of the FEMA-funded CUREE-Caltech Woodframe Project. This project, funded under the FEMA Hazard Mitigation Grant Program, addressed the unexpected damage suffered by woodframe residential structures during the Northridge earthquake. Project testing of complete woodframe buildings and individual components that resist or transmit earthquake loads yielded some interesting findings that needed to be captured in a guidance document.

Another significant event occurred in 1994 when the International Code Council was established to develop a single set of comprehensive and coordinated national model construction codes. Prior to this time, the three organizations that founded the ICC – the Building Officials and Code Administrators International, Inc. (BOCAI), the International Conference of Building Officials (ICBO), and Southern Building Code Congress International, Inc. (SBCCI) – each published a set of model building codes that generally were used in distinct regions of the nation. The initial editions of the ICC's *International Building Code* (*IBC*) and *International Residential Code* (*IRC*) were published in 2000 and updates were issued in 2003 and 2006. The *IBC* replaced BOCAI's *National Building Code*, ICBO's *Uniform Building Code*, and SBCCI's *Standard Buildin*g Code. For prescriptive residential construction, the *IRC* replaced the *One- and Two-Family Dwelling Code* of the Council of American Building Officials (CABO). (Note that the *IBC* contains prescriptive and engineering provisions for light-frame wood construction. In certain cases, the *IBC* prescriptive provisions are different from those in the *IRC*. The National Fire Protection Association's *NFPA 5000 Building Construction and Safety Code* does not contain provisions for prescriptive residential construction.)

In order to address these and other changes, FEMA initiated a complete rewrite of the 1998 document; this course, which retains the FEMA 232 designation, is the result. One- and two-family detached houses of light-frame wood construction are addressed; however, the discussion is relevant to other materials of construction likely to be used for houses including light-frame cold-formed steel and insulated concrete form. Explained in this course are:

- The basic principles of earthquake-resistant design,
- The specific prescriptive seismic provisions of the 2003 *International Residential Code*,
- The results of recent research and analysis, and
- Measures exceeding code requirements that are expected to reduce the amount of damage from an earthquake (see Section 1.2 below).

The course also includes limited guidance on applying the principles of earthquake resistance to house additions and alterations and on anchoring typical house furnishings and equipment such as hot water heaters. Appendices describe the analyses performed in developing this course, present checklists for builders, designers, and plan checkers; explain significant differences between the 2003 and 2006 editions of the *IRC*; and identify reference materials and participants in the project resulting in this course.

1.2 ABOVE-CODE RECOMMENDATIONS

The **above-code** recommendations included in this course describe details that, when incorporated into a house, can be expected to result in improved performance above that expected from a house designed and constructed following the minimum requirements of the *IRC*. The **above- code** techniques reduce the deformations of the house during an earthquake and therefore reduce the amount of damage. **Above-code** recommendations are printed in boldface type in this course and appear, with associated discussion, in boxes. While the **above-code** recommendations are expected to improve the performance of a house in an earthquake and thereby reduce damage, many will involve some added costs. The costs associated with **above-code** recommendations presented in this course are based on an estimate prepared by a homebuilder in the Seattle area and are cited as a percentage of the basic framing cost for the model house analyzed during development of this course. Presenting the cost increase for the various **above-code** recommendations in these terms permits homebuilders in any part of the nation to easily determine what the associated added cost will be in his or her area, thus allowing builders and potential homeowners to make reasonable cost-benefit decisions regarding implementation of the recommendations.

1.3 THE *INTERNATIONAL RESIDENTIAL CODE*

As already indicated, this course focuses on the ICC's 2003 *International Residential Code*, which provides a comprehensive collection of requirements for prescriptive (nonengineered) residential construction. The *IRC*'s stated purpose is to provide:

> . . . minimum requirements to safeguard the public safety, health, and general welfare, through affordability, structural strength, means of egress facilities, stability, sanitation, light and ventilation, energy conservation and safety to life and property from fire and other hazards attributed to the built environment.

The *IRC* addresses other natural hazards in addition to earthquakes (up to limits described in the *IRC* scoping provisions). When considering **above-code** recommendations, construction details intended to reduce the risk from one hazard may be slightly different from those needed to resist another. Thus, care should be taken to consider all natural hazards that present a risk to a specific site and to formulate an appropriate mitigation strategy in accordance with the jurisdiction's building code. Additional guidance is provided in Section 1.8 of this course.

1.4 *IRC* SEISMIC DESIGN CATEGORIES

The *IRC* designates the level of potential seismic hazard for dwellings by assigning a house to a Seismic Design Category (SDC) based on its location. The *IRC* SDCs are A, B, C, D_1, D_2 and E, with A representing the lowest level of seismic risk applicable to residential construction and E, the highest. All residential buildings (detached houses and townhouses) in regions with SDC designations A and B, the lowest levels of seismic risk, are exempt from the seismic requirements of the *IRC*. SDC E regions have such a high level of seismic risk that, with a few exceptions, houses in these regions fall outside the scope of the *IRC* and must be designed using engineering principles following the *International Building Code* or *NFPA 5000*.

Whether or not required by the *IRC* and across all SDCs from A to E, many of the recommendations in this course will improve the resistance of a dwelling to seismic forces, wind forces, and possibly the effects of other natural hazards. The discussion and examples presented in this course focus on houses located in SDCs C, D_1, and D_2.

All U.S. model building codes provide maps identifying the seismic hazard. The 2003 *IRC* seismic design maps (*IRC* Figure R301.1(2) shown in Figure 1-1 designate the Seismic Design Categories for the nation and U.S. territories. It is a simplified version of the maps referenced by the *IBC* and *NFPA 5000* for all building types. The legend correlates the Seismic Design Category with the acceleration expected at a location in terms of gravity (g). A value of 100% g is equal to the vertical acceleration effects of gravity on Earth. More detailed information can be found for a particular building site using a CD-ROM available with the building codes and from FEMA; the CD allows the user to input the latitude and longitude coordinates of the site or the zip code. Zip codes should be used with caution because they may not reflect the highest possible SDC in the area covered by the postal zip code. Similar information is available on a U.S. Geological Survey (USGS) website – http://earthquake.usgs.gov/research/hazmaps (click on "seismic design values for buildings").

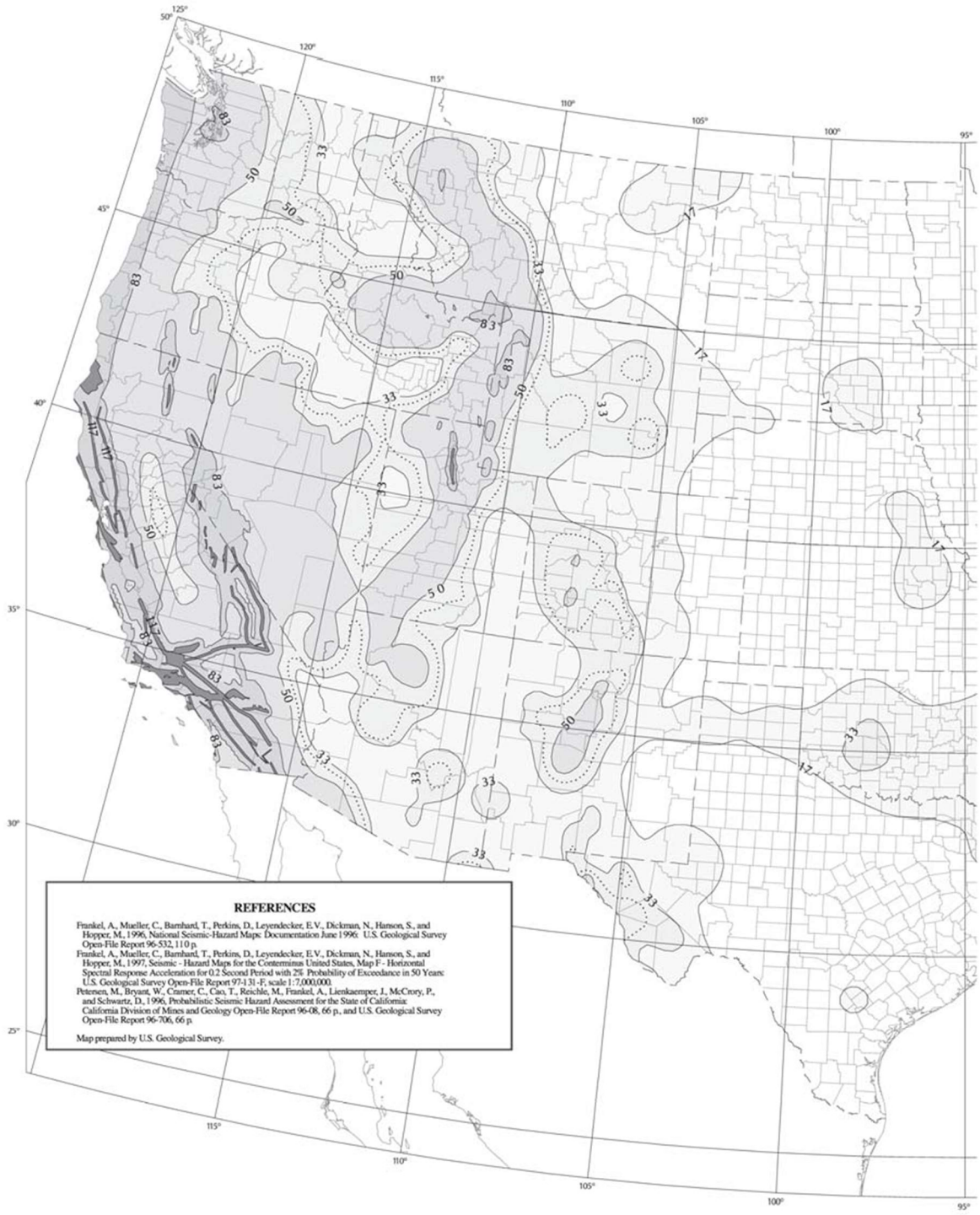

Figure 1-1 Seismic Design Categories – Site Class D.

Purchase this course to see the remainder of the technical materials.