# Residential Guide to Earthquake Design and Construction - Part 1

An Online Continuing Education Course for Engineers

**Course Number: S-5001**

**Credit: 5 Hours / 5 PDH / 5 CPD**

# Residential Guide to Earthquake Design and Construction – Part 1

## Chapter 1: Introduction

### 1.1 OVERVIEW

This course provides information on current best practices for earthquake-resistant house design and construction. It explains the effects of earthquake loads on one- and two-family detached houses and identifies the requirements of the *International Residential Code (IRC)* intended to resist these loads. The purpose of this course is to familiarize engineers with the basic principles of earthquake-resistant design for residential construction.

In order for a structure to fair well during and after an earthquake, adequate construction is required. Because the building code requirements in the *IRC* are minimums, a house and its contents still may be damaged in an earthquake even if it was designed and built to comply with the code. Research has shown, however, that earthquake damage to a house can be reduced for a relatively small increase in construction cost. Hence, this course identifies several above-code techniques for improving earthquake performance.

A typical model house is used to illustrate the concepts discussed and to identify approximate deflections under earthquake loading, which permits performance to be compared for various building configurations using the minimum code requirements and the above-code techniques.

While one- and two-family detached houses of light-frame wood construction are the focus of this course, 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 *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.

## 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 gray 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*

This course focuses on the International Code Council's *International Residential Code,* which provides a comprehensive collection of requirements for prescriptive (non-engineered) 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 (IBC)* or the National Fire Protection Association's *NFPA 5000 Building Construction and Safety Code.*

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 *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 (Note: For the latest version of these maps, see the most current revision of the IRC.) 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.


**Figure 1-1 Seismic Design Categories - Site Class D**

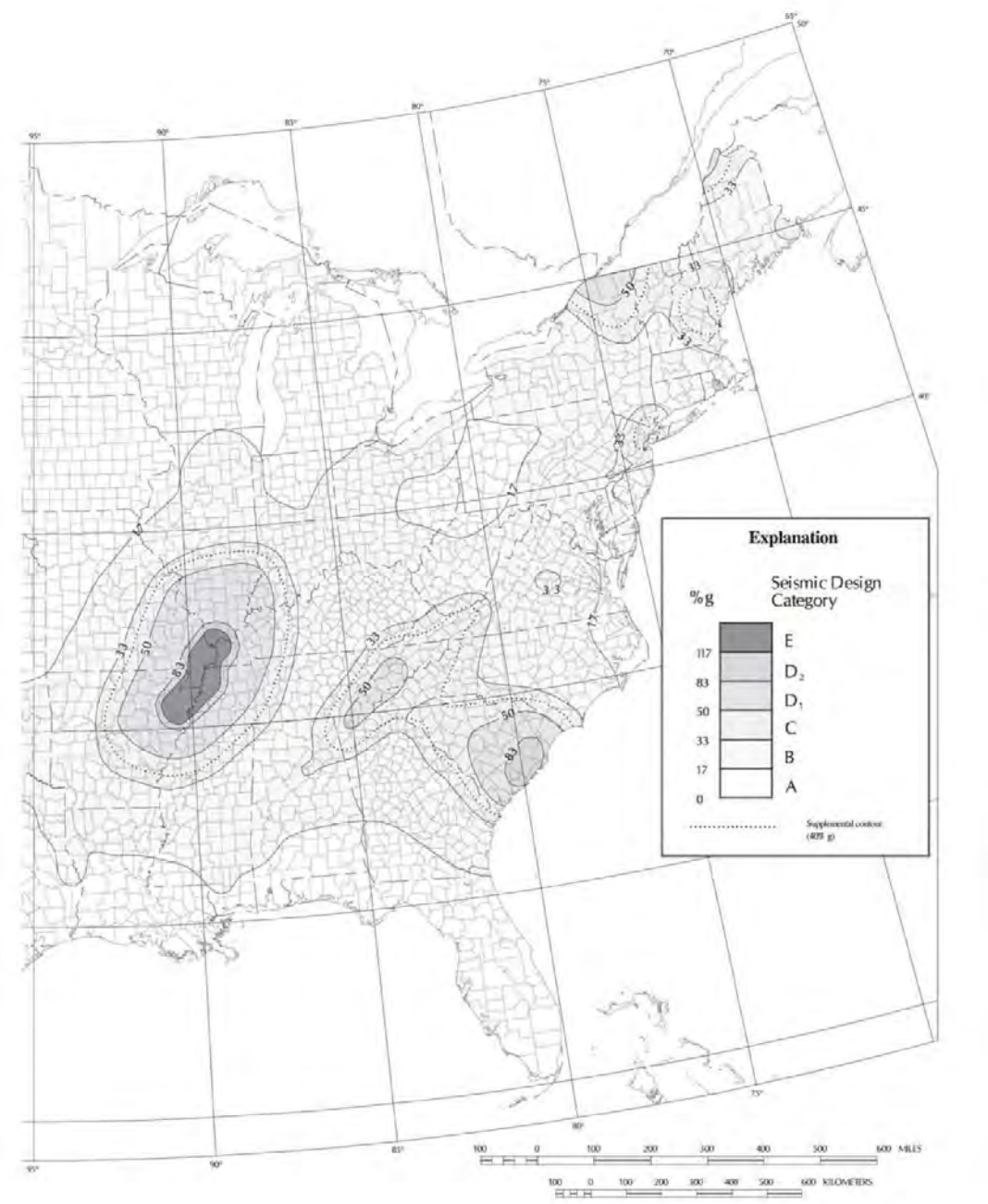


**Figure 1-1 Seismic Design Categories - Site Class D (continued).**

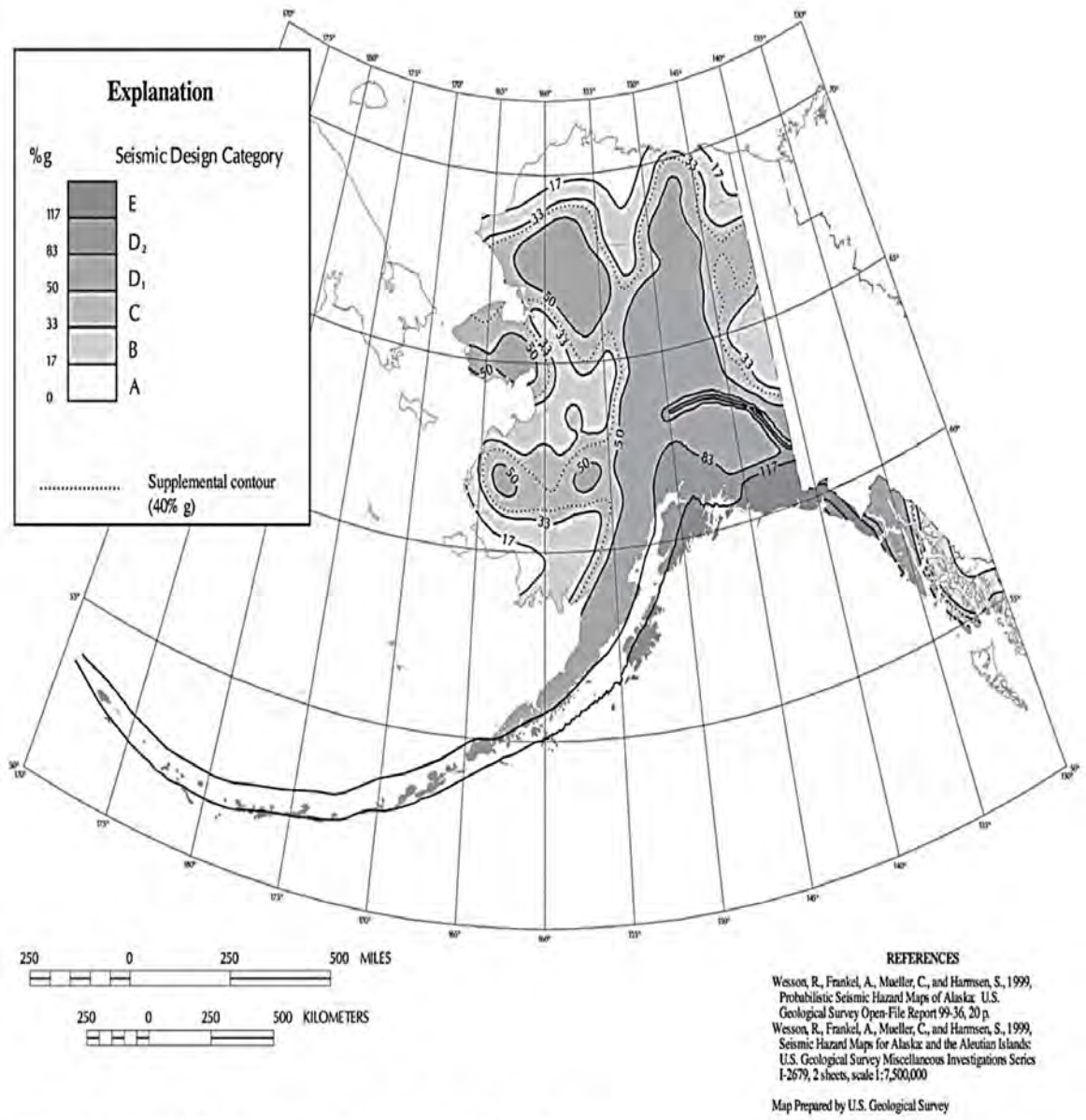


**Figure 1-1 Seismic Design Categories – Site Class D (continued).**

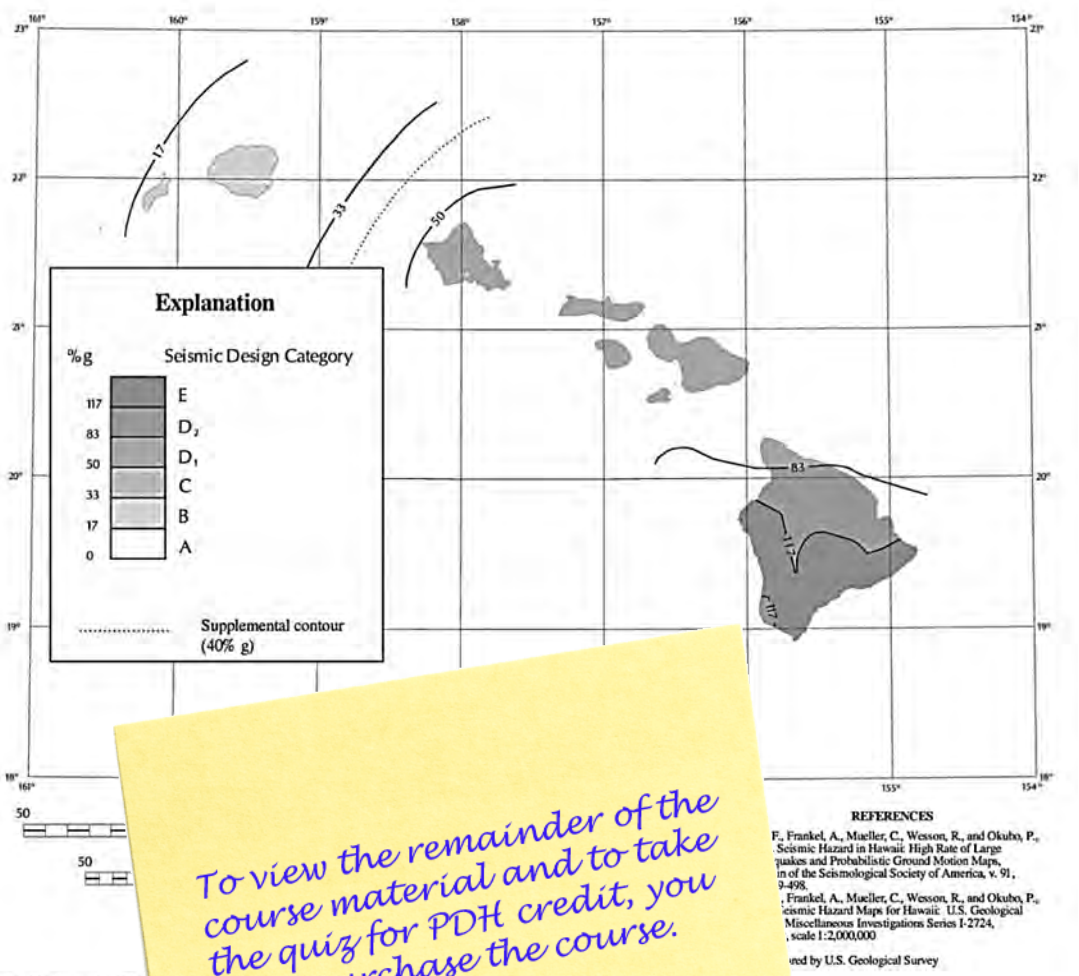


**Figure 1-1 Seismic De**

When using the seismic n uld be aware that local soil conditions have a maj . The *IRC* map incorporates an assumed itions are different from stiff soil (e.g., bedroc al building department may have established spec the local building department to determine i ding site.