# Multihazard Design of Buildings

An Online Continuing Education Course for Engineers

**Course Number: S-1002**

**Credit: 1 Hour / 1 PDH / 1 CPD**

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# Multihazard Design

## Introduction

This course compares the effects of three natural hazards, in terms of their geographical locations, relative warning times, and how likely they are to occur. Fire and life safety considerations are discussed. The design methods used to resist the effects of each natural hazard are discussed in the context of the design methods for the other natural hazards. This integrated approach is a key aspect of multihazard design that must be reflected in a larger integrated approach to the whole building design.

## 1. The Hazards Compared

This course compares the three natural hazards together with issues relating to designing for fire protection. A general understanding of all hazards is necessary in order to develop an integrated approach which is important for locations subject to more than one hazard. Designs for two or more hazards may reinforce one another, thus reducing cost and improving protection. They may also conflict with each other. This course presents a systematic analysis of these multihazard protection methods. The analysis takes the form of the matrices shown in Section 4. Facility planners and designers faced with the challenge of multihazard design requirements will find this course beneficial to prompt analysis at the outset of project design.

### Location: Where do Hazards Occur?

The common public perception of natural hazards is that earthquakes occur in California, floods involve major rivers, tornadoes strike the Midwest, and hurricanes affect the shorelines of the southern Atlantic and Gulf of Mexico. Although there is some truth to this perception as it relates to the highest probabilities, maps that show past disasters reveal that the entire United States is vulnerable to one or more of the three primary natural hazards: earthquakes, floods, or high winds.

- Earthquakes are predominant in the West, but also threaten specific regions in the Midwest, Northeast, and Southeast, and the U.S. territories.[1] The great earthquakes centered on the little town of New Madrid, MO, in 1811 and 1812 caused little damage and only a few casualties; a recurrence of these earthquakes would impact some of the most populous cities of the Midwest. The worst earthquake in the eastern States occurred in Charleston, SC, in 1886; 60 people were killed and the modest sized city suffered the equivalent of about $25 million damage in today's dollars.
- Riverine floods occur along rivers and streams of all sizes, and coastal flooding is associated with storm surges caused by high winds along the entire U.S. shoreline and Great Lakes. Flash floods caused by sudden, intense rainstorms may occur anywhere. Some of the worst floods in U.S. history have been caused by dam failures, often when rivers are already swollen by flood waters.


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- Extreme winds are regional (e.g., hurricanes along the Atlantic and Gulf coasts, the Caribbean, and the South Pacific; tornadoes typically in the Midwest; and downslope winds adjoining mountain ranges), but high winds can also occur anywhere.
- Alaska, Hawaii, parts of the East Coast, and the U.S. territories may all be affected by earthquakes, floods, and high winds.

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1 The U.S. territories include American Samoa, Guam, Northern Mariana Islands, Puerto Rico, and the U.S. Virgin Islands.

Figure 1 illustrates the areas where earthquakes are likely to occur on the U.S. mainland. The contour lines indicate the 2-percent probability of exceedance of ground motion accelerations within each contour area (or the "odds" [2 percent] that the accelerations will be exceeded in a 50year period). Figure 2 is the basic wind speed map from ASCE 7 that is cited in the model building codes and used to select design wind speeds. In addition to high wind regions around the Gulf and Atlantic Coasts, it identifies "special wind regions" in mountainous areas where high winds are likely. Locations where flooding is likely cannot be illustrated in a similar manner because flooding occurs along virtually every body of water, whether large or small. Flood hazard maps are available at the county and municipality level.


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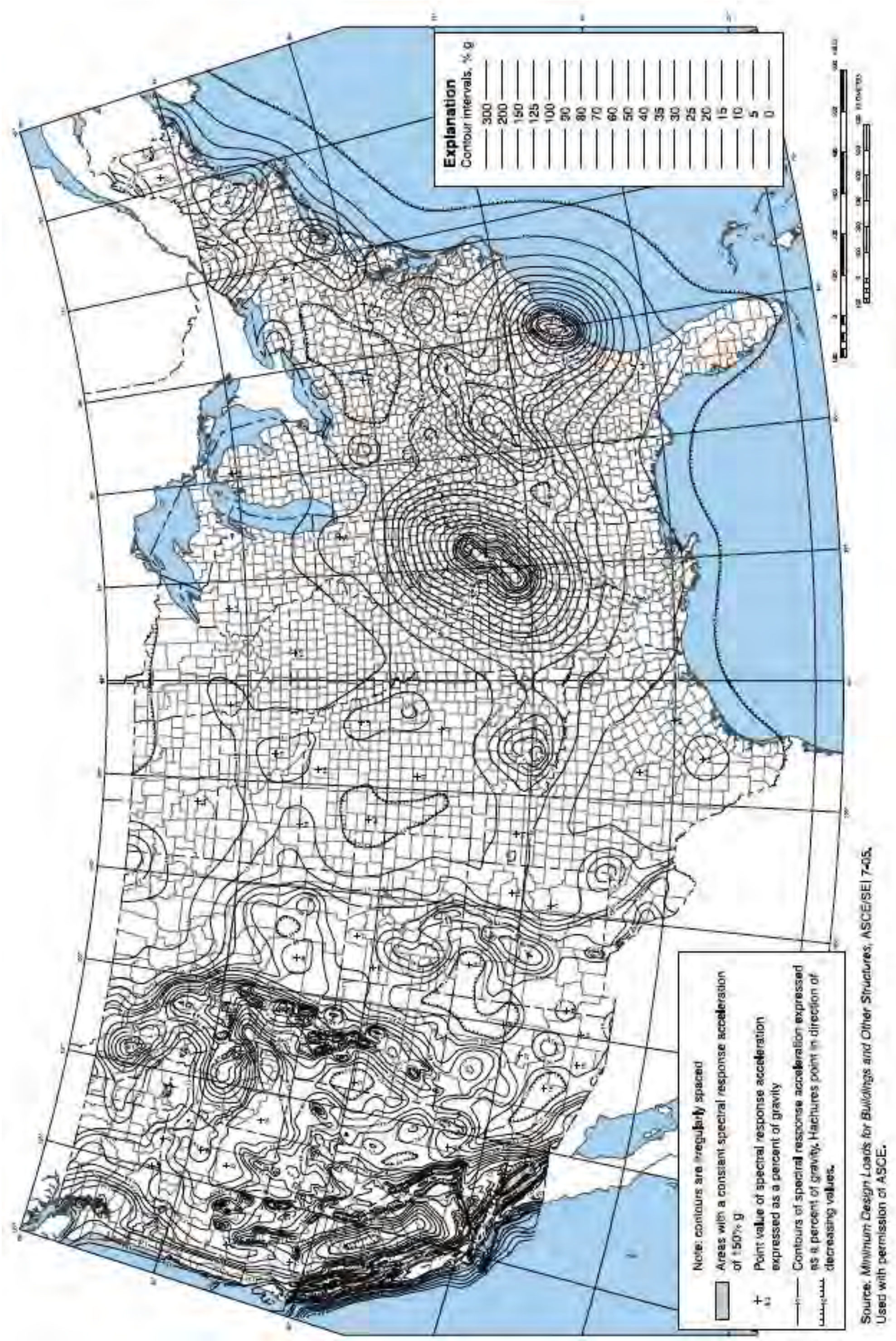


**Figure 1:**
Areas where earthquakes are likely to occur on the U.S. mainland. The contour lines indicate the 2-percent probability of exceedance of ground motion accelerations within each contour area (or the "odds" [2-percent] that the accelerations will be exceeded in a 50-year period).


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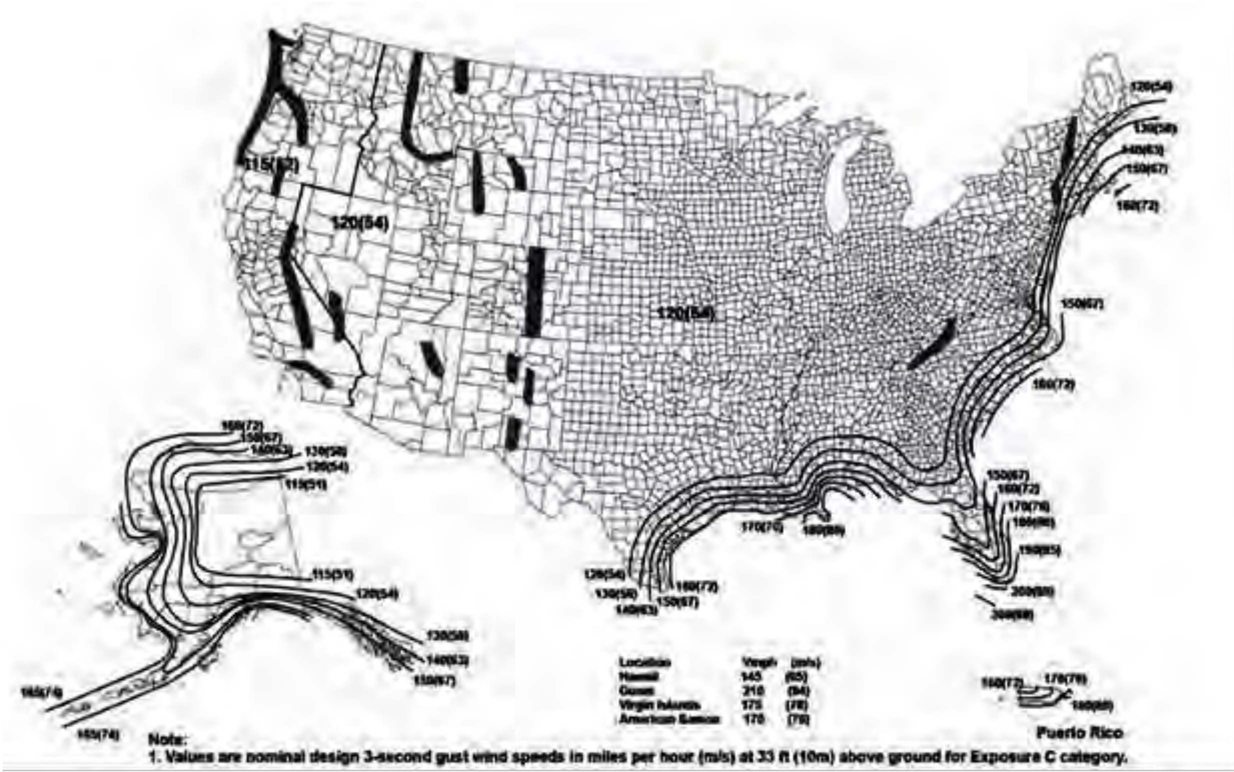


**Figure 2:**
Basic wind speed map from ASCE 7 for Risk Category III and IV buildings and other structures. ASCE 7 is cited in the model building codes and used to select design wind speeds.
SOURCE: ASCE 7-10

**Warning: How Much Warning is There?**

The warning times for the three primary natural hazards vary as a function of many variables:

- Earthquakes are unique among the natural hazards because there is no warning at all, although new sensing devices can give a few seconds warning to locations far from the epicenter. Although much work has been done throughout the world to develop a scientific prediction methodology (based on characteristics such as changes in the dimensional or physical nature of the ground prior to an earthquake, detailed investigation of the geologic strata, or statistical data on the incidence of previous earthquakes), earthquakes must still be regarded as random events within a general envelope of probability.
- Riverine floods (except flash floods) can usually be predicted to give hours or days of warning. National and regional river monitoring systems and numerous local weather and flood warning systems provide improved warning along many waterways.
- Coastal flooding associated with hurricanes can be anticipated because tropical systems can be tracked for days before making landfall. Hurricanes are tracked by the National


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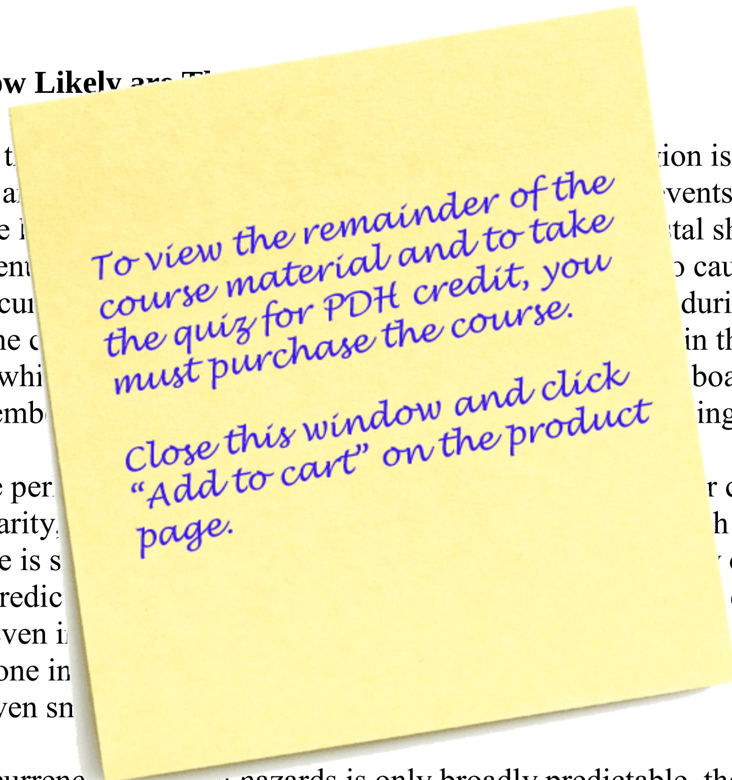
Hurricane Center and their movements are carefully and thoroughly reported although there are many variables that limit the precision of predictions. Other coastal storms, such as nor'easters and those that affect the Pacific and Great Lakes shorelines are less predictable.

- Tornadoes are localized, though sometimes visible from a distance.

However, modern technology allows the National Weather Surface to identify conditions that are conducive to the formation of tornadoes. Typically, they hit a specific location with only a few minutes notice.

**Frequency: How Likely are Th**




For all hazards, t ... ion is much higher than the probability that a ... vents are relatively rare for a given site. Some ... tal shorelines occurs relatively frequen ... cause river and stream flooding can occu ... during specific seasons in some areas of the c ... in the winter and early spring months, whi ... board between June 1st and the end of Novemb ... ing.

Earthquakes are per ... r complete lack of warning, their rarity ... h an earthquake of a given magnitude is s ... of occurrence can reasonably be predic ... example, Massachusetts or Tennessee. Even i ... that many people will not experience one in ... country, the probability of an event is even sn

Because the occurrence ... nazards is only broadly predictable, the frequency of occurrence of future events can only be expressed as probabilities. The probability of occurrence of earthquakes, floods, and high winds is commonly expressed by the term "return period" or "mean recurrence interval," which is defined as the average or mean time in years between the expected occurrence of events of specified intensity.

Prior to the 2000 International Building Code (IBC), the seismic maps in the model buildings codes used a level of shaking (an acceleration value) that corresponds to a 10-percent probability of exceedance in 50 years (or a probability that it would be exceeded one time in approximately 475 years, a 475-year recurrence interval). More recently, research suggests that certain areas, such as the central and eastern United States and in particular the New Madrid Seismic Zone, may be vulnerable to much larger but less frequent quakes. More recent seismic hazard maps produced by the U.S. Geological Survey (USGS) and appearing in the 2000 IBC and later editions show acceleration values for a 2-percent probability of exceedance in 50 years (e.g., a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