

# Unit 5

## Protecting Your Community

### INTRODUCTION

In previous units, we learned the causes of earthquakes and their effects on the natural and built environment and that earthquakes can occur *anywhere* in the United States. How can your community protect itself from the potentially devastating effects of an earthquake? In this unit, we will begin to explore some steps your community can take.

Unit 5 answers the following questions:

- What is mitigation?
- Why use building codes?
- What are the NEHRP *Provisions*?
- What do building codes have to do with Executive Order 12699?

### WHAT IS MITIGATION?

In Unit 1, at the beginning of this course, you read about the devastating effects of the Charleston, South Carolina, earthquake in 1886. That community was totally unprepared for an earthquake striking it. The result was the loss of more than 70 lives, the destruction of 90 percent of the community (buildings, equipment, supplies, personal belongings, etc.) and loss of an unknown amount of income to the community. Unfortunately we have seen many more earthquake disasters since 1886 in the United States and abroad. After each disaster, we have learned a great deal about how to design buildings to resist earthquake forces, how to evaluate the land a building might be built upon and how to plan and build essential buildings so they will remain functional during an earthquake. All of these steps are what we call mitigation.

Mitigation is the set of actions taken to prevent or reduce the risk to life, property, social, and economic activities from natural hazards as earthquakes, floods, and hurricanes. An effective mitigation plan anticipates actions a community must take before a disaster strikes. Planning is one of the most important parts of any mitigation effort. Taking the time up front to make people aware of earthquake risk to their community, making a plan of how to reduce that risk over time and what to do in the event of an earthquake can make a tremendous difference in postdisaster recovery efforts.

There are many different mitigation measures a community can take; we already have mentioned education and planning. A community also can adopt zoning regulations and guidelines on land-use practices. In Unit 4 we explored some of the effects the natural environment can have on the built environment. Making sure that new buildings are not constructed on or near land that is subject to liquefaction, landslides, faults, and tsunamis can be an important mitigation step to prevent or reduce loss of life and property. Building codes are one of the most powerful mitigation tools that can be adopted by a community in anticipation of a seismic event. Over and over again, we have seen that the enforcement of effective building codes will save lives and property.

In the next section, we will talk more about the history of building codes and their use today. A community that is concerned about potential loss of life and property damage due to seismic activity should ensure that seismic considerations have been included in their building codes. What do you think the people of Charleston would have said in 1886 if they knew they could rebuild their city to resist earthquake forces and prevent the devastating effects they had just encountered? Would they have used the seismic factors provided for in today's building codes? What about your community? Are you taking advantage of what we have learned since 1886, or are you still waiting to see what might happen tomorrow?

### **WHY USE BUILDING CODES?**

Building codes have been used in the United States for many years, but they were not used specifically to protect communities from potential earthquake damage until the 1930s. During the Long Beach, California, earthquake of 1933, California Congressman C. Don Field witnessed the collapse of buildings, some of which were public school buildings. Because the State required students to attend school until they were 16 years old, Congressman Field

believed the State was responsible for their safety. Soon after the earthquake, Field sponsored a State bill requiring all new public schools in California to be designed and constructed to withstand earthquake-generated forces; the new law also mandated that the State Architect check and approve all new school building plans. The Field Act protected public schools so effectively that California passed earthquake legislation for hospitals following the 1971 San Fernando earthquake. The California Hospital Act of 1972 set up standards and regulations similar to those the Field Act mandated for public school buildings.

It was these early efforts that helped show the nation that building codes made a difference in reducing the loss of life and property in the event of an earthquake. The strong effect that building codes can have on reducing a community's seismic risk is the main reason the use of building codes is stressed as a way of meeting the seismic considerations in the NEHRP *Provisions*. The enactment of Executive Order 12699 is a significant Federal Government effort to recognize and encourage the use of building codes to reduce the loss of life and property as a result of seismic activity.

### **National Model Building Codes**

Building codes are established to ensure uniform minimum standards of health and safety across the United States. A building code requires that a building or facility be located, designed, and constructed so that any threat to the life, health, and welfare of its occupants and the public is minimized or prevented.

Builders that use building codes in the United States generally use one of the prominent national model building codes, which have been published by separate private organizations.

Model codes have effectively reduced loss of life and property damage in many communities. However, seismic provisions were not always included in model codes. Seismic provisions established standards for how buildings should be located, designed, and constructed to resist ground motion. The NEHRP *Recommended Provisions for the Development of Seismic Regulations for New Buildings* changed that.

## WHAT ARE THE NEHRP *PROVISIONS*?

The Earthquake Hazards Reduction Act of 1970 established NEHRP, a Federal multiagency program that funds research focusing on preventing or reducing loss of life and property damage caused by earthquakes. Based on the collective efforts of engineers, scientists, and tradespeople, the NEHRP *Provisions* encompass all that has been learned over the past 20 years about the responses of buildings to seismic forces and contain seismic design specifications that are technically advanced and widely accepted.

Although the *Provisions* are recommendations for establishing seismic standards and not regulations, the nation's model building codes are based on them. The seismic provisions in the International Building Code (IBC), NFPA 5000 Building Code, and ASCE 7 Design Loads Standard are substantially equivalent to the NEHRP *Provisions*. All communities that adopt the most recent editions of these model codes utilize the most advanced seismic provisions available.

The NEHRP *Provisions* include a number of factors that help engineers, architects, and construction personnel decide what seismic design factors need to be included in a specific building at a specific site. Some of these factors include:

- Seismic forces,
- Seismic hazard maps,
- Seismic Use Groups, and
- Seismic Design Categories.

The following discussions explain each of these factors.

### Determining Seismic Forces

For a given location, the nature of ground motion that occurs during an earthquake will depend on several factors, including:

- Magnitude of the earthquake,
- Duration of ground shaking,
- Distance from the epicenter,
- Type of soil (whether the ground is dense or loose), and
- Depth below the surface where the earthquake begins.

The design and construction of a building also affect the forces that are created within it during an earthquake. The following influence a building most:

- Weight or size,
- Shape and proportion,
- Construction materials, and
- Construction quality.

A seismic code must provide a uniform method by which the nature of ground motion at any location may be assessed and a safe, economical building be designed.

### **Seismic Hazard Maps**

As we have discovered in previous units, different States have different levels of hazard and risk from earthquakes. The NEHRP *Provisions* were created with this in mind. They reflect the relative earthquake hazard of regions across the nation and suggest risk-reduction measures tailored to each region's unique level of hazard. The *Provisions* acknowledge that it makes little economical sense to design a building in New York to resist the same earthquake forces as those a building must resist in California. The NEHRP *Provisions* provide two United States maps (shown in Figures 5-1 and 5-2) that contain quantitative measures from which seismic forces on buildings may be determined. These maps were developed from information for each location on:

- Historical seismicity,
- A location's proximity to known faults, and
- Geological investigations that indicate earthquake ground motion is more or less likely than historical seismicity might indicate.

The two maps give, in slightly different form, estimates of horizontal accelerations for any location in the United States. The accelerations for any location are illustrated in the form of contour lines indicating areas of equal acceleration.

The map in Figure 5-1 shows short-period spectral response accelerations for locations throughout the United States, and the other (Figure 5-2) shows long-period spectral response accelerations. Both maps are needed to give the design engineer information on possible ground shaking and intensity characteristics in a particular area. The first map works well for earthquakes of shorter duration, while the second is better for longer duration earthquakes. Both values are important for the design engineer to consider when designing a building.

### **Seismic Use Groups**

Just as they recognize that different regions require different sets of seismic provisions, the NEHRP *Provisions* acknowledge that buildings require various types of protection as well. The NEHRP *Provisions* take into account the relative importance of some buildings over others within a single community. NEHRP developed a system by which buildings are grouped into categories according to the whole community's use of and need for them. For instance, an entire community would need a hospital during a seismic event, and the collapse of a sports arena would affect many more people than a single dwelling.

Seismic Use Groups reflect this relative importance and place buildings in one of three groups—III being the most critical, I the least. This system is intended to ensure that important buildings such as hospitals, fire stations, and police stations and high-occupancy buildings such as schools, auditoriums, hotels, and office buildings are built using higher standards for seismic protection than other buildings.

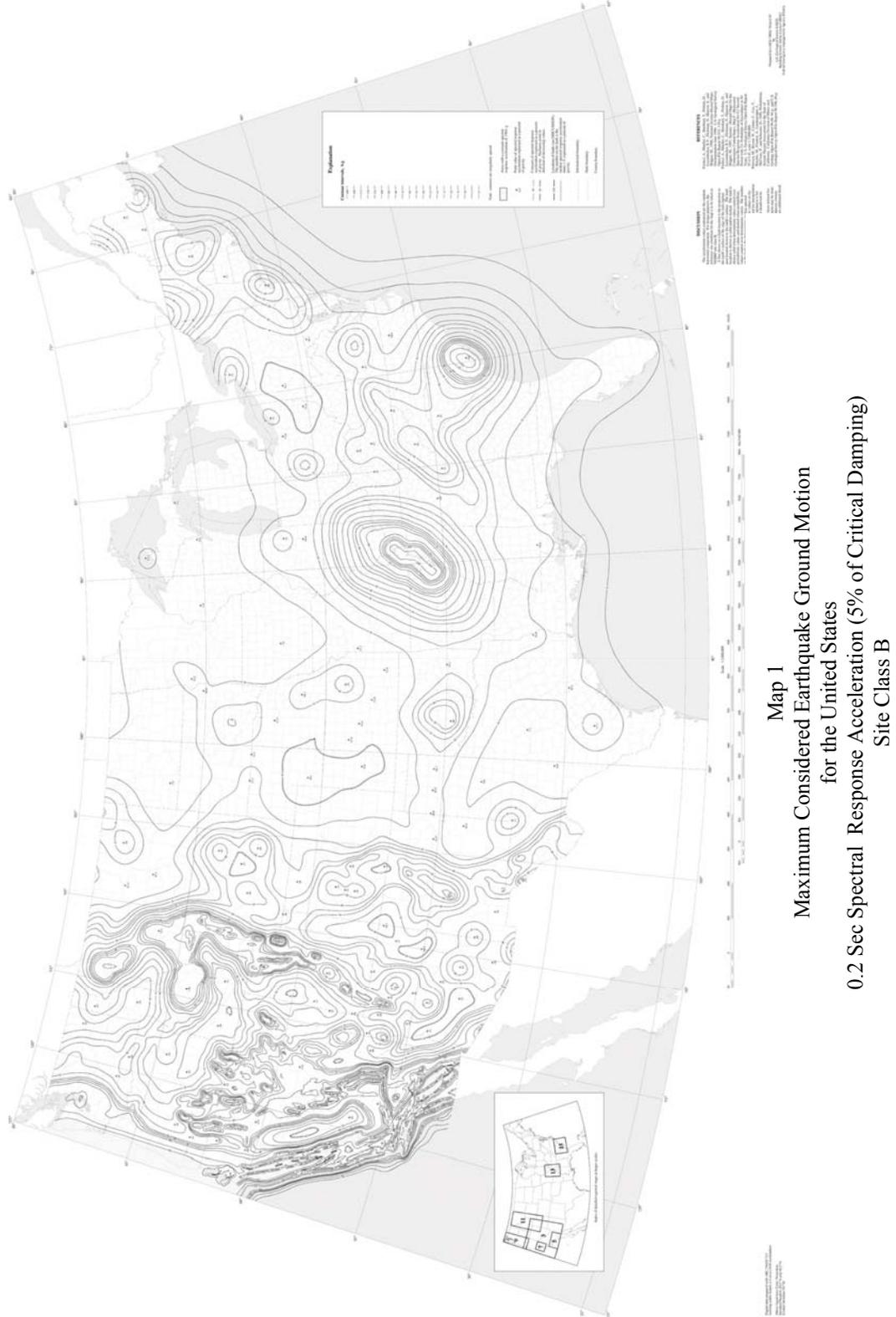


Figure 5-1

Source: U.S. Geological Survey.



Figure 5-3 shows examples of buildings in each Seismic Use Group:

Which buildings in your community would you add to these Seismic Use Groups?

Seismic Use Group	Sample Buildings
I	One- or two-family dwellings
II	Schools
III	Hospitals, Police Facilities

**Figure 5-3**

**Seismic Design Categories**

The *Provisions* also utilize Seismic Design Categories. The Seismic Design Categories consider both a building’s hazard and importance in order to determine the category of seismic performance to which it must be designed. A specific building’s design category is determined using a table that relates design acceleration (from the Seismic Hazard Map) to a building’s Seismic Use Group rating. There are six Seismic Design Categories:

- *Seismic Design Category A* represents structures in regions where anticipated ground motions are minor, even for very long return periods. For such structures, the NEHRP *Provisions* require only that a complete seismic-force-resisting system be provided and that all elements of the structure be tied together. A nominal design force equal to 1 percent of the weight of the structure is used to proportion the lateral system.
- *Seismic Design Category B* includes Seismic Use Group I and II structures in regions of seismicity where only moderately destructive ground shaking is anticipated. In addition to the requirements for Seismic Design Category A, structures in Seismic Design

Category B must be designed for forces determined using NEHRP *Provisions* Maps 1 through 24.

- *Seismic Design Category C* includes Seismic Use Group III structures in regions where moderately destructive ground shaking may occur as well as Seismic Use Group I and II structures in regions with somewhat more severe ground shaking potential. In Seismic Design Category C, the use of some structural systems is limited and some nonstructural components must be specifically designed for seismic resistance.
- *Seismic Design Category D* includes structures of Seismic Use Group I, II, and III located in regions expected to experience destructive ground shaking, but not located very near major active faults. In Seismic Design Category D, severe limits are placed on the use of some structural systems and irregular structures must be subjected to dynamic analysis techniques as part of the design process.
- *Seismic Design Category E* includes Seismic Use Group I and II structures in regions located very close to major active faults and *Seismic Design Category F* includes Seismic Use Group III structures in these locations. Very severe limitations on systems, irregularities, and design methods are specified for Seismic Design Categories E and F. For the purpose of determining whether a structure is located in a region that is very close to a major active fault, the *Provisions* use a trigger of a mapped maximum considered earthquake spectral response acceleration parameter at 1-second period,  $S_L$ , of 0.75 or more regardless of the structure's fundamental period. The mapped short-period acceleration,  $S_S$ , was not used for this purpose because short-period response accelerations do not tend to be affected by near-source conditions as strongly as do response accelerations at longer periods.

Figures 5-4 and 5-5 express the relationship of an area's seismicity to its Seismic Use Group and Seismic Design Category.

**Seismic Design Category Based on  $S_{DS}$**

Value of $S_{DS}$	Seismic Use Group		
	I	II	III
$S_{DS} < 0.167$	A	A	A
$0.167 \leq S_{DS} < 0.33$	B	B	C
$0.33 \leq S_{DS} < 0.50$	C	C	D
$0.50 \leq S_{DS}$	D <sup>a</sup>	D <sup>a</sup>	D <sup>a</sup>
<sup>a</sup> See footnote to Figure 5-5.			

**Figure 5-4**

Source: 2003 NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, Table 1.4.1.

**Seismic Design Category Based on  $S_{DI}$**

Value of $S_{DI}$	Seismic Use Group		
	I	II	III
$S_{DI} < 0.067$	A	A	A
$0.067 \leq S_{DI} < 0.133$	B	B	C
$0.133 \leq S_{DI} < 0.20$	C	C	D
$0.20 \leq S_{DI}$	D <sup>a</sup>	D <sup>a</sup>	D <sup>a</sup>
<sup>a</sup> Seismic Use Group I and II structures located on sites with $S_I$ greater than or equal to 0.75 shall be assigned to Seismic Design Category E, and Seismic Use Group III structures located on such sites shall be assigned to Seismic Design Category F.			

**Figure 5-5**

Source: 2003 NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, Table 1.4.2.

Using this information, an essential building, like a hospital, located in an area experiencing severe seismic accelerations would be assigned to Seismic Design Category E or F and, thus, would be subjected to more stringent seismic regulations. Which Design Category would you assign to a low-occupancy building in an area of high seismicity? Answer: Design Category C or D.

The NEHRP *Provisions* have provided builders with the seismic guidance needed to build seismically safe, economical buildings. These provisions have been adopted by the model building codes—so that the most recent edition of each model building code now contains

seismic provisions that can be applied to all construction done in the United States.

### **WHAT DO BUILDING CODES HAVE TO DO WITH EXECUTIVE ORDER 12699?**

Since 1977, the Federal Government actively has sought ways to decrease the seismic risk to communities throughout our nation. As research on seismic risk reduction has developed, it has become clear that one of the most important factors affecting a community is the quality of the built environment. Time and time again, post-disaster studies have shown that new construction incorporating seismic design features decreases the structural damage done to a community and saves lives.

Saving lives and property is the main purpose of Executive Order 12699. The Executive Order was drafted to “reduce the risks to the lives of occupants of buildings owned, leased, assisted, and regulated by the Federal Government and to reduce risks to the lives of persons who would be affected by earthquake failures of Federal buildings and to protect public investments, all in a cost-effective manner.”

Executive Order 12699 is a wide-reaching order that affects any State and local government and any private institution that is involved with buildings assisted, leased, or regulated by the Federal Government. It requires that all new construction be built according to the seismic standards outlined in the NEHRP *Provisions*. As we noted earlier in this unit, the NEHRP *Provisions* have been incorporated into national model building codes used in the United States. That means that any community that adopts an up-to-date model building code that includes all NEHRP seismic provisions will meet the Executive Order requirements. Any community that hopes to continue receiving Federal funds for new construction that is assisted, leased, or regulated by the Federal Government must be concerned with complying with Executive Order 12699.

In Unit 2, we discussed many of the ways a community can be affected by this order. Your community’s local government officials, architects, lenders, land-use officials, engineers, construction personnel, building-code officials, and many others all will be responsible for making sure they comply with the Executive Order. Though this sounds like a big task, it can be as easy as making sure your community consistently uses one of the most recent model building codes with all its seismic provisions. In the next unit, we will explore what your community can

do to comply with Executive Order 12699.

## **UNIT 5 - SUMMARY**

This unit explored some of the steps a community can take to protect itself from earthquakes. The following questions were discussed:

- What is mitigation?
- Why use building codes?
  - Model building codes
- What are the NEHRP *Provisions*?
  - Determining seismic forces
  - Seismic hazard maps
  - Seismic Use Groups
  - Seismic Design Categories
- What do building codes have to do with Executive Order 12699?

## Unit 5

# Protecting Your Community

## Unit Review

Directions: For each question, circle the letter of the correct response and check your answers with the Answer Guide at the end of the unit.

1. Which of the following is **not** part of effective mitigation planning?
  - a. Earthquake prediction
  - b. Adopting zoning regulations
  - c. Developing land-use guidelines
  - d. Adopting building codes
  
2. In 1933, Congressman C. Don Field set a precedent for building codes by sponsoring a State bill that required all new \_\_\_\_\_ in California to be designed and constructed to withstand earthquake-generated forces.
  - a. hospitals
  - b. State office buildings
  - c. public schools
  - d. all public buildings
  
3. The NEHRP *Provisions* assign every building to one of three Seismic Use Groups based on:
  - a. location, design, and construction of the building.
  - b. importance of the building and how heavily occupied it is.
  - c. age of the building.
  - d. history of earthquake damage to the building.
  
4. A building's Seismic Design Category is based on a combination of its Seismic Use Group and an area's:
  - a. climate.
  - b. geological formations and vegetation.

- c. importance.
- d. seismicity.

## Unit 5

### Protecting Your Community

#### Unit Review - Answer Guide

1. Which of the following is **not** part of effective mitigation planning?
  - a. Earthquake prediction  
Reference: p. 5-2
2. In 1933, Congressman C. Don Field set a precedent for building codes by sponsoring a State bill that required all new \_\_\_\_\_ in California to be designed and constructed to withstand earthquake-generated forces.
  - c. public schools  
Reference: p. 5-3
3. The NEHRP *Provisions* assign every building to one of three Seismic Use Groups based on:
  - b. importance of the building and how heavily occupied it is.  
Reference: p. 5-6
4. A building's Seismic Design Category is based on a combination of its Seismic Use Group and an area's:
  - d. seismicity.  
Reference: pp. 5-9 to 5-11