Chapter 4
How States Can Adopt Seismic Building Codes

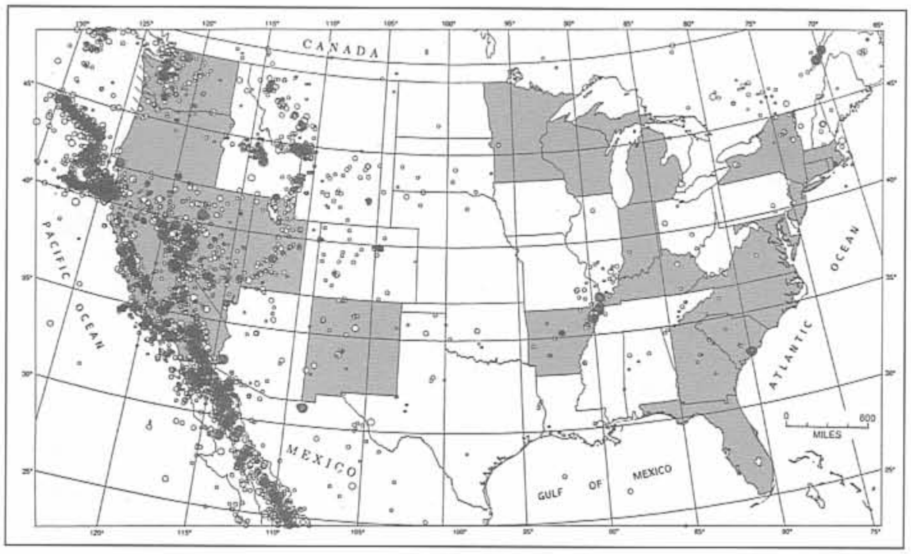


FIGURE 4.1 Historic earthquake locations superimposed on map of states with mandatory building codes for all occupancies. Most states have earthquakes, but not all of them require building codes. (Sources: earthquake locations, USGS, 1989; states with mandatory codes, IIPLR [now IBHS], 1996)

This chapter describes how to adopt a state seismic code. An alternative approach is to encourage the adoption of seismic codes at the local level; that topic is taken up in chapter 5.

Background Information

Code Practices Vary Among the States, From Centralized to Local

All states have a legal right to regulate construction, but not all states exercise this right. Currently forty states and the District of Columbia mandate building code requirements and ten states do not. A statewide code assures a minimum level of protection throughout the state. The most common forms of state building regulation are:

Total preemption. A state agency responsible for building regulations develops the regulations for local implementation and enforcement.

Partial preemption. The state building regulations are minimum standards, and local jurisdictions may adopt equal or more restrictive regulations.

California system. State law directs local jurisdictions to adopt a set of uniform codes for enforcement at the local level; the law only allows amendments reflecting special local conditions.

State Code Requirements: Statutory vs. Administrative

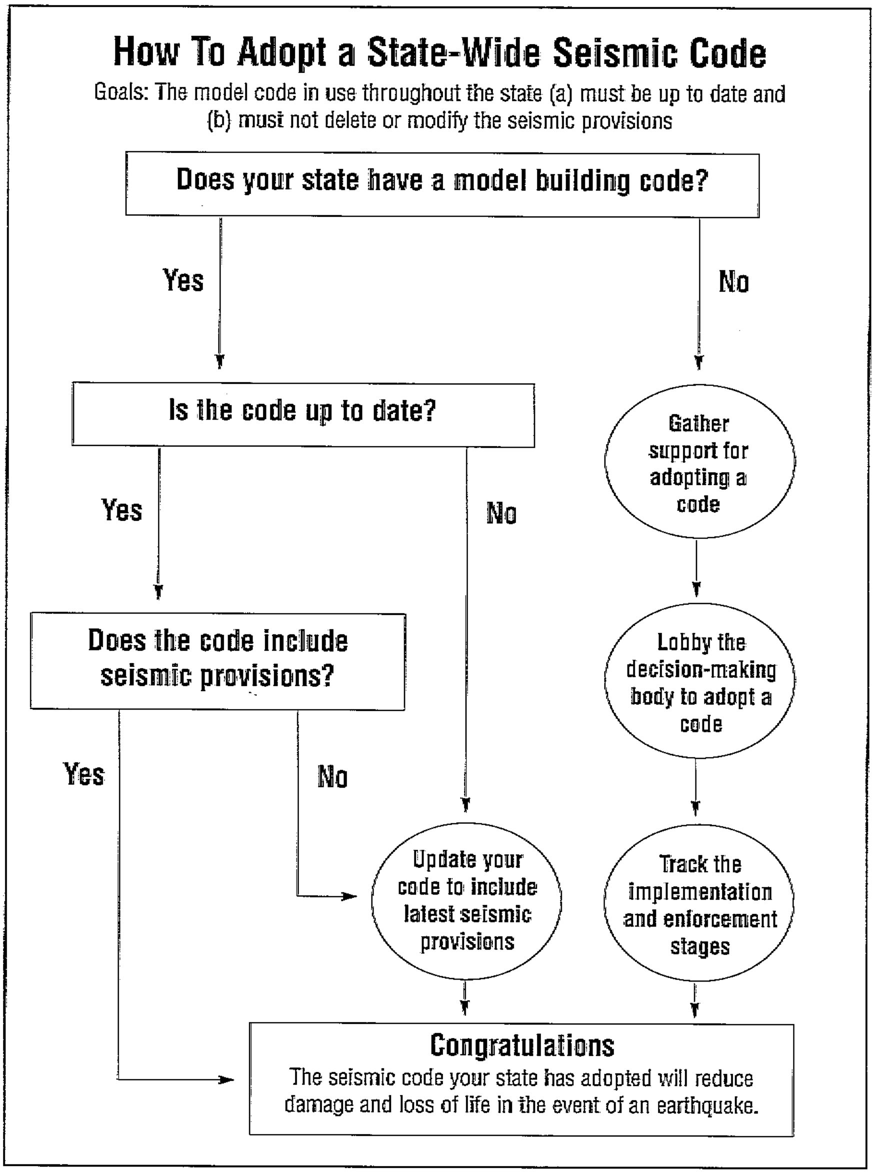
States that mandate building codes describe their powers within either the state's statutes or its administrative code.

Statutory code. Because a state statute is difficult to amend, requiring a building code in statute form assures a degree of permanence and is a statement of the state's long-term commitment to building safety. The best approach is to enact permanent policy statements into a statute and to place the details that need periodic revision into administrative regulations. In order for a building code to become statutory law, a state legislator must sponsor a building code bill, maneuver it through the proper committees, and obtain a positive vote, usually from two houses of the legislature. Once the bill passes, it can be signed by the governor and become law.

Administrative code. Where a building code is required in administrative code, an administrative body, usually a commission or board, is invested with rule-making authority. Additions or revisions to the administrative code do not require legislative approval. An open, public process is required, which is not as involved as statutory reform.

Creating a New Code vs. Adopting a Model Building Code

States may create their own building code or adopt all or parts of an existing recognized model building



code. Because of the complexity, cost, and time of writing an original building code, most states choose to adopt a model building code. By adopting such a code, the state building agency can obtain direct technical assistance from the model building code organization.

Enforcement at State or Local Level

With a statewide building code in place, the state may delegate the enforcement to local governments. Sometimes the state delegates only to those local governments that can prove that they have adequate qualified staff to review plans and provide inspections. This can increase code compliance while avoiding the need for a large state enforcement agency.

Importance of Periodic Updates

Ideally the statute or administrative code provides for the periodic adoption of the most current building code edition. The three model building codes issue new editions every three years. It is important to note that a government must explicitly adopt each new edition of the code. A law cannot state that "the most recent" edition of a code is automatically the operative one. Rather, a law can state an intent to update or can

Virgin Islands Adopt New Building Codes

Over the past ten years, the U.S. Virgin Islands have dealt with a number of serious hurricanes.

Hurricane Hugo struck the Virgin Islands on September 17-18, 1989.[1] This category 4 hurricane caused $3 billion in damage in the Virgin Islands and Puerto Rico. St. Croix and St. Thomas suffered tremendous damage from an unusually prolonged battering of hurricane force winds, with sustained wind speeds estimated at 127 mph at St. Croix and 98 mph at St. Thomas. Some areas were completely devastated. At the time, building construction was governed by the 1972 Virgin Islands Building Code, mandatory throughout the territory. The lateral wind loads in this code were based on sustained wind speeds of 81 mph.

The most damaging hurricane, Marilyn, hit the Virgin Islands on September 15-16, 1995. The storm was officially recorded as a category 3 storm with winds of 110 mph as it passed over St. Thomas. The estimated cost of reconstruction, as of October 1995, was about $3 billion.[2]

After Hurricane Marilyn, FEMA worked with the Territorial Government to assist in the development of building codes incorporating mitigation for all types of structures. In October 1995 the Virgin Islands adopted, by statute, the UBC for public buildings and other structures as well as Chapters 1-7, 10, and 14-35 of the 1994 UBC and Chapters 1-9, 18, 22, and 28-47 of the CABO *One- and Two-Family Dwelling Code* for all other buildings and other structures. FEMA has provided both technical and financial assistance to assist in enforcement, education, and training concerning the new codes.[3]

Overview: Steps Toward Statewide Seismic Provisions

Step 1:
Determine your state's current building code requirement (if any) and develop a strategy for incorporating or initiating current seismic provisions.

Step 2:
Gather support for the proposed changes.

Step 3:
Lobby the decision-making body (state legislature or administrative board or commission) with information explaining why the changes are needed and describing the kind of support you have gathered.

Step 4:
Continue your involvement through the administrative implementation and enforcement stages once the seismic provisions are approved.

mandate that the adopted code must "equal or exceed the standards" of the latest published edition of a code. In any event, the specific published edition of the code must explicitly be adopted as such (with whatever minor revisions the state desires to add).

The following sections describe a step-by-step strategy to achieve statewide seismic provisions.

Step 1: Determine Your State's Current Building Code Requirement (If Any)

The first step in pursuing any strategy to incorporate or initiate seismic provisions is to ascertain what building requirements already exist. You will need to describe deficiencies in the existing code and suggest appropriate actions to correct those deficiencies.

It is important to understand the process followed in your state and learn how to use that process successfully. The process of adopting statewide seismic provisions will vary greatly among states, depending on whether your state currently mandates a building code.

If your state *does* have a code, determine what amendments are needed to incorporate current seismic provisions and pursue these amendments.

If your state *does not* have a code, consider the possibility of introducing a state code that contains current seismic provisions. An alternative is to pursue widespread adoption of seismic provisions in local building codes, although this would be a more resource-intensive effort (see chapter 5).

To ensure the highest level of statewide seismic safety, you should focus your efforts on the two most important points: (a) the code must be up to date and (b) the code must include the latest seismic provisions.

If Your State Does Not Have Building Code Requirements

If your state lacks a building code requirement, you need to take action in order to encourage the adoption of a statewide code. There are several ways to establish an appropriate state building code that contains current seismic provisions.

A new code can be established legislatively or administratively. The best way to ensure long-term safe building practices is to establish the code by statute, using the legislative process. At a minimum, the legislation should specify local adoption of one of the three model codes with seismic provisions. It is much easier to adopt a model code than it is to write an original code. To ensure a minimum level of safety throughout the state, the legislation also must specify a procedure for periodic code updates.

Legislation may be quite detailed or may simply mandate an administrative process of code review and adoption. For example, the legislation may specify the model code to use and the topics to include, or it may leave those decisions to the rule-making board. Examples of legislation are contained in Appendix B; the legislative process is described below in step 3.

You should realize that any legislative enactment of a code requirement also will entail an administrative rule-making process, so you need to understand both processes. The point is this: Where the legislation leaves off, the administrative regulations begin. See step 4 below.

Whether you pursue an administrative or legislated code, always remember your two primary goals: The code in use throughout the state (a) must be up to date (the latest published edition of an accepted model building code) and (b) must not delete or modify the seismic provisions.

If Your State Has a Building Code But Does Not Incorporate Seismic Provisions

Where a state building code exists but does not contain seismic provisions, it should be relatively easy to require seismic design. If the state code is based on one of the three model codes, all of which now contain seismic requirements, all that may be required is adopting the most recent edition of your model code.

There are several ways to incorporate seismic provisions into a code that is not based on one of the three model codes. For example, the seismic provisions can be established by the state, or the state legislature can simply mandate local adoption of any of the model seismic codes. Politically it should be easier to amend an existing state code than to enact a new code.

Statutory code. To amend a code established through legislation, you must find a legislator to sponsor an amendment to the state building act and then work to create support for the proposed changes. Legislative enactment is preferable to revising an administrative code, because statutes are harder to amend or repeal. The legislative process is described below in step 3.

Administrative code. Amending an administrative code to incorporate seismic provisions is typically less cumbersome than amending a statutory code. You should learn the following information about your administrative code: Are the regulations reviewed periodically? When is the next review scheduled? What are the opportunities for public comment?

Whether your state code is established by statute or administrative rule, instituting the revised code will be a multistep process. You will need to plan a strategy before you begin. The strategy should involve steps similar to those for code adoption: gather support, lobby the decision-making body, and monitor implementation and enforcement.

Step 2: Gather Support for Adopting Seismic Provisions

First, get the backing of your department and other relevant state departments and agencies. Identify interest groups whose support you will need and whose arguments you will have to answer. Seek support from a wide range of professional associations. The wider the range of associations, the stronger support will be for your proposed changes. At a minimum you will need the support of representatives from high-earthquake-risk areas. If they do not support the changes, it will be nearly impossible to convince others.

Preparing a sound case for seismic provisions will help to advance your position and generate needed support. Solid arguments in favor of seismic provisions are presented in Step 2 of Chapter 5 and in Appendix G.

To gain support, contact organizations that may be affected by and are interested in code adoption and enforcement in your state. Addresses and phone numbers of several relevant national-scale organizations are included in Appendix E. You should review these lists to get ideas useful for your situation and to identify potential supporting organizations.

Municipal leagues. You can communicate with local governments collectively by means of their professional and lobbying organizations. Every state except Hawaii has a state municipal league. You can find out how to locate the league in your state by contacting the National League of Cities (see Appendix E). Most state leagues probably have a newsletter or magazine, an annual conference, and perhaps

Step 1: Determine Current Code Requirements

- Is the code statutory or administrative?
- Is the code designed by a state agency or by local choice? Is the responsible level of government adequately funded to implement the code?
- Is the code unique to your state or a model code? If it's a unique state code, does the state office provide technical support to local governments to implement the code?
- If it's a model code, which one is it? Has your state modified it? If so, how and to what extent? Which edition is currently adopted? Is it the most recent?
- How is the code updated? How often? By whom? By what process?
- Have all local jurisdictions been granted the authority to adopt and enforce a code?
- Does the code have seismic provisions? Are the model code seismic provisions modified? If so, how and to what extent? Do the seismic provisions reflect the latest *NEHRP Provisions*? (The 1992 SBCCI and BOCA Supplement model codes are the first editions of the codes to incorporate all the *NEHRP Provisions*; the 1991 UBC is also consistent with the *NEHRP Provisions*.) All local codes based on these or subsequent editions are consistent with the *NEHRP Provisions*.

State Seismic Safety Advisory Committees[4]

What Are They?

Seismic safety advisory committees are voluntary bodies selected to advise the state on seismic policy matters. Most often, they are selected by and answerable to the governor, but they also may be advisory to the state legislature. Several states now have such bodies, including Arkansas, Kentucky, Missouri, Oregon, Arizona, Utah, as well as the original one in California.

Advisory committees usually consist of representatives from the following interests: relevant state agencies, universities, utilities, local governments in high-risk areas, technical and professional organizations, energy companies, civic organizations, and sometimes legislators from high-risk areas. Usually the governor's office selects the members, for terms ranging from one year to indefinite. Members are chosen for both their expertise and their interest in reducing seismic hazards. Committee members take their duties seriously, and most work surprisingly hard for little or no money.

What Do They Do?

Seismic safety advisory committees typically meet two to six times per year. In addition, they usually divide up into several subcommittees (e.g., awareness, mitigation, response, public health). These subcommittees often do the real work of the organization. They usually consist of three to six members, who informally communicate and assign tasks throughout the year. Reports of activities in progress are presented at the regular committee meetings. Seismic safety advisory committees serve several functions:

- Make knowledge of local experts available to the legislature and administrative agencies.
- Coordinate the earthquake preparedness activities of state agencies.
- Keep earthquake issues in the public eye.
- Serve as advocates for seismic safety.
- Prepare policy reports and draft legislation.
- Involve people who are interested in and knowledgeable about seismic safety.
- Promote communication between state agencies, local agencies, professional design organizations, and the construction industry.

Case Study in Success: The Arkansas Story

Arkansas formed an Earthquake Advisory Council in 1984, with representatives from state agencies, utilities, universities, hospitals, local agencies, and other interested parties. In the late 1980s, the Council adopted seismic code provisions as a high priority.

Council members drafted a bill and gave public presentations. The bill was introduced in November 1990 (coincident with the aftermath of the Loma Prieta, California, disaster) and cleared the legislature in March 1991—with no opposition votes. Act 1100 requires that all "public structures" be designed to resist seismic forces, in accordance with the minimum requirements of the 1993 revision to the 1991 Standard Building Code or the latest edition with revisions.

Why Do We Need One?

A seismic safety advisory committee can help reduce earthquake hazards in many different ways. The Arkansas Seismic Advisory Committee played a crucial role in drafting and gathering support for the 1991 bill (see Appendix B) that requires all public structures to be designed to resist seismic forces. They can encourage better construction practices, promote earthquake awareness and professional training, provide advice on siting critical public facilities, and help agencies to inventory existing hazards. An active committee can make a real difference in a state's ability to survive the next earthquake.

How Do We Form One?

The easiest way to form a seismic safety advisory committee is by an executive order of the governor. Typically, the idea would be initiated by the governor or by the director of emergency management or geological survey. The governor would then request one of these agencies, in consultation with others, to propose a list of members, all of whom have agreed to serve if selected. The governor's office would then revise and approve the list, and issue the executive order. A seismic safety advisory committee may also be established by the state legislature, with the advantage that the organization becomes more permanent (a disadvantage is that it is much more cumbersome to initiate). The legislature must also consider how to appoint members.

local dinner meetings. Tap into this network:

- Submit an article to their magazine or newsletter.
- Participate in their conferences.
- Organize workshops and invite them.

Building officials. Contact the nearest model building code organization (see Appendix D) to identify nearby jurisdictions with codes and to learn the names of the building officials.

Civil engineers. The American Society of Civil Engineers (ASCE, see Appendix E) is the largest professional organization for civil engineers. The ASCE has sixteen sections divided into branches that cover major metropolitan areas. Many of these groups have regular meetings. ASCE also has twenty-one regional council organizations.

Structural engineers. The ASCE includes structural engineers, and some states have their own professional structural engineers associations. You might also make use of the expertise offered by local members of the Earthquake Engineering Research Institute (EERI, see Appendix E).

Professional engineers. Some states have associations of professional engineers representing licensed engineers in the state, including civil, structural, mechanical, and others. Contact the National Society of Professional Engineers (NSPE, see Appendix E) for information about your state organization.

Architects. The American Institute of Architects (AIA) is the largest professional organization of architects. Contact the national office (see Appendix E) for information on your state or local chapter.

Home builders or contractors. Most states and localities have associations of home builders and building contractors. You will need to meet with them to institute or strengthen codes. Some construction associations, such as the National Association of Home Builders and the Associated General Contractors of America, are members of the Building Seismic Safety Council (NAHB, AGCA, and BSSC, see Appendix E).

City and county managers. Chief administrators of cities and counties belong to the International City/County Management Association (ICMA, see Appendix E). The ICMA has chapters in every state.

Chambers of commerce. Many businesses belong to the Chamber of Commerce. The businesses can be valuable supporters if you convince them of the business disruptions that damaging earthquakes can cause.

The media. The media can be very helpful in educating the public to the benefits of seismic provisions and generating public support for the proposed changes. Try to develop a personal relationship with reporters at major state newspapers and television stations. Offer to provide background information (see Appendix H for sample press releases), and be available for interviews when a newsworthy earthquake elsewhere generates interest in your state.

Finally, do not limit your efforts to potential supporters. You must also identify potential opponents and convince them of the value of your proposed changes. It is better to remove one opponent than to add ten supporters.

Step 3: Lobby the Decision-Making Body

The state legislature or some administrative board or commission has the authority to amend the existing code or adopt a code. You should lobby this decision-making body with information explaining why the changes are needed (i.e., seismic provisions) and describing the kind of support you have gathered.

Step 2: Gather Support for the Proposed Changes

- **Professional engineering and architectural organizations.** Coordinate with organizations such as the American Society of Civil Engineers and the American Institute of Architects. Each group represents a large and influential constituency, and they can lend credible support, expertise, and a network of lobbyists. Letters of support from architecture and engineering associations were very helpful in the enactment of Arkansas' seismic requirement.
- **Building and commerce associations.** Try to gain the support of a building or commerce association. The Masonry Institute of Tennessee, for example, has been very active in promoting seismic design and construction.
- **Local civic organizations.** Meet with local groups and work to gain community support. The League of Women Voters in western Kentucky was instrumental in making earthquakes a public issue in that state.
- **Seismic safety advisory committee.** If your state or locality does not have such a committee, form one. This is a very effective way to keep earthquake issues on the public agenda and can greatly help to initiate new programs and legislation for seismic safety. See page 18.

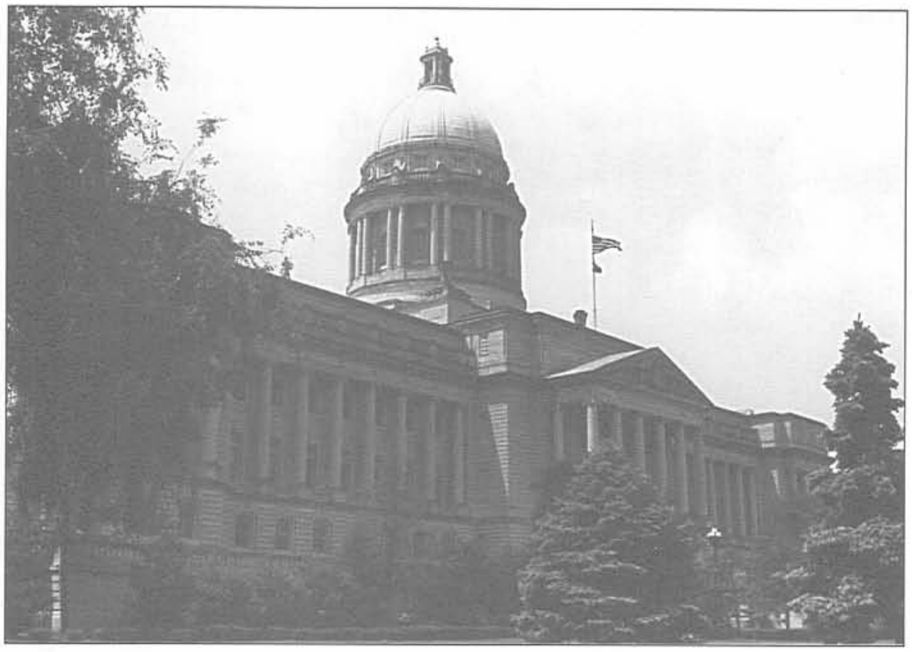


FIGURE 4.2 Kentucky has a statewide building code requirement (state capitol shown above). (Source: Kentucky Legislative Research Commission)

Step 3: Making the Legislative Process Work for You

- Find a member of the legislature to introduce your proposed legislation.
- Gain the support of the Governor's office.
- Research and prepare the draft legislation. Focus on your two main goals: (a) the code must be up to date and (b) the code must include the latest seismic provisions.
- Testify before committee hearings. Be clear, concise, persuasive, and authoritative in your comments.
- Lobby the legislature (both houses) once the bill is reported out of committee.
- Monitor the bill throughout the legislative process, including its final stage in the governor's office.

Implementing changes to the state code may require legislative action. This process can be somewhat involved. The following paragraphs describe how to initiate changes at the legislative level; many of the suggestions given are appropriate for dealing with any decision-making body.

Find a member of the legislature to introduce the bill. You must find a legislator sympathetic to your cause—perhaps he or she lives in an earthquake-prone part of the state or has a reputation for promoting public safety issues. Demonstrate to the legislator that you have built widespread support for the legislation.

Gain the support of the Governor's office. In the end, you will need the Governor to sign the legislation into law. The sooner you can get the Governor's support, the better. Furthermore, many legislators will look to the Governor's office for leadership during the legislative process.

Research and prepare the draft legislation. A legislative research department usually is available to draft the actual bill. If you are able to submit a well-drafted bill or can provide technical support to the legislative staff, their job will be made easier and the process will be facilitated. The more complete your package, the farther it will go through an overworked legislature.

A good strategy is to prepare the bill in advance so that you can move quickly when a window of opportunity opens. Such opportunities typically occur when there is a small earthquake in your state or a disastrous earthquake elsewhere in the world. For example, interest in seismic codes increased in the central and eastern United States following the 1988 Armenian and 1989 Loma Prieta, California earthquakes. Sometimes fires or building collapses cause renewed interest in building code legislation. The statewide building code requirements in both Tennessee and Kentucky (see Appendix B, C) were enacted following fatal fires. At the very least, after the next earthquake scare the state legislature might be willing to pass a statewide seismic design requirement, as Missouri and Arkansas did in 1991 (see Appendix B, C).

Testify before committee hearings. Following its introduction, the bill is assigned to one or more committees. Each committee schedules hearings at which interested organizations and lobbyists may present their comments. The hearing schedule usually is tight. Thus, testimony must be well organized, concise, and effectively presented. You must be able to convince the committee members, in clear and persuasive language, that seismic codes are necessary for the welfare and economic well-being of the state and that voting for the proposed bill will enhance their reputations. Information from this book will help. You should address the following questions:

- What are the chances of a large earthquake happening in your state, and what damage would it do?
- Why is legislation needed?

- How would the legislation affect the state?
- What are its benefits?
- What is the evidence for these supposed benefits?
- What are the costs, and who pays?
- How do the benefits justify the costs?
- Why does your organization support the legislation?
- What other organizations support it?

Remember that dozens of legislative bills are introduced for every one that succeeds, and it's possible that your bill will die in committee, requiring you to begin the process again. If your experience convinces you that legislative approval is not realistic, consider the alternative route of encouraging widespread adoption of local seismic code provisions (see chapter 5).

Lobby the legislature once the bill is reported out of committee. Once the committee recommends the bill to the legislature as a whole, make sure that all the legislators in both houses are provided with complete information about the value of the bill, including documentation of the support you have gathered.

Monitor the bill throughout the legislative process. To succeed, the bill must pass both houses, and the governor must sign it into law. Lacking a positive vote in either house, the bill will die. Once the bill is passed by one house, it moves to the other house, where the process is repeated. Because there may be attempts to amend the bill along the way or in a conference committee of both houses, you must keep monitoring the bill throughout the entire process and maintain support for the bill.

If the bill passes the legislature, the governor may sign or veto it. Again, make sure that the governor's office is provided with complete information about the value of the bill, including documentation of the support you have gathered. If you have done your work well there should be no last-minute opposition, and the governor is likely to sign it into law.

Step 4:The Last Mile: Administrative Implementation and Enforcement

Once you have established the necessary rules changes or statutes and the seismic provisions are approved, continue your involvement through the administrative implementation and enforcement stages.

An administrative department will be directed to develop the rules and regulations for implementation and enforcement. An administrator will need to conduct additional public hearings to consider the proposed rules. You should stay informed of the date(s) of hearings and look for opportunities to present written comments and public testimony.

Draft rules typically will be published for a fixed period of public review. You must stay in touch with the administrator to ensure that you are notified of the review period as soon as it is known and that you receive the draft rules as soon as they are available. There will then be adequate time for you and other supporters to review the proposed rules and provide informed analysis and comments. As with the legislative process, the more persuasive your comments and the more authoritative the commentators, the better your chances for success.

For ongoing enforcement issues see chapter 6, "Improving Code Enforcement."

Step 4: Administrative Implementation and Enforcement Stage

- Organize your support ahead of time. Be prepared to act when the proposed rules are released.
- Find out when the review period will be so that your supporters can be ready.
- Obtain a copy of the draft rules the day they are released.
- Use your supporters to review and comment on the rules.
- Submit written comments and public testimony and be sure your supporters submit comments.
- Be clear, concise, persuasive, and authoritative in your comments.

NOTES

1 Golden, Joseph H., et al., *Hurricane Hugo: Puerto Rico, the U.S. Virgin Islands, and South Carolina*, prepared for the Committee on Natural Disasters, National Research Council, National Academy of Sciences (Washington, DC), 1994.

2 Morrow, B.H., and Ragsdale, A.K., *Early Response to Hurricane Marilyn in the U.S. Virgin Islands*, University of Colorado, Natural Hazards Center, Quick Response Report #82, 1996.

3 Information provided by the Virgin Islands Department of Planning and Natural Resources, Division of Permits.

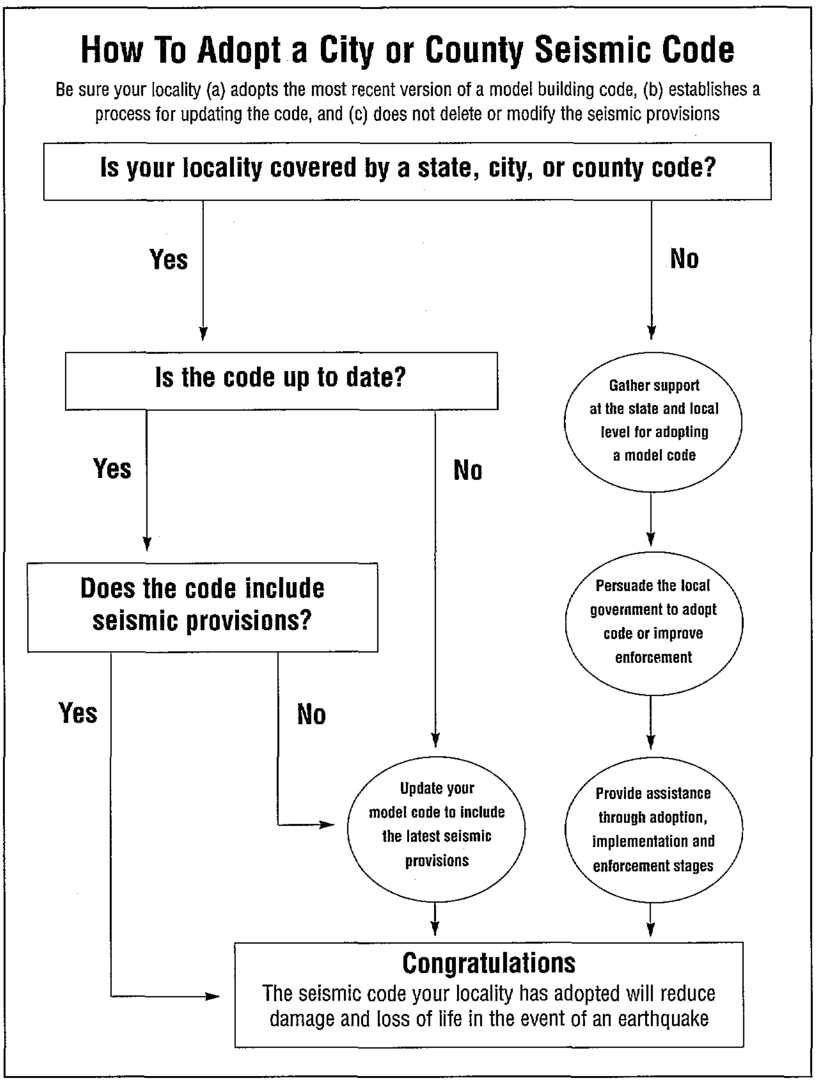
4 Condensed from Olshansky, R., *Reducing Earthquake Hazards in the Central United States: State Seismic Safety Advisory Committees*, prepared by the Department of Urban and Regional Planning, University of Illinois at Urbana-Champaign, and distributed by the Central U.S. Earthquake Consortium, 1992; also see Seismic Safety Commission of California, *Creating a Seismic Safety Advisory Board*, FEMA #266, August 1995.

Chapter 5
How Cities and Counties Can Adopt Seismic Building Codes

This chapter takes up the issues and processes involved in adopting seismic provisions at the city and county level—a viable, albeit time-consuming, alternative to adopting a state seismic code, described in chapter 4.

How To Improve Local Code Requirements

State seismic managers and local officials may find it easiest to adopt seismic provisions through local governmental bodies rather than on the state level. In most cases, localities can take effective action regardless of state requirements.



Step 1: Determine Local Code Practices and Options

Current regulation at the state level will govern options for action at the local level. If your state regulates all local construction, there is little for you to do, although you should satisfy yourself that enforcement is adequate. If your state mandates local adoption of a specified code, check to ensure that the community has complied.

If your state *does not* currently regulate, or if it allows for stricter local regulations, there are numerous options at the local level. The municipality or county can develop its own original code, modify the existing code of a neighboring municipality, or adopt a model building code. If the jurisdiction lacks an adequate code, it is up to the state seismic program manager and local officials to convince the community to initiate a building code.

Statewide inventory of local practices. State seismic program managers should collect information on local practices, to determine which localities within a state are deficient in code adoption and enforcement. At a minimum, communities in the most seismically hazardous parts of the state should be targeted. This information can help identify communities most in need of assistance. Key questions to ask include the following:

- Has a local code been adopted?
- If so, when was it adopted and by what means?

- Is it the latest version?
- Are building permits required?
- How many architects and engineers are on staff?
- What is the name and phone number of the building official?
- What method is used to update the code?
- How frequently is it updated?
- What type(s) of construction are regulated?
- Are seismic requirements part of the current code?

The state of Illinois gathered this kind of information from 300 jurisdictions in the southern part of the state. See their survey instrument in Appendix C.

State seismic managers also can use the information on local code deficiencies to help make an argument to the state for a statewide code (see chapter 4). Documenting the number of communities, or the number of people in communities, without building codes can be a persuasive argument, especially if they are in a seismically vulnerable part of the state.

Authority to adopt a local code. The authority to adopt a local code is usually granted by the state legislature under its police powers, which allow the municipality or county to adopt a building code to promote the public health, safety, and welfare. You need to be sure you have this authority to adopt a code.

Building code regulations are enacted through local ordinances. Municipalities and counties must formally adopt a building code ordinance via a local legislative process. Typically the building code ordinance is drafted, reviewed for legality, proposed, debated through public hearings, and voted on by the city council or county board. Once the ordinance is approved, the municipality or county becomes the enforcement agent.

Model codes are usually the best option. It is highly unlikely that a municipality would have the expertise, budget, or time to develop an original document. Most localities, therefore, identify a model building code in order to make code adoption easy.

If the municipality adopts one of the model building codes, drafting and detailed legal review are not necessary. In addition, each model building code organization supplies a sample ordinance in its code book. These sample ordinances have been used successfully by other municipalities.

The model building code organizations also provide administrative and technical assistance to the municipality during adoption, in addition to other support, such as code provision interpretation, continuing education, and inspector testing and certification (see detailed information in Appendix D). The adoption of a model building code is more than the referencing of a document: It involves becoming a member of a professional organization.

The model building code organizations do not require adoption of codes in their entirety. Specific code sections may be revised to reflect local conditions. The organizations can provide direct assistance in some cases. However, municipalities should be careful that revisions of one section do not adversely affect another section. Remember that through the seismic hazard map the seismic provisions already account for local conditions.

Use of a model code means that the public debate over the code's technical details has already been conducted at the national level. Local opponents questioning technical aspects of the code or the seismic zone maps for your state can be told that the code represents a national consensus of hundreds of engineers and building officials. The maps and the seismic force calculations are

Overview: Steps Toward Local Seismic Provisions

The general steps involved in adopting seismic provisions at the local level are the same as for the state level, with some modifications.

Step 1:
Determine local code practices and what state regulations (if any) govern options for action at the local level.

Step 2:
Gather support at the state and local levels.

Step 3:
Persuade the local government to adopt code or improve code enforcement that includes seismic provisions.

Step 4:
Provide technical assistance throughout the adoption, implementation, and enforcement stages.

Step 1: Determine Local Code Practices and Options

- If your state regulates all local construction, satisfy yourself that enforcement is adequate.
- If your state mandates local adoption of a specified code, ensure that communities have complied.
- If your state does not currently regulate, or if it allows for stricter local regulations, gather information on local code practices and explore your options at the local level.
- Options may include developing an original code, modifying the existing code of a neighboring municipality, or adopting a model building code.
- If a jurisdiction lacks an adequate code, convince the community to initiate a building code.
- Model codes are usually the best option, because of the technical support provided by the code organization.

based on the best current knowledge, are designed by national experts in the field, and are reviewed by committees of engineers and geologists throughout the country. The codes also recognize the realities of local enforcement: The voting members of the model code organizations include the local building officials of your state and region.

Key points. To ensure that a locality has the most current widely accepted standards of seismic design, be sure that it: (a) adopts one of the three model codes, (b) adopts the most recent version of the code, (c) establishes a process for periodic updating of the code, and (d) does not delete or modify the seismic provisions.

Step 2: Gather Support at the State and Local Levels

Wide public support is needed to enact a new community building code. Information gathered in step 1 can help to obtain state support for changing or introducing the local code. It is also important to have the active support of local chapters of professional associations of engineers and architects, such as the National Society of Professional Engineers, American Society of Civil Engineers, and American Institute of Architects. Form partnerships with these organizations (see Appendix E).

Civic groups and local service clubs, such as the League of Women Voters and Rotary Clubs, can provide valuable support. As you pursue contacts in the community, you should also seek support and acceptance by business and construction organizations, such as local businesses, economic development associations, and the Chamber of Commerce. Arrange to give presentations to these groups. Materials for sample workshop presentations are included in Appendix G.

Good rapport with the local media can help your case. Find a receptive reporter and explain the hazards the community faces. Personal relationships work best, as you will need the media's trust if the battle over code adoption gets hot. Even if you do not connect with a particular reporter, there are actions you can take. Send out press releases following earthquakes, to accompany local presentations, or to accompany announcements of state initiatives. Sample press releases are included in Appendix H. Try to be interviewed on a local news or talk program. Send an editorial to the local newspaper. Use material from this book to help make your case!

Opposition typically comes from business and development interests who are afraid that any change in local regulations will scare away new business. A local economy is often somewhat fragile—business people may worry that if their community is perceived as being uncooperative with new business, then economic development will go elsewhere.

To avoid eruption of unexpected controversy during the code-adoption process, you should meet beforehand with the professional, business, and labor organizations likely to be affected. These meetings will be mutually educational. Most of these groups will be surprised to know that the earthquake risk is real, and that seismic codes are widely accepted as a cost-effective technique to reduce hazards. Conversely, you will find that their concerns are genuine and that you may need to design your code implementation process to account for some of their concerns. Try to integrate the concerns of each group into your proposal.

Past experience has shown that initial opponents find that they can live with building codes because codes do not drive business from communities. Businesses have many more important factors than codes to consider in their location decisions. In the words of one building official, "I've never heard of an industry not coming to town because of seismic requirements."

It is true that local officials tend to respond to short-term concerns and, furthermore, prefer results that are visible and immediate. Still, many localities can be persuaded to accept the model building codes. Anticipating some common objections, you might try the arguments given below.

For elected officials: A damaging earthquake can occur during your term of office. The levels of ground-shaking represented on the code's seismic hazard map have a 0.8 percent chance of occurring in any four-year period at each point on the map (such as the community in question), and about a 2 percent chance of occurring in any eight-year period. But these are the *design events* (see page 10). What about a lesser earthquake? An earthquake half as big as the design event could cause severe damage to many structures not meeting the code and little damage to structures built according to seismic code. Such an event has about a 4 percent chance of occurring in any four-year period and about an 8 percent chance in an eight-year period.

For elected officials: Citizens support seismic codes. Studies in California and the central United States have shown that most citizens support seismic building codes, and that elected officials underestimate this support. For example, in 1984 Arizona State University surveyed residents and officials in the high seismic risk area surrounding the New Madrid fault zone.[1] The survey found that 62 percent of residents believed that seismic building codes for new structures are "very important, " and most supported codes even if substantial costs would be involved. In contrast, support by community leaders was much lower at 37 percent. Furthermore, other studies have shown that community leaders greatly underestimate the public's concerns about earthquakes, mistakenly believing public concern to be less than their own.[2]

In a 1994 telephone survey of residents in six hurricane-prone areas, 91 percent of respondents indicated that builders should be required to follow new, stricter building codes even though it might add 5 percent to the cost of a home.[3]

Codes will not hurt business. Building codes have not hurt the economies of the forty-one states that have them, nor have they hurt the 95 percent of all U.S. cities and towns that have codes. Seismic design adds only approximately 1 to 1.5 percent to the cost of a building, according to a 1985 BSSC study.[4]

Is there a chance that local buildings will be shaken by an earthquake at some point? An earthquake can

A Lesson Learned in Jonesboro, Arkansas

In early 1989 the city of Jonesboro, Arkansas, adopted the 1988 *Standard Building Code* (SBC), the first edition of this code with seismic requirements. The same year representatives of a proposed industrial facility were negotiating with city officials, attempting to win as many concessions from the city as possible. The state was very eager to have the facility. The development representatives asked Jonesboro to revoke the seismic provisions. The city council agreed to do it on October 16, the day before the Loma Prieta, California earthquake. In the words of a city official, this was "bad timing." Because of subsequent public pressure the seismic provisions were restored to the code.

It turns out that the entire controversy was unnecessary. What the development representatives did not know was that the structural engineering firm designing the facility was designing it to the 1988 SBC and had never intended to do otherwise. The plant was, in fact, already consistent with the 1988 SBC and built with the seismic provisions in the code. Jonesboro has continued to grow, with the code in place.

FIGURE 5.1 New construction continues to flourish in Jonesboro. (Source: City of Jonesboro)

Step 2: Gather Support at the State and Local Levels

Address the concerns of potential opponents by emphasizing these key points:

- For elected officials: A damaging earthquake can occur during your term of office.
- For elected officials: Citizens support seismic codes.
- Codes will not hurt business.
- A seismic code will improve successful survival of lives, properties, and businesses in the next earthquake.
- Everyone else is doing it.
- It's easy.
- It's good for the community.

Step 3: Persuade Local Governments to Adopt Code or Improve Code Enforcement

Consider educational programs or incentive programs that will appeal to local governmental officials:

- Sponsor workshops on how to use the codes.
- Buy the code books and distribute them yourself.
- Take local officials on an earthquake field trip.
- Consider ways of subsidizing the cost of joining the model building code organizations.
- Provide relevant information to the decision-making committee.
- Monitor the process from beginning to end.

devastate the small businesses in a community. Following the 1994 Northridge, California, earthquake, thousands of small businesses had to relocate or temporarily shut down. Some never opened again. Such interruptions can be fatal to small businesses. Simply the loss of business activity can affect neighboring businesses that are fortunate to survive the earthquake groundshaking.

A seismic code will improve successful survival of the next earthquake. People will live and work in these buildings. Codes work. Look at the evidence of relatively low loss of life in the earthquakes in California in 1989 and 1994. Either a community is designed to survive the next earthquake, or it is not.

Everyone else is doing it. The federal government has set an example with Executive Order 12699. Seismic codes are becoming more prevalent at all levels of government, which means two things: (a) a community will not be at an economic disadvantage for attracting new business and (b) if other communities adopt seismic provisions, those that do not have this safeguard in place invite liability.

It's easy. It doesn't take much to start. Call up a code organization, buy the code, develop a fee structure (to pay for administration), and contract with the county or another nearby agency for initial staffing.

It's good for the community. With a seismic code, residents will know that the community is on its way to seismic safety. The code will reduce long-term liability costs. A good code may ultimately improve the community's insurance rating (see chapter 6). A seismic code is not an admission of community weakness, but rather a sign of community strength. It says that the community values safety, takes itself seriously, and wants to survive natural disaster. All communities need a seismic code regardless of hazard. Seismic codes supplied by the building code organizations account for the unique level of hazard in each community. If a community's hazard is low, the code will reflect that. The seismic hazard zone map is based on the latest national scientific evaluation of earthquake risk, representing the consensus of a number of scientific and professional organizations. The code requirements for each community reflect that estimate of hazard.

Step 3: Persuade Local Government to Adopt Code or Improve Code Enforcement

As part of gaining approval of your proposed changes, consider educational programs or incentive programs that will appeal to local governmental officials:

- Sponsor workshops on how to adopt and enforce the codes. Sample workshop materials are provided in Appendix G. These can be supplemented with area maps and with examples of the model codes.
- Buy the code books and distribute them yourself. You can purchase the codes and other materials directly from the model code organizations. If local officials can see the quality of materials and support provided by the model code organizations, they may be less reluctant.
- Take local officials on an earthquake field trip. For the cost of a bus rental and several lunches, you can show local officials nearby earthquake faults, evidence of past earthquakes, areas susceptible to seismic ground failure, and seismically unsafe buildings.
- Consider ways of subsidizing the cost of joining the model building code organizations. In some

cases, state agencies may be willing to subsidize the cost of local code adoption and enforcement.

Previous experience has shown that it helps to cultivate an inside advocate. Find one or more council members sympathetic to your cause and help them to craft persuasive arguments. Inside advocates might be people who have experienced an earthquake or other disaster, have a professional interest in the subject, or are particularly concerned about public safety issues.

Once the proposed ordinance is prepared and introduced, it usually is assigned to a standing committee or subcommittee, which conducts a public hearing. You will need to work with the committee, provide relevant information, and stay informed regarding its scheduled meetings. Proponents must make their presentations clear, concise, and professional. They should provide factual and persuasive responses to the concerns of interest groups in the jurisdiction. Some of the information presented elsewhere in this book can help in preparing presentations (see step 3 in chapter 4).

If the committee recommends that the ordinance be passed, the governing body usually will call the ordinance up for debate. A strong positive vote by the committee will lessen the possibility of a long debate by the governing body.

You should monitor the approval process carefully from beginning to end, and be prepared to testify and provide additional information as needed to ensure approval.

Step 4: Assist Local Governments Throughout the Adoption, Implementation, and Enforcement Stages

The state seismic program manager and local advocates should be prepared to provide technical assistance throughout the code-adoption process, including the implementation and enforcement stages. Assistance may include information on:

- Seismic hazard in the state
- Function and effectiveness of seismic codes
- Elements of code enforcement
- Services provided by the model code organization

Government officials interested in initiating a new code, or improving their code enforcement, may find it useful to obtain a copy of this entire book.

Implementation and enforcement will follow once the code is adopted and the ordinance is assigned to an agency or department, such as the building or engineering department. In many cases, the new code will initiate a building department that had not previously existed.

The building officials then need to revise existing procedures, such as plan review, permit issuance, and inspection. Personnel training must also be updated as required. Staff members should take courses and receive training materials offered by the appropriate model building code organization (see Appendix D).

It will take some time before the department becomes effective at implementing the ordinance. Professional organizations in the community can help this process by monitoring it and informing the building officials of any problems. (See chapter 6, "Improving Code Enforcement.")

Step 4: Assist Throughout the Adoption, Implementation, and Enforcement Stages

- Provide information about seismic hazards in the state, the function and effectiveness of seismic codes, elements of code enforcement, and services provided by the model code organizations.
- Keep informed of implementation milestones.
- Meet periodically with the building official(s).
- Verify that adequate procedures have been introduced for plan review, inspection, and staff training.
- Inform the building officials of any problems.

NOTES

1 Mushkatel, A.H., and Nigg, J.M., "Opinion Congruence and the Formation of Seismic Safety Policies," *Policy Studies Review*, Vol. 6, No. 4, May 1987.

2 E.g., Wyner, A.J., and Mann, D.E., *Preparing for California's Earthquakes: Local Government and Seismic Safety*, Institute of Governmental Studies, University of California at Berkeley, 1986.

3 Insurance Institute for Property Loss Reduction (now IBHS), *Public Opinion Concerning Various Issues Relating to Home Builders, Building Codes and Damage Mitigation*, IIPLR (Boston, MA), 1995.

4 Building Seismic Safety Council, *Societal Implications: Selected Readings*, FEMA #84, June 1985.

Chapter 6
Improving Code Enforcement: A Critical Link

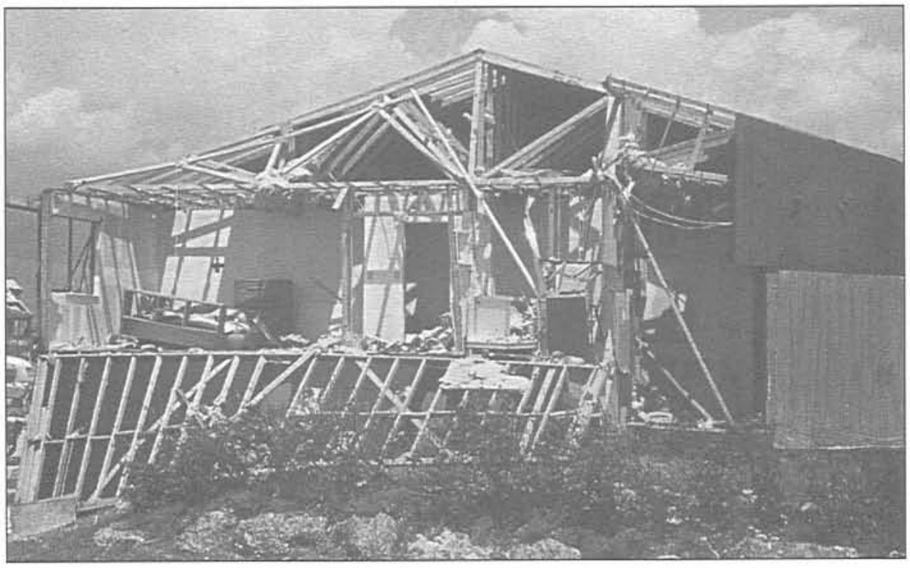


FIGURE 6.1 A substantial portion of the damage from Hurricane Andrew in 1992 was from lack of enforcement of the South Florida Building Code.[1] (Source: FEMA 1993)

A building code is just a book. Enforcement and effective administration of a good code are the keys to achieving the goal of building safer buildings. The information in this chapter applies to any level of government implementing the code, be it state, county, or municipal.

Poor Code Enforcement Results in Deficient Buildings

Recent studies following Hurricanes Hugo and Andrew have shown weaknesses in code enforcement. In 1991 State Farm Insurance Company contracted with SBCCI to evaluate code compliance in twelve randomly selected coastal communities. They found that inspectors and reviewers had little or no training in wind-resistant construction and that there was a general lack of enforcement of adequate connections of windows, doors, and mechanical equipment to the building frame. About half of the communities were not enforcing their own code standards for wind resistance.[2]

Following Hurricane Andrew, reports by a Dade County grand jury and by the Federal Insurance Administration concluded that a substantial portion of the storm's damage was attributable to lack of enforcement of the South Florida Building Code. According to the Insurance Services Office, Inc., at least one-fourth of the record $15.5 billion in insured losses caused by Andrew were because of construction that failed to meet Dade County's code. Thus, even in communities with adequate codes, significant damage can be attributed to poor compliance and enforcement.[3]

In a 1993 study, G.G. Schierle of the University of Southern California found significant problems in quality control of seismic-resistant construction in California. By means of a survey of design professionals and site inspection of 143 projects, the researchers found that key items to resist seismic load are frequently (13 to 72 percent of surveyed units) missing or flawed. Reasons include "inadequate communication, little or no construction observation by design professionals, ignorance, greed, shortsighted false economy, and lack of scrutiny by building inspectors."[4]

Clearly, much effort needs to be spent on improving code enforcement. The weaknesses become apparent only at the moment when resistance is most needed—when the disaster strikes.

Insurers Recognize the Critical Importance of Code Enforcement

The code enforcement problems discovered in the wake of Hurricane Andrew have prompted the insurance industry to initiate a Building Code-Effectiveness Grading Schedule, in order to identify communities with good enforcement practices. It is planned that property owners in communities with such practices will be rewarded with lowered insurance premiums (see box on page 30). This new system, phased in over a five-year period beginning in 1995, should gain the attention of local officials and property owners and improve the political environment for local support of code enforcement.

Elements of Code Enforcement

Code enforcement and administration consist of five sequential elements. The most important aspects of enforcement are plan review and construction inspection, but effective code administration must consider the entire sequence.

Element 1: Keep the Code Provisions Up To Date

Simply adopting a code is not enough. A code is an active document, evolving to reflect new knowledge and new standards of practice. Once a jurisdiction makes a commitment to use a building code, it must be prepared to update its local code on a regular basis.

Element 2: Ensure That Builders Apply for Permits

Obviously, if builders try to avoid the code-application process, then the code cannot do its job. A jurisdiction must have inspectors out in the field who know the community. The inspector needs to be alert to new construction in his or her jurisdiction and must be aware of current active permits.

In addition, public relations is an important aspect of code enforcement. The building department must cultivate and maintain cordial relations with the building and design community. This can be done by arranging informal meetings, sending written materials to local organizations, speaking to community groups, and maintaining memberships in appropriate trade and professional organizations.

Element 3: Have a Qualified Reviewer Review Plans

Plan review is one of the two points at which the local government can affect the details of building construction. At a minimum, plan review verifies that the design complies with the building code. This is the most cost-effective moment to catch mistakes, before any money is spent on construction. Some jurisdictions may also review structural calculations.

Plan reviewers must be fully knowledgeable about code requirements. The code organizations offer certification programs to recognize the capabilities of plan reviewers. Some jurisdictions use licensed architects and engineers who can go beyond code compliance review and verify calculations and overall building safety. An applicant for a building permit must submit plans for review and approval. The building department can approve, require revisions, or reject the plans. Construction cannot begin until the building department confirms that the plans conform to the building code.

Construction of buildings larger than one- or two-family dwellings usually requires architectural and engineering designs. Architects and engineers must be certified or licensed in order to practice in a state. State statutes require that the licensed professional engineer and/or architect place his or her seal and signature on the designs. The seal and signature signify that the design is at the accepted professional standard, which is typically the most recent version of a model building code or technical document. An added incentive for conformity is the legal liability the engineers and architects assume when the seal and signature are placed on the document.

Need for Better Training of Construction Professionals

A recent study by the Earthquake Engineering Research Institute examined why poor construction practices remain a key cause of earthquake damages. It found that a key problem is deficient training for those who construct and inspect buildings.

Specific findings were: (a) seismic resistance is not currently a priority topic for building officials, inspectors, or the trades, (b) there is a lack of conceptual understanding of building performance in an earthquake, (c) there is inadequate communication among education providers, (d) training materials are inadequate in content, and delivery methods are inefficient, (e) there is a lack of certification and continuing education programs, and (f) there is a need for improved on-the-job training.

The message is clear: We must do a better job of training those individuals whose work is directly linked to the performance of buildings during earthquakes.[5]

Benefits to Communities That Enforce Building Codes

Insurers and lenders have begun to realize that adoption and enforcement of building codes in general, and seismic codes in particular, are in their long-term interest. Accordingly, in 1995 the Insurance Services Office, Commercial Risk Services (ISO/CRS) began to phase in a new Building Code-Effectiveness Grading Schedule. By the end of the decade, this schedule will rate the code-enforcement capabilities of every municipality in the United States.

The insurance industry is developing this new grading schedule to reward communities for promoting property and life safety protection through the use and enforcement of modern codes. The system will be used by property insurers to set differential rates among communities based on code-enforcement practices. Property owners in communities with good code enforcement will pay lower insurance premiums—and owners in communities with poor enforcement will pay more.

The grading schedule measures resources and support available to building code enforcement efforts. It assesses each municipality's support for code enforcement, plan review, and field inspection. The grading process includes interviews with municipal officials, examination of documents, review of training requirements and work schedules, staffing levels, and certification of staff members.

The new system is comparable to the fire protection grading system and the community rating system for flood insurance already used by ISO/CRS. These two systems use a rating scale of one to ten, with one representing the best protection and ten indicating no protection.

For more information, contact the coordinating body, the Institute for Business and Home Safety (formerly IIPLR; address in Appendix E).

Element 4: Ensure That Construction Proceeds According to Approved Plans

An owner receives a building permit to construct according to the approved plans, and it is the legal responsibility of the owner to do so. The builder uses the plans to order materials and construct the building. The owner may hire inspectors or the engineers and architects to oversee key aspects of the construction in order to help verify compliance with the plans. To some extent, all government inspection systems depend on the owner's obligation to construct according to the approved plans, which is inherent in the issuance of a permit.

Element 5: Have a Qualified Inspector Inspect the Construction

Inspection is the second point at which the local government can affect the details of building construction. Inspection verifies whether construction is proceeding according to the approved plans and the conditions of the permit. Inspection is typically required at several key stages in the construction process. The inspector has a powerful enforcement tool called a stop work order. A stop work order is issued to the construction firm if the inspector finds a code violation that must be corrected before any further construction is performed. At final inspection, the building can be approved for occupancy.

Depending on the jurisdiction, inspectors may be municipal employees or contracted tradespeople. In either case, building inspectors must be well qualified. They must know how to read building plans and must be familiar with the code. More importantly, they must be familiar with building practices so they can recognize potential problems. Model code organizations offer certification programs to recognize the capabilities of inspectors.

How to Establish an Effective Building Code Enforcement Program

This section outlines the six steps toward establishing an effective building code program. In addition, detailed case studies of six cities and counties are contained in Appendix C.

Step 1: Adopt a Model Code

The first step in establishing a program is to review and adopt a model building code and join the appropriate code organization. Numerous publications and telephone-assistance services will then be available to help the new program get started. The information provided includes organization charts, descriptions of staff duties, fee structures, suggested procedures, and so on. New members may want to take seminars in plan review and inspection before officially initiating the code.

New members can request the model code staff to visit and assist in establishing their program (see information in Appendix D). If extensive help is required, the code organization may be hired to provide the needed assistance. It is easy to get started, because the code organizations are set up to effectively and efficiently provide all the support you need.

Step 2: Establish Fee Structures for Permits and Plan Review

Building departments collect fees to pay for the costs of review, inspection, and associated administrative services. The community sets the fee structure based on its needs. Some communities require the building department to be completely self-supporting; others use the fees to offset only a portion of their true costs. Communities with significant experience in code administration can set fees based on previous budgets. Communities just starting out may prefer to use the fee structures suggested by the code organizations.

Plan review fees typically are based on estimated construction value, which depends on building floor area, type of construction, and proposed use. For example, under the BOCA NBC, the suggested building plan review fee for $1 million construction value is $1,250. Review for mechanical work, plumbing, energy conservation, or electrical work is an additional 25 percent each (i.e., each of these additional reviews, if required, costs $312).

Once plans are reviewed, a permit is issued. Typically the building permit requires an additional fee to pay for inspection costs. As with plan review, the fee is based on the estimated construction value. Under the BOCA NBC, additional permits are suggested for mechanical work, plumbing, and so forth, for an additional 25 percent each.

Fee schedules suggested by the three model building code organizations are provided in Appendix D.

Step 3: Institute a Systematic Plan Review System

A review process must serve the needs of the community and the public agencies. Reviews must be done as quickly as possible so as not to unduly disrupt the construction industry. Clearly, smaller projects should be expected to take less time than larger projects. Applicants should be informed up-front of the time required for review so they can plan their design and construction schedule accordingly. Some departments promise turnaround for small projects within a specified number of days. Some jurisdictions offer fast-track reviews for an additional fee.

Plans usually must be circulated to several additional departments for review, such as the planning, public works, and fire departments. It is best to have one department designated as the lead and to require multiple plan copies from the applicant so as to facilitate multi-department reviews.

Applicants should be kept well informed right from the start. Handouts and checklists are very important so that they know what materials to submit and how the plan will be judged.

Step 4: Adopt an Inspection Schedule

Each code has a recommended inspection schedule based on construction milestones. For example, the BOCA NBC suggests the following inspections for residential buildings: footing forms and trenches, basement and foundation wall forms, footing drains and damp proofing, framing, wallboard, and final. Similar schedules exist for

Elements of Code Enforcement

Element 1:
Keep the code provisions up to date.

Element 2:
Ensure that builders apply for permits.

Element 3:
Have a qualified reviewer review plans.

Element 4:
Ensure that construction proceeds according to approved plans.

Element 5:
Have a qualified inspector inspect the construction.

Multi-State Training Program in Southeastern United States

A two-day training course has been developed for building officials in Standard Building Code states that must now enforce the seismic provisions in the latest SBC (NC, SC, MS, TN, AR). The purposes of the course, developed by CUSEC, SBCCI, FEMA, BSSC, and IBHS, are to (a) raise the level of awareness and understanding of the seismic provisions of the SBC and (b) increase understanding and support of building code adoption and enforcement. Building officials in these states can request the course from their state emergency management agency. Instruction is provided jointly by the state earthquake program manager and an SBCCI instructor.

Improving Code Enforcement in Massachusetts

The Massachusetts State Legislature has passed a law requiring that all building inspectors be certified. Inspectors of Buildings or Building Commissioners must complete the CABO exam as well as the BOCA National Code Exam. In addition to these requirements, they must also possess five years of experience in building inspection and construction. The requirements certify adequate education and training to ensure quality construction and compliance with building codes.

Recently state building inspectors took the ATC-20 course, enabling them to assess damage after an earthquake occurs. This training paid off when these inspectors were called upon to estimate damage after a tornado occurred in the state.

A serious fire in Quincy destroyed a retail warehouse and caused an estimated $7 million in damage. In response to this fire, the state initiated new codes covering the use and occupancy of large retail warehouses.

These initiatives demonstrate the importance of updating enforcement and inspection

How To Establish an Effective Building Code Enforcement Program

Step 1:
Adopt a model code.

Step 2:
Establish fee structures for permits and plan review.

Step 3:
Institute a systematic plan review system.

Step 4:
Adopt an inspection schedule.

Step 5:
Maintain a trained, qualified staff.

Step 6:
Be persistent but patient.

electrical and mechanical work and plumbing.

Typically, the builder or owner will call for inspection when each specified milestone is reached. In addition, inspectors occasionally make unannounced inspections based on their judgment of the work progress and the quality of the contractor.

Step 5: Maintain a Trained, Qualified Staff

Qualified staff members are a must. Ideally some staff members would be licensed engineers and architects, but most departments are too small to justify this cost. At a minimum, reviewers and inspectors must have experience in construction, be able to read plans, and be familiar with the code. Training in engineering or architecture is a plus.

Each of the model building code organizations offers certification in a number of categories for inspectors and plan reviewers. More and more building departments are requiring or rewarding certification in order to recognize staff quality.

Step 6: Be Persistent But Patient

You need to realize that a new code will not be implemented in one day. Adequate enforcement takes many years of experience and learning from mistakes. Procedures evolve over time. Building officials, plan reviewers, and inspectors must receive technical training and continuing education, which cannot be done overnight.

Still, once you adopt a code, the code organizations and other professional organizations offer numerous services to teach you what they have learned over the years. The effort is worth it, as seismic codes afford communities a high degree of improved building safety, which will save lives.

NOTES

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2 Southern Building Code Congress International, *Coastal Building Department Survey*, National Committee on Property Insurance (now IBHS, in Boston), 1992.

3 Federal Insurance Administration, *Building Performance: Hurricane Andrew in Florida*, FIA-22, December 1992.

4 Schierle, G.G., *Quality Control in Seismic Resistant Construction*, report to the National Science Foundation, School of Architecture, University of Southern California, 1993.

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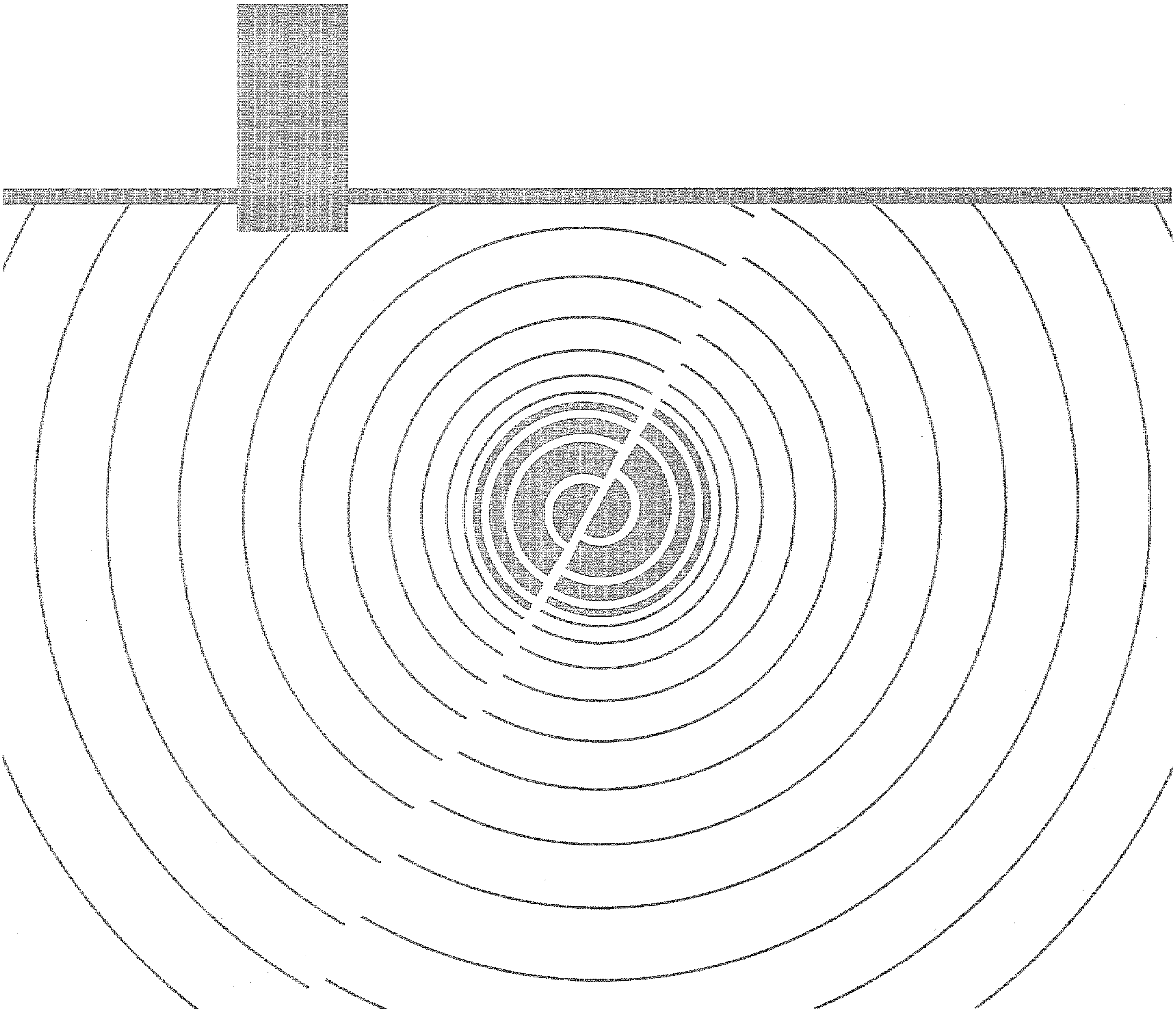
Appendix A: History and Principles of Seismic Design



Appendix A
History and Principles of Seismic Design

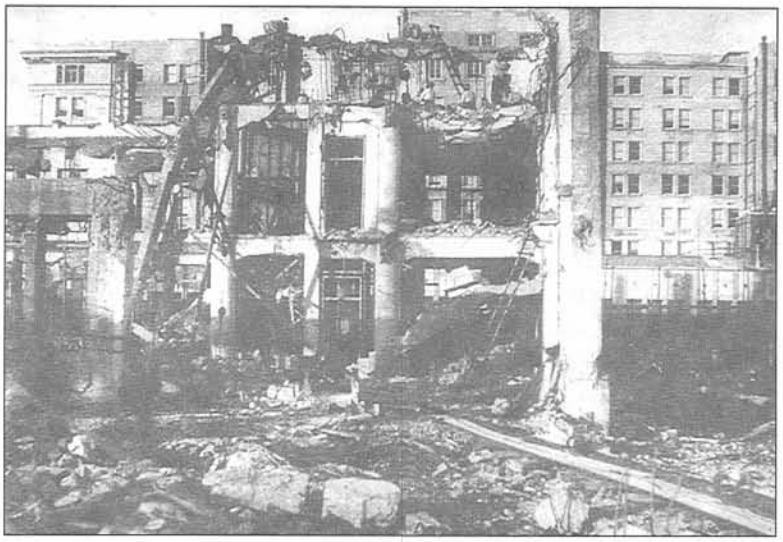


FIGURE A.1 This 8-story reinforced concrete building was one of scores that collapsed during the 1923 Tokyo (Kanto) earthquake. The disaster prompted a limit on building heights. (Source: Carl V. Steinbrugge Collection, Earthquake Engineering Research Center)

History of Seismic Standards

The first quantitative seismic code was developed by an Italian commission following the 1908 Messina-Reggio earthquake, which killed 160,000 people. Following the 1923 earthquake in Kanto, Japan, which killed 140,000 people, the Home Office of Japan adopted a seismic coefficient and a limit on building heights.[1]

First U.S. Seismic Codes: UBC and SEAOC in California

The earliest seismic design provisions in the United States were introduced in the appendix to the 1927 Uniform Building Code (UBC), as a result of the 1925 Santa Barbara earthquake.[2] The 1930 edition included strict specifications for mortar and workmanship on masonry (brick) buildings. However, damage from the Long Beach earthquake of 1933 (Richter magnitude 6.8) proved that unreinforced mortar is unstable in earthquakes. Eighty-six percent of unreinforced masonry buildings in the city of Long Beach experienced either collapse or extensive damage, rendering the buildings useless. Seventy-five percent of schools were heavily damaged. Soon after this earthquake California enacted the Field Act, which specified seismic design forces for school buildings, and the Riley Act, which mandated seismic design for most public buildings throughout the state.

By the 1950s some California municipalities had adopted additional seismic-resistant design and material specifications. UBC was the first model building code to incorporate comprehensive seismic design requirements, though they remained in the appendix for many years. The 1949 edition of the UBC contained the first national seismic hazard map.

In 1957 the Structural Engineers Association of California (SEAOC) began to develop seismic standards for use throughout the state. SEAOC in 1959 published the first edition of *Recommended Lateral Force Requirements and Commentary*, commonly called the *Blue Book*. The *Blue Book* reflected the latest knowledge of seismic design and was used throughout California. The seismic design provisions remained in an appendix to the UBC until the International Conference of Building Officials (ICBO) adopted the *Blue Book* provisions into the main code in 1961. The seismic requirements of the UBC remained largely unchanged, except for some map revisions, until after the 1971 San Fernando earthquake. Revisions were made to the 1973 UBC, and new requirements, based on the work of SEAOC, were introduced in the 1976 edition.

Federal Involvement Expands: The ATC Project

Early in the 1970s the National Science Foundation (NSF) funded a project, under the guidance of the National Bureau of Standards (NBS, now the National Institute of Standards and Technology), to evaluate existing earthquake-resistant design provisions. In 1974 the NBS contracted the project to the Applied Technology Council (ATC). The ATC is a nonprofit corporation established in 1971 to assist the design practitioner in structural engineering. It is guided by a Board of Directors with representatives from various structural and civil engineering organizations. ATC also identifies and encourages research and develops consensus opinions on structural engineering issues.

Over three years ATC published several drafts, which received extensive peer review. In 1978 ATC published the final report titled *Tentative Provisions for the Development of Seismic Regulations for Buildings (ATC 3-06)*. The SEAOC and UBC used the ATC 3-06 report to revise their recommendations and building code.

The NBS in the late 1970s published a *Plan for the Assessment and Implementation of Seismic Design Provisions for Buildings*. This plan analyzed ATC 3-06 and facilitated its development into design standards and building codes.

Further Federal Involvement: NEHRP and the BSSC

In the late 1970s the U.S. Congress passed the Earthquake Hazards Reduction Act of 1977 (PL 95-124), establishing the National Earthquake Hazards Reduction Program (NEHRP), a multi-agency program to fund research and improve practice in reducing earthquake hazards. Since 1977 NEHRP has been the primary source of funding for earthquake research. In 1979 the Federal Emergency Management Agency (FEMA) was established as the lead federal agency for coordinating NEHRP.

The Building Seismic Safety Council (BSSC) was established in 1979 as an independent voluntary body under the auspices of the National Institute of Building Science (NIBS). The purpose of the BSSC is to provide a national forum to foster seismic safety. The concept of the BSSC was developed by the ATC, SEAOC, NIBS, NSF, National Bureau of Standards (now the National Institute of Science and Technology), FEMA, and American Society of Civil Engineers (ASCE). Currently, members of BSSC come from more than fifty organizations, such as the American Consulting Engineers Council, Masonry Institute of America, and American Iron and Steel Institute, all having interest in seismic-related issues.

Under a contract with FEMA, BSSC revised ATC 3-06 through a consensus process of its members. After balloting BSSC members twice and receiving approval, FEMA released the recommendations in 1985 under the title *NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings*, commonly called the *NEHRP Provisions*. The BSSC, with FEMA funding, continues to update the seismic recommendations using a consensus process. The most current edition was published by FEMA in 1994, and the 1997 edition will be published in early 1998.

Federal Buildings: EO 12699 & EO 12941

The federal government, under presidential Executive Order 12699 (January 5, 1990), now requires seismic design for its new buildings. According to the executive order, titled *Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction*, federal agencies must by February 1993 require appropriate seismic design and construction standards for new federal and federally assisted,

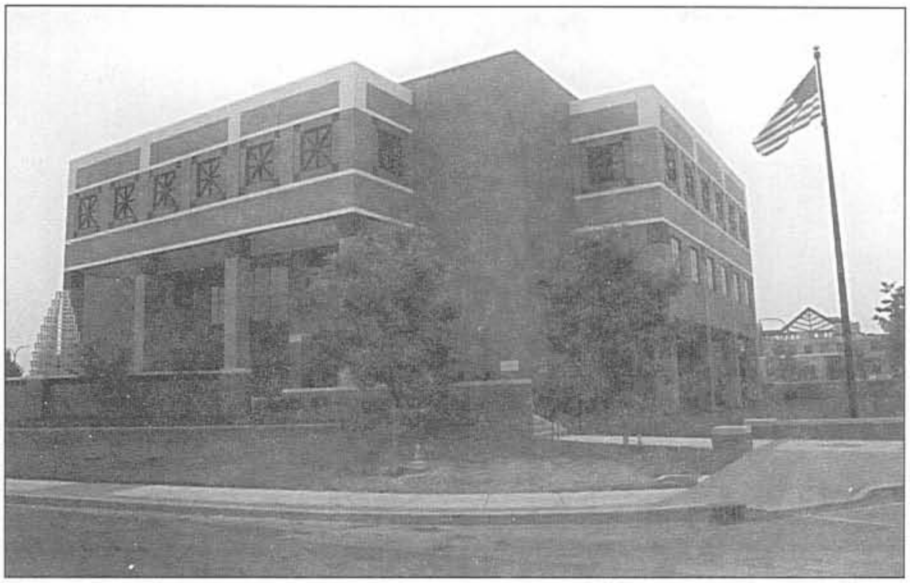


FIGURE A.2 All new federal buildings, such as this federal courthouse in Urbana, Illinois, must be built with seismic design appropriate to the region. (Photo: R. Walker)

leased, and regulated buildings. EO 12699 is significant for state and local governments, because it makes seismic design more prevalent throughout the nation and increases the number of experienced seismic designers and contractors.

Executive Order 12699 is far-reaching, because all new buildings that are owned, leased, or receive federal assistance now must have seismic-resistant design. Also covered are federally regulated or assisted buildings, including single-family homes with Federal Housing Administration or Veterans Administration mortgages.[3]

Under Executive Order 12699, the seismic design provisions used may be those of the municipality or state in which the building is built, so long as the responsible agency or the Interagency Committee on Seismic Safety in Construction (ICSSC) finds that they provide adequately for seismic safety.[4] Accordingly, the ICSSC in 1992 recommended the use of standards and practices that are substantially equivalent to the seismic safety levels in the 1988 *NEHRP Provisions*. Each of the following model codes has been found to provide a level of seismic safety substantially equivalent to the 1988 *NEHRP Provisions*: the 1991 ICBO *Uniform Building Code*, the 1992 *Supplement to the BOCA National Building Code*, and the 1992 *Amendments to the SBCCI Standard Building Code*.

In a May 17, 1995, Recommendation, the Interagency Committee on Seismic Safety and Construction updated this finding. They found that the 1994 UBC, 1993 BNBC, and 1994 SBC provide a level of seismic safety substantially equivalent to that of the 1991 *NEHRP Provisions*. In addition, they found that the National Consensus Standard ASCE 7-93 also provides an acceptable level of seismic safety. Any locality that enforces the current seismic requirements of one of the model codes meets this condition.

The American Society of Civil Engineers' *Minimum Design Loads for Buildings and Other Structures* (ASCE 7-95; see Appendix E for address of ASCE), which supersedes the American National Standards Institute A58.1 standards and subsequent maps adopted for federal use in accord with the order, may be used to determine the seismic hazards in various parts of the country. ASCE 7-95 includes specifications for calculating forces that the building must support, such as earthquake, wind, snow, and building material forces.

Because of EO 12699, it is in the best interests of local governments to adopt seismic codes. To best facilitate the possibility of federal financial assistance for new buildings, local governments would be well advised to adopt one of the model codes that have been found to be seismically adequate. For example, the federal agencies providing financial assistance for housing construction (VA, FHA, HUD) all now require adequate seismic design and construction.

EO 12941, by adopting the *Standards of Seismic Safety for Existing Federally Owned or Leased Buildings*, by the Interagency Committee on Seismic Safety and Construction (ICSSC), promulgates a set of seismic standards for federally owned or leased buildings. It also establishes five triggers for evaluation and possible mitigation of risks in a building. For example, when there is a change of building function, a building is significantly altered, or it has to be rebuilt following a disaster, the building must be evaluated according to the ICSSC standards.[5]

Federal Agency Practices Prior to EO 12699: Some Examples

Prior to EO 12699, many agencies of the federal government had promulgated their own building regulations for federally owned and funded projects. Because of the influence of the federal agencies' standards, increasing numbers of structures throughout the United States have been built to seismic-resistant standards.

The recognized authorities for highway bridge earthquake-resistant design are the American Association of State Highway and Transportation Officials (AASHTO) and the Federal Highway Administration (FHWA). AASHTO has published *The Standard Specifications for Highway Bridges* since 1931 (see Appendix E for address of AASHTO). AASHTO's expressed purpose for publishing these specifications is to guide the preparation of state specifications. The latest edition was published in 1995, and supplements are released yearly. Although seismic design standards were not incorporated into AASHTO's specifications until 1991, they had been adopted as guidelines since 1983. States must use AASHTO specifications in order to receive federal highway funds.

The federal government, through the Interagency Committee on Dam Safety, has published *Federal Guidelines for Earthquake Analysis and Design of Dams*. These guidelines were created to develop consistency among federal agencies involved in the planning, design, construction, operation, maintenance, and regulation of dams.

FIGURE A.3 Following the collapse of the Veteran's Administration hospital in the San Fernando earthquake of 1971, the VA has required seismic design for all its facilities. The hospital building shown in this photo was constructed in 1925 with concrete frames and concrete floors, and hollow-tile walls. This type of building is known to be hazardous in the event of a strong earthquake. (Source: Engineering Features of the San Fernando Earthquake, California Institute of Technology, EERL, 1971)

The 1971 San Fernando, California, earthquake caused a Veterans Administration hospital to collapse. Since then the VA has required its facilities to be designed with earthquake-resistant provisions, in accordance with a seismic design manual published by the VA Office of Facilities.

Principles of Seismic Design[6]

The Goals of Seismic Design

Seismic design provisions are intended to protect the safety of a building's occupants during and immediately following an earthquake. Building codes are primarily designed to save lives and reduce injuries, not to eliminate property loss. Their purpose is to allow for safe evacuation of a building. Seismic provisions attempt to prevent general failures (total collapse), but allow for local damage (damage to noncritical sections). Therefore, a building in compliance with the code probably will not collapse, but it may be rendered unfit for continued use. According to the Structural Engineers Association of California, structures built according to a seismic code should resist minor earthquakes undamaged, resist moderate earthquakes without significant structural damage even though incurring nonstructural damage, and resist severe earthquakes without collapse. Building codes are only minimum design standards.

Lateral Earthquake Forces

Today's seismic provisions specify how to calculate the unique earthquake-induced *lateral force*. These are horizontal forces generated by the ground's side-to-side movement in an earthquake.

The purpose of earthquake engineering and earthquake-resistant design is to construct buildings that can resist horizontal forces. This notion is central to seismic building design. All buildings are designed to stand under the vertical forces of gravity, an obvious constraint because it is always present. Less apparent is the need to design for the occasional occurrence of horizontal forces. Many cities have learned the hard way, after it is too late, that their brick or adobe buildings (or concrete and steel buildings not seismically designed) cannot withstand earthquake ground-shaking.

In designing a building, a structural engineer combines the earthquake-induced lateral force with other code-specified forces, such as wind or snow load, to obtain the maximum probable force. The structure is designed based on the maximum combination. The calculated earthquake forces may be less than the wind or snow force.

Buildings that are tall or have unusual shapes require more extensive design analysis. When a building has a complex shape the designer must employ a dynamic structural response analysis, a computer analysis that simulates the building's swaying (side-to-side movement) during an earthquake. The model reflects the building's behavior, conceptually similar to a vibrating string. The dynamic analysis is more accurate than the simple or "static" analysis but is more time-consuming and costly; therefore it is only used for large-scale structures in which many people could be hurt.

The Council of American Building Officials (CABO) has incorporated construction specifications that increase earthquake resistance for one- and two-family dwellings. The CABO *One- and Two-Family Dwelling Code* contains specific requirements for reinforcing chimneys and fireplaces, tying the building frame to the foundation, and providing walls more resistant to earthquake motion (shear walls). These provisions help to prevent chimneys from falling and homes from shifting off their foundation.

Ductility

Another aspect of seismic design is called *ductility*, the flexibility of buildings. In simple terms, buildings are designed to bend rather than break under earthquake forces. Ductility is the ability of a material to deform without fracturing. For example, ductility is an inherent property of steel. Steel will bend significantly before it ultimately fails, which is called ductile failure. Designing an entire structure to be ductile allows for the parts of a building to deflect in an earthquake before they fail.

In contrast to ductile failure, *brittle failure* occurs without prior visual indication. Unreinforced masonry and unreinforced concrete structures are inherently brittle materials. Steel reinforcement transforms concrete's behavior from brittle to ductile. The American Concrete Institute (ACI) through its *Building Code Requirements for Reinforced Concrete (ACI 318-89)* provides specific criteria for structural design of reinforced concrete structures. One provision is the specification of a minimum amount of reinforcing steel to provide for ductile behavior.

Drift

The codes also try to limit the sway of buildings. This is to prevent nonstructural damage and equipment and inventory damage. Although the structural frame can resist stresses and strains created by *drift*, or horizontal movement of one floor relative to the other, items that are attached to the frame or within its interior may not. The John Hancock Building in Boston in the 1970s had problems caused by excessive drift. Windows crashed to the ground as the building swayed in the wind, until the building was retrofitted to reduce the amount of sway. Damage occurred in Mexico City's 1985 earthquake when swaying buildings pounded into each other. Pounding was a significant factor in 40 percent of the collapsed buildings.[7] The drift was due to inadequate stiffness in building frames and the small distances separating buildings.

Seismic Hazard Maps

All the model codes include a seismic hazard map that indicates likely levels of earthquake ground-shaking and, therefore, potential structural damage in every part of the United States. The hazard map is based on the probability that a specified earthquake intensity will occur during a defined time period.

First Seismic Hazard Map Was Based on Maximum Historic Earthquakes[8]

The first seismic hazard map was published in 1948 by the U.S. Coast and Geodetic Survey and was adopted in the 1949 edition of the UBC, as well as subsequent editions until 1970. In 1969 S.T. Algermissen of the U.S. Geological Survey (USGS) published a seismic hazard map for the contiguous forty-eight states. The original map was created by plotting historical earthquake occurrences and was based only on the recorded maximum earthquake intensities. Because of this, portions of the northeast United States were assigned the same hazard and design requirements as areas in California. This map was the basis for the zoning map in the 1970 UBC, which divided the United States into four zones numbered 0 through 3. A zone 4 was added to California in the 1976 UBC.

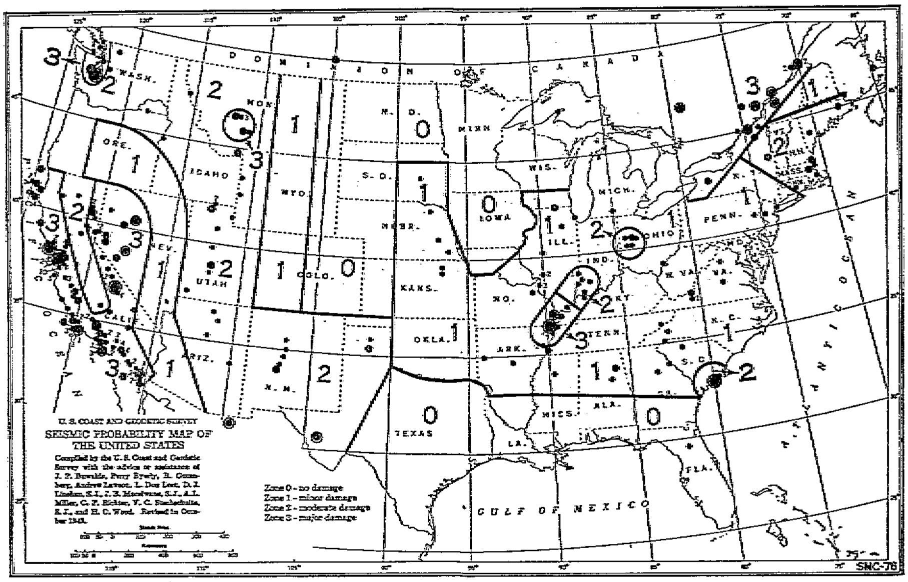


FIGURE A.4 The 1948 seismic hazard map. (Source: U.S. Coast and Geodetic Survey)

1976 Map: Probabilities of Ground-Shaking

In 1976 Algermissen and coworkers refined the map to incorporate the probable frequency of various earthquake intensities. Thus, areas with more frequent earthquakes would be subject to stricter standards of design. They mapped the peak ground acceleration, a measure of the maximum force of earthquake ground-shaking, according to different earthquake intensities expected across the United States. The 1976 map by Algermissen and others depicts the peak ground acceleration that has a 10 percent probability of being exceeded every fifty years. The fifty-year period is typically used as a structure's design lifespan, and 10 percent is consid-

Table A.1 State Codes and Code Influence

State	State Code Name	Basis*	Edition
Alabama	Alabama State Code	SBC	1994
Alaska	Alaska State Code	UBC	1994
Arizona	None		
Arkansas	Arkansas Fire Prevention Code	SBC	1991
California	California Building Code	UBC	1994
Colorado	UBC	UBC	1991
Connecticut	Connecticut State Building Code	BNBC	1992
Delaware	None (done at county level)		
Dist. of Columbia	DC Building Code Supplement	BNBC	1990
Florida	SBC, EPCOT, So. Florida Bldg. Code		1994
Georgia	Georgia State Minimum Std. Bldg. Code	SBC	1994
Hawaii	None (done at county level)		
Idaho	UBC	UBC	1994
Illinois	State (plumbing only)	State	1993
Indiana	Indiana Building Code	UBC	1991
Iowa	Iowa State Building Code	UBC	1991
Kansas	None (uses UBC)	UBC	1991
Kentucky	Kentucky Building Code	BNBC	1993
Louisiana	State Uniform Construction Code	SBC	1991
Maine	None		
Maryland	Model Performance Code	BNBC	1993
Massachusetts	Massachusetts State Building Code	BNBC	1987
Michigan	Building Code Rules	BNBC	1993
Minnesota	Minnesota State Building Code	UBC	1994
Mississippi	None		
Missouri	None		
Montana	Admin. Rules of Montana, Ch. 70	UBC	1994
Nebraska	State Fire Marshall Act	UBC	1979
Nevada	Nevada State Fire Marshall Regulation	UBC	1991
New Hampshire	State Statute	BNBC	1990
New Jersey	State Uniform Construction Code	BNBC	1993
New Mexico	New Mexico Building Code	UBC	1991
New York	Uniform Fire Prevention & Bldg. Code	State	1995
North Carolina	State Building Code	SBC	1994
North Dakota	Century Code	UBC	1994
Ohio	Ohio Basic Building Code	BNBC	1993
Oklahoma	Title 61, Oklahoma Statutes	BNBC	1993
Oregon	Oregon Structural Specialty Code	UBC	1991
Pennsylvania	None		
Rhode Island	State Building Code	BNBC	1990
South Carolina	SBC	SBC	1991
South Dakota	Fire Safety Standards	UBC	1991
Tennessee	SBC	SBC	1994
Texas	None		
Utah	Utah Uniform Building Standards Act	UBC	1994
Vermont	Vermont Fire Prevention & Bldg. Code	BNBC	1987
Virginia	Virginia Uniform Statewide Bldg. Code	BNBC	1993
Washington	State Building Code	UBC	1994
West Virginia	State Building Code	BNBC	1990
Wisconsin	Bldg., Heating, Ventilation & A/C Code	State	
Wyoming	State Code, Ch. 9, Fire Prevention	UBC	1994
Guam	UBC	UBC	
Puerto Rico	Puerto Rico Building Code		
Virgin Islands	UBC	UBC	1994

*Model code on which state code is based.
Sources: Insurance Institute for Property Loss Reduction (now IBHS), April 1996; information on territories was collected by the authors from FEMA and NCSBCS.

ered to be a large enough probability to warrant concern.

It is important to appreciate the probabilistic nature of the Algermissen map. We cannot justify the expense of designing for large but highly improbable events. So we select an event (called the *design event*) that, although large and rare, has a reasonable chance (10 percent) of being exceeded during a building's lifetime (fifty years). The probability selected reflects society's attitude toward risk. This risk acceptance may vary for different uses. Nuclear power plants, for example, are built to much more stringent seismic standards.

It is also important to realize that there is always a chance that an event will exceed the design event—indeed, there is a 10 percent chance of an earthquake that exceeds the design standard. Seismic design standards represent society's balancing of the risks and the costs of designing to withstand that risk.

Finally, one must realize that the zone boundaries themselves are based on probability. There is nothing sacred about the lines on the map; a structure on one side of a zone line is not markedly safer than a structure immediately on the other side. But these maps do represent a consensus of informed scientific opinion of the likelihood of earthquake ground-shaking and its effects. By using these maps as guides to design, we reduce the overall chances of damage to buildings in a region.

ATC Adaptation of the Probabilistic 1976 Map

The ATC revised the 1976 Algermissen map by converting the peak ground acceleration values to effective peak acceleration (EPA) values, another way of describing earthquake ground-shaking. There is no single perfect measure. However, in making the map more user-friendly, it lost accuracy. The effective peak acceleration maps depict peak ground acceleration that has a 5 to 20 percent probability of occurring in a fifty-year period.

From effective peak acceleration, ATC also developed an effective peak velocity map. Effective peak velocity measures the sustained ground movement during an earthquake and is more suitable for building code application to taller buildings. In addition, the ATC maps were revised to follow the boundaries of political jurisdictions to clarify the zones for local building code administration. These maps in ATC 3-06 were used as the basis for the zone map in the *NEHRP Provisions*. A more refined map by the U.S. Geologic Survey appeared in the 1988 *NEHRP Provisions* and has since been adopted by BOCA and SBCCI. The current UBC model building uses similar information for its seismic zone map. The map divides the United States into six earthquake risk zones: 0, 1, 2a, 2b, 3, and 4.

Current Efforts by USGS

The U.S. Geological Survey has recently developed a new generation of seismic hazard maps. These maps are based on the more complete spectrum of ground response to seismic waves, rather than the traditional acceleration and velocity maps. They also use shaking exceedance probabilities of 2 percent and 5 percent in 50 years, in addition to the probability of 10 percent in 50 years that has traditionally formed the basis of seismic hazard maps.[9] The maps currently being balloted for inclusion in the *NEHRP Provisions* are based on the 2 percent in 50 year USGS map, with some changes in high-seismic near-fault areas. The maps will be published with the 1997 edition of the *NEHRP Provisions* and will ultimately be used in the 2000 International Building Code.

NOTES

1 Building Seismic Safety Council, *Improving the Seismic Safety of New Buildings: A Community Handbook of Societal Implications*, FEMA #83, July 1986 edition.

2 This history of seismic codes comes from a number of sources, most notably: Beavers, James E., "Perspectives on Seismic Risk Maps and the Building Code Process," in *A Review of Earthquake Research Applications in the National Earthquake Hazards Reduction Program: 1977–1987*, Walter Hays, ed., U.S. Geological Survey Open-File Report 88-13-A, 1988, 407-432; Whitman, R.V., and Algermissen, S.T., "Seismic Zonation in Eastern United States," *Proceedings, Fourth International Conference on Seismic Zonation*, Vol. I, Earthquake Engineering Research Institute, 1991, 845-869; Martin, H.W., "Recent Changes to Seismic Codes and Standards: Are They Coordinated or Random Events?" *Proceedings, 1993 National Earthquake Conference*, Vol. II, Central U.S. Earthquake Consortium, 1993, 367-376.

3 National Institute of Standards and Technology, *Guidelines and Procedures for Implementation of the Executive Order on Seismic Safety of New Building Construction*, ICSSC RP2.1A, NISTIR 4852, June 1992.

4 Ibid.

5 Todd, Diana, ed., *Standards of Seismic Safety for Existing Federally Owned or Leased Buildings, National Institute of Standards and Technology Report NISTIR 5382*, Interagency Committee of Seismic Safety and Construction Recommended Practice 4 (ICSSC RP 4), February 1994.

6 This summary of seismic design comes from a number of sources, most notably from the Building Seismic Safety Council: *Improving the Seismic Safety of New Buildings: A Community Handbook of Societal Implications*, FEMA #83, July 1986 edition; *Seismic Considerations for Communities at Risk*, FEMA #83, September 1995 edition; and *Nontechnical Explanation of the NEHRP Recommended Provisions*, FEMA #99, September 1995. Also see EERI Ad Hoc Committee on Seismic Performance, *Expected Seismic Performance of Buildings*, Earthquake Engineering Research Institute, February 1994; and Lagorio, Henry J., *Earthquakes, An Architect's Guide to Nonstructural Seismic Hazards*, John Wiley and Sons, Inc., 1990.

7 Geis, Donald A., et al., "Architectural and Urban Design Lessons from the 1985 Mexico City Earthquake," *Lessons Learned from the 1985 Mexico Earthquake*, Earthquake Engineering Research Institute, 1989, 226-230.

8 The information on seismic hazard maps comes from a number of sources, most notably: Beavers, James E., "Perspectives on Seismic Risk Maps and the Building Code Process," in *A Review of Earthquake Research Applications in the National Earthquake Hazards Reduction Program: 1977–1987*, Walter Hays, ed., U.S. Geological Survey Open-File Report 88-13-A, 1988, 407-432; Whitman, R.V., and Algermissen, S.T., "Seismic Zonation in Eastern United States," *Proceedings, Fourth International Conference on Seismic Zonation*, Vol. I, Earthquake Engineering Research Institute, 1991, 845-869; U.S. Department of the Interior, Geological Survey, *USGS Spectral Response Maps and Their Relationship with Seismic Design Forces in Building Codes*, Open-File Report 95-595, 1995; and Leyendecker, Edgar V., Algermissen, S.T., and Frankel, Arthur, *Use of Spectral Response Maps and Uniform Hazard Response Spectra in Building Codes*, Fifth National Conference on Earthquake Engineering, July 1994.

9 Leyendecker, E.V., et al., *USGS Spectral Response Maps and Their Relationship with Seismic Design Forces in Building Codes*, U.S. Geological Survey Open-File Report 95-596, 1995. The most recent versions are available at http://gldage.cr.usgs.gov/eg/