4.3
Building Code Issues

SELLING SEISMIC BUILDING CODES IN THE CENTRAL UNITED STATES

Robert B. Olshansky[1]

ABSTRACT

This paper reports on a CUSEC-funded project to prepare a manual for state and local adoption of seismic building codes in the Central U.S. The message of the manual is simple: A seismic building code is easy to adopt, widely accepted in the design and construction community, and a cost effective way to a safer community. The manual lays out the history of building codes in the United States, the widespread use of building codes, the history and purpose of seismic standards, the effectiveness of seismic codes, the cost of seismic codes, a summary of seismic design practices in the Central United States, methods of state and local code adoption, and strategies for code adoption.

INTRODUCTION

The purpose of this paper is to report on a CUSEC-funded project to prepare a manual for state and local adoption of seismic building codes in the Central U.S. The manual was printed in late 1992. The purpose of the manual is to encourage and facilitate more widespread adoption of seismic codes. Adoption of seismic building codes throughout the Central U.S. is a major goal of CUSEC. The manual is directed at state and local officials, and so is meant to be understandable to lay audiences.

Seismic design standards are now widely accepted in the professional community. Seismic building codes have evolved over the past two to three decades, under the leadership of numerous professional organizations and federal agencies. These standards are now included in all three of this nation's model building codes, and all federal buildings, by Presidential Executive Order 12699 of January 5, 1990, must meet seismic design standards. Still, many states and localities throughout the U.S. have yet to adopt seismic codes, or, in some cases, any building code at all. Reasons vary: antipathy to government

[1]Assistant Professor, Dept. of Urban and Regional Planning, University of Illinois, Urbana, IL 61801

regulation, belief that seismic codes are only appropriate to the West Coast, or fear that such codes will drive up the cost of construction. Yet, studies show that such codes are inexpensive, and are extremely effective.

The manual promotes a cost-effective means toward the widely-accepted national goal of reducing earthquake hazards. Mitigation of earthquake hazards, by improving design and construction practices, is a major stated purpose of the National Earthquake Hazard Reduction Program (see 42 USCS, Sec. 7702). From a public policy perspective, one of the most direct ways to reduce earthquake hazards is to ensure that all new buildings are constructed according to the latest standards of earthquake-resistant design. Existing hazards are difficult and costly to remediate, but at the very least we should prevent any new hazardous buildings from entering into our building stock.

The message of the manual is simple: A seismic building code is easy to adopt, widely accepted in the design and construction community, and a cost-effective way to a safer community. The manual lays out the history of building codes in the United States, the widespread use of building codes, the history and purpose of seismic standards, the effectiveness of seismic codes, the cost of seismic codes, a summary of seismic design practices in the Central United States, methods of state and local code adoption, and strategies for code adoption. This paper summarizes the contents of the manual.

BUILDING CODES IN THE UNITED STATES

The earliest building regulations in North American were for prevention of rapid spread of fire. Fire was the most destructive force in urban areas, as evidenced by New York's 1835 and 1845 fires, the great Chicago fire of 1871, and, of course, the fire following the San Francisco earthquake of 1906. More comprehensive building regulations were introduced in the mid 1800s, largely to reduce the ill effects of residential overcrowding.

Modern building codes regulate building construction and use. Currently, two states have written their own building codes: New York and Wisconsin. Other states that enforce statewide codes use one of several national model building codes.

A model building code is a document, published by a non-profit association of governmental jurisdictions, containing standardized building requirements applicable throughout the U.S. The first model code was prepared in 1905, by the National Board of Fire Underwriters (Dillon, 1985). The U.S. has three prominent model building code organizations: the International Conference of Building Officials (ICBO), which publishes the Uniform Building Code (UBC), the Building Officials and Code Administrators (BOCA), which publishes the National Building Code (NBC), and the Southern Building Code Congress International (SBCCI), which publishes the Standard Building Code (SBC). Each code is updated every three years, through a systematic and democratic process (see Building Seismic Safety Council, 1990). Anyone may propose a code revision, and changes are voted on by the membership at the annual meeting.

As of 1989, the National Conference of States on Building Codes and Standards reported:

> 29 states regulated all construction, relying mostly on local municipal enforcement and regulation;
>
> 8 states regulated only state-owned or leased structures; and
>
> 13 states had no statewide code.

The Federal Trade Commission in 1989 estimated that 95% of all cities and towns were covered by building codes. These local governments either have adopted a model code or are covered by a statewide building code. Model codes save local government the time and cost required to write an original code.

HISTORY OF SEISMIC STANDARDS

The earliest seismic design provisions in the U.S. were introduced in the 1927 Uniform Building Code (Building Seismic Safety Council, 1990). By the 1950s, some California municipalities adopted additional seismic resistant design and material specifications, developed by the Structural Engineers Association of California (SEAOC). The 1970 UBC included the SEAOC Recommended Lateral Force Requirements.

In the 1970s, the federal government began to play a lead role in developing standards for seismic design. In the mid-1970s, the National Bureau of Standards contracted with the Applied Technology Council (ATC), a committee of experts in earthquake design, to evaluate earthquake design provisions. Their report (ATC 3-06), published in 1978, became the basis for revisions in the UBC (Applied Technology Council, 1978). At the same time, the National Earthquake Hazards Reduction Program (NEHRP), established by Congress in 1977, provided a mandate, as well as funding mechanisms, for research in reducing earthquake hazards. The Building Seismic Safety Council (BSSC) was established in 1979, as a voluntary council of organizations with an interest in seismic design and construction. The BSSC reviewed ATC 3-06, polled its members, and released its recommendations in 1985, under the title, "NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings" (Building Seismic Safety Council, 1985). Revised editions were subsequently published in 1988 and 1991 (Building Seismic Safety Council, 1992). These provisions, commonly called the "NEHRP recommendations", have been included in the latest revisions of the Standard Building Code and the BOCA National Building Code.

A recent study for the National Institute of Standards and Technology (NIST) found that all three national model codes contain the most advanced available seismic design provisions (Council of American Building Officials, 1991). This is a significant statement, which would not have been true as recently as three years ago. For the first time, seismic design provisions are readily available for every community throughout the country.

The federal government now requires all its structures to have seismic resistant design. Executive Order 12699, signed by President Bush on January 5, 1990, requires all new federal construction to meet accepted seismic design standards. The order is far-reaching, because it includes all structures owned, leased, regulated, or receiving assistance from the federal government (Todd and Bieniawski, 1992).

EFFECTIVENESS OF SEISMIC CODES

Experience with recent earthquakes, in the U.S. and throughout the world, shows that seismic codes work (see Building Seismic Safety Council, 1990, pp. 42-46). Cities that adopt and enforce seismic codes suffer much less damage than those without such codes. The 1989 Loma Prieta earthquake illustrates the effectiveness of seismic codes. The earthquake measured 7.1 on the Richter scale, at the time the strongest U.S. earthquake since the 1964 Alaskan earthquake. Although the ground shaking was intense within a large metropolitan area, few buildings collapsed. Most of the damage occured to unreinforced masonry buildings, built before the adoption of seismic codes.

COST OF SEISMIC CODES

Cost of building codes, in general, are twofold: the cost of material and workmanship quality, and the cost of administration. Limited studies have suggested that building codes add one to five percent to the cost of housing.

In the early 1980s, the BSSC contracted 17 design firms to perform two designs for each of several typical building types, first using the existing local code, and then using the NEHRP seismic provisions (Weber, 1985). The average increase in structural costs varied, from 1.5% for industrial buildings, to 11.2% for high rises. On average, the cost increases for cities without current seismic codes was 7.6% of structural cost, or 2.1% of total project cost.

A 1992 study, funded by the National Committee on Property Insurance analyzed the estimated costs and benefits of seismic building codes for Memphis, assuming Magnitude 6.0 and 8.0 earthquakes from the southern New Madrid seismic zone (Litan, et al, 1992). It also looked at the costs and benefits of retrofitting in both Memphis and Los Angeles. The study estimated the benefit-cost ratios for Memphis-Shelby County to be 1.85 for the M6 event, and 10.34 for the M8 event. Moreover, the benefit-cost ratio averaged over a 40-year time horizon was estimated at 3.31. Admittedly, such a study depends on generalization of numerous previously-published assumptions regarding expected damages, costs of seismic codes, and earthquake probabilities. Still, the benefit-cost ratios are quite large. Furthermore, the benefits are for reduced shake damage alone, and do not include consideration of reducing the potential for fire, fatalities or injuries, or secondary economic effects. Thus, the benefits are underestimated. This study provides valuable analytic support to the assertion that seismic building codes are cost-effective.

SEISMIC BUILDING CODES IN THE SEVEN CUSEC MEMBER STATES

Within the seven CUSEC charter member states, code coverage varies. Arkansas, Indiana, Kentucky, and Tennessee have statewide building codes. The remaining states, Illinois, Mississippi, and Missouri, have codes that regulate some aspects of buildings. Missouri has a seismic design requirement. Even in the states that have codes, enforcement varies, depending on level of funding for plan review and inspection, and on qualifications of local building officials. Following is a review of seismic code practice in the CUSEC member states.

Arkansas

The Standard Building Code applies to all buildings in Arkansas. The State Fire Marshal is charged with enforcing the fire prevention code as well as "other functions." This has enabled the State to adopt the fire and building codes from SBCCI, collectively called the Arkansas Fire Prevention Code. This means that there is a state seismic code, since SBC now includes seismic requirements.

In March 1991 the Arkansas General Assembly chose to emphasize the importance of seismic design by enacting Act 1100, "An Act to Safeguard Life, Health and Property by Requiring Earthquake Resistant Design for all Public Structures to be Constructed or Remodeled within the Boundaries of this State Beginning September 1, 1991." It was signed by the Governor April 9, 1991. The Act requires that all "public structures" (buildings open to the public, as well as all public works) be designed to resist seismic forces, in accordance with the 1988 SBC or latest edition. The structural design must "be performed by a professional engineer registered in the State of Arkansas who is competent in seismic structural design according to current standards of technical competence." Structural plans must be signed and sealed by a professional engineer. Another key element of the Act is that it specifies a penalty of $1,000 per day of violation. There is no such penalty for violating building codes.

Most larger towns (populations greater than about 10,000, such as West Memphis, Blytheville, and Jonesboro) have building departments, and so they are well-equipped to enforce seismic design and construction requirements. However, enforcement may be a problems in smaller communities, who do not have inspection staff.

Illinois

Illinois has no statewide building code requirement. The only statewide building code in Illinois is that of the Capital Development Board for state-owned buildings.

The Capital Development Board, the construction administrator for the state, responsible for all state buildings, has had a seismic design policy since 1977, based on a resolution of the Board. This policy was reinforced by an "Executive Order for the Reduction of Earthquake Hazards" (Executive Order No. Two, 1990), issued on April 6, 1990. It was patterned after the Presidential Executive Order issued in January of the same

year. The order applies to the construction of all state-owned, leased, or regulated buildings. The order says that state agencies "shall ensure that the building is designed and constructed in accord with appropriate seismic design and construction standards," using "nationally recognized private sector standards and practices". Local building codes deemed adequate by the state may be used. It also states that the Department of Transportation must design and construct all highways in accordance with earthquake design requirements of AASHTO.

Numerous local communities in Illinois have a building code. Over 300 communities in the state have adopted BOCA. Every large city in Illinois uses BOCA, except Chicago, which has its own code (explicitly without seismic standards!). Most Chicago suburbs use BOCA. Smaller cities and county areas outside corporate limits typically do not have any building code. Only the larger cities in southern Illinois have adopted modern building codes with adequate seismic design provisions.

Indiana

Indiana has had a state building code since 1923. It was the first state in the region to have one. Since 1946 it has been based on the UBC, and since 1973, current editions of the Uniform Building Code have routinely been adopted. Thus, when seismic requirements are added or revised in the Uniform Building Code, they become part of Indiana's code. The code is administered by the Department of Fire and Building Services. Plans for all Class 1 structures (e.g., open to public, employ workers) are reviewed by the State, in Indianapolis. Permits and inspections are handled by local governments.

The seismic zone map in the Indiana code has been modified from that in the 1988 Uniform Building Code. Based on a Purdue University study, a zone 2A was created to cover areas with expected M 4.0 recurrence of less than 30 years. This zone covers 20 counties in southwest Indiana; the remainder of the state is in seismic zone 1. Zone 2A encompasses 15 more counties than in the UBC, in part because Indiana believes that the ATC maps, from which the UBC maps are derived, do not consider all seismic sources east of the Rockies, such as the Wabash fault zone.

Each local unit of government is required to adopt the state building code by ordinance, and then either establish a local enforcement authority, or have another unit of government provide the enforcement. In 1984, only 24 units of government had complied, but by July, 1990, 281 jurisdictions had complied. There are still 350 jurisdictions, consisting of small cities and towns in rural areas, which have not complied. The Department of Fire and Building Services has inspectors throughout the state, whose function is to assist local building departments. In areas without designated enforcement, these inspectors are, by default, the local building officials.

Kentucky

Since October 1979, Kentucky has had a state building code, based on the BOCA NBC. The Kentucky Building Code is updated every three years, following the publication

cycle of BOCA. It is administered by the Department of Housing, Buildings and Construction, which was legislatively created in 1978 in order to combine all functions involved in construction of buildings. The Board of Housing, Buildings and Construction is responsible for adopting and amending the code. The 20-member Board is appointed by the Governor to represent the spectrum of interests related to the building industry. Kentucky has a Building Inspectors Certification Program, mandated by the 1982 General Assembly, under which inspectors must pass appropriate examinations to become certified. Still, the Department only has 17 inspectors for the whole state, and local inspectors are not yet well trained to enforce seismic requirements.

Generally speaking, the state is responsible for all major buildings. The state reviews plans, issues permits and provides inspection for these. Smaller buildings and single family homes are handled by local agencies. Communities with qualified personnel can petition to manage all building permit functions themselves. Six of the larger cities and counties (including Louisville, Lexington, and Jefferson County) have done so. The state depends on design professionals to sign and take responsibility for their plans.

Permit applicants may appeal decisions for any reason, and all appeals receive a hearing from a panel selected from among the 20-member Board. This system has been effective in ensuring a fair process.

Mississippi

Mississippi does not have a state building code requirement. All jurisdictions must have the Southern Fire Prevention Code, but not a building code.

Most large municipalities and many counties have adopted the Standard Building Code. Approximately 110 municipalities (out of 400) and 11 counties (out of 82) are members of SBCCI. This includes the counties of DeSoto, Tunica, Tate, Marshall, Quitman, which are the northwesternmost counties in the state, and hence the closest to the New Madrid seismic zone. However, of the 17 counties rated to have the highest risk, only six are SBCCI members. Most of the northwesternmost major municipalities appear to have adopted the SBC.

The Department of Finance and Administration, General Services Division, Bureau of Building is responsible for monitoring contracts for new state buildings. Several years ago the Bureau Director began to require that all new state buildings comply with the standards of the SBC. This is an internal guideline, and not a state code. Since 1983, the Bureau selects the designers, reviews plans, and inspects the construction for compliance with the latest edition of SBC.

Missouri

Building codes in Missouri are enforced locally, including fire safety codes. Most larger communities (population greater than 10,000) have building codes, either BOCA or UBC Very few counties have building codes.

St. Louis and its region uses the BOCA NBC, which in 1987 upgraded St. Louis from Seismic Zone 1 to Zone 2. Both the city and the county adopted this provision in February 1988, apparently with very little opposition (Engineering News-Record, 5/4/89, p. 14).

Missouri's Geologic Hazard Preparedness Act (S.B. 539), which became effective in October 1990, contains requirements for seismic design. It applies to the 47 counties that are expected to experience Modified Mercalli intensities of VII or greater from a magnitude 7.6 earthquake in the New Madrid seismic zone, according to maps by Algermissen and Hopper (1985). The requirement applies to all public and educational buildings, as well as all private structures larger than 10,000 square feet. Each jurisdiction within these counties must adopt an ordinance stating that all new buildings covered by these criteria must "comply with the standards for seismic design and construction" of BOCA or UBC. According to the Division of Design and Construction, all affected local governments (approximately 300) have been notified, and all have passed the required ordinance.

The new seismic code requirement may be difficult to enforce, especially in communities that do not have building codes. State-funded buildings, on the other hand, will now be reviewed for compliance by the state Division of Design and Construction before a lease is signed. Prior to this bill, state buildings were not reviewed for seismic design.

Tennessee

The State of Tennessee has had a mandatory state building code since 1982. By statute (Safety and Health Code, Chapter 18, Sec. 68-18-101), the state fire marshal must promulgate rules establishing minimum statewide building construction safety standards, to "afford a reasonable degree of safety to life and property". The state has been using the Standard Building Code. The 1988 version of this code, the first to include mandatory seismic provisions, was adopted by the state in August 1990. The state has a staff of plan reviewers in the Division of Fire Protection in Nashville, and a staff of inspectors throughout the state. The state also allows local governments to adopt and implement the Standard Building Code themselves, provided that the locally-adopted edition of the state code is newer than six years old. Twenty-five local governments, including Memphis, have approved local codes. The state, however, maintains jurisdiction over all state-owned and educational buildings.

Memphis adopted the 1988 SBC in April 1990, but with lower seismic requirements than those established in the code, and a one-year grace period before needing to meet them. This adoption of the first seismic code in the history of Memphis was extremely controversial. By 1996, unless state law is amended, Memphis will need to adopt the SBC seismic requirements in full. According to various news accounts, several new buildings have been voluntarily designed for seismic resistance. In contrast, state-owned and educational buildings in Memphis fall under the jurisdiction of the state, and so they are required to meet the 1988 SBC requirements in full.

HOW TO ADOPT A SEISMIC CODE

The manual is aimed at state and local governments that do not currently have seismic design requirements. The majority of the manual provides the justification for seismic codes. The final section details how states or localities can adopt a seismic code, whether or not they are already using a building code. Because of the existence of the model codes, adoption of a new code is a relatively simple procedure. And code administration can be self-supporting, via permit application fees. The mechanics of code adoption are straightforward and inexpensive; the politics are the difficult part.

States can choose to adopt a code either legislatively or administratively, depending on which method is likely to be most successful. Adoption of a statewide code generally requires widespread political support. Key groups include: professional engineering and architectural organizations, building associations, local civic organizations, and legislators from the highest risk parts of the state. Typically, political bodies become interested in earthquakes for a number of months following a newsworthy earthquake event. One should assume this to be the case and take advantage of it. A good strategy is to work slowly on gaining the support of a wide variety of professional, business, and political organizations. Then, when a newsworthy earthquake occurs, the legislation is ready to go.

One also can encourage local adoption of codes in states without statewide code requirements. It is true that local officials tend to respond to short-term concerns, and furthermore they prefer results that are visible and immediate. Still, many localities can be persuaded by the following arguments: (1) Codes will not hurt business, (2) A seismic code will improve their survival of the next earthquake, (3) Everyone else is adopting seismic codes, (4) It is easy to adopt a model code, (5) A code will reduce long-term costs to the community, (6) All communities can benefit from a seismic code, regardless of level of risk.

The manual suggests some strategies for building support for seismic codes. All the strategies contain common elements: making personal contact with a variety of interest groups, being persuasive, and being persistent and patient. A key ingredient in being persuasive is having a clear, concise, and credible argument. The authors of the manual hope it can assist in that task, by providing information in a tangible, attractive, and understandable form.

REFERENCES

S.T Algermissen and M.G. Hopper. "Maps of Hypothetical Intensities for the Region." Pages 42-51 in M.G. Hopper, ed., Estimation of Earthquake Effects Associated with Large Earthquakes in the New Madrid Seismic Zone. Open-File Report 85-457. U.S. Geological Survey, 1985.

Applied Technology Council. Tentative Provisions for the Development of Seismic Regulations for Buildings. Report ATC 3-06. San Francisco, CA: Applied Technology Council, 1978.

Building Seismic Safety Council. NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings, 1985 Edition. Washington, D.C.: Federal Emergency Management Agency, 1985.

Building Seismic Safety Council. Seismic Considerations for Communities at Risk. FEMA 83. Washington, D.C.: Federal Emergency Management Agency, October 1990.

Building Seismic Safety Council. NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings, 1991 Edition. FEMA-222. Washington, D.C.: Federal Emergency Management Agency, January 1992.

Council of American Building Officials. Assessment of the Seismic Provisions of Model Building Codes. Gaithersburg, MD: National Institute of Standards and Technology, 1991.

R.M. Dillon. "Development of Seismic Safety Codes." Pages 3-1 to 3-8 in Building Seismic Safety Council, ed., Societal Implications: Selected Readings. FEMA-84. Washington, D.C.: Federal Emergency Management Agency, June 1985.

R. Litan, F. Krimgold, K. Clark, and J. Khadilkar. Physical Damage and Human Loss: The Economic Impact of Earthquake Mitigation Measures. Boston, MA: National Committee on Property Insurance, February, 1992.

D Todd and A. Bieniawski, eds. Guidelines and Procedures for Implementation of the Executive Order on Seismic Safety of New Building Construction. ICSSC RP 2.1-A, NISTIR 4852. Gaithersburg, MD: Nationa Institute of Standards and Technology, June 1992.

S.F. Weber. "Cost Impact of the NEHRP Recommended Provisions on the Design and Construction of Buildings." Pages 1-1 to 1-19 in Building Seismic Safety Council, ed., Societal Implications: Selected Readings. FEMA-84. Washington, D.C.: Federal Emergency Management Agency, June 1985.