WILL DESIGN AND CONSTRUCTION COSTS INCREASE IN MY COMMUNITY?

THE COST OF SEISMIC DESIGN AND CONSTRUCTION

It is widely believed that seismic resistant design and construction are extremely costly. Although it is generally true that some increase in design and construction costs is involved, available data indicate that it is not nearly so great as is sometimes argued.

An analysis of the information supplied by those conducting trial designs as a part of the BSSC program resulting in the draft NEHRP Recommended Provisions indicates that the design and construction costs associated with the seismic upgrade of the structural components of a building will increase the total cost of a building an average of less than 2 percent (see Tables 1 and 2).[6]

- In those trial design cities that do not now enforce seismic code regulations for new buildings (Chicago, Ft. Worth, Memphis, New York, and St. Louis), design and construction costs would increase an average of approximately 2 percent.

- In those trial design cities now enforcing seismic code regulations for new buildings (Charleston, Los Angeles, Phoenix, and Seattle), design and construction costs would increase an average of less than 1 percent.

The data used in this analysis were somewhat limited. Only a selected few of the 52 trial designs were required to include the costs associated with nonstructural building components that in many cases could add considerably to the total cost of a building when designed and constructed in accordance with the NEHRP Recommended Provisions and, of course, this should be taken into account when determining what the likely cost impact will be. However, the analysis itself is one of a kind and, hence, tentative though conclusions based on it may be, they are at least based on real data and statistical analysis rather than on "intuition."

Nevertheless, many fear that **any** increase in cost will generate resistance and have an adverse impact on a community. Those individuals meeting with the BSSC committee were very interested in the cost data presented as well as in other aspects of the economics of seismic resistance construction, particularly in cost-benefit analyses.

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[6]This analysis was conducted for the committee by Stephen Weber of the National Bureau of Standards. His report on this analysis, "Cost Impact of the NEHRP Recommended Provisions, is included in the selected readings volume that accompanies this handbook.

TABLE 1 Percentage Changes in Structural Cost and Total Building Cost for BSSC Trial Designs

City	No. of Designs	Estimated Change in Structural Cost (%)[a]	Projected Change in Total Cost (%)[b]
Cities Without Seismic Code Provisions			
Chicago	10	2.5	0.7
Ft. Worth	3	6.1	1.5
Memphis	6	18.9	5.2
New York	7	7.3	2.1
St. Louis	3	4.5	1.3
Average Percentage Change		7.6	2.1
Cities With Seismic Code Provisions			
Charleston	3	-2.5	-0.6
Los Angeles	10	4.2	1.3
Phoenix	6	6.9	1.9
Seattle	4	-1.1	-0.3
Average Percentage Change		3.1	0.9
Overall Average Percentage Change		5.6	1.6

[a]Percentage change in structural construction cost from the local code to the amended Tentative Provisions as estimated by the BSSC trial design engineering firms, 1983-84.

[b]Projected percentage change in total building construction cost from the local code to the amended Tentative Provisions, derived from estimated structural cost changes by using the following McGraw-Hill's Dodge Construction Systems Costs (1984) data on structural cost as a percent of total building cost:

Low-rise residential	18.1%
High-rise residential	30.0%
Office	28.1%
Industrial	33.7%
Commercial	29.5%

TABLE 2 Percentage Changes in Structural Cost and Total Building Cost for the BSSC Trial Designs by Building Occupancy Type

Occupancy Type	No. of Designs	Estimated Change in Structural Cost (%)[a]	Projected Change in Total Cost (%)[b]
Low-Rise Residential[c]	9	3.6	0.7
High-Rise Residential[d]	12	11.2	3.3
Office	21	4.7	1.3
Industrial	7	1.5	0.5
Commercial	3	5.6	1.7
Average Percentage Change		5.6	1.6

[a]Percentage change in structural construction cost from the local code to the amended Tentative Provisions as estimated by the BSSC trial design engineering firms, 1983-84.

[b]Projected percentage change in total building construction cost from the local code to the amended Tentative Provisions, derived from estimated structural cost changes by using the following McGraw-Hill's Dodge Construction Systems Costs (1984) data on structural cost as a percent of total building cost:

Low-rise residential	18.1%
High-rise residential	30.0%
Office	28.1%
Industrial	33.7%
Commercial	29.5%

[c]Five stories or less.

[d]More than five stories.

Although economic analyses of new construction requirements can be useful in decision-making, their results do not, and should not, necessarily control the decision-making in this area since what is at risk are the people who live, work, and play in a community's buildings. Indeed, as was indicated in Chapter 3, the goal of building code requirements is life safety; consequently, trade-offs between construction costs and protection of life must be made in the seismic area just as they are in other areas.

As was indicated above, those meeting with the BSSC committee were interested in economic information but the degree of concern expressed about costs appeared to reflect the degree to which costs were actually predicted to increase in the specific area.

- At the meetings in Seattle and Charleston, where application of the NEHRP Recommended Provisions instead of their current seismic code provisions was estimated to decrease costs approximately half a percent, there was relatively little discussion of costs.

- At the meetings in Memphis and St. Louis, however, where no seismic regulations are currently enforced and costs are estimated to increase approximately 5 and 1 percent, respectively, a considerable amount of discussion focused on costs. Many also asked for cost-benefit data.

INFORMATION SOURCES

As noted above, the reader is referred to Weber's paper in the selected readings volume published with the handbook for details concerning the estimated impact of the NEHRP Recommended Provisions on design and construction costs.

Additional economic information is also available in the following publications:

Brookshire, David S., and William D. Schulze. 1980. Methods Development for Valuing Hazard Information. Report prepared for the U.S. Geological Survey. Laramie: University of Wyoming, Institute for Policy Research.

Cohen, L., and R. Noll. 1981. "The Economics of Building Codes to Resist Seismic Shock." Public Policy 29(1):1-30.

Dacy, Douglas C., and Howard Kunreuther. 1969. The Economics of Natural Disasters, Implications for Federal Policy. New York: The Free Press.

Ferritto, John M. 1981. "Economic Review of Earthquake Design Levels." ASCE Journal of Structural Engineering (August).

Friesema, H. Paul, James Caporaso, Gerald Goldstein, Robert Lineberry, and Robert McCleary. 1979. Aftermath--Communities After Natural Disasters. Beverly Hills, California: Sage Publications.

Goodisman, Leonard D. 1983. "Disaster Relief Budgeting." Public Budgeting and Finance 3(1)89-102.

Hirschberg, J., P. Gordon, and W. J. Petak. 1978. Natural Hazards: Socioeconomic Impact Assessment Model. Redondo Beach, California: J. H. Wiggins Company.

Milliman, Jerome W. 1982. "Modeling Regional Economic Impacts of Earthquakes." In Social and Economic Aspects of Earthquakes: Proceedings of the Third International Conference Held in Bled, Yugoslavia, edited by Barclay G. Jones and Miha Tomazevic. (For copies, contact Barclay Jones, Program in Urban and Regional Studies, Cornell University, Ithaca, New York.)

Palm, Risa. 1981. Real Estate and Special Study Zones Disclosure: the Response of California Homebuyers to Earthquake Hazards Information. Monograph 32. Boulder: University of Colorado.

Palm, Risa, et al. 1983. Home Mortgage Lenders, Real Property Appraisers, and Earthquake Hazards. Boulder: University of Colorado.

Scawthorn, Charles, et al. 1982. "The Influence of Natural Hazards on Urban Housing Location." Journal of Urban Economics (11):242--251.

Schulze, William D., and David S. Brookshire. 1981. "An Economic Analysis of the Benefits and Costs of Seismic Building Codes." In Earthquakes and Earthquake Engineering: The Eastern United States, edited by James E. Beavers. Ann Arbor, Michigan: Ann Arbor Science Publishers, Inc.

DECISIONS, DECISIONS, DECISIONS!!!

It is not easy for a community to evaluate the probable effects of introducing into its building regulatory process new or improved seismic design requirements.

- Communities like some in California that are used to experiencing small to moderate seismic events are continually aware of the threat and already have taken some protective measures; to those communities, any changes in their current regulations likely would have to be justified by a soundly based costbenefit analysis.

- Communities in seismic risk areas with no memorable seismic experience often have little, if any, concern for regulating the quality of their buildings. Some probably could never be convinced, short of an actual damaging earthquake, that any change in the status quo, regardless of its potential advantages, would be worth the effort.

- The conscientious community that falls somewhere between these two types will have to keep in mind that bringing about change in local practices undoubtedly will have differing effects on various segments of the community, some of which will generate interest, and others, concern.

The effects most often mentioned at the BSSC meetings and worthy of serious consideration by a community's decision-makers are described below. Decision-makers should anticipate the issues and be prepared to address them.

JURISDICTIONAL CONCERNS

An increase in the costs of a new building caused by requiring improved earthquake protection could result in:

- Less new construction and, as a consequence, a reduced supply of housing (especially for the low-income housing market) and commercial and industrial facilities

- Fewer amenities in what is being built

- Businesses deciding to locate in adjacent or nearby jurisdictions where they can build or rent more cheaply

In the last instance, missing out on potential new businesses and the relocation of existing businesses would affect the job market and revenue situation. These matters can be expected to arise in any community

surrounded by jurisdictions with less stringent building regulations, and they will be especially troublesome in those communities located in a large seismic zone that includes many other communities and perhaps two or more states. Concern about being the "first" and, for a while, the only community in an area to require seismic-resistant construction is very real and responding to it is not easy.

LOCAL MATERIALS PRODUCER/SUPPLIER CONCERNS

The version of the NEHRP Recommended Provisions currently being reviewed has met with some criticism from building materials interests. The masonry industry is concerned that new requirements for reinforcing may make its material less competitive. Other industries, including the concrete industry, are concerned that changes in market share may result in the closing of manufacturing plants, layoffs, or both. Since loss of market share by one material implies that other materials will be substituted, construction practice could change and result in the need for worker retraining. Some capital expenditures for new manufacturing facilities also could be required.

PROFESSIONAL RESPONSIBILITY

Generally, the structural engineers at the meetings expressed much concern about professional responsibility. Several had strong opinions about their professional responsibility to advise a client about the need for seismic-resistant design even though the local building code does not require it.

In addition, use of the NEHRP Recommended Provisions in upgrading a code that includes no seismic considerations will require many design practice changes. The NEHRP Recommended Provisions outlines a 13-step process for use in the design and detailing of buildings, most of which could be relatively new to many engineers and architects. During the early phases of the BSSC trial design effort, concern was expressed about the lack of seismic design knowledge and experience of some of the engineers employed by contractors selected to design the hypothetical buildings. This proved to be something of a "red herring," however, in that knowledge and familiarity obviously increase with each design performed.

LEGAL LIABILITY

Of concern at all four of the BSSC meetings was the issue of legal liability. In fact, it was suggested by one municipal code administrator that the best instructional manual regarding responsibility for building safety would be the proceedings from a local court case. There appears to be growing recognition of the fact that communitiy officials and regulatory agencies could be held as liable as building owners and designers for the losses that result from the occurrence of a natural disaster when the hazard was known to exist. In other words, from a legal standpoint, natural disasters are no longer considered to be "acts of God" if the existence of a hazard has been documented by scientists.

Although earthquake-related liability has not yet been tested in the courts, it is almost certain, given the current legal climate, that it ultimately will be.

FACING THE ISSUES

One way to reduce potential jurisdictional competition and a community's initial isolation as it initiates seismic safety efforts is to attempt to gain intergovernmental cooperation on a regional basis. A number of organizations have been formed to pursue such an approach (e.g., see the Charleston and Memphis organizations listed in Chapter 7). Those interested in improving seismic safety might be wise to determine which businesses in the community already require seismic-resistant design and which depend on sophisticated electronic and computer equipment that would be at special risk should an earthquake occur. Support could be gained from those individuals and organizations that already have taken it upon themselves to deal with seismic safety.

The importance of life safety must be emphasized, but in areas where earthquakes have not occurred for a long time and general awareness of the earthquake threat is low, jobs and taxes may well be viewed by many citizens to be of much more "immediate" concern. Nevertheless, when an earthquake occurs, the impacts on all community systems (especially the adverse social and economic impacts) and the duration of response and recovery can be reduced considerably because of seismic-resistant structures. Communities that have not experienced a natural disaster may be unaware of the traumas caused by such an event and of the long-term hardships usually endured afterwards; dissemination of such information may be quite persuasive.

Even though it is difficult to estimate the economic and social impacts of seismic safety, each community must do so for itself as objectively as possible. Decision makers must make sure they understand the possible consequences of any increase in costs of new construction, especially the impacts that could be felt by those members of the community who fall in the lower income ranges. At the same time, they must bear in mind such things as a recent loss expectancy study of the Memphis area which indicates that approximately 3,900 lives could be lost if the area today experienced a seismic event similar to that of 1811-12.

The liability issue should stimulate the building community to do what it can to protect itself from litigation. One key way involves the adoption and enforcement of appropriate seismic building codes. It is also apparent that many members of the building community have a strong enough sense of professional responsibility to recognize the need for seismic design and these individuals should be encouraged to communicate their knowledge and views to their peers.

The decision-makers need to familiarize themselves with the local materials market. They then need to try to objectively determine what effects new or improved seismic regulations will have on the current market situation and what the cost-benefit repercussions would be on the community at large.

A number of other forces can affect the seismic safety decision-making process. For example, in known seismic-risk areas, lenders are beginning to require seismic design and earthquake insurance as a condition for their financial support. Furthermore, many industrial and service organizations (e.g., Monsanto in the St. Louis area, Federal Express in the Memphis area, and Boeing in the Seattle area) already are beginning to require seismic protection in their facilities. It is becoming increasingly important to those businesses and organizations that rely on sophisticated electronic and computer equipment to avoid operational interruptions and shutdowns. To them, ensuring seismic resistance in their structures is a very small price to pay given what they would lose from a major disruption of their operations. Also, some buildings house priceless art or historic treasures that could never be replaced if the building collapsed; indeed, protecting such treasures might stimulate a community to adopt even more stringent seismic safety requirements that cover nonstructural as well as structural components. In short, there are many reasons for safeguarding a building, and these reasons continue to be acted on whether or not a community has seismic-resistant construction standards and whether or not those standards are enforced.

With respect to other potential effects, all of the possible outcomes are not yet known. Seismic-resistant design and construction are obviously already occurring with few, if any, adverse impacts in California, where they are required by a state-wide code, and even in areas without seismic code requirements. Therefore, it may be fair to assume that many of the changes that result from seismic-resistant design and construction will be abosrbed in time much in the same manner as other changes resulting from new technology.

INFORMATION SOURCES

- The regional earthquake consortia and information centers identified in Chapter 7 are valuable resources. Much can be learned from them concerning what is being done in various areas.

- The building community professional societies and the various materials organizations listed in Chapter 7 also can be sources of specific information useful to community decision-makers.

- Weber's paper in the selected readings volume presents information on the cost impact of the NEHRP Recommended Provisions.

The Association of Bay Area Governments (Berkeley, California) has published a variety of publications addressing liability:

Experiences and Perceptions of Local Governments on Earthquake Hazards (1978)

Legal References on Earthquake Hazards and Local Government Liability (1978)

Will Local Government Be Liable for Earthquake Losses? (1979)

Attorney's Guide to Earthquake Liability (1979)

Earthquake Hazards and Local Government Liability: Executive Summary (no date)

The following publications may also be helpful:

Huffman, J. L. 1982. Government Liability for Harm Resulting from Earthquake Prediction and Hazard Mitigation, A Preliminary Report on a Comparative Study. Portland, Oregon: Lewis and Clarke College Law School.

National Association of Attorneys General. 1979. Report of the Special Committee of the National Association of Attorneys General on Earthquake Prediction, Warnings, and Public Policy. Washington, D.C.: National Association of Attorneys General.