

BUILDING SEISMIC SAFETY COUNCIL

The Building Seismic Safety Council (BSSC) is an independent, voluntary body that was established under the auspices of the National Institute of Building Sciences (NIBS) in 1979 as a direct result of nationwide interest in the seismic safety of buildings. It has a membership of 57 organizations representing a wide variety of building community interests. Its fundamental purpose is to enhance public safety by providing a national forum that fosters improved seismic safety provisions for use by the building community in the planning, design, construction, regulation, and utilization of buildings. To fulfill its purpose, the BSSC:

1. Promotes the development of seismic safety provisions suitable for use throughout the United States;
2. Recommends, encourages, and promotes the adoption of appropriate seismic safety provisions in voluntary standards and model codes;
3. Assesses progress in the implementation of such provisions by federal, state, and local regulatory and construction agencies;
4. Identifies opportunities for improving seismic safety regulations and practices and encourages public and private organizations to effect such improvements;
5. Promotes the development of training and educational courses and materials for use by design professionals, builders, building regulatory officials, elected officials, industry representatives, other members of the building community, and the public;
6. Advises government bodies on their programs of research, development, and implementation; and
7. Periodically reviews and evaluates research findings, practices, and experience and makes recommendations for incorporation into seismic design practices.

The BSSC's area of interest encompasses all building-type structures and includes explicit consideration and assessment of the social, technical, administrative, political, legal, and economic implications of its deliberations and recommendations.

The BSSC believes that the achievement of its purpose is a concern shared by all in the public and private sectors; therefore, its activities are structured to provide all interested entities (e.g., government bodies at all levels, voluntary organizations, business, industry, the design profession, the construction industry, the research community, and the general public) with the opportunity to participate. The BSSC also believes that the regional and local differences in the nature and magnitude of potentially hazardous earthquake events require a flexible approach to seismic safety that allows for consideration of the relative risk, resources, and capabilities of each community.

The BSSC is committed to continued technical improvement of seismic design provisions, assessment of advances in engineering knowledge and design experience, and evaluation of earthquake impacts. It recognizes that appropriate earthquake hazard reduction measures and initiatives should be adopted by existing organizations and institutions and incorporated, whenever possible, into their legislation, regulations, practices, rules, codes, relief procedures, and loan requirements so that these measures and initiatives become an integral part of established activities, not additional burdens. The BSSC itself assumes no standards-making and -promulgating role; rather, it advocates that standards-formulation organizations consider BSSC recommendations for inclusion into their documents and standards.

**BSSC PROGRAM ON
IMPROVED SEISMIC SAFETY PROVISIONS**

**SOCIETAL IMPLICATIONS:
SELECTED READINGS**

Prepared for the
Federal Emergency Management Agency
by the
Building Seismic Safety Council
Committee on the Societal Implications
of Using New or Improved
Seismic Safety Design Provisions

BUILDING SEISMIC SAFETY COUNCIL
Washington, D.C.
1985

NOTICE: Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of the Federal Emergency Management Agency. Additionally, neither FEMA nor any of its employees make any warranty, expressed or implied, nor assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, product, or process included in this publication.

This report was prepared under Contract EMW-C-0903 between the Federal Emergency Management Agency and the National Institute of Building Sciences.

For further information regarding this document, contact the Executive Director, Building Seismic Safety Council, 1015 15th Street, N.W., Suite 700, Washington, D.C. 20005.

Reports in the series prepared by the Building Seismic Safety Council as part of its Program on Improved Seismic Safety Provisions include the following:

Societal Implications: A Community Handbook, 1985
Societal Implications: Selected Readings, 1985

Overview of Phases I and II, 1984
Appendixes to the Overview, 1984

NEHRP Recommended Provisions for the Development of Seismic Safety Provisions for New Buildings (draft version for ballot by the BSSC membership), 1984:
Part 1--Provisions,
Part 2--Commentary,
Appendix--Existing Buildings

Trial Designs, 1984:

Charleston Designs by Enwright Associates, Inc.,
Chicago Designs by Alfred Benesch and Company,
Chicago Designs by Klein and Hoffman, Inc. (Parts 1-4),
Ft. Worth Designs by Datum/Moore Partnership,
Los Angeles Designs by S. B. Barnes and Associates,
Los Angeles Designs by Johnson and Nielsen Associates,
Los Angeles Designs by Wheeler and Gray,
Memphis Designs by Allen and Hoshall,
Memphis Designs by Ellers, Oakley, Chester, and Rike, Inc.,
New York Designs by Weidlinger Associates (Parts 1-2),
New York Designs by Robertson, Fowler, and Associates,
Phoenix Designs by Magadini-Alagia Associates,
Phoenix Designs by Read Jones Christoffersen, Inc.,
Seattle Designs by ABAM Engineers, Inc.,
Seattle Designs by Bruce C. Olsen,
Seattle Designs by Skilling Ward Rogers Barkshire, Inc.,
St. Louis Designs by Theiss Engineers, Inc. (Parts 1-2)

Printed in the United States of America.

Chairman

Roy G. Johnston, Brandow and Johnston Associates, Los Angeles,
California*

Vice Chairman

W. Gene Corley, Portland Cement Association, Skokie, Illinois*

Secretary

Neal D. Houghton, Building Owners and Managers Association, Phoenix,
Arizona*

Members

Christopher W. Arnold, Building Systems Development, Inc., San Mateo,
California (representing the American Institute of Architects)
Thomas E. Brassell, American Institute of Timber Construction, Englewood,
Colorado (representing the National Forest Products Association)
Vincent R. Bush, International Conference of Building Officials, Whit-
tier, California (representing the Council of American Building
Officials)
William Campbell, Campbell Construction Company, Sacramento, California
(representing the Associated General Contractors of America)
Henry J. Degenkolb, H. J. Degenkolb Associates, San Francisco, California
(representing the American Society of Civil Engineers)
Gerald Jones, Code Administrator, Kansas City, Missouri (representing
the Building Officials and Code Administrators, International)
James E. Lapping, AFL-CIO Building and Construction Trades Department,
Washington, D.C.
Richard D. McConnell, Office of Construction, Veterans Administration,
Washington, D.C. (representing the Interagency Committee on Seismic
Safety in Construction)
William W. Moore, Dames and Moore, San Francisco, California (repre-
senting the Earthquake Engineering Research Institute)*
Charlene F. Sizemore, Consumer Representative, Huntington, West Virginia
(representing the National Institute of Building Sciences)
Ajit S. Virdee, Rumberger/Haines/Virdee and Associates, Sacramento,
California (representing the Structural Engineers Association of
California)
Alan H. Yorkdale, Brick Institute of America, Reston, Virginia

BSSC Staff

James R. Smith, Executive Director
Elaine Griffin, Secretary

*Member, BSSC Executive Committee.

BSSC COMMITTEE
ON THE SOCIETAL IMPLICATIONS
OF USING NEW OR IMPROVED
SEISMIC SAFETY DESIGN PROVISIONS

Chairman

Christopher W. Arnold, Building Systems Development, Inc., San Mateo,
California

Members

Warner Howe, Gardner and Howe Structural Engineers, Memphis, Tennessee
James E. Lapping, AFL-CIO Building and Construction Trades Department,
Washington, D.C.

Joseph J. Messersmith, Jr., Portland Cement Association, Rockville,
Virginia

Charlene Sizemore, Consumer Representative, Huntington, West Virginia

Consultants

Claret M. Heider, Technical Editor-Writer, Sterling, Virginia

Claire B. Rubin, Program of Policy Studies in Science and Technology,
George Washington University, Washington, D.C.

Stephen F. Weber, Center for Applied Mathematics, National Bureau of
Standards, Gaithersburg, Maryland

BSSC Staff

James R. Smith, Executive Director

Elaine Griffin, Secretary

PREFACE

This volume of selected readings is intended to accompany the volume Societal Implications: A Community Handbook, one of a series of publications prepared by the Building Seismic Safety Council (BSSC) under contract to the Federal Emergency Management Agency (FEMA). The objective of the handbook is simply to provide between two covers a synthesis of what is known about the most significant societal implications of adopting new or improved seismic regulations for new buildings in those communities across the land that are considering such a step. This accompanying volume of selected readings provides a sampling of more detailed information.

The handbook is a companion publication to the NEHRP (National Earthquake Hazards Reduction Program) Recommended Provisions for the Development of Seismic Regulations for New Buildings. Both are intended for voluntary use by interested parties in the nonfederal sector. Comments and suggestions for improvement of the handbook are earnestly solicited. Similar publications are scheduled for completion in the next several months.

FEMA is grateful to the BSSC Board of Direction and its Executive Director, to the BSSC committee members and consultants who prepared the handbook and assembled the selected readings, and to the many other volunteers whose contributions to and participation in the BSSC study have enriched the content of these publications. Similar acknowledgment is due the U.S. Geological Survey for the geotechnical information and the National Bureau of Standards for the structural engineering and cost information contained in the handbook as well as for their support at the four BSSC meetings with building process participants (in Charleston, South Carolina; Memphis, Tennessee; St. Louis, Missouri; and Seattle, Washington) during which many useful insights were obtained.

Federal Emergency Management Agency

This volume of selected readings and the handbook it accompanies have been developed to provide participants in the building process at the local, state, and regional levels with the information they need to adequately address the potential effects on their communities of using new or improved seismic safety design provisions in the development of regulations for new buildings. It represents one product of an ongoing program conducted by the Building Seismic Safety Council (BSSC) for the Federal Emergency Management Agency (FEMA). A brief description of this program is presented below so that readers of the handbook and these selected readings can approach their use with a fuller understanding of their purpose and limitations.

BSSC PROGRAM ON IMPROVED SEISMIC SAFETY PROVISIONS

The BSSC was established in 1979 as an independent, voluntary body with a membership of 57 organizations representing the full spectrum of building community interests. Its fundamental purpose is to enhance public safety by providing a national forum that fosters improved seismic safety provisions for use by the building community in the planning, design, construction, regulation, and utilization of buildings. The BSSC Program on Improved Seismic Safety Provisions is structured to assist FEMA in achieving national seismic safety goals.

Phases I and II

Phases I and II of the BSSC program have focused on new construction. During these phases Tentative Provisions for the Development of Seismic Regulations for Buildings, originally developed by the Applied Technology Council (ATC), were reviewed and revised (in cooperation with the National Bureau of Standards). To assess the economic impact, usability, and technical validity of the amended provisions, 17 design firms in 9 major cities,¹ where the seismic risk varies from high to low, were retained to prepare trial designs of the structural systems of various types of buildings. The trial design effort included 46 buildings and each was designed twice--once according to the amended ATC document and once according to the prevailing local code for the particular location of the design.

The amended ATC document was further revised in light of the results of these trial designs and in late 1984 was submitted by the BSSC for ballot

¹Charleston, South Carolina; Chicago, Illinois; Ft. Worth, Texas; Los Angeles, California; Memphis, Tennessee; New York, New York; Phoenix, Arizona; St. Louis, Missouri; and Seattle, Washington.

to its members (see inside back cover) as The NEHRP (National Earthquake Hazards Reduction Program) Recommended Provisions for the Development of Seismic Regulations for New Buildings.

Phase III

During Phase III of the BSSC program, modifications are being made as a result of this first ballot. The document that results, NEHRP Recommended Provisions--1984, will reflect the consensus approval of virtually all segments of the building community and its publication is expected in late 1985. Since the NEHRP Recommended Provisions document is to present the most up-to-date data and technology in the context of a rational, nationally applicable approach to seismic safety design, its continuous revision and the issuance of subsequent editions are to be expected.

The BSSC also has examined the societal implications that could be expected as a consequence of utilizing the NEHRP Recommended Provisions as a source document in the development of local regulations, especially in communities east of the Rocky Mountains that have, to date, been largely unconcerned about the seismic safety aspects of building design. The handbook and this accompanying volume of selected readings present the results of that study.

Related Efforts

In related efforts the BSSC is examining the likely impact of the NEHRP Recommended Provisions on building regulatory practices and is developing materials and plans for encouraging maximum use of the NEHRP Recommended Provisions. In a joint venture with the Applied Technology Council and the Earthquake Engineering Research Institute, the BSSC is also examining the issues involved in improving the seismic safety of existing buildings and critical facilities. Information on these subjects will be published separately.

SCOPE OF THE HANDBOOK

The potential societal impacts of using new or improved seismic safety design provisions in developing regulations for new buildings are varied and difficult to quantify definitively. Nevertheless, after meeting with building process participants and seismic safety experts and pooling the expertise of its members, the BSSC Committee on Societal Implications has identified a number of potential impacts that require community consideration. The emphasis is on new buildings, and existing facilities are discussed only to the extent that seismic safety provisions for new buildings affect them.

DEVELOPMENT OF THE HANDBOOK

To develop the needed information, the BSSC Societal Implications Committee attempted to identify the many principal concerns, issues, and problems connected with utilization of the NEHRP Recommended Provisions by meeting with building process participants in four selected areas:

- Charleston, South Carolina
- Memphis, Tennessee
- Seattle, Washington
- St. Louis, Missouri

Charleston and Seattle already enforce seismic safety provisions for new buildings while Memphis and St. Louis do not. Although these four communities have somewhat different physical, social, and economic characteristics and different degrees of seismic risk, they are representative of a broad range of seismic conditions and urban characteristics that exist in the United States.

The committee supplemented the information it gathered in the four communities with information from the literature and with the expertise and experience of its individual members so that it could present the users of the handbook with relatively authoritative, if not completely comprehensive, guidance.

CONTENT OF THE HANDBOOK AND THESE SELECTED READINGS

In the chapters included in the handbook:

- The potential impacts identified by the committee are described.
- Information sources and data bases that may be able to provide communities with general as well as specific information and guidance are listed.
- General terms related to earthquakes are defined and the modified Mercalli intensity (MMI) scale and the Richter magnitude scale are described.

In this accompanying volume of selected readings, the committee has assembled a series of papers that address various aspects of the seismic safety issue. A number of these papers were prepared specifically for the BSSC study and several were presented at the BSSC committee meetings with building process participants. Several other papers were originally presented at a 1984 FEMA workshop but were not published. One other paper was suggested for inclusion by a BSSC committee member. Included are:

- An estimate of the impact of the NEHRP Recommended Provisions on design and construction costs developed for the BSSC study

"Cost Impact of the NEHRP Recommended Provisions on the Design and Construction of Buildings", by Stephen F. Weber, National Bureau of Standards

- Descriptions of the seismic hazard in various areas of the United States developed for the BSSC study
 - "Earthquake at Charleston in 1886" by G. A. Bollinger, Virginia Polytechnic Institute and State University
 - "Earthquake Hazards in the Memphis, Tennessee, Area" by Arch C. Johnston and Susan J. Nava, Tennessee Earthquake Information Center
 - "Evaluation of the Earthquake Ground-Shaking Hazard for Earthquake Resistant Design" by Walter W. Hays, U.S. Geological Survey
 - "Introduction to Seismological Concepts Related to Earthquake Hazards in the Pacific Northwest" by Stewart W. Smith, University of Washington
 - "Nature of the Earthquake Threat in St. Louis" by Otto W. Nuttli, St. Louis University
- Explanations of seismic safety codes
 - "Development of Seismic Safety Codes" by Robert M. Dillon, American Council for Construction Education
 - "The Purpose and Effects of Earthquake Codes" by Theodore C. Zsutty, San Jose State University, and Haresh C. Shah, Stanford University
- Descriptions of current seismic hazard mitigation practices and programs
 - "Current Practices in Earthquake Preparedness and Mitigation for Critical Facilities" by James E. Beavers, Martin Marietta Energy Systems, Inc.
 - "Management of Earthquake Safety Programs by State and Local Governments," by Delbert B. Ward, Structural Facilities, Inc.
- A description of recent seismic safety policy research developed for the BSSC study
 - "Summary of Recent Research on Local Public Policy and Seismic Safety Mitigation" by Claire B. Rubin, George Washington University
- A summary of the BSSC committee meetings with building process participants in Charleston, Memphis, St. Louis, and Seattle
- A relatively extensive set of references to serve as the basis for more detailed research

- The list of information sources and the glossary of terms that also appear as Chapters 7 and 8 of the handbook

Although the readings presented herein are far from comprehensive, they are intended to give the handbook user some idea of the sorts of information that are available. In addition, the set of references and the list of information sources, which are included in both the handbook and the selected readings volume, will give interested readers some guidance about what to look for and where to find it when they pursue topics of special interest.

ACKNOWLEDGMENTS

The BSSC and its Committee on Societal Implications is grateful to the many individuals who contributed to this project. The committee is especially grateful to the building process participants in Charleston, Memphis, St. Louis, and Seattle who attended its meetings and so articulately identified issues for committee attention. Special thanks go to those who spoke at and/or developed presentations for the committee's meetings: in Charleston, Charles Lindbergh of the South Carolina Seismic Safety Commission, G. A. Bollinger of Virginia Polytechnic Institute and State University, and Joyce B. Bagwell, of Baptist College; in Memphis, Warner Howe of Gardner and Howe Structural Engineers and Arch Johnston and Susan Nava of the Tennessee Earthquake Information Center; in St. Louis, Otto Nuttli of St. Louis University and John Theiss of Theiss Engineers, Inc.; and in Seattle, Bruce Olson, Consulting Engineer, and Stewart Smith of the University of Washington. The committee also wishes to thank Stephen Weber of the National Bureau of Standards for conducting an economic analysis of the cost impact of the NEHRP Recommended Provisions and for presenting a summary of his findings at each of the four meetings. Walter Hays of the U.S. Geological Survey deserves special recognition for arranging for the speakers and for preparing a special background paper for their use. Finally, the committee wishes to acknowledge the contribution of its consultants and the other authors who graciously allowed their work to be included in the selected readings volume.

REQUEST FOR FEEDBACK

Because every community is unique in some way, FEMA and the BSSC urge those using the handbook and these accompanying readings to provide feedback on their experiences. If the handbook is to serve its purpose as one means for providing up-to-date, experience-based seismic design information, reports from its users are essential.

A "Feedback Sheet" is included at the back of both the reports to make the response process easier and to permit users to request additional information. Every attempt will be made to integrate what is learned into future publications and to inform those who respond about the experiences of other communities and about subsequent BSSC and FEMA efforts.

TABLE OF CONTENTS

COST IMPACT OF THE NEHRP RECOMMENDED PROVISIONS ON THE DESIGN AND CONSTRUCTION OF NEW BUILDINGS	
Stephen F. Weber.....	1-1
CURRENT PRACTICES IN EARTHQUAKE PREPAREDNESS AND MITIGATION FOR CRITICAL FACILITIES	
James E. Beavers.....	2-1
DEVELOPMENT OF SEISMIC SAFETY CODES	
Robert M. Dillon.....	3-1
EARTHQUAKE AT CHARLESTON IN 1886	
G. A. Bollinger.....	4-1
EARTHQUAKE HAZARD IN THE MEMPHIS, TENNESSEE, AREA	
Arch C. Johnson and Susan J. Nava.....	5-1
EVALUATION OF THE EARTHQUAKE GROUND-SHAKING HAZARD FOR EARTHQUAKE RESISTANT DESIGN	
Walter W. Hays.....	6-1
INTRODUCTION TO SEISMOLOGICAL CONCEPTS RELATED TO EARTHQUAKE HAZARDS IN THE PACIFIC NORTHWEST	
Stewart W. Smith.....	7-1
MANAGEMENT OF EARTHQUAKE SAFETY PROGRAMS BY STATE AND LOCAL GOVERNMENTS	
Delbert B. Ward.....	8-1
NATURE OF THE EARTHQUAKE THREAT IN ST. LOUIS	
Otto W. Nuttli.....	9-1
THE PURPOSE AND EFFECTS OF EARTHQUAKE CODES	
Theodore C. Zsutty and Hareesh C. Shah.....	10-1
SUMMARY OF RECENT RESEARCH ON LOCAL PUBLIC POLICY AND SEISMIC SAFETY MITIGATION	
Claire B. Rubin.....	11-1

APPENDIXES

A. SUMMARIES OF THE BSSC MEETINGS IN CHARLESTON, MEMPHIS, ST. LOUIS, AND SEATTLE	A-1
B. GLOSSARY.....	B-1
C. SEISMIC SAFETY INFORMATION SOURCES.....	C-1
D. SELECTED SEISMIC SAFETY REFERENCES.....	D-1

SOCIETAL IMPLICATIONS FEEDBACK SHEET