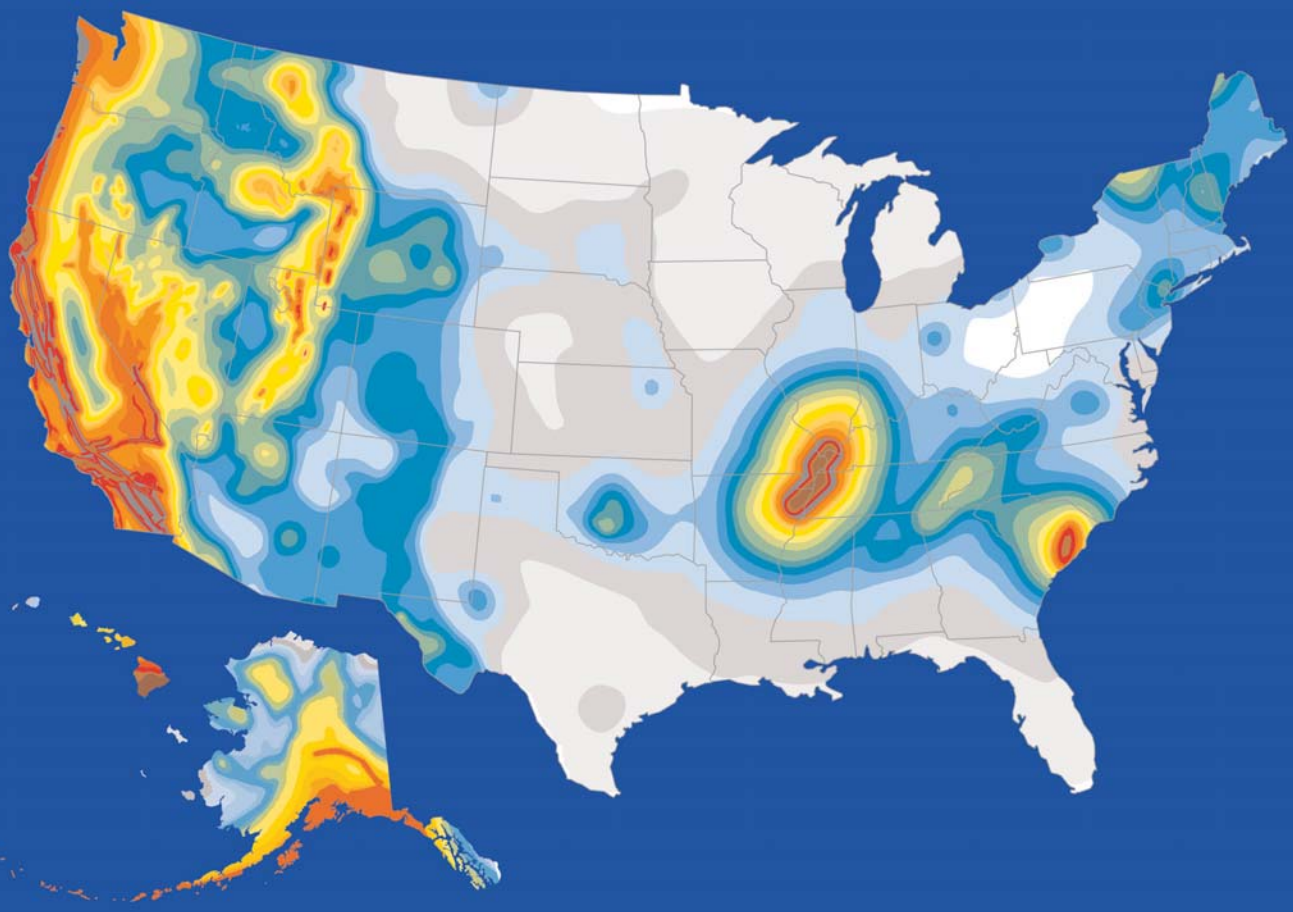


The National Earthquake Hazards Reduction Program

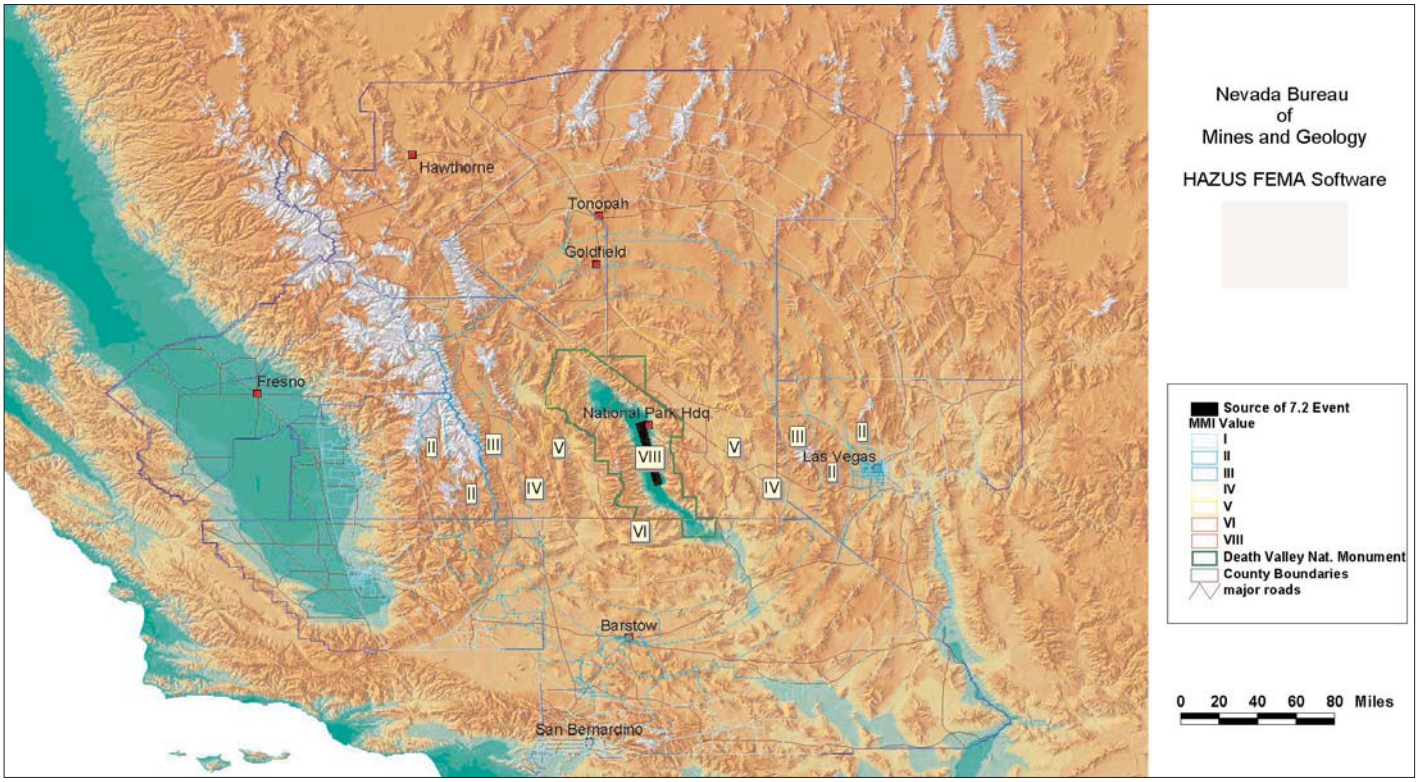
Report to Congress for Fiscal Year 2003 and 2004

January 2005

FEMA

Cover:
National Seismic Hazard 2003 .2 seconds map
(USGS)

Contents



Nevada State Mapping Advisory Committee (NBMG) utilized HAZUS to produced an earthquake scenario for the Death Valley Region and worked with FEMA HAZUS to update the Nevada portion of the earthquake fault database that is part of HAZUS.

Executive Summary

In 1977, Congress passed the Earthquake Hazards Reduction Act (Public Law 95-124), establishing the National Earthquake Hazards Reduction Program (NEHRP), a long-term, national program to reduce the risks to life and property in the United States from earthquakes. The NEHRP agencies, which are described below, work separately and in cooperation with each other and other federal and state agencies, the private sector, universities, and regional, voluntary, and professional organizations to improve the Nation's understanding of earthquake hazards, prepare for earthquakes, and develop knowledge on best practices to reduce earthquake damage.

The Earthquake Hazards Reduction Act of 1977 requires that the Director of the Federal Emergency Management Agency (FEMA) shall:

> "prepare, in conjunction with other Program agencies, a biennial report, to be submitted to the Congress within 90 days after the end of each even-numbered fiscal year, which shall describe the activities and achievements of the Program during the preceding two fiscal years."[1]

This report describes the progress of the NEHRP agencies and their partners in Fiscal Year (FY) 2003 and 2004 in mitigating earthquake losses through basic and directed research and implementation activities in the fields of earthquake science and engineering. The progress described in this report is organized according to the four goals of the *Strategic Plan for the NEHRP for 2001-2005, Expanding and Using Knowledge To Reduce Earthquake Losses* (*Strategic Plan*). The four goals represent the continuum of activities undertaken by the NEHRP agencies, ranging from research and development to application and implementation. The activities form a complementary program that has the ultimate aim of reducing earthquake losses across the Nation.

The foundation of the NEHRP is research, which underpins nearly all of activities of the NEHRP agencies and partners. The basic research supported and conducted by the National Science Foundation (NSF) and the U.S. Geological Survey (USGS) extends across a number of earthquake-related

[1] Beginning in FY 2005, NIST, which has become the lead agency for the NEHRP, will be responsible for submitting an annual report to the Congress on NEHRP activities, as required by the Earthquake Hazards Reduction Authorization Act of 2004, Public Law 108-360, enacted on October 25, 2004.

disciplines, including earthquake engineering, seismology, geology, and the social sciences. The knowledge gained by basic research is used by the National Institute of Standards and Technology (NIST) to help industry adopt and use innovative technologies through problem-focused research and development. FEMA synthesizes NIST and USGS applied research results into useable loss-reduction tools and methods, and uses research results to guide policy and practice into seismic risk reduction.

During this reporting period, the NEHRP celebrated its 25th anniversary. Some of the achievements of the NEHRP over the last 25 years, such as the survival of the Trans-Alaska oil pipeline during the 2002 Denali earthquake, are based on earth science and earthquake engineering research. Mitigation and outreach efforts have resulted in safer homes, schools, and businesses in communities such as Los Angeles and Seattle. All of the accomplishments share common features: science and engineering drive the effort, partnerships are established to achieve results, and the public benefits from the synergy. Two notable domestic earthquakes that occurred during this reporting period illustrate the benefits of the NEHRP in reducing earthquake losses.

The magnitude 7.9 Denali earthquake rocked Alaska on November 3, 2002. This was one of the largest recorded earthquakes in our Nation's history, causing countless landslides and road closures, but minimal structural damage and amazingly few injuries and no deaths. Although the remote location of the earthquake helped ensure that it was not more devastating, advanced seismic monitoring from the USGS and NEHRP partners, long-term research, and a commitment to earthquake preparedness and mitigation played key roles.

The magnitude 6.5 San Simeon earthquake occurred on December 22, 2003, with an epicenter near the Pacific coast in central California. While it did not rupture the surface, the earthquake triggered landslides and caused strong shaking. The worst damage occurred in Paso Robles, 24 miles southeast of the epicenter, where numerous older buildings were damaged and one building collapsed, killing two people. Significant liquefaction also damaged housing and buried utilities in Oceano, nearly 50 miles away. In response to the San Simeon earthquake, the USGS produced a ShakeMap within 9 minutes of the event. The ShakeMap served as the basis for loss estimation by the California Office of Emergency Services using HAZUS, or Hazards U.S., within 1 hour.

One of the most successful risk assessment tools is HAZUS, a cutting edge software program developed by FEMA with the National Institute of Building Sciences (NIBS). In the 7 years since FEMA published the prototype earthquake edition HAZUS97, HAZUS has helped communities across the United States identify and plan for earthquakes by giving them access, free of charge, to specialized databases and GIS-based analytic tools. HAZUS-MH (HAZUS Multihazard) for earthquakes streamlines modeling by merging up-to-date natural hazards engineering and science with a powerful geographic information system. Users can estimate damage and other earthquake effects and then map, display, and manage the results. With the completion of HAZUS-MH in February 2004, FEMA has improved seismic hazard identification and risk assessment methods with the implementation of the fifth version of its nationally applicable earthquake hazard model.

During this reporting period, the NIST continued to conduct problem-focused research and development designed to improve building codes, standards, and practices. In 2003, NIST, in cooperation with the Applied Technology Council (ATC), completed and published an action plan, *The Missing Piece: Improving Seismic Design and Construction Practices (ATC-57)*. The action plan identifies industry priorities in two areas: (1) support of the seismic code development process through technical assistance and development of the technical basis for performance standards; and (2) improved seismic design productivity through the development of tools for the evaluation of advanced technologies and practices. NIST is now looking forward to working with the stakeholder community to explore ways to best meet those needs via a public-private partnership. NIST also expects that this effort will build on NSF-funded basic research, including research conducted as part of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES).

The George E. Brown, Jr. NEES project was initiated by NSF and the earthquake engineering community in response to a congressional mandate (NEHRP Reauthorization Act of 1994) to take stock of the Nation's experimental and testing capabilities in earthquake engineering. NEES will operate from October 1, 2004, through September 30, 2014, and will be managed by the nonprofit NEES Consortium, Inc., which will allocate research time at equipment sites; lead training, education, and outreach activities; and establish ties with U.S. and international partners. The NEES will upgrade, modernize, expand, and network major facilities, including:

- Shake tables used for earthquake simulations
- Geotechnical centrifuges for testing soils and foundations under earthquake loading
- Tsunami wave basin for earthquake simulations
- Large-scale experimentation systems, *e.g.*, reaction wall and modular simulation equipment
- Field monitoring and testing facilities

NEES will lead to a new era of collaboration in earthquake engineering research. Teams of experts in the United States and around the world will have the unprecedented opportunity to jointly plan, conduct, and analyze the results of experiments and models. Easy access to the Network's resources will facilitate broad participation, both informally and through official partnerships, by many communities of users, including researchers, educators, students, engineers, government agencies, professional organizations, industry, and disaster preparedness and response teams. NEES ushers in a new generation of earthquake engineering research. Enhanced understanding of earthquakes and seismic performance made possible by the Network's people, ideas, and tools will lead to innovative, cost-effective measures for better protecting the vast network of facilities and services on which everyone depends.

From these accomplishments and others described in this report, it is apparent that the NEHRP agencies and their partners have made a significant impact on the Nation's earthquake loss-reduction activities in FY 2003 and 2004. Although there are challenges ahead for everyone in the disaster community, the NEHRP is well positioned to both continue as a strong, self-sustaining program and successfully evolve as a key component of the new national infrastructure protection scheme. This report highlights a cross-section of achievements from the NEHRP agencies and their partners that illustrate just some of the many benefits the NEHRP has brought to the public during the past 2 years. By building on these and other achievements, the future holds great promise for protecting our country from earthquakes and other hazards.

Northridge Earthquake, CA, January 17, 1994 — FEMA and local agencies provide a variety of emergency services to the disaster stricken area. Approximately 114,000 residential and commercial structures were damaged and 72 deaths were attributed to the earthquake. Damage costs were estimated at $25 billion. (FEMA News Photo)

I. Introduction

The National Earthquake Hazards Reduction Program

Earthquakes represent the largest single potential source for casualties and damage from a natural hazard in the United States. Although damaging earthquakes occur infrequently, they strike without warning, resulting in catastrophic consequences. The 1994 Northridge, California earthquake, for example, resulted in over 60 deaths, more than 5,000 injuries, and over 25,000 people left homeless. Direct economic losses from the Northridge earthquake are estimated at over $20 billion.

The Northridge earthquake, however, was not even a great earthquake. It was a large (magnitude 6.7) earthquake of relatively short duration (the main shock lasting roughly 15 seconds) that occurred along the fringe of a major metropolitan area and struck during off-hours when impact was reduced. By contrast, the 1906 San Francisco earthquake was estimated as a magnitude 8.3 event, lasting 45 seconds. The largest recorded earthquake in the United States was a magnitude 9.2 event, lasting 3 minutes, that struck Prince William Sound, Alaska on Good Friday, March 28, 1964. Large events such as these can be expected in the United States, and they may not be confined solely to the West Coast region. Two of the most severe earthquakes in U.S. history occurred east of the Rockies: one in Charleston, South Carolina, in 1886 and the other a series of three shocks centered near New Madrid, Missouri, in 1811-12. Measuring an estimated 7.5-7.7 (near magnitude measure), the largest of the New Madrid earthquake series sent shock waves as far west as the Rocky Mountains and as far east as Washington, D.C. and Boston.

Although earthquakes cannot be prevented, their impact on life and property can be managed to a large degree. To that end, the National Earthquake Hazards Reduction Program (NEHRP), which is authorized by the Earthquake Hazards Reduction Act of 1977 (Public Law 95-124), as amended, seeks to mitigate earthquake losses in the United States through both basic and directed research and implementation activities in the fields of earthquake science and engineering.

The NEHRP agencies are the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST); the National Science Foundation (NSF); and the U.S. Geological Survey (USGS). These agencies work together to: improve understanding, characterization, and assessment of hazards and vulnerabilities; improve model building codes and land use practices; reduce risks through post-earthquake investigations and education; improve design

and construction techniques; improve the capacity of government at all levels and of the private sector to reduce and manage earthquake risk; and accelerate application of research results. The role of each of the NEHRP agencies is summarized below.

The NEHRP Agencies

Federal Emergency Management Agency

In Fiscal Year (FY) 2003 and 2004, FEMA had primary responsibility for leading, planning, and coordinating the overall NEHRP effort. The programmatic responsibilities of FEMA include the following:

- Works closely with national standards and model building code organizations, in conjunction with NIST, to promote the implementation of research results
- Promotes better building practices within the building design and construction industry, including architects, engineers, contractors, builders, and inspectors
- Assists in the preparation and dissemination of seismic resistant design guidance and related information on building codes, standards, and practices for new and existing buildings, structures, and lifelines, and the development of performance-based design guidelines
- Provides grants and assistance to enable states to develop mitigation, preparedness, and response plans, and encourages the development of multi-state groups
- Supports state and local governments by providing multi-hazard loss estimation capability for use in planning and response
- Translates research results into technical publications

National Institute of Standards and Technology

The NIST conducts problem-focused research and development to improve building codes, standards, and practices, including the following:

- Promotes better building practices among architects and engineers
- Works with national standards organizations to develop improved seismic standards for new and existing lifelines
- Chairs and provides the secretariat for the Interagency Committee on Seismic Safety in Construction (ICSSC), which recommends practices and policies to reduce earthquake hazards in federally owned, leased, assisted, and regulated facilities

The 1906 San Francisco earthquake.

National Science Foundation

The NSF funds research on earth sciences to improve the understanding of the causes and behavior of earthquakes, on earthquake engineering, and on human response to earthquakes. The activities of the NSF include the following:

- Encourages prompt dissemination of significant findings, sharing of data, samples, physical collections, and other supporting materials, and development of intellectual property so research results can be used by appropriate organizations to mitigate earthquake damage
- Supports individual investigators and university research consortia and centers for research in geosciences and in earthquake engineering
- Works closely with the USGS to identify geographic regions of national concern that should be the focus of targeted solicitations for earthquake-related research proposals
- Supports research that improves the safety and performance of buildings, structures, and lifeline systems using large-scale experimental and computational facilities of the George E. Brown Jr. Network for Earthquake Engineering Simulation (NEES) and other institutions engaged in research and the implementation of the NEHRP

U.S. Geological Survey

The USGS conducts and supports earth science research that increases knowledge about the origins and effects of earthquakes, including the following:

- Develops national and regional seismic hazard maps
- Conducts engineering seismology studies of the ground-shaking phenomenon
- Develops standardized procedures for predicting earthquakes

- Supports an external cooperative grants research program
- Operates national seismograph networks

The NEHRP Partners

Many NEHRP accomplishments result from the coordination and interaction among the four NEHRP agencies and with public and private sector partners. For example, 28 federal agencies and departments are members of the ICSSC, which recommends uniform practices and policies to reduce earthquake risk at federal facilities. The states, private sector, universities, and regional, voluntary, and professional organizations also contribute significantly to earthquake risk-reduction efforts.

The multi-state regional organizations supported by the NEHRP agencies are listed below.

- Cascadia Region Earthquake Workgroup (CREW)
- Central United States Earthquake Consortium (CUSEC)
- Northeast States Emergency Consortium (NESEC)
- Western States Seismic Policy Council (WSSPC)

There also are a number of organizations involved in earthquake risk reduction activities that range from engineering-based professional organizations, private sector organizations, universities, and building code organizations to organizations supported by one or more of the four NEHRP agencies, such as the earthquake engineering centers (EERCs) that were established by the NSF in 1997. Some of the organizations supported by the NEHRP agencies are listed below.

- Disasters Roundtable of the National Academies
- Earthquake Engineering Research Institute (EERI)
- Multidisciplinary Center for Earthquake Engineering Research (MCEER)
- Mid-America Earthquake (MAE) Center
- Pacific Earthquake Engineering Research (PEER) Center
- Southern California Earthquake Center (SCEC)
- Natural Hazards Research and Applications Information Center (NHRAIC)

Scope of This Report

This report responds to the congressional requirement to report on the status of earthquake loss-reduction activities for FY 2003 and 2004. The activities of the four NEHRP agencies, federal agencies, state and local governments, and the private sector, universities, and regional, voluntary, and professional organizations listed above are described to illustrate the nationwide scope of NEHRP's impact. This report is organized by the four NEHRP goals, which are the foundation upon which NEHRP strives to reduce earthquake losses.

Goal A: Develop effective practices and policies for earthquake loss reduction and accelerate their implementation. This goal addresses the spectrum of activities that result directly and indirectly in the reduction of earthquake losses. Among these activities are: developing and promoting incentives for mitigation action; facilitating seismic building code adoption, implementation, and enforcement; and providing technical assistance for developing and using loss-reduction measures. Goal A activities are designed to ensure that information about methods to reduce vulnerability is provided to policymakers, building professionals, and the public.

Goal B: Improve techniques to reduce seismic vulnerability of facilities and systems. This goal includes the development and distribution of tools to guide design and construction practices as well as improvements in the use of new technology, applied research, and problem-focused studies.

Goal C: Improve seismic hazard identification and risk assessment methods and their use. This goal addresses the development and dissemination of products that characterize earthquake-related hazards and vulnerability to accurately measure seismic risk. Included are mapping of ground motion, modeling earthquake effects based on the maps, data collection (geophysical and structures inventory), applying risk assessment modeling to local communities, and operating earthquake information centers.

Goal D: Improve the understanding of earthquakes and their effects. This goal supports research in the science of earthquakes and associated hazards to advance earth science, engineering, and social and economic knowledge. Much of this research is accomplished through earthquake monitoring, post-earthquake investigations, and experimental earthquake engineering research facilities.

This report also includes a progress report on the seismic safety of federal buildings that is required by Executive Orders 12699 and 12941.

FEMA's NEHRP web site home page (www.fema.gov/hazards/earthquakes/nehrp).

II. Achieving the Goals of the NEHRP

The four National Earthquake Hazards Reduction Program (NEHRP) agencies work in close coordination to improve the Nation's understanding of earthquake hazards and to mitigate their effects. The missions of the four agencies are complementary. The Federal Emergency Management Agency (FEMA), which is now a component of the U.S. Department of Homeland Security (DHS), works with the states, local governments, and the public to develop tools and improve policies and practices that reduce earthquake losses. The National Institute of Standards and Technology (NIST) enables technology innovation in earthquake engineering by working with industry to remove technical barriers, evaluate advanced technologies, and develop the measurement and prediction tools underpinning performance standards for buildings and lifelines. The National Science Foundation (NSF) strives to advance fundamental knowledge in earthquake engineering, earth science processes, and societal preparedness and response to earthquakes. The U.S. Geological Survey (USGS) monitors earthquakes, assesses seismic hazard for the Nation, and researches the basic earth science processes controlling earthquake occurrence and effects.

In March 2003, the NEHRP agencies submitted to the Congress the *Strategic Plan for the NEHRP for 2001-2005, Expanding and Using Knowledge To Reduce Earthquake Losses* (*Strategic Plan*). The Strategic Plan serves as the operational plan for the NEHRP agencies and guides federal earthquake research, loss reduction, and mitigation efforts in the United States. The Strategic Plan articulates the mission and the four primary goals of the NEHRP, provides a framework for priority-setting and coordinating activities, and defines priority areas for the future. The activities of the NEHRP agencies and partners in Fiscal Year (FY) 2003 and 2004 are described below under the four primary goals of the NEHRP, as set forth in the Strategic Plan.

NEHRP Accomplishments: Goal A

Through Goal A of the Strategic Plan, the NEHRP seeks to reduce the seismic vulnerability of the built and social environment by disseminating earthquake hazard and risk information and advocating risk reduction techniques. The activities identified under Goal A are designed to accelerate earthquake loss reduction in the public and private sector by engaging and supporting partners at the local, state, and national levels.

Goal A: Develop effective practices and policies for earthquake loss reduction and accelerate their implementation

1: Develop and provide information on earthquake hazards and loss-reduction measures to decision-makers and the public.

2: Promote incentives for public and private sector loss-reduction actions.

3: Advocate state and local government practices and policies that reduce losses in the private sectors.

4: Implement policies and practices that reduce vulnerability of federal facilities.

5: Develop the Nation's human resource base in the earthquake field.

The NEHRP Agencies

Federal Emergency Management Agency

As the lead agency for the NEHRP in FY 2003 and 2004, FEMA had primary responsibility for planning and coordinating the Program, including leadership of the NEHRP Interagency Coordinating Committee (ICC); strategic planning for the NEHRP; organizing and implementing forums, such as conferences and workshops for stakeholders in the earthquake community; implementing interagency agreements with agencies involved in seismic safety activities; and public outreach and awareness.

The ICC, which was chaired by FEMA in FY 2003 and 2004, met on a quarterly basis to discuss the interagency coordination of projects, programs, plans, budgets, and operational NEHRP issues. The periodic meetings of the ICC provided the forum for discussing common activities, exploring crosscutting issues, collaborating on joint projects, identifying and resolving conflicts, and seeking interagency support and cooperation. As needed, Subcommittees were established by the ICC for specific projects, such as the establishment of performance measures for the NEHRP.

The Strategic Plan discusses the need to develop a performance plan for the NEHRP, including the development of performance indicators or measures. For many public sector organizations, implementing performance measurement practices is a challenge because of the difficulty inherent in measuring outcomes. The NEHRP faces this challenge because earthquakes occur infrequently and it is difficult to directly measure how earthquake mitigation activities contribute to dollar losses avoided and a reduction in casualties. An additional challenge to establishing performance measures for the NEHRP is the different missions, goals, and budgets of the four NEHRP agencies.

In FY 2003, FEMA initiated a project to develop a performance management plan that includes a refined set of performance measures for the NEHRP and a framework for tracking, managing, maintaining, and reporting on the performance of the NEHRP. When completed, the performance management plan will assist the NEHRP lead agency with coordination and planning and will assist the other three NEHRP agencies with their responsibilities by enabling them to monitor, improve, and report on program performance at the agency level. The project work to establish performance measures for the NEHRP is being guided by the ICC Subcommittee on Performance Measures, which was established in FY 2004. The performance measures for the NEHRP and the performance management plan will be completed by September 2005.

The primary ongoing responsibilities of FEMA under the NEHRP fall under Goal A and Goal C of the Strategic Plan. The NEHRP is structured such that efforts culminate in the generation of a large range of products that address earthquake hazards, document the associated seismic risk, and provide loss-reduction alternatives. These products, which are generated under Goal A, are largely the outgrowth of activities under Goals B through D of the Strategic Plan. Successful mitigation requires that the products be understood, distributed, accepted, and used, and that a broad base of earthquake-aware individuals be developed and nurtured at all levels. FEMA's responsibility for implementing risk reduction was carried out through activities to develop and distribute earthquake mitigation tools and products so that they can be used effectively. Web sites, publications, press releases, and conferences were some of the means of marketing earthquake mitigation.

In FY 2004, FEMA began work on a publications marketing, outreach, and distribution strategy for the NEHRP. The purpose of the project is to evaluate available information on NEHRP publications and outreach efforts and to identify marketing and further implementation concepts. The marketing strategy, which incorporates a market analysis, audience analysis, evaluation of product quality and distribution, and a strategic market plan, will assist FEMA and the NEHRP agencies to effectively allocate resources to increase the usefulness of NEHRP publications and tools to a wider audience. The marketing strategy also is designed to improve communication and distribution activities to meet the overall NERHP goal of managing the impacts of earthquakes so that loss of life and property are reduced.

In FY 2004, FEMA designed a new web page for the NEHRP that includes sections designed to inform the public and private sector of ongoing activities in earthquake mitigation

by all of the NEHRP agencies and partners. The new web site (www.fema.gov/hazards/earthquakes/nehrp) includes: general information on earthquakes and the NEHRP; NEHRP success stories and community and homeowner success stories; news and events, including press releases and articles and information on upcoming meetings and conferences; FEMA for Kids; links to related earthquake sites; a directory of state earthquake resources; information on Hazards U.S. (HAZUS), the FEMA Geographic Information System (GIS)-based loss estimation software tool; seismic safety for buildings; and frequently asked questions. FEMA also is in the process of making NEHRP technical and non-technical publications accessible in PDF format and text versions on the web site. To facilitate this process, FEMA held a focus group at this year's National Earthquake Conference to gather feedback from a representative cross-sample of participants on the best way to present the publications online.

During this reporting period, FEMA also developed the NEHRP Earthquake Coordinators web site (www.training.fema.gov/emiweb/EarthQuake/welcome.htm). This web site provides state and federal NEHRP Earthquake Coordinators with a training course on earthquake basics, hazards, risks, building science, advocacy and partnerships, and priorities and successful activities.

FEMA also produced numerous products in FY 2003 and 2004 in support of the mission and goals of the Strategic Plan. Among these products are: brochures that highlight the achievements of the NEHRP agencies and partners and brochures that focus on a specific mitigation area, such as retrofit options for homeowners; exhibits for earthquake conferences; PowerPoint presentations for FEMA Mitigation Division staff and other organizations on the activities of the NEHRP; and press releases.

In 2003, FEMA coordinated the activities in celebration of the 25th anniversary of the NEHRP and produced a brochure on the achievements and initiatives of the four NEHRP agencies over the past 25 years that have contributed to making our communities and citizens safer from the effects of earthquakes. The brochure includes a cross-section of selected success stories from the NEHRP agencies that illustrate just some of the many benefits that the NEHRP has brought to the public since its inception. The brochure was distributed at an event commemorating the anniversary at the National Academy of Sciences (NAS) in March 2003.

The National Earthquake Conference, which was funded jointly by FEMA and the USGS, was held in St. Louis, Missouri, on September 26-30, 2004. The four regional earthquake consortia hosted the Conference, which was unique in bringing together the private sector, utilities, non-profit organizations, academics, and as well as scientists, emergency managers, and transportation officials from all levels of government. The discussions were informative and forthright, and sessions provided the private sector and others with examples of success stories in earthquake mitigation that they could take back to their organizations.

In FY 2003, FEMA administered NEHRP's contribution of Emergency Management Performance Grant (EMPG) funds to the State Offices of Emergency Services. (In FY 2004, the administration of the EMPG funds was transferred to the DHS Office of Disaster Preparedness.) The EMPG funding was in addition to the Hazard Mitigation Grant Program (HMGP), which is separate funding after a presidential disaster declaration. NEHRP-related activities conducted by the states with EMPG funds and HMGP funds are described below under the appropriate NEHRP goals.

FEMA's NEHRP Earthquake Coordinators web site (www.training.fema.gov/emiweb/EarthQuake/welcome.htm).

The Multihazard Mitigation Council (MMC) of the National Institute of Building Sciences (NIBS) has been responsible for organizing and conducting the Multihazard Building Design Summer Institute (MBDSI) at FEMA's Emergency Management Institute (EMI) since late 2000. Two sets of 1-week courses were offered to college and university undergraduate structural engineering professors. In 2003 and 2004, a course entitled "Topics in Performance-Based Earthquake Engineering" was offered. A more basic earthquake-resistant design course based on the *NEHRP Recommended Provisions for Seismic Regulations for New Building and Other Structures* was offered in earlier years.

In FY 2003 and 2004, the FEMA Regions continued to support the implementation of effective practices and policies for earthquake loss reduction through support to state earthquake and mitigation programs, promoting the use of HAZUS and NEHRP publications through outreach to various audiences, including professional organizations, emergency managers, and businesses. The FEMA Regions also encouraged mitigation, earthquake awareness and preparedness, and the development of better response and recovery capabilities through exercises. FEMA staff provided support to the earthquake safety exercises of the Central United States Earthquake Consortium (CUSEC) and to the Fifth Army using New Madrid earthquake scenarios in 2003 and 2004, and in Kansas to the United States Army Corps of Engineers (USACE) Tuttle Creek Dam Safety Exercise 2004 that used an earthquake on the Nemaha Fault.

National Institute of Standards and Technology

NIST chairs and provides the Technical Secretariat for the Interagency Committee on Seismic Safety in Construction (ICSSC). The ICSSC is composed of representatives of 32 federal agencies and acts as an advisory body to FEMA and other government agencies on issues of seismic safety. The ICSSC provides consistent standards for seismic safety of federal buildings and establishes consistent guidance on evaluation and mitigation of seismic risks in existing buildings. The ICSSC helps to establish federal agency leadership in ensuring the seismic safety of buildings and lifeline systems. Recent accomplishments of the ICSSC are described below.

- A comparison of the current model building codes (2003 International Building Code (IBC), 2003 International Residential Code (IRC), and 2003 National Fire Protection Association (NFPA) 5000) and American Society of Civil Engineers (ASCE) 7-02 to the 2000 NEHRP Recommended Provisions has been completed. The ICSSC will issue guidance on the use of these codes, based on the findings of the code comparison, to the federal agencies in early 2005.

- ICSSC Subcommittee 2 has developed and implemented a process for development of guidance to federal agencies on seismic safety of lifeline systems. Using this process, Subcommittee 2 has completed a draft report on seismic safety of electric power production and distribution systems. The draft report documents guidance currently used by federal agencies with the responsibility for the construction and operation of such systems, gaps where research is needed to develop guidance for evaluation, and recommendations for use by federal agency owner operators to evaluate and mitigate seismic risks in these systems. The final report, following approval of the ICSSC, will be published in 2005. Subcommittee 2 is planning to undertake a similar effort for water and wastewater systems following completion of the report on electric power production and distribution systems.

- In cooperation with ICSSC member agencies, NIST is carrying out a project to develop a handbook for seismic rehabilitation of existing buildings. NIST has established a searchable database of relevant research conducted since 1990 and has used the database to identify rehabilitation techniques for inclusion in the handbook. The handbook will address 17 standard building types and foundations and is consistent with the *Standard for Evaluation of Seismic Risks in Existing Buildings* (ASCE 31) and the *Prestandard for the Seismic Rehabilitation of Buildings* (FEMA 356). The handbook also will be consistent with current FEMA publications on seismic evaluation of existing buildings (FEMA 310) and seismic rehabilitation of existing buildings (FEMA 356), and will provide practical guidance on the application of available and proven rehabilitation techniques and associated impacts, *i.e.*, relocation of occupants and disruption of business. The handbook will be published in 2005.

National Science Foundation

The Directorate for Engineering at NSF works with its grantees to provide local outreach programs designed to educate the public, promote earthquake awareness, and develop strategies to transfer research findings into implementation. NSF also supports outreach and information dissemination through symposia and through grants to organizations such as the Natural Hazards Research and Applications Information Center (NHRAIC) and the Earthquake Engineering Research Institute (EERI) and its Learning From Earthquakes program.

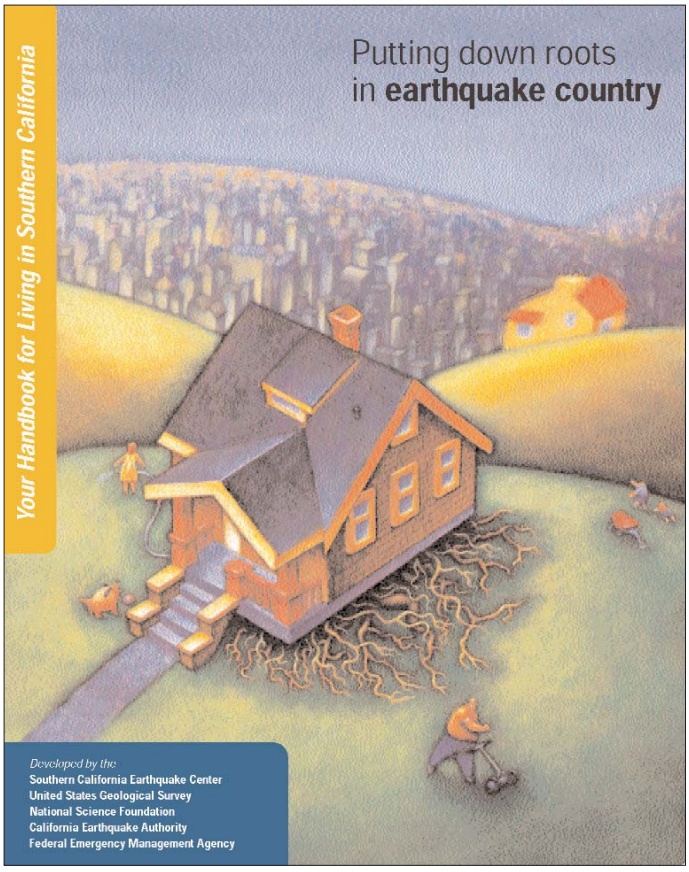
In the reauthorization legislation of the NEHRP in 1994, Congress instructed the President to conduct a needs assessment of earthquake engineering experimental research facilities in the United States. NSF and NIST funded the assessment, which was completed by EERI and resulted in a report published in 1995, *Assessment of Earthquake Engineering*

Research and Testing Capabilities in the United States. The report makes recommendations for improving the capacity of U.S. academic research institutions to continue to carry out world-class earthquake engineering experimental research, and notes that "as the highest priority, existing laboratories must be upgraded and modernized with new testing equipment."

Over the years, NSF has continued to provide significant funding for establishing and modernizing earthquake engineering research facilities in the United States. Today, NSF supports the following research centers and organizations:

- Mid-America Earthquake (MAE) Center at the University of Illinois- Urbana-Champaign
- Multidisciplinary Center for Earthquake Engineering Research (MCEER) at SUNY Buffalo
- Pacific Earthquake Engineering Research (PEER) Center at the University of California-Berkeley
- Southern California Earthquake Center (SCEC)
- Incorporated Research Institutions for Seismology (IRIS)

In FY 2000, NSF started construction of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), a comprehensive and networked system of earthquake engineering test facilities. The NEES project, which was completed at the end of FY 2004, is described under Goal D.



USGS's Putting Down Roots in Earthquake Country handbook cover.

U.S. Geological Survey

The USGS Earthquake Hazards Program is the applied Earth science component of NEHRP. The three basic elements of the USGS Earthquake Hazards Program are assessment and characterization of earthquake hazards; monitoring and reporting earthquake activity and crustal deformation; and conducting research into earthquake causes and effects.

The USGS contributes to earthquake hazard mitigation strategies by estimating and describing the likelihood and potential effects of moderate-to-large earthquakes in high-risk regions of the United States and by transferring this knowledge to individuals, organizations, and agencies that can reduce the impact of potentially damaging earthquakes. Federal, state, and local government agencies; architects and engineers; insurance companies and other private businesses; land-use planners; emergency response officials; and the public rely on the USGS for earthquake hazard information to refine building codes, develop land use strategies, safeguard lifelines and critical facilities, develop emergency response plans, and take other precautionary actions to reduce losses from future earthquakes.

To answer the growing concern over the implications of the Northridge earthquake and other recent seismic events in southern California, the USGS and SCEC developed in 1995 *Putting Down Roots in Earthquake Country*, a graphically illustrated, 32-page color handbook on earthquake science, mitigation, and preparedness. A new version of *Roots*, updated by SCEC and USGS in 2004, features current scientific understanding of when and where earthquakes will occur in Southern California, and how the ground will shake as a result. Updated maps of earthquakes, faults, and potential shaking are included, as well as instructions on how to get information after earthquakes. The preparedness section has been completely reworked and is now organized according to the "Seven Steps on the Road to Earthquake Safety." These steps provide a simple set of guidelines for preparing and protecting lives and property and for surviving and recovering from a damaging earthquake. In January 2004, 200,000 copies were printed with funding from the California Earthquake Authority (CEA) and FEMA; an additional 150,000 copies were printed in September 2004, with funding from the CEA, USGS, Edison, Amgen, Quakehold, and others. Copies of the document are distributed at home improvement centers, via the American Red Cross, and by many other means. The updated handbook is available at http://www.earthquakecountry.info/ and a Northern California version is in development. Both versions

will also be translated into Spanish and versions for other regions may be created.

Regional Consortia

A number of regional organizations have been established to reduce earthquake risk and loss among their populations. These regional organizations work in close cooperation with the NEHRP agencies and other partners.

Cascadia Region Earthquake Workgroup

The Cascadia Region Earthquake Workgroup (CREW) is a non-profit coalition of private and public representatives working together to increase the ability of Cascadia Region communities in the Pacific Northwest to reduce the effects of earthquake events. CREW, which was established in 1996 by the scientific community, promotes efforts to reduce the loss of life and property; conducts education to motivate key decision-makers to reduce risks associated with earthquakes; and fosters productive linkages among scientists, critical infrastructure providers, businesses, and governmental agencies to improve the viability of communities after earthquakes.

In February and March 2004, CREW held special purpose forums for the Oregon land use planning community. Programs were delivered by the University of Oregon Hazards Center and the University of Washington's Institute for Hazards Mitigation. Each half-day forum presented current seismic information and focused on the specific needs of land use planners. A "snow card" approach was used and a paper was presented to CREW and at the annual American Planners Association Conference.

The CREW *Business Survival Kit for Earthquakes and Other Disasters* video includes a CD containing the Institute for Business and Home Safety (IBHS) tool kit. This product will be enhanced with a revised tool kit being developed by the Seattle Disaster Resistant Business Project. CREW is helping edit the document and structuring it as an interactive web-based tool. The kit was distributed at the National Earthquake Conference in St. Louis, Missouri.

Evaluations of the National Earthquake Conference indicated that the event was a resounding success, and CREW deserves much credit. CREW was a sponsor of the National Earthquake Conference and its executive director was one of the four conference chairs. In support of the conference, CREW identified speakers, oversaw the preparation of a conference video, marketed the event, and participated on the steering and subject area committees.

CREW conducted preparatory work for a workshop on April 5, 2004, involving 13 representatives of key area businesses, with the purpose of identifying economic sector impacts to a 6.7 Seattle Fault earthquake. The workshop was conducted by the University of Washington Institute for Hazards Mitigation.

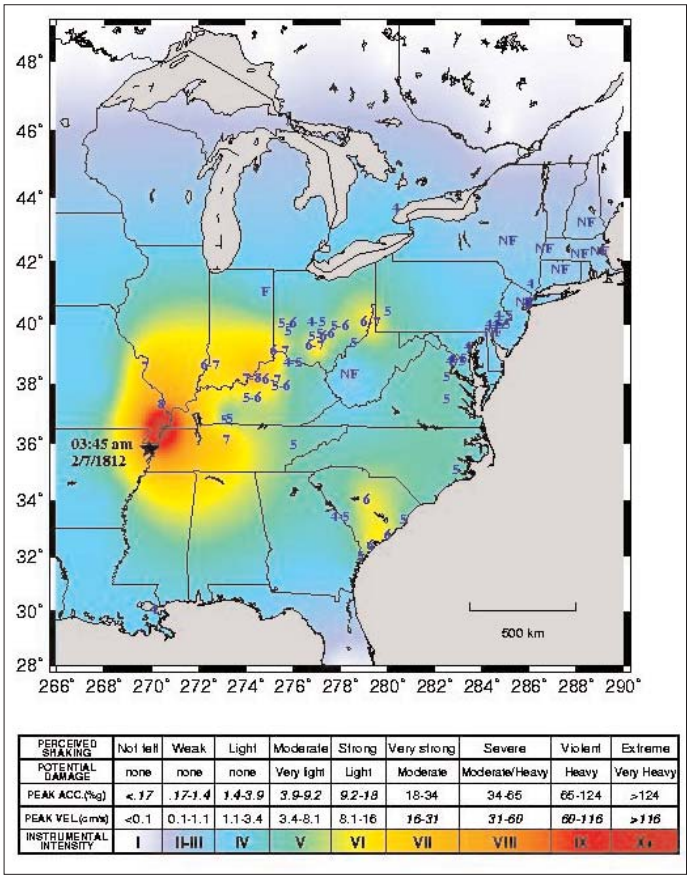
Other CREW activities during the reporting period include:

- Participated in bi-monthly planning meetings of the Partners In Emergency Preparedness conference steering committee, staffed a booth at the conference, and provided presenters.
- Participated in activities of the Contingency Planning and Recovery Managers (CPARM), the Snohomish Business Recovery Managers, and the Association of Contingency Planners (ACP).
- Actively supported the Seattle Disaster Resistant and Business Emergency Network initiatives
- Supported the activities of the Pacific Northwest Economic Region and its scheduled "Blue Cascadia Exercise"
- Provided continuing support to the Western States Seismic Policy Council (WSSPC) and Emergency Management Council

CREW, in partnership with the Oregon Department of Geology and Mineral Industry (DOGAMI), printed 500 copies of *Cascadia Earthquakes – A Clear and Present Danger* and distributed copies at the National Earthquake Conference. The final document will be available for distribution by February 2005.

Central United States Earthquake Consortium

The efforts of CUSEC are built on an all-hazards emergency management approach that centers on preparedness, mitigation, multi-state planning (response and recovery), and research. CUSEC was formed as, and continues to be, a partnership of the Federal Government (primarily FEMA) and the eight member states it represents: Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee. CUSEC also represents 10 associate states: Georgia, Iowa, Louisiana, Nebraska, North Carolina, Ohio, Oklahoma, South Carolina, and Virginia. Earthquakes occurring in the New Madrid Seismic Zone (NMSZ) and in other nearby fault zones can significantly affect these states. CUSEC serves as an integral link in helping its member states bridge the gaps in addressing the seismic hazard between local and state needs and their federal counterparts. This link, and the regional approach to addressing a single hazard shared by multiple states, is one of the four goals of the NEHRP.



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Estimated ShakeMap for the 1812 New Madrid earthquake.

CUSEC activities included assistance in the development of outreach programs, such as earthquake awareness week, to the states of Missouri, Mississippi, Tennessee, and Arkansas. CUSEC, along with the emergency management agencies of Arkansas, Mississippi, and Tennessee, co-sponsored the second annual Tri–State Earthquake conference, which promotes unity of the earthquake program by allowing these neighboring states to combine their efforts. The benefit is greater exposure to the issues and a more cost effective approach than three separate efforts.

During this period, CUSEC continued to expand the concept of regional working groups as a method of bringing focused expertise on the earthquake risk. A key group has included state Public Information Officers, whose expertise in public awareness has resulted in the development of materials such as the *Central U.S. Earthquake Hazard Media Guide*, as well as standardization of press releases used by the CUSEC states, ensuring the release of accurate and concise information to the media and the public.

Technology has enhanced the methods for delivering information. The CUSEC web page added a considerable amount of new information during this period. Information included posting of the NEHRP Strategic Plan; information specific to the working groups; new publications; seismic mapping resources; an update of the original Six Cities Study using FEMA's state-of-the-art HAZUS software; and new links to informational earthquake sites. The web page also provided background on the programs of the CUSEC member states so that visitors could gain a better understanding of how each state addressed the seismic risk and how that relates to the overall regional approach to reducing the risk.

In an effort to determine that earthquake-related educational materials were available for K-3, materials from across the United States were collected and compiled into a database distributed among the CUSEC states. The database serves three purposes: (1) it gives the earthquake program managers of the CUSEC states an idea of the materials available to them; (2) it helps to determine if any gaps exist in the types of materials available; if gaps are determined, these will be considered as future projects; and (3) it helps to identify any duplication that exists so that limited funds that can be used for other purposes.

The coordination of earthquake planning efforts has been a CUSEC priority since the organization's inception in 1983. The regional impact of a major earthquake in the central United States, coupled with complex operational and logistic problems associated with emergency response, underscores the need for a multi-state approach to planning. One of the key multi-state/regional issues that continue to be a priority is coordination among the CUSEC states to address the priorities of one state in relation to its neighboring states. This is an essential process not only for the immediate response needs following an earthquake or other large-scale disaster, but also for economic recovery. An Operations subcommittee was formed to work with the CUSEC Transportation Task Force in addressing key issues raised during this period, such as the establishment of a uniform definition of a priority route.

The strength of CUSEC has been and continues to be built around the partnership approach to addressing the seismic hazard. This partnership, although predominately between public sector organizations, has continued to reach out to the private sector. International Paper Corporation and Simpson Strong Tie, Inc. both became corporate sponsors during this period. Their inclusion in CUSEC's efforts has not only broadened the planning perspective, it also provides the opportunity to gain a better understanding of the emergency preparedness issues important to the private sector.

Training also remained an essential part of CUSEC's efforts. To regionalize the training offered and to build uniformity, CUSEC has encouraged the adoption of the Missouri Structural Assessment Visual Evaluation (SAVE) Coalition as a model for all CUSEC states in the development of their programs. By adopting a program with a similar structure, each state would be assured of a program with a level of accountability. Years of training have yielded numerous

inspectors, but lack of structure in the program in many cases has made it difficult to manage.

A regionalized approach to training was also adopted during this period to stretch available funding. The Postearthquake Safety Evaluation of Buildings (ATC-20) workshops were offered as a collaborative effort. CUSEC provided the basic funding and workshop coordination while the states of Arkansas and Missouri provided the instructors and arranged for the workshop sites. As a contribution to the training effort, each site was provided free of charge. The Arkansas Electric Cooperative and the Missouri Department of Conservation-Discovery Center in Kansas City were both excellent facilities to host the workshop.

To complement state and local mitigation efforts in support of the Disaster Mitigation Act of 2000, and to improve techniques to reduce seismic vulnerability of facilities and systems, training workshops on the Rapid Visual Screening of Buildings for Potential Seismic Hazards were conducted. Used extensively during the 1980s and early 1990s, these workshops provided the training needed by the communities of today to evaluate the structures in their community to determine the level of vulnerability.

During this reporting period, the CUSEC State Transportation Task Force analyzed the need for a regionalized approach to bridge inspection. Using a program developed at Purdue University for the Indiana Department of Transportation (DOT), the CUSEC states are looking at methods to assess the viability of a regional approach.

One of the most effective ways to improve the odds of reducing or eliminating vulnerability is to expose individuals and groups to exemplary efforts undertaken by others in reducing their vulnerability. CUSEC sponsored a field trip to a recently completed project in Tuckerman, Arkansas. Representatives from state departments of education, local emergency management, and universities received first-hand information on a school mitigation project that turned the elementary school's main hallway into a safe room. The project, which was completed under budget and during summer recess, was viewed by field trip participants as a viable project that could be implemented in their communities.

Northeast States Emergency Consortium

The Northeast States Emergency Consortium (NESEC) develops, promotes, and coordinates natural disaster and emergency management activities throughout the Northeast. This includes natural hazard evaluation and assessment, public awareness and education programs, hazard mitigation, and information technology transfer. Connecticut, Maine, Massachusetts, New Jersey, New Hampshire, New York, Rhode Island, and Vermont form the NESEC.

During this reporting period, the Executive Director of NESEC served as Chairman of the Organizing Committee for the National Earthquake Conference in Saint Louis. The effort to organize this conference, which was hosted by the four regional earthquake consortia, spanned a period of 2 years. The conference was attended by more than 300 participants and from all accounts was a tremendous success. The private sector was well represented at the conference, comprising approximately 30 percent of the attendees. The lead agencies and conference organizers are developing a conference report with recommendations for future follow-up actions and activities.

Western States Seismic Policy Council

The WSSPC is a regional earthquake consortium formed as a private not-for-profit corporation. WSSPC draws its membership from the emergency managers and geoscientist directors of 13 western states, 3 territories, a Canadian territory, and a Canadian province. The mission of the WSSPC is to help reduce future earthquake losses by providing a forum to advance earthquake programs throughout the Western Region and by developing and facilitating the implementation of seismic policies and programs through information exchange, research application, and education. WSSPC provides a broad regional and multidisciplinary forum to enhance and create partnership opportunities for seismic hazards mitigation and to fulfill its missions of developing seismic policies and sharing information to promote programs intended to reduce earthquake-related losses.

The Awards in Excellence program recognizes achievement in different areas of earthquake mitigation, preparedness, and response. Categories include mitigation, educational outreach, research, response plans or materials, non-profit agency efforts, seismic legislation, use of new technology, and innovations. Winners are selected by the WSSPC Board of Directors and the awards are featured on the WSSPC website and in the Awards in Excellence volume. Eleven programs from 7 western states won awards in 2003. In 2004, the WSSPC Awards in Excellence program was used as a model for the National Awards of Excellence given at the National Earthquake Conference. A committee comprised of members from numerous national organizations selected the 10 winners from across the country.

WSSPC members develop and adopt policy recommendations that local, state, or federal agencies can implement. These policy recommendations address a range of seismic risk, monitoring, mitigation, and response issues, and provide substantial credible support for earthquake program improvements. The participation of WSSPC member organizations in developing these policies, and rigorous review of these recommendations by stakeholders throughout the region, provide assurance that the recommendations are appropriate and relevant to the particular jurisdiction. The

WSSPC policy committees provide a neutral forum for such policy development by a credible group of experts. The WSSPC adopted eight policy recommendations in 2003 and 2004.

Annual conferences provide a regional and national forum for scientists, engineers, emergency managers, the business community, policymakers, and other stakeholders to exchange ideas and information. In 2003, the WSSPC-led conference focused on Earthquake Loss Reduction and Developing Effective Communication, Realistic Strategies and Successful Mitigation Actions for Communities.

In 2004, WSSPC was the financial, logistical, and marketing manager for the National Earthquake Conference, put on primarily with FEMA, USGS, CREW, CUSEC, and NESEC, but also including representatives from the private sector, non-profit organizations, and state seismic safety and advisory boards. The goal of the conference was to provide a forum for discussion of national earthquake issues and generate ideas for future collaborative actions to be taken to reduce earthquake risk in the United States. One of the outcomes was the production of a 27-minute video "Living with Risk," intended as an educational tool for a general audience.

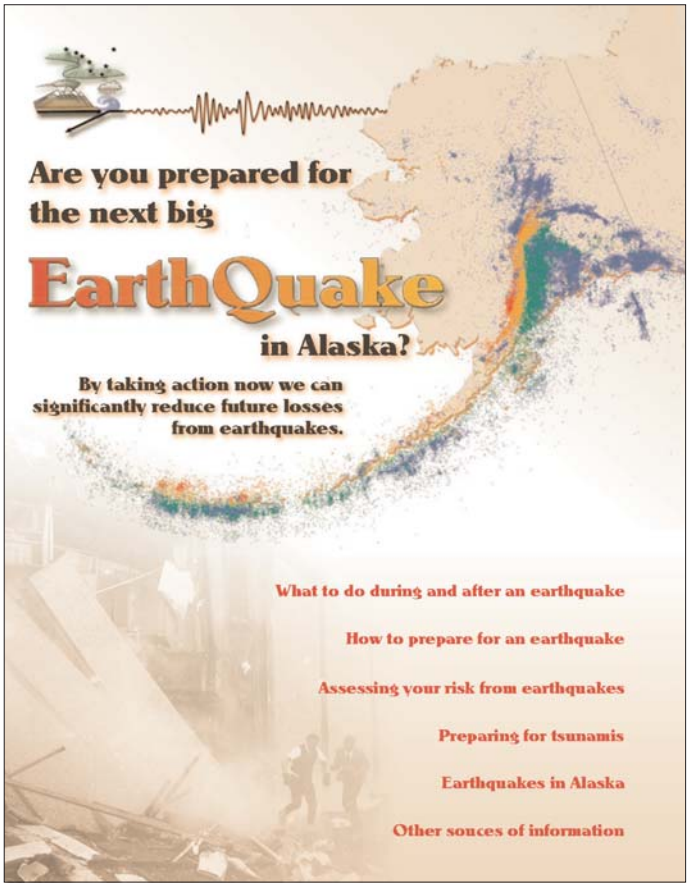
WSSPC, USGS, and FEMA, along with western states geological surveys, sponsored the second Basin and Range Province Seismic Hazards Summit to bring together geoscientists, engineers, emergency managers, and policymakers to discuss the latest earthquake hazards research and to evaluate its implications for hazard reduction and public policy. The meeting highlighted technical issues important to understanding earthquake hazards in the extensional Basin and Range Province.

Selected State, Territorial, And Local Accomplishments

FEMA allocates a portion of its NEHRP funds to state governments as part of the annual EMPG. With the grant funds, state and local agencies undertake numerous activities to protect their citizens from the earthquake hazard. Highlights of some of the many successful state, territorial, and local government efforts in support of Goal A are described below.

Alaska

The Alaska Denali Fault 7.9 earthquake spurred great interest in Alaska's earthquake hazard. Subsequent to the earthquake, there was a surge of requests for non-structural seismic hazard mitigation demonstrations for the Division's outreach tools, including the *Quake Cottage* earthquake simulator and the *Earthquake Resistant Model Home*. These tools provide audiences with effective earthquake preparedness and mitigation lessons as well as build visual relationships to the effects of hazards



Are You Prepared for the Next Big Earthquake in Alaska booklet cover.

affecting structures. Over 11,500 people attended these presentations at 23 public and private schools, at safety events with major petroleum corporations, health institutions, government agencies, and State Fairs. The Division also coordinated a multi-agency effort to update and reprint the earthquake and tsunami preparedness booklet, *Are You Prepared for the Next Big Earthquake in Alaska*. This was a major undertaking; 250,000 copies were printed, with 130,000 copies of the booklet inserted into newspapers statewide commemorating the 40th anniversary of the 1964 Great Alaskan Earthquake.

Alaska's tsunami partnership led to significant mitigation program results. The group conducted remote community assistance visits bringing Earthquake Preparedness, TsunamiReady® and StormReady®, Tsunami Sign Program Awareness, and Disaster Preparedness information to Chignik and Perryville in the Aleutians and Craig, Klawock, Thorne Bay and Hydaburg, located along the Southeast Alaska panhandle. The City of Kodiak, Alaska became Alaska's fifth TsunamiReady® community in February 2004, furthering preparedness initiatives for Alaska's population and its visitors.

The State of Alaska's Division of Homeland Security and Emergency Management (DHS&EM) combines its mitigation, earthquake, tsunami, and preparedness programs to ensure the public is educated about the natural hazard threats.

DHS&EM takes great pride in its partnerships with the University of Alaska Fairbanks Geophysical Institute (UAF/GI), Alaska Department of Natural Resources Division of Geological and Geophysical Survey, Alaska Earthquake Information Center, Alaska Department of Transportation and Public Facilities, West Coast/Alaska Tsunami Warning Center, National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA) Pacific Marine Environmental Laboratory and Tsunami Inundation Mapping Effort (TIME), FEMA, the Department of Interior (DOI), and Alaska's boroughs, local, and tribal governments. Very few projects would be accomplished without quality partnerships and willing participation.

DHS&EM aggressively supports and funds the statewide use of the Municipality of Anchorage's Building Safety Officer to manage and coordinate its Post Disaster Damage Assessment (PDDA) training program. The PDDA Coordinator conducted six Post Disaster Damage Assessment courses resulting in an increase of 195 damage assessment evaluators between the spring of 2003 and summer 2004. Refresher training was also conducted for 47 students. These efforts allow for the tracking of training while ensuring that trained individuals can be contacted and deployed statewide during disasters to support Search and Rescue operations with timely building assessments. Sitka, Alaska is the first community to adopt a section into their statutes concerning damage assessment and allowing the use of volunteer evaluators from other areas.

The Tsunami Inundation Mapping project for Homer and Seldovia, Alaska, sponsored by NOAA and State of Alaska, will be published in late 2004. This project provides potential tsunami mapping coverage to local community partners so that they can tailor the information obtained from the inundation maps toward effective planning efforts. These maps will assist the communities prepare for and mitigate against potential tsunamis. The Alaska Division of Geological and Geophysical Survey produces the final maps for distribution by the local government and emergency management. Seward, Alaska is in the beginning stages of this mapping effort and Sitka, Alaska has recently undergone bathymetric (undersea) mapping by NOAA This information is vital to completing inundation modeling and the subsequent maps after the models are validated.

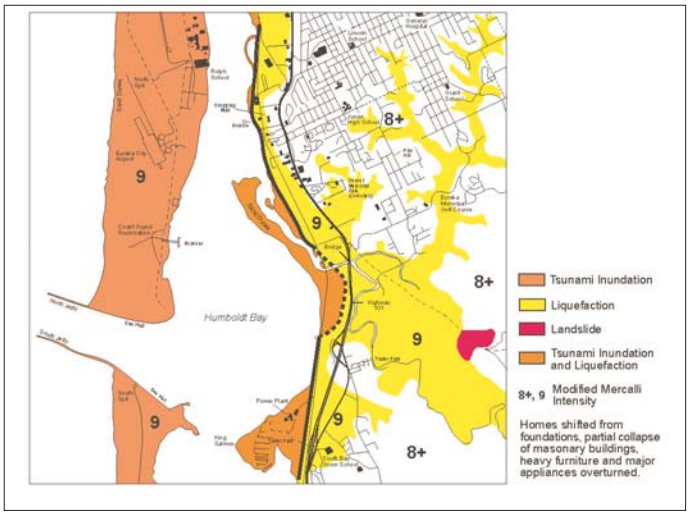
California

Staff of the California Office of Emergency Services (OES) continued to serve on the Board of Directors of the Northern California Chapter of the EERI; the Board of Directors of the NIBS; the California Earthquake Safety foundation; as Chair of the EERI Special Projects and Initiatives Committee (Endowment); the Steering Committee for the 1st International Conference on Urban Hazard Mitigation, to be convened in Kobe in January 2005; and on the organizing and coordinating Committee for the 100th Anniversary Conference for the 1906 Earthquake, including the Conference Steering Committee and the '06 Alliance, which serves to coordinate all 1906 anniversary activities in northern California. In addition, staff serves on numerous state and regional committees to coordinate earthquake preparedness and response planning, including the California Emergency Services Association and Mutual Aid Advisory Committees.

The OES Director and his designate participate on the Board of Directors of the WSSPC and participated in Board and annual meeting activities, including planning for the National Earthquake Conference held in St. Louis in 2004. The California Integrated Seismic Network, as a Region of the Advanced National Seismic System (ANSS) of the USGS, is represented on a number of coordinating committees of ANSS. Staff also participated on a NAS Panel on the economic benefits of seismic networks in the U.S.

OES GIS staff developed and delivered statewide hazard maps to each of the Operational Areas (counties), completing the *Statewide Hazard Atlas* in support of local preparedness and preparation of local plans as part of the Disaster Mitigation Act of 2000 requirements. Atlases were provided in both hard copy and digital formats for use by local planners. The maps included probabilistic earthquake ground motions, historic earthquake epicenters, liquefaction susceptibility (where available), flood, and land slide. Maps were provided to Operational Area emergency managers and land use planning agencies.

Resource Centers in Southern and Coastal Region offices of OES continue to provide information on preparedness, mitigation, and response to the public, local governments, and state agencies. Information is available for day care centers, schools, for persons with disabilities, businesses, and



Tsunami inundation map for Eureka, CA.

the general public. Publications include sample emergency plans, safety elements, mitigation programs, as well as graphic and video materials for presentations to client groups. Hazard mitigation materials address fire, flood, tsunami, landslides, and terrorism, in addition to general earthquake preparedness. Coastal Region staff continues to distribute materials from PrepareNow.org targeted to special populations, including the disabled, the elderly, and non-English speakers.

OES continued the statewide distribution of *School Districts Guide for Nonstructural Earthquake Hazards in California Schools*. The document was also distributed at the National Earthquake Conference and at WSSPC meetings, as well as being available on the OES and NIBS websites.

California, along with other NEHRP states, was inundated with inquires about Douglas Copp and the "triangle of life." The OES earthquake program coordinated with FEMA Region IX and Region X staff, the American Red Cross, and representatives from the other western states in drafting and distributing and official response. The OES position is that based on all available information from the structural engineering and medical communities, the greatest benefit to building occupants in California is provided by the current *Duck (Drop), Cover and Hold* instruction.

The California Earthquake Prediction Evaluation Council (CEPEC) met twice during this reporting period. The first meeting reviewed several commercial proprietary earthquake prediction services being marketed in the United States. The second meeting was convened to review and respond to the press releases related to 'predictions' made by Dr. Vladimir Keilis-Borok of the University of California, Los Angeles. CEPEC met in February 2004 with representatives of the USGS to review Dr. Keilis-Borok's methodology and previous predictions. CEPEC concluded that the "uncertainty along with the large geographic area included in the prediction (about 12,400 square miles) leads (us) to conclude that the results do not at this time warrant any special policy actions in California." CEPEC findings were provided to FEMA, USGS, local governments, and the media.

OES staff participated on the Steering Committee of the NOAA National Tsunami Hazard Mitigation Program (NTHMP) and continued to support use of tsunami inundation maps and public information materials developed by the State and NTHMP to develop evacuation plans and procedures by the coastal cities and counties. OES convened two meetings of the State Tsunami Hazard Steering Committee, comprised of representatives of the coastal counties, to review program progress and set overall program priorities. Two activities were initiated during this period. The first was a Workshop of Tsunami Sources that will focus on developing a probabilistic approach to mapping tsunami inundation along the California Coast. The second activity is a training workshop for coastal jurisdiction emergency managers that will address developing evacuation plans, coordinating public information with adjacent states, and use of NOAA Alert Radio, Emergency Alert Systems, and siren systems to alert coastal residents and visitors to an imminent tsunami threat. OES also contracted with the University of Southern California for the development of inundation maps. Maps have been produced for all counties south of the San Francisco Bay Region, and maps from the Bay to the Oregon border will be completed this year.

Hawaii

The Hawaii State Civil Defense (SCD) Earthquake Program has made notable accomplishments in earthquake loss reduction. The SCD-sponsored Hawaii State Earthquake Advisory Committee (HSEAC) has served as a catalyst to identify and implement priorities in short- and long-range goals of earthquake hazard reduction. HSEAC is composed of a voluntary partnership of scientists, engineers, land use planners, and emergency managers from the federal, state, county, and private sectors.

HSEAC provided technical expertise to the high hazard County of Hawaii to adopt the 2000 IBC. The seismic provisions were written specifically for the island of Hawaii's unique volcanic geology. Moreover, HSEAC wrote seismic structural specifications for the county's simplified design procedures ordinance. Both amendments have been well received by the County of Hawaii Building Division and included as part of the county's proposed adoption of the 1997 Uniform Building Code (UBC) currently under consideration.

HSEAC created and posted a *Construction Guide on Strengthening Existing Houses in Hawaii Against Hurricanes and Earthquakes* on a state hazard mitigation website. The construction guide provides the public with information on how to retrofit unique Hawaii constructed home types, which significantly differ from continental United States home construction. The web site is www.MotherNature-Hawaii.com.

Idaho

The Bureau of Disaster Services and the Idaho Geological Survey have an active and ongoing partnership for assessing and mitigating the state's natural hazards. The partnership also provides an annual field workshop for earth science educators. In addition to supporting counties in promoting earthquake awareness and loss-reduction techniques, a multi-agency advisory committee provides input to the Survey's mapping activities, which provide input to the seismic studies.

The annual field workshops for earth science educators studied the geology and geologic hazards of the Clearwater River area in west-central Idaho in 2003 and the Long Valley area in western Idaho in 2004. Teachers use workshop information to create curricula that combine science with hazard awareness to engage students at various levels—from mapping buildings using GIS and an abbreviated Rapid Visual Screening inventory to identifying non-structural hazards in their schools.

In 2004, the Bureau of Disaster Services funded workshops on Postearthquake Safety Evaluation of Buildings (ATC-20). The Bureau of Disaster Services also funded all-hazards mitigation planning for 13 counties.

Activities of the Idaho earthquake hazard reduction program include:

- Increased inquiries from insurance agencies, banks, and citizens about location of active faults and local seismicity
- Increased opportunities for educators and building officials in appropriate hazard mitigation techniques
- Increased interest in, and participation by, teachers in earthquake education
- Increased adoption and updating of building codes—important because Idaho is developing rapidly, so that an up-to-date building code will have a positive impact on the new building stock
- Increased interest in retrofit codes so that older buildings are seismically stronger
- Increased response to annual surveys of public buildings by the Idaho Division of Building Safety

Maine

The State of Maine has a staff person within the Maine Emergency Management Agency who provided earthquake-related support to various activities within the State, including the following:

- Updated the seismic portion of the State Emergency Operations Plan
- Provided Maine Department of Transportation personnel in Bridge Design and in Road Construction divisions with seismic mitigation information and with information about various EMI courses, including the HAZUS courses
- Provided the University of Maine Engineering faculty with information about various seismic-related courses, including the MBDSI courses
- Provide schools with seismic-related educational materials
- Provided the Maine Department of Education unit that reviews school construction plans with seismic mitigation publications
- Participated in seismic notification for tests and actual events

Missouri

The Missouri State Emergency Management Agency (SEMA) Earthquake Program continues to promote earthquake loss-reduction practices and policies by encouraging mitigation, sponsoring earthquake awareness and preparedness programs, and developing better response and recovery capabilities through exercises.

SEMA made the initial request to CUSEC to hold an earthquake exercise in 2007 for all of the states that would be affected by an earthquake along the New Madrid Fault. SEMA also continues to provide funding and support for the SAVE Coalition to train and certify post-earthquake structural inspectors in the Post-earthquake Safety Evaluation of Buildings (ATC-20 training). SAVE now has over 1,200 volunteer member inspectors qualified to perform post-earthquake structural inspections.

Each year, SEMA and the Missouri Seismic Safety Commission hold a weeklong earthquake awareness campaign. The campaign features: (1) a signed Governor's Proclamation; (2) the Missouri SEMA Public Information Officer e-mail posts to the homepage, a media kit with press releases, and brochures to 130 Emergency Management Directors and 185 media venues in the 47 counties at risk; (3) seminars conducted in St. Louis and other population centers; (4) earthquake display at the Truman Building and Capitol in Jefferson City and St. Louis Science Center; and (5) a hands-on event at the St. Louis Science Center.

Montana

With fewer resources available to sustain efforts in Montana, it has been necessary to become extremely creative with finances and resources. As Montana is no longer able to send out publications and other materials in mass quantities, reliance on its web site for supplying information has become a critical part of the State's focus. The entire "Earthquake

Preparedness Month" campaign is delivered online. Where Montana once sent out thousands of fliers, bookmarks, posters, press releases, and fact sheets, Montana now provides that information via its web site. This approach has saved the program money and is much more effective in reaching the public. In this regard, fewer resources have contributed to a better campaign effort. The program manager continues to visit schools, businesses, and governmental agencies to provide training on earthquake preparedness.

Nevada

Funding from NEHRP has been instrumental in reducing risks from earthquakes in Nevada. Funds from NEHRP through FEMA have been used to support the Nevada Earthquake Safety Council, which advises the State Division of Emergency Management on earthquake issues. The Council, with the help of the Nevada Bureau of Mines and Geology (the state geological survey) and the Nevada Seismological Laboratory, undertook several projects in public education, preparedness, and mitigation. Minutes of quarterly meetings of the Council, technical guidelines adopted by the Council, and related documents are available on the Web (http://www.nbmg.unr.edu/nesc/index.html).

A major accomplishment of the Council was the passage of Nevada Assembly Bill 59. This bill, which was signed into law by the Governor near the end of the 2003 biennial session of the Nevada Legislature, requires adoption of the seismic provisions of the IBC for state buildings and by local jurisdictions, and requires adoption of standards for the investigation of earthquake hazards relating to surface ruptures and liquefaction.

Oregon

The Oregon Seismic Safety Policy Commission has convened a task force to support the issuance of Government Obligation Bonds to implement Senate Joint Resolutions 21 and 22 that authorized the state to issue bonds to finance seismic retrofit of public education buildings and emergency service buildings. This task force is working closely with the State Senate President for submission to the legislature.

The Oregon DOGAMI and Oregon Emergency Management (OEM) have partnered to survey county emergency managers on the seismic vulnerability of their emergency facilities. Oregon University System is currently evaluating its campus facilities for seismic vulnerability and prioritizing retrofit projects.

In partnership with Oregon Natural Hazards Workgroup, OEM promoted "drop, cover, and hold" earthquake and tsunami drills and evacuations through Earthquake Awareness activities and presentations.

Puerto Rico

As part of the Puerto Rico State Emergency Management Agency (PRSEMA) role to save lives and properties in the Commonwealth of Puerto Rico, the following earthquake activities were conducted:

- Creation, reproduction, and dissemination throughout the 78 municipalities of educational pamphlets associated with preparedness, response, mitigation, and recovery to reduce the loss of life and property, in coordination with the American Red Cross.

- Conduct of a Tsunami Workshop for Local and State Emergency Managers. This workshop provides historical tsunami data, possible earthquake, submarine landslide, volcano activities, and explosions that could cause tsunamis. Also included is information on equipment availability, present and future activities to enhance community awareness, and the establishment of topographic and bathymetric data and photo collection for the entire Caribbean zone.

- Creation, reproduction, and dissemination throughout the 78 municipalities of an interactive CD for youths, teens, and adults that provides graphics, maps, games, and an informative pamphlet regarding preparedness, response, recovery, terrorism, and mitigation.

- In coordination with the Puerto Rico Seismic Network, conducted seven seismic and tsunami-related activities, which include the establishment of a technical Seismic Committee; seismic and tsunami-related workshops for government officials; tsunami alert system data; a tsunami drill scenario for schools located on the coast; update to the Seismic Network website with PRSEMA's data and other emergency preparedness, response, recovery, and mitigation information; and participation in the Annual National Tsunami conference.

- Conducted 12 mitigation activities for "Special Communities" for the entire family to promote positive mental health during disasters.

- Conducted four workshops for State and Regional Hazard Mitigation Team representatives on mitigation measures and activities related to the State Mitigation Program, including the Annual PRSEMA Conference held in May 2004.

- Conducted 20 site inspections of potential Emergency Disaster Recovery Centers for certification and use in case of an emergency of disaster.

- Developed and adopted a Standard State Hazard Mitigation Plan.

- Continued work with the International Code Council (ICC) and the NFPA to develop and maintain disaster-resistant building codes and work with communities to promote local adoption of disaster resistant building codes, in coordination with the Puerto Rico State Fire Department.

- Developed guidance documents, multi-hazard training courses, and other resources to improve risk assessments, mitigation planning, and residential and commercial construction practices for multi-hazard risk reduction.

- Actively coordinated with other federal departments and agencies to identify ways to work together to support national mitigation goals, and to keep and secure new partnerships with business, non-profit, faith-based, and public sector organizations at the national, state, and community levels.

- Supported the development and use of seismic design guidance for new construction and for upgrading existing buildings and other structures in partnership with regulatory agencies.

- Increased the number of Emergency Action Plans in communities located below significant and high-hazard-potential dams.

Washington

Every year, April is designated "Disaster Preparedness Month." The theme of the campaign is "Prepare Because You Care." Local jurisdictions, state agencies, schools, businesses, and the general public distribute materials. A statewide earthquake "Drop, Cover and Hold" drill is conducted with over 1.5 million citizens participating. The campaign provides an excellent opportunity to educate and increase awareness on the seismic risk the public faces and how to mitigate it. Achievements included two WSSPC National Awards in Excellence in 2003 for overall excellence in mitigation and educational outreach. In addition, five International Association of Emergency Managers (IAEM) 2003 and three IAEM 2004 Media Awards were received for earthquake products produced for the campaign.

In conjunction with the Seismic Safety Committee (SSC), Washington Emergency Management Division (EMD) and Department of Natural Resources/Division of Geology and Earth Resources fostered implementation of SSC Policy Recommendations by developing a report for the Emergency Management Council. One of the top recommendations was the state adoption of the IBC, which was approved by the 2003 legislature and signed by the Governor on May 14, 2003.

EMD's How the Smart Family Survived a Tsunami book cover.

EMD and the Institute of Geological and Nuclear Sciences in New Zealand partnered to quantify the public and private sectors' understanding of earthquake and tsunami hazards on the Washington coast, their knowledge of the Washington State All Hazard Alert Broadcasting (AHAB) Radio and NOAA Weather Radio notification systems, and their preparedness to deal with earthquake and tsunami activity. To fix deficiencies noted in the school assessments, EMD developed and published a book for K-6, *How the Smart Family Survived a Tsunami*. The book addresses the tsunami warning process, the Washington's AHAB Radio, and actions they should take when a tsunami warning is received. The book also includes information on a family disaster plan and disaster supply kit. The book is now being used nationally by other tsunami at-risk states and has been given to the International Tsunami Information Center for use by countries susceptible to tsunamis. It provides a baseline for emergency managers in developing risk communication, public education, and

mitigation planning. The book won the 2004 National Earthquake Conference Award of Excellence.

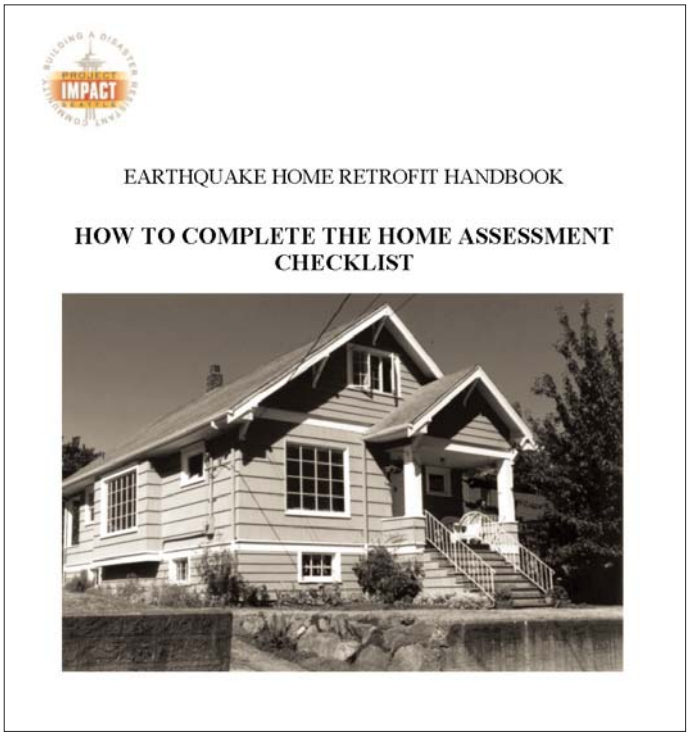
EMD partnered with the private sector to design and develop the AHAB Radio System to provide both tone and voice alert notification to at-risk communities for any hazardous situation. It can be powered by wind, solar, or commercial electricity. When used in concert with the NOAA Weather Radio, it becomes a highly effective alert and notification system. A pilot system was installed with a wind-generated powered system on a beachhead in Ocean Shores, Washington, in June 2003. Five electrical systems were installed in 2004 for port security, volcano, and tsunami warning. The system is presently being deployed in Alaska, California, American Samoa, and Guam. Fiji, Tonga, and Samoa are now interested in the system. In partnership with the City of Seattle and NOAA, the State is installing four systems on the Seattle waterfront that will be used for alert and notification but also have chemical detectors, a weather station, cameras, and seismometers allowing real-time reporting for all hazards. This proof of concept will be completed in May 2005. The AHAB Radio won the 2004 National Earthquake Conference Award of Excellence.

EMD, the State/Local Tsunami Workshop in partnership with the Provincial Emergency Program, British Columbia, and Olympic Peninsula Intertribal Cultural Advisory Committee developed an Earthquake Tsunami Tribal Video for the K-6 State Tsunami Curriculum. Elements include a native storyteller from the Hoh Tribe and an imaginative and dramatic two-dimensional animated story of a large earthquake and tsunami off the Washington coast, as seen through the eyes of a young boy. This video is the first of its kind and was showcased at an Earthquake Tribal Workshop hosted by the Quinault Nation in April 2004. A State of Washington Certificate of Commendation signed by the Governor was presented to the storyteller in the video for her outstanding work to better prepare children and families for an earthquake or a tsunami through the creative use of Northwest Coastal Native American oral history, art, and culture. The film is now available in Alaska, California, and Oregon; eight South Pacific Nations have been given permission to reproduce the video for use in their public education programs.

EMD and the Quinault Nation partnered to host the first Earthquake Workshop for Tribes in Washington State. Federal, state, and tribal representatives participated in this workshop that educated tribal officials on the earthquake and tsunami threat in the state and provided public education materials and training opportunities specifically for tribal officials. Many of the speakers were tribal members, ensuring that information important to them was disseminated and provided a backdrop for tribes to showcase their efforts in emergency management for possible use as a template by other tribes. The workshop featured a field trip to areas of subsidence along the Washington coast that provided linkage of scientific evidence to coastal Native American oral history. The workshop has increased the understanding of tribal needs, how to better approach those requirements, and has enhanced cooperation among government-to-government officials.

A 2-year project to develop a comprehensive scenario discussing the impacts of a potential M6.7 earthquake on the Seattle Fault and providing recommendations for policy makers will be completed in 2004. The recommendations will focus on mitigation. Development of the scenario project is guided by a multi-disciplinary, public/private steering committee. Funding support is provided by the EERI. Among the organizations involved in the project are EMD, City of Seattle, City of Bellevue, USGS, Structural Engineers Association of Washington, ASCE, University of Washington, and CREW. HAZUS was used to develop the scenario, which will provide the framework for engineers, emergency managers, and response personnel to identify key policy issues that coincide with the Washington Emergency Management Council's Seismic Safety 2004 Policy Recommendations.

Washington was the first state in the Nation to receive FEMA approval of its enhanced hazard mitigation plan. The plan identifies earthquakes as one of the state's priority hazards. The concept of "best available science" required by land-use planning in the State was used to develop the plan's hazard profiles for earthquake, tsunami, and landslide. EMD provided



Washington State's Project Impact Earthquake Home Retrofit Handbook cover.

these and other natural hazard profiles to all local jurisdictions around the State for use in local hazard mitigation plans. The profiles are posted on the EMD web site and have been used by a variety of individuals and groups.

In February 2003, EMD partnered again with Seattle Project Impact, a public-private mitigation partnership led by the City of Seattle Emergency Management, to develop a toolkit. Under the Disaster Resistant Business (DRB) Program, partners have spent 18 months building the DRB Toolkit to assist businesses of all types and sizes to prepare themselves against all-hazards using best practices and low-cost strategies. The DRB Program is using industry experts to create easy-to-follow steps that will assist businesses to create their own disaster plan if they do not have one, or improve a plan that already exists. Seattle Project Impact will use the website as a clearinghouse for business disaster solutions and examples. The DRB Toolkit will be an interactive web-based resource that can be used within the region or anywhere it is needed.

Under Seattle Project Impact's Regional Home Retrofit Program, 19 cities and counties are now participating on the earthquake strengthening effort. Based on the standard type of construction used throughout the state before earthquake code adoption, over 250,000 houses are vulnerable. In 2003, EMD connected the SSC-Buildings representative to the Regional Home Retrofit effort, as he is also a representative of the Washington Association of Building Officials. Including building officials in this program has been a key to success, as all of the retrofits are permit-driven to provide quality control in following the pre-engineered prescriptive standards. Over 600 homes have been retrofitted to date.

The Nisqually Earthquake provided an opportunity to showcase mitigation success and also provide increased mitigation efforts through the HMGP. Examples of HMGP awards are:

- **City of Aberdeen – Fire Station Seismic Retrofit:** This project completed a seismic retrofit in the main fire station that installed positive connections for the overhead beam structures and seismic switches and sensors to open apparatus doors at the time of sensing seismic movement. As part of the grant, the city completed a hazard mitigation plan.

- **Highline Water District – Reservoir Seismic Retrofit:** Highline Water District completed two separate seismic retrofits and pipe flexibility projects at seven sites. These involved retrofitting standpipes, elevating tanks, and protecting ground level tanks to ensure operation and continuity after an event for drinking water and fire protection. As part of the grant, a hazard mitigation plan has been developed.

- **Clark College – Structural Seismic Retrofit:** This project provided for structural seismic improvements to seven buildings on the Clark College campus, including pinning of bricks. Structural reinforcements will improve performance and reduce the potential for damage, loss, hardship, and suffering to students and staff.

Other Organizations

The NEHRP is a partnership of many organizations that have the common goal of keeping us safe from the earthquake hazard. The organizations involved in earthquake risk reduction activities range from engineering-based professional organizations, private sector organizations, universities, and building code organizations to organizations supported by one or more of the four NEHRP agencies, such as the earthquake engineering centers (EERCs) that were established by the NSF in 1997. Highlights of some of the many successful activities conducted by professional organizations in support of Goal A are described below.

Earthquake Engineering Research Institute

The EERI is a national, nonprofit technical society of engineers, geoscientists, architects, planners, public officials, and social scientists. The objective of EERI, which was founded in 1949, is to reduce earthquake risk by advancing the science and practice of earthquake engineering, by improving understanding of the impact of earthquakes on the physical, social, economic, political, and cultural environment, and by advocating comprehensive and realistic measures for reducing the harmful effects of earthquakes.

The Northern California chapter of EERI has held several workshops, with FEMA support, to transmit technical engineering knowledge to more than 200 building officials and water and school district managers. The technical engineering knowledge will enable them to better prepare for earthquakes in northern California by putting into practice new programs to strengthen their systems, address non-structural hazards, and identify structurally vulnerable buildings. Many of these earthquake techniques are easily transferable to other natural and technological hazards and to Weapons of Mass Destruction (WMD).

During the past 2 years, EERI has been able to use funds in the Cooperative Agreement to support travel for dozens of students and young professionals to attend the EERI Annual meetings, to learn about the latest research and design techniques that improve understanding of the seismic hazard, the design and rehabilitation of buildings and other structures, and social and policies issues that currently challenge seismic risk reduction.

Initiated through an EERI Technical Seminar in Seattle, EERI members and others have been drawing on funds from the EERI Endowment, plus additional support from the FEMA Cooperative Agreement, to develop a comprehensive, multidisciplinary, seismic risk scenario and Call to Action for Puget Sound. The scenario development led by EERI members brought together members of the Washington Structural Engineers Association, the state Division of Emergency Services, FEMA Region X, the USGS, and CREW in a major voluntary effort to create this valuable tool. The completed scenario will be distributed to more than 2,000 EERI members in the United States in CD-ROM format and printed and distributed to decision makers and others in the Puget Sound area. It will be publicly unveiled in early 2005 by the State of Washington's Emergency Management Division, in a public forum aimed at the region's decision makers. It will also serve as a valuable model for other communities that wish to develop a scenario to help create public interest in and support for the adoption of seismic risk reduction policies.

Multidisciplinary Center for Earthquake Engineering Research

The goal of MCEER, which is housed at the State University of New York at Buffalo, is to enhance the seismic resiliency of communities through improved engineering and management tools for critical infrastructure. MCEER works toward this goal by conducting integrated research, outreach, and education activities. MCEER maintains a clearinghouse of earthquake publications and resources on its website.

MCEER researchers have made many key contributions to the two most advanced building codes and seismic guidelines over the years. MCEER researchers have continued to engage practitioners through their contributions in the ATC (under sponsorship of the FEMA ATC-58 project). The next-generation performance-based seismic design procedures developed under this project will express performance directly in terms of the quantified risks that the building owner or decision maker will be able to understand. These risks may be expressed in a variety of formats, including expected loss for a given earthquake event, probable maximum loss over a given number of years, the probability of loss exceeding a specified value over a period of years, the net present value of future potential losses, average annualized loss, and other formats depending on the needs of individual decision makers. Stakeholder guidance will be developed to assist decision makers in selecting appropriate risk levels as the basis of design and upgrade projects. Engineering guidelines will be prepared to assist design professionals to develop building designs that are reliable and capable of meeting the selected risk criteria. The ATC-58 project is completely oriented toward implementation and does not undertake new research. Instead, it draws upon available existing information and upon new research results that will be generated during the life of the project. Given the considerable body of new knowledge generated by MCEER on the seismic retrofit of structural and nonstructural systems and components in acute care facilities and on the development of decision support methodologies, MCEER will become a natural "feed" to this important implementation project.

Natural Hazards Research and Applications Information Center

The NHRAIC works to strengthen communication between the hazards academic and applications communities to improve the implementation of hazard mitigation and emergency management programs. It is a widely recognized resource for researchers and practitioners who wish to obtain the most current knowledge available to solve hazard-related problems. The Center accomplishes its work through four major activities: information dissemination, an annual workshop, information services, and research. The majority of the Center's work is supported by a NSF grant. During this reporting period, nine other federal agencies contributed funds to NSF to support the grant.

The Center's information dissemination program is composed of three parts: production of the bimonthly newsletter, the *Natural Hazards Observer*; publication of monographs, working papers, Quick Response (OR) research reports, special publications, bibliographies, and other reports, including the Natural Hazards Informer series and the *Natural Hazards Review* journal; and Internet activities, which include the distribution of an electronic newsletter, *Disaster Research*, and maintenance of a web site.

The *Natural Hazards Observer*, now in its 28th year of publication, is the Center's most visible and highly regarded activity. Since 2001, the *Observer* has devoted considerable attention to the consequences of the September 11 terrorist attacks, as well as to homeland security policies and programs. The "On the Line" section of the *Observer* included commentaries on emergency evacuation of individuals with special needs, FEMA's multi-hazard mapping initiative, community-based preparedness for urban/wildland fires, and the legislation, policies, and principles that serve as the basis for all-hazards emergency planning. In 2003, the *Observer* was distributed to over 15,000 individuals in the United States and abroad. In addition to hard-copy mailings, each issue of the *Observer* is available on-line via the Center's web site in both html and PDF formats.

The Center's publications program includes many types of publications. These publications range from full-length research studies (monographs), to research-in-progress or article-length discussions (working papers), bibliographies,

QR research reports, and other special publications. The Center also publishes the *Natural Hazards Informer* series, and in cooperation with the ASCE, the *Natural Hazards Review* journal.

In 2003, the Center completed a 604-page Special Publication containing findings from QR research undertaken in the aftermath of the September 11, 2001, terrorist attacks. The volume, *Beyond September 11: An Account of Post-Disaster Research* (*SP*39), contains contributions from researchers who received funding from the Center, as well as from researchers funded through other sources. During FY 2003, seven new QR reports were published, all of which are available free on-line.

In 1999, the Natural Hazards Center established a state-of-the-art publications series called the *Natural Hazards Informer*. Written by experts in the field, each issue features a summary and synthesis of current information on a specific hazards topic, as well as a description of emerging knowledge about which readers should be aware. An electronic version of each issue of the Informer is available from the Center's web site, thereby making the series accessible to a wider audience.

The *Natural Hazards Review* is dedicated to bringing together authors representing the physical, social, and behavioral sciences; engineering; and regulatory and policy disciplines in a forum that addresses cutting edge, holistic, and cross-disciplinary approaches to natural hazards loss and cost reduction.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Observer
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Worst-Case Thinking
An Idea Whose Time Has Come
— an invited comment

Editor's Note: This past year the ***Observer*** *examined six great catastrophes threatening the United States and the world. We thought it appropriate to wrap up the "Disasters Waiting to Happen" series with a general discussion of worst-case thinking and the value it lends to disaster policy.*

Some people say that 9-11 changed everything. That's wrong. It changed some things. But, aside from increasing feelings of vulnerability to disaster, too much remains unchanged. Too much disaster policy continues to take a command-and-control stance. Too many officials still believe the panic myth. And there's been precious little preparation where disasters really happen—at the local level: in offices, schools, trains, and the like. Recognizing our local needs and adopting a strategy of preemptive resilience to foster response abilities before catastrophe strikes would mark a significant change in how we approach disaster, a much needed change. So, what might get us closer to preemptive resilience? An increase in the frequency and intensity of disasters could prompt a reorientation in thinking. So could efforts by academics to further establish the practical applications and general relevance of what we study, and so could an emphasis on worst cases. It's tough to make a case for the latter; I need to build up to it.

The Natural Hazards Observer cover.

The Center distributes a bi-weekly, worldwide electronic newsletter, *Disaster Research* (DR), via the Internet. DR provides information about recent disasters; research-in-progress; legislative, policy, and institutional developments; new programs, projects, and information sources; and upcoming meetings. Perhaps more important, the newsletter allows subscribers to post queries, responses, and comments to the entire readership and thus facilitates global access to knowledgeable individuals and resources.

The Center also maintains the Natural Hazards Center Web Site from which a wealth of information can be accessed (http://www.colorado.edu/hazards). Back issues of *DR* and the *Observer* and other Center publications, the Center's library database (HazLit), and materials from the annual hazards workshop are complemented by extensive lists of resources of information about hazards. These include contact information for hazards-related agencies, organizations, and institutions; a roster of useful periodicals; abstracts of recent hazards literature; links to other hazards information sources; and a comprehensive schedule of upcoming conferences. In 2003, staff devoted a considerable amount of time to redesigning the web site to make it more user-friendly.

The 28th annual invitational Hazards Research and Applications Workshop was held in Boulder, Colorado, July 13-16, 2003. This event was attended by 333 public- and private-sector professionals involved in all aspects of hazards. About 11 percent of the participants were from outside the United States. Countries represented included Australia, Canada, Japan, Mexico, and Switzerland.

The library of the Natural Hazards Center is one of the largest in the United States and worldwide, covering materials on the social science aspects of natural, technological, and human-induced hazards and on strategies for reducing losses from those events. Library holdings currently include over 28,000 books, periodicals, reports, individual articles, CDs, videotapes, and other materials. The library is available for use by students, researchers, practitioners, and others seeking to obtain information regarding hazard-related issues.

In September 2003, a consortium of which the Center is a member received an information technology research (ITR) grant from the NSF. The 5-year ITR project, which is entitled "Responding to the Unexpected," is headquartered at the University of California at Irvine. The project seeks to explore ways in which advanced information technology solutions can be used to improve the management of extreme events such as major earthquakes and terrorist attacks. Partners in the project, which is known as "RESCUE-ITR" ("Responding to Crises and Unexpected Events"), include the City and County of Los Angeles, the City of San Diego, and the City of Irvine. The Center's role in the project will be twofold: to develop a better understanding of the factors associated with the

adoption and implementation of advanced technologies in emergency management and to provide research-based input into modeling efforts, *e.g.*, behavioral and risk communication modeling, that are being undertaken by other investigators.

Pacific Earthquake Engineering Research Center

The PEER Center is an engineering research center administered under the NSF's Engineering Research Centers Program and is headquartered at the University of California at Berkeley. The PEER Center is a part of NSF's program to reduce losses due to earthquakes through the NEHRP. The Federal Government, the State of California, and private industry provide funding for PEER. Investigators from over 20 universities and several consulting companies conduct research in earthquake-related geohazard assessment, engineering seismology, risk management, public policy, and geotechnical and structural engineering.

The mission of PEER is to "develop and disseminate performance-based earthquake engineering (PBEE) methodology and supporting technologies to meet the safety, functionality, and economic needs of owners and society." PBEE is the current widely accepted state-of-the-art methodology for the seismic design of buildings and other structures, in which owners and other decision makers define performance targets in terms of safety, cost, and functionality needs. This approach translates these performance targets into engineering criteria that aim to produce facilities that perform to expectations. To help make seismic hazard mitigation more cost effective, the PEER Center has undertaken a user-driven research approach where researchers, funding entities, and those who implement seismic hazard mitigation work together to develop credible and useful contributions to increasing seismic safety throughout the United States and international communities. The PEER Center's research and technology transfer activities contribute to the four major goals of the NEHRP by helping to systematically reduce seismic risk through the development of PBEE technologies and products, the transfer of the results of PEER's research to the public and private sectors, and in the training of future students, engineers, and researchers.

PEER's research has two heavily interrelated major components: the Core Program and the Lifelines Program. Under the Core Program, the PEER Center is developing PBEE technologies that address the economic and safety needs of property owners and society. Applied research for utilities and transportation systems is conducted under the Lifelines Program.

PEER has created extensive databases that allow us to better characterize and predict future earthquake shaking that may affect a facility or network.

PEER undertook a number of earthquake mitigation activities during this reporting period for Goal A. From a broader societal perspective, PEER's work is contributing to a better understanding of how performance-based regulations fit within the broader regulatory system. Performance-based approaches are founded on the notion that regulations should be based on achievement of specified results rather than on adherence to particular technologies or prescribed means. This notion has been widely accepted as a basis for improving social and environmental regulations; variants of performance-based regulations have been adopted for aspects of air and water quality, building and fire safety, consumer product safety, energy efficiency, food safety, forest practices, nuclear power plants, pipeline safety, and worker safety. Adoption of performance-based regulations requires consideration of how to characterize outcomes, what constitutes desired achievements with respect to the outcomes, and how to measure the level of performance that is obtained. In addressing these fundamental questions from the perspective of affected stakeholders, PEER is laying the groundwork so that PBEE will be an effective basis for achieving building and infrastructure earthquake safety.

PEER has developed significantly improved understanding of the building blocks of PBEE. In the area of strong ground motion, PEER has created extensive databases that allow us to better characterize and predict future earthquake shaking that may affect a facility or network. In the area of engineering, PEER has developed improved models for ground failure (fault rupture and liquefaction); procedures for mitigating ground failure; methods for evaluating failure of existing hazardous buildings, bridges, and electric utility systems;

design procedures for improved performance of existing and new facilities; and models for performance of building contents. In areas of loss modeling, PEER is developing procedures for computing losses and ways of customizing these to meet specific client needs.

PEER is sponsoring research to hasten the adoption and utilization of performance-based risk management among major stakeholders (facility owners and operators, risk managers and insurers, and building-code officials). PEER has contributed to various aspects of earthquake risk management, including work to articulate decision considerations, evaluate earthquake losses, and facilitate implementation of PBEE tools and frameworks. On the topic of decision considerations, PEER has contributed fundamental knowledge on the basis for decisions, including the framing of decisions, financial and other tools for evaluating choices, and studies of how to best present the metrics to stakeholders. PEER has discovered the importance of emphasizing tradeoffs, as opposed to absolute decision metrics, with one important exception being concerns about catastrophic events leading to "risk-of-ruin." On the subject of earthquake losses, PEER has improved fundamental knowledge of the losses and costs associated with structural and non-structural damage to buildings. On implementation, PEER has investigated issues and barriers associated with moving from current prescriptive building codes to emerging performance-based regulations.

NEHRP Accomplishments: Goal B

Goal B activities assure the availability of improved techniques to reduce the seismic vulnerability of facilities and systems. These improvements are achieved through several means, including publication of design, construction, and evaluation guidelines for buildings and lifelines; development of tools to assist in the use of the guidelines; problem-focused research and development to fill knowledge gaps; execution of coordinated post-earthquake investigations; publication of long-term studies to address special problems identified after major earthquakes; cooperation with professional and trade associations to improve the use of technology; advocacy; and the international exchange of information.

Goal B: Improve techniques to reduce seismic vulnerability of facilities and systems

1: Facilitate technology transfer among standards organizations, state and local governments, and private-sector professionals.

2: Improve earthquake loss-reduction knowledge and the quality of practice.

3: Support efforts to improve seismic standards and codes and improve design and construction practices for buildings and lifelines.

The NEHRP Agencies

Federal Emergency Management Agency

The Building Seismic Safety Council (BSSC) of NIBS has partnered with FEMA since the agency's inception to achieve the goals of the NEHRP, primarily to develop effective practices and policies for earthquake loss-reduction and accelerate their implementation and to improve techniques to reduce seismic vulnerability of facilities and systems.

During FY 2003 and 2004, the BSSC completed work on the 2003 edition of the *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures*. The seventh edition of this landmark work reflects the results of recent research and includes seismic design maps based on current USGS hazard maps. The 2003 Provisions document and its accompanying *Commentary* (FEMA Publication 450, Parts I and II) have the consensus approval of the 64 BSSC member organizations and reflect the voluntary efforts of approximately 200 of the Nation's experts on seismic design and construction who contributed their time and expertise in the national interest.

In response to life safety concerns expressed to FEMA by officials in the State of Washington, the BSSC mounted an effort during FY 2004 to develop up-to-date earthquake performance guidance concerning the large steel storage racks commonly used in large home supply and discount stores.

In complementary efforts funded by FEMA, the BSSC's Code Resource Support Committee (CRSC) worked to advance incorporation of the *Provisions*' requirements in the Nation's model building codes and standards. Proposals for change based on the 2003 *Provisions* have been developed for incorporation in the 2006 editions of the ICC's IBC and IRC. CRSC representatives also worked on the committees developing the NFPA model building code, and are involved in the process to update that document. Further, participants in the BSSC *Provisions* update process developed a proposal to modify the seismic provisions in the national load standard (ASCE 7) published by the ASCE to reflect the 2003 *Provisions*. CRSC representatives have responded to local requests for assistance in adopting the *Provisions*-based seismic requirements appearing in the model building codes.

Work to update documents produced earlier by the BSSC to stimulate awareness and use of the *NEHRP Recommended Provisions* and to serve as the basis for education and training programs was initiated during the past 2 fiscal years and is nearing completion. These documents include a guide to application

of the 2000 and 2003 *NEHRP Recommended Provisions* (FEMA Publication 351), a non-technical explanation of the *Provisions* (FEMA Publication 99), and a new version of FEMA's guide for homebuilders that introduces the seismic provisions in the 2000 IRC (FEMA Publication 232). BSSC volunteer experts participated in a variety of meetings and conferences to introduce the concepts embodied in the *Provisions*.

The MMC of NIBS has conducted several projects related the NEHRP goals to develop effective practices and policies for earthquake loss-reduction and accelerate their implementation, improve techniques to reduce seismic vulnerability of facilities and systems, and improve seismic hazard identification and risk assessment methods and their use. The American Lifelines Alliance (ALA) was established by FEMA in 1998 as a public-private partnership to reduce the earthquake risks to lifelines (essential utility and transportation systems that serve communities across all jurisdictions). When the MMC began managing the ALA at the beginning of FY 2003, the scope of ALA efforts was broadened to encompass all hazards. Several earthquake-specific projects and several all-hazards projects considering earthquake risks were conducted in FY 2003-2004:

- The development of a guideline providing comprehensive but easy to follow guidance for the seismic design of piping systems in essential facilities such as power plants, chemical process facilities, oil and gas distribution systems and terminals, and critical post-disaster facilities such as hospitals.

- The development of a guideline presenting design provisions for use in evaluating the integrity of buried pipelines for a variety of applied loads, including earthquake ground motion. The ASME B31 Guideline Committee is considering the integration of this guidance into its standard.

- The development of proposals for revising the above ground steel storage tank seismic design requirements contained in American Petroleum Institute (API) and American Water Works Association (AWWA) standards. API and AWWA standards featuring the revised requirements are being balloted.

- The development of a guide presenting the available performance data for six classes of mechanical components that often must perform critical functions during and after earthquakes (valves, valve operators, pumps, compressors, fans, and packaged air-handling units).

- The development of a set of design provisions to provide water utilities with clear and practical guidance for designing water pipelines with improved resistance to damage from earthquakes.

- The development of procedures that can be used to evaluate the probability of earthquake damage to water transmission systems.

- The development of guidelines for use by electric poser, oil and natural gas pipeline, and wastewater system owners and operators in defining the scope of actions necessary to assess system performance during and after hazard events.

- The periodic assessment of ALA-developed matrices that provide an overview of the current status of natural and manmade hazards guidance available to lifeline system operators in the United States.

National Institute of Standards and Technology

The NEHRP Strategic Plan identified a technology transfer gap that limits the adaptation of basic research knowledge into practice. The Strategic Plan recommends an expanded problem-focused research and guidelines development effort to facilitate the implementation of new mitigation technologies.

As a first step, NIST requested the ATC to convene a workshop of national leaders in earthquake design, practice, regulation, and construction in July 2002. The purpose of the workshop was to assess the state of knowledge and practice and to suggest an action plan to address the gap between research and practice. The action plan identifies industry priorities in two areas: (1) support of the seismic code development process through technical assistance and development of the technical basis for performance standards; and (2) improved seismic design productivity through the development of tools for the evaluation of advanced technologies and practices. The action plan, "The Missing Piece: Improving Seismic Design and Construction Practices (ATC-57)," was published in 2003 and is available from the ATC, www.atcouncil.org. NIST now looks forward to working with the stakeholder community to explore ways to best meet those needs via a public-private partnership. NIST expects this effort will build on NSF-funded basic research, including that conducted as part of the George E. Brown, Jr. NEES Consortium.

In the aftermath of the World Trade Center Disaster, Congress gave NIST the authority to investigate major building failures in the United States, including those caused by earthquakes. The National Construction Safety Team (NCST) Act gives NIST the authority to dispatch teams of experts within 48 hours

following a major building disaster. The Act specifies that the NIST Director develop implementing procedures that "provide for coordination with Federal, State, and local entities that may sponsor research or investigation of building failures, including research conducted under the Earthquake Hazards Reduction Act of 1977." In addition, the Committee Report 107-530 published by the House Science Committee on June 25, 2002 states that, "The Director should clearly define how earthquake researchers and Teams will carry out their responsibilities in a coordinated fashion in cases where building failures have been caused by an earthquake."

NIST's responsibilities under the NCST Act have been incorporated into the recently completed plan to coordinate post-earthquake investigations issued by the NEHRP agencies. The plan (USGS Circular #1242) states that, within 48 hours, NIST will examine the relevant factors associated with building failures that occur as a result of the earthquake and will make reasonable efforts to consult with the other NEHRP agencies before determining whether to conduct an investigation under the Act. Any NIST investigation conducted under the authority of the Act will be limited to failures of one or more buildings or on one class or type of building selected by NIST. In early 2004, NIST participated in a series of tabletop exercises with representatives from the other NEHRP agencies. The exercises simulated the response to earthquake scenarios in different parts of the United States to test the plan.

NIST initiated a project to develop and implement performance criteria for codes and standards, tools, and practical guidance for prevention of progressive structural collapse. Progressive collapse refers to the spread of a structural failure–by a chain reaction–that is disproportionate to a localized triggering failure, often due to abnormal loads. Such collapse can result in a disproportionate loss of life and injuries. The project is considering four distinct but interrelated strategies to mitigate progressive collapse: (1) System design concept; (2) Retard collapse after triggering event; (3) Built-in redundancy via alternate load paths; and (4) Retrofit and design to "harden" structure.

NIST's Building and Fire Research Laboratory conducted standard fire tests at the UL (Northbrook) Furnace.

A key focus of the project is to develop retrofit and design methods that take advantage of the synergies associated with mitigating progressive collapse under multiple threats (blast, impact, fire, wind, and earthquake). The project depends heavily on the development and use of advanced modeling and simulation tools to evaluate the vulnerability of structural systems to progressive collapse under different threats. The project is reviewing and using knowledge gained from controlled demolition technology and builds on that knowledge to develop effective mitigation strategies for progressive collapse. Finally, the project is developing performance criteria and methods to mitigate progressive structural collapse cost-effectively for both new and existing structures based on a combination of existing knowledge, the results of analytical model sensitivity studies, and laboratory and field measurements. NIST has completed a draft best practices guideline and is currently revising the guideline based on comments received from practitioners. The revised guideline will be published in early 2005.

NIST is using a multi-hazard approach to facilitate the development of mitigation technologies. In addition, building fires can often result following an earthquake. The objective of the Fire Safety Design and Retrofit of Structures project is to develop significantly improved standards, tools, and practical guidance for the fire safety design and retrofit of structures. The project is focusing on standards and tools for design of steel and concrete structures and on verified predictive tools and performance criteria to evaluate structural fire performance in real fires.

Five key factors are being considered in developing such performance-based methods.

1. While the current standard fire endurance test method, which stipulates a prescribed time-temperature exposure, is adequate to compare relative performance of structural components, it does not provide any indication about the actual performance, *i.e.*, load carrying capacity, of a component in a real fire environment, *i.e.*, involving fire of building contents.

2. The role of structural connections, diaphragms, and redundancy in enabling load transfer and maintaining overall structural integrity during fire is ignored in structural design. Current design methods are based on fire endurance tests of single components and do not account for the behavior of inter-component connections or the complex two- and three-dimensional behavior of the entire structure.

3. There is a need to evaluate the effectiveness of alternative retrofit, design, and fire protection strategies to enhance structural fire endurance (including alternate cementitious spray or board systems, intumescent coatings, high-performance fire protective coatings, active suppression systems, and more sensitive sensing and monitoring). No practical, high-level models exist today that couple the fire dynamics to the structural system response, and the resulting transient, multi-dimensional heat transfer through structural components made with multiple materials.

4. There is a lack of knowledge about the fire behavior of structures built with innovative materials, *i.e.*, high-strength concrete or steel structures.

5. There is a need to better model and predict the fire hazard to structures from internal and external fires, *i.e.*, due to accidents or terrorist threats. This includes deterministic and probabilistic models for specifying the magnitude, location, and spatial distribution of fire hazards on structures; determination of reliability-based load factors for combined dead, live, and fire loads and resistance factors for loss in structural strength and stiffness; and methods for load and resistance factor design (LRFD) under fire conditions.

The project is developing performance criteria and methods to assure cost-effective structural performance under fire for both retrofit and design applications based on a combination of existing knowledge from around the world, the results of analytical model sensitivity studies, and laboratory and field measurements.

NIST chairs and provides the technical secretariat for the US-Japan Joint Panel on Wind and Seismic Effects (UJNR). The Panel provides a government-to-government forum for the exchange of research data and information between countries that share similar concerns regarding earthquake and wind effects on the built environment. The Panel adopted a strategic plan, jointly developed by NIST and the Public Works Research Institute, at its 33rd Joint Meeting in May 2001. The strategic plan streamlined the operation of the Panel and emphasized the importance of joint research on topics of mutual interest. The Panel has seven technical task committees through which this cooperation occurs:

- Geotechnical Engineering and Ground Motion
- Next-Generation Building and Infrastructure Systems
- Dams
- Wind Engineering
- Transportation Systems
- Advanced Information and Communication Technology for Disaster Prevention and Public Health
- Storm Surge and Tsunami

The Panel is actively exploring the formation of a Task Committee on Fire Performance of Building and Transportation Structures. This new Task Committee will be formed jointly between the Panel on Wind and Seismic Effects and the Panel on Fire Research and Safety.

The Task Committee on Transportation Systems completed a joint guideline on testing of bridge isolation systems in September 2004. This joint guideline establishes consistent methods for evaluating performance of these systems and will be published and used in both the United States and Japan.

The Panel held a successful 36th Joint Meeting in May 2004 at which 27 technical papers were presented. NIST published the proceedings of the 36th Joint Meeting in September 2004.

National Science Foundation

Goal B activities sponsored by the NSF are described below under the earthquake engineering research facilities funded by NSF.

U.S. Geological Survey

In the Municipality of Anchorage, Alaska, the USGS worked in conjunction with the UAF to integrate 14 new strong motion recording systems with an existing network of 22 stations operated by the UAF. The enhanced, 36-station network will provide the critical data needed to generate near-real-time ShakeMaps of the Anchorage area. USGS-led efforts in Anchorage have significantly improved the quality and quantity of seismic instrumentation needed for emergency response and the assessment and mitigation of damaging earthquakes in south-central Alaska.

As part of the Anchorage upgrades, ANSS instrumented the 20-story, State of Alaska (Atwood) building with digital sensor systems located at 10 levels throughout the structure. The USGS Menlo Park office was responsible for installing the structural monitoring system, while UAF personnel installed the interconnecting conduit, cabling, and other ancillary equipment. The ANSS funding also allowed for the installation of sensors and recording systems for a network of six underground (borehole) recording stations located adjacent to the Atwood Building. The combined network represents one of the best instrumented urban areas and soil/structure systems in the country. Data recorded by this network will be

The ANSS funding also allowed for the installation of sensors and recording systems for a network of six underground (borehole) recording stations located adjacent to the Atwood Building..

invaluable to civil and structural engineers for assessing soil-structure interaction, building response, and building performance during large earthquakes.

The Atwood Building installation was unveiled at an event commemorating the 40th anniversary of the 1964 Good Friday earthquake. The March 26 event was sponsored by the USGS, the UAF GI, and members of the local engineering community. Alaska is the most seismically active state in the United States, and the Good Friday earthquake, at moment magnitude 9.2, was the second largest earthquake ever recorded.

Selected State, Territorial, And Local Accomplishments

Alaska

The UAF/GI installed real time earthquake monitoring equipment in the State Emergency Coordination Center (SECC). The system provides immediate earthquake notification showing seismic station depictions of the quake, scientific data, and graphically relates the earthquake to adjacent communities. It allows the SECC to quickly contact communities to gather impact data for potential damage estimates. Alaska is installing this system in other emergency operation centers around the state.

Hawaii

SCD sponsored a series of statewide professional structural and non-structural seismic safety workshops. Structural engineers from the DOI, Bureau of Reclamation, presented at the workshops, which were videotaped for future broadcast on public access channels.

HSEAC also provided technical review of state dam safety earthquake construction standards at the request of the State Department of Land and Natural Resources.

Missouri

SEMA's Earthquake Program Manager continues to act as staff to the Missouri Seismic Safety Commission to urge the adoption of building codes at the local level, support earthquake education, and to sponsor outreach programs.

In addition, SEMA continues building a strong relationship with the Missouri Department of Insurance to educate Missouri's citizens, local government, and the insurance industry about ways to mitigate earthquake damages and the need for appropriate insurance coverage in endangered areas, and to plan for responding to a major earthquake.

Oregon

Oregon conducted a state-wide earthquake exercise QUAKEX 2003 in April 2003, participated in City of Portland full-scale earthquake exercise Shake Ex 04, and produced the *Earthquake Preparedness and Mitigation Guidance*.

Washington

In partnership with the NTHMP, EMD continues to work with the engineering community to investigate whether there are adequate building designs available for both high seismic loading (zone 4 or equivalent in the IBC) and a tsunami inundation area. An example of the problem is Ocean Shores, which would be subject to strong shaking from a Cascadia Subduction Zone earthquake and tsunami inundation within 30 minutes, giving no time for evacuation. This workshop is developing guidance for retrofitting buildings to withstand both the earthquake and tsunami. This year, data has been collected to assess construction requirements of structures requiring earthquake and tsunami design and workshops have been held to review and agree to proposal requirements. This data will be given to FEMA for development of a structural guidance document within the next 3 years.

Other Organizations

Earthquake Engineering Research Institute

NEHRP support has made it possible for EERI to develop and distribute many new publications, including oral histories, monographs, post-earthquake reconnaissance reports, and CD-ROMs from recent damaging earthquakes. These publications are aimed at the engineering and design communities, and disseminate the latest analytical and design techniques. Monographs issued in this period focus on bridge design, energy dissipation systems, and risk analysis, and will enable practicing engineers to incorporate these new techniques into the design and rehabilitation of new and existing buildings and bridges. These publications are

distributed free of charge to over 2,000 EERI members throughout the United States and abroad.

Each year, EERI has awarded a Fellowship to a practicing professional from one of the many fields that contribute to earthquake engineering, to enable that person to gain greater skills and broader expertise in earthquake hazards reduction. In recent years, the fellowships have supported work of professionals in structural engineering, tsunami hazard mitigation, and the earth sciences. The results of their research projects have been incorporated into current building codes and practices, into tsunami hazard modeling, and most recently by helping to bridge the gap between geologists and geotechnical engineers in better understanding the mechanism of liquefaction in earthquakes.

Each year, NEHRP funds also have supported a graduate research fellow from engineering, earth science, or public policy in the completion of their graduate studies. This fellowship is prestigious and very highly sought after. Students have been selected from many universities throughout the United States. Their work has contributed to the goals of NEHRP by developing new tools specific to each of their disciplines that will reduce losses from future earthquakes. All of the recipients have gone on to careers as highly regarded researchers in earthquake engineering or related fields of public policy and decision sciences. Many are in academic positions, where they are influencing a whole new generation to embrace a commitment to earthquake hazard mitigation.

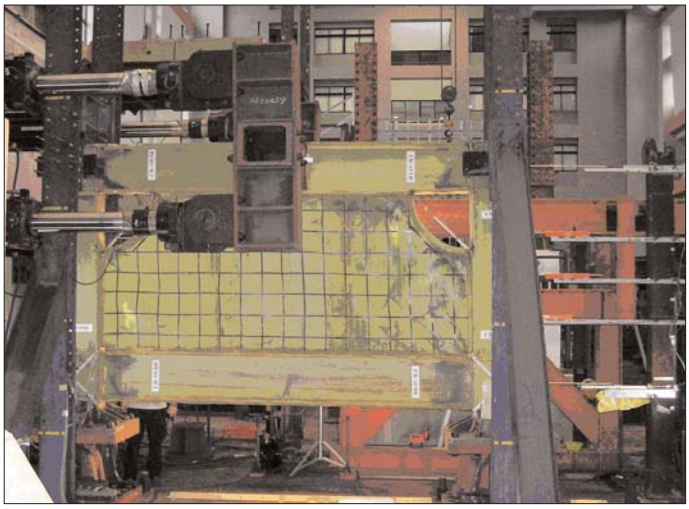
Multidisciplinary Center for Earthquake Engineering Research

As part of its research dedicated to the seismic retrofit of acute care facilities, MCEER initiated a co-operative experimental program with National Taiwan University and the National Center for Research on Earthquake Engineering (NCREE) to investigate the seismic performance of Shear Plated Walls (SPW) designed and fabricated using low yield strength (LYS) steel panels and Reduced Beam Sections (RBS) added to the beam ends. A total of four LYS SPW specimens were designed by MCEER researchers, fabricated in Taiwan, and tested collaboratively by MCEER and NCREE researchers at the NCREE laboratory in Taiwan.

The results of the tests indicated that SPW buildings with low yield steel webs appear to be a viable option for use in resistance of lateral loads imparted during seismic excitation. Collaborative research between MCEER and NCREE is now focusing on developing reliable models that can capture the experimentally observed behavior, and investigating the benefits of this system on enhancing the seismic performance of nonstructural components in acute care facilities.

An advanced systems analysis expands the frontiers of science and engineering by enabling, for the first time, a quantitative prediction of functional degradation of the utility power network under natural and manmade disasters. The degradation of the power network can severely impact the economy and welfare of the community it serves. MCEER's multi-institutional and multidisciplinary team of investigators (involving more than 20 students with diverse backgrounds) collaborated with industry users such as Los Angeles Department of Water and Power (LADWP), Southern California Edison, Memphis Light Gas and Water, and with international partners such as Taiwan Power and NCREE in Taiwan, and Bridgestone Corporation in Japan. This collaboration led to the development of a pioneering software system integrating Western Electricity Coordinating Council's (WECC) power grid database with the Electric Power Research Institute's (EPRI) Interactive Power Flow analysis code. WECC's database covers 14 western states and beyond. This integration is achieved through an advanced GIS framework that allows visual demonstration of the impact of disasters. Innovative use of GIS allows incorporation of natural hazard and infrastructure information and societal data (such as location and number of households served by the network). The software can predict, for example, the possibility of power black-out in each service area of LADWP in Los Angeles after an earthquake, also demonstrating that events as remotely located as the State of Washington can have an impact on Los Angeles. It allows stakeholders to decide if such a possibility is acceptable for various earthquake scenarios, and whether proposed seismic retrofit schemes can be cost-effective. Efforts are continuing to upgrade the software to integrate both of LADWP's water and power networks, and to assess their combined and interdependent performance during an earthquake.

Using finite element analyses and full-scale experiments on pipe specimens supplied by the LADWP, MCEER researchers



MCEER Shear Plated Wall (SPW) specimen being tested at the National Center for Research on Earthquake Engineering (NCREE) in Taiwan.

developed fiber reinforced polymers (FRPs) in collaboration with industry participants. When the FRPs are wrapped around the joints of large diameter water pipelines during new construction or retrofit activities, they substantially increase the axial load capacity of the joints, in many cases doubling pipeline resistance against earthquake compressive loads. The FRPs are now commercially available from several companies. Model contract documents and specifications for FRP strengthening are being prepared by LADWP and MCEER in the construction of over $100 million of new trunk lines in Los Angeles. MCEER researchers also developed and executed the largest laboratory experiments ever performed of ground rupture effects on buried pipelines. The experiments were used to validate an analytical model for evaluating ground rupture effects on pipeline bends, which are critical locations for stress concentration. The analytical model and experimental results were used to make inexpensive changes in welds and wall thickness at the bends that increase capacity by over 100 percent. The work was recognized by the Japan Gas Association Best Paper Award in 2003 and was used to develop a Large Displacement Soil-Structure Interaction Facility for Lifelines at Cornell University, which will be part of the George E. Brown, Jr. NEES sponsored by NSF.

The Federal Highway Administration (FHWA) is overseeing MCEER's ongoing work to produce design guidelines for use by highway bridge engineers on the following subjects: seismic retrofitting of highway bridges and other highway structures such as retaining walls, slopes, tunnels, pavements, and culverts; seismic retrofitting of highway bridge trusses; seismic isolation of highway bridges; and seismic behavior of timber bridges. These references will help transportation agencies and their engineers assess the risk of seismic damage to bridges and take appropriate action to mitigate the risk. These publications are being made available to potential users to disseminate knowledge gained from recent research. Workshops are planned as a means of introducing these into the engineering community.

MCEER conducted a research task to develop ways of improving the seismic performance of slab-on-girder steel bridges through the use of embedded energy dissipators and intelligent semi-active control devices located at or in the end-diaphragms. The relative flexibility of these bridges in the transverse direction may result in overstressing or even failure of load-carrying components such as the end-diaphragms, beams, shear connectors between the deck and girders, bearings, piers, and columns. By using structural dampers or semi-active devices to dissipate energy at the end diaphragms, the safety and reliability of steel bridges can be improved. The results of this research will enable the development of guidelines for use in the design of new bridges and the retrofit of existing bridges using control devices to optimize structural performance and safety.

MCEER has conducted a study on energy dissipation of compression members in concentrically braced frames, and is conducting experimental work to expand this knowledge to improve the seismic performance of steel truss bridges and piers.

Pacific Earthquake Engineering Research Center

In the event of a major earthquake, those who are called upon as first responders will be critical to determining how emergencies are handled, including police officers, emergency operators, hospital staff, and fire fighters. Before these emergency personnel can even begin to do their job properly, however, they need electric power.

As a result of research sponsored by the California Energy Commission's PIER program and PG&E, and conducted by the PEER, new tools and methods are being developed to make electric power transmission more reliable in the event of a major seismic event. Among the areas under study are the substations that receive and distribute electricity to large areas. The major causes of outages during past earthquakes were the catastrophic failures of circuit breakers, transformer bushings, and disconnect switches at the substations.

Concrete is a popular building material. For the most part, it serves its purpose well. To perform well during earthquakes, however, reinforced concrete buildings and bridges need to be properly reinforced with steel. This lesson has been learned and relearned in past California earthquakes, including the 1971 San Fernando earthquake, 1979 Imperial Valley earthquake, 1989 Loma Prieta earthquake, and 1994 Northridge earthquake.

Many hazardous concrete buildings, including many government buildings, also have high and important occupancies, posing a significant life safety risk. One challenge has been deciding whether a building is indeed at high risk: earthquake engineers need better evaluation tools to sort out the good buildings from the bad ones. Another reason is the high cost of building retrofitting; better tools are needed for cost-effective, non-intrusive retrofitting.

PEER has recognized the need and the challenge of mitigating the high seismic risk posed by some of our older existing building stock, and has devoted a significant portion of its research activity toward this problem.

PEER researchers and industry practitioners have successfully applied and tested the performance-based engineering methodology through application to several building and bridge case studies. In one case, the methodology has been applied for the seismic assessment of a science laboratory on the University of California at Berkeley campus to investigate mitigation techniques for a high-tech laboratory as well as the

inter-relationships to the larger campus network of which the laboratory building is a part. Working closely with professional engineering consultants and university administrators, PEER is providing campus administration with tools to assess campus risk, to develop retrofit/mitigation strategies, and to conduct disaster planning. This study is being coordinated with a FEMA-supported Disaster Resistant University initiative, whose aim is to develop a model that other university and industrial campuses can follow. In a case study of a highway bridge, PEER is working in collaboration with CALTRANS and FHWA to investigate bridge performance and its inter-relationships to highway network performance needs for post-earthquake emergency response and recovery. Demonstration of the PEER methodology through these and other case studies is leading to broad acceptance of the methodology in the earthquake engineering research and practice communities.

The PEER Center work with other earthquake engineering research centers in the United States and in Europe, Japan, and Taiwan, already has led to the sharing of information regarding specific PBEE research results for bridge components and highway transportation system studies that can help emergency response officials direct traffic around major blockages.

NEHRP Accomplishments: Goal C

Seismic hazard identification and risk assessment are critical components of NEHRP's earthquake mitigation strategy. Under Goal C, NEHRP agencies identify and quantify seismic hazards through improved seismic monitoring and through detailed geological and geophysical characterization of regions of active faulting. The seismic hazard information then becomes the foundation upon which subsequent risk assessment models are based.

PEER is working in collaboration with CALTRANS and FHWA to investigate bridge performance and its inter-relationships to highway network performance needs for post-earthquake emergency response and recovery.

Goal C: Improve seismic hazard identification and risk assessment methods and their use

1: Provide rapid, reliable information about earthquakes and earthquake-induced damage.

2: Improve seismic hazard characterization and mapping.

3: Support development and use of risk and loss assessment tools.

The NEHRP Agencies

Federal Emergency Management Agency

Securing the Nation's communities, businesses, housing, and infrastructure from disasters requires a comprehensive approach that includes hazard resistant construction, prudent land use, emergency preparedness, rapid response and recovery, and increased awareness of multiple threats. Information on potential damage, shared at federal, state, and local levels, is a key to these life-saving priorities.

To assess risk and share data effectively requires a nationally applicable, computer-based disaster planning and analysis tool able to:

- Estimate size and location of possible threats
- Calculate resulting damage and disruption
- Utilize supporting data from varied sources
- Link with other emergency management and planning tools before, during, and after disasters

In 1992, through agreements with FEMA, the NIBS began crafting such a tool, beginning with the potential effects of earthquakes. Methodologies reviewed by seismic experts were programmed into advanced, easily usable software called HAZUS. Before the debut of HAZUS in 1997, plotting the likely result of an earthquake required expensive engineering consultants, laborious hand calculations, and piecemeal use of computers.

In the 7 years since FEMA published the prototype earthquake edition HAZUS97, HAZUS has helped communities across the United States identify and plan for earthquakes by giving them access, free of charge, to specialized databases and GIS-based analytic tools. Planning with HAZUS can save lives, property, and tax dollars.

HAZUS-MH (HAZUS Multihazard) for earthquakes streamlines modeling by merging up-to-date natural hazards engineering and science with ESRI's powerful geographic

information system, ArcGIS. Users can estimate damage and other earthquake effects and then map, display, and manage the results. Interoperability with other software is aided by the use of standard third-party platforms, editable national databases, and access to external data and the capabilities of other models.

With the completion of HAZUS-MH in February 2004, FEMA has improved seismic hazard identification and risk assessment methods with the implementation of the fifth version of its nationally applicable earthquake hazard model. HAZUS-MH supports the latest revision of the original earthquake tool plus integrated multihazard analysis with new flood and hurricane damage models. A third-party integration option gives operational access to other natural and man-made hazard models. HAZUS-MH maintains two data management tools designed to help users incorporate their own detailed, site-specific data for more precise results:

- Building Inventory Tool (BIT) for tax assessor data.
- Inventory Collection and Survey Tool (InCAST) for building data.

The updated Earthquake Model continues to enable better collaboration among federal, state and local agencies, and the private sector.

- HAZUS-MH is supporting state and local agencies in implementing programs for Pre-Disaster Mitigation under the Disaster Mitigation Act of 2000.
- HAZUS-MH is supporting a congressionally mandated program to determine the benefits of mitigation.
- Twenty user groups consisting of public and private sector HAZUS users have been formed in cities, such as Los Angeles and San Francisco, to discuss uses and applications of HAZUS and to pool resources and data to identify and carry out specific projects.
- Twice the number of emergency managers has been trained to use HAZUS-MH than were trained in the 6 years following the release of HAZUS97.
- The number of new users implementing HAZUS-MH is expected to rise dramatically with the expansion of capability from earthquake-only to earthquake, hurricane, flood, and third-party software modeling.

HAZUS-MH's latest earthquake software incorporates over 20 databases including Census Bureau demographics and other federal resources. To refine and improve results, HAZUS can readily import site-specific soils, liquefaction, building, and population data from several common formats. HAZUS-MH's data management system is designed to permit future operation from the Internet.

The Earthquake Model provides estimates of damage to property, hospitals, fire and police stations, schools, bridges and other transportation facilities, and utilities. Ground motion and ground failure information is used to calculate earthquake damage. The model also addresses building debris generation, fires that occur after earthquakes, casualties, shelter requirements, and economic losses. The Earthquake Model includes the Advanced Engineering Building Module for analysis of earthquake resistant construction in individual and groups of buildings.

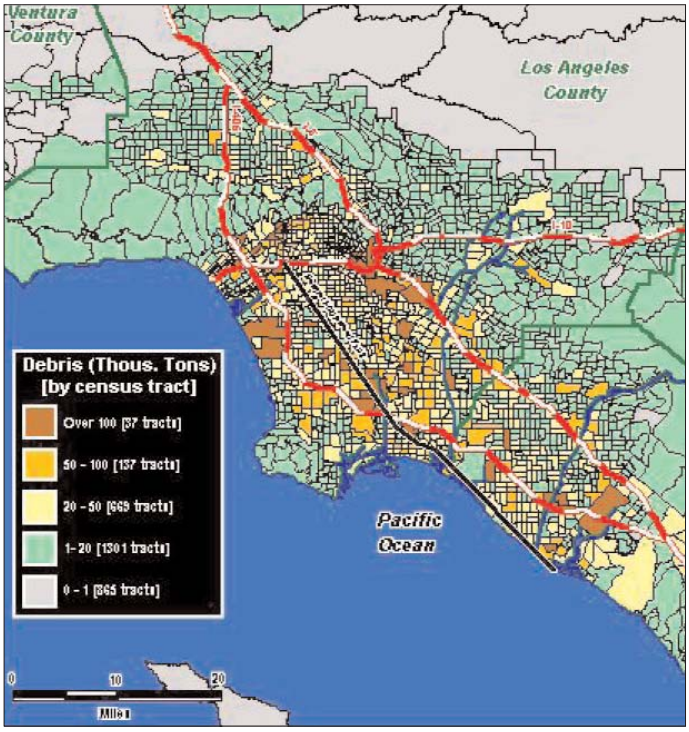
A sixth edition of the HAZUS Earthquake Model, which will be released as part of HAZUS-MH MR1, will feature faster runtimes for supporting rapid loss estimation during earthquake response operations, a capability to add specialized local building types to the earthquake analysis, updated third-party software platforms, and numerous improvements based on user input.

HAZUS-MH for earthquake analysis is available on a combination of CD-ROMs and DVDs from the FEMA website at www.fema.gov/hazus. From here, technical and software user manuals are available for viewing or downloading. Technical support for HAZUS users is provided on-line, via telephone and fax, and through FEMA-sponsored training. HAZUS-MH MR1 availability will be streamlined to a set of DVDs.

The FEMA Region VII Earthquake Program continues partnering with Missouri SEMA to reduce seismic vulnerability of facilities and systems. FEMA Region VII staff held the kickoff meeting of the Heartland HAZUS Users Group in May 2004. Staff also partnered with the University of Missouri-Rolla (UMR) Hazard Mitigation Institute and the UMR School of Engineering to provide HAZUS-MH training to a class of 30 students from businesses, federal, state and local agencies, and UMR. Regional staff promoted earthquake safety and the use of HAZUS through various exhibits and presentations, including the 2003 Annual Conference of the Association of State Flood Plain Managers in St. Louis. Regional staff also serves on the Advisory Committee for the USGS St. Louis Urban Seismic Mapping Project.

U.S. Geological Survey

USGS national seismic hazard maps are used to develop new, unified building codes for the United States. The maps integrate geologic mapping, fault locations, fault slip rates, and earthquake recurrence intervals, and analyses of crustal deformation, ground-motion patterns, and recent seismicity. These maps are in digital format and provide, as a function of latitude and longitude, the maximum severity of ground-



Debris generated from a HAZUS simulated earthquake scenario.

shaking (in terms of horizontal acceleration) that can be expected during exposure periods of 50, 100, and 250 years. The maps serve as the basis for applying the seismic design criteria contained in the building codes, and the maps and their associated databases are also being used to predict earthquake losses and to define insurance risks. This earthquake hazard mapping effort includes Hawaii, Puerto Rico, the U.S. Virgin Islands, American Samoa, and Guam. Periodic review and updating of the seismic hazard maps to incorporate new information are among the highest priorities for the USGS. The USGS works closely with earthquake researchers, engineers, and state and local government representatives across the United States to ensure that the base geologic data represent the most current and accurate information available.

The USGS National Hazard Maps are the federal and industry standard used throughout the country for Building Seismic Design Codes, U.S. Environmental Protection Agency requirements, insurance-loss estimation, and hazards assessment and emergency-response planning by FEMA. Updated and revised maps were published in FY 2002. Review and updating of the maps by USGS benefited from the participation of many state and federal agencies as well as the private sector. The FY 2002 revision took into account a wide range of recent research results related to past earthquakes in various regions of the United States and related urban centers, including the Pacific Northwest (Seattle), southern California (Los Angeles), central California (San Francisco-Oakland), the Western States (Las Vegas, Salt Lake City), the Central United States (Memphis, St. Louis), and the Eastern United States (Boston, Charleston). USGS has begun planning the process for the next periodic map update in 2008.

A component of the seismic hazard assessment effort is the preparation of design maps for use in model building codes. The USGS seismic hazard maps are incorporated into the *NEHRP Recommended Provisions*, which serve as the resource documents for the IBC and the IRC. The IBC and IRC have largely replaced regional-based codes in the United States, and will be subject to periodic updates every 3 years. As part of the design map effort, USGS researchers released a CD-ROM that allows designers to easily locate pertinent seismic map design parameters; this single source for all design information represents a significant timesaving for designers. The model code groups include the CD with all copies of the code document that are sold.

The national-scale earthquake hazards maps cannot take into account variations in the amplitude and duration of seismic shaking caused by local geologic structures and soil conditions. The USGS generates products that address the specific hazards in high- to moderate-risk urban areas, such as the San Francisco Bay area and Los Angeles, California; Seattle, Washington; Salt Lake City, Utah; Memphis, Tennessee; and Charleston, South Carolina. Earthquake shaking scenarios are being developed for public planning, and modeling of ground motion is being provided for engineering applications. In conjunction with these products, the USGS conducts workshops to ensure the proper transfer of knowledge and to help design effective mitigation.

The Memphis area is part of the NMSZ, an area of frequent earthquakes that stretches along the lower Mississippi Valley just west of Memphis, Tennessee, into southern Illinois. More earthquakes occur in this zone than any other part of the United States east of the Rockies. The USGS and the Center for Earthquake Research and Information (CERI) at the University of Memphis updated probabilities of earthquakes in the NMSZ. The new estimate is that there is a 7 to 10 percent chance, in the next 50 years, of a major earthquake similar to the series of several magnitude 7 to 8 events that occurred in 1811-1812, and a 25 to 40 percent chance of a magnitude 6.0 or greater earthquake. A suite of detailed hazard maps for Memphis and Shelby County, Tennessee, were completed in FY 2003. These include new 1:24,000-scale geologic maps for Memphis; a map of seismic wave amplification potential that demonstrates the enhancement of seismic shaking near the Mississippi River; and a 3-D model of the sedimentary structure and shear wave velocity of rocks and soils underlying the city, used to predict the path of seismic waves. Together with Georgia Tech, the USGS developed a new methodology for calculating the potential for soil liquefaction during strong shaking and applying the method in maps for the Memphis and Shelby County areas. In a dramatic phase of

the work, large blasts were detonated deep within sediments along the Mississippi River to simulate an earthquake, helping scientists to understand how seismic "waves" move through the deep sand and clay layers of sediment that are characteristic of the region. In this experiment, USGS scientists used newly-installed strong motion seismographs, part of the ANSS, to record the explosions and learn more about how buildings and other infrastructure are affected by ground shaking. Builders, developers, and the insurance industry can factor this kind of earthquake shaking information into how and where buildings are built and how building codes and zoning regulations are developed. Earth scientists and engineers will use the information to study seismic wave propagation and soil amplification, to estimate earthquake hazard, and to develop safer structures.

Extending back into the 17th century, there is a record of earthquakes striking various locations in the central United States. In FY 2001, the USGS published a new full-color wall poster map of the central United States showing all of the historic earthquakes recorded or otherwise known to have occurred in the region since 1699. The map area includes the well-known NMSZ. The poster map (USGS Geologic Investigations Series I-2812) is an important educational tool for the population in the region and also serves as a planning document for agencies such as the CUSEC and FEMA for promoting earthquake preparedness.

USGS recently unveiled an up-to-date and comprehensive nationwide compilation of information on known or suspected active faults. Accessible via a user-friendly Web interface at: http://Qfaults.cr.usgs.gov/, the database summarizes geologic, geomorphic, and geographic data for about 2,000 faults in the United States that are believed to be sources of earthquakes greater than magnitude 6 and having documented activity during the past 1.6 million years. Much of the information is based on paleoseismology, which is the geologic study of prehistoric earthquakes. Paleoseismology combines geologic tools such as trenching with archeological-style analysis to determine the times and sizes of ancient earthquakes in the Quaternary Period. The database is designed to fulfill the needs of a broad group of users, ranging from the science community to the general public. The seismic hazard assessment community will benefit from public access to all data available on potential earthquake sources in one location. The database will allow these users to identify faults that have likely produced strong ground motion in the geologically recent past and that may contribute to future seismic hazards. Other potential users include the earthquake-engineering community, the insurance industry, and companies managing large infrastructures, such as pipelines or power-transmission networks. In addition, state and local planners can use the database to locate potential earthquake sources on maps. Similarly, emergency response officials can use the database to plan earthquake drills and to identify and fortify critical infrastructure near active faults. Finally, the general public is becoming increasingly aware of potential hazards in their environment. The USGS, as well as State Geological Surveys, frequently are called upon to respond to questions regarding the location of hazardous faults that may impact the lives of the population at large.

Regional Consortia

Cascadia Region Earthquake Workgroup

For the Cascadia Scenario Project, CREW Board members are working jointly with the Oregon DOGAMI to prepare a document describing the seismic risks facing the Cascadia Region. This is a follow-up to the HAZUS working group products completed last year. The CREW leadership also attended a HAZUS training program held at FEMA's EMI and supported the Washington State HAZUS Users Group.

Central United States Earthquake Consortium

The Association of CUSEC State Geologists has continued to look at ways to improve seismic hazard identification and risk assessment methods and their use. Working in collaboration with other CUSEC partners, the Association has developed a mapping partnership that includes the USGS-Mid America Mapping Center, the CUSEC State Transportation Task Force, and the USGS Earthquake Hazards Program. Efforts have consisted of collection of shear wave data for the purpose of revising the Borcherdt Soils Classification. In support of this effort, workshops were held to demonstrate the benefits of using geoscience products at the community level.

CUSEC also sponsored field trips during this period to observe field work by the USGS in collecting shear wave information throughout the central United States. The field trips provided an opportunity for researchers and non-researchers to discuss the importance of this type of work and how it can be used. The interaction has resulted in the pursuit of additional field investigations in other areas of the central United States.

During this period, new seismic recording instruments were installed in New Harmony, Indiana, further enhancing the limited seismic network in the central United States.

One of the most promising tools for identifying and ultimately improving the region's seismic risk is HAZUS. Participants at introductory workshops represented local and state government, as well as university students.

To improve the understanding of earthquakes and their effects, CUSEC offered a number of workshops specifically focused on the earthquake hazard and its associated risk. The

understanding of the earthquake risk is directly tied to the understanding of the hazard in the central United States. The low recurrence intervals of seismic events, and the longer return periods between them, contributes to a lack of understanding. Working with the USGS, the Association of CUSEC State Geologists has provided basic Earthquake 101 workshops to increase the level of understanding not only for those who are responsible for the community's safety, but also for those who can be champions for the cause.

A considerable amount of work has also gone into preparing for the next damaging event so that valuable information is not lost. The coordination of the research response is an essential element in this effort. It is also important that the collection of this information does not interrupt the emergency response that would take place. To address these issues, CUSEC organized a committee to assist in the development of a research coordination plan. The Post Earthquake Technical Clearinghouse Plan will help assure a smooth co-existence between the research and emergency response efforts.

Northeast States Emergency Consortium

NESEC established a HAZUS-MH and GIS Assistance and Coordination Center within its existing office in Wakefield, Massachusetts. NESEC's priority is to provide direct support to those Northeast State Emergency Management Agencies that presently do not have the resources and staff to develop an in-house GIS and HAZUS-MH capability.

Selected State, Territorial, And Local Accomplishments

Alaska

Alaska is using VRISKMap® software to facilitate risk and vulnerability analysis from earthquake and other natural hazards. The software allows Mitigation Staff to overlay hazard maps, delineate by degree of hazard, and run queries giving population and infrastructure associated information to determine potential impact and estimated losses. Alaska is currently assisting its largest communities and boroughs with developing Local All-Hazard Mitigation Plans to fulfill the Disaster Mitigation Act of 2000 criteria. These plans are essential for identifying the risks, vulnerabilities, and the economic impact to the State's population and infrastructure from natural hazards, such as Alaska's extensive earthquake hazard. These plans cover approximately 83 percent of Alaska's population. Mitigation Plans will soon be coordinated with a web-based interface using MitigationPlan.com® software to facilitate associating local hazard mitigation plans, hazard data, strategies, goals, and initiatives with the State Plan.

Arkansas

Arkansas has trained several local coordinators and economic development districts on planning for disasters, developing risk assessments, and identifying their hazards. Currently, Arkansas and several of its counties are using HAZUS to run risk assessments and to help develop their local hazard mitigation plans.

California

OES Earthquake Program staff continues to serve on the HAZUS Earthquake committee and as beta testers for the earthquake module of HAZUS-MH. Staff performs benchmark evaluations of beta versions before formal release by FEMA. HAZUS continues to be used extensively by OES GIS staff in northern and southern California in the development of planning scenarios for state agencies and local governments. OES uses both HAZUS generated ground motions as well as ShakeMap ground motion maps to generate earthquake loss estimates. Staff also continues to participate in the HAZUS Users Groups in the Bay Area and southern California and with the ESRI HAZUS Users.

OES used HAZUS to provide initial assessments of damage in the San Simeon earthquake (December 22, 2003) and for the Parkfield earthquake in 2004. In both earthquakes, HAZUS estimates with ShakeMap input were used to assist state and local agencies and FEMA in determining response priorities.

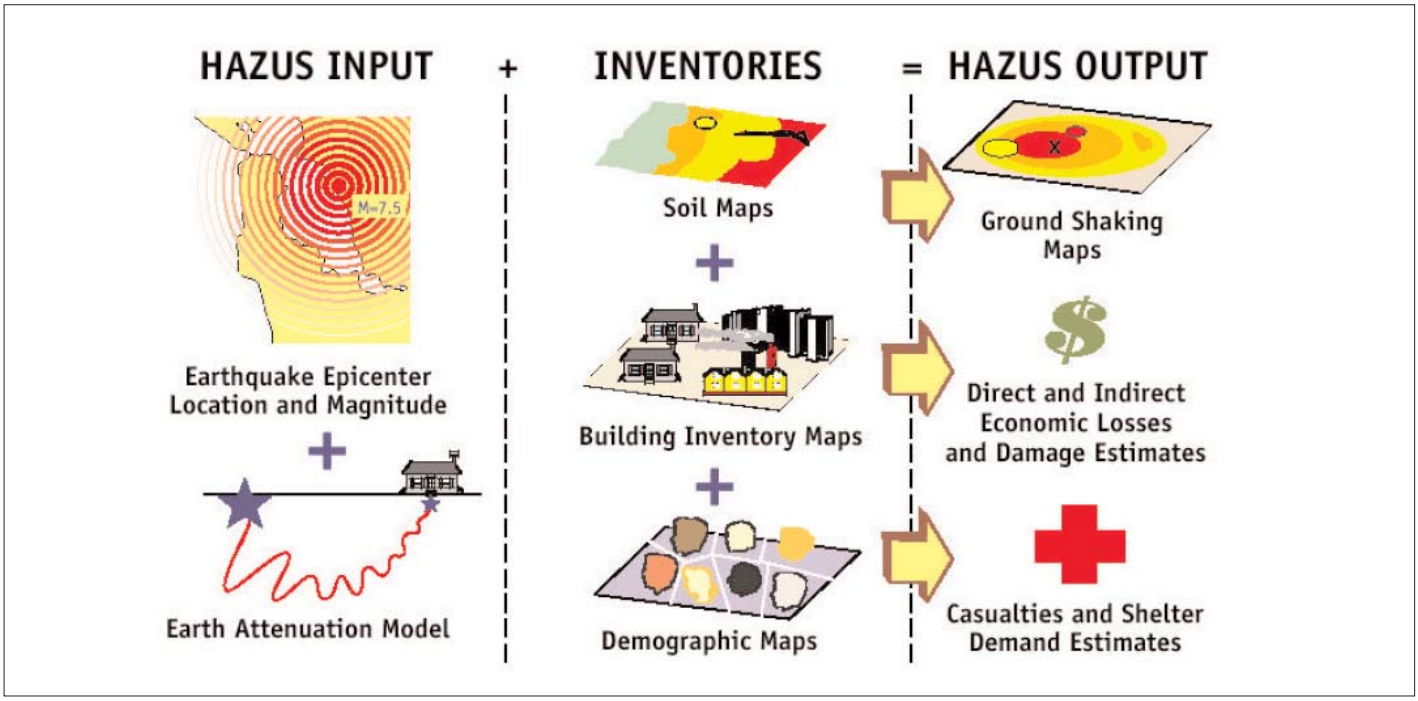
Hawaii

HSEAC successfully implemented the HAZUS Earthquake Loss Estimation Methodology using a newly constructed Building Inventory Database for Hawaii and Maui Counties that yield more accurate damage results. Moreover, during a destructive Hawaii earthquake event, the Pacific Disaster Center (PDC) will generate a HAZUS report and construct a power point graphics briefing within 60 minutes after earthquake origin time for critical decision-making by the Hawaii Emergency Management community.

HSEAC and the PDC developed a HAZUS Atlas of 20 credible earthquake damage scenarios for use in community planning in mitigation, preparedness, and emergency response and recovery.

Idaho

The Bureau of Disaster Services and Idaho Geological Survey are working with network operators, end-users, and representatives of USGS to develop a plan to implement the ANSS in the state and to resuscitate failing networks. The plan is available at the Bureau of Disaster Services website, http://www2.state.id.us/bdsmitigation/resources_doc.html#.



Earthquake Loss Estimation using HAZUS.

Urban geologic hazard mapping is a high priority in Idaho. The Idaho Geological Survey has completed updated versions of the Idaho fault map, posted on the Survey's website (http://www.idahogeology.org/Services/GeologicHazards/default.htm). The Survey also completed quaternary maps in northern, western, and central Idaho that address landslide and faulting hazards.

Missouri

SEMA continues to partner with the Missouri DNR to address earthquake geologic issues and provide support to the Seismic Safety Commission. DNR collects, interprets, and provides geologic information, maps, and reports regarding the potential for geologic hazards, including earthquakes, landslides, and sinkhole collapses. DNR also continues mapping Missouri's geologically seismic areas, an effort initiated with NEHRP seed money provided by FEMA and the USGS.

New Jersey

The New Jersey earthquake hazard reduction program emphasis during FY 2003-2004 has been a continuing effort to populate the HAZUS loss estimation model in concert with New York State and New York City through a cooperative, multi-agency organization known as NYCEM (New York Area Consortium for Earthquake Loss Mitigation). Under this multi-year program, data for counties radiating outward from the New York metropolitan area has been developed and integrated into the HAZUS model.

New Jersey data for HAZUS is provided by two organizations under contract from the New Jersey Office of Emergency Management. The New Jersey Geological Survey (NJGS) provides geological and earthquake history data. During 2003-2004, the NJGS completed geologic databases for Middlesex County and Passaic County. An engineering consulting firm provided structural and census information in 2003-2004 and completed studies for Morris, Middlesex, and Passaic Counties.

Middlesex County

Geologic, topographic, and test-boring data were acquired and analyzed to map seismic soil class, liquefaction susceptibility, and landslide susceptibility for Middlesex County. The soil class, liquefaction susceptibility, and landslide susceptibility data were entered into the HAZUS model for each census tract in the county. The HAZUS model was run with the full upgraded geologic data and with the default geologic data for earthquake magnitudes of 5.5 and 6. To assess the effect of liquefaction, runs were also made with full upgraded geology and with upgrade without liquefaction for magnitudes 5, 5.5, 6, 6.5, and 7. The upgraded geology changed both the spatial distribution of damage and the total damage estimates compared to default geology. The upgraded geology produced greater building damage in the lower Raritan River valley and Arthur Kill areas of the county, where salt-marsh soils are softer and more liquefiable than the default, and less building damage in most other areas, where till, weathered-bedrock soils, and Cretaceous clay and sand are stronger than the default. Because most soils in the county are stronger than the default, the total economic loss is between 10 and 20 percent less with the upgraded geologic data than with the default data at all magnitudes. Adding liquefaction

increases building damage about 10 percent in susceptible census tracts, especially at magnitudes less than 7, but results in less than a 5 percent increase in total loss for the entire county. This is a minimum value because the model does not calculate damage to roads, railways, and underground utilities caused by liquefaction. Structures particularly susceptible to damage from permanent ground displacement, such as pipelines and bridges, show significantly increased breakage when liquefaction is added.

In addition to the HAZUS data upgrades and runs, shear-wave velocity was measured on four soil types (Cretaceous clay, Cretaceous sand, Pensauken Formation sand and gravel, and stream-terrace sand) at a total of 12 locations. These measurements were made to check the soil-class assignments, which use test-drilling data as a proxy for shear-wave velocity. The measured velocities generally confirmed the assignments. Weathering reduces velocities in the near-surface parts of Cretaceous sand and clay, an effect previously observed in till in glaciated terrain.

Passaic County

Geologic, topographic, and test-boring data were acquired and analyzed to map seismic soil class, liquefaction susceptibility, and landslide susceptibility for Passaic County. The soil class, liquefaction susceptibility, and landslide susceptibility data were entered into the HAZUS model for each census tract in the county. The HAZUS model was run with the full upgraded geologic data and with the default geologic data for earthquake magnitudes of 5.5 and 6. To assess the effect of landslides, runs were also made with full upgraded geology and with upgraded geology without landslide hazard for magnitudes 5.5, 6, and 7. The upgraded geology changed both the spatial distribution of damage and the total damage estimates compared to default geology. The upgraded geology produced greater building damage in the Pompton River valley, Preakness Valley, and parts of the Passaic River valley, where glacial-lake and alluvial soils are more liquefiable than the default, and less building damage in most other areas, where till, bedrock, and glacial gravel are stronger than the default and have low liquefaction susceptibility.

In addition to the HAZUS data upgrades and runs, shear-wave velocity was measured on four soil types (alluvium, glacial sand, glacial gravel, and till) at 12 locations. These measurements were made to check the soil-class assignments, which use test-drilling data as a proxy for shear-wave velocity. The measured velocities confirmed the assignments.

Over the past 2 years, three studies were performed using the soil information and geologic data to forecast the losses that Morris, Passaic, and Middlesex Counties could suffer after an earthquake. These studies describe the scale and extent of damage and disruption that may result from potential earthquakes in these counties and compliment current and past earthquake loss-estimation work in Bergen, Essex, Hudson, and Union Counties, as well as the greater NY-CT-NJ Metropolitan Region. An improved building inventory for the counties was established for implementation in HAZUS. The infrastructure represents a combined 1.1 billion square feet, and a total replacement value of $73.1 billion. Almost 543,000 households are in these counties, representing a total population of 1.7 million.

New York

A preliminary forecast of the type of losses that the New York City area could suffer after an earthquake is the subject of a study funded by FEMA Region II and coordinated by MCEER. The initial stages of this study involved fact-finding and assessment, with the development of preliminary soil maps and building inventories. The primary objective of this study was to carry out an initial risk characterization for Manhattan below 59th Street. The report documents the findings of a preliminary study focusing on seismic risks in the New York City area.

The tasks of this study were to:

- Become familiar with earthquake loss estimation methodologies and HAZUS.
- Perform HAZUS scenario runs in the New York City area using default soil and building information supplied by the HAZUS code.
- Perform HAZUS scenario runs using two representative census tracts in Manhattan to examine the sensitivity of loss estimation to different soil conditions and different building inventories.

The preliminary results of the research indicate:

- Dramatic differences in total loss estimates between runs done with default values and runs done with improved estimates of soil conditions and building inventories.
- Differences are more dramatic for smaller magnitude events.
- Total loss estimates in the modified runs can differ significantly with those of the default (by more than a factor of 10).
- The effect of switching to better estimates of building inventory can be as important as the effect of switching to better estimates of soil conditions.
- Parts of New York City have the unique characteristic of a considerable percentage of tall buildings.

- It is of paramount importance to establish better estimates for soil conditions and building inventory for the entire New York City area.

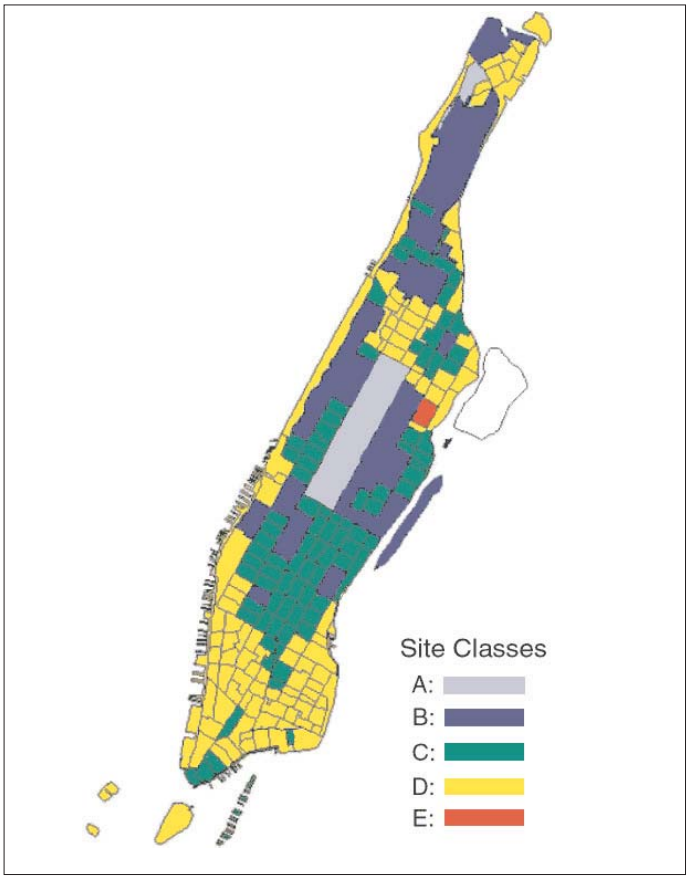
During the last 2 years, work refining the research to develop a more accurate loss estimate was undertaken. This included:

- Providing better data for building age, type, quality, height, square footage, and seismic design level, and performing sensitivity analyses to determine their relative importance.

- Upgrading soil and building inventory information for the entire New York City area.

- Developing and upgrading more accurate fragility curves for the type of buildings unique to the New York City area.

The goal of this loss estimation project is provide a framework for businesses and agencies to take mitigation actions to reduce potential damage and losses from an earthquake.



Generated by HAZUS, this map describes the distribution of soil/rock types across the island, with higher elevations in uptown Manhattan on stiff rock/soil (Class B), intermediate type C in Midtown, and softsoil (Class D) in lower Manhattan, along the identified fault zones in Upper Manhattan and in low-lying, coastal areas.

The New York State Emergency Management Office has been an active user of HAZUS since it was first introduced by FEMA in 1994. Major efforts have included collaboration with the NYCEM study of the New York metro area; spearheading efforts with the New York State Geological Survey in shear wave velocity testing of the state's surficial geology, leading to the development of county level HAZUS ready soil site classification maps; a HAZUS validation study based on a comparison of observed versus modeled losses from the Ausable Forks, New York earthquake; incorporation of HAZUS-based risk assessments into the State Hazard Mitigation Plan; and assisting New York City Office of Emergency Management in adopting and using HAZUS.

Vermont

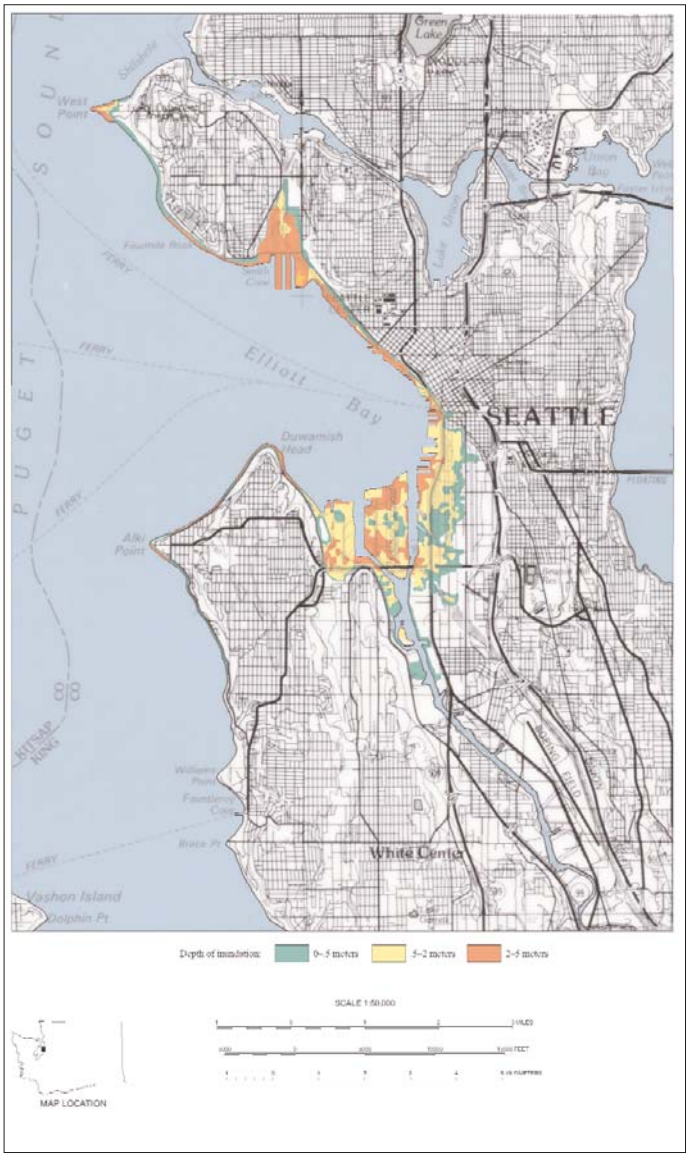
For the first prototype of a pre-disaster mitigation plan in Vermont, the Vermont Geological Survey ran a number of HAZUS-MH scenarios to predict earthquake damage in Addison County. The earthquake estimation and loss data were transferred to plans that will be adopted by towns as preparation for earthquake events. The State of Vermont recently submitted to FEMA the Draft State Hazard Mitigation Plan. The Vermont Geological Survey supplied HAZUS-MH information for the plan based on postulated events in and around Vermont. HAZUS-MH was used for the critical portion of the plan to indicate risk, vulnerability, and estimating losses.

Washington

The State of Washington produced reconnaissance NEHRP site class maps and liquefaction susceptibility maps for every county in the state. Detailed maps were prepared for select cities. The project was funded by an HMGP grant awarded after the February 2001 Nisqually earthquake. The maps support state IBC/IRC implementation and are used in mitigation and preparedness planning at the state and local level.

In partnership with the NTHMP and the NOAA Center for TIME, Washington produced tsunami hazard maps for Seattle, Whidbey Island, Bellingham, and Anacortes. The maps are used in land use planning at the state, county, and community level, and in response-planning activities at state and local level.

Washington continued the collaborated effort with FEMA and FEMA Region X to teach HAZUS locally to the public and private sector. The HAZUS course has been updated to teach HAZUS-MH and is followed up with one-on-one training within the local jurisdiction to ensure that HAZUS is correctly loaded and used. A Washington HAZUS Users Group (HUG) meets monthly and works with various jurisdictions/private entities on HAZUS issues and better data sharing among all



Tsunami hazard map of Seattle.

state HAZUS users. The course allows students to deal with local issues and focuses on a multi-disciplinary approach to using HAZUS for hazard mitigation. HAZUS training is more accessible to the local communities and provides the opportunity for the emergency manager and others to take HAZUS directly to local officials and community groups.

The City of Seattle completed a HAZUS Pilot Project on designated schools. The project used HAZUS-MH to support emergency response plans for schools in the Seattle Public School District. It emphasized the seismic vulnerabilities of school facilities, nearby bridges, and other resources upon which the schools would depend in an emergency. Using HAZUS-MH, each "Hazard Impact Area" was analyzed based on several earthquake scenarios to produce damage estimates that will later be used to support mitigation and preparation planning. The project also produced two maps for each participating school showing resources in their area. The goal is to develop a template that school districts in Washington can use to assess their school structures and develop appropriate mitigation and preparedness plans.

Other Organizations

Earthquake Engineering Research Institute

In 2003, the University of California, Berkeley EERI Student chapter, together with leading practicing engineers in EERI, partnered with the City of Berkeley to conduct a walkabout, to help city officials identify and inventory seismically vulnerable multi-unit, soft story buildings in their community. The students were excited to put their academic knowledge to such practical use and further reinforced their decision to make earthquake engineering a career.

Multidisciplinary Center for Earthquake Engineering Research

For the past several years, MCEER has been developing, under the sponsorship of the FHWA, a new methodology for deterministic and probabilistic seismic risk analysis of highway systems nationwide. MCEER has recently implemented this new methodology into a public-domain software package named REDARS (Risks from Earthquake Damage to Roadway Systems).

This software has since become an important tool in enabling research collaboration between the three EERCs. For example, CALTRANS has initiated a trial study to apply REDARS to a region of the Bay Area Highway Network. While CALTRANS funding for this project is from outside the three EERCs, the PEER Center and MCEER-FHWA are providing input to the project. MCEER-FHWA is providing technical support for a more user-friendly demonstration version of REDARS. PEER is sharing data sets developed previously in its own Highway Demonstration Project of the Bay Area and is interested in cooperating on the implementation of enhanced bridge performance models and hazard modules in REDARS. The MAE Center also is exploring whether REDARS could potentially be used for a small region, *e.g.*, Memphis, to serve as a validation/calibration to the more global loss modeling work by MAE researchers. Facilities and modules in REDARS that are amenable to implementation within the MAE Center Visualization module MAEVIZ are also being considered as part of this tri-center collaboration.

MCEER has produced seismic risk analysis software called REDARS 1.0 that will allow transportation asset owners to perform network analysis for pre-event planning and post-event response. A validation study was successfully completed using historical data in the Los Angeles metropolitan area and in June 2003, MCEER hosted a researcher and user workshop to verify the direction of product development being done to produce REDARS 2.0. Completed work consists of (a)

developing a public-domain version of software (REDARS 2.0) that will be based on the seismic risk analysis methodology; (b) expanding various technical features of the hazards and component modules of this software; (c) programming new variance-reduction and decision-guidance that will substantially reduce the number of scenario earthquakes and simulations needed to achieve given confidence levels and limits for probabilistic applications of the REDARS methodology for seismic risk analysis of highway systems; and (d) documentation of alternative approaches for representing relative costs and risks of various highway system seismic risk reduction options that may be evaluated in future applications of REDARS.

MCEER also is developing fragility curves for seismically retrofitted bridges and effects on transportation network performance.

Pacific Earthquake Engineering Research Center

Soil-structure interaction is where energy and motion are transferred from the soil to a structure or building. This is an area of complex activity during earthquakes. By developing tools to reduce the uncertainty in models for soils structure interaction, engineers can better understand the performance of foundation elements, buildings, and structures during earthquakes. The PEER center is creating tools for computing soil structure interaction using the OpenSees platform.

A major Lifelines Program project kicked off by the PEER Center is the Next Generation of Attenuation Project. This project is made up of many individual projects in the PEER Lifelines program. It is anticipated that the updated attenuation relations will lower uncertainty levels compared to the current versions, thereby potentially driving down the cost of future structures. The project will also develop new computer models describing how soil or geologic structure can increase ground motion under certain conditions. This effort uses personnel from the PEER Center universities, consultants, the USGS, the California Geological Survey, the California Department of Transportation, and the SCEC.

Recognizing the need to improve access to earthquake ground motion data, PEER embarked on an effort to create a web-based, searchable database of strong ground motion data. The first step was to gather the most important records from around the world. The next step was to ensure that all the data had been processed consistently and reliably. The third step was to gather related information, such as earthquake magnitude, distance, site conditions, and other relevant engineering parameters. Finally, PEER created the online database to make all the information available. In its completed form, the PEER Strong Motion Database brings together over 1,500 strong ground motion records from 143 different earthquakes in a web-accessible format.

NEHRP Accomplishments: Goal D

Activities under Goal D comprise the basic research component of the NEHRP and cover a range of disciplines from geology to seismology, to earthquake engineering and structural engineering, to the behavioral and economic sciences. NSF and USGS are the two primary NEHRP agencies supporting Goal D, with USGS emphasizing geologic and seismologic disciplines and NSF supporting these areas, in addition to studies of the built environment and the behavioral and economic impact of earthquakes.

Goal D: Improve the understanding of earthquakes and their effects and consequences

1: Improve monitoring of earthquakes and earthquake-generating processes.

2: Improve understanding of earthquake occurrence and potential.

3: Improve earthquake hazards assessments and develop earthquake-potential estimates as planning scenarios.

4: Improve fundamental knowledge of earthquake effects.

5: Advance earthquake engineering knowledge of the built environment.

6: Advance understanding of the social and economic implications of earthquakes.

The NEHRP Agencies

National Science Foundation

The NSF created and continues to fund the George E. Brown, Jr. NEES, a major national infrastructure project to create a complete system of test facilities that will revolutionize earthquake engineering research. The project was initiated by NSF and the earthquake engineering community in response to a congressional mandate (NEHRP Reauthorization Act of 1994) to take stock of the Nation's experimental and testing capabilities in earthquake engineering.

NEES will operate from October 1, 2004, through September 30, 2014, and will be managed by the nonprofit NEES Consortium, Inc., which will allocate research time at equipment sites; lead training, education, and outreach activities; and establish ties with U.S. and international partners. The NEES will upgrade, modernize, expand, and network major facilities, including:

- Shake tables used for earthquake simulations
- Geotechnical centrifuges for testing soils/foundations under earthquake loading
- Tsunami wave basin for earthquake simulations
- Large-scale experimentation systems, *e.g.*, reaction wall and modular simulation equipment
- Field monitoring and testing facilities

The NEES is using ultra-high-speed Internet2 technology to link 15 nationally distributed earthquake research facilities. NEES' collaborative and integrated experimentation, computation, theory, databases, and model-based simulation will improve the seismic design and performance of U.S. civil and mechanical infrastructure systems. The NEES network provides interoperability, resource sharing, scalable, and efficient net-wide deployment, open-system standardization, database consistency and integrity, and modularity in both software and hardware architectures.

NEES will lead to a new era of collaboration in earthquake engineering research. Teams of experts in the United States and around the world will have the unprecedented opportunity to jointly plan, conduct, and analyze the results of experiments and models. Easy access to the Network's resources will facilitate broad participation-both informally and through official partnerships-by many communities of users, including researchers, educators, students, engineers, government agencies, professional organizations, industry, and disaster preparedness and response teams. Individuals and teams can take part in NEES activities onsite or at remote locations and can participate in different kinds of research, from individual and small group studies to "grand challenge" projects in which teams from different institutions and organizations pursue a comprehensive systems approach to a specific, broad-based earthquake engineering problem.

To help guide NEES through the next decade, a panel organized by the National Research Council (NRC) of the National Academies has developed a long-term research agenda for the earthquake engineering research community. This plan identifies important research needs that are well suited to investigate techniques involving NEES equipment sites and resources, especially with regard to the integrated research approach that the Network embodies. NEES research will provide the foundation for the development of new technologies in critical areas such as:

- High-performance materials used to strengthen buildings, bridges, soils, and critical lifelines;
- Performance-based engineering involving codes and decisions related to seismic risk, new designs, and retrofitting

A tsunami wave basin.

- Structural controls to protect buildings, bridges, and other structures
- Monitoring tools and sensors to conduct rapid post-earthquake condition assessment of the built environment
- Advanced warning systems to protect coastal regions from earthquake-generated tsunamis
- *In situ* evaluation and remediation to improve and stabilize soil response during earthquakes
- Improved techniques to protect critical lifelines such as above- and below-ground fuel, water, and sewer pipelines and electrical, communication, and transit systems during earthquakes
- Improved simulation tools for analyzing more complete and comprehensive models of seismic performance
- Methods to improve decision making with regard to planning and evacuation, emergency response, and post-earthquake recovery

NEES ushers in a new generation of earthquake engineering research. Enhanced understanding of earthquakes and seismic performance made possible by the Network's people, ideas, and tools will lead to innovative, cost-effective measures for better protecting the vast network of facilities and services on which everyone depends.

U.S. Geological Survey

The USGS has the federal responsibility for monitoring and notification of seismic activity in the United States. The USGS fulfills this role by operating the U.S. National Seismograph Network (USNSN), the National Earthquake Information Center (NEIC), and the National Strong Motion Program (NSMP), and by supporting 16 regional networks in areas of moderate-to-high seismic activity. All of these efforts are

coordinated under the ANSS, http://www.anss.org/. The USGS also supports geodetic monitoring systems that measure the static deformation of the Earth's crust due to earthquakes and earthquake-generating processes. The geodetic monitoring is done with high-precision, land-based surveying techniques and the satellite-based GPS. Data derived from these monitoring systems are used to identify seismic hazards and, following an earthquake, to rapidly characterize the probable size and extent of damage, assess the continuing risks from aftershocks and related ground-motion and ground-failure hazards, and facilitate the work of response officials.

The USGS and cooperating universities operate regional seismic networks in areas of high seismicity. Data from all U.S. seismic networks are used to monitor active tectonic structures in much greater detail than is possible with the national scale network. Each region has a local data center where the data are processed and regional catalogues of earthquakes are produced. These data centers serve as local distribution points for transmitting information about earthquakes to the public, local and state agencies, and other regional interests. The regional data centers relay earthquake data in real time to the NEIC as well as to other regional networks. Data centers also provide information about regional earthquake hazards and accepted mitigation practices, and those data centers located at universities provide training and research facilities for students.

Conventional seismometers used in earthquake monitoring networks cannot accurately record strong ground and building motions caused by large, nearby earthquakes; yet these technical data are extremely valuable for the design of earthquake-resistant buildings and other structures. Through the NSMP, the USGS maintains about 840 strong motion recorders in 35 states and territories. The strong motion data show the amplitude, frequency content, and duration of strong accelerations caused by an earthquake. These parameters are direct inputs to computer models and scale models of structures to test their performance under realistic earthquake shaking.

Geodetic networks provide essential information about movement of the land surface near faults and earthquake source zones. The USGS is working with universities and local agencies to conduct geodetic investigations using GPS and laser-ranging surveys. A dense network of continuous GPS stations is being installed in southern California in cooperation with the National Aeronautics and Space Administration (NASA), NSF, and Scripps University to determine the distribution of long-term crustal deformation and the spatial and temporal variations of the strain field. During the next year, with funding support from USGS cooperators, new stations will be sited and installed, communications and data retrieval operations will be developed, and processing and archiving centers will be established. The USGS has a lead role in the operation of the network, with responsibility to maintain stations and download and interpret the data. In addition, the USGS is investigating a new satellite technology, Interferometric Synthetic Aperture Radar (InSAR), that has the potential of quickly and accurately providing large aerial maps of pre- and post-earthquake land deformation. Work is under way to develop computational tools necessary to efficiently analyze, interpret, and model InSAR data. The InSAR results in southern California will be used to augment, check, and, if necessary, correct the independent GPS measurements.

In 2000, Congress authorized the upgrade of the seismic monitoring networks in the United States through the implementation of the ANSS. The ANSS initiative is being used to improve the performance and integration of the national and regional seismic monitoring networks whenever funds are available. The primary goals are to unify, modernize, and expand earthquake monitoring equipment and activities in the United States. Implementation of an ANSS would involve five basic components: (1) an expanded U.S. National Seismograph Network; (2) expanded and modernized regional networks; (3) creation of dense networks of urban stations capable of monitoring strong motion both on the ground and in structures; (4) two portable, temporary seismograph arrays that can be rapidly deployed following an earthquake; and (5) upgrade and integration of regional and national recording centers with the capability of disseminating data and information in real time. An important emphasis of ANSS is improved monitoring in metropolitan areas in regions of high-to-moderate seismic risk. In total, ANSS envisions the addition of 6,000 new seismic monitoring instruments in over 25 urban centers; 3,000 of these would be deployed in reference sites, *i.e.*, ground based, and an additional 3,000 in structures. Implementation of ANSS would also result in improved integration of existing networks and the replacement of obsolete equipment at 1,000 stations in regional networks across the Nation.

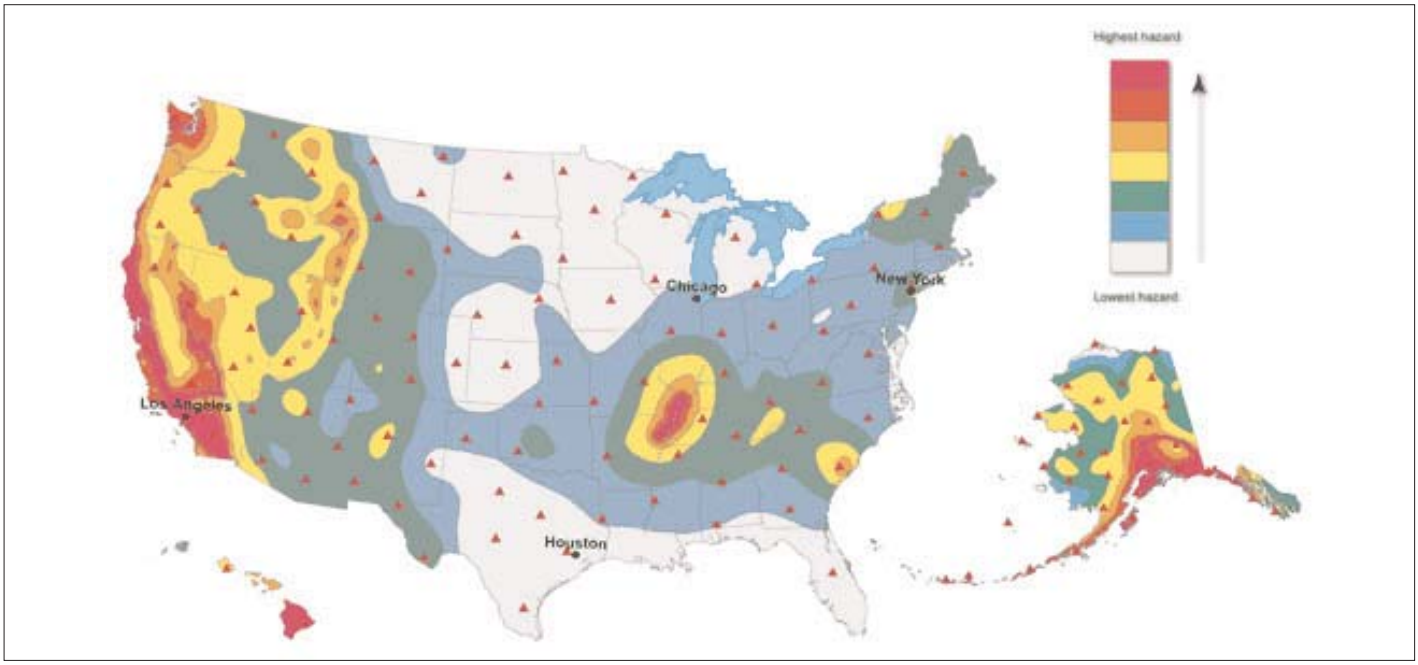
As part of the expansion and modernization of earthquake monitoring in the United States that is being carried out through the development of ANSS, USGS installed 64 seismic stations in FY 2004, significantly expanding the ANSS and meeting its Government Performance Results Act (GPRA) targets and increasing the total number of ANSS urban and regional monitoring stations. A major accomplishment was the expansion of the ANSS national seismic "backbone" network from 53 to 63 stations. This backbone network provides a nationwide earthquake detection capability of magnitude 3.5 or better–essentially allowing the rapid

technical characterization of all felt earthquakes. This has been a major program goal for many years, and its achievement means that a key performance target of the program's Five-Year Plan has been met–nearly 4 years ahead of schedule. ANSS is also working with the NSF to expand the backbone network to 80 stations. NSF will provide funding in FY 2005-FY 2006 for 17 new ANSS backbone stations and 8 station upgrades as part of their EarthScope research initiative. USGS will install, operate, and maintain the stations as part of ANSS. The design goal for the ANSS backbone network is 100 stations, with a national earthquake detection capability of magnitude 3.0.

The ANSS initiative provides comprehensive new data on earthquake ground-shaking in urban areas. ShakeMap, a flagship product of the ANSS, is a tool used to rapidly portray the extent of potentially damaging shaking following an earthquake. It is generated and served via the Internet within minutes of the earthquake, and is used primarily for emergency response, loss estimation, and public information. ShakeMap coverage areas include urbanized areas of California, the Seattle-Tacoma metro area, Anchorage, and the Reno/Las Vegas corridor. Efforts are underway to bring the system online in the Memphis/New Madrid region as instrumentation in these areas increases. Maps made immediately after the 2003 San Simeon (M6.5) and 2004 (M6.0) Parkfield, California earthquakes were used by a variety of agencies and responders, although the impact of both earthquakes was relatively low due to their remote locations.

ShakeCast is a fully automated system designed to deliver specific ShakeMap products to critical users and trigger established post-earthquake response protocols. ShakeCast provides utilities and other large organizations with instantaneous, hierarchical listings of users' affected facilities, notifies users (via pager, cell phone, e-mail) when user-set thresholds have been exceeded, and automatically initiates other software systems, *e.g.*, loss estimation, GIS. Currently, the CALTRANS Bridge Engineering Division and PG&E are testing the prototype system. CALTRANS has over 25,000 bridges and overpasses under their responsibility in California and will use ShakeCast to construct an instantaneous snapshot of the likely damage to each, thereby allowing them to prioritize traffic rerouting, closures, and inspections following a damaging earthquake. In 2005, USGS will be coordinating with several other large, critical facility agencies to implement ShakeCast, including the California Department of Water Resources (Division of Dam Safety), Washington Department of Transportation, Washington State and the City of Seattle Emergency Management Divisions, FEMA, and the LADPW. Deployment of ShakeCast to better use USGS ShakeMaps will greatly enhance these agencies' ability to respond to and recover from earthquakes.

The USGS Community Internet Intensity Map is an automatic web-based system for rapidly generating seismic intensity maps based on reports collected from Internet users immediately following earthquakes. These volunteer reports are plotted on a map and provide a general, regional picture of how widely and intensely an earthquake was felt. These maps also provide important information on regional-to-local variations in shaking intensity and are particularly valuable in areas with few seismometers. This system—popularly known as "Did you feel it?"—has now received over 1/2 million individual responses in the United States. Based on this



Existing and proposed ANSS stations and shaking hazards in the US.

success, the system was recently expanded to work in all areas of the world. Rather than ZIP codes, international Internet users simply pick from over 55,000 cities; their local intensity of shaking gets instantly mapped based on the city location and is available to all via the Internet. This worked well for a recent magnitude 5.9 earthquake in Romania, with reports of shaking coming in from six different countries the day after the system went online. Further efforts to increase awareness of the global system will be made in the 2005. The global maps can be found at http://earthquake.usgs.gov under "Did You Feel It?" by selecting "Outside US."

The USGS, along with NSF, funds the SCEC, a 40-institution research consortium headquartered at the University of Southern California. SCEC was founded in 1991 with a mission to gather new information about earthquakes in southern California, integrate this information into a comprehensive and predictive understanding of earthquake phenomena, and communicate this understanding to end-users and the general public to increase earthquake awareness, reduce economic losses, and save lives. Leading scientists from institutions throughout the country participate in SCEC. To support this community, SCEC also engages in information technology research that will revolutionize methods of doing collaborative research and distributing research products on-line. In addition, the SCEC Communication, Education, and Outreach Program offers student research experiences, web-based education tools, classroom curricula, museum displays, public information brochures, online newsletters, and technical workshops and publications.

Three notable domestic earthquakes occurred during this reporting period. USGS scientists studied the short- and long-term effects from the magnitude 7.9 Denali earthquake which rocked Alaska on November 3, 2002. This was one of the largest recorded earthquakes in our Nation's history, causing countless landslides and road closures, but minimal structural damage and amazingly few injuries and no deaths. The remote location of the earthquake helped ensure that it was not more devastating; however, advanced seismic monitoring from the USGS and partners, long-term research, and a commitment to hazard preparedness and mitigation also played key roles. For example, in the late 1960s and early 1970s, USGS scientists serving on a federal task force were instrumental in ensuring that the Alaska pipeline was designed and built to withstand the effects of a magnitude 8.0 earthquake. USGS design guidance proved to be on-target, and the pipeline suffered little damage. This earthquake is likely similar to ones destined to occur on the San Andreas Fault, in particular its northern portion that ruptured in 1906, and its southernmost reaches near Palm Springs and San Diego, which last ruptured around the year 1640. Such an earthquake could have disastrous impacts on the densely populated urban areas nearby. Therefore, scientists are making detailed observations of the earthquake, including the ruptured ground surface along the Denali fault line, strong seismic shaking, and induced landslides and liquefaction in the region, to more accurately assess the hazards from such earthquakes and relay those assessments to local officials in ways that could be acted upon.

The M6.5 San Simeon earthquake occurred on December 22, 2003, with an epicenter near the Pacific coast in central California. While it did not rupture the surface, the quake triggered landslides and caused strong shaking, with the worst damage in Paso Robles, 24 miles southeast of the epicenter, where numerous older buildings were damaged and one building collapsed, killing two people. In addition, significant liquefaction damaged housing and buried utilities in Oceano, nearly 50 miles away. Repeated thrust-type earthquakes such as this are responsible for building California's Coast Ranges. The area around San Simeon has experienced significant earthquakes in 1853, 1906, and 1952, the last being the largest at magnitude 6.2 and centered just 6 miles from the San Simeon event. Similar "blind" thrusts caused the magnitude 6.7 Coalinga earthquake in 1983, also in the Central Coast Ranges, as well as the $47 billion Northridge earthquake that struck the Los Angeles area in 1994. In response to the San Simeon earthquake, the USGS produced a ShakeMap within 9 minutes of the event. The ShakeMap served as the basis for a loss estimation by the California OES using FEMA's HAZUS software within 1 hour. Such estimations used to take 1-2 days, with OES calling each county and waiting for estimates based on field visits. CALTRANS used the ShakeMap information to determine the number and location of bridges that needed to be inspected. USGS data and analysis allowed PG&E to decide not to defer critical maintenance on the Diablo Canyon nuclear power plant when it was demonstrated that the earthquake had actually reduced stress on the faults near the plant. USGS also provided real-time information on aftershock location and probability of occurrence.

The long-anticipated M 6.0 Parkfield earthquake struck central California at 17:15:14 UTC on September 28, 2004. The epicenter was located 11 km southeast of the rural town of Parkfield adjacent to Gold Hill and on the San Andreas Fault. The 2004 Parkfield earthquake is the sixth in a series of similar earthquakes that have occurred on the Parkfield section of the San Andreas Fault since the great (M7.8) 1857 Fort Tejon earthquake. The 2004 Parkfield earthquake, anticipated since 1984, occurred on the San Andreas Fault within a dense network of geophysical sensors specifically designed to trap it. No precursory changes were observed even though the epicentral region was instrumented to detect a variety of subtle precursors that might be used for short-term earthquake prediction. Little structural damage occurred in the rural epicentral region, but surprising near-source variations in the strong shaking were recorded. Strong

shaking decreased more rapidly with distance than predicted by models that serve as the basis for current building codes.

The USGS supported a project to demonstrate the potential to solve challenging scientific and engineering problems by combining the capabilities of the USGS and the NSF-sponsored IRIS and the NEES. A pilot field study was conducted in August 2004 on the use of state-of-the-art seismic recording instrumentation. A new NEES shaker truck generated seismic waves as proxies for earthquake waves. The excitement of the community about the potential of such collaborations was evident in the growth of the experiment to include resources and participants from the MAE Center, SCEC, the Center for Embedded Network Sensing, and the High Performance Wireless Research and Education Network (all NSF-supported), and the Los Alamos National Laboratory (LANL). A tremendous dataset was collected for study of non-linear sediment response, ground motion site and basin effects, basin and fault imaging, and broad-scale deep imaging. Collaborations continue with ongoing analyses and intriguing new results already are beginning to emerge.

In the summer 2004, earthquake researchers completed a 10,000 foot scientific drillhole to within a few hundred meters of the San Andreas fault near the Central California town of Parkfield. The research team, spearheaded by the USGS and Stanford University, will make field and laboratory measurements and install a variety of underground instruments that will help scientists better predict the timing and severity of earthquake activity along the 800 mile-long fault. This completed Stage 1 of the ambitious drilling project called the San Andreas Fault Observatory at Depth (SAFOD), one of the four components of NSF's EarthScope MRE initiative. Data are now being analyzed in preparation for the commencement in April 2005 of Stage 2 drilling, which will extend the borehole to cross the San Andreas fault at a depth of approximately 3 km. When complete, SAFOD will be the first underground earthquake observatory to penetrate a seismically active fault zone, giving scientists a unique opportunity to continuously monitor a section of the fault where earthquakes actually happen. The drilling project is a collaborative effort between the USGS, NSF, and the International Continental Drilling Program (ICDP).

In recognizing the important role that sedimentary basins play in controlling strong-ground motions from earthquakes, the USGS has conducted structure and velocity imaging and wave propagation studies in the Santa Clara Valley ("Silicon Valley"), south of San Francisco Bay. This major population center is exposed to a significant seismic hazard from bounding faults, with the San Andreas Fault on the west and the Hayward and Calaveras Faults on the east. A variety of seismic and geologic studies have led to a new 3D structural model for the Santa Clara sedimentary basin. A series of seismic imaging experiments have yielded revised

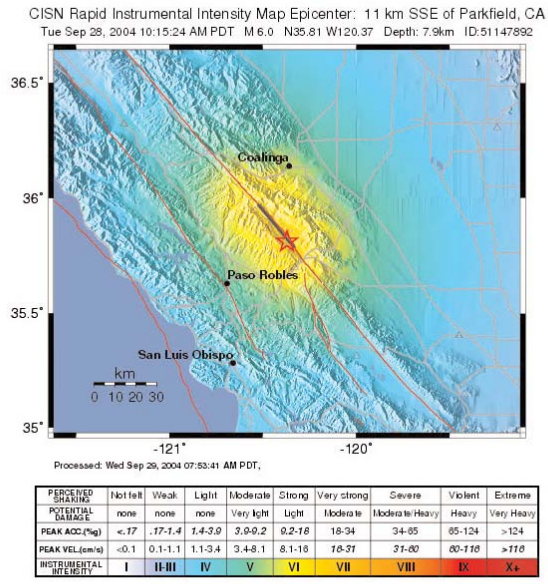


Figure 3. Intensity map (CISN).

An instrumental shaking intensity map for the 2004 Parkfield earthquake.

information on the velocities of buried geologic units. Together, this information forms the basis for an improved capability to predict ground motions from potentially damaging earthquakes. Our predictions are being compared with actual ground motion recordings of local earthquakes from a 50-element array of portable recorders. The studies underway in the Santa Clara Valley are capable of forming the template for seismic hazard evaluation in other urban areas across the United States.

The USGS and King County (Washington) signed an Interagency Agreement that funds a detailed investigation of the Southern Whidbey Island fault near the Brightwater Wastewater Treatment plant site, a $1.8 billion dollar project and the largest public capital improvement project in Washington State. The USGS identified the probable extension of the fault last summer using a combination of aeromagnetic, Lidar imagery, and field studies. Based on these studies and using funding from King County, the USGS has opened four research trenches across two distinct strands of the fault. These trenches reveal evidence of young faulting cutting through the Brightwater site and evidence of significant liquefaction that has occurred in past earthquakes. Neither result was initially considered in plant design; the USGS subsequently met with the Brightwater engineering design team to discuss the implication of the findings on seismic and foundation design.

Selected State, Territorial, And Local Accomplishments

Hawaii

Hawaii supported the USGS ANSS to upgrade seismic networks in Hawaii to more rapidly detect earthquakes and generate products that estimate ground-shaking effects. Hawaii also partnered with NOAA, the State Office of Planning, and the University of Hawaii to gather data on unique volcanic-based soil profiles for the islands of Hawaii and Maui. The information will be used to upgrade HAZUS models to more accurately simulate soil ground shaking effects to improve damage estimates.

Nevada

Funding from the NEHRP has been critical to better characterizing the earthquake hazards in urban and suburban areas in Nevada. NEHRP funds through the USGS and NSF have supported seismic monitoring that has led to new discoveries about deep earthquakes in northern Nevada and fault studies in northern and southern Nevada. The combination of geodetic measurements (chiefly from ultrahigh precision global positioning system instruments), seismic monitoring, geologic mapping, and fault-trench studies is revealing that about 20 percent of the motion between the Pacific Plate and the North American Plate is along the Walker Lane, a zone of northwest-trending strike-slip faults in western Nevada and eastern California. Most of the remainder of the plate motion is accommodated along the San Andreas fault system farther west in California.

Oregon

Trench investigation along the Portland Hills Fault by DOGAMI reveals deformed sediment layers, providing strong evidence of fault activity during the past 10,000 years.

DOGAMI and the USGS are currently conducting Light Detection and Ranging remote sensing terrain imaging in the Portland Metro area to better define active faults and locate unknown faults.

DOGAMI released a new Map of Selected Earthquakes for Oregon, 1841 through 2002, that pinpoints 14,000 historic and recent earthquakes.

Texas

The Texas Regional Seismographic Network recently grew to a total of eight permanent stations with the addition of a new station in West Texas (MNTX) in 2003 and a new station in Nacogdoches in 2004 (NATX). These new stations are both joint projects between the University of Texas (UT) at Austin, Texas Tech University, and the USGS. In conjunction with the installation of MNTX, the State forged an additional collaboration with seismologists at UT El Paso to broaden the circle of those interested in and willing to help maintain the station. In conjunction with station NATX, a similar collaboration was forged with scientists at Stephen F. Austin State University. Both of these stations are members of the ANSS.

MNTX and NATX are equipped with state-of-the-art three-component broadband seismometers (Streckeisen STS-2) and 24-bit digitizers (Quanterra Q730) and each delivers its data in quasi-real-time to the NEIC in Golden, Colorado, to be analyzed jointly with data from other ANSS stations. The MNTX station is equipped with satellite communications; the NATX station delivers its data via the Internet. NATX came online in August 2004 and is delivering high quality data quite reliably. These new stations join JCT (Junction, TX), LTX (Lajitas, TX), and HKT (Hockley, TX) as flagship ANSS stations.

In addition to the flagship stations, four other stations make up the TexSeis network. These include MDO (MacDonald Observatory, near Fort Davis, TX), LBTX (Lubbock, TX), and AMTX (Amarillo, TX). These consist of Guralp 40T seismometers, which are also three-component and broadband but have slightly noisier characteristics than the STS-2 seismometers at MNTX and NATX and the Guralp 3T seismometers at LTX and JCT, and significantly higher than the top-of-the-line (but no longer manufactured) Streckeisen STS-1 at HKT.

In July 2004, MNTX, after being online only 8 months, received a direct hit by lightning. Despite elaborate protection, virtually every electronic component of the station was ruined and must be replaced. The USGS immediately agreed, as is stipulated in the terms of the Memorandum of Agreement, to replace all the equipment and get the station back in operating order. While it is not rare for stations to be struck by lightning, every station has elaborate lightning protection and it is quite uncommon for them to be damaged so severely. Only time will tell if this will be a recurring problem at MNTX. At the moment, there is no reason to move the station to a different location or install it differently. The site is outstanding, as is the access provided by the owner (UT Permanent Land Fund) and the rhyolite host rock, which provides excellent coupling to bedrock. A great deal of effort was expended in identifying and obtaining permission to use this site, and there is no reason to believe that other sites in the region would suffer fewer lightning strikes.

An additional station near Austin (ATX) was planned and the site was prepared for installation. Upon testing, however, it was discovered that the sensor intended to be installed at ATX was defective. The sensor is recording data but because it has only the vertical and one horizontal component functioning, real-time data communications were not installed. The

seismometer will be sent back to the manufacturer for repair before its permanent installation at ATX.

The ANSS stations are also serving as the backbone of a new, 10-year project funded by the NSF, called EarthScope. This program might be characterized as a "Mission to North America" because its goal is to understand the structure and composition of our continent and the processes by which it has evolved to its current state. One of the four components of EarthScope is USArray, a dense deployment of 400 seismographic stations in stripes across the United States, from west to east. Each deployment will last for approximately 1 year, and then the stations will be removed and re-deployed to the east. The unprecedented density of the deployments will bring a great deal of new data and information, particularly from regions such as Texas, that have been historically under-instrumented and are less active seismically. However, these deployments will still be temporary and it is important to densify the distribution of permanent stations as well—to provide long-term baseline observations, help guide us to features of particular interest for more intensive study, and to calibrate the temporary stations so they can be used to maximum advantage. TexSeis is a critical regional network in this nationwide backbone.

The goal is to ensure that every earthquake of magnitude 3.0 or greater that occurs in or near Texas will be located and reported in the NEIC catalog. There are several reasons for this choice. First, although magnitude 3.0 events are generally too small to cause damage, they aid in identifying seismogenic faults, and thereby facilitate understanding the tectonics of the Texas region. Second, they provide useful data to model the regional structure. This structural information is needed to understand larger events when they occur. Finally, the ultimate aim is to provide comprehensive information about the characteristic and maximum intensities of ground motion that could be expected to occur in Texas as a result of future earthquakes. Rather than focus efforts on existing cities, it is prudent to record data that can be used to estimate seismic hazards statewide, including areas that are now sparsely populated, and might experience growth in the future. These estimates of ground accelerations are needed by engineers and architects to design appropriate buildings for each location. The successes of building codes in protecting lives during earthquakes are underscored by almost every event in the western United States.

Other Organizations

Earthquake Engineering Research Institute

In FY 2003 and 2004, funding continued for the support of EERI Student Chapters, now located at 23 universities throughout the United States, including Puerto Rico and one in Vancouver, BC. The involvement of these young people, while still in school, has influenced numerous students to choose earthquake engineering and earthquake hazard reduction as a career. Many of these students have, in turn, shared their knowledge and passion about earthquake mitigation with students in elementary and secondary schools in the Midwest, Southeast, and California, stimulating excitement about earthquake engineering and earthquake hazard reduction in our future scientists and engineers.

- Students at Notre Dame University pride themselves in the outreach activities they have sponsored, helping to make a difference in the lives of young people and spreading earthquake awareness. Their Shakes & Quakes program aimed at K-12 is designed to stimulate young minds and allow them to better understand the way new, life-saving technologies, such as base isolation, change the way in which engineered structures behave in severe earthquakes. The chapter members visit local classrooms and demonstrate how buildings perform using a portable shake table, LEGO and K'NEX models.

EERI's Shakes & Quakes program aimed at K-12 is designed to stimulate young minds and allow them to better understand the way new, life-saving technologies, such as base isolation, change the way in which engineered structures behave in severe earthquakes. In this picture, elementary students wait anxiously for the quake to end.

- Students in the Georgia Tech Chapter of EERI have created a community outreach program for local elementary and middle schools. They visit classrooms and discuss earthquakes and the damage they can cause, as well as preparedness measures. They work with students to build a model three-story building on a portable shake table and subject it to motions from the Northridge and Kobe earthquakes. The program is working to create interest in earthquake engineering, math, and science.

NEHRP funds have enabled EERI to expand its comprehensive website to provide access to the EERI Newsletter, immediate information after damaging earthquakes, post-earthquake reconnaissance reports, and links to critical, technical information and programs of value to engineers and others engaged in earthquake hazard mitigation throughout the world. The value of web-based information is that it provides easy access to those in areas of less frequent seismic activity and expertise to cutting edge research and knowledge about earthquake hazard mitigation.

In 2003, EERI brought together experts from many disciplines in a technical workshop focusing on the "legacy of earthquake engineering" to identify contributions earthquake engineering has made to other fields of natural and technological hazard mitigation in the past, and to look to the future, to the potential that earthquake engineering offers to mitigate other natural and technological risks and terrorist threats. A final document summarizing the past and potential contributions is expected to be published later this year.

The Year 2006 will be the 100th anniversary of the great 1906 San Francisco Earthquake. NEHRP funds have begun to underwrite early planning of an international conference that will be held in San Francisco in 2006 to commemorate the event. EERI, the Seismological Society of America, and the California Governor's OES will convene the conference as partners. The conference will focus on developments in the earth sciences, engineering, and emergency planning and response that have taken place during the past century and offer insights to deal with challenges ahead. It is expected that this will be the largest, most important earthquake conference in history, attracting several thousand emergency managers, earth scientists, and engineers from all over the world to learn about current codes and practices, emergency procedures, and gain new insights into the opportunities presented by developments in engineering and earth science research.

In February 2004, EERI organized a charette at the Alexandria campus of the Virginia Polytechnic Institute and State University. Students and architects competed on designs for new public buildings in Washington D.C. that utilized the security recommendation in FEMA 426, *Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings*. Findings from the charette will be included in FEMA 430, *Building, Site, and Layout Design Guidance to Mitigate Potential Terrorist Attacks*, currently in development by EERI. This publication will describe concepts in landscape design and architecture that can mitigate the threat of terrorist attack, without compromising public access to and enjoyment of a space. It will include a discussion of current planning efforts of the National Capital Planning Commission to redesign and secure the public spaces in Washington D.C. The target audience is architects and landscape designers who work on public buildings and spaces. The book is currently at a 75 percent draft stage.

Designing for Earthquakes: A Manual for Architects is an update of a manual produced in 1978. Part of FEMA's Multihazard Risk Management Series, the book is intended to educate architects about the earthquake hazard and current trends and issues in seismic structural design and building codes. A 99 percent draft was presented by EERI to FEMA for final review in September 2004. The document will be published as FEMA 454.

In a project funded jointly by FEMA and NSF, EERI is surveying current academic programs at university departments of architecture throughout the United States to determine the nature and extent of seismic design in the education of today's architects. The results will be provided to NSF in the spring 2005 and will hopefully be a tool to influence increased attention to hazards mitigation in the education of today's architects.

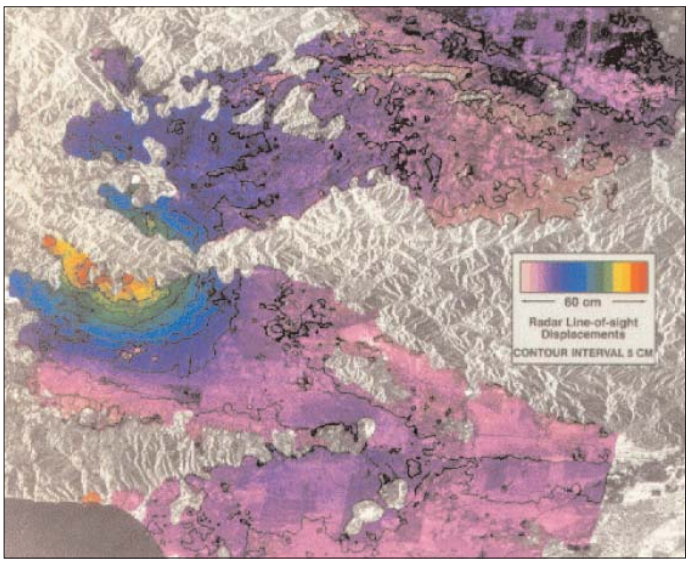
Multidisciplinary Center for Earthquake Engineering Research

To advance hazard mitigation, it is essential to enhance public understanding about hazards and the necessary steps to achieve it–on personal, political, and scientific levels. MCEER endeavors to work with disseminators of information to reach the public arena, using its website, public briefings, publicly oriented publications, and media opportunities. Perhaps more significantly, however, such prominent media vehicles as the Discovery Channel and the New York Times, to name but a few, are important conveyors of messages critical to the execution of earthquake and other hazard mitigation efforts. MCEER has worked with the Discovery Channel on three programs in the last 2 years to advance understanding of the earthquake hazard and potentials for mitigation. One of these of particular pride to MCEER-which derives substantial financial support from the State of New York-is *Earthquakes in New York City?*, which was designed to educate viewers in the eastern United States either unaware or unwilling to accept the threat of earthquakes outside of California. To further this message in print media, MCEER contributed to a full-page article in the New York Times this past summer, highlighting

the vulnerability of the city to many hazards and the ongoing efforts to help mitigate against them. The same article described the integration of information for all hazards and illustrated the potential connections between earthquake research and research related to other hazards, such as blast.

Assessing damage and disruption and prioritizing response resources are perhaps the most significant challenges facing crisis managers after a major disaster. Rapid impact and damage assessment—for example, the identification of collapsed structures—is especially critical because research on earthquake mortality and morbidity indicates that death tolls rise following earthquakes unless trapped victims can be found and extricated in a timely manner. Rapid and accurate situation assessment also helps response managers to better estimate impacts and allocate resources to areas of greatest need. Recognizing that remote-sensing technologies can make a major contribution to improving post-disaster damage and situation assessment, MCEER researchers have carried out pioneering research on post-earthquake damage assessment using a range of remote-sensing techniques, including synthetic aperture radar and moderate resolution optical imagery. Most recently, researchers have been investigating the use of high-resolution QuickBird imagery in post-disaster reconnaissance in the December 2003 Bam earthquake.

The increasing availability of high-resolution images and improved potential for collecting data in near-real-time, *i.e.*, through the use of unmanned airborne vehicles, are making even more significant advancements possible. Remotely-sensed data are now being used in the development of new tools, such as the VIEWS (Visualizing Earthquake Impacts With Satellite Imagery) system, which was developed by MCEER researchers and deployed for post-earthquake reconnaissance following the Bam event. The goal of MCEER's remote sensing research group is to triangulate data obtained using different technologies and merge those data with advanced GIS to develop integrated decision support systems for post-earthquake response.



Synthetic aperture radar (SAR) interferogram showing relative found displacements measured after the 1994 Northridge earthquake.

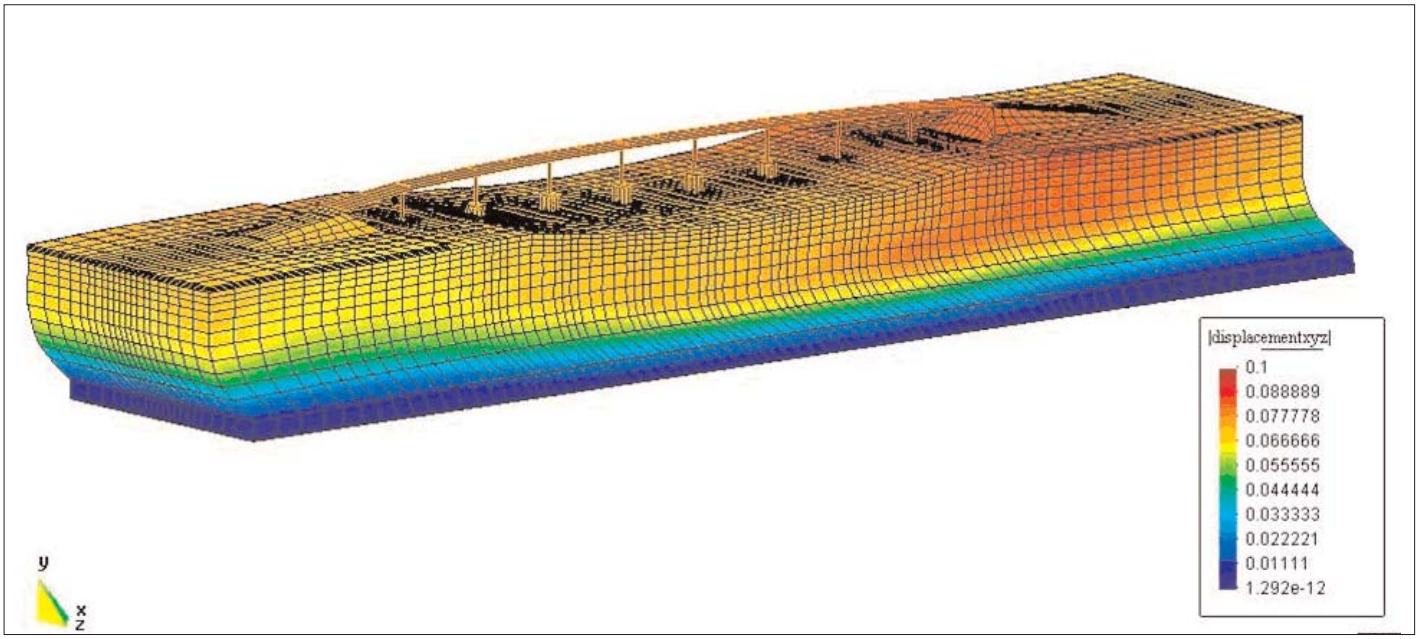
The FHWA and MCEER have conducted workshops and conferences to further the exchange of knowledge among research professionals and engineers in the United States and abroad. Annual collaborative workshops have been held with Japan, Taiwan, and the People's Republic of China. Workshop proceedings are available to researchers and practitioners to gain a better understanding of policy and practices employed elsewhere.

The 4th National Seismic Conference, which was held in Memphis, Tennessee on February 8-10, 2004, drew over 200 registrants from state transportation departments from across the United States. The venue especially allowed participants from the mid- America zone to participate. Attendance and interest is evidence of the increased awareness and of the need to protect highway structures in parts of the country where severe earthquakes can hit, but do so with a return period of several hundred years. Topics at the conference included the provisions available for the design of new bridges as well as case studies of successful retrofit strategies.

Instrumentation for seismic monitoring was purchased as part of MCEER's FHWA contract and delivered for the cable stayed bridge in Cape Girardeau, Missouri. Data will be collected and transmitted for further study to USGS, FHWA, Missouri DOT, and Illinois DOT. Upon appropriate security clearance, data will be shared with authorized researchers and educators. This response data will help engineers and academics gain a better understanding of the dynamic characteristics of the new bridge and pave the way for more earthquake resistant designs in the future.

Pacific Earthquake Engineering Research Center

A centerpiece of PEER's program is new research on simulation models and computational methods to assess the performance of structural and geotechnical systems. Breaking the barriers of traditional methods and software development protocols, PEER has embarked on a completely new approach in the earthquake engineering community by developing an open-source, object-oriented software framework. OpenSees is a collection of modules to facilitate the implementation of models and simulation procedures for structural and geotechnical earthquake engineering. By shared development using well-designed software interfaces, the open-source approach has effected collaboration among a substantial community of developers and users within and outside of PEER. Unique among software for earthquake engineering, OpenSees allows integration of models of structures and soils



PEER's OpenSees computer model representation of soil-structure interaction of a bridge.

to investigate challenging problems in soil-structure-foundation interaction. In addition to improved models for reinforced concrete structures, shallow and deep foundations, and liquefiable soils, OpenSees is designed to take advantage of the latest developments in databases, reliability methods, scientific visualization, and high-end computing.

PEER has developed state-of-the-art computational and information technologies to compute in detail how buildings and bridges respond to earthquake ground motions. PEER is making significant advances in computational procedures, and is educating a new generation of earthquake engineers who are familiar with the latest information technologies. To accelerate development and broaden acceptance, PEER has made its computational technologies available on-line and has promoted use through user/developer workshops.

Immediately after a major earthquake, emergency responders and operators of lifeline systems in the affected area need guidance as to the likely distribution of damage. In areas that are densely instrumented with a network of seismometers, the measured distribution of strong ground shaking can be rapidly assembled and broadcasted as an indirect measure of likely damage. In sparsely instrumented locations, however, insufficient empirical data may be available. To supplement such data, new methods make it possible to automatically determine finite-source parameters of earthquakes such as the causative fault plane characteristics and rupture velocity. These source parameters are then used to simulate near-fault ground motions for areas where there are no nearby recording instruments. This process can be carried out automatically, to produce and distribute estimates of shaking within 30 minutes of the event, and can then be reviewed and updated by seismologists in real time. The process is aided by previous PEER studies aimed at improving simulation technologies. This is an important contribution toward the objective of near-real-time reporting of earthquake shaking hazard, and has been provided to ShakeMap V2.x software for widespread application.

The Architect of the Capitol has voluntarily striven to observe seismic safety standards in the spirit of Executive Orders 12699 and 12941.

III. Seismic Safety of Federal Buildings: A Progress Report on Federal Agencies' Execution of Executive Orders 12699 and 12941

Executive Order 12699—Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction

Executive Order 12699, issued in 1990, applies to federal agencies that are responsible for (1) designing and constructing new federal buildings, (2) constructing and leasing new buildings for federal use, (3) providing or guaranteeing financing for new buildings, or (4) regulating the structural safety of new buildings. The Order directs these agencies to maintain and ensure the use of appropriate seismic design and construction standards for new buildings within their purview. Activities carried out pursuant to Executive Order 12699 during Fiscal Year (FY) 2003 and 2004 are reported below for each affected agency.

Architect of the Capitol

Although it is not required to comply with Executive Orders as an agency of the legislative branch, the Architect of the Capitol has voluntarily striven to observe seismic safety standards in the spirit of Executive Orders 12699 and 12941. During FY 2003 and 2004, the Architect of the Capitol required that all new construction for the legislative branch comply with the seismic resistance provisions of the Building Officials and Code Administrators (BOCA) International's National Building Code (NBC).

Department of Commerce

The Department has required that new facilities designed for its use meet all building codes in effect where the building is to be located, including seismic safety codes.

Department of Defense

For more than 30 years, the Department of Defense (DoD) has maintained seismic design standards for new facilities built for the Army, Navy, and Air Force. During FY 2003 and 2004, DoD worked to develop supplemental standards applicable to new construction of critical national defense assets. The U.S. Army Corps of Engineers (USACE) continued its development of tools and standards that can be used to improve seismic design for new buildings, power generation facilities, dams, retaining walls, and mechanical and electrical equipment. The Naval Facilities Engineering Command (NAVFAC) began updating the seismic design criteria for Navy piers and wharves.

Department of Energy

The Department of Energy (DOE) is responsible for the safety of personnel and activities at all of its sites. This includes protecting structures and occupants from the effects of earthquakes and other natural phenomena through appropriate policies, rules, orders, standards, guidance, and practices.

During FY 2003 and 2004, evaluations continued to show that DOE's seismic design requirements were substantially equivalent to the standards mandated under Executive Order 12699, and DOE continued to require that its orders and standards relating to natural hazards be consistent with part 830 (Nuclear Safety Management) of Title 10 of the Code of Federal Regulations (10 CFR Part 830).

DOE Order 420.1A, "Facility Safety," required that DOE facilities be designed, constructed, and operated so that the public, workers, and the environment are protected from the adverse impacts of earthquakes and other natural hazards. Related design guidance was provided in Design Guide DOE G-420.1-2. The Department continued to require that new buildings be constructed in accordance with DOE Standard (STD) 1020-2002, "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities." Accompanying standards included DOE-STD-1021, "Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components;" DOE-STD-1022, "Characterization Criteria;" and DOE-STD-1023, "Assessment Criteria."

Following are examples of recent progress in seismic safety relating to new structures at DOE sites:

- Oak Ridge National Laboratory, Tennessee—At the Y-12 National Security Complex, seismic hazard studies were updated to reflect all new information obtained over the last 10 years, including the latest U.S. Geological Survey (USGS) and NEHRP seismic hazard maps. Studies relating to the spallation neutron source facility concluded that the structural design of the facility's target building can accommodate the latest USGS regional accelerations. New buildings constructed during the past 2 years are in compliance with the seismic requirements of International Building Code (IBC) 2000.

At the Oak Ridge National Laboratory's Y-12 National Security Complex, seismic hazard studies were updated to reflect all new information obtained over the last 10 years, including the latest USGS and NEHRP seismic hazard maps.

- Pantex Plant, Texas—The seismic requirements of DOE Order 420.1A, DOE STD-1020-2002, and IBC 2000/2003 were incorporated into site design and construction projects, and used in designing the Building 12-44 and Building 12-64 upgrade projects.

- Savannah River Site, South Carolina—DOE began a reevaluation of the Site's probabilistic seismic hazard analysis. This work is being performed using hazard determination methodology, the latest assessments of local seismic sources, and ground motion attenuation models.

- Lawrence Livermore National Laboratory, California—DOE STD-1020-2002 was formally adopted into the Laboratory's Work Smart Standards, requiring the use of IBC 2000 Seismic Use Group I (or equivalent) criteria for designs of new Performance Category 1 Structures, Systems, and Components (SSCs), and Seismic Use Group III criteria for new Performance Category 2 SSCs. For Performance Category 3 SSCs, peak ground accelerations are determined from the site's probabilistic seismic hazard analysis and used in conjunction with DOE STD-1020-2002 for building designs or evaluations. These criteria were used in designing or constructing several

new structures, including Building 155 (isotope separation facility); Building 140 (international security research facility); Building 471 (central cafeteria); Building 368 (bio-safety level-3 facility); and Buildings 142, 242, and 264 (replacement office buildings).

- Bonneville Power Administration, Oregon—DOE worked to implement IBC 2000/2003 seismic requirements for new construction during 2003 and 2004. It now enforces IBC 2003 and the code's state supplements, requirements that are consistent with state building codes and NEHRP provisions applicable within Bonneville Power's service region.

- Lawrence Berkeley National Laboratory, California—The molecular foundry was designed to the requirements of the 2001 California Building Code and the Laboratory publication LBNL RD 3.22, "Lateral Force Design Criteria."

- Brookhaven National Laboratory, New York—The Building Code of New York State, May 2002 Edition, which is consistent with IBC 2000, was used in designing two new buildings: the Center for Functional Nanomaterials and the Research Support Building.

- Los Alamos National Laboratory, New Mexico—The Laboratory updated the structural chapter of its "Engineering Standards Manual," as well as the majority of its construction specifications, to ensure compliance with Executive Order 12699, DOE Order 420.1A, DOE G-420.1-2, and DOE STD-1020-2002.

DOE is responsible for the safety of personnel and activities at all of its sites. This includes protecting structures and occupants from the effects of earthquakes. This illustration is an example of properly anchored cylinders.

- Hanford Site, Washington—The Richland Operations Office issued a contract modification to clarify the requirements of subpart B of 10 CFR Part 830, and to ensure that the contractors apply these requirements during the planning or conceptual-design stage of any new facilities subject to subpart B. The Office of River Protection has been applying DOE Order 420.1A to the design and construction of the high-level waste, pre-treatment, and low-activity waste buildings. This Office has also begun reassessing portions of the 1996 probabilistic seismic hazard analysis relating to the waste treatment and immobilization plant. The objective is to reduce the uncertainty in the seismic design basis that resulted from extrapolating California attenuation data to the Hanford Site, and from limited shear wave velocity data. New shear wave velocity profiles down to 500 feet are being acquired using downhole and spectral amplification of surface wave techniques. Geophysical data are being reanalyzed, the latest Pacific Earthquake Engineering Research Group attenuation relations are being applied, and uncertainty in attenuation related to interbedded sediments among basalt layers between 500 and 1,500 feet in depth is being remodeled.

- Idaho National Engineering and Environmental Laboratory, Idaho—Twenty-five outdated analog instruments were replaced with digital strong motion accelerographs in facilities and at free-field sites (not within buildings). Earthquake analysis programs were replaced with SEISAN, a program that allows analyses of both seismograms and accelerograms. Performance Category 3 and 4 design-basis earthquake site response analyses and enveloping time histories were developed (5 percent damped spectra) for the Idaho Nuclear Technology and Engineering Center (completed) and the Test Reactor Area (in review).

Department of Health and Human Services

Standards and guidelines have been in place since 1992 for federally assisted construction that is within the purview of the U.S. Department of Health and Human Services. Since 1999, the Department has also maintained construction guidelines for buildings to be leased by the Indian Health Service (IHS). All new Departmental facilities must comply with the seismic requirements of national model construction codes.

Federal Bureau of Prisons

The Federal Bureau of Prisons, a component of the U.S. Department of Justice, published seismic design and certification guidelines in accordance with the Department's Seismic Safety Program. These guidelines require that new

buildings constructed for the Bureau comply with the National Fire Protection Association's Building Construction and Safety Code (NFPA 5000) and the seismic safety standards of the Interagency Committee for Seismic Safety in Construction (ICSSC). Any local requirements that are more stringent must also be met.

Federal Emergency Management Agency

For buildings leased by FEMA, compliance with the requirements of Executive Order 12699 is included in the standard GSA lease language. The building owner must affirm compliance.

For buildings owned by FEMA, the Facility Management Branch has a 2-year-old assessment of all FEMA buildings. FEMA also tracks the condition of buildings through the Real Property Management System (RPMS). Seismic issues or retrofitting are not kept track of in this system; repairs that are generally accomplished are deferred maintenance or updating mechanical and other systems. The Facilities Management Branch will work to identify the best means of capturing seismic retrofit opportunities in the RPMS and during condition assessments.

General Services Administration

In 2003, the General Services Administration (GSA) adopted the family of codes issued by the International Code Council (ICC) in lieu of the NBC, the Uniform Building Code (UBC), and the Standard Building Code (SBC). Structural designs for new buildings have since conformed to the latest edition of IBC.

GSA promotes the use of new technology in seismic safety and has investigated, tested, and installed steel-plate shear walls, unbounded braces, and base isolators in buildings. The design of the Seattle Federal Courthouse incorporated a steel-plate shear wall system in conjunction with concrete-filled pipe columns for its seismic lateral system. This innovative approach, referred to as the Steel Plate/Composite Concrete Shear Wall System, was developed over 24 years through collaboration among GSA, the University of California at Berkeley, Magnusson Klemencic Associates, and the Canadian Institute of Steel Construction. It provides the building's primary system for gravity, wind, and earthquake resistance, and is expected to improve seismic performance, speed up construction, and save construction dollars.

The Civil Engineering Research Foundation awarded the 2004 "Charles Pankow Award for Innovation" to the GSA Seattle Courthouse Team and Magnusson Klemencic Associates at the American Society of Civil Engineers (ASCE) awards ceremony on May 12, 2004. The Pankow award recognizes collaborative efforts that demonstrate innovative design-, materials-, or construction-related research and development, transferred into practice, that enhance productivity and performance in the industry.

Public Works and Government Services Canada invited the director of GSA's Pacific Rim Region Property Development Division, and the manager of GSA's Seismic Safety Program, to participate in an informal exchange on seismic and security issues facing both agencies. GSA seismic engineers subsequently gave presentations on seismic and security criteria and on recent project successes and challenges.

GSA and the Pennsylvania State University Department of Architectural Engineering are conducting research on a multihazard-resistant, panelized brick-veneer wall system. The objectives are to develop (1) a brick-veneer wall system with steel stud backup walls that minimizes the potential for cracking under high wind loads; (2) a prefabricated, panelized wall system with seismic isolation connections; and (3) a method of strengthening the wall system for improved performance under impact and blast loading situations. Dynamic racking tests will be performed to verify in-plane seismic isolation. The wall system will be designed to offer optional enhancement of impact resistance through the use of composites.

To secure private-sector expertise and achieve excellence in seismic-structural and blast design, the Office of the Chief Architect awarded three supplemental Seismic/Structural Blast contracts to nationally recognized firms. These contracts are available for use by all GSA regional offices as well as by other executive branch agencies.

Department of the Interior

The Department of the Interior (DOI) Seismic Safety Program has implemented all requirements of Executive Order 12699. The Department has required use of the latest, most stringent building codes since before the Order was issued, and its practices for new buildings conformed to "Recommendation of Design and Construction Practices in Implementation of Executive Order 12699" even before its issuance in 1995.

Seismic safety resources that DOI applies to the design and construction of new federal facilities include Departmental requirements about the use of appropriate model building codes, and analyses of local building codes that may be used for particular projects. New facilities are designed by DOI's in-house engineering design resources, or by private architecture and engineering (A&E) firms under contracts that require them to use the most current state and local structural design codes. Regardless of their source, all designs are reviewed by DOI engineers to ensure compliance with seismic safety and other technical requirements.

Within DOI, seismic safety issues are routinely discussed among the bureaus' seismic safety contacts. Departmental

seismic safety coordinators routinely conduct workshops, attended by all bureau seismic safety contacts, where compliance with the Seismic Safety Program is discussed. Program compliance is monitored and documented through frequent Department-wide seismic safety status reports. The Department also shares information on seismic safety with other agencies.

DOI bureaus occasionally receive requests to supersede prescribed building codes with local building codes. On these rare occasions, DOI seismic safety coordinators review the local codes to ensure that they are at least as stringent as the prescribed code.

National Aeronautics and Space Administration

The National Aeronautics and Space Administration (NASA) has incorporated the requirements of Executive Order 12699 into its "NASA Facilities Program Implementation Requirements" policy document. NASA provides technology updates prepared by ICSSC to the facility engineers at NASA centers and installations.

NASA's decentralized management structure allows its facility engineers to meet user requirements and still provide well-designed and well-constructed facilities that conform to today's engineering and environmental standards and practices, and national and local building codes. NASA views implementation of Executive Order 12699 as good engineering practice. Incorporation of all appropriate safety standards and codes is left to the design professionals working on each project.

NASA centers conduct design reviews to ensure compliance with all standards, codes, laws, and Executive Orders. In-house personnel check designs prepared by contracted architects and engineers, and peer reviews are held for in-house designs. Life-safety standards are used for most facilities; higher standards are used when mission-critical facilities are involved. NASA facility engineers evaluate each prospective facility in consultation with the end users to determine the appropriate level of safety.

Seismic safety has been a priority and a routine part of facility planning, design, construction, and budgeting at NASA headquarters and at NASA centers in seismically active areas. The Facilities Engineering and Real Property Division at NASA headquarters leads NASA seismic safety efforts. A member of the Division serves on the ICSSC and oversees dissemination of seismic safety information. NASA uses local and model building codes and relies upon the ICSSC to determine which model code best meets NEHRP requirements.

Executive Order 12699 has had little impact on NASA because it has always been NASA practice to design and construct facilities that meet or exceed current seismic safety standards. Contracting procedures used for new construction have not changed and NASA has not allocated additional staff, funding, or training in response to the Order. Designing to current safety standards (seismic or other) is considered to be an engineer's professional responsibility, although NASA provides the training needed to keep its engineers current in their fields. Although it costs more to design and construct buildings to ever more stringent seismic safety standards and codes, NASA believes that these added costs are necessary to provide safe facilities and should be considered in the overall economic justification of new facilities.

Department of the Navy

The Department of the Navy (DoN) has maintained a seismic safety policy that is in full compliance with the requirements of the Earthquake Hazards Reduction Act of 1977 and Executive Orders 12699 and 12941. The DoN component that designs and constructs Navy shore facilities, the NAVFAC, is responsible for establishing cost-effective design policies and criteria for DoN that incorporate adequate seismic safety standards.

In July 2002, DoN, in partnership with the other military services in the DoD, updated the building standards and design criteria for new U.S. military facilities in Unified Facilities Criteria (UFC) 1-200-01, "Design: General Building Requirements." UFC 1-200-01 incorporates nationally accepted private-sector standards and practices, referencing IBC 2000 along with specific code modifications for facilities unique to DoD. DoN and the other DoD services have since begun updating UFC 1-200-01 to reference IBC 2003.

This will ensure that DoD's seismic safety building standards and design criteria continue to reflect the most current, nationally accepted private-sector standards and practices.

NAVFAC Instruction 11000.40, "Seismic Safety Requirements for Navy Owned and Leased Buildings," released in October 2003, updates and promulgates DoN-specific seismic safety policy. It requires that all new Navy buildings, whether owned or leased, must be designed and constructed in accordance with UFC 1-200-01. Similarly, the NAVFAC P-73 "Real Estate Procedural Manual" requires that new leases comply with current NAVFAC seismic criteria.

Tennessee Valley Authority

The Tennessee Valley Authority (TVA) has the technical expertise needed to develop designs, including seismic designs, for a wide variety of buildings. TVA also provides financial assistance for building construction through its economic development programs and through loans made to its electric power distributors.

TVA has the technical expertise needed to develop designs, including seismic designs, for a wide variety of buildings.

TVA has continued to update the implementation procedure for Executive Order 12699 that it originally issued in 1993. This procedure establishes compliance requirements for new buildings and for additions to existing buildings, specifying document review processes, the responsibilities of the approval engineer and construction verifier, minimum qualifications for the approval engineer and construction verifier, and required documentation. It also includes a model seismic safety clause to be used in contracts for new construction and expansions.

TVA's approval engineers, who perform building plan and specification reviews related to seismic safety, must meet the following minimum qualifications: have a degree in structural or civil engineering, have at least 5 years of experience in structural design and in analysis of building framing and foundations, and be a licensed professional engineer. Construction verifiers, who review final construction to ensure that it is consistent with design drawings and specifications, must be competent in construction methods to a degree that ensures accurate performance of this function. Contractor personnel can fill either of these roles provided they meet the minimum qualifications.

During each construction project, the approval engineers and construction verifiers are required to provide a certificate of seismic compliance to TVA's seismic safety coordinator. The coordinator has programmatic responsibility for ensuring that seismic safety requirements are being met by TVA's operating groups. The contractor's architect or engineer with responsibility for the building design must submit a written statement to TVA that acknowledges the provisions of Executive Order 12699 and identifies the code used for seismic design.

Executive Order 12699 also affects TVA's economic development programs that provide financial assistance for new construction. These programs review beneficiaries' design and construction contracts to verify seismic safety compliance. The beneficiaries are local and regional economic-and industrial-development organizations located within the Tennessee Valley area. Assistance is provided for new construction within industrial parks, for expansion of existing industrial facilities, and for other construction associated with commercial and business development.

TVA operates some facilities, such as nuclear power plants and dams, which require special seismic safety standards. TVA's nuclear facilities are regulated by the Nuclear Regulatory Commission (NRC) and are designed to an operating basis-earthquake and a safe shutdown-earthquake that fully meet NRC requirements. TVA's Dam Safety Program operates under the *Federal Guidelines for Dam Safety* and complies with the seismic safety requirements specified therein.

Department of Veterans Affairs

The Department's seismic regulations were promulgated long before the 1993 deadline set by Executive Order 12699. Department of Veterans Affairs (VA) Handbook H-18-8 (formerly H-08-8), "Seismic Design Requirements," has been periodically updated, with the latest edition released in December 2003. The requirements in this handbook reference, and are fully coordinated with, the following national model codes and standards: IBC 2003; ASCE Standard 31-02, "Seismic Rehabilitation of Existing Buildings;" FEMA 350, "Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings;" FEMA 353, "Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications;" and FEMA 356, "Prestandard and Commentary for the Seismic Rehabilitation of Buildings."

VA has invested significant funds since 1973 to ensure that all new construction projects, as well as seismic upgrades of existing buildings, are in full compliance with VA seismic design standards. Although budget constraints have slowed new construction in recent years, seismic upgrade projects continue to receive significant funding. Recent projects involving seismic design for new buildings include the following: a building being designed for Anchorage, Alaska, that will house regional offices and outpatient clinic facilities; a new medical facility being planned for Las Vegas, Nevada; a replacement inpatient building constructed in Memphis, Tennessee; and an inpatient facility being planned for San Juan, Puerto Rico.

Executive Order 12941—Seismic Safety of Existing Federally Owned or Leased Buildings

Executive Order 12941, issued in 1994, applies to federal agencies that own or lease buildings for federal use. The Executive Order directed the ICSSC to adopt minimum standards of seismic safety for existing federally owned or leased buildings. In accordance with the adopted minimum standards, federal agencies were required to evaluate and mitigate unacceptable seismic risk in their buildings.

In addition, the Executive Order required that federal agencies estimate the costs of bringing their buildings into compliance with ICSSC standards and directed FEMA to use these cost estimates to prepare a report for Congress "on how to achieve an adequate level of seismic safety in federally owned and leased buildings in an economically feasible manner." In late FY 2000, FEMA submitted a draft of this report to the Office of Management and Budget (OMB). FEMA has made several revisions to the report in response to this review and has resubmitted the report to OMB.

Activities carried out pursuant to Executive Order 12941 during FY 2003 and 2004 are reported below for each affected agency.

Architect of the Capitol
During FY 2003 and 2004, the Architect of the Capitol required that renovation projects, when feasible, include upgrades to the seismic safety standards specified in ICSSC Recommended Practice 4, "Standards of Seismic Safety for Existing Federally Owned or Leased Buildings and Commentary." One such project is the renovation of the U.S. Botanic Garden's administration building, planned for FY 2006. In the design for this work, hazardous elements such as an incomplete load path were corrected by strengthening roof-to-wall connections. The added cost for this seismic upgrade was projected to be less than 1 percent of total project costs.

The Architect of the Capitol has also been including seismic studies in its condition assessments of existing buildings. These evaluations are guided by ASCE Standard 31-03, "Seismic Evaluation of Existing Buildings."

Department of Commerce
The Department of Commerce has a small number of facilities, and few of them failed the seismic evaluations carried out pursuant to Executive Order 12941. One of the Department's bureaus, the National Institute of Science and Technology (NIST), has no facilities needing seismic rehabilitation at this time. The other primary bureau, the National Oceanic and Atmospheric Administration (NOAA), has a few buildings that have been identified as needing rehabilitation.

The National Weather Service (NWS), a part of NOAA, has been systematically renovating all of its facilities, and this work has included the correction of any seismic deficiencies. NWS awarded a contract to renovate its office in St. Paul Island, Alaska, in mid-September 2004; project completion is anticipated by the end of September 2005. This will remedy one of the Department's most severe seismic deficiencies.

Department of Defense
DoD has followed the intent of Executive Order 12941 with a passive triggering program in compliance with ICSSC Recommended Practice 6, "Standards of Seismic Safety for Federally Owned and Leased Buildings." During FY 2003 and 2004, the USACE and NAVFAC pursued a variety of activities aimed at enhancing seismic safety among existing facilities.

USACE has been developing seismic evaluation and mitigation tools, including computer programs, criteria documents, process flowcharts, decision-making templates, a relative seismic hazard map, and an expanded benchmark-year table with Tri-Services criteria. These tools are designed for use with buildings, power generation facilities, mechanical and electrical equipment, retaining walls, dams, and other existing construction.

USACE and DoD started working with other ICSSC-member agencies to develop a pilot program on seismic safety within the Nation's lifeline infrastructure systems. Initial work has focused on the electric power system. USACE has also used its ongoing partnership with the power marketing administrations of DOE and DOI's Bureau of Reclamation to identify common interests and concerns regarding the electric power system.

In addition to providing direct emergency assistance following earthquakes, researchers from USACE's Engineering Research and Development Center have carried out numerous post-earthquake reconnaissance trips. These trips are intended to improve scientists' understanding of the seismic behavior of structural and geotechnical materials.

In March 2000, NAVFAC issued "Seismic Hazards Mitigation Program for Facilities Outside of the United States, Its Territories and Possessions," to reduce inconsistencies between the level of protection afforded existing Navy facilities within the United States and the protection afforded

NAVFAC recently began updating the seismic design criteria used for evaluating Navy piers and wharves.

overseas facilities. Since then, occupied Navy buildings overseas have been inventoried; modified procedures have been developed to estimate the potential seismic risks faced by the occupants, missions, and assets of Navy facilities in Europe; and a prioritized seismic risk strategy has been created for Europe that is based on the results of the seismic risk estimation procedures.

NAVFAC recently began updating the seismic design criteria used for evaluating Navy piers and wharves, and began contributing to the development of a new version of FEMA 172, "NEHRP Handbook of Techniques for the Seismic Rehabilitation of Existing Buildings." The latter effort, which is being managed by NIST, will update best practices and recommendations for seismic rehabilitation of existing buildings, and make FEMA 172 consistent with other FEMA documents that address the seismic safety of existing buildings.

In 2003, NAVFAC developed draft guidelines for reassessing Navy buildings that were found to have the potential for being "exceptionally high risk" (EHR) in prior seismic evaluations conducted pursuant to Executive Order 12941. These guidelines, which are now being reviewed by DoN, are intended to (1) update and refine the list of potentially EHR buildings by incorporating risk mitigation actions carried out to date, and (2) establish a process for prioritizing further evaluations of these buildings that is based on potential damage estimates, occupancy, and mission criticality.

NAVFAC has also been participating with FEMA in a pilot project involving the use of an enhanced version of the Hazards US (HAZUS) software at the Puget Naval Shipyard/Bremerton Naval Station. The intent is to demonstrate the usefulness of HAZUS as an effective and strategic disaster-related decision-support tool, and to validate its ability to rapidly predict the potential seismic risk to a single building or a portfolio of buildings using limited information.

Department of Energy

DOE natural phenomena hazards (NPH) mitigation programs continued through FY 2003 and 2004. Headquarters personnel focused on reviewing and updating requirements and standards used in mitigating earthquake effects. Field-level activities included identifying and reducing vulnerabilities to earthquakes through compliance with Executive Orders 12699 and 12941, and continuing site characterization efforts to improve understanding of seismic hazards.

DOE STD-1020-2002, which is consistent with the requirements of ICSSC Recommended Practice 6, has guided DOE's efforts to evaluate and prioritize existing facilities for seismic mitigation, as required under Executive Order 12941. Additional guidance has been provided through DOE Order 420.1A, which is consistent with the latest NEHRP and industry seismic design standards. Because DOE has many buildings containing hazardous materials, which require more stringent evaluation criteria, this order includes supplemental requirements in the areas of nuclear safety, explosives safety, fire protection, nuclear criticality safety, and NPH safety.

Following are examples of recent progress in seismic safety relating to existing structures at DOE sites:

- Oak Ridge National Laboratory, Tennessee—The Laboratory began implementing its plan to evaluate buildings for compliance with DOE STD-1020-2002. The one building found to be seismically deficient during the initial evaluations conducted pursuant to Executive Order 12941 was retrofitted to meet IBC 2000 seismic requirements. At the Y-12 National Security Complex, seismic evaluations of existing nuclear facilities were performed in preparing the documented safety analysis reports required under 10 CFR Part 830. These evaluations were based on the site's newly updated seismic hazard studies, which were more stringent than those required by ICSSC Recommended Practice 6.

- Pantex Plant, Texas—The Pantex site evaluated its building inventory for potential seismic risks (Paragon Structural Engineering report) and concluded that 359 buildings (49 percent of the inventory) were exempted from seismic evaluation. Evaluations of existing nuclear and nuclear-explosive facilities were completed, and a schedule for evaluating existing explosive processing facilities was approved for FY 2005 and 2006. A project plan was developed to further investigate specific areas of concern that emerged from the nuclear and nuclear-explosive facility evaluations.

- Savannah River Site, South Carolina—The glass waste storage and tritium extraction buildings were determined to meet the performance requirements and implementation standards of DOE Order 420.1A, as well as applicable national standards for the protection of personnel and processes during NPH events. These requirements are more stringent than those of ICSSC Recommended Practice 6.

- Lawrence Livermore National Laboratory, California—A mitigation program and a prioritization system were implemented for buildings found to be seismically deficient in evaluations conducted pursuant to Executive Order 12941. Fifty-three buildings (approximately 8 percent of the building inventory) had been identified as having unacceptable seismic deficiencies. A 10-year seismic rehabilitation plan was developed for the 16 most

vulnerable buildings. It was determined that rehabilitation in the remaining 37 buildings could await major renovations. Seismic improvements have already been made during renovations in the following buildings: Building 151 (chemistry laboratory), 100 percent of seismic upgrades completed; Building 321C (engineering technology complex), 100 percent completed; Building 298 (physics laboratory), 85 percent completed; Building 141 (engineering building), 70 percent completed; and Building 511 (plant engineering maintenance facility), 30 percent completed.

- Bonneville Power Administration, Oregon—DOE evaluated one additional building for seismic vulnerabilities during FY 2003 and 2004.

- Lawrence Berkeley National Laboratory, California—Using FEMA 310, "Handbook for Seismic Evaluation of Buildings—A Prestandard," and its successor, ASCE Standard 31-03, the Laboratory has completed 23 building evaluations since 2003.

- Los Alamos National Laboratory, New Mexico—The Laboratory completed seismic evaluations required under Executive Order 12941 for those existing facilities that did not have a model building type assigned to them in the Department's Facility Information Management System. A program modeled on SAFER, the seismic safety program of the University of California at Berkeley, is being considered to assist in prioritizing mitigation in existing facilities.

- Idaho National Engineering and Environmental Laboratory, Idaho—The Idaho Nuclear Technology and Engineering Center prepared seismic qualifications for the bins in Calcined Solids Storage Facility 1.

- Sandia National Laboratories, New Mexico—Sandia National Laboratories (SNL) has completed many seismic upgrades since evaluating its existing facilities in 1998. SNL policy is to consider seismic upgrades to existing facilities when building modifications are made. On the basis of recently revised seismic data provided by USGS, the Sandia Site Office has requested that SNL reassess the 1998 evaluations to determine current vulnerabilities, and prioritize seismic upgrades among high-risk facilities. Since the evaluations were performed in 1998, 12 buildings have been classified as high-risk facilities. Of these, three essential facilities have been upgraded (Buildings 800, 802, and 880), and two facilities have been evacuated and demolished (Buildings 805 and 841). Two additional buildings are scheduled for demolition in FY 2007 and FY 2010 (Buildings 806 and 807). The remaining high-risk facilities are part of a conceptual design study that is evaluating renovation or replacement.

Environmental Protection Agency

The Environmental Protection Agency (EPA) developed its National Seismic Safety Program in 1997 and has since worked to ensure that all of its facilities become compliant with seismic safety requirements. EPA has been evaluating seismic safety in buildings scheduled for major alterations and, more recently, has begun assessing facilities that are subject to potential seismic risk, regardless of whether renovations are planned.

During FY 2003 and 2004, EPA completed seismic safety mitigation or evaluation activities at three EPA-owned facilities. These projects are described below.

- Region 10 Laboratory, Manchester, Washington—EPA discovered during construction of a new wing at the Laboratory that the design of the addition, completed in 1999, had inadequately addressed EPA's seismic safety requirements, and had positioned concrete footings for the wing on beach deposits susceptible to liquefaction and lateral spreading. EPA concluded that these findings posed unacceptable risks for this critical facility and immediately undertook remedial actions. EPA obtained a full analysis from a qualified seismic engineer, strengthened the new tilt-up wall concrete building, and installed more than 100 Geopiers into native soil below the beach deposits. The dedicated efforts of engineers and contractors resulted in a successful outcome with minimal delay (about 2 months) and added costs acceptable to EPA. EPA also retained a seismic engineer to evaluate the existing laboratory in accordance with FEMA 310, because a major renovation of the structure was planned. Several deficiencies were identified, and mitigation measures were incorporated into the planned structural modifications. The first phase of the renovation began in September 2004.

- National Health and Environmental Effects Research Laboratory, Western Ecology Division, Corvallis, Oregon—In 2003, EPA conducted a Tier 1 study of the main building in accordance with FEMA 310. The results indicated that a Tier 2 study was required, including geotechnical exploration. A report with findings, conclusions, and recommendations is due in November 2005. Preliminary reports indicate that the potential for failure of the soils and foundations during a seismic event is low or negligible, but that some building modifications may be needed to achieve acceptable seismic safety.

National Health and Environmental Effects Research Laboratory, Western Ecology Division, Corvallis, Oregon.

- National Risk Management Research Laboratory, Water Supply and Resources Division, Edison, New Jersey—EPA is constructing an emergency operations center in a World War II-era building located at its Laboratory in Edison. A seismic safety analysis of the existing structure was included in the design process, and it revealed the need for additional structural-steel seismic bracing throughout the roof framing. This bracing was incorporated into the construction drawings and has been installed in the 30,000 square-foot, one-story building.

EPA has begun to evaluate its main laboratory at the Coastal Ecology Branch in Newport, Oregon; this was prompted primarily by changes in seismic performance requirements in the Northwest over the past decade. Also, as part of major renovations at the Andrew W. Breidenback Environmental Research Center in Cincinnati, Ohio, EPA is conducting a seismic safety evaluation of the main, seven-story laboratory building. Through all of these actions, EPA is continuing to work to ensure that its people and property are protected during seismic events.

Federal Bureau of Prisons

The Federal Bureau of Prisons has continued to require that all major renovation projects at existing facilities nationwide include prevailing seismic safety standards and building codes, as applicable, in the project design plans and specifications. The Bureau receives no special funding or appropriations specific to this effort.

General Services Administration

As of September 2004, GSA had fully evaluated 43 percent of the 745 federally owned buildings that it had previously targeted as seismically deficient. Seismic evaluations of existing buildings are conducted in accordance with ASCE Standard 31-03; life safety is the minimum acceptable performance level for existing federal buildings.

Funding limitations preclude rehabilitation of all buildings found to have seismic deficiencies. To facilitate efficient and effective use of available funds, GSA prepared a nationwide list of owned properties ranked by seismic risk. This "Seismic Hazard Priority List" ranks buildings for rehabilitation on the basis of their location, type of structural framing, and number of occupants. Rehabilitation of existing buildings is performed in accordance with FEMA 356.

GSA conducts risk analyses of seismically deficient buildings to assess their vulnerability and the costs of improving their seismic performance through partial or complete retrofits. Each such analysis yields a probable maximum loss (PML) estimate, the maximum expected financial loss to the structure from earthquake damage. The PML represents loss on property in its current condition, without the benefit of renovation or retrofit. Even though a building may not be in compliance with GSA life-safety criteria, if the life-safety risk for occupants is low, the building is deemed acceptable for occupancy during the period of the analysis. The risk-analysis tool helps in determining whether risks are acceptable for occupancy when seismic mitigation must be delayed until funds become available.

In mid-2004, GSA began installing 75 friction pendulum isolators at the Pioneer Courthouse in Portland, Oregon. This building, a 129-year-old national historic landmark, is the second oldest federal courthouse west of the Mississippi River and is ranked second in historic significance among GSA buildings. When the work to seismically isolate and rehabilitate the courthouse is complete, the structure will be the first base-isolated federal building in the Pacific Northwest.

In addition to its seismic work with federally owned buildings, GSA has effectively applied seismic safety standards to the privately owned, leased buildings within its purview. GSA is responsible for about 63 percent of all privately owned buildings leased by the Federal Government. Approximately 15 percent of the buildings leased by GSA are located in regions with high seismicity. GSA includes language in all of its new leases requiring building owners to meet the requirements of ICSSC Recommended Practice 6, and GSA engineers review and verify seismic certifications submitted by owners' engineers.

GSA partnered with USGS to produce guidelines, revised in November 2002, for installing seismic instrumentation in buildings. The main objective of deploying seismic instrumentation is to enhance understanding of the behavior of structures and of their potential for sustaining damage under the dynamic loads of earthquakes. Better understanding can lead to new design and construction practices that can reduce future earthquake damage. "Seismic Instrumentation of Buildings," the guidelines document prepared under this joint GSA-USGS project, includes sample specifications for seismic building instrumentation systems.

Department of Health and Human Services

The Department found seismic deficiencies at its IHS facilities during 1999 and 2000. The total cost of correcting these problems was estimated to be $149 million. Various strategies have since been developed to correct the deficiencies, including removing buildings from the Department's property inventory and incorporating structural and non-structural seismic upgrades into all major renovation projects. As a result, the deficiencies have been reduced by approximately 33 percent over the past 4 years.

Department of the Interior

The overall seismic rehabilitation cost estimate that the Department prepared in 1998 had two components: costs developed for each deficient building in high seismic zones, and a statistical projection of high-zone costs to buildings in moderate and low seismic zones. During FY 2003 and 2004, the DOI Seismic Safety Program continued to extend the inventorying, screening, and evaluating requirements of ICSSC Recommended Practice 6 to buildings in moderate and low seismic zones. This involves identifying seismically deficient buildings in these zones and developing building-specific rehabilitation cost estimates that are consistent with estimates prepared for high-zone buildings. These new building-specific estimates will replace the statistically projected rehabilitation cost estimate for buildings in low and moderate zones.

DOI has actively pursued the mitigation of unacceptable seismic risk in existing buildings, which is a specific requirement of ICSSC Recommended Practice 6. The Department has placed a high priority on addressing deferred maintenance issues, including seismic safety issues, that affect the health and safety of employees and the public. DOI has framed this priority in budget guidance, requesting a 5-year plan from each DOI bureau addressing, as a priority, critical health and safety deferred maintenance. These plans will include the rehabilitation of high-risk buildings identified pursuant to Executive Order 12941.

Mitigation designs for the Department's highest-risk buildings were initiated in FY 1999, and a specific funding plan is in place that allows mitigation resources to be directed to these structures. DOI has developed a risk-based methodology that determines the mitigation priority of all buildings found to be seismically deficient. This innovative approach has allowed the Department to move quickly to initiate seismic risk reduction projects at the highest-priority facilities as funding permits.

The Department's seismic safety coordinators manage meetings of the DOI Seismic Safety Team, which includes seismic safety contacts from each bureau. The U.S. Forest Service and IHS have also participated in Team meetings. Meeting agendas encompass general coordination, resource sharing, training, compliance, Seismic Safety Program implementation, program annual reports, and bureau status reports. The Team has met with and made presentations to seismic safety program directors from the State of California, the Salt Lake City School District, and the City of Seattle, and has met with numerous service providers and manufacturers of seismic restraints.

Department of Labor

During FY 2003 and 2004, the Department of Labor's seismic safety activities related to buildings that it owned and leased for the Employment and Training Administration's (ETA) Job Corps program. Before buildings are purchased for the Job Corps, ETA evaluates their seismic safety and forwards its findings and recommendations, including cost estimates for any required mitigation, to the Department for review. ETA monitors planned renovations of leased facilities to determine whether accompanying seismic upgrades are required, and reviews upcoming lease renewals to determine whether the lessor must complete mitigation work or certify seismic compliance before the Department can renew the lease.

ETA completed detailed seismic analyses of Job Corps facilities that were unable to be exempted from such scrutiny through earlier screening performed under Executive Order 12941. These analyses, comprising FEMA 310 evaluations and preparation of mitigation recommendations, were performed at five Job Corps centers. The buildings found to require mitigation and the mitigation strategies pursued are described below for each center.

- Memphis Job Corps Center—An A&E firm has begun preparing mitigation designs for the Center's main building and gymnasium.

- Los Angeles Job Corps Center—Buildings 1 (main), 2 (education), 3 (business, education), and 4 (residential) were found to be in need of seismic mitigation. The Center has decided to vacate these structures and find alternate facilities in cooperation with the lessor.

- Sacramento Job Corps Center—A contract has been awarded to demolish and replace the gymnasium.

- Sierra Nevada Job Corps Center—A project has been funded to design seismic upgrades for Buildings 11 (Donner Hall), 15 (Washoe Hall), 18 (Lassen Hall), 19 (Comstock Hall), 20 (Fremont Hall), 21 (Carson Hall), 22 (cafeteria), and 31 (theater).

- Cascades Job Corps Center—The lessor, the State of Washington, has agreed to let contracts to design and install seismic upgrades for Buildings 24 and 28; the Department of Labor will contribute funds toward this work.

National Aeronautics and Space Administration

During the late 1970s and the 1980s, NASA implemented a seismic safety review process in areas of high seismicity and modified many existing buildings. Since then, NASA has continued these efforts by programming facility revitalization projects that comply with current building codes and seismic standards. Seismic safety has remained a prime consideration among facility engineers at NASA centers located in vulnerable areas. NASA has also continued to work with FEMA, the ICSSC, and other agencies in developing seismic evaluation methodologies and proposed Executive Orders.

Since NASA incorporated the requirements of Executive Order 12941 into the "NASA Facilities Program Implementation Requirements" policy document, its centers have continued to respond by evaluating existing buildings and determining which require seismic upgrades or replacement. Mitigation projects are considered in NASA's yearly budget deliberations. Despite the budget constraints it has faced, NASA has maintained a prudent course of identifying and upgrading facilities that may present unwarranted risks from seismically induced hazards. Buildings leased by NASA are required to comply with seismic safety standards before the lease is executed.

In FY 2003, NASA completed a seismic survey of facilities at the Jet Propulsion Laboratory (JPL) in Pasadena, California. In 2004, NASA prepared a preliminary engineering report concerning seismic upgrades for a tall office building at JPL that was initially evaluated in FY 2002. On the basis of these studies, NASA decided to replace this building. NASA also completed construction documents for the seismic retrofit of another building at JPL and made plans to seek bids for the project in FY 2005.

At the Ames Research Center in Mountain View, California, NASA completed seismic upgrades in two buildings; these projects were initiated in FY 2002 and FY 2003. In FY 2004, NASA began seismically strengthening two more buildings at the Center and made plans to upgrade another building in FY 2005. NASA has also hired consulting engineers to evaluate three more buildings at the Center, and will budget funds for seismic upgrades as needed.

In FY 2003, NASA completed a seismic survey of facilities at the JPL in Pasadena, California.

Department of the Navy

In October 2003, DoN issued NAVFAC Instruction 11000.40 to update and promulgate DoN seismic safety policy. This instruction adopted ICSSC Recommended Practice 6 as the minimum acceptable seismic standard for the Department's existing owned and leased buildings within the United States, its territories, and possessions.

Department of Veterans Affairs

The Department has been evaluating and mitigating seismic risk at its health care facilities since the mid-1970s. In response to Executive Order 12941, VA has combined the risk data that it had already developed with data generated through additional screening and evaluation studies (including detailed studies of 220 buildings), to create an extensive building inventory containing detailed infrastructure and seismic risk data.

Of the 6,000 buildings in the VA inventory, 700 are subject to some level of seismic risk. Of those 700 structures, 150 have been designated as high-risk and 75 as EHR. Buildings subject to high or exceptionally high risk are ranked individually by severity of risk in the inventory. The inventory is being used to develop project-level mitigation cost estimates for incorporation into VA's major construction program.

At the close of FY 2004, 12 seismic mitigation projects were under way or had recently been completed in Puerto Rico and California, Montana, Oregon, and Washington. Each of these projects is listed below along with its status at the end of the fiscal year.

- VA Long Beach Healthcare System, Long Beach, California—The retrofit for Building 133 (nursing home) was being designed, and A&E firms were being selected for the Building 7 (wards and clinic) and Building 126OP (outpatient facilities) work.

- VA Palo Alto Health Care System, Menlo Park Division, Menlo Park, California—Building 137 (psychiatric facilities) was scheduled to be demolished and Building 324 (wards and administrative offices) to be replaced.

- VA Palo Alto Health Care System, Palo Alto Division, Palo Alto, California—A&E firms were being sought for the Building 2 (psychiatric facilities) and Building 4 (research facilities) retrofits, and seismic upgrades had been completed in Buildings 23 (therapeutic gymnasium) and 40 (boiler house).

- Sacramento VA Medical Center, Mather, California—A construction contract had been issued for the Building 650 (hospital) retrofit.

- VA San Diego Healthcare System, San Diego, California—Seismic design work was underway for Building 1 (medical center).

- San Francisco VA Medical Center, San Francisco, California—The design work for Building 203 (inpatient hospital) was in progress.

- Sepulveda Ambulatory Care Center and Nursing Home, Sepulveda, California—Seismic construction had been completed in Building 99 (nursing home).

- West Los Angeles Healthcare Center, Los Angeles, California—Retrofits were being designed for Buildings 114 (research laboratory) and 500 (main hospital).

- VA Montana Health Care System, Fort Harrison, Montana—Work had been completed on Building 154A (outpatient clinic).

- Portland VA Medical Center, Portland, Oregon—Construction was set to begin on the upgrades for Buildings 6 (research facilities) and 16 (research and administrative facilities).

- San Juan VA Medical Center, San Juan, Puerto Rico—A&E selection was in process for work on Building 1 (main hospital).

- VA Puget Sound Health Care System, American Lake Division, Tacoma, Washington—Seismic upgrades were under construction in Buildings 6 (domiciliary), 61 (mental health facilities), and 85 (mental health facilities).

As these projects indicate, VA has made seismic safety an important goal for its health care facility managers and has aggressively supported construction funding for the rehabilitation of seismically deficient buildings. The Department has issued a seismic safety directive mandating specific organizational responsibilities and directing facility managers to develop strategic plans to address seismically at-risk facilities.

VA owns the National Strong Motion Instrumentation Network, which records and analyzes seismic activity through 85 recording systems located at 60 VA medical centers around the country. USGS operates and maintains this network under an interagency agreement with VA. Recently, VA had USGS replace the old analog strong motion instruments at 45 medical centers with more sophisticated digital instruments.

VA has continued to participate, along with FEMA, ICSSC, and the BSSC, in the development of seismic standards, code comparisons, and data collection initiatives. The manager of VA's seismic program routinely attends related conferences and keeps up with the state of the art in seismic risk analysis and mitigation.

This photos was taken on a survey along and near the Denali fault after Alaska's Nov. magnitude 3 7.9 earthquake. (USGS)

IV. Future Directions

On October 25, 2004, Congress enacted the Earthquake Hazards Reduction Authorization Act of 2004, Public Law 108-360. Public Law 108-360 provides for a number of changes affecting the National Earthquake Hazards Reduction Program (NEHRP) starting in Fiscal Year (FY) 2005, including the transfer of lead agency status over the NEHRP from the Federal Emergency Management Agency (FEMA) to the National Institute of Standards and Technology (NIST). Another significant change is the requirement that NIST establish an Advisory Committee on Earthquake Hazards Reduction. The Advisory Committee, which will be comprised of representatives from research and academic institutions, industry standards development organizations, state and local government, and financial communities, will make recommendations to the NEHRP agencies in implementing the Program. Beginning in FY 2005, these recommendations will be included in an annual report to the Congress, rather than a biennial report, on NEHRP progress.

The *Strategic Plan for the NEHRP for 2001-2005, Expanding and Using Knowledge To Reduce Earthquake Losses* (*Strategic Plan*) articulates the mission and the four primary goals of the NEHRP, provides a framework for priority-setting and coordinating activities, and defines priority areas for the future. In FY 2004, the NEHRP Interagency Coordinating Committee (ICC) established a Subcommittee on Performance Measures. By the end of FY 2005, the ICC Subcommittee will have established performance measures for the NEHRP based on the mission, goals, objectives, and priorities in the Strategic Plan. These performance measures will serve as the foundation for updating the Strategic Plan and will provide the basis for both assessing progress and establishing priorities and future direction of the NEHRP.

Over the next year, the NEHRP agencies will continue to build on the projects and initiatives described in Section II of this report. Recent events also will bring a new focus to some of the NEHRP agencies' priorities and future directions, some of which are described below.

Federal Emergency Management Agency

In response to the magnitude 6.5 San Simeon earthquake on December 22, 2003, the California Office of Emergency Services used FEMA's HAZUS software program, in

conjunction with a ShakeMap produced by the U.S. Geological Survey (USGS), as the basis for arriving at loss estimation within 1 hour of the event.

In the 8 years since FEMA published the prototype earthquake edition HAZUS97, HAZUS has helped communities across the United States identify and plan for earthquakes by giving them access to specialized databases and GIS-based analytic tools.

The FEMA HAZUS earthquake loss estimation methodology uses mathematical formulas and information about building stock, local geology, the location and size of potential earthquakes, economic data, and other information to estimate losses from a potential earthquake. HAZUS uses ArcGIS to map and display ground shaking, the pattern of building damage, and demographic information about a community. Once the location and size of a hypothetical earthquake is identified, HAZUS estimates:

- ground shaking
- the number of buildings damaged
- the number of casualties
- the amount of damage to transportation systems
- disruption to the electrical and water utilities
- the number of people displaced from their homes
- the cost of repairing projected damage and other effects

In FY 2005, FEMA's Mitigation Division released HAZUS-MH MR1 (HAZUS-MH Version 1.1), an updated and revised version of HAZUS-MH that includes a sixth edition of the HAZUS Earthquake Model. In addition to providing estimates of damage to property, hospitals, fire and police stations, schools, bridges and other transportation facilities, and utilities, the Earthquake Model addresses building debris generation, fires that occur after earthquakes, casualties, shelter requirements, and economic losses. HAZUS-MH MR1 features faster runtimes for supporting rapid loss estimation during earthquake response operations, a capability to add specialized local building types to the earthquake analysis, updated third-party software platforms, and numerous improvements based on user input. A FEMA priority is to continue to update HAZUS to best meet the needs of the public and decision-makers in preparing for and responding to earthquakes and other natural disasters.

National Institutes of Standards and Technology

For over 100 years, the Nation has relied upon NIST for scientific and technical expertise, not only to enhance national security but to promote economic growth, commerce, and trade. In times of war or other national emergencies, NIST scientists and engineers have stepped forward with a vast array of expertise and knowledge in areas as diverse as radio transmission and forensic DNA typing.

Through approximately 120 ongoing and newly initiated research and standards development projects, NIST is helping law enforcement, the military, emergency services, information technology, airport and building security, and other areas protect the American public from terrorist threats. Similar to earthquake hazard reduction, an essential tool in responding to extreme events is a solidly built and protected infrastructure. NIST is contributing to this goal through projects focused on strengthening the safety and security of buildings and the physical infrastructure.

In August 2002, NIST launched a $16 million, multi-year federal building and fire safety investigation of the World Trade Center disaster. The study of World Trade Center Buildings 1 and 2 and World Trade Center Building 7 is focusing on the building construction, the materials used, and all of the technical conditions that contributed to the outcome of the World Trade Center disaster. Similar to most of NIST's work, this project is a partnership with many organizations and world-class experts. From this study, NIST expects to learn-and pass on-many lessons in several different areas, including structural fire protection, life safety, and engineering practice. These broader R&D and dissemination efforts will focus on using the results of the World Trade Center investigation to develop cost-effective solutions to improve the safety of existing and future buildings against extreme events such as fires, attacks, and natural disasters, including earthquakes. NIST will release the final investigation report on World Trade Center Buildings 1 and 2 in April or May 2005. The WTC 7 report will be issued as a supplement to the main report, with a draft issued in May and the final in July 2005.

These NIST efforts also will help provide a better understanding of how emergency responders and building occupants behave in a crisis, and to use the lessons learned to help occupants survive future disasters and enable emergency responders to do their jobs more safely and effectively. NIST expects to engage leaders of the construction and building community in the implementation of proposed changes to practices, standards, and codes. Guidance and practices based on this study will be disseminated broadly to standards and code-developing organizations and to state and local agencies.

NIST believes the resulting code reforms will further protect property and save lives, as well as provide better emergency response capabilities and procedures in future disasters.

National Science Foundation

The December 26, 2004, tsunami in South Asia is one example of how the NEHRP agencies can rapidly focus their efforts to respond to events and look to the future to reduce the impacts of these events. With the appropriate information, communities and nations can characterize risks and determine how best to allocate resources for detection, warning, and preparedness. The National Science Foundation (NSF), in cooperation with the world research community, will continue to generate new knowledge about the natural phenomena of earthquakes and tsunamis, the design of better coastal structures, the development of early warning and response systems that can mitigate loss of life, and recovery from such disasters.

NSF has long funded scientific and engineering research infrastructure to detect and understand the impacts of earthquakes, tsunamis, and other phenomena. Prominent examples include the real-time Global Seismographic Network (GSN), the data from which forged the critical core of the early warning of the December 26, 2004, earthquake. This Network, operated by the Incorporated Research Institutions for Seismology (IRIS), is funded in partnership by NSF and the USGS, and is the primary international source of data for earthquake location and tsunami warning.

NSF also funds research designed to support damage and loss prediction and avoidance for the United States and elsewhere, including earthquake and tsunami effects on buildings, bridges, and critical infrastructure systems, and estimates of economic consequences, human and societal impacts, and emergency response. NSF recently established the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), a major national infrastructure project to create a complete system of test facilities. The project is revolutionizing earthquake-engineering research. NSF-funded researchers create physical and computational simulations to study how earthquakes and tsunamis affect buildings, bridges, ports, and other critical infrastructure. The NEES Tsunami Wave Basin at Oregon State University is now the world's most comprehensive facility for studying tsunamis and storm waves.

U.S. Geological Survey

During the past year, more than 27 major disasters were declared in the United States from earthquakes, landslides, storms, fires, and floods. The year ended with the tragic tsunami in the Indian Ocean, triggered by a magnitude 9 earthquake off the coast of Sumatra. As part of a 2-year commitment by the Administration to expand tsunami detection and monitoring to protect residents in the U.S. and its territories, the USGS facilities and operations will provide more robust detection and notification of earthquakes that could trigger tsunamis. USGS will conduct this effort in partnership with National Oceanic and Atmospheric Administration (NOAA). USGS also will enhance its volcano monitoring program and will maintain a strong landslide program to provide advance warnings of potential debris flow and landslides.

As part of the Administration's plan to improve the safety of the United States, the USGS also will increase its ability to rapidly determine the location, size, and depth of large earthquakes; improve landslide models and alert systems; improve monitoring of the most dangerous volcanoes in the United States; and work with its partners to ensure timely warnings for all geologic hazards.

The NEHRP is a very successful program that has significantly improved our Nation's ability to prepare for, respond to, recover from, and mitigate earthquakes. The NEHRP will succeed in meeting the challenges brought about by earthquakes by continuing to combine the talents, expertise, and energy of the NEHRP agencies and all of its partners. In looking to the future, the NEHRP will play a critical role by making the performance of our buildings and lifelines highly measurable and predictable. This measurement and prediction ability will provide the critical foundation upon which to achieve specified levels of performance and seismic risk reduction via workable and practicable solutions. The United States, through the work of the NEHRP, will be safer and more secure for it.

List of Acronyms

ACP	Association of Contingency Planners
A/E	Architect/Engineer; Architectural/Engineering
AHAB	All Hazard Alert Broadcasting
ALA	American Lifelines Alliance
ANSS	Advanced National Seismic System
AOC	Architect of the Capitol
API	American Petroleum Institute
ASCE	American Society of Civil Engineers
ATC	Applied Technology Council
AWWA	American Water Works Association
BOCA	Building Officials and Code Administrators
BSSC	Building Seismic Safety Council
CALTRANS	California Department of Transportation
CEA	California Earthquake Authority
CEPEC	California Earthquake Prediction Evaluation Council
CERI	Center for Earthquake Research and Information
CPARM	Contingency Planning and Recovery Managers
CREW	Cascadia Region Earthquake Workgroup
CRSC	Code Resource Support Committee
CUSEC	Central United States Earthquake Consortium
DHS	Department of Homeland Security
DHS&EM	Division of Homeland Security and Emergency Management (Alaska)
DNR	Department of Natural Resources
DoD	Department of Defense
DOE	Department of Energy
DOGAMI	Department of Geology and Mineral Industry (Oregon)
DOI	Department of Interior
DoN	Department of the Navy
DOT	Department of Transportation
DR	Disaster Research Newsletter (NHRAIC)
DRB	Disaster Resistant Business Program
EERC	Earthquake Engineering Research Center
EERI	Earthquake Engineering Research Institute
EHR	Exceptionally High Risk
EMA	Emergency Management Agency
EMD	Emergency Management Division (Washington)
EMI	Emergency Management Institute (FEMA)
EMPG	Emergency Management Performance Grant
EPA	Environmental Protection Agency
EPRI	Electrical Power Research Institute
ETA	Employment and Training Administration (DOL)
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FRP	Fiber-Reinforced Polymer
FY	Fiscal Year
GIS	Geographic Information System
GPRA	Government Performance and Results Act
GSA	General Services Administration
HAZUS	Hazards U.S.
HMGP	Hazard Mitigation Grant Program

HSEAC	Hawaii State Earthquake Advisory Committee
HUG	HAZUS Users Group
IAEM	International Association of Emergency Managers
IBC	International Building Code
IBHS	Institute for Business and Home Safety
ICC	International Code Council; Interagency Coordinating Committee
ICDP	International Continental Drilling Program
ICSSC	Interagency Committee on Seismic Safety in Construction
IHS	Indian Health Service
InSAR	Interferometric Synthetic Aperture Radar
IRC	International Residential Code
IRIS	Incorporated Research Institutions for Seismology
ITR	Information Technology Research
JPL	Jet Propulsion Laboratory
LADWP	Los Angeles Department of Water and Power
LANL	Los Alamos National Laboratory
LRFD	Load and Resistance Factor Design
LYS	Lowe Yield Strength
MAE Center	Mid-America Earthquake Center
MBDSI	Multihazard Building Design Summer Institute
MCEER	Multidisciplinary Center for Earthquake Engineering Research
MMC	Multihazard Mitigation Council
NAS	National Academy of Sciences
NASA	National Aeronautical and Space Administration
NAVFAC	Naval Facilities Engineering Command
NBC	National Building Code
NCREE	National Center for Research on Earthquake Engineering
NEES	Network for Earthquake Engineering Simulation
NEHRP	National Earthquake Hazards Reduction Program
NEIC	National Earthquake Information Center
NESEC	Northeast States Emergency Consortium
NFPA	National Fire Protection Association
NHRAIC	Natural Hazards Research and Applications Information Center
NIBS	National Institute of Building Sciences
NIST	National Institute of Standards and Technology
NJGS	New Jersey Geological Survey
NMSZ	New Madrid Seismic Zone
NOAA	National Oceanic and Atmospheric Administration
NPH	Natural Phenomena Hazards, DOE
NRC	Nuclear Regulatory Commission; National Research Council
NSF	National Science Foundation
NSMP	National Strong Motion Program
NTHMP	National Tsunami Hazard Mitigation Program
NYCEM	New York Area Consortium for Earthquake Loss Mitigation
OEM	Oregon Emergency Management
OES	Office of Emergency Services
OMB	Office of Management and Budget
PDC	Pacific Disaster Center
PEER	Pacific Earthquake Engineering Research Center
PML	Probable Maximum Loss
PRSEMA	Puerto Rico State Emergency Management Agency

QR	Quick Response Research Reports (NHRAIC)
RBS	Reduced Beam Sections
REDARS	Risks from Earthquake Damage to Roadways Systems Software
RPMS	Real Property Management System
SAFOD	San Andreas Fault Observatory at Depth
SAVE	Structural Assessment and Visual Evaluation
SBC	Standard Building Code
SCD	State Civil Defense (Hawaii)
SCEC	Southern California Earthquake Center
SECC	State Emergency Coordination Center (Alaska)
SEMA	State Emergency Management Agency (Missouri)
SNL	Sandia National Laboratory
SPW	Sheer Plated Walls
SSC	Seismic Safety Commission (Washington); Structures, Systems and Components (DOE)
TIME	Tsunami Inundation Mapping Effort
TVA	Tennessee Valley Authority
UAF/GI	University of Alaska Fairbanks, Geophysical Institute
UBC	Uniform Building Code
UFC	Unified Facilities Criteria
UJNR	U.S.-Japan Joint Panel on Wind and Seismic Effects
USACE	United States Army Corps of Engineers
USGS	U.S. Geological Survey
USNSN	U.S. National Seismograph Network
UT	University of Texas
VA	Department of Veterans Affairs
VIEWS	Visualizing Earthquake Impacts with Satellite Imagery
WECC	Western Electricity Coordinating Council
WMD	Weapons of Mass Destruction
WSSPC	Western States Seismic Policy Council

Executive Order 12699: Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction

By the authority vested in me as President by the Constitution and laws of the United States of America, and in furtherance of the Earthquake Hazards Reduction Act of 1977, as amended (42 U.S.C. 7701 et seq.), which requires that Federal preparedness and mitigation activities are to include "development and promulgation of specifications, building standards, design criteria, and construction practices to achieve appropriate earthquake resistance for new… structures," and "an examination of alternative provisions and requirements for reducing earthquake hazards through Federal and federally financed construction, loans, loan guarantees, and licenses…" (42 U.S.C. 7704(f)(3, 4)), it is hereby ordered as follows:

Section 1. Requirements for Earthquake Safety of New Federal Buildings

The purposes of these requirements are to reduce risks to the lives of occupants of buildings owned by the Federal Government and to persons who would be affected by the failures of Federal buildings in earthquakes, to improve the capability of essential Federal buildings to function during or after an earthquake, and to reduce earthquake losses of public buildings, all in a cost-effective manner. A building means any structure, fully or partially enclosed, used or intended for sheltering persons or property.

Each Federal agency responsible for the design and construction of each new Federal building shall ensure that the building is designed and constructed in accord with appropriate seismic design and construction standards. This requirement pertains to all building projects for which development of detailed plans and specifications is initiated subsequent to the issuance of the order. Seismic design and construction standards shall be adopted for agency use in accord with sections 3(a) and 4(a) of this order.

Section 2. Federally Leased, Assisted, or Regulated Buildings

The purposes of these requirements are to reduce risks to the lives of occupants of buildings leased for Federal uses or purchased or constructed with Federal assistance, to reduce risks to the lives of persons who would be affected by earthquake failures of federally assisted or regulated buildings, and to protect public investments, all in a cost-effective manner. The provisions of this order shall apply to all the new construction activities specified in the subsections below.

(a) Space Leased for Federal Occupancy. Each Federal agency responsible for the construction and lease of a new building for Federal use shall ensure that the building is designed and constructed in accord with appropriate seismic design and construction standards. This requirement pertains to all leased building projects for which the agreement covering development of detailed plans and specifications is effected subsequent to the issuance of this order. Local building codes shall be used in design and construction by those concerned with such activities in accord with section 3(a) and 3(c) of this order and augmented when necessary to achieve appropriate seismic design and construction standards.

(b) Federal Domestic Assistance Programs. Each Federal agency assisting in the financing, through Federal grants or loans, or guaranteeing the financing, through loan or mortgage insurance programs, of newly constructed buildings shall plan, and shall initiate no later than 3 years subsequent to the issuance of this order, measures consistent with section 3(a) of this order, to assure appropriate consideration of seismic safety.

(c) Federally Regulated Buildings. Each Federal agency with generic responsibility for regulating the structural safety of buildings shall plan to require use of appropriate seismic design and construction standards for new buildings within the agency's purview. Implementation of the plan shall be initiated no later than 3 years subsequent to the issuance of this order.

Section 3. Concurrent Requirements

(a) In accord with Office of Management and Budget Circular A - 119 of January 17, 1980, entitled "Federal Participation in the Development and Use of Voluntary Standards," nationally recognized private sector standards and practices shall be used for the purposes identified in sections 1 and 2 above unless the responsible agency finds that none is available that meets its requirements. The actions ordered herein shall consider the seismic hazards in various areas of the country to be as shown in the most recent edition of the American National Standards Institute Standards A58, Minimum Design Loans for Buildings and Other Structures, or subsequent maps adopted for Federal use in accord with this order. Local building codes determined by the responsible agency or by the Interagency Committee for Seismic Safety in Construction to provide adequately for seismic safety, or special seismic standards and practices required by unique agency mission needs, may be used.

(b) All orders, regulations, circulars, or other directives issued, and all other actions taken prior to the date of this order that meet the requirements of this order, are hereby confirmed and ratified and shall be deemed to have been issued under this order.

(c) Federal agencies that are as of this date requiring seismic safety levels that are higher than those imposed by this order in their assigned new building construction programs shall continue to maintain in force such levels.

(d) Nothing in this order shall apply to assistance provided for emergency work essential to save lives and protect property and public health and safety, performed pursuant to Sections 402, 403, 502, and 503 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) (42 U.S.C. 5170a, 5170b, 5192, and 5193), or for temporary housing assistance programs and individual and family grants performed pursuant to Sections 408 and 411 of the Stafford Act (42 U.S.C. 5174 and 5178). However, this order shall apply to other provisions of the Stafford Act after a presidentially declared major disaster or emergency when assistance actions involve new construction or total replacement of a building. Grantees and subgrantees shall be encouraged to adopt the standards established in section 3(a) of this order for use when the construction does not involve Federal funding as well as when Federal Emergency Management Agency (FEMA) funding applies.

Section 4. Agency Responsibilities

(a) The Director of the Federal Emergency Management Agency shall be responsible for reporting to the President on the execution of this order and providing support for the secretariat of the Interagency Committee on Seismic Safety in Construction (ICSSC). The ICSSC, using consensus procedures, shall be responsible to FEMA for the recommendation for adoption of cost-effective seismic design and construction standards and practices required by sections 1 and 2 of this order. Participation in ICSSC shall be open to all agencies with programs affected by this order.

(b) To the extent permitted by law, each agency shall issue or amend existing regulations or procedures to comply with this order within 3 years of its issuance and plan for their implementation through the usual budget process. Thereafter, each agency shall review, within a period not to exceed 3 years, its regulations or procedures to assess the need to incorporate new or revised standards and practices.

Section 5. Reporting

The Federal Emergency Management Agency shall request, from each agency affected by this order, information on the status of its procedures, progress in its implementation plan, and the impact of this order on its operations. The FEMA shall include an assessment of the execution of this order in its annual report to the Congress on the National Earthquake Hazards Reduction Program.

Section 6. Judicial Review

Nothing in this order is intended to create any right or benefit, substantive or procedural, enforceable at law by a party against the United States, its agencies, its officers, or any person.

George H.W. Bush

The White House

January 5, 1990

Executive Order 12941: Seismic Safety of Existing Federally Owned or Leased Buildings

By the authority vested in me as President by the Constitution and laws of the United States of America, and in furtherance of the Earthquake Hazards Reduction Act of 1977, as amended by Public Law 101-614, which requires the President to adopt "standards for assessing and enhancing the seismic safety of existing buildings constructed for or leased by the Federal Government which were designed and constructed without adequate seismic design and construction standards" (42 U.S.C. 7705b(a)), it is hereby ordered as follows:

Section 1. Adoption of Minimum Standards

The Standards of Seismic Safety for Existing Federally Owned or Leased Buildings (Standards), developed, issued and maintained by the Interagency Committee on Seismic Safety in Construction (ICSSC), are hereby adopted as the minimum level acceptable for use by Federal departments and agencies in assessing the seismic safety of their owned and leased buildings and in mitigating unacceptable seismic risks in those buildings. The Standards shall be applied, at a minimum, to those buildings identified in the Standards as requiring evaluation and, if necessary, mitigation. Evaluations and mitigations that were completed prior to the date of this order under agency programs that were based on standards deemed adequate and appropriate by the individual agency need not be reconsidered unless otherwise stipulated by the Standards. For the purposes of this order, buildings are defined as any structure, fully or partially enclosed, located within the United States as defined in the Earthquake Hazards Reduction Act of 1977, as amended, (42 U.S.C. 7703 (5)), used or intended for sheltering persons or property, except for the exclusions specified in the Standards.

Section 2. Estimating Costs of Mitigation

Each agency that owns or leases buildings for Federal use shall, within 4 years of the issuance of this order, develop an inventory of their owned and leased buildings and shall estimate the costs of mitigating unacceptable seismic risks in those buildings. The cost estimate shall be based on the exemptions and evaluation and mitigation requirements in the Standards. Guidance for the development of the inventory and cost estimates will be issued by the ICSSC no later than 1 year after the signing of this order. Cost estimates with supporting documentation shall be submitted to the Director of the Federal Emergency Management Agency (FEMA) no later than 4 years after the signing of this order.

Section 3. Implementation Responsibilities

(a) The Federal Emergency Management Agency is responsible for (1) notifying all Federal departments and agencies of the existence and content of this order; (2) preparing for the Congress, in consultation with the ICSSC, no later than 6 years after the issuance of this order, a comprehensive report on how to achieve an adequate level of seismic safety in federally owned and leased buildings in an economically feasible manner; and (3) preparing for the Congress on a biennial basis, a report on the execution of this order.

(b) The National Institute of Standards and Technology is responsible for providing technical assistance to the Federal departments and agencies in the implementation of this order.

(c) Federal departments and agencies may request an exemption from this order from the Director of the Office of Management and Budget.

Section 4. Updating Programs

The ICSSC shall update the Standards at least every 5 years. It shall also update the Standards within 2 years of the publication of the first edition of FEMA's Guidelines for Seismic Rehabilitation of Buildings and Commentary.

Section 5. Judicial Review

Nothing in this order is intended to create any right to administrative or judicial review, or any other right, benefit, or trust responsibility, substantive or procedural, enforceable at law by any party against the United States, its agencies or instrumentalities, its officers or employees, or any person.

The White House

December 1, 1994