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Introduction

Chairman Wu, Ranking Member Smith and Members of the Subcommittee, thank you for inviting me to testify on the reauthorization of the National Earthquake Hazards Reduction Program (NEHRP). My testimony focuses not only on the National Institute of Standards and Technology (NIST) but also on the four-agency NEHRP partnership. NEHRP's partner agencies are NIST, the Federal Emergency Management Agency (FEMA), the National Science Foundation (NSF), and the U.S. Geological Survey (USGS). It is also very important to note that the NEHRP partnership extends far beyond the four statutory federal agencies to include other federal agencies, State and local governments, professional organizations, model building code and standards organizations, and earthquake professionals in the private sector and academia. Without this extended network of organizations and individuals, NEHRP would not fulfill its statutory responsibilities effectively.

In the five years since the last NEHRP reauthorization hearings were conducted, the U.S. has experienced a relatively quiet period of seismic activity. However, seismologists agree that large, damaging earthquakes in the U.S. are inevitable and unpredictable. Globally it has been anything but quiet, from the December 2004 magnitude-9 earthquake and ensuing tsunami that devastated the Indian Ocean region to the May 2008 magnitude-7.9 earthquake in the Sichuan province of China, in which tens of thousands of people lost their lives. Both events followed decades or even centuries of quiescence on the faults where they struck and are sadly sobering reminders of the unexpected tragedies that can occur.

The USGS has recently issued updated assessments of earthquake hazards in the U.S. that provide appropriate perspectives for us. In 2008, the USGS, the Southern California Earthquake Center (SCEC), and the California Geological Survey (CGS), with the support from the California Earthquake Authority (CEA) jointly produced a forecast of a 99+% certainty of California's experiencing a magnitude-6.7 or greater earthquake within the next 30 years. It is noteworthy that the recent L'Aquila earthquake in central Italy, in which over 300 people perished, had a magnitude of 6.3, slightly less than that which is postulated for California.

While concern for future earthquake activity is always great in California and elsewhere along the West Coast, earthquakes with magnitudes ranging from 5 to 6 struck Nevada and along the Illinois-Indiana border in 2008, the latter generating reports of shaking in sixteen states and into Canada.

As you know, NEHRP was established by Congress in 1977, to "reduce the risks of life and property from future earthquakes in the United States." The Program is predicated on the belief that earthquakes are inevitable and will occur without warning, but that there is much the nation can do to minimize their consequences. The NEHRP agencies strive to perform the needed research and then translate the research results into actions that accomplish that goal. During the past five years, the NEHRP agencies have worked diligently to ensure that United States (U.S.) citizens are less threatened by devastating earthquakes.

NEHRP Organization

The last reauthorization of NEHRP (PL 108-360) directed that a number of changes in program organization, leadership, and reporting be made: establishing NIST as the Program Lead Agency, directing the creation of the NEHRP Interagency Coordinating Committee (ICC) and the external

Advisory Committee on Earthquake Hazard Reduction (ACEHR), and requiring a new Strategic Plan and annual Program reports.

Interagency Coordinating Committee

Prominent among these changes has been the creation of the NEHRP ICC, which is composed of the Directors/Administrators of the four Program agencies and the Directors of the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP). The ICC is chaired by the NIST Director. The ICC has met on eight occasions and has conducted informal exchanges of information on other occasions – the ICC has been very actively engaged in Program leadership. The creation of the ICC has resulted in a significant increase in program visibility in each agency and in the Executive Office of the President, and it has elevated key interagency decisions to be discussed and agreed to at the agency leader level. While many program decisions can be made at the working level, the direct involvement of the agency leaders has greatly improved program coordination and efficiency.

For example, as a part of the process of preparing a new Strategic Plan for the program, the ICC asked the non-statutory working level Program Coordination Working Group (PCWG) to assess the then-existing Strategic Plan and ongoing program activities, so that “gaps” could be identified for inclusion in the new plan.

The ICC has also actively overseen the development of NEHRP’s annual reports and, most importantly, the development of the new Strategic Plan for the program that was released in October 2008. For each of these documents, the PCWG has briefed the ICC formally at one or more of its meetings. The ICC members viewed the significance of the Strategic Plan to be so great that it remained fully engaged with its development throughout the period of intense activity that went into its preparation.

Advisory Committee on Earthquake Hazards Reduction

Paralleling the formation of the ICC was the requirement for the establishment of the Program advisory committee. The ACEHR was formed initially in 2007 and consists of 16 leading earthquake professionals from across the U.S., from all walks of the non-federal sector. The ACEHR has 15 appointed members and one *ex officio* member, the Chairperson of the USGS Scientific Earthquake Studies Advisory Committee (SESAC), an advisory body established by the 2000 Fire Administration and Earthquake Hazards Reduction Authorizations (PL 106-503). While the ACEHR by statute provides its advice to the NIST Director, the committee is truly engaged across NEHRP, from fundamental seismological issues to building code implementation. In addition, social scientists on the committee ensure that economic issues and human factors are being considered by the NEHRP agencies. The ACEHR submitted its first formal report to the ICC in 2008 and followed that report with a May 2009 letter report. The ICC is committed to thoughtful consideration of these reports.

Lead Agency

Accompanying the statutory requirements for creating the ICC and ACEHR, the 2004 reauthorization designated NIST as the NEHRP Lead Agency. To address this requirement, NIST established a formal NEHRP Secretariat office in early 2006. The Secretariat is responsible for supporting the activities of both the ICC and ACEHR. In addition, the Secretariat coordinates the working-level activities of the agencies and produces required reports in conjunction with the staff-level Program Coordination Working Group (PCWG), which includes representatives of the four program agencies. At this level, NEHRP also

links its activities to those of the broader National Science and Technology Council Subcommittee on Disaster Reduction. While NIST “leads” NEHRP activities through the Secretariat, it is only with the outstanding teamwork of all the agencies working together that NEHRP accomplishments occur. There is a genuine camaraderie, sense of common purpose, and dedication to improving earthquake safety among the agency representatives.

NEHRP Strategic Plan

A major recent accomplishment of the program is its new Strategic Plan that was released in late 2008 (http://www.nehrp.gov/pdf/strategic_plan_2008.pdf). The new plan was developed during two years of intense, thoughtful work by the PCWG. The ICC and ACEHR provided review and input. The NEHRP agencies initiated the plan development in 2006 by soliciting public comments on the previous plan that had been released in 2003 and again, at the end of the plan development period, solicited public comments on the pre-final draft before publishing its final version.

Vision

The Strategic Plan sets a NEHRP vision:

A nation that is earthquake-resilient in public safety, economic strength, and national security.

The NEHRP agencies see this vision as one that sets a fresh course for NEHRP. This course recognizes the importance of not only improving public safety in future earthquakes but also enhancing our economic strength and national security through greater resilience. For example, if a future southern California earthquake severely damaged the ports of Los Angeles and Long Beach, as happened to the ports of Kobe, Japan, in 1995, there would be national economic implications. Similarly, if a future New Madrid-type earthquake in the Central U.S. severely damaged one or more major Mississippi River crossings in the Saint Louis to Memphis region, transcontinental highway and rail transportation, as well as oil and natural gas transmission could be severely disrupted. Working with its partners in both the federal and non-federal sectors, NEHRP can and should provide tools to assist the government and corporate entities who must address those challenges.

The new vision not only sets this broad focus beyond safety alone but also recognizes the national need for improving our resilience in the face of future damaging earthquakes. While many detailed definitions of resilience exist, the NEHRP agencies can simply view it as the nation’s capability to maintain its functions or recover from future earthquakes. While NEHRP’s best intentions are to provide State and local governments, and the private sector, with the tools they need to improve the survivability of their infrastructure and real property in future earthquakes, future earthquakes will still inflict serious damage. Even though response and recovery activities are not the direct statutory focus of NEHRP, NEHRP does play a role in providing the means for improving response and recovery capacity. For example, led by FEMA and USGS, the NEHRP agencies are engaging in scenario demonstration projects, such as the 2008 *Great Southern California Shakeout* activity. These projects serve to catalyze both pre-earthquake mitigation measures and post-earthquake response and recovery activities to State and local leaders.

Plan Structure

The strategic plan sets three overarching program goals, each with four or more key objectives – improve understanding of earthquake processes and impacts; develop cost-effective measures to reduce earthquake impacts on individuals, the built environment, and society-at-large; and improve the earthquake resilience

of communities nationwide. The goals are not agency-specific. Indeed all three goals involve synergies among the agencies. In addition to the goals and objectives, the plan sets out nine areas of strategic priority for the program, areas of great importance to the nation that will be emphasized as resources become available to address them.

The NEHRP strategic plan also outlines a number of significant guiding principles. These principles are not so much specific objectives as they are philosophies that the NEHRP agencies agree must be employed as NEHRP advances to achieve the new vision. Three of those principles are highlighted briefly here. First, the NEHRP agencies will continue and enhance their cooperation with the earthquake professional community, those professionals in all walks of life who deal with earthquake-related issues. NEHRP has enjoyed the benefits of a long partnership with this community, and attention to this relationship is critical. Second, the NEHRP agencies will seek, within their designated mission areas, closer ties to the international community. Not only can the NEHRP-developed technologies be applied to help others, but also the U.S. can also learn from advances that are being made abroad. Finally, the NEHRP agencies will seek to foster synergies among disciplines as well as with those who work with other hazards, such as wind, flood, and fire. Current examples of such synergistic work include:

- NSF has pioneered numerous inter and multi-disciplinary activities in its NEHRP-related programs.
- FEMA has extended its earthquake loss estimation program, Hazards US (HAZUS), to include flood and other hazards.
- The USGS has launched multi-hazard demonstration projects in southern California and the Pacific Northwest.

In looking at interactions with leaders in multi-hazard areas, the NEHRP agencies are aware of both the similarities, significant differences and linkages that exist among the hazards. Most of the technical issues that are closely tied to monitoring hazard occurrence, assessing the resulting risks, and developing tools, standards, and guidelines for design and construction differ substantially from hazard to hazard, making direct interactions at that level difficult. However, there are opportunities for the coordination of some NEHRP activities with those that are ongoing for other hazards. There are similarities in disaster response that can and should be shared with those who work in the other hazard areas (FEMA), and there are similarities in structural response mechanisms that occur in earthquakes and in blast or impact situations (FEMA, NIST, NSF). Some key linkages provide some excellent opportunities for multi-hazard cooperation, *e.g.*, tsunami warnings for such events that are caused by earthquakes (USGS-provided data used by the National Weather Service) and structural fire effects from any source (NIST). The NEHRP agencies are also aware of the 30+ year history of organized NEHRP interaction with the earthquake professional community and State and local governments; this provides much organizational experience that can be shared with those working in other hazards-related fields.

Recent NEHRP Accomplishments-Fostering Technology and Knowledge Transfer

The NEHRP agencies have worked both individually and collectively in recent years on initiatives that are intended to improve the nation's earthquake resilience. Recent NEHRP annual reports provide substantial information regarding program activities. Examples are highlighted below.

Workshops

In 2007 and 2008, the four partner agencies worked with the national earthquake safety community, through a series of workshops, to identify future research and implementation needs that support the new strategic plan. The first such workshop addressed research and implementation issues associated with evaluating and strengthening existing buildings. Three subsequent workshops addressed research needs to support the full implementation of Performance-Based Seismic Design, which was mentioned prominently in the last reauthorization; the basic scope of a national Post-Earthquake Information Management System that would support both organized post-earthquake reconnaissance activities and the development of a national electronic repository of information gathered through such activities; and, guidance for communities of all sizes on how to formulate and conduct earthquake scenarios that meet community objectives. These workshop activities have effectively fostered communication and cooperation among the agencies and between them and the earthquake practitioner community. The agencies are strongly committed to other such workshops in the future.

The NEHRP agencies form a team, with each member agency having key roles in the successful development and transfer of new knowledge into practice. Below are examples of successful implementation of knowledge transfer from one NEHRP agency to others:

USGS

The USGS is the applied earth science component of NEHRP. USGS efforts are complemented by basic research projects that are supported by NSF. USGS reports on earthquake size, location, and impacts; develops seismic hazard assessment maps and related mapping products; builds public awareness of earthquake hazards; and supports targeted research to improve monitoring and assessment capabilities. USGS carries out these responsibilities through partnerships with the other NEHRP agencies, State and local governments, and university researchers.

The USGS supports targeted research activities, working in concert with NSF. As an example of its current research efforts, Light Detection and Ranging (LIDAR) topographic imaging is being used to map fault scarps that are hidden by vegetation and were previously unknown. This activity has revolutionized our understanding of earthquake hazards in the Pacific Northwest.

Monitoring

Since the last reauthorization of NEHRP, the USGS has made great strides in its delivery of comprehensive earthquake information from monitoring systems, both in the U.S. and worldwide. In the U.S., monitoring is accomplished via the developing Advanced National Seismic System (ANSS), which has added enough modern seismic instruments to rapidly deliver instrument-based shaking intensity information in five high-risk metropolitan areas out of 26 planned and is now deployed at a total of 822 stations. The ANSS is a partnership between the USGS and its State and university partners. Internationally, USGS works in partnership with NSF and the Incorporated Research Institutions for Seismology (IRIS) to utilize the Global Seismographic Network for earthquake monitoring. Complementing the field monitoring capability is the USGS National Earthquake Information Center (NEIC), which assimilates all monitoring data on a 24/7 basis and issues rapid reports of potentially damaging earthquakes to key federal, State, and local institutions, as well as to an electronic mailing list of over 100,000 users. Since the last reauthorization, USGS has implemented full on-site 24/7 operations at NEIC and developed products such as the Prompt Assessment of Global Earthquakes for Response

(PAGER) system that provides rapid estimates of the population exposed to strong shaking and delivers that to aid agencies, emergency managers, and others who use it to prioritize response activities.

Mapping

In 2008, USGS released new national seismic hazard maps that incorporate the most recent field observations and research results. These maps show that earthquakes are serious threats in 46 states. The maps are being used now to develop design maps for national model building codes. FEMA and USGS closely collaborate on these activities, ensuring that the most recent and technically sound hazard information is considered by the American Society of Civil Engineers (ASCE) and the International Code Council (ICC). The new maps differ from older maps primarily in their incorporation of recent research results in areas near significant known faults. The new research has resulted in ground-motion models that increased expected shaking in western Washington and Oregon, near the Cascadia subduction zone, but decrease expected shaking in the Central and Eastern U.S. somewhat. In many areas of the western U.S., the new models lower expected shaking levels for taller, “long-period” buildings. The USGS is also developing more detailed urban hazard maps for various areas; such maps have been released recently for Memphis and Seattle and are currently underway for St. Louis and Evansville, Indiana.

Scenario Exercises

Also in 2008, the USGS, CGS, and SCEC produced a plausible scenario of a rupture of the southern end of the San Andreas fault that could result in about 1,800 deaths, 50,000 injuries, and economic losses exceeding \$200 billion in the greater Los Angeles area. This scenario formed the basis for the *Great Southern California Shakeout* earthquake preparedness and response exercise in late 2008. The *Shakeout* was supported by FEMA, NSF, USGS, and numerous State and local organizations. Over five million Southern California residents participated in the *Shakeout*, making it the largest public preparedness event ever held in the U.S. Plans are underway for a statewide version in 2009.

NSF

NSF provides the basic research arm for NEHRP, supporting research that addresses earth science, geotechnical and structural engineering, lifeline engineering, the social sciences, and integrating all these disciplines.

NSF supports fundamental research related to earthquake processes: seismology, geodesy, rock mechanics, paleoseismology (geologic studies of prehistoric earthquakes), structural geology, and relevant theoretical, modeling, and laboratory projects. Recent outcomes from these programs range from explanatory mechanisms for episodic tremor and slip observed along plate boundaries around the world to insight into the slip differential across the southern San Andreas Fault using interferometric synthetic aperture radar imagery, global positioning systems, and seismic measurements. This work has substantially improved the description and understanding of the strain building up along major plate boundary faults such as the southern San Andreas Fault and the San Jacinto Fault.

The Southern California Earthquake Center (SCEC) is a 5-year program funded by NSF and USGS. SCEC’s main goal is to produce a physics-based understanding of Southern California earthquake phenomena through integrative study of tectonics, active fault systems, fault zone processes, fault rupture and ground motions. SCEC scientific accomplishments have been incorporated into practical products, such as the USGS National Seismic Hazard Maps, as well as new seismic attenuation relations developed

by the Next Generation Attenuation (NGA) Project at the Pacific Earthquake Engineering Research (PEER) Center. NSF supports SCEC to advance seismic hazard research using high-performance computing, with the aim of utilizing petascale computing facilities when they become available in the 2010-2011 timeframe. SCEC's Petascale Cyberfacility for Physics-based Seismic Hazards Analysis (*PetaSHA*) project has goals to reach earthquake simulations at frequencies up to 10Hz, including development of a dynamic rupture platform (*DynaShake*) that can generate kinematic source descriptions that emulate dynamic descriptions. *DynaShake* will be used to develop kinematic rupture models for several observed earthquakes (for validation), as well as several large San Andreas Fault ruptures and a large reverse faulting earthquake.

NEES

Noteworthy among NSF activities since the last NEHRP reauthorization has been the completion of construction and initial operations of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES). NSF completed the \$82 million Major Research Equipment and Facilities Construction for NEES in September 2004, developing world-class experimental facilities at 15 academic institutions across the U.S. and accompanying cyberinfrastructure. The testing facilities include seismic shake tables, geotechnical centrifuges, a tsunami wave basin, large strong-floor and reaction-wall facilities with unique testing equipment, and mobile and permanently installed field equipment. The network's cyberinfrastructure technology links the facilities via the *Internet2* grid, forming the world's first prototype of a distributed "virtual instrument." The cyberinfrastructure also provides a national repository for experimental data, as well as numerical simulation and collaborative tools.

NEES plays a major role in NEHRP. The NEES multi-user facility concept serves a unique role among NEHRP agency investments for basic earthquake engineering research, providing diverse experimental capabilities, substantial user support, emphasis on education and outreach, and a university environment characterized by openness for academic, industry, and government use. NSF works with the other NEHRP agencies to periodically update the NEES earthquake research agenda. NEES has promoted change in the research culture for the earthquake engineering community through open access to unprecedented experimental capabilities, collaboration with experimental facility staff to develop formal testing protocols, archival of all experimental data in a community data repository for reuse by other investigators, and a new generation of students trained in advanced experimentation techniques and analytical modeling.

NSF supports research utilizing NEES through annual program solicitations. Many of these NSF-supported projects include practitioner and industry partners to help design experimental and analytical investigations and to speed technology transfer. NEHRP agency partners and other federal agencies support projects to transfer NEES research findings into technical briefs for practitioners, performance-based seismic design (PBSD) guidelines, and seismic provisions. For example, NIST plans to utilize NEES research facilities in any future earthquake-related testing that it conducts.

Research using NEES is creating the underpinning knowledge for PBSD guidelines; expanding the knowledge base for incorporating high-performance materials and advanced technologies in buildings, bridges, and critical utility systems; and developing new concepts for structural systems. NEES research also provides knowledge to mitigate the effects of ground failure caused during earthquakes by liquefaction, lateral spread, landslide, and soil failure at foundations. NEES experimental data are leading to more comprehensive analytical models for structures subject to near-collapse seismic loading.

Research at the tsunami wave basin has produced the largest experimental data set to date for three dimensional granular landslide-generated tsunamis.

NSF's Memorandum Concerning Cooperation in the Area of Disaster Prevention Research with the Japanese Ministry of Education, Culture, Sports, Science, and Technology enables U.S. researchers to use both NEES and Japan's Earth Defense (*E-Defense*) shake table, the world's largest shake table, to simulate seismic performance on large- to full- scale models with geotechnical and structural innovations. The first NSF-supported NEES research project to use *E-Defense*, a project on multi-story wood frame behavior, is commencing at *E-Defense* in summer 2009.

As of September 2007, the three NSF-supported research centers—the Multidisciplinary Center for Earthquake Engineering Research (MCEER) led by the University at Buffalo, the Mid-America Earthquake (MAE) Center led by the University of Illinois at Urbana-Champaign, and the PEER Center led by the University of California, Berkeley —completed 10 years of NSF support. The centers are continuing through various combinations of university, State, and private sector support, and with other federal funding. Through NSF support, these centers have made major contributions to the development of performance-based seismic design; improved fundamental understanding of seismic performance of structures ranging from buildings, bridges, and acute care facilities to critical utility lifelines; and developed advanced technologies to improve earthquake mitigation and response.

NSF has continued to provide support, along with other federal agencies, for the Natural Hazards Center at the University of Colorado, Boulder. The Center's annual workshop each July brings together leading U.S. natural hazards researchers, policy makers, and practitioners. This is the major national forum for linking the producers of research with appropriate user communities.

NIST

In 2006 and 2007, NIST devoted significant attention to the task of establishing the NEHRP Secretariat and initiating the various organizational functions that have already been discussed. A critical part of the NIST effort has been the establishment of the NEHRP web site (www.nehrp.gov) that contains much information about the Program, links to all of the NEHRP agency sites, and links to other organizations that are involved with earthquake-related research and implementation issues. Efforts are now underway to incorporate an electronic clearinghouse of documents produced by NEHRP activities within the web site. NIST also recently initiated a NEHRP-wide study by the National Research Council (NRC) that will provide a broad roadmap for the NEHRP agencies to consider as they implement the new Strategic Plan. The NRC study assembles a broad panel of national experts in all aspects of earthquake risk reduction to help identify and prioritize possible activities that could be considered to achieve the objectives set out in the NEHRP Strategic Plan.

NIST's technical role in the Program may be summarized as one of linking the basic research products that come from NSF-supported university research with the implementation activities that are largely led by FEMA. Commencing in 2007, in a strong commitment to the Program, NIST began to rebuild its capabilities in the earthquake research arena, which had been largely dormant for a number of years, to bridge the research-to-implementation gap. This rebuilding effort has been enlarged for 2009. NIST has formed its research program around several key theme areas: providing technical support for the earthquake engineering practice and building code development process; developing the technical basis for performance-based seismic design (PBSD); supporting the development of technical resources that improve earthquake engineering practice; and, making evaluated technologies available to practitioners in

the design and construction communities. These activities are consistent with the NIST mission of serving the measurement and standards needs of the building and fire safety industries. NIST is a critical source of metrics, models, and knowledge for predicting the extent of damage from natural and man-made hazards, mitigating their impact, and helping to enhance the disaster resilience of communities and the built environment.

In 2007, NIST established a partnership with the NEHRP Consultants Joint Venture, which links NIST with the nation's leading earthquake engineering researchers and practitioners. The first product of this effort was released in 2008, a short *techbrief* document for structural engineers who design reinforced concrete frame buildings in areas of high seismic activity. Several additional projects are ongoing. In addition, NIST began to rebuild its in-house capabilities in 2008 by hiring new earthquake research staff members; this process continues today, with staff increases anticipated in 2009 and 2010, contingent on available resources.

Given the unique nature of the necessary interaction between NIST and FEMA in fulfilling their respective roles, the two agencies have formed a special partnership with their programs that involves complete, frequent exchanges of project information and in some instances actual direct collaboration on projects that involve complementary topic areas.

FEMA

FEMA acts as NEHRP's primary "implementation arm," though the other agencies contribute to Program implementation efforts. Similar to NIST, FEMA has demonstrated its commitment to NEHRP through a significant increase in support in 2009.

FEMA has a very prominent NEHRP leadership role in working with the practitioner community, the ASCE, and the ICC to support the development of model building code provisions. As it has done for many years, FEMA is working with the Building Seismic Safety Council (BSSC) to develop the next generation of the *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures* that will be available in 2010 for future use in model building codes. USGS supports the development of the *Recommended Provisions* with its hazards mapping activities.

While working on this document for the future, FEMA is also working directly with the model building code organizations to assist in the development of new seismic provisions for the 2009 editions of the International Codes, or "I-Codes," that are promulgated by the ICC. The I-Codes have been adopted in part or whole by all 50 states, standardizing safe design practices nation-wide. At the ICC's initial code change hearings for the 2009 edition, FEMA staff and contractors attended various portions and provided testimony on many proposed code changes for the *International Building Code* (IBC), the *International Existing Building Code* (IEBC) and the *International Residential Code* (IRC). This testimony included supporting proposed code changes submitted by FEMA, proposed code changes where FEMA worked with the proponents, and proposed code changes that other parties submitted. In some instances, FEMA spoke in opposition to proposed code changes that weakened the code.

While working with the national model building code and standards organizations on issues that are sufficiently mature to be considered for building code adoption, FEMA also continues to support projects to develop guidelines for designers. It is in this area that FEMA is working very closely with NIST, and this partnership and the resulting development, publication, dissemination, and promotion of building design and construction materials are signature elements of the NEHRP. In the past 30 years, FEMA has

developed and published over 200 earthquake design guidance publications on all aspects of earthquake mitigation, including: seismic design and construction of new buildings; the retrofitting of existing hazardous structures, including the need for affordable seismic retrofitting techniques; and other related structural and non-structural issues. FEMA also conducts or supports related outreach activities to promote training courses and publications.

Existing buildings pose a much greater risk than new buildings, as most were constructed prior to current building codes and many are collapse hazards. FEMA has published an entire series of publications on existing buildings, from rapid screening of many buildings to guidance on seismic rehabilitation of an existing hazardous building.

In another example, in 2008, FEMA completed the 50% draft of the *Guidelines for Seismic Performance Assessment of Buildings*, and an accompanying Performance Assessment Calculation Tool (PACT), which is the first phase of the multi-year project to develop the Next-Generation Performance-Based Seismic Design (PBSD) Guidelines for New and Existing Buildings. The project is based on the *Next-Generation Performance-Based Seismic Design Guidelines, Program Plan for New and Existing Buildings*, published by FEMA as FEMA 445. As part of the PBSD project, FEMA also recently published a document that provides methodologies on how to test the performance of building components, *Interim Protocols for Determining the Seismic Performance Characteristics of Structural and Nonstructural Components* (FEMA 461). This publication was developed in concert with the three national earthquake engineering research centers that NSF supported through the end of 2007.

A prominent new FEMA public outreach effort began in 2008 with the new *QuakeSmart* initiative, which is designed to encourage business leaders and owners in areas that are at risk from earthquakes to take actions that will mitigate damage to their businesses, provide greater safety for customers and employees, and speed recovery if an earthquake occurs. The goal of *QuakeSmart* is to build awareness within the business community of earthquake risks and to educate businesses, particularly small and emerging ones, on the relatively simple things they can do to reduce or mitigate the impacts of earthquakes, thus supporting community preparedness. The effort began with a series of Community Forums in four cities in the Midwest and on the West Coast. Further forums are scheduled for late 2009.

To support and increase the adoption of their earthquake resiliency measures, the NEHRP agencies, led primarily by FEMA, maintain strong partnerships with other earthquake and hazards-related agencies, State and local governments, academia, the research community, code enforcement officials, design professionals, and the remainder of the private sector.

FEMA provides technical and financial assistance to States and multi-state consortia to increase awareness of the earthquake hazard and to foster plans to reduce seismic vulnerability. To provide State financial assistance, FEMA administers the all-hazards Pre-Disaster Mitigation (PDM) Grant Program for States and communities; the Hazard Mitigation Grant Program (HMGP), an all-hazards post-disaster grant program; and the Emergency Management Performance Grants (EMPG) Program, which provides grants to States to improve emergency management performance and is administered by FEMA's Preparedness Directorate.

FEMA also supports a series of multi-state consortia and organizations, including the Cascadia Regional Earthquake Working Group (CREW), which serves States in the Pacific Northwest affected by the Cascadia Subduction Zone and related faults; the Central United States Earthquake Consortium (CUSEC), which serves the States impacted by the New Madrid seismic zone; the Northeast States

Emergency Consortium (NESEC), which serves northeastern states on a multi-hazard basis; and the Western States Seismic Policy Council (WSSPC). FEMA's support to these organizations is in the form of grants to support earthquake-related outreach and educational activities that promote earthquake mitigation and awareness.

FEMA also funds the National Earthquake Technical Assistance Program (NETAP), a program to support earthquake mitigation training for State and local officials. Through the National Earthquake Technical Assistance Program (NETAP), FEMA supports development of training curricula on earthquake mitigation topics and provides courses for State and local officials and businesses throughout the U.S.

To improve education and awareness, FEMA has co-sponsored series of informational conferences, including the National Earthquake Conference held in St. Louis, MO in September 2004 and in Seattle in April 2008, as well as the 100 Year Anniversary of the 1906 San Francisco Earthquake. In total, several thousand individuals attended numerous presentations on earthquake-related topics.

In a project closely related to its other NEHRP efforts, FEMA completed development and publication of its *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis*. This document was jointly funded by FEMA and NOAA. Tsunami safety is a critical issue for several coastal communities along the West Coast of the U.S. that are vulnerable to tsunami. The States of Oregon and Washington have already expressed interest in using this publication.

Conclusion

Damaging earthquakes, while infrequent in the U.S., can be among the costliest natural disasters, measured both in terms of economic impact and lives lost or disrupted. There is still much to be learned about earthquakes and their impacts. This is true both in the scientific fields and in the engineering disciplines. What we do know highlights the continuing need for greater preparedness and mitigation, if the NEHRP vision for the nation is to be realized. The four NEHRP agencies have a strong partnership, both among themselves and with the nation's earthquake professional community that continues to focus on that vision.

Chairman Wu, thank you again for the opportunity to testify on NEHRP activities. This concludes my remarks. I will be happy to answer any questions you may have.