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ARE WE PREPARED? ASSESSING EARTHQUAKE RISK REDUCTION IN THE UNITED STATES

HEARING

BEFORE THE

SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

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ARE WE PREPARED? ASSESSING EARTHQUAKE RISK REDUCTION IN THE UNITED STATES

THURSDAY, APRIL 7, 2011

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 10:04 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Benjamin Quayle [Chairman of the Subcommittee] presiding.

RALPH M. HALL, TEXAS
CHAIRMAN

EDDIE BERNICE JOHNSON, TEXAS
RANKING MEMBER

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

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Subcommittee on Technology and Innovation

Are We Prepared? Assessing Earthquake Risk Reduction in the United States

Thursday, April 7, 2011

10:00 a.m.-12:00 p.m.

2318 Rayburn House Office Building

Witnesses

Dr. Jack Hayes
Director, National Earthquake Hazards Reduction Program, NIST

Mr. Jim Mullen
Director, Washington State Emergency Management Division and President, National Emergency Management Association

Mr. Chris Poland
Chairman and Chief Executive Officer, Degenkolb Engineers and Chairman, NEHRP Advisory Committee

Dr. Vicki McConnell
Director, Oregon Department of Geology and Mineral Industries

HEARING CHARTER

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION U.S. HOUSE OF REPRESENTATIVES

Are We Prepared? Assessing Earthquake Risk Reduction in the United States

THURSDAY, APRIL 7, 2011
10:00 A.M.—12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

Purpose

On Thursday, April 7, 2011 the Subcommittee on Technology and Innovation of the Committee on Science, Space, and Technology will hold a hearing to examine earthquake risk in the United States and to review efforts supporting the development of earthquake hazard reduction measures, and the creation of disaster-resilient communities.

Witnesses

Dr. Jack Hayes is the Director of the National Earthquake Hazards Reduction Program (NEHRP) at the National Institute of Standards and Technology (NIST).

Mr. Jim Mullen is the Director of the Washington State Emergency Management Division and the President of the National Emergency Management Association (NEMA).

Mr. Chris Poland is the Chairman and Chief Executive Officer of Degenkolb Engineers and the Chairman of the NEHRP Advisory Committee.

Dr. Vicki McConnell is an Oregon State Geologist and the Director of the Oregon Department of Geology and Mineral Industries.

Brief Overview

The hearing will examine various elements of the Nation's level of earthquake preparedness and resiliency including the U.S. capability to detect earthquakes and issue notifications and warnings, coordination between federal, state and local stakeholders for earthquake emergency preparation, and research and development measures supported by the federal government designed to improve the scientific understanding of earthquakes.

Background

Earthquake Risk and Hazard in the United States

Portions of all 50 states are vulnerable to earthquake hazards, although risks vary across the country and within individual states. Twenty-six urban areas in fourteen U.S. states face significant seismic risk. Earthquake hazards are greatest in the western United States, particularly in California, Oregon, Washington, Alaska, and Hawaii. Though infrequent, earthquakes are unique among natural hazards in that they strike without warning. Earthquakes proceed as cascades, in which the primary effects of faulting and ground shaking induce secondary effects such as landslides, liquefaction, and tsunami, which in turn set off destructive processes within the built environment; structures collapse, people are injured or killed, infrastructure is disrupted, and business interruption begins. The socioeconomic effects of large earthquakes can reverberate for decades.

The recent earthquake that struck off the coast of northern Japan on March 11, 2011, illustrates that the effects of an earthquake can be catastrophic. The earthquake, recorded as a 9.0 on the Richter scale, is the most powerful quake to hit the country, and it triggered a devastating tsunami that swept over cities and farmland in the northern part of the country. As Japan struggles with rescue efforts, it also

faces a nuclear emergency due to damage to the nuclear reactors at the Fukushima Daiichi Nuclear Power Station. As of March 31, the official death toll from the earthquake and resulting tsunami includes more than 11,600, and more than 16,000 people were listed as missing. The final toll is expected to reach nearly 20,000. More than 190,000 people remained housed in temporary shelters; tens of thousands of others evacuated their homes due to the nuclear crisis and related fear.

The National Earthquake Hazards Reduction Program (NEHRP)

In 1977 Congress passed the Earthquake Hazards Reduction Act (P.L. 95–124) establishing NEHRP as a long-term earthquake risk reduction program for the United States. The original program focused on research to understand and predict earthquakes. NEHRP's focus was changed in 1990, when Congress decreased the emphasis on earthquake prediction, expanded the program objectives, and required federal agencies to adopt seismic safety standards.

Currently under NEHRP, four federal agencies have responsibility for long-term earthquake risk reduction: NIST, FEMA, the NSF, and the USGS. Current program activities are focused on four broad areas including supporting the development of effective earthquake hazard reduction measures, promoting the adoption of these measures by federal, state, and local governments, improving the basic understanding of earthquakes and their effects on people and infrastructure, and developing and maintaining the Advanced National Seismic System (ANSS), the George E. Brown Jr. Network for Earthquake Engineering and Simulation (NEES), and the Global Seismic Network (GSN).

Primary responsibilities for the NEHRP agencies break down as follows:

- NIST is the lead NEHRP agency and has responsibility for the planning and coordination of the program. NIST also promotes earthquake resistant design and construction practices through building codes, standards, and construction practices.
- FEMA assists other agencies and private-sector groups to prepare and develop earthquake risk modeling tools, and aids the development of performance-based codes for buildings and other structures.
- NSF supports basic research to improve the safety and performance of buildings and structures using the research facilities of NEES and other institutions engaged in earth sciences, engineering, and social sciences relevant to understanding the causes and impacts of earthquakes.
- USGS conducts research to assess earthquake causes and effects, produces national and regional seismic hazards maps, monitors and rapidly reports on earthquakes and their shaking intensities in the U.S. and abroad. The USGS maintains the ANSS and the GSN.

The table below shows the authorized and enacted levels of funding for NERHP over the last reauthorization period.

National Earthquake Hazards Reduction Program (NEHRP) Funding

(dollars in millions)

Agency	FY09 Authorized*	FY09 Enacted	FY10 Enacted	FY12 Request	FY12 Request versus FY10 Enacted	
					$	%
NIST	*14.6*	*4.1*	*4.1*	*4.1*	0	0
NSF	*64.7*	*55.0*	*55.3*	*53.8*	*(1.5)*	*(2.7)*
USGS	*88.9*	*61.2*	*62.8*	*57.6*	*(5.2)*	*(8.3)*
FEMA	*23.6*	*9.1*	*9.0*	*6.4*	*(2.6)*	*(28.9)*
Total:	**191.8**	**129.4**	**131.2**	**121.9**	**(9.3)**	**(7.1)**

*the last year NEHRP was authorized was FY09

110th and 111th Congressional Hearings

The House Committee on Science, Space, and Technology held one hearing in the 111th Congress entitled "Reauthorization of the National Earthquake Hazards Reduction Program" to review NEHRP in preparation for reauthorization. The Subcommittee also held two hearings related to this legislation during the 110th Congress.

Reauthorization

The last year to provide an authorization for NEHRP was fiscal year 2009. The House passed reauthorization legislation (H.R. 3820) in the last Congress, but it was not considered by the Senate.

Issues for Examination

Coordination of Federal Preparedness Efforts

The Subcommittee has requested that witnesses address the coordination between federal, state, and local stakeholders, and their roles in earthquake preparedness efforts. Witnesses will also discuss how well NEHRP is functioning, opportunities to improve coordination among the NEHRP agencies, and the priorities for NEHRP moving forward.

Hazard Mitigation Costs and Benefits

Much of the expense resulting from damage caused by earthquakes is borne by the federal government. Witnesses are asked to discuss the costs and benefits of hazard mitigation spending, specifically, whether the cost of government investments in natural hazard mitigation with the objective of reducing or eliminating losses from future natural disasters results in a measurable benefit.

The State of Hazards Reduction Science

In the Strategic Plan for the National Earthquake Hazards Reduction Program Fiscal Years 2009–2013 [1], the NEHRP agencies list nine strategic priorities to accomplish the goals of understanding earthquakes and their impacts, developing cost-effective measures to reduce these impacts, and improve earthquake resiliency nationwide. The Subcommittee has asked witnesses to address how these goals are bring accomplished, challenges faced by the NEHRP agencies, and how research priorities align with the strategic plan goals. Also, in a recent National Research Council report [2], eighteen preparedness tasks were identified, ranging from basic research to community-oriented applications. Witnesses have been asked to discuss how this "roadmap" helps to further NEHRP goals and implement the NEHRP Strategic Plan to provide the basis for a more earthquake resilient nation.

Response and Recovery Planning

The Subcommittee has requested that witnesses address research and development for hazard mitigation tools and products. These activities must meet the needs of state and local officials who must prepare their communities for disasters and help them respond. How well do NEHRP activities meet state and local needs, how could efforts be better aligned, and what are the lessons that can be drawn from the resilience demonstrated in responding to a moderate earthquake in preparing for a great one?

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[1] National Earthquake Hazards Reduction Program, *Strategic Plan for the National Earthquake Hazards Reduction Program Fiscal Years 2009–2013, October 2008*, http://www.nehrp.gov/pdf/strategic—plan—2008.pdf.

[2] National Research Council of the National Academies, *National Earthquake Resilience: Research, Implementation, and Outreach*, March 2011, http://www.nap.edu/catalog.php?record—id=13092.

Chairman QUAYLE. The Subcommittee on Technology and Innovation will come to order.

Good morning. Welcome to today's hearing entitled "Are We Prepared? Assessing Earthquake Risk Reduction in the United States." In front of you are packets containing the written testimony, biographies and truth in testimony disclosures for today's witnesses. I now recognize myself for five minutes for an opening statement. I would like to welcome all the witnesses here today for this hearing.

In light of the devastating effects of the recent earthquake and subsequent tsunami that struck off the coast of northern Japan on March 11th, many countries are examining their own level of preparedness. The scale of the human tragedy is difficult to comprehend, and our thoughts and prayers are with the people of Japan. It is always a challenge to measure how prepared we are for the next unexpected event, and whether current efforts are adequate.

Although earthquake risks vary across the country, portions of all 50 states are vulnerable to these hazards. Twenty-six urban areas in 14 different U.S. states face significant seismic risk. My own district in Arizona does not lie on top of a major subduction zone or fear the threat of tsunamis. But I believe today's topic is important for all of us. Earthquake catastrophes have the potential not only to destroy lives and buildings, but also to wreak havoc on civil and industrial infrastructure and the national economy.

In Japan, the aftereffects of the earthquake have reduced supplies of water and electricity, hampering Japan's ability to export many manufacturing products and forcing some businesses to slow or stop operation all together. Supply chains for important technology products here in the United States have also been interrupted, directly impacting our productivity.

The impacts and consequences of a major earthquake are felt on a global scale. These hazards consequently represent a serious threat to both national security and global commerce. Given our current economic situation, it would be even more painful for the United States to endure a disastrous earthquake, the socioeconomic effects of which would reverberate for decades.

This Committee has supported ongoing work amongst four federal agencies focused on researching and developing techniques to minimize the devastation of earthquakes. This includes improving forecasting, supporting the development of effective hazard reduction measures, engineering disaster-resilient buildings, and furthering our basic understanding of earthquakes and their effects on people and infrastructure. Coordination of these elements is important in order to effectively deal with these hazards, and communication between federal, state and local stakeholders is critical.

Much of the federal research and development effort is housed in the National Earthquake Hazard Reduction Program, also known as NEHRP. This program coordinates the earthquake hazards reduction efforts of the National Institute of Standards and Technology, the National Science Foundation, the United States Geological Survey and the Federal Emergency Management Agency. Coordination of these agencies' work provides the public and private sectors with the necessary scientific and engineering informa-

tion to prepare for earthquakes, and hopefully reduce their impact. NEHRP was last authorized in 2009, and while the House passed reauthorization legislation in the last Congress with bipartisan support, it was not considered by the Senate.

We have an excellent panel of witnesses today, who will examine earthquake risk in the United States and review efforts supporting the development of earthquake hazard reduction measures. We will hear perspectives from the director of a federal program created to reduce earthquake hazards, a state geologist, an emergency management professional, and a structural engineer and member of a national advisory committee overseeing earthquake engineering programs. I would like to extend my appreciation to each of our witnesses for taking the time and effort to appear before us today.

Thanks again to our witnesses for their participation. I look forward to a productive discussion.

[The prepared statement of Mr. Quayle follows:]

PREPARED STATEMENT OF CHAIRMAN BEN QUAYLE

Good morning. I'd like to welcome everyone to today's hearing.

In light of the devastating effects of the recent earthquake and subsequent tsunami that struck off the coast of northern Japan on March 11, many countries are examining their own level of preparedness. The scale of the human tragedy is difficult to comprehend and our thoughts and prayers are with the people of Japan. It is always a challenge to measure how prepared we are for the next unexpected event, and whether our current efforts are adequate.

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Much of the federal research and development effort is housed within the National Earthquake Hazard Reduction Program, also known as NEHRP [″KNEE–HURP″]. This program manages the earthquake hazards reduction efforts of the National Institute of Standards and Technology (NIST), the National Science Foundation (NSF), the United States Geological Survey (USGS) and the Federal Emergency Management Agency (FEMA). These agencies have distinct but highly complementary missions. Coordination of these agencies' work provides the public and private sectors with the necessary scientific and engineering information to prepare for earthquakes, and hopefully reduce their impact. NEHRP was last authorized in 2009. While the House passed reauthorization legislation in the last Congress with bipartisan support, it was not considered by the Senate.

We have an excellent panel of witnesses before us today, who will examine earthquake risk in the United States and review efforts supporting the development of earthquake hazard reduction measures. We will hear perspectives from the director

of a federal program created to reduce earthquake hazards, a state geologist, an emergency management professional, and a structural engineer and member of a national advisory committee overseeing earthquake engineering programs. I'd like to extend my appreciation to each of our witnesses for taking the time and effort to appear before us today.

Thanks again to our witnesses for their participation. I look forward to a productive discussion. With that, I now recognize the gentleman from Oregon, Mr. Wu, for his opening statement.

Chairman QUAYLE. With that, I now recognize the Ranking Member of the Subcommittee, the gentleman from Oregon, Mr. Wu, for his opening statement.

Mr. WU. Thank you very much, Mr. Chairman, for calling this very important hearing to assess the state of earthquake risk reduction in the United States and our readiness, and thank you to our witnesses. Many of you have traveled a long distance to be here with us today, and I appreciate it very much as does the rest of the Committee.

Our hearts go out to the Japanese people as they continue their work to recover and rebuild from last month's devastating earthquake and ensuing tsunami. The loss of life and property is a stark reminder of the destruction that can be caused by a large-scale earthquake, even in a country like Japan that is on the leading edge in earthquake preparation and mitigation, and this tragedy certainly forces us to take stock of our own vulnerabilities.

As an Oregonian, I am particularly concerned with the prospect of a similar disaster occurring in the Pacific Northwest. Off the coast of Oregon, Washington and northern California, we have the Cascadia subduction zone, and this fault is currently locked in place, but research over the last 30 years indicates that the same stress now accumulating has been released as a large earthquake once about every 300 years dating back to the last ice age about 12,000 years ago. The last Cascadia earthquake occurred 309 or 310 years ago. It was a magnitude 9.0 earthquake, the same destructive magnitude as the one that stuck Japan. All indications show that we Oregonians can expect another quake any time. It is a matter of when, not a matter of if.

When the next earthquake occurs on our fault, there will be prolonged shaking, perhaps for as long as five minutes, with the potential to collapse buildings, create landslides, and destroy water, power, and other crucial infrastructure and lifelines. Such an earthquake will also likely trigger a devastating tsunami that could overwhelm the Oregon coast in less than 15 minutes, resulting in potentially thousands of fatalities and billions of dollars in damage.

Unfortunately, this type of disaster scenario is not limited to the Western United States. In fact, more than 75 million Americans across 39 states face significant risk from earthquakes.

The good news is that we have already learned a lot about how to prepare for, mitigate, and respond to a large-scale earthquake. There is a lot of work already underway to help us better understand earthquakes, develop safer building construction standards, and ensure that affected communities can respond to and recover from earthquakes as quickly as possible.

The National Earthquake Hazards Reduction Program, or NEHRP—lovely acronym—has driven us to make significant progress in this area. I expect that we will hear testimony today

that the four NEHRP agencies, NIST, FEMA, NSF and USGS, are making significant strides with at-risk communities by developing new hazard maps, model building codes, and public outreach efforts. I have no doubt that the progress we have made through NEHRP has enhanced the safety of our communities and will save lives. NEHRP's good work must be continued.

That is why I have reintroduced the Natural Hazards Risk Reduction Act, which will reauthorize the NEHRP program. This bipartisan legislation passed the House by an overwhelming margin in the last Congress, and already this year, my bill has been introduced in the Senate, where they are moving quickly to mark it up next week. I look forward to working with my colleagues on this Subcommittee and Full Committee, and in the Senate to get this bill signed into law as quickly as possible, so that we can continue addressing the large challenges that remain: retrofitting existing structures, improving the performance of critical infrastructure, and encouraging the adoption of mitigation measures by households, businesses, and communities. And I might add here that I am particularly interested in education measures, education that can reduce casualties from earthquakes but especially along the Oregon coast where appropriate education not only of the coastal population but of the populations in the valley, well, what we call the valley where a significant number of people vacation on the coast is particularly important so that people will head for high ground immediately after the ground stops moving so that they can have a good chance of avoiding the ensuing tsunami.

We are here today to engage in a productive discussion about where we stand, particularly in relation to other countries that have suffered large-scale earthquakes, in terms of our preparedness and resiliency to earthquakes, and what more needs to be done.

Thank you very much, Mr. Chairman, for holding this important hearing and I look forward to the witness testimony.

[The prepared statement of Mr. Wu follows:]

PREPARED STATEMENT OF RANKING MEMBER DAVID WU

Thank you, Chairman Quayle, for calling this very important hearing to assess the state of earthquake risk reduction in the United States. And thank you to our witnesses for being here today. Many of you have traveled a great distance to be here, and I appreciate that.

Our hearts go out to the Japanese people as they continue their work to recover and rebuild from last month's devastating earthquake and tsunami. The loss of life and property is a stark reminder of the destruction that can be caused by a large-scale earthquake, even in a country like Japan that is on the leading edge in earthquake preparation and mitigation. This tragedy forces us to take stock of our own vulnerabilities.

As an Oregonian, I am particularly concerned with the prospect of a similar disaster occurring in the Pacific Northwest. Off the coast of Oregon, Washington, and Northern California lies the Cascadia Subduction Zone. This fault is currently locked in' place, but research shows that the same stress DOW accumulating has been released as a large earthquake once about every 500 years. The last Cascadia earthquake occurred 300 years ago. It was a magnitude 9.0, the same destructive magnitude that hit Japan last month. All indications show that we Oregonians can expect another one at any time.

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The National Earthquake Hazards Reduction Program, or NEHRP, has driven us to make significant progress in this area. I expect that we will hear testimony today that the four NEHRP agencies—NIST, FEMA, NSF, and USGS—are making significant strides with at–risk communities by developing new hazard maps, model building codes, and public outreach efforts.

I have no doubt that the progress we have made through NEHRP has enhanced the safety of our communities and will save lives. NEHRP's good work must be continued.

That is why I have reintroduced the *Natural Hazards Risk Reduction Act,* which will reauthorize the NEHRP program. This bipartisan legislation passed the House by an overwhelming margin in the last Congress. Already this year, it has been introduced in the Senate, on the heels of the recent disaster in Japan.

I look forward to working with my colleagues on this Committee and in the Senate to get this bill signed into law as quickly as possible, so that we can continue addressing the large challenges that remain: retrofitting existing structures, improving the performance of critical infrastructure, and encouraging the adoption of mitigation measures by households, businesses, and communities. We're here today to engage in a productive discussion about where this country stands—particularly in relation to other countries that have suffered large-scale earthquakes—in terms of our preparedness and resiliency to earthquakes, and what more needs to be done.

Thank you again, Mr. Chairman, for holding this hearing. And thank you again to the witnesses for being here. I look forward to your testimony.

Chairman QUAYLE. Thank you, Mr. Wu.

If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

At this time I would like to introduce our witnesses and then we will proceed to hear from each of them in order. Our first witness is Dr. Jack Hayes, Director of the National Earthquake Hazards Reduction Program at the National Institute of Standards and Technology. Next we will hear from Mr. Jim Mullen, President of the National Emergency Management Association and Director of the Washington State Emergency Management Division. Our third witness is Mr. Chris Poland, the Chairman and Chief Executive Officer of Degenkolb Engineers and Chairman of the NEHRP Advisory Committee. Our final witness is Dr. Vicki McConnell, Oregon State Geologist and Director of the Oregon Department of Geology and Mineral Industries.

Thanks again to our witnesses for being here this morning. As our witnesses should know, spoken testimony is limited to five minutes each. After all witnesses have spoken, Members of the Committee will have five minutes each to ask questions.

I now recognize our first witness, Dr. Jack Hayes, Director, National Earthquake Hazards Reduction Program, National Institute of Standards and Technology.

STATEMENT OF DR. JACK HAYES, DIRECTOR, NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM, NIST

Dr. HAYES. Chairman Quayle, Ranking Member Wu and Members of the Subcommittee, thank you for inviting me today to testify on the state of earthquake risk reduction in the United States. My testimony reviews the impact of the NEHRP partnership that

includes FEMA, NIST, which is my home agency, NSF and USGS. This partnership also includes other federal agencies, state and local governments, non-governmental professional organizations, model building code and standards organizations, and earthquake professionals in the private sector and academia.

NEHRP fosters unique cooperation among the four agencies with each agency having a crucial role that complements but does not overlap or compete with the roles of the other NEHRP agencies. Briefly, NSF supports relevant basic research in the earth and social sciences and the relevant engineering disciplines. The USGS carries out earthquake hazards assessments, earthquake monitoring and notification, and targeted research in those areas. NIST serves as the program lead agency and develops and tests earthquake-resistant design and construction practices. And finally, FEMA promotes the implementation of earthquake safety tools and policies focusing on the development of earthquake-resistant building codes and practices.

NEHRP has an Interagency Coordinating Committee consisting of the leaders of each NEHRP agency and the directors of OMB and OSTP. This committee, the ICC, provides overall program direction. NEHRP also has an external advisory committee that provides independent assessment of our work and recommends warranted program changes back to the ICC. The current chair of the advisory committee, Mr. Chris Poland, is also a witness at this hearing. We have developed a strategic plan that guides our partnership. As stated in that plan, our vision is to create a Nation that is earthquake-resilient in public safety, economic strength and national security.

How are we achieving this vision? Significantly, NEHRP is not a regulatory body. We develop, disseminate and promote knowledge, tools and practices for earthquake risk reduction, working through coordinated multidisciplinary interagency partnership both internal to NEHRP and with our stakeholders. We emphasize resilience, or the ability for a community, region or even the Nation to recover in a timely manner from the occurrence of an earthquake or other hazard, recognizing that this is key to long-term sustainability. Attaining resilience requires coordinated application of planning, mitigation, redundancy, robustness, and response and recovery activities.

Our NEHRP annual reports, website and other publications cover our activities. While I summarize some recent program highlights in my written testimony, time does not allow me to review them in detail with you now. Of course, I will certainly respond to any specific questions you may have later.

During the last 14 months, we have seen devastating earthquakes in Haiti, Chile, New Zealand and Japan. We offer our sympathy to these nations and their citizens who have been affected by these events. Despite their tragic consequences, these events teach us numerous lessons that can be applied at home. There are many technical and scientific aspects of these earthquakes that we are investigating, but two overarching lessons are already clear. First, these devastating earthquakes strike without warning, and often at locations where their full impacts are not expected or understood. Second, earthquake preparedness and resilience meas-

ures can greatly reduce earthquake impacts, human suffering, and societal and economic disruption. The purpose of NEHRP is to ensure that we are prepared and that we do not have to relearn those two lessons here at home.

Chairman Quayle and other Subcommittee Members, thank you again for the opportunity to testify on NEHRP efforts to reduce earthquake risk in the United States. This concludes my remarks, and I shall be happy to answer any questions that you may have.

[The prepared statement of Mr. Hayes follows:]

PREPARED STATEMENT OF DR. JACK HAYES DIRECTOR, NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM, NIST

Introduction

Chairman Quayle, Ranking Member Wu and Members of the Subcommittee, on behalf of Secretary of Commerce Gary Locke and the Department of Commerce, thank you for inviting me to testify on the current activities of the National Earthquake Hazards Reduction Program (NEHRP) today. Before I start, I wanted to share with you that all of us at the Department share in the grief felt by people around the world for the people of Japan. On behalf of the Department of Commerce, Secretary Locke expressed his condolences at the Embassy of Japan on March 23rd.

My testimony provides an overview of the statutory four-agency NEHRP partnership that includes the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST)—my home agency, the National Science Foundation (NSF), and the U.S. Geological Survey (USGS). This partnership also extends far beyond these Federal agencies to include other Federal agencies, state and local governments, non-governmental professional organizations, model building code and standards organizations, and earthquake professionals in the private sector and academia. Without this extended "family" of dedicated earthquake professionals, the NEHRP agencies simply could not fulfill their statutory responsibilities effectively.

In the almost-two years since I last testified before this Subcommittee, the U.S. has fortunately continued to experience a relatively quiet period of seismic activity. However, worldwide seismic events during that time, particularly those around the Pacific "Ring of Fire" that borders the West Coast of the U.S., have been devastating, taking many lives, disrupting many other lives, and costing billions in direct and indirect impacts on infrastructure and economic activity. Since the beginning of 2010, we have witnessed horrific losses of life in Haiti (over 230,000) and Japan (toll still unknown but numbering in the tens of thousands) due to the combined earthquake and tsunami impacts, and lesser, but nevertheless significant, losses of life in Chile and New Zealand. The toll in terms of human life is overwhelming, and we all offer our heartfelt sympathy to those nations and their citizens.

The NEHRP agencies have begun analyzing lessons-learned from all of these tragic events. Some preliminary "big picture" lessons are already clear. The 2010 Haiti and Chile earthquakes provided a stark contrast in the effectiveness of modern building codes and sound construction practices. In Haiti, where such standards were minimal or non-existent, many thousands were killed in the collapses of homes and other buildings. In Chile, with much more modern building codes and engineering practices, the loss of life, while still tragic, was far smaller, about 500, despite the fact that the Chile earthquake had a significantly higher magnitude of 8.8 (M8.8) than the Haiti earthquake (M7.0). The fault rupture that caused the Chile earthquake released approximately 500 times the energy released in the Haiti earthquake. The Chilean building code provisions had been based in large part on U.S. model building codes that have been developed by researchers and practitioners who have been associated with and supported by NEHRP.

Scientists and engineers have not yet had enough time since the 2011 earthquakes in New Zealand (M6.3) and Japan (M9.0) to draw detailed conclusions. We do know that Japan and New Zealand are international leaders in seismology and earthquake engineering—we in the U.S. partner with our counterparts in both countries, because we have much to learn from one another. Despite their technical prowess, leaders in both countries have been taken aback by the amount of damage that has occurred. One lesson we take from this before we even begin detailed studies is that we still have much to learn about the earthquake hazards we face and

the engineering measures needed to minimize the risks from those hazards. Assuming that we already know everything we need to know is the surest strategy for catastrophe. The other broad lesson that has already become clear from both of these events is that local, and indeed national, resilience —to recover in a timely manner from the occurrence of an earthquake or other hazard event—is vital, going far beyond the essential, but narrowly focused, issue of ensuring life safety in buildings and other locations when an earthquake occurs. In Christchurch, NZ, the central business district has been largely closed since the February 21 earthquake, severely impacting the local economy. Some reports indicate as many as 50,000 people are out of work as a result of this closure. In Japan, the impact of the March 11 earthquake and resulting tsunami have been far worse on the national economy, with energy, agriculture, and commercial disruptions of monumental proportions. Some estimates already put the economic losses over $300 billion, and economic disruption is certain to continue for years and extend far beyond Japan's shores.

The 2010 and 2011 events followed decades or even centuries of quiescence on the faults where they struck and are 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. For example, in 2008, the USGS, the Southern California Earthquake Center (SCEC), and the California Geological Survey (CGS), with support from the California Earthquake Authority (CEA), jointly forecast a greater than 99% certainty of California's experiencing a M6.7 or greater earthquake within the next 30 years. The recent New Zealand earthquake, at M6.3, is slightly less severe than that which is postulated for California. The recent Chile and Japan earthquakes, at M8.8–M9.0, occurred in tectonic plate collision zones where one plate overrides another; that characteristic is closely comparable to those which generated 1964 Alaska earthquake and more ancient earthquakes off the coasts of Oregon and Washington, in the Cascadia Subduction Zone. Seismologists thus believe that what we have recently observed in Chile and Japan should serve as clear indication to us for what may likely occur again someday off the Alaska, Oregon, and Washington coasts.

While concern for future earthquake activity is always great along our West Coast, the National Research Council has noted in its publications that 39 states in the U.S. have some degree of earthquake risk, with 18 of those having high or very high seismicity. In 2011 and 2012, earthquake practitioners and state and local leaders in Memphis, St. Louis, and other Midwestern locales will participate in events that will commemorate the bicentennial anniversary of the New Madrid sequence of earthquakes, which included at least four earthquakes with magnitudes estimated at 7.0 or greater.

NEHRP is predicated on the reality 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 ensure that U.S. citizens are less threatened by devastating earthquakes. As described briefly in this testimony, the NEHRP agencies work in partnership, with each agency fulfilling its unique role, to perform a national service that simply cannot be duplicated by others. The studies and monitoring of the earthquake hazard cuts across both governmental and commercial boundaries. The research and implementation in both science and engineering by the NEHRP agencies is made possible by the "critical mass" they provide, which would not otherwise be possible if all responsibilities were left to the many states and (for the most part) small corporate entities that work in this field.

NEHRP Organization, Leadership, and Reporting

NEHRP is authorized through the Natural Hazards Risk Reduction Act of 2004. The Senate Committee on Science, Commerce, and Transportation has introduced S. 646, the Natural Hazards Risk Reduction Act of 2011, to reauthorize these program. A similar bill was passed through the House of Representatives in the last session of Congress. We and the other agencies involved look forward to working with both chambers of Congress in the 112th Congress on this important legislation. The NEHRP Interagency Coordinating Committee (ICC) and the external Advisory Committee on Earthquake Hazard Reduction (ACEHR) continue to provide leadership to the program.

Interagency Coordinating Committee

Since 2006, the ICC has been very actively engaged in NEHRP leadership, meeting formally and conducting informal exchanges of information. This has resulted in a significant increase in program visibility in each agency and in the Executive Office of the President and has elevated key interagency decisions directly to the

agency leader level. The direct involvement of, and interactions between the agency leaders has greatly improved program coordination and efficiency. The ICC has actively overseen the development of NEHRP's annual reports and, most importantly, the development of the new NEHRP Strategic Plan that was released in October 2008. The ICC members viewed the significance of the Strategic Plan to be so great that they remained fully engaged with its development throughout its preparation.

Advisory Committee on Earthquake Hazards Reduction

The ACEHR advises the NEHRP program on trends and developments in the science and engineering of earthquake hazards reduction; Program effectiveness in carrying out Program activities; Program management, coordination, implementation and activities; and any need for Program revision. The ACEHR first met in 2007 and consists today of 16 leading earthquake professionals from across the U.S., from all walks of the non-Federal earthquake practitioner sector.

Lead Agency

The 2004 reauthorization designated NIST as the NEHRP Lead Agency with primary responsibility for planning and coordinating the Program.

While NIST "leads" NEHRP activities it is only with the outstanding teamwork of all the agencies working together under well defined roles and responsibilities that NEHRP accomplishments occur. There is a genuine camaraderie, sense of common purpose, and dedication to improving earthquake safety and resilience among the agency representatives.

NEHRP Strategic Plan

Vision

The 2008 Strategic Plan presents a new NEHRP vision for our nation:

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

This vision sets a fresh course for NEHRP, recognizing the importance of not only improving public safety in future earthquakes but also enhancing national economic strength and security. For example, if a southern California earthquake severely damaged the ports of Los Angeles and Long Beach, as happened to the port of Kobe, Japan, in 1995, there would be national economic implications. Similarly, if a major earthquake occurred in the Central U.S., one or more Mississippi River transcontinental rail or highway crossings in the Saint Louis to Memphis region, as well as oil and natural gas transmission lines 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 private sector entities who address those challenges.

More significantly, the vision also recognizes the need for improving our national resilience in the face of future damaging earthquakes. Achieving resilience requires coordinated application of mitigation, redundancy, robustness, and response and recovery activities and is a vital issue for the nation.

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*[1] and subsequent similar activities. These projects serve to catalyze both pre-earthquake mitigation measures and post-earthquake response and recovery activities for state and local leaders.

Plan Structure

The Strategic Plan sets three overarching program goals that involve synergies among the agencies: improve understanding of earthquake processes and impacts (basic research); develop cost-effective measures to reduce earthquake impacts on individuals, the built environment, and society-at-large (applied research and development); and, improve the earthquake resilience of communities nationwide (knowledge transfer and implementation).

The Plan also sets out nine areas of strategic priority for the program, areas of great importance to the nation that will be emphasized more prominently as resources become available to address them: fully implement the Advanced National Seismic System (ANSS); improve techniques for evaluating and rehabilitating existing buildings; further develop performance-based seismic design (PBSD); increase

[1] *Http://www.shakeout.org/*

consideration of socioeconomic issues related to hazard mitigation implementation; develop a national post-earthquake information management system; develop advanced earthquake risk mitigation technologies and practices; develop guidelines for earthquake-resilient lifeline components and systems; develop and conduct earthquake scenarios for effective earthquake risk reduction and response and recovery planning; and, facilitate improved earthquake mitigation at state and local levels.

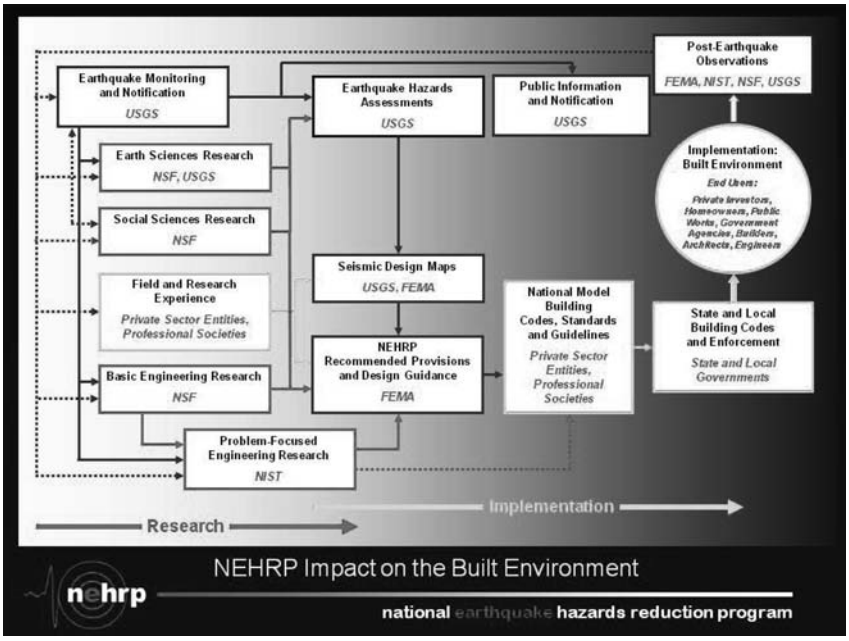

Figure 1. Primary NEHRP Activity Areas

The slide above shows the primary roles of the four agencies and further emphasizes that NEHRP is incomplete without the significant contributions made by those outside the four agencies—in fact, that non-Federal community is a major factor in the historic success of NEHRP. In addition to the strong principles of ensuring synergy without duplication, the NEHRP agencies will seek, within their designated mission areas, closer ties to the international community. Not only can NEHRP-developed technologies be applied to help others, but the U.S. can learn from advances that are being made abroad.

NEHRP agencies seek to foster synergies among disciplines as well as with those who work with other hazards, such as wind, flood, and fire. The NEHRP agencies are aware of the similarities, differences, and linkages that exist among the hazards. Most of the technical issues that are 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 have parallels for other hazards: e.g., similarities in disaster response that can and should be shared with professionals in other hazard areas and similarities in structural response analysis for earthquakes and for blast or impact situations. Some key linkages provide 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, which typically have not enjoyed long histories of such cooperation.

Recent NEHRP Activities-Fostering Technology and Knowledge Transfer

The NEHRP agencies have worked both individually and collectively in recent years to improve the nation's earthquake resilience. Annual reports on the Program activities can be found at www.nehrp.gov. The following are brief descriptions of agency roles and accounts of some of their more prominent recent activities, as reported at the March 2011 ACEHR meeting.

USGS

The USGS is the applied earth science component of NEHRP. USGS delivers rapid characterization of 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. Noteworthy in 2011 is the USGS role in the U.S.-Japan Natural Resources Panel for Earthquake Research; this panel will be actively engaged in analysis of the recent Japan earthquake and its impacts on U.S. practice.

Monitoring

The USGS has significantly advanced its delivery of comprehensive earthquake information from monitoring systems, in the U.S. and internationally. In the U.S., monitoring is accomplished via the developing Advanced National Seismic System (ANSS), which is now deployed at about 25% of its planned capacity. Internationally, USGS works in partnership with NSF and the Incorporated Research Institutions for Seismology (IRIS) to maintain the Global Seismographic Network as a tool for earthquake monitoring and research. The USGS National Earthquake Information Center (NEIC) assimilates all monitoring data on a 24/7 basis and issues rapid reports of potentially damaging earthquakes to key Federal, state, and local institutions, and to an electronic mailing list of over 250,000 users. USGS has implemented full on-site 24/7 operations at the NEIC and developed products such as the Prompt Assessment of Global Earthquakes for Response (PAGER) system that provides rapid (within minutes of earthquake detection) estimates of population exposure to strong shaking in earthquakes worldwide and delivers that to aid agencies, emergency managers, and others who use it to prioritize response activities. The most recent version of PAGER provides order-of-magnitude estimates of fatalities and economic losses. The USGS is also working with the Department of Veterans Affairs (VA) to install seismic instrumentation at 27 VA medical centers around the country—this will provide valuable information on actual building responses in future earthquakes.

Mapping

In 2008, the USGS released new U.S. national seismic hazard maps based on the most recent field observations and research results. The maps show that earthquakes are serious threats to 75 million people in 39 states. The USGS used these updated hazard maps to develop new "risk-targeted earthquake" (RTE) design maps for national model building codes that focus on the likelihood over time of building collapse due to earthquake ground motions instead of simply focusing on the likelihood of earthquake ground motions themselves. This has resulted in a lowering of earthquake design forces for many types of buildings in the Central and Eastern U.S. 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-Based Exercises

In 2008, the USGS, California Geological Survey, and Southern California Earthquake Center 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 2008 Great Southern California Shakeout earthquake preparedness and response exercise. Over five million Southern California residents participated in the Shakeout, making it the largest public preparedness event ever held in the U.S. The State of California has begun annual renditions of the Shakeout exercise across the state. Along with FEMA, the USGS is supporting similar activities for the Great Central U.S. Shakeout that will be staged in April 2011.

Central U.S. Activities

The Central U.S. has been a major focus of the USGS and its partners in the past year, with the approach of the bicentennial of the 1811–12 New Madrid earthquake sequence there, which still ranks among the most severe earthquakes ever experienced in the U.S. In addition to its work in support of upcoming Great Central U.S. Shakeout, the USGS is working to support the FEMA National Level Exercise (NLE) 2011. In response to recommendations made by the NEHRP ACEHR, the USGS is working through its National Earthquake Prediction Evaluation Council (NEPEC) to support an independent evaluation of the hazard posed by the New Madrid Seismic Zone (NMSZ). The Arkansas Geological Survey and Center for Earth-

quake Research and Information at the University of Memphis, a regional network in the USGS Advanced National Seismic System, has been actively monitoring the recent swarm of low-magnitude earthquakes in north-central Arkansas.

NSF

NSF is NEHRP's primary basic research arm, supporting research that addresses earth science, geotechnical and structural engineering, lifeline engineering, and the social sciences, and integrating those disciplines. Following the devastating 2010 earthquakes in Haiti and Chile, NSF convened workshops to develop consensus reports on research needs.

Earth Science

NSF supports fundamental research related to seismology, geodesy, soil and rock mechanics, paleoseismology—the 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. This work has substantially improved the description and understanding of strain buildup along major plate boundary faults such as the southern San Andreas Fault and the southern California San Jacinto Fault.

Following the 2010 earthquake in Haiti, NSF awarded grants supporting a five year project that installed and maintains 100 field stations around the Caribbean basin to provide continuous GPS (ground deformation) and weather monitoring. This new network is known as COCONet (Continuously Operating Caribbean GPS Observational Network).

NEES

Established in 2004, the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) provides world-class experimental facilities at 14 academic institutions across the U.S. The 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," and includes a national repository for experimental data, as well as numerical simulation and collaborative tools.

NEES plays 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. NEES has promoted change in the earthquake engineering research culture 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. NEHRP agency partners FEMA and NIST, 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 in model building codes.

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. U.S. and Japanese researchers meet at least annually to discuss topics of mutual research interest and have a close collaborative relationship; as a result, several joint U.S.-Japan projects have now been performed using the E–Defense facility.

NSF continues to support, along with other Federal agencies, the Natural Hazards Center at the University of Colorado, Boulder. The Center's annual July workshop assembles 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

NIST has devoted significant attention to establishing the NEHRP program. The Secretariat has established the NEHRP web site (www.nehrp.gov) that contains much information about the Program, links to all of the NEHRP agency sites, links to other organizations that are involved with earthquake-related research and implementation issues, and an electronic clearinghouse of documents produced by NEHRP activities.

Through the NEHRP Secretariat, NIST has sponsored a NEHRP-wide study by the National Research Council (NRC) that will provide a broad 20-year roadmap for the NEHRP agencies to consider as they implement the NEHRP Strategic Plan. The NRC study assembled a broad panel of national experts in earthquake risk reduction to identify and prioritize possible activities that could be considered to achieve the objectives set out in the NEHRP Strategic Plan, and to estimate the costs of those activities. The results of the study were released on March 30, 2011 and are now widely available.

In 2010 and 2011, the NEHRP Secretariat has also worked to support the U.S.-Japan Natural Resources Panel on Wind and Seismic Effects and is currently in frequent communication with Japanese counterparts regarding possible cooperative efforts to survey and analyze the damage that occurred in the recent Japan earthquake. The NEHRP Secretariat is also engaged in leading the Federal Interagency Committee on Seismic Safety in Construction (ICSSC) and currently supports s an independent study to develop updated standards for seismic evaluation and rehabilitation of existing Federal buildings.

NIST's technical role in NEHRP is chiefly 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 and continuing now, in a strong commitment to the Program, NIST began strengthening its capabilities in the earthquake research arena, to bridge the research-to-implementation gap. The NIST earthquake risk mitigation research program supports several key areas: providing technical support for the earthquake engineering practice and building code development process; developing the technical basis for performance-based seismic design; supporting the development of technical resources that improve earthquake engineering practice; and, making developed and 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.

NIST performs about half of its earthquake research via a contractual partnership with the NEHRP Consultants Joint Venture, which links NIST with the nation's leading earthquake engineering researchers and practitioners. Several projects have been completed, and additional projects are ongoing. In addition, NIST has been building its in-house capabilities by hiring new earthquake research staff members.

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. The Administration has committed NIST to support post-earthquake investigations for NEHRP. The President's 2012 budget request includes funding to support the formation of a formal Disaster and Failure Studies Program at NIST that would include post-earthquake investigation activities, in addition to field studies in a number of other hazards areas. Following the 2010 Chile earthquake, FEMA, NIST, and USGS staff members joined scientists and engineers sponsored by American Society of Civil Engineers (ASCE) and the NSF-supported Earthquake Engineering Research Institute (EERI) Learning from Earthquakes (LFE) program in surveying the damage to Chilean infrastructure. Following the field work, NIST co-sponsored a Chile research needs meeting with American Society of Civil Engineers and the Pacific Earthquake Engineering Research (PEER) Center that resulted in NIST's making mid-year programming changes to focus key research efforts on lessons learned from the Chile earthquake.

FEMA

While the other agencies contribute to NEHRP implementation efforts, FEMA is NEHRP's primary implementation and outreach arm.

Implementation Activities

FEMA has a prominent NEHRP leadership role in working with the practitioner community, the ASCE, and the International Code Council (ICC) to support the development of model building code provisions. FEMA works 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 (FEMA P–750) that was released in early 2010 for use in future ASCE standards and model building codes. USGS in turn supports the development of the Recommended Provisions with its hazards mapping activities.

FEMA works directly with the model building code organizations to assist in the development of new seismic provisions for new 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. FEMA supports projects to develop earthquake engineering guidelines for designers and works closely with NIST in this activity. This partnership and the resulting development, publication, dissemination, and promotion of building design and construction materials are signature elements of NEHRP.

FEMA has developed and published over 200 earthquake design guidance publications on all aspects of earthquake risk mitigation, including: seismic design and construction of new buildings; evaluation and cost-effective rehabilitation/retrofit of existing hazardous structures; and other related structural and non-structural issues. FEMA has pioneered developmental work that supports the emergence of Performance-Based Seismic Design of buildings. Basic research supported by NSF has supported this effort, and, in recent years, NIST has initiated several knowledge transfer projects that complement the FEMA activity. PBSD is essential to fostering resilience in the constructed environment, because it helps engineers to work with building owners to enhance building performance beyond the basic life safety that is provided by the prescriptive measures found in model building codes.

FEMA began a significant new public outreach effort in 2008 with its 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 initiative began with a series of Community Forums in four cities in the Midwest and on the West Coast. Further forums are scheduled and FEMA is working with the Home Depot and ServiceMaster companies to broaden public outreach.

Outreach Activities

To support and increase the adoption of NEHRP earthquake resiliency measures, FEMA leads NEHRP efforts to 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 to increase awareness of the earthquake hazard and to foster plans to reduce seismic vulnerabilities. To provide state financial assistance, FEMA administers the Earthquake Hazards Reduction State Assistance Program which provides financial support to 33 states and territories.

FEMA also provides grants to support earthquake-related outreach and educational activities that promote earthquake mitigation and awareness to 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).

In addition to outreach activities to promote training courses and publications, to improve education and awareness, FEMA has co-sponsored series of informational conferences, including the National Earthquake Conference held in Seattle in April 2008, as well as the 100 Year Anniversary of the 1906 San Francisco Earthquake. Along with USGS, FEMA is providing support for the upcoming National Level Exercise (NLE) 2011 and the Great Central U.S. Shakeout. The NLE 2011 will focus on testing the earthquake catastrophic plan and the emergency response capacity of the NMSZ states.

In a project closely related to its other NEHRP efforts, FEMA completed development and publication of its Guidelines for Design of Structures for Vertical Evacu-

ation from Tsunamis. This document was jointly funded by FEMA and the National Oceanic and Atmospheric Administration (NOAA). NOAA issues tsunami warnings and leads the TsunamiReady program, a community preparedness and mitigation initiative. Tsunami safety is a critical issue for many 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. This publication has taken on added significance as a result of the recent Japan earthquake and tsunami.

Conclusion

The earthquakes of the past fourteen months—Haiti, Chile, New Zealand and now Japan—remind us of the persistent nature of the tectonic forces active within the Earth. There is nothing we can do to stop these processes, but the impacts of earthquakes, while not completely avoidable, can be greatly reduced.

Two major lessons from the recent earthquakes can be simply stated:

- Devastating earthquakes strike without warning, often at locations where their size and impacts are not fully expected.
- Earthquake preparedness and resilience measures can greatly reduce losses of lives, property, economic capacity, and societal well being.

These lessons seem obvious. But, we have recently seen nature teach them to us again, at the expense of others less fortunate and incompletely prepared. There is no need or justification for us to be forced to re-learn these lessons at home. Our challenge is to see that the new knowledge and experience gained through NEHRP continues to be developed and applied to domestic practices and policies that foster a more resilient American society.

Chairman Quayle and other Subcommittee Members, thank you again for the opportunity to testify on NEHRP activities. This concludes my remarks. I shall be happy to answer any questions you may have.

BIOGRAPHY FOR DR. JACK HAYES DIRECTOR, NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM, NIST

Dr. John (Jack) R. Hayes, Jr. is the Director of the National Earthquake Hazards Reduction Program (NEHRP) of the Engineering Laboratory (EL) at the Department of Commerce's National Institute of Standards and Technology (NIST). Dr. Hayes joined NIST in early 2006. NEHRP is the Federal government's program to reduce risks to life and property from earthquakes. As director, Dr. Hayes provides overall program management, coordination and technical leadership; strengthens program effectiveness by facilitating implementation of earthquake risk mitigation measures; and builds and maintains effective partnerships with NEHRP program agencies and stakeholders in industry, academia and government. Dr. Hayes also leads in-house NIST efforts to perform earthquake engineering research in support of NEHRP.

Dr. Hayes joined NIST after serving as leader of seismic and structural engineering research at the U.S. Army Engineer Research and Development Center's (ERDC) Construction Engineering Research Laboratory (CERL) in Champaign, IL. At CERL, Dr. Hayes was actively involved in earthquake engineering research for the U.S. Army Corps of Engineers. He also collaborated extensively with the earthquake engineering program at NSF, including work within the Mid-America Earthquake Center, and has been directly involved with a number of significant earthquake mitigation projects for FEMA. Working with key personnel at USGS, Dr. Hayes helped develop the seismic provisions for the American Society of Civil Engineers' ASCE 7-05 standard and a new Department of Defense tri-services seismic design manual.

Prior to his tenure at CERL, Dr. Hayes was Research Civil Engineer and Senior Scientist at the Engineering Research Division of the U.S. Air Force Engineering and Services Laboratory (1984-1988); Structural Engineer at the U.S. Air Force Armament Division (1982-1984); Assistant Professor of Civil Engineering at the Virginia Military Institute (1980-1982); Civil Engineer and NATO Infrastructure Staff Officer at the Headquarters U.S. Air Forces in Europe (1977-1980); and Civil Engineer Officer at Tinker AFB, OK (1975-1977).
Dr. Hayes is a retired Lieutenant Colonel in the U.S. Air Force Reserves and is a registered Professional Engineer in Florida and Virginia.

Education: University of Illinois at Urbana-Champaign, Ph.D., Civil Engineering, 1998; University of Virginia, M.E. (Tau Beta Pi), Civil Engineering, 1975; Virginia Military Institute, B.S. (Distinguished Graduate), Civil Engineering, 1973.

Latest Publications: Annual Report of the National Earthquake Hazards Reduction Program (NEHRP); Seismic Design of Reinforced Concrete Special Moment Frames: A Guide for Practicing Engineers

Chairman QUAYLE. Thank you, Dr. Hayes.

I now recognize Mr. Jim Mullen, Director, Washington State Emergency Management Division, and President of the National Emergency Management Association, to present his testimony.

STATEMENT OF MR. JIM MULLEN, DIRECTOR, WASHINGTON STATE EMERGENCY MANAGEMENT DIVISION AND PRESIDENT, NATIONAL EMERGENCY MANAGEMENT ASSOCIATION

Mr. MULLEN. Thank you, Chairman Quayle, Ranking Member Wu and distinguished Members of the Subcommittee for the opportunity to testify today regarding earthquake preparedness. I am President of the National Emergency Management Association and we represent the state emergency management directors of the 50 states, territories and the District of Columbia. I have submitted my written statement for the record already so I will take advantage of this opportunity to summarize my statement and leave some time for questions.

The initial phase of an incident, whether it is an earthquake or a tsunami or a hurricane, usually involves the lights and sirens of response, and while firefighters, law enforcement officials and emergency medical personnel bravely constitute the traditional first responders, emergency managers provide the all-important function of coordination. Emergency managers often manage multiple events simultaneously while preparing for a wide range of hazards from floods and earthquakes to category 5 hurricanes and terrorist attacks.

The response to an incident usually includes three phases of escalation. First, the local jurisdiction responds with immediately available assets. Should the local jurisdiction become overwhelmed, my counterparts at the state level are available to provide more robust state capabilities. On occasion, an event will even overwhelm the state, and this is usually the only time in which the Federal Emergency Management Agency is called upon to offer assistance. Without broad coordination by emergency managers during the response phase and this escalation of assistance, the transition from response to recovery would be nearly impossible.

In my written statement, I go into more detail on the National Earthquake Hazard Reduction Program and other witnesses have and will address it specifically, but I would be remiss if I didn't stress the importance of Congress reauthorizing this program. Without adequate authorization and funding of NEHRP, the collaborative work done by several federal agencies and institutes could leave communities without a critical source of research and technical assistance on earthquake preparedness. This work is invaluable during the planning for a response, but irreplaceable during a disaster. Programs such as NEHRP and the response and recovery issues I just discussed will be on display this May during a national-level exercise throughout the mid-central United States. This exercise is sponsored by FEMA, and through the simulation of a major earthquake on the New Madrid Seismic Zone will test the policies and doctrines of the Federal Government and eight states. This endeavor will involve thousands of government officials

at the federal, state, local and tribal levels, members of the private sector and the general public. Once this exercise is complete, I am quite sure the Committee will be interested in any after-action report FEMA can make available.

Exercises, and programs such as NEHRP only go so far, however, in establishing a baseline capability for response and exercise efforts. Each year, Congress supports one of the most critical programs the Federal Government has to offer. The Emergency Management Performance Grants, or EMPG, allow state and local emergency managers the ability to enhance their capability to protect lives and property. This coordination between state and local emergency managers is critical prior to an event. Since inception, EMPG has required a 50 percent non-federal match, and many state and local jurisdictions regularly overmatch.

To give you an idea of the impact of EMPG, consider the following examples. In 2009, 59 disasters occurred which required a Presidential Declaration and federal assistance. At the state level, however, 180 disasters required a gubernatorial declaration but no federal assistance, and another 122 events required State resources but no declaration. Without solid capabilities at the state and local levels afforded through EMPG, these events normally not requiring federal action could need significant federal expenditures.

As you can see, the emergency management process is complicated, and while I strayed somewhat from earthquakes specifically, this demonstrates the need to be prepared for a wide range of events from the initial response to the transition to recovery to the various levels of support FEMA can offer and the programs such as EMPG and NEHRP help states stand on their own. There is much we can accomplish if that program continues.

The emergency management team stands ready to continue assisting you in Congress in ensuring the safety and security of millions of Americans against a broad range of hazards and threats.

I thank you for this opportunity to testify and I look forward to your questions.

[The prepared statement of Mr. Mullen follows:]

PREPARED STATEMENT OF MR. JIM MULLEN, DIRECTOR, WASHINGTON STATE EMERGENCY MANAGEMENT DIVISION AND PRESIDENT, NATIONAL EMERGENCY MANAGEMENT ASSOCIATION

Introduction

Thank you Chairman Quayle, Ranking Member Wu, and distinguished Members of the Subcommittee for the opportunity to testify today regarding earthquake preparedness and efforts undertaken each and every day by dedicated emergency management professionals to help protect lives and property.

Emergency management is far more complex, however, than discussing specific response and recovery efforts of just one hazard. We often manage multiple events simultaneously while preparing for a wide range of hazards from floods and earthquakes to Category 5 hurricanes and terrorist attacks.

While other witnesses today have highlighted the attributes of the National Earthquake Hazard Reduction Program (NEHRP), I will go over general response and recovery issues, current efforts underway to simulate a massive earthquake in the Mid-Central region of the country, and recommend the best way you can support your state and local emergency managers.

Response & Recovery

A major event involving multiple disciplines is complex and difficult to manage. While firefighters, law enforcement officials, and emergency medical personnel often constitute the traditional first responders, emergency managers provide the all important coordination function. This coordination far exceeds the initial response as emergency managers also maintain responsibility for the transition from the lights and sirens of response into the complex and often long-term efforts of recovery.

Once an event occurs, the response is a three-tiered process of escalation where the level of support is directly related to the need of the impacted jurisdiction. The initial response is at the local level where first responders and local emergency managers provide assistance. Should the incident exceed the capacity of those local responders, the state may offer assistance in myriad ways including personnel, response resources, financial support, and mutual aid. On rare occasions, an event will even overwhelm the state's ability to mount an effective response. This is usually the only time in which the Federal Emergency Management Agency (FEMA) is called upon to offer assistance.

FEMA assistance is triggered by a direct request from the Governor to the President. Should the President deem the event worthy of federal assets, a Presidential Disaster Declaration is declared and FEMA can provide assistance such as assets from the Department of Defense, financial aid, and expertise.

Disaster assistance from FEMA traditionally comes in one of three forms. The first is the Public Assistance (PA) Program which provides supplemental financial assistance to state and local governments as well as certain private non-profit organizations for response and recovery activities required as a result of a disaster. The PA Program provides assistance for debris removal, emergency protective measures, and permanent restoration of infrastructure. Federal share of these expenses are typically not less than 75 percent of eligible costs. The PA Program encourages protection from future damages by providing assistance for Hazard Mitigation Measures pursuant to Section 404 of the Stafford Act during the recovery process.

The next level of assistance is the Individual and Family Grant Program or Individual Assistance (IA) which may provide money and services to eligible individuals in the declared disaster area when losses are not covered by insurance and property has been damaged or destroyed. Assistance for Individuals and Households may include cash grants for housing assistance and other needs assistance. Homeowners may use these grants for essential repairs to make their residence safe, secure, and livable. IA is designed to help with critical expenses not already covered by other means.

Finally, the federal government can provide assistance to prevent damage from occurring in the future through the Hazard Mitigation Grant Program (HMGP). HMGP provides funding to local communities for projects and plans to reduce damages, losses, and suffering in future disasters. Hazard mitigation is the ongoing effort to lessen the impact disasters have on lives and property. Coupled with HMGP, FEMA sponsors programs including Flood Mitigation Assistance Program (FMA) and Predisaster Mitigation Program (PDM). Such measures could include communities removing homes from flood-prone or landslide-prone areas, elevating houses, tornado safe rooms and community shelters, and other projects that may help reduce the impact from the next inevitable disaster.

While FEMA can provide all these forms of assistance after a disaster, part of the preparedness puzzle is learning how we all work together in forming a seamless response and recovery effort. As emergency managers, we best practice through the use of regular exercises and after-action reviews.

New Madrid National Level Exercise

After a significant event, the question is often asked "Can this happen to us?" In the case of the recent earthquake in Japan, the answer is most certainly "yes." In fact, one of the most severe earthquakes in history occurred in 1812 along the New Madrid Seismic Zone (NMSZ) in the Mid-Central United States.

This year, FEMA is sponsoring National Level Exercise 2011 (NLE 2011). The purpose of NLE 2011 is to prepare and coordinate a multiple-jurisdictional integrated response to a national catastrophic event—specifically a major earthquake in the central United States region of the NMSZ.

The exercise will involve thousands of government officials at the federal, state, local, and tribal levels, members of the private sector, and the general public. Participants will conduct simultaneous, related exercise activities at Command Posts, Emergency Operation Centers and other locations in the Washington DC. area and the eight affected central U.S. states including Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee. NLE 2011 will offer agencies and

jurisdictions a way to validate their plans and skills in a real-time, realistic environment and to gain the in-depth knowledge only available through experience.

NLE 2011 is also an opportunity to continue highlighting to the public their need to be prepared for earthquakes, and specific steps they can take to be ready. Exercises only go so far, however, in establishing a baseline capability for response and exercise efforts. Each year Congress supports one of the most critical programs the federal government has to offer. The Emergency Management Performance Grant (EMPG) Program allows state and local emergency managers the ability to enhance the capability to protect life and property.

Emergency Management Performance Grants

Often referred to as the "backbone of the nation's emergency management system," EMPG allows state, tribal, and local governments to make key investments in building capacity and enhancing the capability of states and localities to respond to disasters.

EMPG stands as the only source of federal funding directed to state, local, and tribal governments for planning, training, exercises, and key professional expertise for all-hazards emergency preparedness. In addition, EMPG supports emergency operations centers, which are the coordination hubs for all disaster response and to conduct risk and hazard assessments. The program also provides public education and outreach, enhanced interoperable communications capabilities, and the ability to manage statewide alerts and warnings.

Since inception, EMPG has required at least 50 percent non-federal match. This partnership recognizes every level of government as having an interest in building emergency management capacity nationwide. Even during these tough economic times, state and local governments continue to demonstrate a commitment to building capacity by contributing far in excess of the required 50 percent contribution.

EMPG allows states and local jurisdictions to respond to or support emergency incidents involving threats to life or property. Direct support includes activation of emergency operations centers, deployment of personnel, and the mobilization of resources. In order to illustrate the impact of EMPG throughout the emergency management community, it is significant to call attention to the many disasters occurring each year not requiring a presidential disaster declaration.

For example, in 2009, 59 disasters occurred requiring a presidential declaration and federal assistance. At the state level, however, 180 disasters required a gubernatorial declaration but no federal assistance, and another 122 events required state resources but no declaration. According to a recent joint survey we conducted with the International Association of Emergency Managers (IAEM), more than 44,637 actual local and tribal emergency response incidents, including 19,571 state response incidents, were supported utilizing EMPG funds. Without solid capabilities at the state and local level afforded through EMPG, events normally not requiring federal action could realize significant federal expenditures.

National Earthquake Hazard Reduction Program

While other witnesses have discussed NEHRP, I would be remiss if I did not also make mention of the program in this testimony. Since Congress established NEHRP in 1977, the building code standards, technical guidance, education, and research have been critical to reducing risks to life and property resulting from earthquakes. FEMA works in a support role to the National Institute of Standards and Technology (NIST) which is the lead agency under NEHRP. The emergency management community relies heavily on the actionable data provided by the program.

One of the key responsibilities of FEMA is supporting public-private partnerships to help inspire and sustain disaster-resilient communities. By providing estimates of potential losses due to seismic hazards to decision makers on the State and local level, FEMA leverages the work supported by NEHRP allowing communities to develop earthquake resistant design, public outreach and education programs, and construction standards and building codes.

Without adequate authorization and funding of NEHRP, the collaborative work done by NIST, National Science Foundation, FEMA, and the U.S. Geological Society could leave communities without a critical source of research and technical assistance. The information disseminated by NEHRP partner agencies inform public education efforts and this outreach can help communities across the country understand seismic risks and use this understanding to take action by mitigating their homes and businesses.

For example, in my home State of Washington, we utilize NEHRP to conduct seismic needs assessments of public schools with the aim of developing a methodology

to assess all public schools for seismic safety throughout the state. We are also creating a plan for improving our resilience to damaging earthquakes through the Resilient Washington State Initiative. Due to the success of this initiative, Oregon has also recently passed a resolution to complete a similar resiliency project.

We remain thankful of FEMA Administrator Fugate's continued support of the use of hazard and risk data developed by NEHRP and other similar programs used to inform mitigation decisions throughout the emergency management community. He also consistently discusses the need to invest in mitigation on the early and often to alleviate response and recovery efforts and costs after an incident occurs. As we learned following the catastrophic disaster in Japan last month, even the best mitigation efforts cannot prevent damage or loss of life from an earthquake but it unequivocally reduces the risk and helps a community recover sooner as a sustainable and safer place to live and do business.

Conclusion

As you can see, the response and recovery from any hazard, not just earthquakes, is complex and fraught with potential pitfalls. The continued support from Congress can provide emergency managers the assets to continue effectively managing these events in order to protect lives and property. EMPG, NEHRP, and the range of response and recovery programs constitute an invaluable toolbox of options for emergency manager. As you continue to explore these issues, we offer NEMA as a resource.

BIOGRAPHY FOR MR. JIM MULLEN, DIRECTOR, WASHINGTON STATE EMERGENCY MANAGEMENT DIVISION AND PRESIDENT, NATIONAL EMERGENCY MANAGEMENT ASSOCIATION

JAMES M. MULLEN
President, National Emergency Management Association
Director, Washington State Emergency Management Division

Jim Mullen became the Washington State Director of the Emergency Management Division effective July 21, 2004. He has been an outspoken advocate of local and county emergency managers. Innovation has characterized his tenure at Washington EMD: he has dramatically increased the public education outreach effort, which includes the highly praised Map Your Neighborhood Program initiative. A second innovation has been to increase the direct, two-way interaction between the public and private sector, with the promise of more in the future.

Mr. Mullen served as Director of Emergency Management for the City of Seattle for 12 years. Seattle Emergency Management received a number of national awards and other recognition during that period for community mitigation, community preparedness and disaster response planning. During his tenure he established a professional staff that was considered one of the most talented in the nation in terms of innovation and performance in nine presidentially declared disasters. The International Association of Emergency Managers (IAEM) recognized Mr. Mullen for his "outstanding contribution to Emergency Management" and as an "outstanding representative of our discipline".

In October 2010 Mr. Mullen was elected Vice President of the National Emergency Management Association (NEMA), and assumed the office of President of NEMA January 14, 2011. Prior to becoming President of NEMA he served as NEMA's Region 10 Vice President and as Mitigation Committee chairman. He is a member of the National Homeland Security Consortium and was a driving force behind the formation of the National Collaborative Mitigation Alliance.

Throughout his career in emergency management, Jim has contributed constructive commentary on the impact of the Homeland Security Department upon FEMA, and the collateral impact upon the safety of the nation from all hazards.

Chairman QUAYLE. Thank you, Mr. Mullen.

I now recognize Mr. Chris Poland, Chairman and Chief Executive Officer, Degenkolb Engineers, and Chairman of the NEHRP Advisory Committee, for five minutes to present his testimony.

STATEMENT OF MR. CHRIS POLAND, CHAIRMAN AND CHIEF EXECUTIVE OFFICER, DEGENKOLB ENGINEERS AND CHAIRMAN, NEHRP ADVISORY COMMITTEE

Mr. POLAND. Thank you, Mr. Chairman, Members of the Committee. I appreciate the opportunity to testify on behalf of the American Society of Civil Engineers.

Over the course of my structural engineering career that began in the early 1970s, the goal of seismic design has undergone a radical change. When I started working, it was all about keeping people safe. Since then, the primary goal has expanded to also include protecting communities so that they can recover quickly, and that is a much more complicated problem. This transition brought with it the need to design parts of the community to be undamaged and immediately usable, other portions to be usable while being prepared, and the majority be usable after repair. The communities' lifeline systems need to be designed so that they can be restored quickly and support recovery.

Achieving this goal is the focus of the current national strategic plan for the NEHRP program. We believe it is in the federal interest to continue pursuing resilience for the sake of national security, interstate commerce, public safety, economic strength and community restoration. I would also like to point out that this work will stimulate jobs and protect neighborhoods, protect people and the small businesses that serve them.

You have asked us to comment on whether we think we are prepared, and what I can say as a structural engineer is that depends. We are certainly more prepared than Haiti was prepared. But at the same time, we know that we are nowhere near as prepared as Japan was prepared, and we know what happened in Japan.

For me, I don't think we are prepared as a Nation to face a major earthquake and the impacts it will have. The vast majority of our building stock and utility systems in place today were not designed for earthquake effects, let alone given the ability to recover quickly from strong shaking and land movement. The tools and process we have available to achieve those goals are honestly too expensive to implement.

Each earthquake brings different styles of shaking, and new insights into the performance of the built environment. Each event reminds us that there is a lot of uncertainty about what causes failures and that generally leaves the profession developing conservative solutions to the problems the observe. That is what causes the very expensive price tag. Continuing and expanding the significant ongoing research will lead to engineering tools and processes that will allow the needed cost-effective solutions to be developed and implemented.

Last week, the National Research Council of the National Academies released a study that recommends a roadmap of what needs to be done to implement the NEHRP strategic plan. The NRC list

of needed activities is comprehensive and it certainly justifies the reauthorization of the NEHRP program. They have called for a 20-year program that moves at a much faster pace than NEHRP is currently proceeding. On behalf of my clients who seek to achieve resiliency at an affordable level, I fully support the NRC recommendations and call for a faster pace. We need to accomplish resiliency in our Nation, and at the pace we are going, we are not going to accomplish it maybe ever.

I recognize the NRC programs address four fundamental needs of resiliency. They point out that we need to significantly increase our ability to gather information, data, catalog it and store it on what happens. Extensive instrumentation is needed to understand how strong the earthquake shakes everywhere after an event. We know the shaking is different in every block of a city. You can tell that by the damage that occurs, and right now we only have a handful of instruments in each city to tell us what is happening.

In addition to that, a network of operation centers is needed to record, catalog and maintain information related to the impacts on society and their response. Just cataloging how a community responds to and recovers from an earthquake, that process has never been done in a coordinated matter. We need that information.

We need a framework that defines resilience in terms of what is needed to recover. Resiliency is more about improvisation, adaptation and redundancy than about how any single building or system performs. We design single buildings and systems but we need resilient communities. We should not spend money on things that we can improvise around. A consistent national framework for measuring, monitoring and evaluating community resilience is needed to guide the development of the new tools and processes. This is a fundamental need that we have. We need social science research to quantify the role of improvisation and adaptation and to determine how decisions are made.

Achieving earthquake resilience requires a community-based holistic approach to response that includes decisions and actions that are based on overarching goals, a clear understanding of the built environment, rapid and informed assessment data, and planned reconstruction and recovery. Research on the gathered data will allow lessons to be learned in one community and transferred to the next. That is a process that doesn't go on right now.

Finally, we need to develop performance-based engineering design tools that can be used nationwide. For the past decade, the engineers have been developed performance-based standards but these early efforts have been severely limited by insufficient data on building performance, insufficient analysis tools to predict performance, and inadequate training in the use of developing techniques. Basic research, extensive full-scale testing, applied research and implementation programs are needed to complete the development of the standards that will make achieving resilience affordable and cost-effective.

I appreciate the opportunity to present our views and urge you to recognize the value of the work, the extraordinary work that needs to be done and to reauthorize the NEHRP program. I would be very happy to answer any questions you have. Thank you.

[The prepared statement of Mr. Poland follows:]

PREPARED STATEMENT OF MR. CHRIS POLAND, CHAIRMAN AND CHIEF EXECUTIVE OFFICER,
DEGENKOLB ENGINEERS AND CHAIRMAN, NEHRP ADVISORY COMMITTEE

Mr. Chairman and Members of the Committee: I am Chris Poland and I am testifying on behalf of the 140,000 members of the American Society of Civil Engineers (ASCE). At ASCE, I am Chairman of the Infrastructure and Research Policy Committee. Additionally, I serve as Chairman, Degenkolb Engineers; and I serve as Chairman of the National Earthquake Hazards Reduction Program (NEHRP) Advisory Committee.I am registered civil and structural engineer, and have worked for more than 35-years as an advisor on government programs for earthquake hazard mitigation and in related professional activities.

My professional experience includes projects of all construction types, ranging from new design to seismic retrofit and rehabilitation and historic preservation. I was the founding co-chair of the NEHRP Coalition for Seismic Safety and chaired the ASCE Standards Committee on Seismic Rehabilitation and the U.S. Department of Veterans Affairs Advisory Committee on Structural Safety. I am a member of Boards of the San Francisco Chamber of Commerce and the San Francisco Planning and Urban Research Association and elected as a member of the National Academy of Engineering in recognition of my career long work in support of Performance Based Earthquake Engineering. I served on the Board of the Earthquake Engineering Research Institute (EERI) for ten years in two separate roles, first as the Secretary and then as the President from 2001 to 2002.

ASCE, founded in 1852, is the country's oldest national civil engineering organization representing more than 140,000 civil engineers in private practice, government, industry and academia dedicated to the advancement of the science and profession of civil engineering. ASCE is a 501(c)(3) non-profit educational and professional society. Research in civil engineering, properly conceived, conducted and implemented, should assure significant advances in the quality of life of individuals by providing essential service with minimal adverse effects on the environment by applying the principle of sustainable development and disaster resilience.

ASCE is pleased to offer this testimony before the Technology and Innovation Subcommittee on the House Science, Space and Technology Committee on the hearing, "Are We Prepared? Assessing Earthquake Risk Reduction in the United States".

Shift from Safety to Resilience

During my career as a Structural Engineer and Earthquake Professional, the focus and goal of seismic design work has undergone a radical change. As the result of the damage and economic impact that occurred during major earthquakes and other natural disasters over the past 20 years, the primary goal of hazard reduction has shifted from one aimed at protecting people to one that also seeks to protect the built environment to the extent necessary to allow rapid recovery. This transition brought with it the need to design portions of the built environment to be immediately usable without interruption, other portions to be usable while being repaired, and the majority to be usable after repair. This change in performance expectation is often referred to as a change from a life safety goal to a resilience goal. Achieving this goal is the focus of the current strategic plan for the National Earthquake Hazard Reduction Program (NEHRP 2008). This is new territory and the basic research, applied research, and guidelines that are needed for success are in a formative stage.

It also must be recognized that resilience is not just about the built environment. It starts with individuals, families, communities, and includes their organizations, businesses, and local governments. In addition to an appropriately constructed built environment, resilience includes plans for post event governance, reconstruction standards that assure better performance in the next event, and a financial roadmap for funding the recovery. This new style of planning and implementation must be tailored to the socioeconomic and cultural aspects of each community. Resilient communities form resilient regions and states which in turn will create a resilient nation. While the nation can promote resilience through improved design codes and mitigation strategies, implementation and response occur at the local level. Making such a shift to updated codes and generating community support for new policies are not possible without solid, unified support from all levels of government.

The federal government needs to set performance standards that can be embedded in the national design codes, be adamant that states adopt contemporary building codes including provisions for rigorous enforcement, provide financial incentives to stimulate mitigation that benefits the nation, and continue to support research that delivers new technologies that minimize the cost of mitigation, response, and recovery. Regions need to identify the vulnerability of their lifeline systems and set pro-

grams for their mitigation to the minimum level of need. Localities need to develop mandatory programs that mitigate their built environment as needed to assure recovery. (ACEHR 2009)

Are we prepared?

No.

The vast majority of our building stock and utility systems in place today were not designed for earthquake effects let alone given the ability to recover quickly from strong shaking and land movement. Earthquake Engineering is a new and emerging field and only since the mid 1980s has sufficient information been available to assure safe designs. Design procedures that will assure resilience are just now being developed. Strong, community destroying earthquakes are expected to occur throughout the United States. In most regions outside of California, little is being done about it. While modern building codes and design standards are available, they are not routinely implemented on new construction or during major rehabilitation efforts because of the complexity and cost. Many communities do not believe they are vulnerable and if they do accept the vulnerability, find the demands of seismic mitigation unreachable.

The problem of implementation and acceptance does not just lie with the public, but also with the earthquake professionals. Because this is an emerging area of understanding, conservatism is added whenever there is significant uncertainty. Earth Science research has made great strides in identifying areas that will be affected by strong shaking. Unfortunately, each earthquake brings different styles of shaking and building performance. This leaves many structural engineers generally uncertain about what causes buildings to collapse, and unwilling to predict the extent of damage that will occur, let alone whether a building will be usable during repairs or if lifeline systems can be restored quickly enough. Resilience demands transparent performance and significant earthquake science and earthquake engineering research and guideline development is needed to bring that ability to communities.

Recommend areas that need Federally Sponsored Research

The NEHRP was originally conceived to provide the knowledge, tools, and practices needed for earthquake risk reduction and has steadily made progress toward that goal. Many argue that the research that is needed to assure safety is complete. While that is debatable, it is certainly not the case for the research and tools needed to provide resilience. The 2009–2013 NEHRP Strategic Plan represents a broad-based and comprehensive statement of what activities are needed to achieve resilience through basic research, development of cost effective measures to reduce impacts, and sponsorship of implementation programs at all levels. It was developed over a three year period with input and review by the earthquake professional community and represents consensus about what needs to be done by the Federal Government through the core Federal Agencies.

Last Week, the National Research Council of the National Academies (NRC 2011) released a study that recommends a road map of national needs in research, knowledge transfer, implementation, and outreach that will provide the tools needed to implement the NEHRP Strategic Plan and achieve its vision of a nation that is earthquake resilient in public safety, economic strength, and national security. The NRC study stands on a foundation of numerous similar reports that have been produced over the past 20 years and have persistently outlined what is needed. The list of references in the NRC report includes a complete listing of the available studies and recommendations. The list of needed activities is comprehensive, and the extent of work needing to be accomplished is long. It is an outstanding list of what can be done and what eventually needs to be done. The nation needs to continue stepping toward resilience, and the goals objectives and tasks outlined in the NEHRP Strategic Plan need to be achieved. The reauthorization of the NEHRP program is a mandatory minimum step to maintain the momentum that has been developed. Accelerating the pace of achieving the goals of that plan will bring many benefits and the value is well documented.

Key areas in need of improvement that are supported by the Federal Government

The NEHRP Strategic Plan is recognized as an appropriate plan for achieving national resilience. The NRC Road Map is a detailed assessment of what needs to be done in the next 20 years to implement the plan. As a practicing Structural Engineer and Earthquake Professional, I recognize the need for every effort and my clients will benefit significantly from the resulting work. From my perspective, they

are all a part of the following four key areas that must benefit from federally supported research if we are to have the knowledge and tools to become resilient:

(1) *Comprehensive worldwide monitoring and data gathering related to earthquake intensity and impact.*

Extensive instrumentation is needed to adequately record the size and characteristics of the energy released and the variation in intensity of strong shaking that affect the built environment. We are lucky if we obtain a handful of records for entire cities but in reality thousands are needed to record the dramatic differences that occur and to understand the damage that results. In addition, the geologic changes that occur due to faulting, landslides, and liquefaction need to be surveyed, recorded, and used to understand the future vulnerability of the built environment to land movement. A network of observation centers is needed to record, catalogue and maintain information related to the impacts on society, and the factors influencing communities' disaster risk and resilience. At present, earthquake engineering is based more on anecdotal observations of damage that are translated into conservative design procedures without the benefit of accurate data about what actually happened. In my mind, expanded monitoring is the single most important area that will reduce the cost of seismic design and mitigation that will allow us to achieve greater resilience.

(2) *Overarching Framework that defines resilience in terms of Performance Goals*

Resiliency is all about how a community of individuals and their built environment weather the damage, respond and recover. It is more about improvisation and redundancy than about how any single element or system performs. Buildings and systems are designed one structure at a time for the worst conditions they are expected to experience. This approach worked well when life safety was the goal, and there was no need to consider the overall performance of the built environment. Resiliency, however, demands that performance goals and their interdependencies are set at the community level for the classes of structures and systems communities depend during the recovery process.

Facilities providing essential services during post earthquake response and recovery must function without interruption. Electric power is needed before any other system can be fully restored. Emergency generators can only last a few days without additional deliveries of fuel. Power restoration, however, depends on access for emergency repair crews and their supplies. Community level recovery depends on neighborhoods being restored within a few weeks so the needed workforce is available to restart the local economy. People must be able to shelter in place in their homes, even without utilities, but cannot be expected to stay and work after a few days without basic utility services. To ensure that past and future advances in building, lifelines, urban design, technology, and socioeconomic research result in improved community resilience, a framework for measuring, monitoring and evaluating community resilience is needed. This framework must consider performance at various scales-e.g., building, lifeline, and community-and build on the experience and lessons of past events.

Only the Federal government can break the stalemate related to setting performance goals that if left alone will eventually cripple the nation.

(3) *Social Science Research to quantify the role of improvisation and adaptation, how decisions are made at all levels and the need for rehabilitation.*

American cities are an eclectic collection of buildings and lifeline systems built over the life of a city. The vast majority were built before adequate design codes and standards were available to assure the needed durability and performance. Achieving earthquake resilience requires a community-based, holistic approach that includes decisions and actions that are based on overarching goals, a clear understanding of the built environment, rapid and informed assessment data, and planned reconstruction and recovery.

Communities build based on traditional standards and when affected by major earthquakes respond and recover based on intuition, improvisation, and adaptive behaviors that are drawn from the individuals available to participate. The lessons learned in one community and event rarely translate to the next community affected. In a perfect world, all buildings and systems could be rehabilitated to the needed level to assure resilience. In reality, the majority will not be rehabilitated unless financial incentives are provided. Such incentives are only appropriate and affordable when the subsequent action will contribute

to a community's resilience. Only through social science research will the balance between mitigation and response be understood.

(4) *Performance-Based Earthquake Engineering design tools*

Earthquake engineering is done every day based on the available building codes, design standards, industry best practices and intuition of the nation's earthquake professionals. Engineers traditionally have not been asked to disclose how buildings will perform, only whether or not they "meet the code". For most buildings, that means nothing with regard to their safety or usability after a major event.

For the past decade, engineers have been developing performance-based standards, but these early efforts are severely limited by insufficient data on building performance, insufficient analysis tools to predict performance, and inadequate training in the new techniques that are under development. New standards that support resiliency are needed throughout the seismic regions of the nation and need to be included in the development of national design and rehabilitation codes. Basic research, extensive full scale testing, applied research and implementation programs are needed to make the necessary seismic mitigation efforts affordable and cost effective.

Summary

In conclusion, ASCE supports research, practices and policies that identify earthquake hazards and mitigate earthquake risks, including:

- Continuance and expansion of the National Earthquake Hazards Reduction Program (NEHRP) and similar initiatives.
- The use of state-of-the-art performance standards for existing critical, essential, educational and disaster-recovery facilities, such as hospitals, schools and emergency shelters.
- Targeting buildings that are likely to collapse in major earthquakes for mandatory retrofit, reduced occupancy, reconstruction or demolition.
- Improvements of collaborative community preparedness and their related civil infrastructure with vulnerable regions so that they are economically resilient to earthquake hazards.
- Development of nationally accepted consensus-based standards for evaluation and retrofit of existing buildings;
- Development of national seismic standards for new and existing lifelines.
- Improvement of seismic mitigation applications focusing on low cost techniques; and
- Improvement of large risk mitigation programs at organizations, including at state Departments of Transportation, and at utilities.

Thank you for the opportunity to present our views, I would be happy to answer any questions you might have and to provide the Committee with further information.

References

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BIOGRAPHY FOR MR. CHRIS POLAND, CHAIRMAN AND CHIEF EXECUTIVE OFFICER, DEGENKOLB ENGINEERS AND CHAIRMAN, NEHRP ADVISORY COMMITTEE

Degenkolb

Chris D. Poland
Structural Engineer and Senior Principal
Chairman, CEO

Education
B.S. Summa Cum Laude, Mathematics,
University of Redlands, 1972

M.S. Structural Engineering, Stanford University, 1974

Registration
California – Civil Engineer, 1977
License No. 27243

California – Structural Engineer, 1980
License No. 2336

Hawaii – Structural Engineer, 1983
License No. 5428

Professional Affiliations
Chairman, National Earthquake Hazard Reduction Program Advisory Committee
Chairman, Seismic Mitigation Committee, San Francisco Planning and Urban Research Association
Chairman, Strong Motion Advisory Committee, Strong Motion Instrumentation Program, California Seismic Safety Commission
Chairman, Standards Committee on Seismic Rehabilitation, American Society of Civil Engineers
Chairman, Department of Veterans Affairs Advisory Committee on Structural Safety, Washington, DC
Executive Committee, Council of American Structural Engineers
Earthquake Engineering Research Institute, President, 2001-2002, Honorary Member, 1995
Structural Engineers Association of Northern California, College of Fellows, 2003
Seismological Society of America
American Institute of Architects

Chris Poland's career includes a broad range of structural engineering projects and a wide variety of professional activities. These include new design work, seismic analysis, structural evaluation, strengthening of existing buildings, failure analysis work, historic preservation, and research activities. He has taken an active role in advancing the practice of structural engineering through public advocacy, participating in numerous professional associations, regularly publishing technical papers, and presenting his findings in professional forums. Additionally, he has participated in the development of state and federal standards.

Chris serves as CEO of the firm. He served as President and CEO of Degenkolb Engineers from 1990 to 2008, CFO from 1985 to 1996, and Chairman since 2001. Since 1985, Degenkolb has grown 400% through deliberate, strategic planning and consistent operations. There are now more than 140 employees in the six west coast offices.

Chris is the immediate past President of the Earthquake Engineering Research Institute (EERI), where he also served as Director/Secretary-Treasurer for 6 years. On behalf of EERI, he is currently working with the House of Representatives Subcommittee on Science, Space, and Technology on the Reauthorization of the Earthquake Hazards Reduction Act. He chaired the EERI/SSA/OES 2006 Annual conference that drew more than 3,000 professionals to San Francisco in commemoration of the 100th anniversary of the 1906 Bay Area earthquake.

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Degenkolb

Chris D. Poland
Relevant Experience

He has participated in numerous research projects sponsored by the National Science Foundation, the U.S. Geological Service, the National Institute of Standards/Technology (NIST), and the Federal Emergency Management Agency (FEMA). This research has contributed, among other things, to the development of federal standards for seismic evaluations and mitigation (an NIST study), and numerous guidelines related to earthquake hazard reduction activities such as the National Earthquake Hazard Reduction Series Program (NEHRP) Handbooks for the seismic evaluation of existing buildings (FEMA 178, etc.).

Chris served as Principal Investigator of the American Society of Civil Engineers project team for the update of FEMA 273, which has been published as the ASCE 41, Standard for the Seismic Rehabilitation of Buildings. He also participated as a member of the project team for the update of FEMA 178, which has been published as ASCE 31.

Chris was the Chairman of the Vision 2000 Codes Committee of the Structural Engineers Association of California. Under his leadership, a 500 page document entitled Performance Based Seismic Engineering of Buildings: Interim Recommendations was published in 1995. The work, sponsored by FEMA and the California Office of Emergency Services, defines the conceptual framework for future seismic codes that will permit performance-based engineering. This work is currently referenced worldwide.

Career Highlights

OSHPD Report on the Impact of the Loma Prieta Earthquake on Bay Area Hospitals

Mitchell Earth Sciences Building, Seismic Evaluation, Stanford University, Stanford, California

Iris & B. Gerald Cantor Center for Visual Arts, Seismic Retrofit and Expansion, Stanford University, Stanford, California

Stanford Memorial Church, Earthquake Damage Repair, Seismic Retrofit, Stanford University, Stanford, California

ATC-14 Evaluating the Seismic Resistance of Existing Buildings, Principal Author

ATC-21 and 22, Co-Principal Investigator

ATC-28, Seismic Rehabilitation of Buildings—Phase 1: Issues Identification and Resolution. Project Engineering Panel Member.

Murrah Building Study

Memorial Chapel, Seismic Retrofit, University of Redlands, Redlands, California

Chairman QUAYLE. Thank you, Mr. Poland.

I now recognize our final witness, Dr. Vicki McConnell, Oregon State Geologist and Director, Oregon Department of Geology and Mineral Industries, for her testimony.

STATEMENT OF DR. VICKI McCONNELL, DIRECTOR, OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Dr. MCCONNELL. Thank you, Chair Quayle and Mr. Wu, and I really appreciate the opportunity to be able to speak with you today, and thank you for this opportunity to comment on the state of earthquake risk reduction in the United States to discuss the importance of the coordination between federal, state and local stakeholders and for emergency preparedness and allowing me to recommend improvements to federal programs.

As stated, my name is Vicki McConnell and I am the Director of the Department of Geology and Mineral Industries for Oregon. We work in close partnership with several federal programs that are focused on earthquake hazards characterization and risk reduction. We implement those programs at the state and local level.

I am also representing the Western States Seismic Policy Council, whose mission is to develop seismic mitigation policies and share information to promote those programs intended to reduce earthquake-related losses through 13 western states, three U.S. territories and western Canada. This council serves as a shining example of FEMA- and USGS-funded programs through NEHRP that assist in reducing earthquake risk in the United States.

And even though I am the Oregon State Geologist, I want to just remind you as a geologist that earthquakes and the hazards caused from earthquakes care little about state or national boundaries. You have to really look at the full geologic regions and we have to think about national investments in risk reduction.

First and foremost, I want to stress that the return on investment made by building resilient communities is tremendous. By definition, resilient communities spring back and they cost much less. The cost is minimized to get everyone back up and running. So my primary recommendation to you is to maintain robust federal programs within the National Science Foundation, NOAA, NIST, NASA, FEMA and the USGS that address earthquake and tsunami hazard research, mitigation and preparedness, particularly the cooperative federal-to-state and local programs that implement those federal missions and goals.

It is now estimated that the fatalities in Japan from the Tohoku earthquake and tsunami may reach 25,000, and the economic damage may reach $300 billion, and as has been stated before, our hearts go out to everyone in Japan and our condolences for their losses.

We did not escape unscathed here in the United States, though. We had tens of millions of dollars in damage in Hawaii, Oregon and California, and we had one fatality, all of that from the tsunami from the earthquake. Although it is going to take time to assess what has happened in Japan, it is clear that Japan's research and development, their technology and preparedness saved hundreds of thousands of lives and damages that would have gone into

more billions from that earthquake, something that we need to take a lesson from them.

And as Mr. Wu summarized, we have very similar geologic and seismic areas off the northwest coast of the continental United States and the coastline of Alaska. We have in historic times witnessed a 9.0 magnitude earthquake on the Cascadia Subduction Zone in 1700 as well as the 1964 9.2 magnitude Aleutian-Alaska Subduction Zone earthquake. We also now realize that magnitude 8 and higher earthquakes can occur along these same areas, and the reason we know that is because of the NSF and USGS funding opportunities for basic earthquake science.

I want to quickly go through some of the programs that are important for what we see: NSF's research at universities to understand and monitor earthquakes, the USGS Advanced National Seismic Network, our crucial seismic network, the USGS Earthquakes Hazards Program, which has external grants that bring in local expertise in science and engineering, and the NOAA Tsunami Warning Program and the National Tsunami Hazard Mitigation Program, which really is our leading edge for understanding and mitigating tsunami hazards. Finally, don't forget about the NASA fleet of earth-observing satellites and their help with these.

I want to thank you again for this opportunity to comment on the Nation's earthquake preparedness and the federal programs that assist building resilient communities. I would be happy to answer any questions. Thank you.

[The prepared statement of Dr. McConnell follows:]

PREPARED STATEMENT OF DR. VICKI MCCONNELL, DIRECTOR, OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

My name is Vicki S. McConnell. I am the Director of the Oregon Department of Geology and Mineral Industries (DOGAMI), an executive branch agency in the State of Oregon. I serve Governor Kitzhaber and the state as the Oregon State Geologist. The agency is tasked by statute to be the centralized source of geologic and geoscientific data and geologic hazard data for the State of Oregon. As such we work in close partnership with several federal programs that are focused on earthquake hazards characterization and risk reduction. We implement those programs at a state and local level. My testimony will focus on the state of these programs, how they do or do not accomplish their goals of earthquake risk reductions, and recommendations for improvement.

I am also representing the Western States Seismic Policy Council (WSSPC) whose mission is to develop seismic mitigation policies and share information to promote programs intended to reduce earthquake-related losses throughout the 13 western states, three U.S.territories, a Canadian territory and a Canadian province, and liaisons to seven western state seismic safety councils and commissions. WSSPC is a 501(c)(3) non-profit organization and is funded by the Department of Homeland Security's Federal Emergency Management Agency (FEMA) and the U.S. Geological Survey (USGS). Headquartered in Sacramento, California, members are the State Geological Survey and Emergency Management Directors.

Thank you for this opportunity to comment on the state of earthquake risk reduction in the United States, discussing the importance of coordination between federal, state, and local stakeholders for emergency preparedness, and allowing me to recommend improvements to federal programs.

Although I will be providing examples about how Oregon is working toward earthquake risk reduction and identifying and mitigating the hazards associated with earthquakes I want to stress that earthquake faults, seismic hazards, tsunamis, and seismic-induced landslides care little for state or national boundaries. When considering the effects of these hazards and how to reduce those effects we must consider the geologic regions and think about national investments in risk reductions.

First and foremost, I want to stress that the return on investment made by building resilient communities is tremendous; resilient communities spring back quickly with rapid economic recovery; with infrastructure from schools to roads reoccupied

and with the need for state and federal assistance minimized. My primary recommendation to you is to maintain robust federal programs within the National Science Foundation, NOAA, NIST, NASA, FEMA, and the USGS that address earthquake and tsunami hazard research, mitigation, and preparedness particularly the cooperative federal-to-state and local programs that implement the federal missions and goals.

Some examples of these federal programs include the USGS Earthquake Hazard Program, the NIST-administered National Earthquake Hazards Reduction Program and the NOAA administered National Tsunami Hazards Mitigation Program. These are federal programs that build resilient communities and do so through collaboration with experts outside the federal government. Through competitive and other grants, federal agencies work with scientists, engineers and local-area experts to understand the hazard, prepare communities, reduce losses and keep the local economy on track after a natural disaster hits.

We must continue to observe and understand hazards, prepare for hazards, mitigate potential losses and respond to hazardous events. These long-standing federal programs and partnerships provide the foundation for resilient communities. While the events in Japan are tragic, the fatalities, injuries and losses could have been orders of magnitude worse if not for Japan's attention to research, technology and preparedness leading to some of the most resilient communities in the world.

I offer four examples of work being conducted in Oregon that is crucial to developing resilient communities. These projects were possible because of federal assistance from NEHRP and other programs. My written testimony provides references to all four if you would like further information.

> Oregon is the first state in the nation to conduct an evaluation of the seismic vulnerability of all public schools and emergency response facilities statewide and to develop a grant program to assist with seismic rehabilitation of the most vulnerable facilities. While these are primarily state funded programs both relied on data and guidance provided by NEHRP. By funding overarching development standards and guidelines, the national program assists the states with developing comprehensive research and science and engineering evaluations.1
>
> Portland METRO Multi-Hazard Project. Through a collaborative effort of DOGAMI and USGS Earthquake Hazard Program, USGS Landslide Hazard Program, and National Cooperative Geologic Mapping Program a series of hazard maps for the Portland Oregon metro area are being developed. These maps will be used to drive the development of local land use planning and building codes for the Portland urban growth zone. [1]
>
> Oregon's Department of Transportation published in 2009 the Seismic *Vulnerability of Oregon State Highway Bridges: Mitigation Strategies to Reduce Major Mobility Risks.* This study incorporates FEMA HAZUS risk assessment modeling funded by NEHRP as well as NEHRP soil conditions data to determine peak ground acceleration (PGA). Their findings indicate that 38% of state-owned bridges in western Oregon would fail or be too heavily damaged to be serviceable after a magnitude 9.0 earthquake and that repair or replacement would take 3–5 years essentially cutting the Oregon coastal communities off from the rest of the state.
>
> The Oregon Lidar Consortium is using an excellent modern technology called light detection and ranging (or lidar) to identify and locate faults and related hazards throughout Oregon. Lidar allows us to image the bare earth by removing vegetation, so we can see fault structures, old landslides and other features that define hazards. Lidar was developed through research and development, led primarily by researchers funded through the National Science Foundation and the U.S. Geological Survey. It is now an essential tool for research and for land-use planning. See Figure 1 for an example of bare earth lidar imagery of fault scarps or go to: http://www.oregongeology.org/sub/projects/olc/default.htm

It is now estimated that the fatalities in Japan from the Tohoku earthquake and tsunami may reach 25,000 and the economic damage may reach $300 billion. Across the Pacific Ocean—there was $30 million in damage in Hawaii, $7 million in damage in Oregon, and one death and more than $50 million in damage in northern

[1] To view the final seismic vulnerability report go to: http://www.oregongeology.org/sub/projects/rvs/default.htm. To view the results of the rehabilitation grant programs go to: http://www.oregon.gov/OMD/OEM/plans—train/SRGP.shtml

California. Most of the death and damage in Japan and beyond Japan can be attributed to the tsunami. Although it will take more time to assess what has happened in Japan, it is clear that Japan's R&D, technology and preparedness saved hundreds of thousands of lives and billions of dollars in damages from the massive earthquake and also probably from the ensuing massive tsunami.

We have similar geologic and seismic areas off the northwest coast of the continental United States and the coastline of Alaska as they do off the coast of Japan. The Pacific Plate and other smaller plates are subducting beneath the North American Plate and in all three areas history has recorded very large magnitude megathrust earthquakes followed by massive tsunamis. These include a magnitude[2] 9.0 Cascadia Subduction Zone earthquake in northwestern United States in 1700, a magnitude 9.2 Aleutian-Alaska Subduction Zone earthquake in Alaska in 1964, and the recent magnitude 9.0 Tohoku earthquake. Additionally, we now realize that these subduction zones are prone to magnitude 8.0 and higher earthquakes occurring as frequently as ten times the magnitude 9.0 and larger earthquakes. See Figure 2 at the end of this testimony for a timeline of Cascadia Subduction Zone earthquakes over the last 10,000 years.

Are we ready for another Cascadia Subduction Zone earthquake? Or an earthquake on the Portland Hills Fault similar to the recent New Zealand earthquakes? No we are not; however we have made great strides toward understanding and mitigating for such natural disasters through state implemented programs funded in partnership with federal agencies or that use data gathered by federal agencies.

Your Subcommittee and the Full Committee can help to ensure that the federal programs are there to help the states develop resilient communities across the nation. My colleagues here today are explaining the excellent work that NIST and FEMA are conducting and I bring your attention to several other federal agency programs whose mission is to reduce earthquake risk..

NSF supports research at universities to understand and monitor earthquakes and tsunamis. NSF's EarthScope-US Array experiment, which has been deploying a network of seismic instruments that are moving across the country, has demonstrated how useful a robust national seismic network could be. For example, the U.S. Array instruments helped to detect several low magnitude seismic swarms in Oregon. While not directly hazardous, this previously undetected seismic activity indicates areas in the state that need additional hazard characterization and research. Unfortunately, most communities cannot afford to maintain the U.S. Array instruments so they have been pulled out as NSF's experiment moves east. The remaining USGS-supported regional seismic network can no longer detect the smaller events that would help us understand earthquakes or that might be critical for an early warning system for many urban areas throughout the country.

The USGS 's Advanced National Seismic System (ANSS) is crucial for developing earthquake resilience. It includes a backbone network, a global information center, a strong ground motion network and 15 regional networks. When an earthquake strikes, ANSS delivers real-time information, providing situational awareness for emergency-response personnel. The Pacific Northwest regional array in my area is operated jointly by the University of Washington and the University of Oregon. USGS support of a national seismic and geodetic network, with collaboration from state and university-based regional networks, is vital to understand and mitigate the hazards related to earthquakes. Without greater support for these networks they may deteriorate, leaving us highly vulnerable to earthquake hazards (essentially blind to earth movements). We recommend that the USGS work closely with their state and local stakeholders to design the information tools and seismic hazard maps that are useful to land use planning and emergency response.

The USGS Earthquake Hazards Program is also vital to earthquake resiliency. The external Earthquake Grants program, which has successfully engaged leading scientists and engineers through a peer-reviewed grant process brings local expertise to basic and applied earthquake research. We recommend that progress to build a prototype earthquake early warning system be evaluated and continued. This system would warn people within seconds after a major earthquake starts to shake the ground, in time for many people to take cover, protect their children, and automatically implement electronic safety measures (such as opening firehouse doors, slowing trains, and backing up computers). Japan already has a functional system in place, but the President's budget calls for the United States to stall its efforts. The system that we need would surely save lives and facilitate a rapid recovery after an earthquake strikes. The Earthquake Hazards Program also needs funding to take advantage of new technologies (such as better seismic instrumentation, more

[2] Earthquake magnitudes are expressed in the moment magnitude scale.

geodetic measurements, and more use of lidar in mapping faults) that are improving our abilities to reduce risks from earthquakes.

The NOAA Tsunami Warning Program and the National Tsunami Hazard Mitigation Program in concert with federal earthquake programs and in partnerships with state efforts is essential to understanding and mitigating tsunami hazards. While we did have death and damage in the United States resulting from the Tohoku earthquake and tsunami it would have been much, much worse without the federal programs designed to track distance tsunami activity, model and calculate the waves' path and arrival times, advise and warn state and local communities, and most importantly empower communities to prepare and respond. Developing resilient communities depends on understanding the social and demographic factors that affect how individuals and communities respond to natural disasters and to best deliver the message that, "Yes, you can plan for and survive an earthquake or tsunami." Oregon has 7 communities and 3 counties that have been declared "Tsunami Ready" through NOAA's Tsunami Ready program.

It is important to require federal programs and their stakeholders to coordinate their activities and missions to optimize the investment. An example of this coordination is the Advisory Committee on Earthquake Hazards Reduction (ACEHR) that guides and advises the many NEHRP programs.

Finally above all of these coordinated activities in R&D and technology is the NASA fleet of Earth-observing satellites. These satellites provide information about the land, ocean and atmosphere before and after an event. DESDyNI, which stands for Deformation, Ecosystem Structure and Dynamics of Ice is under development and would observe deformation from earthquakes, volcanic eruptions and landslides, among other things. It would include InSAR and lidar to follow earth movements. It would be helpful to support the development of this satellite without too much delay because of budgetary concerns. (http://science.nasa.gov/missions/desdyni/)

Thank you, again, for this opportunity to comment on the Nation's Earthquake Preparedness and the federal programs that assist building resilient communities.

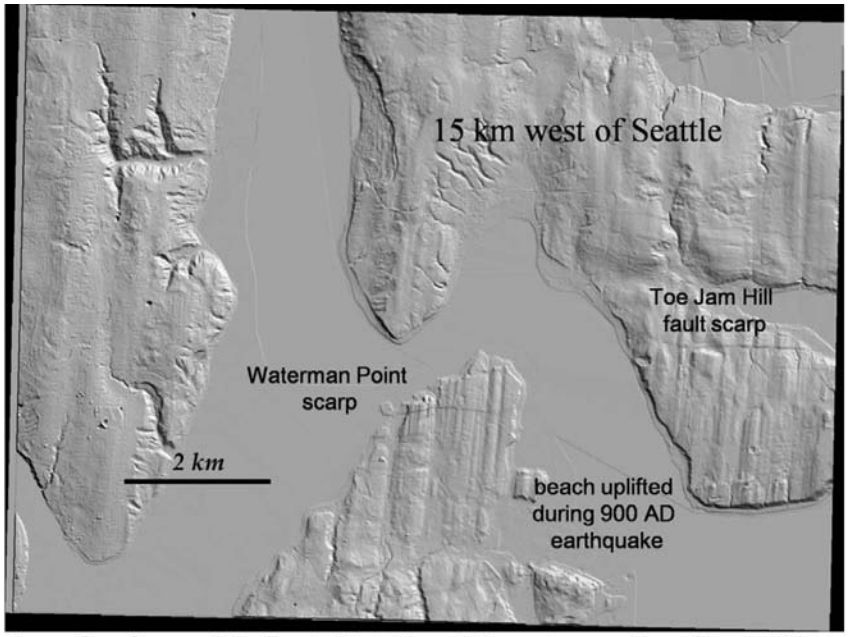

Figure One. Scarps of the Seattle Fault Zone delineated across Puget Sound, WA. Bare earth Lidar image from the Puget Sound Lidar Consortium, Finding Faults with Lidar in the Puget Sound Lowland.

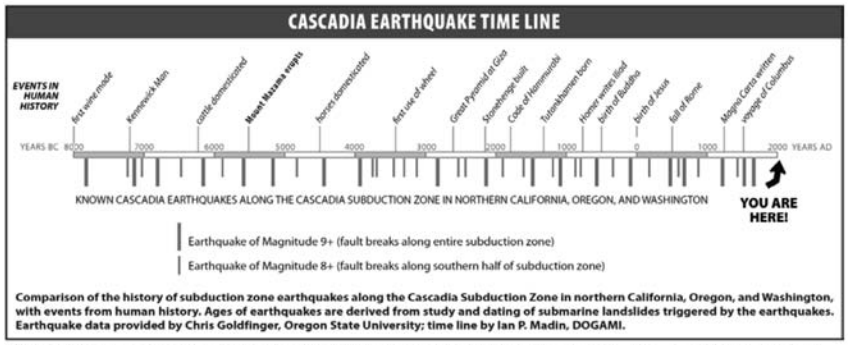

Figure 2. Funding though the National Earthquake Hazard Reduction Program in the National Science Foundation and the U.S. Geological Survey has allowed local experts to study and reveal the earthquake history of the Cascade Subduction Zone.

BIOGRAPHY FOR DR. VICKI MCCONNELL, DIRECTOR, OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Biography for:
Vicki S. McConnell, Ph.D., R.G.
State Geologist and Director
Oregon Department of Geology & Mineral Industries (DOGAMI)
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My career in geology and geochemistry spans three decades and covers a wide variety of interests and issues. During my tenure at US DoE Sandia National Laboratories in Albuquerque, NM I worked on diverse earth and material science problems from vadose zone fluid transfer to magma energy research. This experience was invaluable as I developed an understanding that you must look across science specialties to address practical solutions.

Graduate and post graduate work focused on developing new applications for stable and radiogenic isotope geochemistry to understand timing of volcanically driven hydrothermal systems. A primary interest was to apply research to quantifying intensities and expected timing of geothermal fluxes from magma intrusion. My research in the Long Valley caldera in California and Novarupta Volcano in Alaska brought me in contact with the sometimes counter issues of resource development and natural hazard mitigation. Involvement in the research for alternate energy sources such as geothermal and magma energy has satisfied a personal interest in spanning the gap from basic research to applied science. I continue to be interested in renewable energy research and applicability.

I conducted volcano hazard mapping in the Aleutian Islands while at the USGS Alaska Volcano Observatory where I learned the necessity of presenting scientific information and data that can be used as decision tools.

Two ongoing personal goals have been to participate in activities that will demystify science for the general public of all ages and in supplying scientific information for policy decision making. These goals prompted me to make the move from research and field work to Deputy State Geologist for the DOGAMI. I was honored to be appointed State Geologist and Director for the agency in 2004. Indeed this position allows me to address my goals through nearly every aspect of my job.

Oregon is a state with very dynamic geology that includes active volcanoes, subduction zone earthquake activity, and a coastline and marine landscape rich in hazards and resources. Much of my work nowadays includes grappling with the balance between resource management, hazards mitigation, and protection of the communities.

I presently serve as the President-Elect to the American Association of State Geologists.

Chairman QUAYLE. Thank you, Dr. McConnell, and thank you to all the witnesses for their testimony. We are going to enter into the question portion of this discussion, and I want to remind Members that Committee rules limit questioning to five minutes. The Chair will at this point open the round of questions, and I recognize myself for five minutes.

Dr. Hayes, I want to start with you. In your testimony, you talked about the importance of collaboration and linkages amongst NEHRP partners. There is an interagency coordinating committee, an external advisory committee on earthquake hazards reduction, and four federal agencies that have responsibility for long-term risk reduction; is there any redundancy in these efforts or do all agencies play a distinct role in NEHRP?

Dr. HAYES. That is a good question. In my written testimony, I actually posted what has infamously been referred to as the wiring diagram for NEHRP. I understand from our legislative affairs people that NIST has never used such a figure in testimony before but it is a good, graphic representation of what NEHRP is and what it does. I don't think there is any duplication of effort among the agencies. I think that there are complementary activities at the four agencies. The National Science Foundation is responsible for basic research, but it is also responsible for training the next generation of leaders in this area for our country, and that is a really, really important part of what they do.

FEMA, on the other hand, is at the other end of the spectrum, if you will, and FEMA is responsible for the implementation efforts, and FEMA works very, very closely with the national model building code organizations, particularly the American Society of Civil Engineers and the International Code Council, to get the results of NEHRP research into the national model building codes and then get adopted by states and localities around the Nation.

In the middle, USGS plays an extremely important role in the whole process with its monitoring program, its hazard mapping program, the work that it is now doing in the early, early stages of trying to understand how early warning might be implemented. It is an extremely valuable part of the process that is not duplicated in any other agencies.

Finally, my agency is responsible for doing applied R&D, if you will, to bridge the gap between the basic research done at the National Science Foundation and the really applied work that is done at FEMA.

Chairman QUAYLE. Thank you.

Mr. Poland, in your testimony you compared the different results of the earthquakes that occurred in Haiti and Japan, and even what happened in the Northridge quake, and the quake that occurred in San Francisco. You mentioned that it would be cost-prohibitive to retrofit buildings across the United States. What is your suggestion to minimize the repercussions of an earthquake? Do you mostly look at where different communities lie along faults? For example, a city is close to the San Andreas fault, you obviously take different things into account than cities in middle America located away from the New Madrid fault line.

Mr. POLAND. As I mentioned, the biggest problem we have is that the built environment that we have right now in the country has

not been designed for earthquake effects, both in terms of public safety and in terms of being able to recover and resiliency. And so the biggest problem we have is, what do we do with 85 or 90 percent of our buildings and systems that are not adequate for the kind of performance that we want. When I spoke about it being cost-prohibitive, I was speaking about retrofitting those buildings and those systems so that they can perform properly, and that is what costs so much money. The most important thing is to not fix or retrofit anything that doesn't need to be fixed and not to do it too much. I can say that.

Okay. How do we stop doing it too much? The first thing is that the earth science research has to continue to move forward to expand our understanding of how strong the ground is going to shake, what the damage to the land is going to be and what the impact on the buildings is going to be, so that needs to continue so that we can better understand where the pockets of shaking are going to occur. Right now we consider huge areas that are going to shake very hard and in reality when we look at the damage and we look at the instrumentation that is available, we see that there are pockets of damage that occur so there is a whole body that needs to be done there.

Secondly, it is just the techniques we use to analyze buildings and determine how much they need to be retrofitted. It is based on anecdotal evidence that we gather from our field reconnaissance. We go out and we look at earthquake damage. We see broken buildings, don't really know how strong the ground was shaking and determine what we need to do to stop that. Through full-scale testing and basic research and applied research, we can learn and have learned a lot about how to improve building performance just enough, and it is this just-enough idea that will bring the cost down and make it affordable.

Chairman QUAYLE. You were talking about community awareness; since you don't want to do too much, is your goal to focus on one specific pocket that will resist a certain level of earthquake so that the area can be up and running post earthquake and basically prioritizing different pieces of infrastructure so that cleanup and repair work can happen in a much more efficient manner?

Mr. POLAND. That is correct, and the focusing is really around the systems and buildings that are needed for the recovery. The buildings that you need during the emergency response period need to be running all the time. The big issue that we have right now is we recognize that our workforce, the neighborhoods need to be restored within a few months in order for the economy to come back to life and so the systems that support the neighborhoods and the small businesses need to be taken care of next, and then the commercial districts and the industrial areas need to be taken care of after that, an orderly process of doing that, and then, as you said, recognizing in the community what areas are inherently safer than others, don't shake as hard, and focusing attention in those areas is one of the keys.

Chairman QUAYLE. Okay. Thank you very much.

The Chair now recognizes Mr. Wu for five minutes.

Mr. WU. Thank you very much, Mr. Chairman.

Dr. McConnell, you mentioned in your testimony—this is really a question for all of the witnesses. You mentioned that one study found that up to 38 percent of Oregon's highway bridges would fail in the case of a magnitude 9.0 earthquake and that it would take potentially five years to repair or replace these damaged bridges, and this would leave some communities, especially coastal communities, cut off from the rest of the state for a number of years. Can you all comment on how we are trying to design resiliency into crucial lifelines, and as Mr. Poland has said, also work on workarounds for some of these where we cannot design in survivability in the first round?

Dr. MCCONNELL. Chair Quayle and Mr. Wu, I appreciate that question and the comment. That particular study was designed and taken and carried forth by the Oregon Department of Transportation, and they did use the data and information that was gleaned from NEHRP whenever they developed their scenarios, so that is very important to bring this back around is how are we using the information and data that is coming out of NEHRP for very practical questions like are the bridges going to be there if we have that type of earthquake. It doesn't matter if the roads are there if you can't get across the bridge.

So what I would like to say in answer to your question is, in building resiliency, and, as Mr. Poland said, you must recognize and prioritize those infrastructure, those buildings, those parts of the community that you really need to have there both during and immediately after. So yes, it would take us three to five years to fix every one of those bridges but not every one of those bridges need to be fixed right off. What we need to do is recognize where are those priority lifelines and particularly the ones to the coast that need those bridges fixed, and those are the ones you start. Those are the ones you focus on. And we are actually working with—and I say "we", the State of Oregon, working with the Department of Transportation, emergency management, a variety of other agencies and working with our federal partners toward developing those type of identifying the infrastructure that really needs the first look at and to try to fix those first as we work through these kind of projects. Because otherwise you look at it and you just say this is going to cost so much and it is going to take so long, we can't get our arms around it, but we absolutely can. You just have to think strategically. And it engages everyone, not just the earthquake, not just these programs that work on earthquake and work on earthquake science but the Department of Transportation. Those types of agencies as well need to be incorporated into these discussions.

Mr. WU. Thank you very much.

Mr. Poland? Well, it is fine if you have nothing further to add.

Mr. POLAND. I have nothing further to add.

Mr. WU. Okay. Terrific.

Dr. Hayes, your agency works on developing some model codes, and that applies to buildings, I believe, and also potentially to bridges and other structures. Do you want to comment on this from the perspective of critical infrastructure?

Dr. HAYES. We don't do work on bridges and those kinds of structures. The Federal Highway Administration is primarily respon-

sible for that work. We do focus on the building side of the problem, if you will. I don't think there is any doubt that we have a long way to go to have a completely coordinated approach to our lifelines in virtually every major city in the United States. That is an area that I think that the advisory committee that Mr. Poland chairs, as well as this NRC report that he referred to, have mentioned as an area that we really need to be looking at as we go into the future. It is an area that is not as well established as the buildings area is. There is no question about that.

Mr. WU. Thank you very much, Dr. Hayes.

My second question, before my time runs out, is that we do have a number of nuclear reactors that are sitting on active seismic zones, and I believe one of them is on the West Coast. Can you all comment on what can be done to build resiliency and recovery into these nuclear facilities? You know, what we found in Japan is that it wasn't the earthquake, it was the tsunami and the loss of electricity and it affected both the reactor itself and the fuel that was stored in pools on top of the reactor facility. Can you all comment on how we can do a better job with our own nuclear facilities?

Dr. HAYES. You are looking at me, so I will give you a short answer. NEHRP itself does not address the nuclear facilities in the United States. That is the responsibility of the Nuclear Regulatory Commission and the Department of Energy. So we really don't directly get engaged with that. However, we have frequent communications with the folks over in Rockville at NRC, and in fact, the day before the horrendous earthquake in Japan hit, we had a staffer from the NRC briefing the NEHRP advisory committee on the activities there. There are many interactions that occur between the USGS and the Nuclear Regulatory Commission that are tied to examining the ground motions and the propagations of those motions following an earthquake, so there is interaction there but it is not a formal responsibility of the program.

Mr. POLAND. I would just like to add that the design process that has been done for nuclear power plants since their inception has been extraordinarily rigorous and much more detailed and much more carefully done than for any other kind of construction by many orders of magnitude. Our facilities, our nuclear facilities from a standpoint of strong shaking are the safest buildings that we have in the Nation.

The problem in Japan, as you mentioned, had to do with the tsunami, and it wasn't that they didn't think they were going to have a tsunami. They had a wall. The wall wasn't tall enough. The backup systems didn't work as well as they thought that they would. All of that would be factored into the programs that we have now just like they are being done, and that extra level of redundancy will be added. Our nuclear power plants are designed with many, many levels of redundancy, and you have to look at what the worst cases are. They do a better job of that. Looking at our power plants that are on the West Coast, it is my understanding that we are not facing that same kind of tsunami issue but it is causing a reevaluation and consideration of what is being done. I just wanted to add that this is a much higher level of consideration and sophisticated design than is done anywhere else.

Mr. WU. I may follow up later.

Chairman QUAYLE. Thank you.

The Chair now recognizes the gentleman from Texas, Mr. Smith, for five minutes.

Mr. SMITH. Thank you, Mr. Chairman. Mr. Chairman, let me thank you and particularly the Full Committee Chairman for scheduling such a timely hearing, given what has occurred recently in Japan, and let me confess at the outset that my first question is directed towards Dr. Hayes and my second question is to Mr. Poland, and confess that it is a very provincial question, so I hope you will excuse that, and it is this. Over the last several weeks, the Texas Advanced Computing Center in Austin, which is part of my district, came to the assistance of Tokyo's Earthquake Research Institute and other scientists in Japan, who reached out to them when Japan's own high-performing supercomputers, used to research earthquake tremor scenarios and radiation disbursal simulations, were knocked offline due to power outages.

So the question, Dr. Hayes, is this. How much does the National Earthquake Hazards Reduction Program, which you manage, rely on supercomputing capabilities and how much do you invest in supercomputing capabilities for earthquake research?

Dr. HAYES. I can't give you a quantitative answer because I have never actually attempted to gather that specific information, but much of the work that is being sponsored by the National Science Foundation and by USGS involves the use of supercomputers. I would have to find out more specific information for you. Obviously where it is appropriate to use them, they are being used in the research that is being performed.

Mr. SMITH. Okay. Dr. Hayes, thank you.

Mr. Poland, second question is, does your advisory committee find the current level of investment in supercomputing adequate, and given the tight budgets, in what research areas would you recommend a higher or lower level of investment for earthquake research?

Mr. POLAND. Quite honestly, our advisory committee has not considered or discussed the investment in supercomputers.

Mr. SMITH. Maybe I am giving you and Dr. Hayes some new ideas here today. Do you think you will get to that?

Mr. POLAND. I do believe that we will. I think that supercomputing gives us the ability to do community-wide simulation and detailed building simulation and simulation of systems. They are necessary to do the kind of estimation of what the damage is going to be. I think that that level of simulation is going to be very necessary for us to move forward and figure out what we need to do to make our systems more resilient.

Mr. SMITH. Okay. Now, let me know what additional research you do on that subject, if you would.

Last question is this. It has to do with the budget. And let me ask each of the panelists if they would to give a very, very quick response. You don't necessarily have to limit it to good or bad, but be as brief as you can.

In the fiscal year 2012 budget request currently before Congress, the President's Office of Management and Budget canceled NASA's Deformation, Ecosystem Structure and Dynamics of Ice satellite mission, which would monitor for and anticipate earthquakes, vol-

canoes, landslides, glacial ice sheet changes and other practical applications, in favor of other NASA satellite missions to monitor greenhouse gases. How will that cancellation affect earthquake research? And Dr. Hayes, let us just go down real quickly, if you could.

Dr. HAYES. Sir, I will have to find out more information for you on that. Since NASA is not a part of the NEHRP program, we don't directly deal with that. We were known of that cancellation. Actually it was made aware to the advisory committee about three weeks ago, and——

Mr. SMITH. Maybe I should make it easy for you. Can the cancellation be good? I mean, there is some common sense involved here too.

Dr. HAYES. Well, I don't mean to be evasive but I am a structural engineer like Mr. Poland is, and so I don't know a good answer to that question. I will be glad to find out for you.

Mr. SMITH. We will go to Mr. Mullen then. Thank you.

Mr. MULLEN. Sir, I can only say that I am a consumer of research. It is best if I don't try to produce too much. Any information I get, I will be happy to use as an emergency manager.

Mr. SMITH. Mr. Poland?

Mr. POLAND. As I mentioned, one of the biggest uncertainties we have is when and where and how strong the earthquakes are going to occur. We are looking forward to the day when we have clear information. There is reason to believe that satellite observation is going to give us some of that information. That is a hope. In that sense, it is important. How much will it affect our work today? Not very much.

Mr. SMITH. Thank you.

And Dr. McConnell?

Dr. MCCONNELL. Thank you. The satellite you mentioned here with the acronym DESDynI is of great interest to looking at building baseline topographic information for areas that may be vulnerable to earthquakes, volcano hazards, etc. You can then—because what you are looking at both InSAR and LIDAR, which are acronyms for types of digital imaging, is are there changes, are there subtle changes in the topography that may be indicating that we have stresses building up or that we have inflation occurring in volcanic areas. These are things we are very sensitive to when we are doing hazards monitoring, and this particular satellite would be of great interest to broadening our monitoring capabilities and looking at what we call interferometry.

Mr. SMITH. Good to hear. Thank you, Dr. McConnell.

Thank you, Mr. Chairman.

Chairman QUAYLE. Thank you, Mr. Smith. Before I recognize our next questioner, I just wanted to let everybody know that there actually has been another earthquake off the east coast of Japan just an hour and a half ago, magnitude about 7.5. We have just been notified. So our thoughts and prayers are definitely with the people of Japan right now.

The Chair now recognizes the gentleman from Maryland, Mr. Sarbanes, for five minutes.

Mr. SARBANES. Thank you, Mr. Chairman. Thank you to the panel.

If all of the measures you would like to see put in place with resiliency and preparation and recovery and so forth represent, say, 100 on a scale of 1 to 100, where would you say we are on that scale as a Nation right now? Anybody want to try to quantify that?

Mr. POLAND. One to 100. We are talking about here with the federal investment involved in developing tools and knowledge and implementation programs. I would think we are down in the 25 range. We have a fair set of tools that are expensive to use. We have a set of implementation programs that would help states and regions become more resilient but they are not really being implemented right now and so we are really at a very low level.

Mr. SARBANES. So we are in the 20s out of 100 in terms of investing our attention and resources to the problem, but in terms of our preparedness as a Nation, according to the standards you would set to be enough prepared for the kinds of scenarios that you model, where are we on that scale from 1 to 100?

Mr. POLAND. I guess they are going to let me talk. I would say it is even lower, maybe 10.

Mr. SARBANES. Okay.

Mr. POLAND. Let me just say quickly that in areas of very high seismicity in California, Oregon and Washington, there have been building codes in place for 20 years that are going to help people be safe. Other parts of the country that we talk about, those things are not in place.

Mr. SARBANES. Well, that was the next question I wanted to ask you. I assume that the West Coast would be higher on the scale than other places, so California, where would you put that?

Mr. POLAND. From a scale of safety, I believe that California will maybe 50 or 60. On a scale of resilience to be able to recover quickly and not have a significant impact on the national economy, we are still down in the 10–20 range.

Mr. SARBANES. Okay. Humans are notoriously shortsighted about everything, and even with the earthquake activity of recent days, we will get back to being shortsighted even on this question, and I wonder if you could speak to—I mean, I would imagine if you went to any budget hearing at a local level, at a city, municipality level or at the state level if earthquake preparation and resiliency was even on the budget document, it would be on the last page on the last line because there are so many other things obviously that are pulling on our resources and our attention. So it makes me wonder how much—and I think you have spoken to this a little bit, but the opportunity to piggyback the kinds of things you want to see done onto other kinds of initiatives that are out there that have greater priority in the minds of planners and budgeters and all the rest of it so that you can kind of come along with a little bit, of leverage and not so much add a cost, say, well, as long as you are doing X, Y and Z, why not add this into the mix, and that can go to codes and building standards and so forth. But it also could go particularly well with community resiliency planning, and I wonder if you could speak to that and maybe throw in whether sort of green building codes and sustainable building codes are ones where there can be some added elements with respect to resiliency and so forth. Thank you.

Mr. MULLEN. Sir, let me try to help with some of that. I will tell you that on the West Coast, there are significant discussions taking place in local communities about earthquakes and tsunami threats and measures that should be taken. One of the things we haven't really talked about is the importance of the general public understanding not only the risk they face but the measures they can take to protect themselves. I am very enthusiastic about getting a warning about something that might be coming like the tsunami warning we got a few weeks ago really helped us but the type of events, the no-notice events that we would deal with in the central Puget Sound or in Oregon or on the coast, they are not going to get a lot of warning for an earthquake. One of the things that we need to do is make sure people are prepared to take the protective steps that they need immediately. They need to be able to drop cover and hold. They need to know that they have got—that they need to have some resources for themselves. And on the coast, we have been working hard with the communities about their evacuation programs, knowing what it means to move quickly. The ground motion in an earthquake that is right off our coast is your signal. We also have an elaborate system of warning systems that we can activate to tell people to move to high ground.

The difficulty we have, the challenge that communities have as they prepare with us and they have worked with us is there is not a vertical evacuation site that is necessarily readily available to every community, and so we have been trying to plan for the type of vertical evacuation structure that would be necessary on the coast in the Port of Los Angeles or Long Beach or Ilwaco where those folks can get to a place of safety which may not be the warmest, driest place but it will at least be above any kind of potential wave. That is an important step. There is no such structure right now but the communities are planning with it.

I think the key to this whole thing that you are getting at in terms of where people are, and I would not hazard a guess about the scale because I would just be making something up. I will tell you if you educate people about the risks that they face and you level with people about what they can do to protect themselves and their families, whether it is the average citizen, someone running a business or the emergency management community or the local elected officials, you begin to generate the kind of interest that will get people looking at this as another issue that they have to deal with and move it up on that committee agenda. The national-level exercise I spoke of in my testimony is an attempt in the Midwest, in eight Midwestern states to begin to educate people at the same time that we are determining whether our doctrines and plans are going to work for us or not. That will be an extremely challenging exercise. We expect failure to occur because we want to find out what our condition is. So we are very eager to find out where we are weak, where we have got strengths and make sure we capitalize on the strengths and shore up the weaknesses.

Chairman QUAYLE. Thank you very much.

The Chair now recognizes the Chairman of the Full Committee, the gentleman from Texas, Mr. Hall.

Chairman HALL. Thank you, Mr. Chairman. I thank you for inviting a very capable group of witnesses here, and don't judge our

interest or our appreciation of you by empty seats here because it is kind of a desperate time up here. Right now we are all looking for a bus ticket home or how long we are going to have to stay here. But in this day and time with the hurricane, the tsunami, the earthquake and other vicissitudes of nature, your testimony is very timely and very important to us, and we have probably the hardest working man in the entire hearing room that sits to my left here, and he is taking down everything that is said, and all these Members will be given copies of your answers, and you are not in vain when you are talking to our very capable Chairman and Ranking Member and a few of us here. So I thank you for that. That is all I really want to say.

We had a hearing some 15 years ago on asteroids, and with the thought in mind of getting everybody in the world to work together to determine whether or not—and I learned at that hearing something that I didn't know then and hadn't even heard of it. An asteroid had just passed Earth and by their testimony, only missed us by about 15 minutes sometime in the 1980s. And those are things that people like you live with every day and know about that we don't know about, and we cast our legislation based on the testimony of folks like you that are kind enough to prepared yourself, leave your offices, come here and give us your testimony, and I thank this good Chairman and Mr. Wu for gathering such a good group here and asking proper questions, and I yield back my time.

Thank you, Mr. Chairman.

Chairman QUAYLE. Thank you, and the Chair now recognizes the gentleman from Tennessee, Mr. Fleischmann, for five minutes.

Mr. FLEISCHMANN. Thank you, Mr. Chairman and Mr. Wu. This is a particularly pertinent Subcommittee hearing and topic, and I appreciate the opportunity to participate.

And also Chairman Hall, I want to thank you. I am one of those freshmen to the witnesses, and it has been a great privilege. I serve on three committees and I represent the Oak Ridge area, so I have got the lab and Y12, but the hearings that we have been having in Science, Space, and Technology and the tremendous leadership from Chairman Hall and I think bipartisan cooperation has been outstanding on these issues, so I thank you for being here.

Our thoughts and prayers go out to the people of Japan. I was unaware of the additional earthquake Mr. Chairman. I am very sorry to hear that.

I have some questions. I think I will start with Dr. Hayes, if I may. Dr. Hayes, what is NEHRP's relationships with other countries, and what are other countries federal earthquake research and development programs? How are they different or similar to ours?

Dr. HAYES. I don't know that there is another country that does it quite the way we do it. I think that that is largely because different governments are organized in different ways. But we really have many international partnerships within the National Earthquake Hazard Reduction Program. Probably right at the moment, what would be most of interest to all of you all is the fact that we work very closely with the Japanese. There are two bilateral committees or panels that are involved with earthquake-related issues between the United States and Japan. One is in the seismological

area. It is called, the basic title of it is Earthquake Research, and the other is in the engineering area, wind and seismic effects. We are in close contact with the Japanese. My counterparts on the Japanese part of the committee that I co-chair for the United States and I have been in frequent contact for the last several weeks since the earthquake hit there. We fully anticipate that we will be going over there once things have passed into a study stage from where they are now still response and recovery and the radiation issues are resolved. We will be working closely with them.

The National Science Foundation works very closely with their Japanese counterparts. The world's largest experimental facility, what we call a shaking table that you can build models on and actually subject them to earthquake effects is just outside of Kobe, Japan, between Kobe and Kyoto, and we actually have cooperative projects where U.S. funded projects are placed on that shaking table and U.S. and Japanese researchers work literally side by side on those projects and we typically meet every September to review the kinds of technical issues that are being performed. At the moment, there is a group from the American Society of Civil Engineers with one person from NIST in New Zealand examining some of the damage that occurred in the Christchurch earthquake a few weeks ago as well.

USGS has far more bilateral arrangements of that kind because the ground issues are the same no matter what national border is in place whereas the built environment can depend greatly upon the society in which you are examining the issues and so USGS does a lot more with the other countries than the rest of us, but we work with many other countries all the time.

Mr. FLEISCHMANN. Thank you, sir. I appreciate that.

Dr. McConnell, how, if at all, do the costs of preparing for earthquakes diminish as you become more prepared? Once a community reaches a certain level of preparation, can its annual investment be reduced? And how do you measure a community's level of resilience?

Dr. MCCONNELL. Well, I guess I will tackle that last one first as I am not sure that we have an ability to quantify how you measure a community's level of resilience. What we would look at—what we would really look at is, have they met certain goals depending on what their hazard is that they are looking at, and I will use an example of coastal communities that have—on the Oregon coast that have both the earthquake hazard from the Cascadia Subduction Zone and impending tsunami, both a local tsunami and distant tsunamis as we see that they had to deal with after the Tohoku earthquake.

So as you invest in your infrastructure and your built environment based on good earthquake research and tsunami research, where are the areas that are in the inundation zones, where are your building codes and where is your land-use decision making, as you build up that infrastructure in the built infrastructure, what you really need to shift your work on and that we are realizing is, as Mr. Mullen said earlier, is on the outreach and the education because the demographics of our communities aren't that everyone is there, that they have seen everything that has happened, that their grandparents live in the same community that they live in

and that this kind of a level of awareness is ingrained in the communities. So yes, you would invest less in your infrastructure and you would begin to invest more in continuing that education and outreach so that you stay resilient.

Mr. FLEISCHMANN. Thank you.

Chairman QUAYLE. Thank you, Mr. Fleischmann.

The Chair now recognizes Mr. Wu for a quick follow-up.

Mr. WU. Thank you very much, and with that request for a quick follow-up and the good example of the Full Committee's Chair, I will submit a question about codes for the record and ask the witnesses to respond.

Just a quick follow-up on the nuclear power issue. The reactors that we have at San Onofre and Diablo Canyon and I believe at Hanford are all pressure reactors and require electricity to circulate water through them, and I realize now that this is an NRC issue but there is significant contact. There is a different model for reactors, and I believe that Oregon State University has been working on this for quite some time and also a couple of other research centers, and this is a passive circulation system that doesn't require electricity, and I know that you all are not experts in this field but in terms of resiliency and the conversations about resiliency that we have had, if you all care to address this, and if not, we will forward this question on to someone else. If you would care to address this, I would assume that these smaller reactors that are very similar to the reactors that are in nuclear-powered ships and submarines, that a passive circulation system that does not require electrical power to circulate the coolants, that would be an inherently more resilient system, especially if they can be distributed in, say, five reactors rather than one highly powered, high-pressure reactor. That is the question.

Dr. HAYES. What I would like to offer is to pass the question to my counterparts at NRC and get a well-informed answer for you. Anything I would say would be strictly speculative. But I will be happy to try to help with answering the question by doing that.

Mr. WU. That is absolutely terrific, and Mr. Chairman, I think—well, I am not going to go there about Committee jurisdiction. But I find that answer very helpful. Thank you very much.

Chairman QUAYLE. Thank you.

And I want to thank the witnesses for their valuable time and testimony and the Members for their questions. The Members of the Subcommittee may have additional questions for the witnesses, and we will ask you to respond to those in writing. The record will remain open for two weeks for additional comments and statements from Members. The witnesses are excused.

Thank you all for coming. The hearing is now adjourned.

[Whereupon, at 11:12 a.m., the Subcommittee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Jack Hayes, Director, National Earthquake Hazards ReductionProgram, NIST

Questions for the Record
The Honorable Ben Quayle

House Committee on Science, Space, and Technology
Subcommittee on Technology and Innovation

Are We Prepared? Assessing Earthquake Risk Reduction in the United States

Thursday, April 7, 2011
10:00 a.m.

Questions for Dr. Hayes:

1. Looking forward, what are your thoughts on the reauthorization legislation of the National Earthquake Hazards Reduction Program being coupled with the National Windstorm Impact Reduction Program?

   Answer: The leaders of the four National Earthquake Hazards Reduction Program (NEHRP) agencies (FEMA, NIST, NSF, and USGS) believe that the suggested coupling is wise from the global leadership and direction standpoint, but the specific technical activities associated with reducing the risks associated with each hazard must be administered and performed separately.

   The NEHRP agency leaders favor coupling the two programs at the senior leadership and management level. Coupling at this level (*i.e.*, the statutory Interagency Coordinating Committee) will improve federal natural hazards leadership, communications, and management efficiency and facilitate a multi-hazards approach to developing risk reduction measures in the United States. This approach is reflected in the language of H.R. 1379 and S.646, both titled Natural Hazards Risk Reduction Act of 2011, that are now being considered. We also suggest that the language being considered for the National Windstorm Impact Reduction Program (Title II of the Act) be expanded to include storm surge, storm surge loading, and structural response to storm surge in the Program and Activities sections of the legislation.

   While the NEHRP agency leaders view overarching leadership to be sensible, the technical issues associated with research, hazard monitoring and assessment, and building code implementation are almost all distinctly different from one hazard to another (*e.g.*, wind vs. earthquake). Combining the technical activities for the different hazards would be counterproductive, and the NEHRP agency leaders strongly recommend against doing so.

2. In your opinion, what areas of directed research are the most cost-effective to pursue in reducing earthquake vulnerabilities? Are there areas of research and development that have not been focused on, but should be, to result in cost savings?

Answer: The NEHRP agency leaders believe that the nation should strive for earthquake resilience[1]. The NEHRP Strategic Plan[2] reflects this belief and outlines a structured approach for reducing our national earthquake vulnerabilities. A new National Research Council (NRC) report[3] endorses that approach and presents a 20-year roadmap for achieving the broad goals outlined in the Strategic Plan. The Strategic Plan outlines complementary, but non-overlapping, activities at each of the four NEHRP agencies that require completion to achieve the goal of national earthquake resilience.

Key areas of R&D that should be pursued include: **performance-based earthquake engineering** (PBEE), **evaluation and strengthening of older existing buildings**, and **resilient lifeline (*e.g.*, water, power supply) components and systems**. These areas are highlighted as Strategic Priorities in the Strategic Plan.

- PBEE is essential for designing buildings and other structures to specific performance levels, rather than simply focusing on life-safe prescriptive procedures. This will foster improved cost-effectiveness in construction and permit building owners to tailor their buildings to function in a desired manner.

- Improved accuracy in evaluating existing buildings and improved cost-effectiveness in strengthening seismically deficient buildings will encourage building owners to take prudent, affordable measures to make their buildings safer – it is most important to note that our older existing building stock is far more extensive than the newly constructed building stock will be for many years to come.

- Improving lifeline survivability and recoverability, which have been largely ignored in many parts of the U.S., are essential for improved community resilience, particularly to support response and recovery (both short and long term).

These three areas have been repeatedly identified by the Advisory Committee on Earthquake Hazards Reduction (ACEHR) as high priority areas for research and implementation, and they have been identified in the recently released NRC report (reference 3) as three of 18 needed major NEHRP activity areas. Importantly, all of these research areas would benefit from better monitoring of earthquake shaking through continued implementation of the USGS Advanced National Seismic System (ANSS).

In suggesting these areas that can benefit from additional emphasis (some work has already been completed or is being undertaken), it is essential to note that successful accomplishment in these research areas requires research and other activities in many other areas that are already included in the Program. For example, the national hazard assessment activities of the USGS are essential for providing accurate characterization of earthquake-induced loads

[1] The National Research Council has recently defined "a disaster-resilient nation" as "one in which its communities, through mitigation and pre-disaster preparation, develop the adaptive capacity to maintain important community functions and recover quickly when major disasters occur" (see reference 3).
[2] http://www.nehrp.gov/pdf/strategic_plan_2008.pdf
[3] *National Earthquake Resilience: Research, Implementation, and Outreach*, National Academies Press, 2011.

and deformations, and the work of FEMA in working with national standards and model building code organizations and state and local government entities is essential for getting the R&D results into the hands of users.

Questions for the Record
The Honorable David Wu

House Committee on Science, Space, and Technology
Subcommittee on Technology and Innovation

Are We Prepared? Assessing Earthquake Risk Reduction in the United States

Thursday, April 7, 2011
10:00 a.m.

Questions for Dr. Hayes:

1. As you know, strong and modern building codes are often cited as the most effective tool for limiting the impact of an earthquake. How do model building codes in the U.S. compare to building codes in Chile, Haiti, Japan, and New Zealand and what lessons can we learn, or have we learned, about the design of resilient structures from the recent earthquake in these countries?

   Answer: First, some brief background information is appropriate:

   - *Haiti earthquake: 12 January 2010, magnitude 7.0 (M7.0).* Haiti had no building code and very little awareness of earthquake hazard. The result was 227,000 people killed; 300,000 injured; 1.3 million displaced; over 97,000 houses destroyed; and over 188,000 homes damaged.[4] Many of the major buildings that survived the earthquake were owned, designed, and constructed by foreign interests[5].

   - *Chile earthquake, 27 February 2010, M8.8.* Chile is a modern country with capable engineers and seismologists who are aware of the country's seismic hazard and history of numerous large earthquakes. The number of confirmed deaths is slightly over 500[6]; many of these were caused by drowning in the tsunami that accompanied the earthquake. The earthquake ground shaking, ground failure, and tsunami caused damage to buildings, highways, bridges, railroads, ports, airports and other facilities and systems. Estimates of economic damage are around $30 billion[7].

     There is no doubt that losses would have been much greater if Chile had not been prepared for the earthquake. Chile has building codes and standards to improve life safety in earthquakes. Many of the Chilean building code elements are adapted from standards used in the United States. Many of the buildings and infrastructure elements

[4] Casualty and damage estimates from USGS National Earthquake Information Center: http://earthquake.usgs.gov/earthquakes/eqinthenews/2010/us2010rja6/#summary .
[5] http://www.eeri.org/site/images/eeri_newsletter/2010_pdf/Haiti_Rpt_2.pdf .
[6] http://earthquake.usgs.gov/earthquakes/eqinthenews/2010/us2010tfan/#summary .
[7] http://www.nbr.co.nz/article/chile-quake-death-toll-hits-700-losses-could-reach-us30bn-119393 .

designed and constructed according to these standards performed well in the earthquake. In other cases, observed performance was less satisfactory, suggesting there may be shortcomings in the available standards and programs for earthquake risk reduction.

- *New Zealand earthquakes, 3 September 2010, M7.0, and 21 February 2011, M6.1.* The first earthquake occurred 30 miles west of Christchurch, seriously injuring two people, and causing widespread but not severe damage. The second earthquake was almost a "direct hit" on Christchurch, occurring 3 miles from the city center. It caused over 170 deaths, injured 1,500, destroyed or heavily damaged about 100,000 buildings, and severely disrupted all lifelines (*e.g.*, water, sewer, power), resulting in at least $12 billion in damages[8,9]. Like Chile, New Zealand is an advanced country with modern building codes, similar to those in the U.S., and with active earthquake risk mitigation programs. It is clear that the earthquake caused very high shaking levels in the central business district of Canterbury, levels that exceeded those expected every 500 years, despite the fact that the earthquake itself was of moderate size. One cause of the extensive damage may be that the hazard assessments on which the building codes are based did not identify active geologic faults near the city. It is also clear that soil liquefaction (ground failure) was a major contributor to the total amount of damage that occurred. Assessment of the 2011 earthquake is still underway. In the meantime, projections by some New Zealand authorities are that Christchurch will take twenty years to recover[10].

- *Japan earthquake and tsunami, 11 March 2011, M9.0.* Japan is the most advanced country in the world with respect to earthquake preparedness, the application of modern earthquake engineering and design concepts in construction, and resources spent on earthquake monitoring and earthquake engineering research. Japan is still in the disaster recovery phase, but preliminary reports assert that the damage from earthquake shaking was not severe and about as expected. All evidence to date indicates that the majority of the damage is from the effects of the unexpected height and run-up area of the tsunami and not from ground shaking. The tsunami water levels at the Fukushima nuclear power plants were over 40 feet above sea level; this flooded the cooling water power systems and their emergency backups. Survey teams, including some from the U.S., are beginning to visit the damaged area to conduct detailed studies on how buildings and other structures performed. To date human losses are estimated to be over 14,000 killed, with a like number still missing. Reconstruction costs are estimated to be as high as $600 billion[11].

  The Japanese building codes, which are in general comparable to U.S. codes and standards, seem to have performed very well in terms of accommodating the ground motions. The tsunami effects are not considered to be something that can be generally accommodated in actual building construction. Japan relied primarily on a

[8] http://www.community.net.nz/communitycentre/news/national/chchrebuild.htm .
[9] http://www.foxbusiness.com/industries/2011/03/02/swiss-sees-industry-loss-christchurch-quake-12-billion/ .
[10] http://www.nytimes.com/2011/04/27/world/asia/27briefs-christchurch.html?_r=1&ref=earthquakes .
[11] http://www.nytimes.com/2011/04/28/business/global/28yen.html?scp=4&sq=japan&st=cse .

system of tsunami sea walls for tsunami protection, and the magnitude of the earthquake and resulting tsunami overwhelmed those defenses.

The first noteworthy lesson to be drawn from the 2010 and 2011 earthquakes is that ***high quality, enforced building codes and standards clearly improve life safety***. The tragic loss of life in Haiti contrasts with lesser (still tragic) numbers of dead in Chile, New Zealand, and Japan (when we consider deaths due to ground shaking). While not specifically true for each and every building code provision, the building codes in Chile, New Zealand, and Japan are not entirely different from the national model building codes in the U.S. However, it must be pointed out that the U.S. has a system that requires state and local adoption and enforcement of model building codes that are developed on a national scale by the private sector. By contrast, in Japan, building code requirements are enforced on a national basis. The NEHRP agencies work with U.S. national model codes and standards organizations to provide best practices documents. Many state and local jurisdictions in the U.S. have not adopted the latest earthquake-resistant building code provisions.

The second lesson seen by the NEHRP agencies is that ***even the most advanced model building codes and standards still have limitations***, so that ***much remains to be learned***. Unfortunately, actual earthquake experience, especially in advanced countries, is still the best earthquake engineering research "laboratory." In Chile, despite modern building codes that closely parallel those in the U.S., some buildings failed. The NEHRP agencies are studying those issues now. In New Zealand, soil liquefaction was a serious problem that overwhelmed what in some cases may have been good building structural systems and were certainly solidly functioning lifeline systems; it is noteworthy that liquefiable soil conditions are significant problems throughout the mid-Mississippi valley region that is associated with the New Madrid Seismic Zone. Also in New Zealand, field surveys show that many older masonry buildings had been strengthened using various techniques. Some of those methods worked but others did not – the earthquake promises to deliver significant lessons in strengthening techniques that can be applied across the U.S., but particularly in the Central and Eastern U.S. In Japan, the fault segment that ruptured caused much greater displacement of the sea floor than scientists in Japan anticipated, leading to a much larger than expected tsunami.

Questions for the Record
The Honorable Randy Neugebauer

House Committee on Science, Space, and Technology
Subcommittee on Technology and Innovation

Are We Prepared? Assessing Earthquake Risk Reduction in the United States

Thursday, April 7, 2011
10:00 a.m.

Questions for Dr. Hayes:

1. How does the National Earthquake Hazards Reduction Program coordinate with the Nuclear Regulatory Commission and related agencies, and how confident are you in the earthquake risk management operations undertaken at nuclear facilities in the United States?

   Answer: The Nuclear Regulatory Commission (NRC) is not a statutory participant in the National Earthquake Hazard Reduction Program (NEHRP); however, the NEHRP agencies work closely with NRC on many issues related to the seismic safety of nuclear power plants and the stowage of nuclear waste. For example, NRC uses the results of NEHRP (USGS) seismic hazard assessments and earthquake monitoring in reviewing the safety of power plants. Where NRC requires specific information or studies of particular problems, they often engage NEHRP agencies to perform the work. In the 1990's, the NRC and the USGS worked cooperatively to improve seismic monitoring in the eastern United States.

   The NEHRP agencies acknowledge and appreciate the solid work performed by NRC to form new regulations and approaches to design for nuclear facilities to mitigate seismic risk. Outcomes from NRC work that can be applied to the more general building and lifeline infrastructure in the United States are acknowledged for potential use in the NEHRP mission. This is particularly true in the field of seismic hazard assessment and mapping – USGS works very closely with NRC in this area. By coincidence, for example, on the day of the March 11 Great Tohoku (Honshu, Japan) earthquake, an NRC research engineer gave a presentation on NRC's earthquake work to the Advisory Committee on Earthquake Hazards Reduction (ACEHR). NEHRP intends to maintain open coordination and communication with NRC.

   Nuclear power plants are designed and constructed to more stringent seismic safety standards than those normally used for structures that do not handle radioactive fuels and materials, so it is outside the collective expertise of the NEHRP agencies to assess NRC earthquake risk management activities. NRC is closely monitoring the events that have unfolded in Japan and assessing any possible implications those events may hold for the U.S.

Questions for the Record
The Honorable Chip Cravaack

House Committee on Science, Space, and Technology
Subcommittee on Technology and Innovation

Are We Prepared? Assessing Earthquake Risk Reduction in the United States

Thursday, April 7, 2011
10:00 a.m.

Questions for Dr. Hayes:

1. The United States is in the middle of a fiscal crisis. In the coming months, Congress is going to have to make some very hard decisions about the priorities of this nation. Why should Congress consider the National Earthquake Hazards Reduction Program (NEHRP) a priority and what are some recent accomplishments of this agency that justifies the millions of dollars that Congress has invested in this program?

   Answer: Consider the following capstone NEHRP achievements that have evolved over the life of the Program and continue to evolve with time – they would not have occurred without NEHRP:

   - ***The single most significant achievement has been the development and continuous improvement of recommended provisions for the nation's model building codes and standards.*** This is a very important and practical benefit. The *NEHRP Recommended Provisions for New Buildings and Other Structures*, a volume which is developed and periodically updated by FEMA with assistance from the other NEHRP agencies and the Building Seismic Safety Council, forms the basis of standards issued by the American Society of Civil Engineers (ASCE), which then are adopted in national model building codes issued by the International Code Council. Ultimately, these standards and model codes are adopted and enforced by state and local governments nationwide and are incorporated into industry practices throughout the U.S. and the world. In addition to the NEHRP contributions to design provisions for new buildings, NEHRP has provided the basis for the provisions for evaluating and strengthening existing buildings that are also promulgated by ASCE.

   - ***NEHRP-supported advances in earthquake process characterization; earthquake hazard and risk assessment; seismic instrumentation, monitoring, and data analysis; and rapid notification of earthquake events and their potential effects have been nothing short of revolutionary.*** NEHRP products show the distribution and severity of ground shaking; estimate losses and fatalities for all major earthquakes nationally and worldwide within a few minutes; and provide the latest knowledge on earthquake hazard

and risk for use by the engineering community in its application of the nation's model building codes and standards. This information is used by emergency response managers, infrastructure operators, government officials, and the general public. NEHRP is getting closer to being capable of providing early warning in properly instrumented areas; such warning can provide precious seconds to take mitigating steps in processes that are very sensitive to earthquake activity.

- ***The NEHRP agencies, principally NSF and USGS, have supported the development of new generations of scientists and engineers via providing grants and contracts that have supported cutting-edge research at academic institutions across the U.S.*** While the NEHRP-related projects covered by these grants and contracts have also advanced the state of earthquake science and engineering, to great national benefit, they have provided the resources needed to "grow" future generations of leading earthquake professionals across the U.S.

- ***The NEHRP agencies, again principally NSF and USGS, have been responsible for establishing and maintaining many of the nation's advanced earthquake data collection and research facilities.*** The George E. Brown, Jr, Network for Earthquake Engineering Simulation (NEES) forms a national infrastructure for testing geotechnical, structural and nonstructural systems, and for permanently housing the data from that testing in forms easily available to all via the Internet. When completed, the Advanced National Seismic System (ANSS) will provide a comprehensive nationwide system for monitoring seismicity and collecting data on earthquake shaking on the ground and in structures. NEHRP has also participated in developing the Global Seismographic Network (GSN) to provide data on earthquake events worldwide.

While the NEHRP capstone accomplishments presented above stand out, it is also worthwhile to consider how our national treatment of the earthquake hazard has changed so significantly during the life of the Program. Most of these changes occurred almost solely because of NEHRP.

Consider the past: Before the early 1970's ("pre-NEHRP"), most of the U.S. population was either oblivious to or in denial of the earthquake hazard. School children were not trained on what to do if an earthquake struck. There was no support for state and local level earthquake response exercises. In many states, the officials in charge of emergency management and surveys of geological hazards had never met. There were at least three model building codes applied nationally, with rudimentary seismic provisions. These provisions were founded, in part, on seismic hazard maps that consisted of six broad zones, with some zonal boundaries simply following state lines. If an earthquake occurred within the United States it could be many hours, or even days, before any official announcement was made, and this would only give the location and magnitude. Earthquake-resistant design and engineering concepts were based on the observations and theoretical work of a small cadre of gifted and dedicated engineers. The ground motion input functions for their designs were based on a handful of "strong-motion" records that had been printed by primitive analog instruments on photographic paper.

Today, earthquake response drills are regularly conducted in areas of moderate to high seismic hazard. School children are trained to get under their desks to avoid falling debris (and tell their parents about what to do – *drop, cover, and hold on*). Federal, state, and local officials exercise their earthquake emergency response procedures and responsibilities. Private companies, hospitals, public utilities, financial institutions, and all levels of society participate in these drills – on April 28, 2011, about 3 million individuals participated in the "Great Central U.S. Shakeout." NEHRP has played a key role in raising public awareness of earthquake risks in the U.S. and the need to mitigate those risks. Earthquake notifications are provided by NEHRP in a matter of minutes, not hours, with earthquake monitoring on a 24/7 basis in a National Earthquake Information Center (NEIC) that reports vital earthquake magnitude, location, and possible damage information. The reports are used by emergency managers at all levels of government to immediately understand the scope of the problem facing them. They are also used by infrastructure management officials to determine which facility, bridge, or overpass to inspect first. The strong shaking from the earthquake is recorded digitally on modern instruments that do not go off-scale in the same manner that older instruments did. Earthquake engineering faculties at dozens of universities use these data to develop new concepts in earthquake-resistant design. These concepts can be tested on massive equipment designed to replicate earthquake conditions. Engineers do not have to wait for the next earthquake to test their ideas. Worthy concepts are further developed into practical design and construction for incorporation into the seismic safety elements of model building codes. There is a single model building code for seismic safety used in the United States whose seismic provisions are largely based on the periodically updated *NEHRP Recommended Seismic Provisions for Buildings and Other Structures*[12]. This code is revised periodically to benefit from advanced developments. The codes are based on a comprehensive, national seismic hazard model that is reviewed and revised in conjunction with the code development cycle. Progress is being made in performance-based-design that not only protects the inhabitants of a building (the goal and limit of most code provisions) but also ensures that the building can be used for its intended function immediately after an earthquake. States in areas of moderate to high seismic hazard have programs to promote earthquake damage mitigation practices. Most of these programs focus on homeowners and operators of small businesses.

When the significant contributions of NEHRP presented above are considered, our nation's current fiscal challenges are precisely why NEHRP is needed. With our fragile economy, the nation simply cannot afford earthquake losses on the scales recently seen in other advanced countries that have comparable building codes and other mitigation and preparation efforts. Large earthquakes are inevitable in the U.S., but with adequate preparation afforded by the many tools provided by NEHRP, earthquake disasters are not. NEHRP provides the U.S. with the tools needed to minimize national costs from losses in future U.S. earthquakes at a relatively modest national cost. The annual combined budgets of the four NEHRP agencies (approximately $125 million) are less than 0.1% of the direct losses experienced in the recent Japan earthquake[13].

[12] This document is produced regularly by FEMA in close cooperation with leading practitioners and researchers via the Building Seismic Safety Council and contains information developed through the efforts of all four NEHRP agencies.
[13] See reference 12.

In the past 16 months, earthquakes in Haiti, Chile, New Zealand, and Japan have killed over 250,000 people and caused hundreds of billions of dollars in losses, with economic impacts extending internationally. It will be a generation before the affected areas of these countries recover normalcy. Estimates of the recent losses in Japan are already at $600 billion[14] in direct losses[15], and some experts postulate that the total of both direct and indirect losses will likely make the March earthquake the world's first "trillion dollar disaster." The recent earthquakes that have occurred internationally provide insights into similar events that can occur in the U.S. The seismological conditions that led to the Chile and Japan earthquakes (and tsunamis) are very much like those off the coasts of the Pacific Northwest and Alaska (and similar earthquakes have occurred in both locations). The geotechnical conditions that led to the significant damage in New Zealand, as well as the characteristics of general building stock there, are quite similar to what is found in the Central U.S. and other locations here. The NEHRP agencies cannot guarantee "zero losses" in future U.S. earthquakes, but past experience suggests that proper application of the tools provided by NEHRP efforts can greatly reduce losses.

Finally, the activities that are performed or supported by the NEHRP agencies simply cannot be duplicated by others. First, much of what NEHRP accomplishes as a Federal activity enables earthquake resilience across multiple state and local boundaries. Second, state and local governments do not have the resources to duplicate NEHRP's activities by pooling their individual budgets. Third, the U.S. construction industry is not a monolith of large private sector entities but is instead primarily a diverse collection of small companies that simply do not have the resources to perform their own R&D. The same can be said of private risk assessment firms; they rely heavily on data and basic studies conducted by NEHRP agencies.

2. Looking forward, I expect all federal agencies to do more with less. This is simply the fiscal reality. Can all of you talk about ways that NEHRP can be reformed so it can work more efficiently and still accomplish its core mission?

Answer: From an organizational standpoint, NEHRP is a solid, well-functioning inter-agency program. Most outside observers, such as the Advisory Committee on Earthquake Hazards Reduction (ACEHR) that was created by PL 108-360, strongly believe NEHRP has achieved concrete, effective coordination and cooperation. The Interagency Coordinating Committee (ICC) that was also created by PL 108-360 brings the leaders of FEMA, NIST, NSF, and USGS together with the leaders of OMB and OSTP to form a senior leadership body that ensures the agencies are working together effectively and efficiently, without duplication of effort.

The ICC overview ensures that there is no duplication or wasteful competition between NEHRP agencies in carrying out their roles. Each agency's role in NEHRP is consistent with its core mission and budget. Agency roles are clear-cut and distinct, allowing the agencies to be mutually supportive in ensuring that the Program achieves its overall goals. NSF supports

[14] See reference 12.
[15] See reference 12.

relevant, basic research in engineering and in the earth and social sciences. The USGS carries out earthquake hazards assessments for building codes, monitoring and notification of seismic activity, and targeted research in these areas. NIST serves as lead agency and develops and tests earthquake-resistant design and construction practices for use in building codes. FEMA promotes the implementation of earthquake safety tools and policies, focusing on the development of earthquake resistant building codes and practices. The "wiring diagram" figure that accompanied my written testimony graphically portrays how the NEHRP agencies work together without duplication of capability or effort.

The ICC and ACEHR also provide the overarching perspective that supports continuous Program reassessment focused on efficiency and mission accomplishment. The ICC provides the global senior leadership for this process, and the ACEHR provides annual outside expert assessment of the Program's effectiveness. In addition, the NEHRP agencies reach out to third party experts to provide insight on Program planning for the future. The agencies often utilize expert knowledge from individual earthquake professionals and professional organizations outside the Federal Government to provide insights on future Program activities. For example, the Building Seismic Safety Council provided the NEHRP agencies with a comprehensive report in 2009 on the *Research Required to Support Full Implementation of Performance-Based Seismic Design* (NIST GCR 09-917-2). More significantly, the National Research Council (NRC) just released its recommended future roadmap for earthquake risk mitigation-related activities in the U.S. in its report *National Earthquake Resilience: Research, Implementation, and Outreach* (National Academies Press, 2011).

Finally, the ICC members fully appreciate the implications of the current Federal budget climate. The four agency combined NEHRP budget has not grown in recent years – the 2005 enacted budget was about $127 million, and the President's requested budget for 2012 is about $122 million. Budgets in the intervening years have varied only slightly. The budget requested by the Administration for 2012 is fiscally prudent in the current budget climate and funds the highest priority activities for advancing earthquake resilience. The goal of earthquake resilience must be considered in the context of other national priorities, but this investment is essential to provide public safety in vulnerable regions of our nation. The Administration continuously re-evaluates its investment and priorities in this area.

3. I know that all of us are concerned about the recent events in Japan and want to do everything possible to assist the Japanese people. What role has NEHRP played in assisting the Japanese government and more broadly, how would you describe NEHRP's relations with other foreign governments?

Answer: It is beyond the statutory scope of NEHRP to provide substantial assistance to another country following a major foreign earthquake, but the NEHRP agencies routinely work with the U.S. Agency for International Development's Office of Foreign Disaster Assistance to support training, hazard assessment, earthquake monitoring and other activities. NEHRP has offered assistance to Japan in assessing the causes and effects of the recent earthquake and tsunami, and NEHRP-supported scientists and engineers have been working

closely with their Japanese colleagues to learn from this event. NEHRP continues to hold intra-government conference calls in order to coordinate and manage U.S. response.

Because Japan is an advanced country, lessons learned in Japan may have direct application in the United States. It has been difficult to get NEHRP personnel into Japan because of possible interference with the ongoing response and recovery efforts and the uncertainty regarding the nuclear crisis at the Fukushima nuclear facility, but this is now slowly changing. As of this writing, growing numbers of individuals have been able to visit the impacted area, and larger teams are being formed in cooperation with NEHRP's Japanese counterparts.

NEHRP's formal coordination with Japan is accomplished in two broad mechanisms. First, under the aegis of the U.S.-Japan Cooperative Program in Natural Resources (UJNR), two bilateral panels exist: *Earthquake Research* and *Wind and Seismic Effects*. These panels meet annually to share research and practical results and to plan and coordinate joint experiments and investigations. These panels have been in place for about thirty years and, in our view, have been very effective and worthwhile. NEHRP has been in almost constant contact with its Japanese counterparts since the March 2011 earthquake, and tentative plans are now being made for at least one joint reconnaissance effort. Second, in support of basic and applied engineering research goals, NEHRP, via NSF, has a strong cooperative agreement with Japan on the use of earthquake engineering research facilities and performance of cooperative experiments. This agreement leverages the capabilities of the U.S. George E. Brown, Jr. *Network for Earthquake Engineering Simulation* (NEES) with those of the Japan *E-Defense* facility (the world's largest earthquake shaking table). The NEES partnership of 14 world class U.S. earthquake engineering research laboratories with *E-Defense* provides leveraging on an unprecedented scale for NEHRP.

One of the unique aspects of the world earthquake professional community is that, regardless of their nationality, earthquake professionals share a sense of common purpose in preventing lost lives and injuries. Cooperation normally comes easily, with or without formal arrangements.

In addition to Japan, the NEHRP agencies have formal agreements with the People's Republic of China in earthquake research and engineering. And, during the past 16 months, NEHRP agencies have had representatives in Haiti, Chile, and New Zealand, offering assistance and studying the effects of the recent damaging earthquakes. As previously mentioned, similar engagements in Japan are pending. Within the Global Seismic Network there are about 60 agreements with other countries for the joint operation of seismic stations and for the collection and sharing of seismic data. Representatives of NEHRP agencies regularly attend international meetings that focus on earthquake hazard assessments and earthquake engineering research and practices. Often NEHRP representatives work, as needed, through the standing international agreements of their home agency. NEHRP engages the international earthquake community as needed following an event but otherwise on a relatively informal basis.

4. Can you speak about the interactions the NEHRP has with local governments? What types of information does NEHRP share with local entities and how is that information communicated?

Answer: The most effective way in which NEHRP supports local communities is in the development of national model building codes. Local communities do not have the technical and financial resources to develop their own building codes; they rely on adopting relevant sections of a model code. The most common model code used in the United States today is the *International Building Code* (IBC) developed by the International Code Council (ICC). The seismic provisions of this model code primarily reference the American Society of Civil Engineers (ASCE) national standard *Minimum Design Loads for Buildings and Other Structures* (ASCE 7) which in turn is based almost wholly on FEMA's *NEHRP Recommended Seismic Provisions for New Buildings and Other Structures* (FEMA P-750).

NEHRP, through FEMA, maintains an Earthquake State Assistance Program which supports a dedicated State Earthquake Program and the achievement of measurable improvements in earthquake mitigation activities at the State and local levels. This program supports developing mitigation plans; preparing inventories and conducting seismic safety inspections of critical structures and lifelines; updating building codes, zoning codes, and ordinances to enhance seismic safety; and increasing earthquake awareness and education.

Additionally, FEMA provides direct training and technical assistance to local communities via the National Earthquake Technical Assistance Program. This program ensures that local knowledge capacity on earthquake risk reduction is strengthened and directly supports the effective delivery of NEHRP guidance and standards.

NEHRP supports regional seismic safety consortia that work to coordinate and implement seismic safety policies at the state and local level. These consortia include the Western States Seismic Policy Council (WSSPC), the Central U. S. Earthquake Consortium (CUSEC), the Northeast States Emergency Consortium (NESEC), and the Cascadia Region Earthquake Working Group (CREW).

FEMA's *QuakeSmart* project is used to inform local businesses of earthquake vulnerabilities and recommend steps that can be taken to reduce business losses following an earthquake.

During the past several years NEHRP has cooperated with state and local interests in the *Great California Shakeout*, an annual, multi-day event focusing on earthquake awareness and earthquake response drills. In 2010, 7.9 million Californians participated in *Shakeout* activities. The shakeout model has been adopted by groups in Nevada, the Pacific Northwest, the Midwest, and Utah. The *Central US Shakeout* was held on April 28, 2011 and had over 3 million registered participants.

NEHRP agencies have worked with local officials to develop detailed seismic hazard assessments in Seattle, Washington; Evansville, Indiana; Shelby County (Memphis), Tennessee; and Oakland, California.

Finally, NEHRP has worked with local interests in publishing a handbook that describes earthquake hazards to homeowners and gives explicit directions on what they can to make their homes safer and less vulnerable to earthquake damage. This document, *Putting Down Roots in Earthquake Country,* has been published in region specific editions for California, Utah, Idaho, Alaska, and the Central U.S. It has been published in Spanish, Chinese, and other languages. Shortened versions are widely distributed as newspaper inserts. NEHRP has worked with the American Red Cross and local interests in this effort.

Responses by Jim Mullen, President of the National Emergency Management Association (NEMA)

Questions submitted by Representative Ben Quayle

Q1. In your opinion, what areas of directed research are the most cost effective to pursue in reducing earthquake vulnerabilities? Are there areas of research and development that have not been focused on, but should be, to result in cost savings?

A1. As emergency managers, we benefit greatly from the research produced by groups such as those funded by NEHRP. Reference publications are published based on NEHRP research and utilized by states to provide practical information and guidance for earthquake mitigation. Some recent examples which have been of assistance to states include Techniques for Seismic Rehabilitation of Existing Building (FEMA 547) and Seismic Considerations for Steel Storage Racks Located in Areas Accessible to the Public (FEMA 460). These documents are made available to public, private, and non-governmental organizations to provide specific information earthquake design and mitigation. The documents are distributed whenever the state conducts training on earthquake mitigation.

NEHRP participation in post-earthquake building and infrastructure investigations, like those conducted for the recent Japan, New Zealand, Chile, and Haiti earthquakes, provide valuable information on the performance of facilities in earthquakes. The findings from these investigations are used to inform U.S.building code revisions, building practices, and earthquake mitigation procedures.

Questions submitted by Representative Randy Neugebauer

Q1. What do you see as the United States' greatest flaw in its current earthquake hazard reduction strategies, and what can be done to address that? How much would improving the strategy rely on additional federal funding?

A1. The greatest flaw in the current earthquake reduction strategy is a lack of integrated hazard reduction measures across the suite of FEMA programs and divisions. By implementing hazard reduction programs within a single division, FEMA has not leveraged the unique work done in the other parts of the agency in order to build capabilities for earthquake mitigation, preparedness, response, and recovery.

NEHRP activities carried out by FEMA are housed within the Mitigation Directorate but should also incorporate preparedness, response, and recovery aspects as well-which would help approach hazard reduction in a holistic way. Better integration of earthquake hazard reduction programs into the other areas of the agency would leverage the resources already at their disposal, allowing the agency to accomplish more with limited funds.

When programs operate independently of one another, efforts may be duplicated which wastes precious federal, state, and local money. In addition, risk reduction measures can often be implemented with many different types of hazards in mind. By understanding the connection between a bridge built to withstand an earthquake, and a bridge built to withstand a bomb blast, limited mitigation and preparedness dollars can be spent efficiently and effectively.

In 2009, NEMA wrote a white paper with numerous other stakeholders, including FEMA, and the paper articulated suggestions for necessary elements of a mitigation strategy. "If the discussion of mitigation of future loss was embedded in a wider variety or policy and public choice discussions, then decisions that inadvertently increase risk would either be avoided or, at least, acknowledged in an open and transparent dialogue. (For example, an opportunity would have been a requirement to include hazard mitigation measures, or at least their consideration, in the project guidance for the Infrastructure Investment Act of 2009)."

Questions submitted by Representative Chip Cravaack

Q1. The United States is in the middle of a financial crisis. In the coming months, Congress is going to have to make some very hard decisions about the priorities of this nation. Why should Congress consider the National Earthquake Hazards Reduction Program a priority and what are some recent accomplishments of this agency that justifies the millions of dollars that Congress has invested in this program?

A1. By funding the National Earthquake Hazard Reduction Program (NEHRP), Congress has the opportunity to invest in the safety and security of vulnerable communities. NEHRP has provided the resources and leadership leading to significant advances in understanding the risk earthquakes pose and the best ways to counter them. Through NEHRP, the federal government has engaged in seismic monitoring, mapping, research, testing, engineering and related reference materials for code development, mitigation, and emergency preparedness. NEHRP has served as the backbone for protecting U.S. citizens, their property, and the national economy from the devastating effects of large earthquakes. Although NEHRP is well known for research programs, it is also the source for hundreds of new technologies, maps, design techniques, and standards that are used by design professionals every day to mitigate risks and save lives, protect property, and reduce adverse economic impacts.

Each state approaches public outreach and education campaigns differently, relying on proven techniques which communicate best with their constituents. The State of Alaska, for example, has benefited from NEHRP and the corresponding NETAP (National Earthquake Technical Assistance Program) in the following ways:

- NEHERP state assistance is currently being used to develop and install earthquake safety education kiosks in three communities where there were fatalities in the 1964 Great Alaskan Earthquake. The kiosks will present 1964 survivor interviews, earthquake science information and safety instruction. These kiosks target residents and the large tourist populations which visit the State every year and include practical life saving information on earthquakes.
- NETAP provided qualified instructors for the hospital seismic mitigation course that was attended by facility leaders from both the private non-profit and for-profit hospitals in the South-central Alaska area.
- NEHERP assistance to state's program provided funding to complete an active earthquake fault database for the State which coordinates with the USGS fault database and provides fault location information for builders and infrastructure planners as well as the general public.

In Washington State, NEHRP funding has been instrumental in the conduct of a pilot project to assess seismic vulnerability of school buildings in two local jurisdictions which may prompt more widespread attention by school districts across the state, using the methodology in the pilot. NEHRP funds are also being used to assess critical interdependencies as part of the Resilient Washington initiative.

As mentioned before, each state approaches earthquake risk reduction in a unique way, and the NEHRP website contains many success stories to illustrate their work.

Q2. Looking forward, I expect all federal agencies to do more with less. This is simply the fiscal reality. Can all of you talk about ways that NEHRP can be reformed so it can work more efficiently and still accomplish its core mission?

A2. NEHRP activities carried out by FEMA are housed within the Mitigation Directorate ofthe agency but should also incorporate preparedness, response, and recovery aspects as well which would help approach hazard reduction holistically. Better integration of earthquake hazard reduction programs into the other areas of the agency would leverage the resources already at their disposal allowing the agency to do more with their limited funds. This integration already occurs at the state and local levels where earthquake programs and initiatives are coordinated across division lines often incorporating multiple areas of the agency to fully accomplish mission assignments.

When programs operate independently of each other, efforts can be duplicated, wasting precious federal, state, and local money. In addition, risk reduction measures can often be implemented with many different types of hazards in mind. By understanding the connection between a bridge built to withstand an earthquake, and a bridge built to withstand a bomb blast, limited mitigation and preparedness dollars can be spent efficiently and effectively.

In 2009, NEMA wrote a white paper with numerous other stakeholders, including FEMA, and the paper articulated suggestions for necessary elements of a mitigation strategy. "If the discussion of mitigation of future loss was embedded in a wider variety or policy and public choice discussions, then decisions that inadvertently increase risk would either be avoided or, at least, acknowledged in an open and transparent dialogue. (For example, on opportunity would have been a requirement to include hazard mitigation measures, or at least their consideration, in the project guidance for the Infrastructure Investment Act of 2009)." By embedding mitigation

across the spectrum of disaster related activities, duplication of effort and funding can be avoided.

Q3. Can you speak to the interactions that NEHRP has with local governments? What types ofinformation does NEHRP share with local entities and how is this information communicated?

A3. NEMA specifically represents the state emergency management directors of all 50 states, Territories, and the District of Columbia. Therefore, while NEMA works closely with our local counterparts, it would be imprudent for us to comment specifically on the relationship between NEHRP and local governments.

Q4. There is a great deal of expense that the federal government must endure when a natural disaster such as an earthquake occurs. Can you discuss the costs and benefits of hazard mitigation spending?

A4. To quantify the effectiveness of mitigation projects, Congress commissioned two studies. One study, conducted by the National Institute of Building Sciences in 2005, reported for every $1 spent on various mitigation activities, $4 in response and recovery costs are saved.

In September 2007, the Congressional Budget Office evaluated the Predisaster Mitigation Grant Program (PDM) in a report titled "Potential Cost Savings from the Pre-Disaster Mitigation Program." In the report, compiled disaster data suggests that for every $1 spent on mitigation projects, losses from future disasters are reduced by $3. As the years pass, the return on investment grows since development in risky locations continues. While comprehensive studies remain valuable and very effective in accurately analyzing facts and figures, the success of mitigation projects are often best seen in pictures of property improvements, and in personal stories of community survival. NEMA has worked with States to compile success stories of mitigation projects completed to address many different types of hazards, from flooding to ice storms and these examples exist in every state and their benefits can be seen after each disaster.

The value placed on hazard mitigation projects differ from state to state, and are certainly considered more vital in areas of the country where disaster relief dominates state and local spending; but the understanding that prevention is more effective and responsible than reacting after a catastrophic event is universal. To realize cost saving as budgets become more constrained contributing to mitigation grant programs are wise investments for state and local officials.

Although natural disasters receive the most news coverage when they create the significant damage, successful mitigation projects by definition create non-events. The value of mitigation funds are judged by what does not happen, rather than what did. While comprehensive estimated cost-benefit examples are important figures to consider when deciding the relevance and effectiveness of mitigation programs, more telling are the dramatic real life stories of mitigation projects fulfilling their purpose and truly changing how States and localities are affected by disaster.

Responses by Mr. Chris Poland Chris Poland, Chairman and Chief Executive Officer, Degenkolb Engineers and Chairman, NEHRP Advisory Committee

Questions submitted by Representative Ben Quayle

Q1. Looking forward, what are your thoughts on the reauthorization legislation of the National Earthquake Hazard Reduction Program being coupled with the National Windstorm Impact Reduction Program.

A1. I support reauthorization legislation that couples NEHRP with NWIRP as was done during the last session in HR 3820. While the technical issues related to mitigating the effect of earthquakes and wind are quite different, the programs needed to define pre-event mitigation, response and recovery activities are quite similar. The two programs will benefit from independent advisory committees of professionals expert in the respective hazards. At the same time, oversight of both programs by a common Interagency Coordinating Committee is needed to avoid duplication and the development of inconsistent practices. Both programs need to carry sufficient authorization levels to carry out their activities at a much faster pace than currently funded.

Q2. In your opinion, what areas of directed research are the most cost effective to pursue in reducing earthquake vulnerabilities. Are there areas of research and development that have not been focused on, but should be, to result in cost savings?

A2. The NEHRP Strategic Plan and the recently published NRC Report outline the work that needs to be done. Among those recommendations, I believe that the following three areas of directed research will be the most cost effective in the long run.

(a) Development of a set of nationally applicable performance goals for buildings and lifeline systems that support resilience at all levels. Quantification of the role of improvisation and adaptive behavior is needed to understand how badly a community can be damaged and still recover quickly enough to maintain its cultural and economic viability. That should be the basis of the minimum standards for all construction. Up to now, these performance goals have been set by engineers focused on life safety, one building at a time, and defined in a non-transparent manner. Resilience must be approach from a community basis, involve all related stakeholders and perspectives, and remain transparent throughout.

(b) Development of national design guidelines for all lifeline systems that deliver the specific and transparent performance standards established for national resilience. Damaged regions cannot begin significant recovery until transportation routes for repair crews and are open, electric power, fuel and water are available, and waste water handling systems are operational. At present there is no overarching performance standard available or even agreement on what the restoration timeframes and priorities should be.

(c) Development of affordable and enforceable standards for the rehabilitation of existing buildings and lifeline systems. Most of the research to date has focused on the development design standards for new construction. That's good, but the vast majority of the infrastructure is already in place and not due for replacement for decades. The needed systematic upgrade of the in-place construction to the resilience level will only occur when the cost is significantly reduced and enforceable, mandatory programs are developed.

Responses by Dr. Vicki McConnell, Director, Oregon Department of Geology and Mineral Industries

Questions submitted by Representative Ben Quayle

Q1. Looking forward, what are your thoughts on the reauthorization legislation of the National Earthquake Hazards Reduction Program being coupled with the National Windstorm Impact Reduction Program?

A1. I can see the applicability of including the two natural hazard reduction programs under the umbrella of one act whose mission is to reduce impacts of natural hazards. There may be overlap in certain agency charges regarding both hazards (e.g., in NIST and NSF charges) and it is possible that some of the basic research in developing tools to assess vulnerability and communicate risks may be applied to multiple hazards. I have concerns about the dilution of efforts and funding to characterize, monitor, and mitigate for very different hazards if the two acts become more entwined. We do not monitor for wind storms like we monitor for earthquakes, nor does the basic or applied research for these hazards have much in common. The benefits to hazard mitigation reduction of both programs could be impacted.

Q2. In your opinion, what areas of directed research are the most cost effective to pursue in reducing earthquake vulnerabilities. Are there areas of research and development that have not been focused on, but should be, to result in cost savings?

A2. In my opinion, basic research into understanding earthquake processes and applied research into identifying and characterizing earthquake hazards returns high value for the investment. It is critical to understand and quantify the problem before you begin designing for or mitigating to reduce vulnerability. Investment in basic research that develops models and tools to assess vulnerability and risk from multiple hazards would also assist states in implementing mitigation and local land use decision making thus helping to build resilient communities. For example, presently we cannot compare the relative risk a community faces between earthquakes, floods, volcanoes, or other natural hazards making it difficult for communities to develop reasonable response and recovery plans that are comprehensive.

Questions submitted by Representative Chip Cravaack

Q1. The United States is in the middle of a fiscal crisis. In the coming months, Congress is going to have to make some very hard decisions about the priorities of this nation. Why should Congress consider the National Earthquake Hazards Reduction Program a priority and what are some recent accomplishments of this agency that justifies the millions of dollars that Congress has invested in this program?

A1. This program should be considered a priority because the products from the four agencies that are tasked with implementing the program reduce the national vulnerability to potentially catastrophic earthquakes, and in the long run save the nation money. The program funds research into understanding the hazard (NSF and USGS), assessing the vulnerability (NSF and FEMA), monitoring (USGS), determining the risk, and developing standards and methods to reduce that risk (NIST). This targeted approach allows full consideration of how to mitigate the hazard, and through cooperation with state and local experts actually, reduces the risk. Too often federally funded programs only address one or two aspects of natural hazard risk reduction, such as only basic research, but that will not get the nation to resiliency.

I offer two examples of recent work toward earthquake risk reduction to which NEHRP funding has contributed. Both examples incorporate and study the effect of the multiple hazards that an earthquake can cause over space and time, and both examples show how coordination and cooperation spanning federal, state, and local agencies and the private sector can leverage the greatest benefit for cost of informing and educating our citizens, and building strong communities. First is the Great Southern California Shakeout earthquake drill that was first activated in 2008. Through the USGS Earthquake Hazards Program and NEHRP funding, the USGS Multi-Hazards Demonstration Project developed the most likely earthquake scenario for southern California. In cooperation with NSF, FEMA, and a host of state, local and private sector co-sponsors the scenario became the basis of full response earthquake drill. The results from such activities help identify gaps in the ability to respond and recover from a natural hazard, thus helping communities understand if they are facing a disaster or a catastrophe. The full drill is now in its third year of activity, and the concept has been expanded to the central U.S. and the Madrid Fault Zone. I refer you to the data and information-rich website if you are interested in reviewing the many publications and outreach products of this project: http://www.shakeout.org/.

In the Pacific Northwest, the USGS Earthquake Hazard Program and state and local agencies have taken a slightly different tack to accomplish similar goals of understanding and developing mitigation tools to reduce the risk of the multiple hazards posed by an earthquake in the Portland Oregon and Seattle Washington metropolitan areas. Here, scientists are using state-of-the-science high resolution lidar data to identify and locate earthquake fault scarps and landslides. That information is combined with comprehensive bedrock and surface geologic mapping to develop digital spatial maps of the potential hazard zones. Lidar data and susceptibility maps are being developed that will indicate areas in communities that are vulnerable to earthquake-induced landslides, liquefaction, and ground acceleration. Understanding the extent of the hazard, and identifying the vulnerable areas will allow for risk reduction through better land use planning, emergency response plans, and recovery strategies.

Q2. Looking forward, I expect all federal agencies to do more with less. This is simply the fiscal reality. Can all of you talk about the ways NEHRP can be reformed so it can work more efficiently and still accomplish its core mission?

A2. I commend the original concept for implementing NEHRP by incorporating the purpose and goals of the program into the already existing agencies that were conducting similar work, instead of creating yet another federal agency silo. Improvements and streamlining can always be made to increase efficiency, and certainly all four agencies should look closely at their missions and charges, and reduce or eliminate overlaps and redundancies. I refer you to the recently published National Research Council's evaluation of the NEHRP: National Earthquake Resilience: Research, Implementation and Outreach. One recommendation of the NRC committee would be "to consider that an analysis to determine whether coordination among all organizations that contribute to NEHRP could be improved would be useful and timely." http://www.nap.edu/catalog/13092.html

Q3. There is a great deal of expense that the federal government must endure when a national disaster such as an earthquake occurs. Can you discuss the costs and benefits of hazard mitigation spending?

A3. Federal Emergency Management Agency (FEMA) has researched this question in light of their charge to prepare for natural disasters, as well as respond to them. Determining the benefit-to-cost of investing in mitigation for a natural disaster such as an earthquake is complex, yet some excellent work has gone into quantifying the benefits and costs. FEMA models have been developed in conjunction with engineers, public officials, and economists, and are generally accepted on making public decisions for mitigating natural hazards. Analysis of the hazard mitigation grants awarded from 1993—2003 indicate that 1.5-to-1 benefit on average is derived from mitigation of earthquake hazards. An important factor with benefit-to-cost analysis of earthquake hazard mitigation is that such mitigation is anticipated to reduce the loss of life and injury by as much as 62%, much higher than other mitigation for other natural hazards, such as floods or wind (http://bechtel.colorado.edu/porterka/Rose-et-al-2007–NHR–BCA.pdf).

Appendix II

Additional Submitted Statements for the Record

SUBMITTED STATEMENT BY REPRESENTATIVE RANDY NEUGEBAUER, MEMBER, SUBCOMMITTEE ON TECHNOLOGY AND INNOVATION, COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY, U.S. HOUSE OF REPRESENTATIVES

Mr. Chairman, thank you for holding this full Committee hearing to examine the United State's level of preparedness for earthquakes and how we can continue to reduce the related risks. The recent earthquake off the coast of Japan has had devastating consequences for the Japanese people, economy, and environment, and it is appropriate for us to consider how prepared our nation is for a natural disaster of that magnitude.

Thank you.

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