Testimony of

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A Review of the National Earthquake Hazards Reduction Program (NEHRP)

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Introduction

Chairman Smith, Ranking Member Johnson, and Members of the Committee, my name is Dr. Steven McCabe, and I am the Director of the National Earthquake Hazards Reduction Program (NEHRP or Program), located within the Engineering Laboratory at the National Institute of Standards and Technology (NIST) in the Department of Commerce. NIST leads the four-agency NEHRP partnership, which includes the Federal Emergency Management Agency (FEMA), the National Science Foundation (NSF), and the U.S. Geological Survey (USGS). Thank you for the opportunity to appear before you today to discuss NIST's and NEHRP's role in making measurable progress towards reducing the earthquake risk facing U.S. communities.

Earthquake concerns are truly national in scope. Forty-two states and a number of territories face serious risk from earthquakes. In recent decades, the United States has experienced a relatively quiet period of major seismic activity. We have not experienced the likes of the damage caused by the 1964 Alaska earthquake, the 1971 San Fernando earthquake (a motivating factor for the creation of NEHRP), the 1989 Loma Prieta earthquake, or the 1994 Northridge earthquake. More recently, the United States has experienced significant increases in seismic activity in areas of the country not generally associated with earthquakes, including in southern Kansas and in Oklahoma, and the 2011 Mineral, Virginia, earthquake was a wakeup call for the eastern portion of the United States.[1] There are simply no areas of the Nation with zero risk from earthquakes. Furthermore, since the last major U.S. earthquakes occurred, the Nation has continued to concentrate more of its populations into urban areas, exposing higher percentages of people and structures to devastation from a single large earthquake or resulting tsunami.

Mitigation efforts, through such measures as improved building codes, can make a significant difference in saving lives, which is the primary goal of earthquake-related provisions in U.S. building codes and standards. The 2010 Haiti and Chile (Maule) earthquakes illustrated the need for and effectiveness of modern building codes and sound construction practices. In Haiti, where building codes are minimal at best, the M7.0 earthquake resulted in a death toll estimated at over 220,000. By contrast, Chile has more modern building codes, based on U.S. model building codes and standards, and the M8.8 Maule earthquake resulted in approximately 500 deaths.[2] NEHRP was created to address the reality that earthquakes are inevitable and will occur without warning, but that there is much the Nation can do to reduce their consequences.

NEHRP Organization and Background

Congress created NEHRP through the Earthquake Hazards Reduction Act of 1977 (Public Law 95-124) and the Program was last reauthorized under the National Earthquake Hazards Reduction Program Reauthorization Act of 2004 (Public Law 108-360). The NEHRP Reauthorization Act designated NIST as the NEHRP Lead Agency with primary responsibility for planning and coordinating the Program. Pending passage of new reauthorizing legislation, the NEHRP agencies continue to perform duties outlined in Public Law 108–360 within agency-established budget allocations.

[1] https://news.nationalgeographic.com/news/2014/07/140717-usgs-earthquake-maps-disaster-risk-science/.
[2] https://www.earthmagazine.org/article/chiles-quake-larger-less-destructive-haitis

The 2004 Reauthorization Act also created the Advisory Committee on Earthquake Hazards Reduction and the NEHRP Interagency Coordinating Committee, each providing important input to the Program.

The Advisory Committee on Earthquake Hazards Reduction (ACEHR) is a Federal Advisory Committee that assesses effectiveness of the program. The ACEHR consists of 15 leading earthquake professionals from across the U.S. and provides advice to the NEHRP agencies on issues concerning earthquake hazard assessment and risk mitigation.

The Interagency Coordinating Committee (ICC) is comprised of the principals of the four NEHRP agencies, plus the Director of the Office of Management and Budget and the Director of the Office of Science and Technology Policy. One major action of the ICC was to approve the NEHRP Strategic Plan.

NEHRP Strategic Plan
The Strategic Plan, required under the National Earthquake Hazards Reduction Program Reauthorization Act of 2004, presented NEHRP's vision for our Nation: *A Nation that is earthquake-resilient in public safety, economic strength, and national security.*

This vision recognizes the importance of not only improving public safety in future earthquakes but also enhancing national economic strength and security, and highlights the need for improving national resilience following future damaging earthquakes.

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

The Plan also outlines nine areas of *strategic priority* for the Program:

(1) fully implement the Advanced National Seismic System (ANSS);
(2) improve techniques for evaluating and rehabilitating existing buildings;
(3) further develop Performance-Based Seismic Design (PBSD);
(4) increase consideration of socioeconomic issues related to hazard mitigation implementation;
(5) develop a national post-earthquake information management system;
(6) develop advanced earthquake risk mitigation technologies and practices;
(7) develop guidelines for earthquake-resilient lifeline components and systems;
(8) develop and conduct earthquake scenarios for effective earthquake risk reduction and response and recovery planning; and,
(9) facilitate improved earthquake mitigation at state and local levels.

I am very pleased to report significant progress in the goals and areas of strategic priority in the Plan, notably the improvements in national seismic instrumentation, improvements in building codes and in the application of PBSD, and continued work at the state and local levels to implement mitigation efforts. However, much remains to be done especially concerning the

existing building stock, the risk mitigation of lifelines such as those supplying electricity, water and wastewater and communication services and in improving the resilience of communities to seismic events.

To continue looking to the future, ongoing work with scenarios is helping to guide future direction of the Program. USGS just released a scenario, the HayWired Scenario, on April 18, 2018, the anniversary of the 1906 San Francisco earthquake. The HayWired Scenario depicts a realistic scenario based on a M7.0 earthquake on the Hayward fault system in the San Francisco Bay Area, the estimated impacts on infrastructure, communities and individuals can be seen as significant. These USGS scenarios continue to offer NEHRP a means to evaluate current and future Program activities to meet the issues identified by these scenarios. [3]

NEHRP Agencies

The NEHRP agencies work to perform needed research and translate the research results into actions that mitigate the impact on the Nation. The NEHRP agencies work in partnership, with each agency fulfilling its unique role in the Program. NEHRP performs inherently governmental roles including: the development of national hazard models and maps; disaster investigations concerning engineering, geology, seismology and social science aspects of an earthquake; participation in the development of model building codes and associated standards; and the funding of basic research.

The Program extends beyond the four NEHRP 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 community of dedicated earthquake professionals, the NEHRP agencies could not fulfill their statutory responsibilities nearly as well.

USGS

The USGS, also testifying here today, 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.

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 supports the education of future generations of earthquake practitioners across the Nation.

FEMA

FEMA has the NEHRP leadership role in working with the practitioner community, the American Society of Civil Engineers, and the International Code Council to support the

[3] https://www.usgs.gov/natural-hazards/science-application-risk-reduction/science/haywired-scenario?qt-science_center_objects=0#qt-science_center_objects
http://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=14d2f75c7c4f4619936dac0d14e1e468

development of model building codes and standards provisions that form the basis for most state and local building codes in the U.S.

NIST

NIST has a dual role within NEHRP. NIST leads the Program with responsibilities that include Chairing the ICC and establishing the ACEHR; drafting and updating NEHRP strategic and management plans; submitting annual reports to Congress on NEHRP activities; and fostering interagency coordination and cooperation.

NIST also carries out applied research to develop and deploy advances in measurement science related to earthquake engineering, including performance-based tools, guidelines, and standards for designing buildings to resist earthquake effects and to improve building safety, and to enhance disaster resilience of buildings, infrastructure, and communities. NIST has devoted considerable effort in supporting the further development of PBSD concepts, conducting a seminal comparison of design outcomes from PBSD and traditional building code design approaches.[4] NIST's research has also (1) provided data to support improved codes and standards for use by structural engineers through testing of structural elements under seismic loading; (2) developed improved modeling and assessment techniques for existing buildings; and (3) assessed the impact of new materials in improving seismic performance.[5] NIST is also examining historical costs of strengthening Federal buildings for improved seismic performance to gain insight into the costs associated with future mitigation options. [6]

NEHRP Agencies Collaboration

NIST is actively collaborating with FEMA in addressing nonductile concrete building performance, such as that noted in the Los Angeles area for older buildings designed prior to the 1980's when building codes did not provide the performance levels of codes now in effect. Research over the past 30 years, much of it funded by the NEHRP agencies, has provided information for engineers concerning the design of reinforced concrete buildings to withstand even higher levels of shaking than was the basis in these older codes. Current work by NIST is developing new modeling approaches for more accurately predicting capacity of these older concrete structures. These older buildings can be identified for additional study using triage tools developed by FEMA. It is important to note that NSF funded initial work on this problem that led to significant attention by the public and by local governments.

Another class of building that has been found to perform poorly in strong earthquakes is soft first story wood buildings, defined as multi-story buildings with openings in the first story typically for parking. The openings reduce the lateral capacity of the first floor, which can cause collapse during strong shaking, as was seen in the Northridge earthquake of 1994. FEMA has published a number of studies in retrofit approaches for these buildings for use by engineers. Moreover, NSF funded research into the performance of these types of structures, including full scale shake table testing. The result is that in 2013, San Francisco enacted the Mandatory Soft Story Retrofit Program, based in part on work sponsored by NEHRP, and on the observed effects during the 1989 Loma Prieta earthquake where many building failures of this type were noted.

[4] https://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.1863-1.pdf.
[5] https://nehrp.gov/.
[6] https://dx.doi.org/10.6028/NIST.TN.1973.

In 2015, the City of Los Angeles enacted Ordinance 183893, which is a mandatory retrofit program for these two classes of buildings, soft first story wood-frame buildings and the nonductile concrete buildings. Seismologist Dr. Lucy Jones, on loan from USGS and working with the City of Los Angeles, was a key voice in this process. Thus, the enactment of this important ordinance is a direct result of the activity of all four NEHRP agencies in addressing this problem.[7]

NEHRP agencies continue to work with other Federal agencies to increase seismic risk awareness and resiliency for the Federal community. For example, NIST NEHRP worked closely with Federal agencies on their implementation progress reports. The first round of reports was received in early April 2018 and provides information on new building design activity and significant insight into the existing Federal building inventory. The reporting process also provides the opportunity for dialogue with agencies on best practices, research developments and sharing of other information across agencies regarding this important subject. Along these same lines, in September of 2016, the U.S. Government Accountability Office issued "Earthquakes: Additional Actions Needed to Identify and Mitigate Risks to Federal Buildings and Implement an Early Warning System," that focused on seismic safety of existing federally owned and leased buildings. This information complements the data obtained from the recent progress reports.[8]

NEHRP – Beyond Life Safety

The design of structures in the U.S. historically has focused on life safety. Preventing collapse so that occupants could safely leave damaged buildings has been the goal inherent in building codes since their inception in 1915. However, starting with Loma Prieta in 1989 and Northridge 1994, there has been a growing call for expedited recovery from earthquake and other natural hazard events. Significant economic interruptions due to earthquake damage are no longer acceptable. The impact of earthquake damage can be dramatically shown by recent earthquakes. One example includes the 1995 M6.9 earthquake that struck Kobe, Japan, severely damaging its major port facilities. What was once the world's sixth busiest container port immediately dropped to 25th in the world and has not regained its pre-earthquake status nearly 23 years later.

While life safety is essential to achieve in design, there also must be recognition of the need for resilience to natural hazard events and for improved building performance to reduce damage. NIST has initiated a large effort to aggressively study the engineering, social, economic, and policy issues concerning making communities resilient. NIST developed the *Community Resilience Planning Guide* for use by local communities in planning their own resilient future.[9] This effort connects to the SPUR, the San Francisco Bay Area Planning and Urban Research Association, efforts in California[10] and to the Rockefeller 100 Resilient Cities program.[11] NIST

[7] http://www.ladbs.org/services/core-services/plan-check-permit/plan-check-permit-special-assistance/mandatory-retrofit-programs.
[8] https://www.gao.gov/products/GAO-16-680.
[9] https://www.nist.gov/topics/community-resilience/community-resilience-planning-guide.
[10] https://www.spur.org/
[11] https://www.100resilientcities.org/.

also has funded a resilience center to provide tools for communities as they forge a resilient future.[12]

NIST provides communities with an economic decision framework for the evaluation of investment strategies designed to improve community resilience. NIST participated in the development of a new standard that was issued by ASTM International in April 2018. ASTM E3130 "Standard Guide for Developing Cost-Effective Community Resilience Strategies."[13]

Improved building performance is another aspect of moving towards resilience. A recent study completed by NIST and Resilient Community Groups considered what would be required in terms of research and implementation for adoption of an "Immediate Occupancy" performance objective for building design. The goal is to improve building performance to the point that occupants would be able to quickly re-occupy business and residential buildings following a natural hazard event. A change to an immediate occupancy design philosophy represents a significant step beyond the traditional goal of life safety in building design. Properly achieved, the serious economic impact noted in the examples cited above could be avoided or reduced. However, a change to immediate occupancy design is a sweeping concept requiring more deliberate study into its engineering, economic, social, and policy aspects.

As we conclude 40 successful years of NEHRP, we are entering a new era of possibilities. The demand for improved building performance and reduced economic and social impacts from disasters of all kinds, offers a real opportunity for NEHRP not only to continue its successful, collaborative partnership but to incorporate changes in knowledge and technology together with social expectations to examine how to reduce the risk of damage from earthquake to a greater degree than has historically been the case. The country needs resilient communities and reduced losses from natural hazards. While we don't know when major earthquakes will occur in the future, we do know that with continued effort by the NEHRP agencies, engagement with both communities and earthquake professionals we can improve the performance of our Nation when future earthquakes occur.

NEHRP Reauthorization

NIST has worked with and looks forward to continuing to work with the House Committee on Science, Space and Technology concerning reauthorization of NEHRP.

In the decade since the passage of the public law, new needs have been identified—new seismic activity has been identified, new programs are in place at agencies and, importantly, new knowledge is available for use in the mitigation effort. Reducing the damaging impacts of earthquakes is a national problem. Earthquakes cross state boundaries, and state-federal partnerships are therefore critical. Solutions to earthquake-related problems can best be handled in a coordinated manner that crosses jurisdictional boundaries. In addition, the engineering industry that addresses almost all earthquake mitigation problems is composed of many small

[12] http://resilience.colostate.edu/.
[13] https://www.astm.org/newsroom/new-astm-international-standard-supports-community-resilience

entities, so that private sector efforts alone are simply inadequate to address major challenges. Federal leadership continues to be critical to this endeavor.

Conclusion

Our challenge is to ensure 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 Nation. We must keep working to mitigate the impacts of earthquakes on our communities. Painful lessons from past earthquakes must not be repeated. NEHRP is an integral part of the private-public collaboration that continues to reduce risk of damage to our communities from seismic ground motions.

Thank you again for the opportunity to testify on NEHRP. I am happy to answer any questions that you may have.

Steven L. McCabe

Steven McCabe is the NEHRP Director, providing overall program management and coordination; facilitating implementation of earthquake risk mitigation measures; and building and maintaining effective partnerships with stakeholders in industry, academia and government and the four NEHRP agencies. McCabe also is the Group Leader of the NIST Earthquake Engineering Group. In this position, he serves as the NIST representative on the NEHRP Program Coordination Working Group. He manages earthquake engineering research that is conducted in house at NIST or through outside contractors. The overall approach is to combine in-house and extramural expertise to address key research and knowledge-transfer issues in earthquake engineering.

Prior to joining NIST in 2011, McCabe worked in the private sector, in academia and at the Federal level. He was Chief Executive Officer of NEES Consortium, Inc. from 2007 to 2010, where he was responsible for management and operation of the George E. Brown, Jr., Network for Earthquake Engineering Simulation (NEES), funded by the National Science Foundation (NSF).

From 1985 to 2007, McCabe taught structural engineering courses and conducted research as a faculty member in the Department of Civil, Environmental, and Architectural Engineering at the University of Kansas, where he is a professor emeritus. He served as department chair from July 1998 through September 2002. His research interests included earthquake engineering and structural dynamics as well as the application of computer-based nonlinear analysis techniques to static and dynamic analysis problems. A particular interest is the identification of damage levels and reserve capacity in structures under dynamic loads.

During 2002–2005 McCabe served as program manager for the Structural Systems and Hazard Mitigation of Structures Program in the Division of Civil and Mechanical Systems at NSF. He managed research funding for structural performance under extreme loading, both natural and manmade, as well as supporting work in structural health monitoring.

Before beginning his academic career, McCabe worked in the private sector as a design and resident engineer primarily in the nuclear- and fossil-power industries. He is a registered professional engineer and has been active in many national and international professional societies.

Education:
Ph.D. Civil Engineering, 1987, University of Illinois at Urbana-Champaign
M.S. Mechanical Engineering/Engineering Mechanics, 1974, Colorado State University
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Fulbright Scholar, 1995–1996, Norwegian Institute of Technology in Trondheim