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Hearing on

"Advances in Earthquake Science: 50th Anniversary of the Great Alaskan Quake."

The 1964 magnitude 9.2 Alaska earthquake will forever be remembered for its size (the largest earthquake ever recorded in the US), duration (over 4 minutes of strong shaking) and the widespread damage (impacting 50,000-100,000 square miles, 131 casualties, and economic losses of $2.5 billion in today's dollar). The 50 years following this earthquake has marked an unprecedented period of great progress in our understanding of earthquakes and how to build to minimize the impact of earthquakes. As a result, we are much more prepared, much safer and much more resilient; however, more can be done to protect our infrastructure. Below, I highlight the areas where we have seen significant progress in the last 50 years.

Building Codes & Design

Building codes were woefully inadequate at the time of the 1964 Alaska Earthquake. Buildings that were designed and built 50 years ago would likely sustain damage in a moderate to large earthquake. Although building codes are updated frequently, some of the most significant changes have occurred after major earthquakes identified or emphasized structural deficiencies. The 1971 San Fernando and 1994 Northridge earthquakes were two such landmarks in terms of building codes.

Advances in structural dynamics by the late 1960s encouraged structural engineers to consider not only seismic forces, but also the movement or "ductility" a structure must undergo in an earthquake. Ductility - the ability to bend without breaking – was recognized as the key to earthquake resistant design. Buildings without ductility can exhibit brittle failures resulting in building collapse. Studies and lab tests by researchers demonstrated that good detailing – for example, the placement of steel reinforcement in the right quantity and location - was critical and could provide sufficient ductility in concrete structures.

Retrofitting

A large percentage of the built infrastructure was designed and constructed prior to the introduction of modern seismic codes which were introduced in the early-to-late 1970s. These structures are highly vulnerable to damage or destruction in earthquakes. Seismic retrofit (or rehabilitation) strategies have been developed to reduce the vulnerability of homes, buildings, and other infrastructure exposed to earthquakes. Coupled with the development of retrofit systems was the development and use of earthquake protection systems (isolators, energy dissipators). These systems offer vastly improved performance over conventional design for buildings and bridges, not just life-safety but continued functionality.

Significant efforts from the research community have been focused on developing and testing effective retrofit approaches on buildings, bridges, and other infrastructure types. These studies have been instrumental in developing new approaches for retrofit and improving existing approaches. Many of the approaches for retrofitting used today were developed using National Earthquake Hazards Reduction Program (NEHRP) resources.

Seismic retrofitting of vulnerable structures is critical to reducing risk. It is important for protecting the lives and assets of building occupants and the continuity of their work. On the whole, communities with retrofitted structures are less likely to sustain significant loss-of-life or injuries, will be more resilient and will recover from earthquakes more rapidly. Businesses that use retrofitted buildings are more likely to survive damaging earthquakes and to sustain shorter business interruptions.

Seismic Design and Retrofitting Works!

The impact of the improvements to building codes and retrofitting technologies could be seen in the 1987 Whittier Quake, 1991 Sierra Madre Quake, 1992 Landers Quake, 1989 Loma Prieta, and 1994 Northridge Quake. Los Angeles city officials say that more than 200,000 people were living in retrofitted brick buildings when the Northridge Quake hit. Not a single death or injury was reported from more than 37,000 units in 1,300 strengthened buildings. The structures that were built or strengthened under the new, stricter code experienced limited damage, while those structures that had not been retrofitted suffered greater damage.

Public Policies

Significant progress has been made in the area of public policy as it relates to earthquakes. Public policies regarding performance of hospitals, emergency operations centers, city halls, and schools didn't exist 50 years ago. The lack of safety of another class of existing structures became a prominent policy consideration following the 1971 San Fernando Earthquake. Several hospitals, including the Veteran Administration and the Olive View Hospitals, collapsed in the earthquake; 44 people died at the VA hospital alone. As a result, the 1973 California State Alquist Hospital Safety Act mandated that new hospital structures have higher seismic safety standards.

California Senate Bill 1953, passed in 1994, required that acute care facilities built before 1973 (including approximately 474 buildings) be upgraded to certain standards. According to the legislation, by 2008, these structures should not pose a significant threat to life; by

2030, hospitals are to be retrofitted to a level capable of providing services to the public after disasters.

Education and Training

In 1964, the only earthquake engineers were in California, Japan and Mexico. Now, earthquake engineering is taught all over the country, including schools in states that are not traditionally thought of as being in a seismic zone, such at Georgia Tech. In fact, just this week, researchers at Georgia Tech are conducting one of the largest seismic retrofit studies ever conducted right in the middle of downtown Atlanta - to develop and validate cost effective retrofits for unsafe reinforced concrete buildings. This project, along with hundreds of others, would not be possible without the continued support of the National Earthquake Hazards Reduction Program, specifically the Network for Earthquake Engineering Simulation (NEES)Program. The NEES Program has made a number of unique studies a reality. From large scale testing of the California levee system to testing of buried pipelines, the NEES program has provided the research community with the opportunity to test a range of systems in a fashion that we could not even imagine 50 years ago.

Finally, I would like to reiterate that we still have more work to do to prepare for the impact of earthquakes. There exists thousands of vulnerable buildings and critical infrastructure systems in areas moderate-to-high seismic zones. Identifying and finding cost-effective retrofit approaches before an earthquake strikes is critical. However, the American people are safer, and our cities more resilient socially and economically, than we were 50 years ago. This is a direct result of NEHRP-funded research, knowledge transfer, and education/outreach programs.

The George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES)

The George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) is a shared-use network that features 14 advanced experimental equipment sites and field stations. They are linked by a robust cyberinfrastructure, the NEEShub at nees.org, which includes a central data repository, simulation, and collaborative capabilities. Sponsored by the National Science Foundation (NSF), NEES is dedicated to the mitigation of earthquake and tsunami risks. Researchers, educators, students, practitioners, academic institutions, partnering organizations, and funding agencies collaborate through NEES to advance and disseminate mitigation knowledge and strategies.

NEEScomm, the NEES operation, cyberinfrastructure, and education and outreach headquarters at Purdue University, is dedicated to serving the community through effective stewardship, deploying robust user-requirements driven cyberinfrastructure, and providing leadership in network-wide education and outreach activities.

The NEES program is authorized by Act of Congress under the National Earthquake Hazards Reduction Program (NEHRP). NEEScomm is supported by the National Science Foundation, Dr. Joy M. Pauschke, NSF Program Coordinator, through cooperative agreement number: CMMI-0927178.

Visit http://nees.org for more information.

National Earthquake Hazards Reduction Program

The National Earthquake Hazards Reduction Program (NEHRP) was established by the U.S. Congress when it passed the Earthquake Hazards Reduction Act of 1977, Public Law (PL) 95–124. At the time of its creation, Congress' stated purpose for NEHRP was "to reduce the risks of life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards reduction program." In establishing NEHRP, Congress recognized that earthquake-related losses could be reduced through improved design and construction methods and practices, land use controls and redevelopment, prediction techniques and early-warning systems, coordinated emergency preparedness plans, and public education and involvement programs.

Since NEHRP's creation, it has become the Federal government's coordinated long-term nationwide program to reduce risks to life and property in the United States that result from earthquakes. Since NEHRP's 1977 beginnings, Congress has periodically reviewed and reauthorized NEHRP (1980, 1981, 1983, 1984, 1985, 1988, 1990, 1994, 1997, 2000, and 2004.) While changes have occurred in program details in some of the reauthorizations, the four basic NEHRP goals remain unchanged:

- Develop effective practices and policies for earthquake loss reduction and accelerate their implementation.
- Improve techniques for reducing earthquake vulnerabilities of facilities and systems.
- Improve earthquake hazards identification and risk assessment methods, and their use.
- Improve the understanding of earthquakes and their effects.

In its initial NEHRP authorization in 1977, and in subsequent reauthorizations, Congress has recognized that several key Federal agencies can contribute to earthquake mitigation efforts. Today, there are four primary NEHRP agencies:

- Federal Emergency Management Agency (FEMA) of the Department of Homeland Security
- National Institute of Standards and Technology (NIST) of the Department of Commerce (NIST is the lead NEHRP agency)
- National Science Foundation (NSF)
- United States Geological Survey (USGS) of the Department of the Interior