Washington Office
101 Constitution Ave., N.W.
Suite 375 East
Washington, D.C. 20001
(202) 789-7850
Fax: (202) 789-7859
Web: http://www.asce.org

Statement of Anne S. Kiremidjian, Ph.D.
For the hearing entitled

AMERICA'S NATURAL DISASTER PREPAREDNESS: ARE FEDERAL INVESTMENTS PAYING OFF?

Before the
Committee on Commerce, Science and Transportation
United States Senate

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Mr. Chairman and Members of the Committee: I am Anne Kiremidjian and I am testifying on behalf of the American Society of Civil Engineers (ASCE). During my forty years of involvement with ASCE I have served as Chair of various committees and most recently as Chair of the Executive Committee on Disaster Reduction and Management (CDRM) and Chair of the Executive Committee of the Technical Council on Lifeline Earthquake Engineering (TCLEE). As professor of structural engineering at Stanford, I have been the direct beneficiary of the funding to the National Science Foundation (NSF), US Geological Survey (USGS), National Institute of Standards and Technology (NIST) and the Federal Emergency Management Administration (FEMA). These organizations have supported my research, educational and business endeavors. In addition, I have served on the board of directors, institutional boards and external advisory board to the various research centers and consortia on earthquake engineering research. Over the years I have also actively participated in committees and workshops that have set the standard for research and development related to earthquake engineering and disaster mitigation.

My research focus over the past thirty-eight years has been on the development of earthquake hazard and risk assessment methodologies, and wireless structural monitoring sensors and systems for rapid structural damage assessment from normal loads and extreme loads such as those from large earthquakes. My research has been greatly enhanced by the numerous first-hand observations and investigations of the damage, social and economic consequences following major earthquakes around the world.

Founded in 1852, ASCE is our nation's oldest civil engineering organization representing more than 140,000 civil engineers in private practice, government, industry and academia. ASCE is a 501(c)(3) non-profit educational and professional society. Research in civil engineering aims to advance the quality of life of individuals and our society by building innovative structures and infrastructure and by providing essential service with minimal adverse effect on the environment by applying the principles of sustainable development and disaster resilience.

ASCE is pleased to offer this testimony before the United States Senate Committee on Commerce, Science and Transportation on the hearing: *"America's Natural Disaster Preparedness: Are Federal Investments Paying Off?"*

Have Our Federal Dollars Been Paid Off?

Since the establishment of the National Earthquake Hazard Reduction Program in 1977, we have made tremendous strides towards our understanding of the earthquake phenomenon, its effects on the built environment, and on the social and economic systems that may be affected by the occurrence of a major earthquake. To site a few examples, the ground shaking maps produced by USGS are extensively used in building and other infrastructure design and assessment; the three earthquake engineering centers (the Pacific Earthquake Engineering Research Center (PEER), the Multi-hazard Center on Earthquake Engineering Research (MCEER), and the Mid-America Research Center (MAE) have each focused on development of models and technologies for their respective geographic regions of interest; they have changed the design paradigm from the traditional code-based prescriptive approach to a performance based approach where the design of building and other infrastructure is expected to achieve performance goals geared towards not only life safety but also toward functionality and rapid recovery after an earthquake event; Over the past ten years, the Network for Earthquake Engineering Simulation (NEES) has performed the systematic testing of scaled structures and structural components enabling validation of theoretical models; hospitals and schools are being upgraded or completely reconstructed to meet higher performance as a result of our increased understanding of the needs following a major earthquake; local governments perform periodic emergency response drills in the attempt to identify gaps in their emergency plans; tsunami evacuation routes have been identified and marked to aid in the event of a tsunami; technologies such as base isolation systems, various damping and energy dissipative devices to reduce damage to structures, wireless structural monitoring sensing systems, nano-level and bio-inspired sensing devices for more robust damage detection, and remote sensing techniques are being developed for rapid information retrieval, damage assessment and control of structures; similarly rapid mapping dissemination following an event are now made available after every earthquake in California, as the shake maps produced by USGS, and can be used by local and state governments in their early stages of planning for the response and recovery operations, the multi-hazard loss estimation software tool HAZ-US developed by FEMA is also being used by state, local and the government to estimate potential losses for scenario events; and so on. By no means is this intended to be a comprehensive list and I am sure to have missed some key developments and innovations in this brief summary.

In a 2005 study supported by FEMA and the U.S. Department of Homeland Security, the Multihazard Mitigation Council (MMC) of the National Institute of Building Sciences (NIBS) conducted a study "*Natural Hazards Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities*" (http://www.fema.gov). One of the main conclusions from this study was that for every dollar spent by FEMA in mitigation activities during the period from 1993 to 2003 society saved $4 on the average. Moreover, the mitigation activities "resulted in significant benefits to society as whole" and "represented significant potential savings to the federal treasury in terms of future increased tax revenues and reduced hazard-related expenditures". Mitigation is indeed one of the most effective ways of reducing the consequences of large earthquakes and other natural occurrences and potentially preventing them from becoming disasters.

The Tohoku, Japan earthquake of March 11, 2011 combined with the tsunami and damage to the Fukushima Daichi Nuclear Power plant resulted in perhaps one of the worst natural disaster we have seen during our lifetimes. Preliminary estimates of the total losses are approximately $600B (S&P) of which $300B are attributed to the earthquake shaking and the tsunami. The tsunami waves were estimated to range from 9 m to 37.9 m in height causing the majority of building and other infrastructure destruction with 13,591 confirmed deaths, 4,916 injuries and 14,497 missing. Early damage reports, however, are indicating that structures built to meet current design criteria performed overall very well. Damage has been primarily to older buildings and other infrastructure that were built with much less stringent seismic design criteria. Like the United States, and perhaps even more so, Japan has had a long tradition to invest in earthquake research and development. We have also been the beneficiary of the extensive funding by the Japanese government following the 1995 Kobe, Japan earthquake which spent more than $100M in seismic instrumentation both for ground motion and building performance monitoring and more than $500M to build the world's largest shake table enabling full scale testing of structures subjected to earthquake motions. Perhaps it is premature to make a conclusion based on these early observations, but one might say that the advances made toward current design practices are paying off.

Can We Prevent Future Natural Disaster?

No.

Why Not?

An earthquake does not become a disaster if it occurs in an unpopulated area. It becomes a disaster when it affects densely built and populated communities that are not prepared to cope with the forces of strong and great earthquakes. Here are some of the reasons why we find it difficult to prevent future disasters from earthquakes:

- We are still in the process of understanding the true effects of strong earthquakes – ground shaking, ground deformations and tsunamis – because large earthquakes such as the Tohoku, Japan earthquake of March 11, 2011 occur rarely, we have not been able to obtain direct information on their consequences;
- The performance of various ground conditions, structures and infrastructure components is only now beginning to be understood with much remaining to be investigated and evaluated;
- Many technologies that can prove to be useful in disaster response and recovery are only in the form of prototypes, untested in real situations;
- Majority of structures and infrastructure systems were built before current design methods were developed;
- Our structures, lifelines and transportation systems are old and deteriorating;
- Many earthquake prone areas in the US did not adopt seismic design until recently – e.g. Oregon adopted seismic requirements in 1994;
- Great earthquakes affect vast geographic regions - e.g. a repeat of the 1906 San Francisco earthquake would affect all cities and towns spanning a 400+ km segment from San Juan Bautista to Eureka; an earthquake of moment magnitude 9 on the Cascadia subduction zone will affect all communities along the Oregon and Washington coastline;
- Critical facilities are being upgraded (e.g hospitals, police and fire stations) but local and state governments lack the resources to address the problems more aggressively;
- Key industrial facilities are potentially vulnerable but at present it is up to the owners to evaluate their performance – failure of these facilities can have a serious economic impact on a community and the rest of the country;
- Local and state governments lack the resources to evaluate their earthquake risk in order to develop and implement disaster mitigation policies – e.g., the State of Oregon had

undertaken a plan to identify vertical evacuation structures for tsunami refuge; these activities have stopped due to budget cuts

Funds are needed for fundamental and applied research that encompasses the geosciences, geotechnical engineering, structural and infrastructure engineering, social and economic sciences, and policy decision-making. Recent strong earthquakes have shown that we are only now beginning to understand the phenomenon and its consequences. As an emerging field it requires extensive research and development that can only be achieved through the dedicated efforts of its professionals with appropriate funding. Community resilience to major earthquakes can only be achieved through the implementation of findings from the research and development and through appropriate mitigation and preparedness actions.

Where Are the Greatest Gaps?

A comprehensive approach for earthquake related research and development that takes further steps toward community resilience is laid out in the 2009-2013 NEHRP Strategic Plan. In addition, the National Research Council of the National Academies (NRC 2011) has 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 (Poland, 2011). Key areas that need extensive investigation include:

- Worldwide monitoring and data gathering and interpretive tools
    - Instrumentation for assessing the energy release and variation of intensity of strong shaking of earthquakes;
    - Instrumentation of buildings and other infrastructure components
    - Methods and tools for data assessment and interpretation leading to useful information
- Framework for resilience in terms of performance goals that consider communities as systems of structures, lifelines, people, economics and governments, and their interdependencies
- Social science research to quantify the role of improvisation and adaptation, how decisions are made at all levels and the need for rehabilitation
- Development of Performance-Based Earthquake Engineering (PBEE) design tools to enable rapid and widespread adaptation of advanced design methods
- Development of new technologies and adaptation of existing technologies for pre-disaster assessment and for rapid response and post disaster evaluation

The recent earthquakes of February 22 and 25, 2011 in Christchurch, New Zealand and the great magnitude 9 earthquake of March 11, 2011 in Tohoku, Japan present an unprecedented opportunity to study their effects to communities, geographic exposure and design practices that are the closest to those in the US. The extensive instrumentation placed by Japan prior to the earthquake has provided a wealth of new information that needs to be investigated in collaboration with our Japanese colleagues. The social, economic and policy implications from the earthquake and tsunami are unlike any other event we have seen during our short history of earthquake research. It is imperative that funds be allocated to study these earthquakes and use the lessons to greatly enhance the resilience of our communities to large earthquakes.

Summary:

In conclusion, ASCE plays critical role in the research, implementation and policies for earthquake hazard and risk mitigation leading to resilient communities. The activities can be achieved through continued support of the National Earthquake Hazards Reduction Program by focusing on the specific goals mapped in the Program's Strategic Plan. Funding for research on the Tohoku 2011 earthquake presents a unique and long-awaited opportunity to study the effects of a truly great earthquake on a community that most resembles our.

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

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