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Statement of

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before the

Subcommittee on Economic Development, Public Buildings
and Emergency Management
of the
Committee on Transportation and Infrastructure
U.S. House of Representatives

May 19, 2015

Chairman Barletta and distinguished members of the Subcommittee on Economic Development, Public Buildings, and Emergency Management, I am John Hooper, a Senior Principal and Director of Earthquake Engineering with Magnusson Klemencic Associates. On behalf of the American Society of Civil Engineers, it is my pleasure to provide this testimony to you regarding "Pacific Northwest Seismic Hazards: Planning and Preparing for the Next Disaster." My testimony will review the state of seismic design in the Pacific Northwest and address a key component needed to produce more resilient communities. As Senior Principal and Owner of a 200-person structural and civil engineering firm headquartered in seismically active Seattle for the last 95 years, and having witnessed firsthand the impact earthquakes can have on a community, this is a matter of great importance to me.

In addition to designing building structures throughout the West Coast, across the country, and around the world, I have also participated in structural building code development and earthquake engineering research for nearly 3 decades. I have served in various capacities for those efforts, and am currently the Chair of the American Society of Civil Engineer's ASCE 7 Seismic Subcommittee.

This subcommittee is tasked with developing the seismic requirements that the vast majority of state and local jurisdictions throughout the United States, as well as other countries, adopt for their seismic regulations. Jurisdictions adopt these seismic requirements by way of voluntarily adopting the International Building Code (IBC), a comprehensive code that sets coordinated and comprehensive requirements for building design and performance. The majority of state and local jurisdictions adopt the IBC to capitalize on the code's vast volume of compiled knowledge, then modify as appropriate based on their specific jurisdictional needs and priorities.

The IBC references "ASCE 7 Minimum Design Loads for Buildings and Other Structures" (ASCE 7) for the design requirements for most natural hazards, including seismic. ASCE 7 is developed by a consensus standards development process that has been accredited by the American National Standards Institute (ANSI) and provides the technical information necessary for use in design of buildings and other structures.

Development Background of Seismic Codes and Standards

Structural engineering of buildings is very technical and complex, and designing for locations with earthquake potential is even more advanced and specialized. To aid in your understanding of ASCE 7's recommendations today, I would like to briefly explain how current standards of seismic engineering have evolved.

Seismic design requirements have been enforced in the United States for over a century, with their origins in the 1906 San Francisco Earthquake. Since that seminal event, seismic design regulations have evolved extensively. Initially, seismic design requirements were developed through the voluntary efforts of structural engineers in California for use in their state in order to mitigate future losses from earthquakes. Over time, these requirements were adopted into the Uniform Building Code (UBC). The UBC, originally published in 1927, was the building code used by states and jurisdictions throughout the western United States, including the Pacific

Northwest. These efforts continued through the mid-1990s, when the UBC, along with other building codes, was consolidated into the IBC.

A major contribution to the evolution of seismic design was development by the National Earthquake Hazards Reduction Program's (NEHRP's) of the "NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures" (or simply the NEHRP *Provisions*), originally published in 1985. These seismic design guidelines were developed voluntarily by engineers from around the country, with leadership and support from the Federal Emergency Management Agency (FEMA) as well as the Building Seismic Safety Council, which managed the overall effort. The NEHRP *Provisions* have been continually updated since that first version, with the next version due for publication the end of 2015. Over the last 3 decades, the *Provisions* have evolved into a widely available, trusted, state-of-the art seismic design resource document with requirements that have been adapted for use in the nation's model building codes and standards. The *Provisions* also serve as the resource document to the seismic design requirements currently found in ASCE 7. This collaboration between the NEHRP *Provisions* and ASCE 7 has been in existence for over 20 years.

Pacific Northwest Seismic Hazards

The Pacific Northwest is a fairly complicated seismic hazard region. Due in large part to the research led by the United States Geological Survey (USGS) for nearly 3 decades, the region's seismic hazards are much better understood today, including the hazard associated with the Cascadia Subduction Zone. The Cascadia Subduction Zone is a convergent plate boundary that stretches from northern Vancouver Island to northern California. It is a very long, sloping subduction-zone fault that separates the Juan de Fuca and North America plates.

The Cascadia Subduction Zone has produced numerous events of up to Magnitude M_W9 over the past thousands of years. However, the potential of an event on the Cascadia Subduction Zone was not fully understood until the USGS research findings of the late 1980s were presented to the structural engineering community in the Pacific Northwest. Based on this research, the seismic zone maps in the 1994 UBC were modified to include the effects of the Cascadia Subduction Zone. Research on the potential shaking hazard of the Cascadia Subduction Zone continues to be refined today, and there is still more to be learned.

Policymakers, emergency planners, and structural engineers in the Pacific Northwest are very aware of the shaking that can result from a Cascadia Subduction Zone event. I personally have been involved in numerous earthquake workshops and emergency planning exercises based on this event. The recent subduction zone earthquakes in Indonesia (2004), Chile (2010), and Japan (2011) have only heightened awareness. I made immediate follow-up visits to the site of the Chile event (as well as Loma Prieta and Northridge, California, 1989 and 1994, respectively; Kobe, Japan, 1995, Manzanillo, Mexico, 1995; and Taiwan, 1999) for the purpose of researching and analyzing building performance to share with the engineering community.

Due to continued publicity regarding new research findings, the public also appears to be genuinely aware of the Cascadia Subduction Zone's potential. However, it is fairly clear that the public, and perhaps some policymakers and emergency planners, are not aware of the performance goals associated with the seismic design requirements found in ASCE 7.

Seismic Performance Goals

The vast majority of the public is also not aware of the seismic performance goals for buildings associated with the ASCE 7 seismic design requirements. The seismic performance goals for ordinary buildings, defined as "Risk Category II" structures in the building code, such as office buildings, hotels, retail shops, and residential buildings, are to protect life given "rare" earthquake ground shaking at a site and to achieve a uniform, low likelihood of building collapse given "very rare" earthquake ground shaking. Under those goals, damage to the point where it may not be economically feasible to repair a building is possible, if not probable. For critical and essential facilities, defined as "Risk Category III" and "Risk Category IV" structures in the building code, such as emergency operation centers, police and fire stations, and hospitals, the performance goals are enhanced relative to ordinary buildings, with the intent that these facilities will experience damage but be functional following "rare" earthquake ground shaking.

A "very rare" event represents earthquake ground shaking that has a recurrence interval of approximately 2,500 years (denoted in ASCE 7 as the "Risk-Targeted Maximum Considered Earthquake," or MCE_R). A "rare" event assumes earthquake ground shaking at 2/3 of that experienced during a "very rare event," with a recurrence interval ranging from 200 to 1,000 years depending on where the site is located (denoted in ASCE 7 as the "Design Earthquake" or DE).

Create More Resilient Communities through More Resilient Design

To provide more resilient designs, and therefore more resilient communities, a change is required in these seismic performance goals. This change will come with increased construction costs. Some federal, state, and local jurisdictions have provided, or are considering, enhanced performance for some of their projects. This enhanced performance will likely target performance similar to what is required for critical or essential facilities described previously. Some large companies that would be financially affected by an extended shut down have already invested in enhanced seismic design for their projects. Typically, though, private owners and developers are generally unaware of the expected performance of a "code-designed" building, with corresponding potential negative impacts, and the potential benefits an "enhanced" seismic design can bring to their project. The few owners and developers I have communicated with that do have a good understanding will typically only implement an enhanced design if they can achieve a reasonable return on their investment.

Policymakers are aware of these issues. Changing the design approach for an entire community to increase resiliency will be a challenge. First, the turnover of building stock in a typical community is low, so enhancing the performance of existing buildings will require seismic upgrading. However, it is not necessary that *all* buildings achieve enhanced performance to achieve a resilient community. Careful planning is needed to determine which buildings and facilities should be subject to enhanced seismic design or seismic upgrading. Second, and equally important, for a community to be resilient, the remainder of the community's lifelines must also be seismically designed or upgraded to an enhanced performance level, including roads, bridges, water and sewer lines, power (electrical and gas) distribution systems, fiber optic lines, etc. Finally, given the need to provide enhanced seismic design for both buildings and lifelines to achieve a resilient community, the key element is to fund these capital costs. Regardless of these challenges, through policymaker leadership and careful community planning, the beginnings of resilient communities can…and increasingly will…be achieved.

Improve Building Performance by Embracing NEHRP Seismic Research

To continue to improve understanding of building performance from earthquake shaking, research funding is required. While great strides have been made over the past 30 years, there are still many technical problems to solve—especially finding better, more economical ways to provide enhanced seismic performance so that the goal of community resiliency can be better achieved.

As previously described, the National Earthquake Hazards Reduction Program has made significant contributions to seismic design requirements incorporated into today's codes and standards. The program has also provided vital contributions in both applied and basic research to help mitigate seismic risk and achieve community resilience. Last reauthorized by Public Law 108-360 in 2004, the program underwent the most significant changes in its history, with strong support from the earthquake risk-reduction community. However, authorization of the program expired in October 2009. One of the best things Congress can do to further the cause is to move swiftly to reauthorize the program.

Since being created by Congress in 1977, NEHRP has provided the resources and leadership that have led 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 creation of related reference materials for building code development, risk 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 its research programs, it is also the source for hundreds of new technologies, maps, design techniques, and guidelines that are used by design professionals every day to mitigate risks, save lives, protect property, and reduce adverse economic impacts.

NEHRP makes Americans safer and our nation more secure, resilient, and financially stronger through research in the earth and behavioral sciences, public policy, and engineering, followed by implementation of the findings. ASCE and I urge you to work with the Science, Space and Technology Committee to reauthorize this vital program.

Thank you for the opportunity to share my views regarding "Pacific Northwest Seismic Hazards: Planning and Preparing for the Next Disaster."