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SCHOOL OF CIVIL & ENVIRONMENTAL ENGINEERING
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COMMITTEE ON HOMELAND SECURITY AND GOVERNMENT AFFAIRS
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PREPAREDNESS AND INTEGRATION
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Mr. Chairman and Members of the Subcommittee on state, local, and private sector preparedness and integration, thank you for the opportunity to testify on “Earthquake Preparedness - What the U.S. can Learn from the 2010 Chilean and Haitian Earthquakes”. My testimony will highlight the risks associated with a potential catastrophic earthquake event in the United States, and address opportunities to improve infrastructure resilience. My perspective is as an earthquake engineer who has studied the performance of the built infrastructure in the US, with a focus on the Central and Southeastern United States (CSUS). Internationally, I have worked extensively in Haiti since the January 12, 2010 earthquake, having led a team of 28 engineers, scientists, and planners to study the effects and survey building damage in Port-au-Prince. My work in Haiti is on-going in two veins: first to provide structural advice as the recovery gets underway and second to better prepare Haiti, and by extension other places, for future earthquakes and other hazards.

Haiti Earthquake: January 12, 2010.

The Haiti earthquake is likely the most catastrophic natural disaster in modern times, particularly when viewed on a per capita basis. The magnitude 7.0 Haiti earthquake (January 12, 2010) resulted in over 250,000 deaths, over 300,000 injured, 1.3 million displaced, and 250,000 homes either destroyed or critically damaged. In contrast, the much larger magnitude 8.8 Chile earthquake resulted in less than 600 deaths, and less than 12,000 people injured

Figure 1: Collapse Presidential Palace in Port-au-Prince, Haiti

There are numerous reasons for the differences in the outcomes including the location of the epicenters of the two earthquakes to major city centers, fault mechanisms, and local soil conditions.

However, there is no doubt that the advanced level of seismic design and preparedness in Chile as compared to Haiti is the primary contributing factor in the significant differences observed between these two earthquakes. Chile has a long history of large earthquakes including the 1985 M8.0, 1960 M9.5, 1943 M8.2, and 1906 M8.2. Because of this history of large and frequent earthquakes, Chile has been diligent in ensuring its buildings and other infrastructure are designed according to updated seismic codes. On the contrary, Haiti had not experienced a major earthquake in over 200 years, and therefore was not prepared for the earthquake that struck on January 12, 2010.

Seismic Hazard in Central and Southeastern United States

There are several regions in the US that have a history of large, but infrequent earthquakes, and therefore are not prepared in terms of appropriate building designs with earthquake details. In particular, the cities around the New Madrid Seismic Zone (St. Louis, MO, and Memphis, TN), and the Charleston, SC, region are at risk of catastrophic failure from a large earthquake.

Although not generally considered a seismically active region, large earthquakes have occurred in the Central and Southeastern US, primarily due to the activity of the New Madrid Seismic Zone (NMSZ)). The NMSZ stretches from northeast Arkansas to southern Illinois, cutting through Missouri, Western TN, and western KY. The series of three earthquakes that struck the NMSZ in 1811-12 are considered among the largest earthquakes in US history (in the contiguous

US), with magnitude estimated at around 7.5-8.0. The earthquake was felt as far west as Denver, CO, and as far east as Philadelphia, PA.

Charleston, SC, is also a region of large, but infrequent earthquakes. On August 31, 1886, a large earthquake hit the Charleston, SC region, with an estimated magnitude 7.0 was felt as far as Chicago, IL and Boston, MA.

While most earthquakes occur along plate boundaries, such as is the case with California's San Andrea fault, earthquakes in the NMSZ and Charleston, SC, known as "intraplate" earthquakes are less frequent, but equally damaging. Moreover, the geological conditions of the older crust in the central and eastern United States results in earthquake waves that travel much farther, and therefore, will have a much more wide-spread set of effects than a comparable sized quake on the west coast.

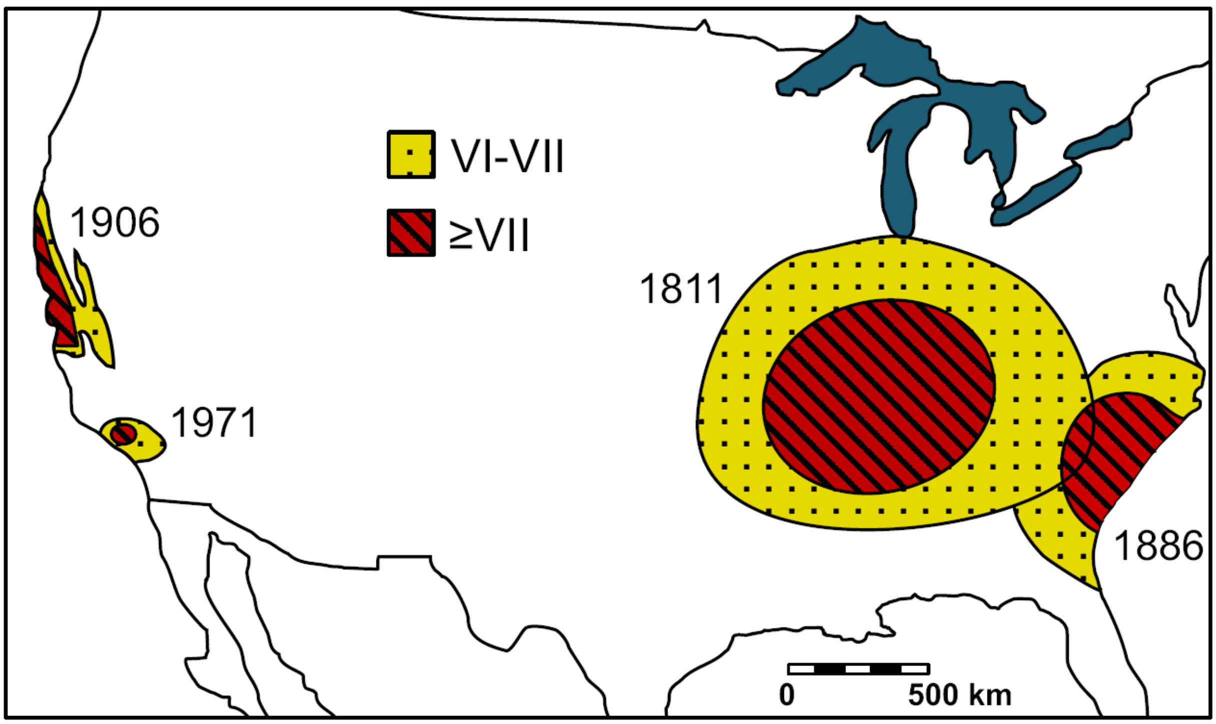

Figure 2: Map of US Showing Area Affected by 1811 New Madrid Earthquake, 1886 Charleston Earthquake, 1906 San Francisco Earthquake, and 1971 San Fernando Earthquake.

What are the risks associated with effects of catastrophic earthquakes in US?

The primary risk of catastrophic earthquakes in the US is the likely failure and damage to the built infrastructure. Today, the NMSZ region is highly populated and densely covered with homes, commercial buildings, and critical infrastructure such as bridges, pipelines, and power/telecommunications, Dams/Levees, etc. Damage to these critical infrastructure systems would have disastrous consequences on the regional, national, and global economies. The transportation system in the central US serves as a primary means to move $2 trillion dollars worth of good through the US. It is expected that many of the bridges in the region, including some bridges crossing the Mississippi river could collapse and be unusable for weeks or longer. In addition, there would be severe interruptions to oil and gas services due to severely damaged pipelines.

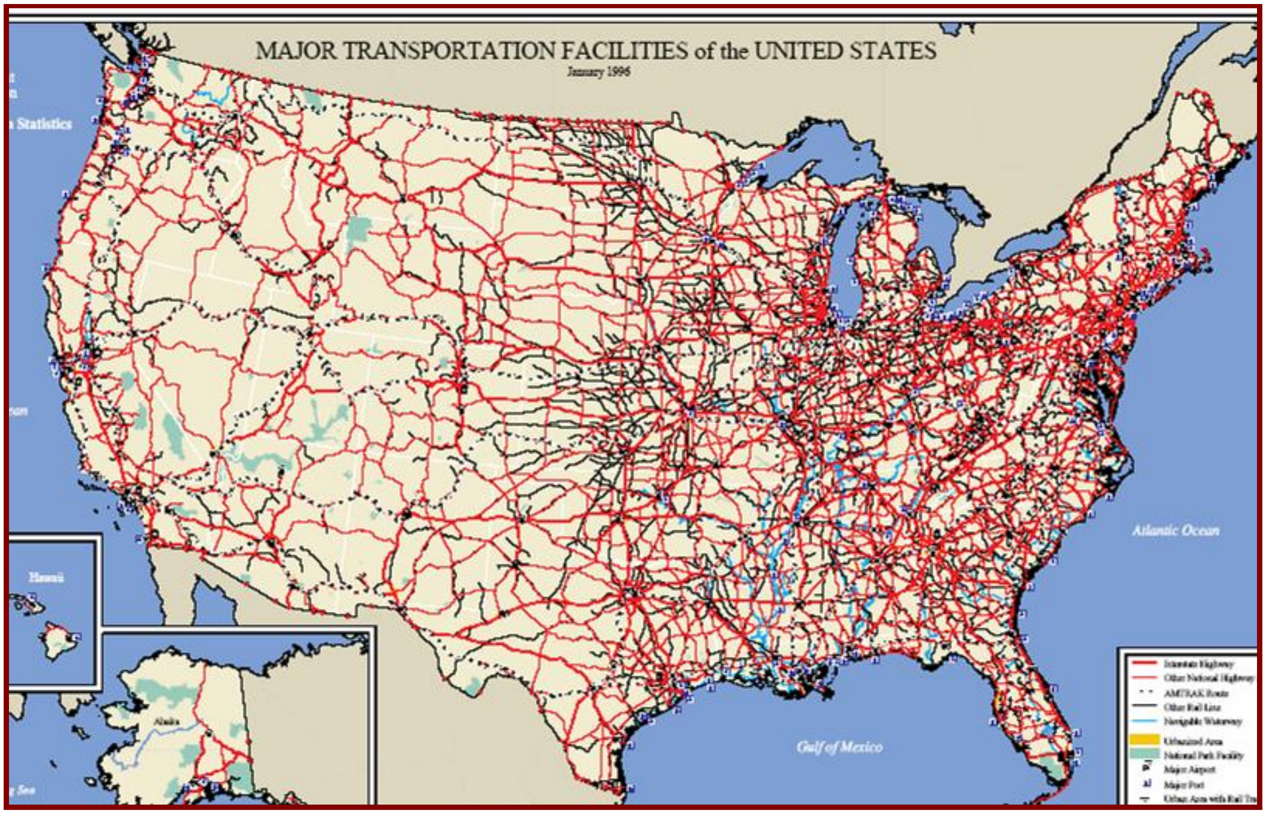

Figure 3: Map Show the Dense Transportation Network in the Central and Southeastern US.

Based on geologic research, the USGS estimates that there is a 7-10 percent probability of a New Madrid earthquake comparable to those that occurred in the 1811-12 series in the next 50 years. Such a strong earthquake would rock the entire eastern half of the country and prove devastating to a broad section of the country. A recent study[1] by the Mid-America Earthquake Center on the Impact of a New Madrid Seismic Zone EQ on the Central USA estimates that nearly 750,000 buildings would be damaged in the states surrounding the NMSZ. In addition, there would be over 3000 bridges damaged, and over 400,000 breaks and leaks to local and interstate pipelines. Approximately 2 ½ million households would be without power and 86,000 injuries and fatalities are estimated to occur. The study estimated direct losses at $300 billion, and indirect losses at $600 billion. Similarly, a 2005 study[2] of the Charleston, SC, region indicated that a repeat of the 1886 earthquake would be equally catastrophic, although more localized, with significant damage to schools, hospitals, fire stations, and lifeline systems such as bridges, pipelines, and ports.

Another factor compounding the risk of catastrophic effects of an earthquake is the nation's aging and deteriorating infrastructure. Physical infrastructure in the United States is deteriorating rapidly, becoming increasingly more complex, more interconnected, and thus more vulnerable to system-wide failure due to physical decay or inadequate design for current demands. Unless we address our aging infrastructure, we will find ourselves in much greater risk of catastrophic failure during a major earthquake.

Using Science and Engineering to Understand Risks and Improve Infrastructure Resilience.

The recent studies on the possibilities of catastrophic failures in the case of a large earthquake in the Central and Southeastern US(CSUS) demonstrates the scope of the problem and reinforces the need to implement measures to reduce seismic risk. We know that hundreds of thousands of buildings and key critical infrastructure systems remain at risk of significant damage when a large earthquake strikes the CSUS.

We cannot prevent the buildup of tectonic stress along fault lines, nor can we pinpoint the exact moment when a disastrous earthquake will strike. With the leadership of the NEHRP agencies, namely USGS, NSF, NIST, and FEMA, significant progress has been made in our understanding of the earthquake hazards in the various parts of the United States, as well as the vulnerabilities associated with different types of structural systems. New design codes and guidelines have incorporated lessons learned from recent earthquakes, as well as new knowledge developed from researchers and practicing engineers in cooperation with the NEHRP agencies. The transfer of scientific research successes from the NEHRP efforts to building and design codes is one important step towards earthquake preparedness in the United States. Still, there is more work to be done.

Earthquake preparedness involves a few different key elements, including pre-earthquake rehabilitation of buildings, bridges, and other key infrastructure systems subjected to earthquake loads. Reinforcement actions, such as adding steel jackets to existing columns, or adding steel restrainer columns are examples of measures that have been proven effective in mitigating the damage caused by earthquakes. Small investments now can yield significant savings later. The California Department of Transportation (CALTRANS) is a good example of the return on investment from retrofit of bridges. Following the 1971 San Fernando earthquake, CALTRANS initiated a retrofit program for bridges that were deemed vulnerable to damage from earthquakes. These same bridges, when subjected to shaking during the 1994 Northridge Earthquake, withstood the earthquake loads with minimal damage.

These types of applications of science and engineering to mitigate the effects of earthquakes can only be sustained over time with an educated workforce that is proficient in math, science, and engineering. As a Professor of Civil & Environmental Engineering, I would be remiss if I did not underscore the continuing need to strengthen STEM education at the K-12, university, and post-graduate levels. Such an educational foundation is dependent on sustained federal funding and is elemental in developing a workforce that is equipped to understand, plan for, and mitigate the effects of earthquakes, and other natural hazards on the built environment.

My main message to this panel is that it is critical that we continue to apply science and engineering knowledge to develop innovative technologies and designs to increase our earthquake preparedness. We also need to continue to enhance building codes and establish priorities for mitigation strategies that limit damage to key buildings and critical infrastructure. Prioritized mitigation strategies can assist in identifying infrastructure systems that are most at risk of damage and/or failure, so that we can begin developing ways to fortify them against future earthquakes.

Mr. Chairman, this concludes my remarks. I would like to thank you and the committee for the opportunity to share my thoughts with you.