Earthquake

▶"Earthquakes move mountains. But so do imagination and ingenuity — when matched with implementation."

▶"Earthquakes have long been feared as one of nature's most damaging hazards. Earthquakes continue to remind us that nature still can strike without warning and, after only a few seconds, leave casualties and damage in their wake."

▶"Although earthquakes cannot be prevented, current science and engineering provide tools that can be used to reduce their damage. Science can now identify, with considerable accuracy, where earthquakes are likely to occur and what forces they will generate. Engineering provides design and construction techniques so that buildings and other structures can survive the tremendous forces of earthquakes."

▶"Earthquakes are ferocious events. They can shake the ground loose. They can shatter the earth. Earthquakes can, quite literally, move mountains. But the extent of the damage an earthquake causes will be a direct result of the extent of our knowledge — the extent of our planning — and the extent to which we employ both to protect our people."

▶"FEMA's goal for the National Earthquake Hazard Reduction Program (NEHRP) is to spearhead a comprehensive effort to make our structures safer, our citizens better informed and more secure, and to place mitigation and preparedness at the center of earthquake policy. That means we must improve our ability to understand and forecast earthquakes and their impacts. It means we must improve model building codes and land use practices."

▶"Today, fundamental questions are being raised over the degree of exposure to seismic risk throughout the United States. There is a growing recognition that regions with low seismic hazard may actually have high seismic risk."

▶"An examination of recent earthquakes around the world reveals a pattern of steadily escalating damages and losses. While the seismic ***hazard*** has remained

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relatively constant over time, the seismic *risk* has increased substantially. This is primarily because there has been a significant increase in urban development in seismic prone areas and because aging building stock is particularly vulnerable to earthquakes."

▶In the past, we have focused on the earthquake hazard, the location and type of faulting and ground failure and the distribution of strong ground motion. We must now turn to an examination of the earthquake risk, the exposure of buildings, infrastructure, and the population to the potential effects of earthquakes, as we develop mitigation policies, priorities, and strategies."

Senior FEMA Officials

▶"There is an old saying: Earthquakes don't kill people—buildings do!"

▶"Earthquakes do not injure or kill people. Poorly built manmade structures injure and kill people."

▶"During the 20th Century, on average 20,000 people died from earthquakes each year. With the United States having four percent of the world's population, 760 of those deaths should have been in this country. Will we be as lucky in the 21st Century?"

▶"Based on worldwide statistics, there is a one percent chance of an earthquake causing one million fatalities in the 21st Century. There are only 125 cities in the world where this could occur and 20 of them are in the United States."

▶"During the 20th Century, worldwide, 5000 people lost their lives every 900 days in a single earthquake. What's in store for the United States in the 21st Century?"

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▶"To reduce earthquake risk we must mitigate. To mitigate we must implement."

▶"We as earthquake engineers take great pride in our building codes; however, until they are tested we will not know what we have achieved. They will be tested. It is only a matter of time."

James E. Beavers, Deputy Director, Mid-America Earthquake Center

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▶"We keep being surprised by earthquakes. We were surprised at Northridge in 1994 when a previously unappreciated thrust fault moved in an earthquake that saw accelerations well in excess of gravity. We were also surprised at how poorly some of the steel-frame buildings performed during that earthquake and at how much risk certain insurance companies had assumed. In 1999 we were surprised that over 15,000 people lost their lives in Turkey in an area where building codes and standards were supposed to have been as good as in this country. And in September 2000 we were surprised that a relatively small earthquake, a magnitude 5.2, caused over $50 million in damage near Napa, California, on yet another fault that hadn't been recognized as being active. How surprised will we be, in terms of business recovery, insurance and mortgage liability, infrastructure vulnerability, emergency preparedness and response, structural engineering, and Earth science, when the next damaging earthquake occurs? How surprised will we be when a magnitude 5 earthquake hits New York City? Or when a magnitude 6 quake hits Montreal or Boston? Or when a magnitude 7 quake hits Las Vegas? Or when a magnitude 8 earthquake again hits the San Francisco Bay area or Memphis? Or when a magnitude 9 earthquake simultaneously hits Seattle, Portland, and Vancouver? I think I can safely predict that we will be tremendously surprised, unless we are better prepared for the inevitable earthquakes."

▶"Over one million people throughout the world lost their lives from earthquakes in the last 100 years. We can hypothesize about the reasons why earthquakes in the United States appear to have had relatively few deaths. Perhaps it is due to our

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good understanding of the hazard and risk, or our economy is so good that we can afford to have strong building codes and enforce them well. But perhaps it is simply luck. Had the Northridge earthquake in 1994 struck while kids were in school, we would have almost assuredly seen many more deaths. If a major earthquake were to strike again in places that 100 or 200 years ago were not nearly as populated as they are today, and that includes almost everywhere in the U.S. - St. Louis, Seattle, and Reno - just how lucky would we be?"

Dr. Jonathan G. Price, President, Association of American State Geologists

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▶"Earthquakes in an area of low probability but high consequence, such as the central U.S., create their own special needs."

▶"Earthquakes will always find the weak link in our communities' infrastructure."

▶"For all that we know about earthquakes, they are still one of nature's most unpredictable hazards."

▶"Earthquakes are not just a west coast problem."

▶"Only through collaboration and coordination can the earthquake problem be truly addressed."

Jim Wilkinson, Executive Director, Central US Earthquake Consortium

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▶"Earthquakes and other natural events have devastated the places we live throughout our existence. In the 21st Century we have the opportunity, and the means, to change those longstanding patterns of destruction, and forge a new worldwide paradigm of sustainable resistance."

Jill Stevens-Johnston, Mitigation Coordinator for the Central US Earthquake Consortium

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▶"Earthquakes represent the largest single potential for casualties and damages from a natural hazard facing this country. They represent a national threat, as all but

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seven states in the US are at some level of risk. In our most recent earthquake disaster, Northridge, a moderate earthquake centered on the fringe of a major metropolitan area caused an estimated $40 billion in damage."

FEMA statement before the Subcommittee on Basic Research, Committee on Science, United States House of Representatives, 2/23/99

▶"While casualties have been dramatically reduced in recent US earthquakes, the dollar losses of widespread, non-life threatening damage are gigantic — over $30 billion in Northridge — and this damage also leads to business interruption, loss of housing, insurance instability, and loss of jobs. Estimates are that future single earthquakes...may result in losses of $50-100 billion. Thus, our codes and design and construction practices are only partially successful — if the war against death is almost won, the war against destruction is far from over."

▶"While improved codes and design practices have made great advances possible in the design of new buildings; the main threat lies in the nation's inventory of vulnerable existing buildings."

▶"Like other social problems, the earthquake hazard will not be addressed adequately until we understand both the social processes that produce earthquake vulnerability and the policy steps that need to be taken to reverse those processes."

▶"Studies of the effects of a 7.0 magnitude earthquake in the Hayward fault in the east San Francisco Bay show that as many as 100,000 (housing) units could be lost and around 50,000 units of temporary housing could be needed. To our knowledge, no plans are in place, at state or federal levels, to deal with this level of temporary housing need. We believe that this is a potential social disaster waiting to happen."

▶"The most effective ways of reducing the seismic hazard are to construct well-engineered new buildings and seismically to rehabilitate hazardous existing buildings. The same principles apply to our transportation and utility infrastructure.

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The first involves the adoption and maintenance of good codes and building practices in all seismic regions. Good progress is being made in this area. The second is much more difficult, because investments in earthquake risk reduction do not result in immediate paybacks and financial returns to the investor. Therefore, building owners are often reluctant to upgrade existing structures and instead elect to invest money in projects that offer a more immediate prospect of financial return. Also, there are currently no financial incentives in place, such as tax credits or low-interest loans, to make these investments more attractive."

▶"Over the next twenty years, most of the nation's seismic risk will be the result of vulnerability that already exists in our existing infrastructure. Unless ways are found to encourage the active reduction of this risk, progress in this area is likely to be quite slow."

▶"I believe that the earthquake risk can be substantially reduced, but it will take generations, and continuous planning and effort by government agencies, institutions, professions, owners and the general public...it is necessary also to improve our disaster response methods and management."

▶"...we must ensure that the pace of urban development does not overtake our mitigation efforts, so that we are running fast but standing still. Thus, we must continue to plan and work on all fronts and the federal government must continue to provide the support that is needed at the local level and to the design professions."

Chris Arnold, Earthquake Engineering Research Institute,
Testimony and answes before the House Committee on Science, Subcommittee on Basic Research, February 23, 1998

▶"...most pervasive images and lessons from both the Turkey and Taiwan earthquakes are...thousands of failures on non-ductile concrete buildings. Non-ductile concrete structures are a serious problem for the US. Not only do we have a

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significant inventory of non-ductile concrete buildings in California, but we have a very significant inventory of non-ductile concrete buildings outside California in places like Washington State, the New Madrid area (Missouri, Tennessee, Arkansas adjacent to the Mississippi River, Charleston, SC, and Boston, MA, etc. This places a substantial portion of the US building stock at risk from high impact, low recurrence earthquakes.

▶"We should not think that we are safe because our code adoption and compliance are better than Turkey's. Upwards of 80 percent of the US building stock in earthquake-vulnerable areas was designed before modern ductile design principles were incorporated in codes."

▶"There is an urgent need to develop an inventory of buildings in seismically active areas of the US to identify where non-ductile concrete buildings and other vulnerable structures (e.g., unreinforced masonry and open first story wood frame apartments) are located. All citizens should have access to knowledge about the buildings they live and/or work in, but this type of inventory is not currently available.

▶"We can do little to reduce the hazard embodies in an active fault or a major earthquake, but we can do a lot about the risk to the structures that we design and build. It is important to remember the frequently quoted observation that earthquakes do not kill, but collapsed buildings and facilities do."

Professor Thomas O'Rourke, Cornell University,
Testimony and answers before the House Committee on Science, Subcommittee on Basic Research, Hearing on the Turkey, Taiwan and Mexico City Earthquakes: Lessons Learned