THE JAPAN EARTHQUAKE & TSUNAMI AND WHAT THEY MEAN FOR THE U.S.

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The Federal Emergency Management Agency (FEMA) and the multi-agency National Earthquake Hazards Reduction Program (NEHRP) joins with the rest of the United States and indeed the rest of the world in expressing our concern to the Japanese people as they recover from their historic magnitude 9.0 earthquake and resulting tsunami. Our thoughts and prayers go out to all who were affected by this ongoing tragedy.

Immediately after the earthquake, NOAA's Pacific Tsunami Warning Center and West Coast and Alaska Tsunami Warning Center both issued tsunami warnings for Hawaii, the U.S. West Coast, Alaska and the island territories in the Pacific. Fortunately, the tsunami generated by this earthquake which hit Hawaii and the West Coast caused relatively minor damage that was generally limited to beach front and harbor facilities. However, past tsunamis have been far worse, and the caution shown by Federal, State and local officials was certainly warranted. One only has to look back to 1960, when an earthquake in Chile resulted in a 35 ft tsunami in Hilo, Hawaii that killed 61 people to see that their caution was justified.

WHAT HAPPENED IN JAPAN

The Japan earthquake was on a subduction zone fault, where the Pacific tectonic plate is being pushed underneath Japan. This type of fault is responsible for the largest earthquakes and often generate large tsunamis. Interestingly, this earthquake was proceeded by a M7.2 and 3 M6+ foreshocks two days before. Fault modeling suggests a rupture zone of 350x150 km in size with peak slips of 18+ meters. Aftershocks from this earthquake have included one M7, almost 50 M6, and hundreds of M5 and smaller. In addition, this event also triggered separate earthquakes in western Honshu (M6.1) and offshore northwestern Honshu (M6.6).

The earthquake damage in Japan was limited, partly because of the epicenter was almost 100 km from shore, but mostly due to the building codes that Japan has in force. Japanese building codes are more restrictive than those in the US as they call for building designs that are stronger and consequently more expensive. This philosophy appears to have paid off as we have not seen the collapse of any engineered buildings. While ground motion values may have been minimized by the distance of the epicenter, this was a very long duration earthquake, which is common for subduction zone events. Long duration shaking is something we may not have fully accounted for in our building codes and may have worked some building components to the point of failure where shorter shaking duration would not have. The only building collapses we have seen so far have generally been of older wood residential buildings. Japanese home construction traditionally uses heavy tile roofs for protection from typhoon winds. However, these heavy roofs can overtax a wood frame home if it is not properly built or maintained.

While Japanese structures performed very well in the earthquake, we have heard many reports of damage to non-structural components, which are the building's architectural elements, utilities, contents, etc. This type of damage continues to be a problem that we have documented in every earthquake, and is often responsible for greater dollar losses than actually structural damage. This type of damage often also results in the loss of function of the facility. A common example of this type of damage is damage to piping, such as fire sprinkler heads breaking from ceiling impact. This type of damage to a critical facility such as a hospital, this can greatly impact a community's response and recovery. For residential buildings, this type of damage can include a water heater falling over if not strapped to a wall or the collapse of shelving or cabinets.

The tsunami generated by this earthquake was measured as high as 33 feet (10 meters) and was responsible for most of the damage and fatalities that we are now seeing. It was the first tsunami to strike a modern, developed coastline, and it was devastating. While Japan generally incorporates seawalls and other structural protection to protect most developed areas, this tsunami overwhelmed all of these defenses. The tsunami reduced most of the wood frame homes to kindling. However, there were also some examples of larger, heavier multi-story concrete structures that survived the tsunami.

The emergency management philosophy in both countries is that it is impossible to reasonably build residential structures that can withstand tsunami loads, and that the only way to protect the population is to train them to evacuate to high ground when a warning is given. For a tsunami whose source is far enough away, there are established warning systems that provide sufficient time for evacuations. For a near source tsunami like the one that just occurred in Japan, the warning is the earthquake itself. We have heard many reports of people evacuating to high ground, but obviously many were not able to evacuate.

WHAT THIS MEANS FOR THE U.S. - EARTHQUAKE

Our attention as both scientists and emergency managers can't help but turn closer to home and wonder what effects a similar earthquake might have on our country. The National Earthquake Hazards Reduction Program (NEHRP) is responsible for the coordination and support of Federal earthquake-related activities; see www.nehrp.gov. FEMA, along with NIST, NSF and USGS, work to advance earthquake knowledge and awareness as well as reduce future losses. There are several lessons from the Japan earthquake and tsunami for the U.S. that the NEHRP agencies will try to capture.

The earthquake confirmed the importance of proper building codes and building construction. The adoption and enforcement of an adequate building code is the most effective loss prevention measure that a State or community can do. This was the single most important difference between last year's Haiti and Chile earthquakes, and it was proven again in Japan. Using funding under the NEHRP, FEMA has a long history of working the nation's model building codes and consensus standards and continues to work with the industry to keep them current.

However, building codes only work when the data behind them is current and accurate. Earthquakes are really the only true testing lab for our building codes and design standards. It is imperative that the NEHRP agencies fund the investigation of building performance after every major earthquake. By evaluating how buildings and their components perform in an earthquake and by comparing that performance to actual ground motion data from recording instruments, we can better assess their performance and better calibrate our building codes and standards. Often, better knowledge has led to us being able to reduce conservatism in the code, making earthquake-resistant construction more cost effective. Such specific building performance data will also allow FEMA to better calibrate one of its newest products that is nearing completion; *Seismic Performance Assessment Methodology for Individual Buildings*, which is currently being developed for FEMA by the Applied Technology Council under their ATC-58 project and which will eventually be published as FEMA P-58.

The issue of nonstructural damage continues to be a critical one that we have seen occur in every earthquake. We have heard of at least one report of a hospital in Japan being rendered inoperable. FEMA has just completed a major rewrite of their guidance document, *Reducing the Risks of Nonstructural Earthquake Damage*, FEMA E-74. It is now far more extensive and provides protection criteria for many different components. This new publication can be found at http://www.fema.gov/plan/prevent/earthquake/fema74/index.shtm.

The earthquake also confirmed the importance of individual preparedness. When an earthquake, or any other major disaster strikes, it may take days for emergency services to be able to respond to all of those in need and for necessities such as water, food and power to be restored. Every family should plan for and be prepared to survive a major earthquake or other hazard. This includes making and following a plan on what to do when an earthquake strikes, having an earthquake supply kit stocked with water, food, medicines, and other supplies you and your family will need to survive at least 3 days and preferably a week, and teaching each family member what to do during and after an earthquake. There are several FEMA resources to help you do this, including:

- Earthquake Safety Checklist, FEMA 526, http://www.fema.gov/library/viewRecord.do?id=1664

- Earthquake Home Hazard Hunt Poster, FEMA 528, http://www.fema.gov/library/viewRecord.do?id=1666

- Earthquake Safety Guide for Homeowners, FEMA 530, http://www.fema.gov/library/viewRecord.do?id=1449

WHAT THIS MEANS FOR THE U.S. - TSUNAMI

The tsunami demonstrated the awesome power of water when it is unleashed in the form of a tsunami. In the last 150 years, deadly tsunamis have struck Hawaii, Alaska, California, Oregon, Washington, American Samoa, Puerto Rico, and the U.S. Virgin Islands. All US coastlines can be impacted by tsunamis, but some are at much greater risk. The type of fault that ruptured in Japan is almost identical to the Cascadia subduction fault that lies off the coast of Washington, Oregon and northern California. The Cascadia zone fault last ruptured in 1700, and is capable of unleashing a tsunami every bit as strong and as devastating as the one that struck Japan.

As described above, it is impossible to reasonably build residential structures that can withstand tsunami loads, and that the only way to protect the population is to train them to evacuate to high ground when a warning is given. For a near source tsunami like the one that just occurred in Japan or the one that would occur on the Cascadia fault, the warning is the earthquake itself.

This only works when residents and visitors are properly trained and aware of what to do immediately after an earthquake. Such training and awareness is an ongoing task for local officials. This also only works when the population can reach high ground within the 15-30 minutes. For locations where high ground is not accessible, FEMA worked with NOAA to develop and publish *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis*, FEMA P-646, which is a technical guide on the design and construction of vertical evacuation shelters and can be found at http://www.fema.gov/library/viewRecord.do?id=3463 and *Vertical Evacuation from Tsunamis: A Guide for Community Officials*, FEMA P-646a, which is a non-technical guide for community leaders on how to specify and use vertical evacuation shelters and can be found at http://www.fema.gov/library/viewRecord.do?id=3808. The FEMA P-646 Guidelines document builds on early vertical evacuation work done in Japan.

FEMA is a partner agency of the National Tsunami Hazard Mitigation Program (NTHMP), which is led by NOAA and includes all 29 U.S. coastal States, Territories and Commonwealths, and the USGS. The community-focused partnership is designed to reduce the impact of tsunamis on U.S. coastal communities, enabling all levels of government to work toward the common goal of saving lives of people at tsunami risk along our Nation's coastlines, and reducing damage to property and the economy. For more information, see http://nthmp.tsunami.gov/.

FEMA is committed to not only preparing for tsunami and other disasters, but to mitigating damage to those kinds of events when they do occur. Through the NTHMP, FEMA and its partners work with high-risk communities on signage for awareness; developing evacuation maps and inundation maps from inundation models; use of science and technology to identify and assess the hazard; development and implementation of community education and outreach programs; providing decision-makers with tools to develop tsunami hazard mitigation plans and procedures; supporting land use planning to minimize tsunami risk whenever possible; support improved building codes, standards and practices to ensure buildings which could potentially be affected are as resilient as possible.

FEMA and its partners are helping the nation prepare for, and mitigate, tsunami hazards, but there are also steps the public should take now:

- Be aware of your surroundings and which areas are most at risk (that includes home, workplace, schools, etc.) You can find tsunami inundation maps for your state here:
    - California -- http://www.conservation.ca.gov/cgs/geologic_hazards/Tsunami/Inundation_Maps/Pages/Statewide_Maps.aspx
    - Oregon – http://www.oregongeology.com/sub/earthquakes/coastal/Tsumapsbycity.HTM

- Washington – http://www.emd.wa.gov/hazards/haz_tsunami.shtml
- Alaska – http://www.aeic.alaska.edu/tsunami/index.html
- Hawaii -- http://www5.hawaii.gov/tsunami/

- Know the hazard zones, evacuation routes, and locations of the nearest high ground, tsunami shelter and/or assembly area where you live, work, and visit by contacting your local or state emergency management agency. Practice the safe walking route to shelter and assembly areas. Be sure you understand the evacuation plans of your child's school.

- Visit http://www.ready.gov for more information on forming a family disaster plan, building a family disaster supply kit, and staying informed.

- Sign up to receive Tsunami Warning Center email or text messages at http://weather.gov/ptwc/subscribe.php or http://wcatwc.arh.noaa.gov/watcher/tsunamiwatcher.phptsunami

- Learn more about tsunami science and what you can do to help at http://nthmp.tsunami.gov/index.html

- Learn more about vertical evacuation and other ways you can stay safe during a tsunami at: http://www.fema.gov/hazard/tsunami/index.shtm

FEMA's mission is to support our citizens and first responders to ensure that as a nation we work together to build, sustain, and improve our capability to prepare for, protect against, respond to, recover from, and mitigate all hazards.