Report cites 'liquefaction' as key to much of Japanese earthquake damage

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Liquefaction induced by the recent earthquake in Japan caused nearly three feet of settlement at this water purification plant that serves 19,000 people, breaking pipes and flooding underground structures. Measuring the damage are Jennifer Donohue, a member of the Geotechnical Extreme Events Reconnaissance team with Geosyntec Consultants, and an engineer from the Wanigawa Water Purification Plant. (Photo by Scott Ashford, courtesy of Oregon State University)

(PhysOrg.com) -- The massive subduction zone earthquake in Japan caused a significant level of soil "liquefaction" that has surprised researchers with its widespread severity, a new analysis shows.

The findings also raise questions about whether existing building codes and engineering technologies are adequately accounting for this phenomenon in other vulnerable locations, which in the U.S. include Portland, Ore., parts of the Willamette Valley and other areas of Oregon, Washington and California.

A preliminary report about some of the damage in Japan has just been concluded by the Geotechnical Extreme Events Reconnaissance, or GEER advance team, in work supported by the National Science Foundation.

The broad geographic extent of the liquefaction over hundreds of miles was daunting to experienced engineers who are accustomed to seeing disaster sites, including the recent earthquakes in Chile and New Zealand.

"We've seen localized examples of soil liquefaction as extreme as this before, but the distance and extent of damage in Japan were unusually severe," said Scott Ashford, a professor of geotechnical engineering at Oregon State University and a member of this research team.

"Entire structures were tilted and sinking into the sediments, even while they remained intact," Ashford said. "The shifts in soil destroyed water, sewer and gas pipelines, crippling the utilities and infrastructure these communities need to function. We saw some places that sank as much as four feet."

Some degree of soil liquefaction is common in almost any major earthquake. It's a phenomenon in which saturated soils, particularly recent sediments, sand, gravel or fill, can lose much of their strength and flow during an earthquake. This can allow structures to shift or sink and significantly magnify the structural damage produced by the shaking itself.

But most earthquakes are much shorter than the recent event in Japan, Ashford said. The length of the Japanese earthquake, as much as five minutes, may force researchers to reconsider the extent of liquefaction damage possible in situations such as this.

"With such a long-lasting earthquake, we saw how structures that might have been okay after 30 seconds just continued to sink and tilt as the shaking continued for several more minutes," he said. "And it was clear that younger sediments, and especially areas built on recently filled ground, are much more vulnerable."

The data provided by analyzing the Japanese earthquake, researchers said, should make it possible to improve the understanding of this soil phenomenon and better prepare for it in the future. Ashford said it was critical for the team to collect the information quickly, before damage was removed in the recovery efforts.

"There's no doubt that we'll learn things from what happened in Japan that will help us to mitigate risks in other similar events," Ashford said. "Future construction in some places may make more use of techniques known to reduce liquefaction, such as better compaction to make soils dense, or use of reinforcing stone columns."

The massive subduction zone earthquakes capable of this type of shaking, which are the most powerful in the world, don't happen everywhere, even in other regions such as Southern California that face seismic risks. But an event almost exactly like that is expected in the Pacific Northwest from the Cascadia Subduction Zone, and the new findings make it clear that liquefaction will be a critical issue there.

Many parts of that region, from northern California to British Columbia, have younger soils vulnerable to liquefaction - on the coast, near river deposits or in areas with filled ground. The "young" sediments, in geologic terms, may be those deposited within the past 10,000 years or more. In Oregon, for instance, that describes much of downtown Portland, the Portland International Airport, nearby industrial facilities and other cities and parts of the Willamette Valley.

Anything near a river and old flood plains is a suspect, and the Oregon Department of Transportation has already concluded that 1,100 bridges in the state are at risk from an earthquake on the Cascadia Subduction Zone. Fewer than 15 percent of them have been retrofitted to prevent collapse.

"Buildings that are built on soils vulnerable to liquefaction not only tend to sink or tilt during an earthquake, but slide downhill if there's any slope, like towards a nearby river," Ashford said. "This is called lateral spreading. In Portland we might expect this sideways sliding of more than four feet in some cases, more than enough to tear apart buildings and buried pipelines."

Some damage may be reduced or prevented by different construction techniques or retrofitting, Ashford said. But another reasonable goal is to at least anticipate the damage – to know what will probably be destroyed, make contingency plans for what will be needed to implement repairs, and design ways to help protect and care for residents until services can be restored.

Small armies of utility crews are already at work in Japan on such tasks, Ashford said. There have been estimates of $300 billion in damage.

The recent survey in Japan identified areas as far away as Tokyo Bay that had liquefaction-induced ground failures. The magnitude of settlement and tilt was "larger than previously observed for such light structures," the researchers wrote in their report.

Impacts and deformation were erratic, often varying significantly from one street to the next. Port facilities along the coast faced major liquefaction damage. Strong Japanese construction standards helped prevent many buildings from collapse – even as they tilted and sank into the ground.

More information: The GEER advance team report that was just published is available online at bit.ly/edQqhF

Provided by Oregon State University