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Symposium Highlights Findings from Indian Ocean Earthquake and Tsunami Investigations

By Mark Fitzgerald

ASCE's Technical Council on Lifeline Earthquake Engineering (TCLEE) and Coastal, Oceans, Ports and Rivers Institute (COPRI), together with the Institution of Civil Engineers (ICE), hosted a symposium at the Wilshire Grand Hotel in Los Angeles on October 25 that offered a variety of presentations from engineering and research specialists concerning observations and conclusions related to the earthquake and tsunami that occurred last December in the Indian Ocean. A major preliminary event of ASCE's 2005 Annual Civil Engineering Conference, the symposium featured two keynote addresses—analyses of both the earthquake and the tsunami—as well as a series of discussions concerning the damage that was caused to such lifeline facilities as ports, highways, bridges, water and sewer systems, pipelines, telecommunications and electrical systems, airports, and hospitals. Scientific information regarding earthquakes, tsunamis, and the environment was also covered, and many speakers emphasized the need for engineers to improve design, analysis, mitigation, and building codes.

The first keynote speaker, Lucile M. Jones, Ph.D., a geologist with the U.S. Geological Survey (USGS), began her discussion with a brief explanation of the geology and seismology of earthquakes. “The largest earthquakes in the world happen along the boundaries of subduction zones, which might have faults that are 200 kilometers wide,” she said after explaining that today’s experts base an earthquake’s magnitude on the seismic moment, which is calculated by multiplying the fault area by the degree of slip. “The 2004 Sumatra earthquake was the largest earthquake that we’ve recorded in the world in the last 40 years,” she continued. “It had larger magnitude than even the great Alaskan earthquake of 1964 and the seismic moment release was more than we’ve seen in the whole world over the last 30 years. So this was a huge event.”

Jones went on to discuss the potential of an earthquake happening along the Cascadia subduction zone, a fault that extends from mid-Vancouver Island to northern California and divides the Juan de Fuca Plate and the North American Plate. “We have our own tsunami waiting in the U.S.,” she said. “The good news is that in the Pacific Northwest we have a lot of cliffs and tsunamis can’t make it up over cliffs.” Emphasizing the importance of earthquake education and mitigation, Jones concluded by recognizing the need for engineers to design and build more resilient systems of infrastructure. “Earthquakes may be inevitable, but disaster does not have to be,” she observed. “Engineers who are designing to resist earthquakes need to remember that the biggest earthquakes really are much bigger than imagined—for every 10 earthquakes of a magnitude 7 we get one earthquake of a magnitude 8, but bear in mind that a magnitude 8 releases 30 times the energy of a magnitude 7.”

Robert A. Dalrymple, Ph.D., P.E., M.ASCE, a professor of civil engineering at Johns Hopkins University, was the second keynote speaker. Using research from tide records, numerical modeling, and videos of the tsunami, he presented an overview of the formation and progress of the waves that struck the coastal regions near the Indian Ocean. “The tide records tell us the amount of time that elapsed before the tsunami reached shorelines,” he explained. “They also show the reverberations of the tsunami bouncing around the Indian Ocean, and, in fact, bouncing around the world, because all of the oceans experienced the tsunami—it went on for days.”

Dalrymple also pointed out that the most credible models of the tsunami came from data that was obtained in the immediate days and weeks after the disaster. “It was important to get good ephemeral data,” he said. “Good tsunami modeling means good warning systems, but because it took a relatively long time for the earthquake to occur, anywhere from 6 to 13 minutes, and because the earthquake was so long, the tsunami actually went laterally to the earthquake propagation direction; so the earthquake ripped to the north and the tsunami went east and west. In the very near shores, where the waves are breaking, the challenges of modeling become more difficult, and that's where a lot of research is being done now."

Recognizing the need for coastal engineers and researchers to design numerical models that more accurately reflect how tsunamis form from earthquakes and how the resulting waves will break along certain coastlines, Dalrymple added: "We need to have better modeling of the bottom displacement and how the water responds to that displacement. As we start these propagation models, we need to know how the pre-surface of the wave begins and we need better modeling of the wave as it propagates into beaches, harbors, and communities."

ASCE's tsunami assessment team leaders—Curtis Edwards, P.E., M.ASCE, of the Thailand team; Donald Ballantyne, P.E., M.ASCE, of the Sri Lanka team; and Alex Tang, P.E., M.ASCE, of the India team—presented findings from their investigations and provided an update on the progress of the ongoing recovery and rebuilding efforts. In the afternoon, Amar A. Chaker, Ph.D., P.E., M.ASCE, discussed lessons that ASCE has learned from the tsunami and future actions that the Society might pursue in regard to post-disaster investigations, advancing civil engineering knowledge, the development of standards and reports, continuing education, and disaster mitigation advocacy. "ASCE has developed very good relationships with local folks in various countries, but what can it do to keep those relationships alive, beyond the initial field investigation and report?," asked Chaker. "In ASCE's reports, engineers mostly state facts and observations, but should the Society go beyond this and make recommendations in terms of codes and the enforcement of codes, planning and zoning, and in areas reconstruction?" Chaker went on to suggest that ASCE could also provide leadership by promoting advocacy for the roles of civil engineers in society, motivating civil engineers to consider individual elements of the built-environment as part of communities and systems, and offer guidance so that decision makers can make informed decisions.

Carl Strand, P.E., M.ASCE, the editor of a forthcoming monograph about the earthquake and tsunami, concluded the symposium by discussing the scope of TCLEE's final report which is scheduled to be released later this year. Although the nature of the devastation in Sri Lanka is still being analyzed, TCLEE has already released a preliminary manuscript, *Sumatra-Andaman Islands Earthquake and Tsunami of Dec. 26, 2004, Lifeline Performance Report*, which reflects findings of investigations (from Thailand, the Andaman and Nicobar Islands, and the South India Peninsula) into the damage of such lifelines as water supply, electricity, transportation infrastructure, and communication systems.

According to the preliminary report, an early tsunami warning system would have saved lives. The report also concludes that the destruction from the tsunami was caused by seawater contamination of the water supply and the impact of large debris picked up by the first wave and driven by the second and third waves. In addition, the report emphasizes the following recommendations for mitigating future damage from earthquakes and tsunamis: a regionally appropriate early warning system must be developed for each area; port facilities should institute comprehensive underwater survey and inspection programs for piers and wharves, as well as providing real time instrument systems such as tide gauges, seismograph, accelerometer and recording devices to automatically send out warnings of an impending tsunami after an earthquake; for low lying coastal areas, designers need to plan for tsunami inundation and the force of impact from waves and large debris (cars, trucks, boats, building parts, etc.) on lifelines such as pipelines, power and telecommunications systems, and elevated water supplies; vessels should immediately vacate harbor waters after an earthquake and sail to deep water, using their whistles as an interim early warning system; and critical facilities should be designed on robust foundations with flow-through first stories, limited structural areas facing the tsunami, and drainage control for the ebbing tide.

"There is a lot of editing still to be done," Strand noted. "But we are going to do our best to get as much as we can into a final format by the tsunami's anniversary, which will be December 26. We plan on incorporating findings from the Sri Lanka investigation and making further recommendations. We expect that this will be a publication that is going to be around for a long time, so we're working in a very professional manner towards a monograph that I think ASCE and TCLEE and everybody can be proud of."