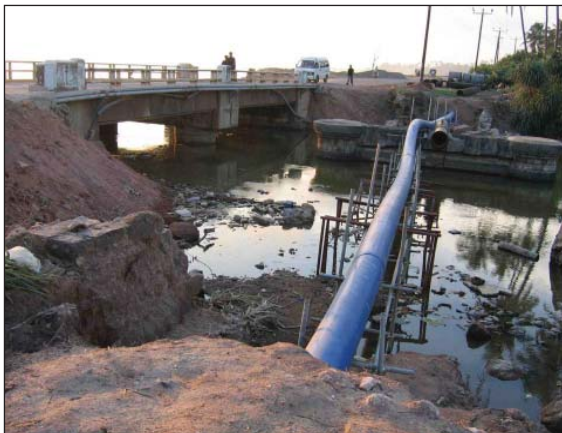


# SUMATRA-ANDAMAN ISLANDS EARTHQUAKE AND TSUNAMI OF DECEMBER 26, 2004 LIFELINE PERFORMANCE

Edited by Carl Strand and John Masek



Technical Council on Lifeline Earthquake Engineering

Monograph No. 29  
October 2005

*Preliminary—For Comment Only*

**ASCE**

**Sumatra-Andaman  
Islands Earthquake  
and  
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## Abstract

On December 26, 2004, one of the largest earthquakes to occur during the last hundred years began approximately 160 km west of northern Sumatra. From its epicenter, the fault rupture propagated approximately 1,250 km in a northerly direction along the Andaman-Sunda subduction zone. The moment magnitude ( $M_w$ ) for this earthquake has been calculated to be between 9.0 and 9.3. The average slip is estimated to have been 20 m for the southern half of the rupture and 7 m for the northern half. There was a 4 m to 5 m vertical component to the rupture, which caused a sudden displacement of the overlying water column, setting in motion a transoceanic tsunami that struck coasts along the Andaman Sea, Bay of Bengal, Indian Ocean, and Arabian Sea.

Casualties and damage to lifelines were caused by the earthquake shaking and by the tsunami in northern Sumatra, the islands off the west coast of northern Sumatra, and the Andaman-Nicobar Archipelago. The other areas where casualties or damage to lifelines were incurred during this event were affected solely by the tsunami, even though the earthquake was lightly felt in many of those areas. The earthquake, tsunami, or both affected a wide variety of lifelines. In the aftermath, there was an unprecedented outpouring of assistance from countries all over the world.

Many of those who perished might have been saved if there had been a regional tsunami-warning system. Implementing such a system will be a major challenge—not only in terms of the technology required, but also the public education and repetitive drills.

## Preface

The Earthquake Investigation Committee of the Technical Council of Lifeline Earthquake Engineering (TCLEE), American Society of Civil Engineers (ASCE), was established to initiate, organize, train for, coordinate and evaluate the performance of lifelines following earthquakes. Members of the committee are employees of lifeline industries, consulting engineers, and academics from the United States and Canada. Committee members provide services on a voluntary basis. For some earthquake investigation, companies do not require an individual to take vacation time for the investigation and may provide some support for expenses. ASCE also provides support to partially reimburse expenses. In addition to the time and expense associated with the reconnaissance trip, the substantial effort by each individual to prepare a short report for the TCLEE Web page and the full report for the monograph series is all done on a voluntary basis. The cost of this effort is from 10 to 30 or more times the support that is provided by ASCE.

Individuals participating in the investigation need not be members of the committee or members of ASCE, but are expected to follow the committee's earthquake investigation practices as described in the ASCE publication, "Guide to Post-earthquake Investigation of Lifelines." Members of the investigation team coordinate with other groups and may participate in groups organized by other organizations. They gather both good and poor performance data, from domestic and foreign earthquakes, in order to provide information for practitioners to improve the performance of the lifeline systems. The foreign earthquakes that have been investigated include the 1985 Chile, 1988 Soviet Armenia, 1990 Philippines, 1991 Costa Rica, 1992 Turkey, 1994 Kobe, 1999 Kocaeli, 1999 Chi-Chi, and 2003 Algeria earthquakes.

The Kobe earthquake report was the first foreign earthquake investigation report published by ASCE as a TCLEE monograph. The first domestic earthquake investigation report published by ASCE as a TCLEE monograph was for the Northridge earthquake. Prior to this time TCLEE prepared a lifeline report that was published by the Earthquake Engineering Research Institute (EERI). The Earthquake Investigation Committee continues to cooperate with EERI to provide an abbreviated version of lifeline performance in Earthquake Spectra (EERI publication). TCLEE also publishes brief preliminary reports on the ASCE/TCLEE Web page.

To provide information on the tectonic and ground motion data, experts in these fields are often asked to contribute to the reconnaissance report. This information is of value in providing a perspective to the lifeline damage report.

Alex Tang

September 2005

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- No. 1 Recent Lifeline Seismic Risk Studies, Kiremidjian, Anne S., Editor, 1990.
- No. 2 Seismic Lost Estimates for a Hypothetical Water System, A Demonstration Project, Taylor, Craig E., Editor, August 1991.
- No. 3 Guide to Post-Earthquake Investigations of Lifelines, Schiff, Anshel J., Editor, August 1991.
- No. 4 Lifeline Earthquake Engineering, Proceedings of the 3rd U.S. Conference on Lifeline Earthquake Engineering, August 22-23, 1991, Los Angeles, CA, Cassaro, Michael, Editor, August 1991.
- No. 5 Lifeline Earthquake Engineering in the Central and Eastern U.S., Ballantyne, Donald, Editor, September 1992.
- No. 6 Lifeline Earthquake Engineering, Proceeding of the 4th U.S. Conference on Lifeline Earthquake Engineering, August 10-12, 1995, San Francisco, CA, O'Rourke, Michael J., Editor, August 1995.
- No. 7 Critical Issues and State of the Art on Lifeline Earthquake Engineering, Schiff, Anshel J. and Buckle, Ian, Editors, October 1995.
- No. 8 Northridge Earthquake: Lifeline Performance and Post- Earthquake Response, Schiff, Anshel J., Editor, August 1995.
- No. 9 Seismic Design for Natural Gas Distributors, McDonough, Peter W., August 1995.
- No. 10 Methods of Achieving Improved Seismic Performance of Communications Systems, Tang, Alex, and Schiff, Anshel J., Editors, September 1996.
- No. 11 Guide to Post-Earthquake Investigation of Lifelines, Schiff, Anshel J., Editor, July 1997.
- No. 12 Seismic Guidelines for Ports, Werner, Stuart D., Editor, March 1998.
- No. 13 Overcoming Barriers: Lifeline Seismic Improvement Programs, Taylor, Craig E., Mittler, Elliott, and Lund, Le Val, September 1998.
- No. 14 Hyogo-Ken Nambu Earthquake of January 17, 1995-Lifeline Performance, Schiff, Anshel J. Editor, 1998.
- No. 15 Guidelines for the Seismic Evaluation and Upgrade of Water Transmission Facilities, Eidinger, John M. and Avila, Ernesto A., Editors, January 1999.
- No. 16 Optimizing Post-Earthquake Lifeline System Reliability (Proceedings of the 5th U.S. Conference on Lifeline Earthquake Engineering, Seattle, Washington, August 12-14, 1999.), Elliott, William M., and McDonough, Peter W., Editors, August 1999.
- No. 17 Ismit (Kocaeli), Turkey Earthquake of August 16, 1999, Including Duzce Earthquake of November 12, 1999 -Lifeline Performance, Tang, Alex K., Editor, September 2000.
- No. 18 Chi-Chi, Taiwan, Earthquake of September 21, 1999 -Lifeline Performance, Schiff, Anshel

J., and Tang, Alex K., Editors, October 2000.

No. 19 Gujarat (Kutch) India, M7.7 Earthquake of January 26, 2001 and NAPA M5.2 Earthquake of September 3, 2000, Eidinger, John M., Editor, June 2001

No. 20 The Nisqually, Washington, Earthquake of February 2001 - Lifeline Performance, McDonough, Peter W., Editor, February 2002

No. 21 Acceptable Risk Process - Lifelines and Natural Hazards, Taylor, Craig E., and VanMarcke, Erik H., Editors, March 2002

No. 22 Seismic Screening Checklists for Water and Wastewater Facilities, Heubach, William F., Editor, September 2002

No. 23 Atico, Peru Mw 8.4 Earthquake of June 23, 2001, edited by Curtis L. Edwards, October 2002

24 Lifeline Performance of El Salvador Earthquakes of January 13 and February 13, 2001, Le Val Lund, Editor and Carl Sepponen, Editor, September 2002

No. 25 Advancing Mitigation Technologies and Disaster Response for Lifeline System: Proceedings of the Sixth U.S. Conference and Workshop on Lifeline Earthquake Engineering, Beavers, J.E., Editor, August 2003.

## Other TCLEE Publications

Duke, C. Martin, Editor, *The Current State of Knowledge of Lifeline Earthquake Engineering*, Proceedings TCLEE Specialty Conference, August 30-31, 1977, Los Angeles, CA, (Later designated as the 1st U. S. Conference on Lifeline Earthquake Engineering), August, 1977.

Dowd, Munson, Editor, *Annotated Bibliography on Lifeline Earthquake Engineering*, 1980.

Smith, D. J., Jr., Editor, *Lifeline Earthquake Engineering, The Current State of Knowledge 1981*, Proceedings of the Second TCLEE Specialty Conference, August 20-21, 1981, Oakland, CA, (Later designated as the 2nd U. S. Conference on Lifeline Earthquake Engineering), August 1981.

Hall, William J., *Advisory Notes on Lifeline Earthquake Engineering*, 1983.

Nyman, Douglas, NSF Principal Investigator, *Guidelines for the Seismic Design of Oil and Gas Pipelines Systems*, TCLEE Committee on Gas and Liquid Fuels, 1984.

Cooper, James, Editor, *Lifeline Earthquake Engineering Performance, Design and Construction*, 1984.

Cassaro, Michael and Martinez-Romero, E., Editors, *The Mexico Earthquake, 1985, Factors Involved and Lessons Learned*, 1986.

Eguchi, Ronald and Crouse, C. B., *Lifeline Seismic Risk Analysis - Case Studies*, 1986.

Wang, Leon R. L. and Whitman, Robert, *Seismic Evaluation of Lifeline Systems-Case Studies*, 1986.

Cassaro, Michael and Cooper, James, Editors, *Seismic Design and Construction of Complex Civil Engineering Systems*, 1988.

Werner, Stuart D. and Dickenson, Stephen E., Editors, *Hyogo-Ken Nambu (Kobe) Earthquake of January 17, 1995: A Post-Earthquake Reconnaissance of Port Facilities*, TCLEE Ports Committee, 1996.

## **ASCE Manual**

Schiff, Anshel J., Editor, Guide to Improved Earthquake Performance of Electric Power Systems, ASCE Manual 96.

## **TCLEE Earthquake Investigation Reports**

TCLEE has also prepared numerous earthquake reports that have appeared in other publications. References to these reports and ten short reports associated with TCLEE monographs can be viewed on the ASCE/TCLEE web site address given below. The ten short reports are each about 5 to 15 pages long, contain a summary of main observations and some pictures and can be downloaded.

[www.asce.org/community/disasterreduction/tclee\\_home.cfm](http://www.asce.org/community/disasterreduction/tclee_home.cfm)