National Science Foundation – Geo-Engineering Earthquake Reconnaissance

Turning Disaster into Knowledge

Advancing earthquake-resistant design demands that we understand what happened when the earth last shook.

Overturning of slender building on shallow foundation in Adapazari, Turkey during the 1999 Kocaeli Earthquake (Observation made at N40.7841 E30.3998 on 8/25/99 at 1240).

Earthquake engineering is an experience-driven field. Documenting and sharing the key lessons learned from major earthquake events around the world contributes significantly to advancing research and practice in earthquake engineering. The importance of detailed mapping and surveying of damaged areas cannot be overemphasized as it provides the base data of well-documented case histories that drive the development of many of the design procedures used by engineers.

Many engineering methods are based on observations from past earthquakes. Field observations are particularly important in the field of geo-engineering, because it is difficult to replicate in the laboratory soil deposits built by nature over thousands of years. Much of the data generated by a major earthquake is perishable and therefore must be collected within a few days of the occurrence of the earthquake. Thus, engineers must be ready to investigate the next one.

NSF has historically supported geo-engineers, who have self-assembled to form effective post-earthquake reconnaissance teams. The documentation of the geotechnical effects of the 1999 Kocaeli earthquake through the joint EERI-NSF reconnaissance effort described in Youd et al. (2000) is a great example of what can be accomplished. The goals of the recently formalized

NSF-sponsored Geo-Engineering Earthquake Reconnaissance (GEER) Association are to advance the profession's capabilities to conduct post-earthquake reconnaissance and to interface more effectively with complementary organizations. GEER is developing an enhanced systematic approach and associated procedures for performing NSF-sponsored post-earthquake geo-engineering reconnaissance.

Many of the innovative techniques employed in recent post-earthquake reconnaissance efforts, such as use of digital photography, GPS devices, personal digital assistants, and digital mapping tools, were developed by NSF-sponsored geo-engineers working as part of GEER survey teams. The ability of GEER to respond rapidly and access creative ideas of both experienced and new geo-engineers is unmatched by any other organization. However, these efforts can be improved through better coordination and further innovation.

GEER is working to broaden, diversify, and train a new generation of geotechnical engineers in post-earthquake reconnaissance. It is also applying new technologies that can effectively contribute to post-earthquake reconnaissance, such as GPS (Global Positioning System), Airborne and Terrestrial LIDAR (LIght Detection And Ranging), and satellite optical and SAR (Synthetic Aperture Radar) images.

The GEER Association is led by the GEER Steering Committee, which is a group of geo-engineers who have considerable post-earthquake reconnaissance experience. The GEER Steering Committee receives guidance from a broad-based Advisory Panel. The GEER Advisory Panel is a larger group of prominent geotechnical engineers, earthquake engineers and scientists in related fields, and personnel belonging to organizations that actively participate in post-earthquake reconnaissance. The GEER Association currently has over a hundred members who support the goals of GEER and participate in its activities.

Together these engineers and scientists are ensuring that we understand what happened the last time the earth shook.

GEER Steering Committee
Jonathan Bray, Chair, Jean-Pierre Bardet, Co-Chair, David Frost, Robert Kayen, William Lettis, Ellen Rathje, Nick Sitar, and Leslie Youd

GEER Advisory Panel
D. Bloomquist, R. Borcherdt, R. Boulanger, L. Cluff, M. Crawford, R.E. Crippen, C. Edwards, S.L. Kramer, R. Hanson, L.F. Harder, Jr., W. Holmes, T.L. Holzer, I.M. Idriss, R.J. Love, J.R. Martin, II, R.S. Olsen, T.D. O'Rourke, C Scawthorn, R.B. Seed, P. Somerville, J.P. Stewart, K. Tierney, and H. Yeh.

NSF Program
GeoEnvironmental Engineering and GeoHazards Mitigation
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Website
GEER Association: http://gees.usc.edu/GEER/

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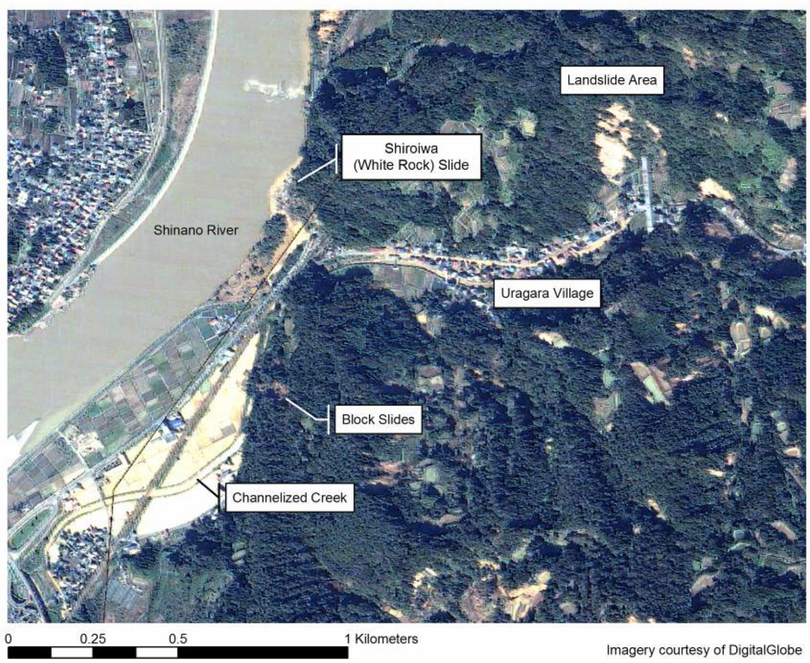
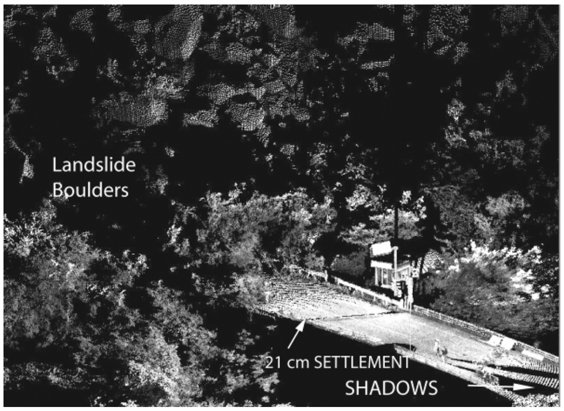


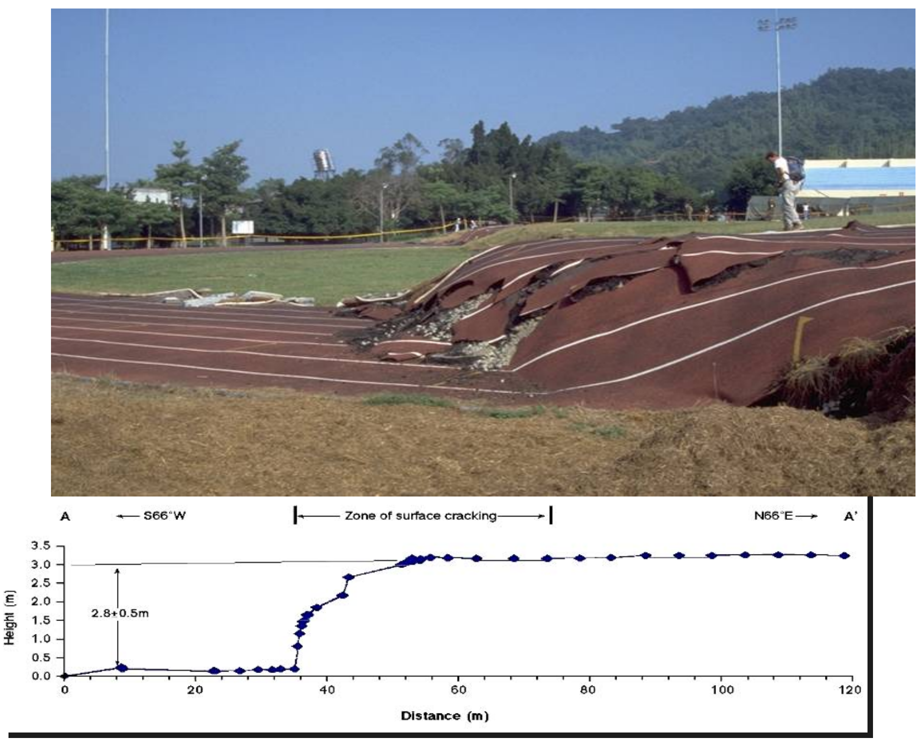


The reconnaissance for the 2004 Niigata Ken Chuetsu earthquake in Japan provided geo-engineers an opportunity to use new technologies in their field studies. Very high resolution (VHR) optical satellite images were used to document earthquake-induced landslides, including the Shiroiwa (White Rock) Slide. Additionally, aerial photography and terrestrial LIDAR were used to document this large failure and better understand its effect on the adjacent road and bridge.

Credit: *Rathje et al. (2006) "Remote Sensing Observations of Landslides and Ground Deformation from the 2004 Niigata Ken Chuetsu Earthquake," in* *Soils and Foundations*, *Japanese Geotechnical Society, 46(6), 831-842.(with partial NSF support).*

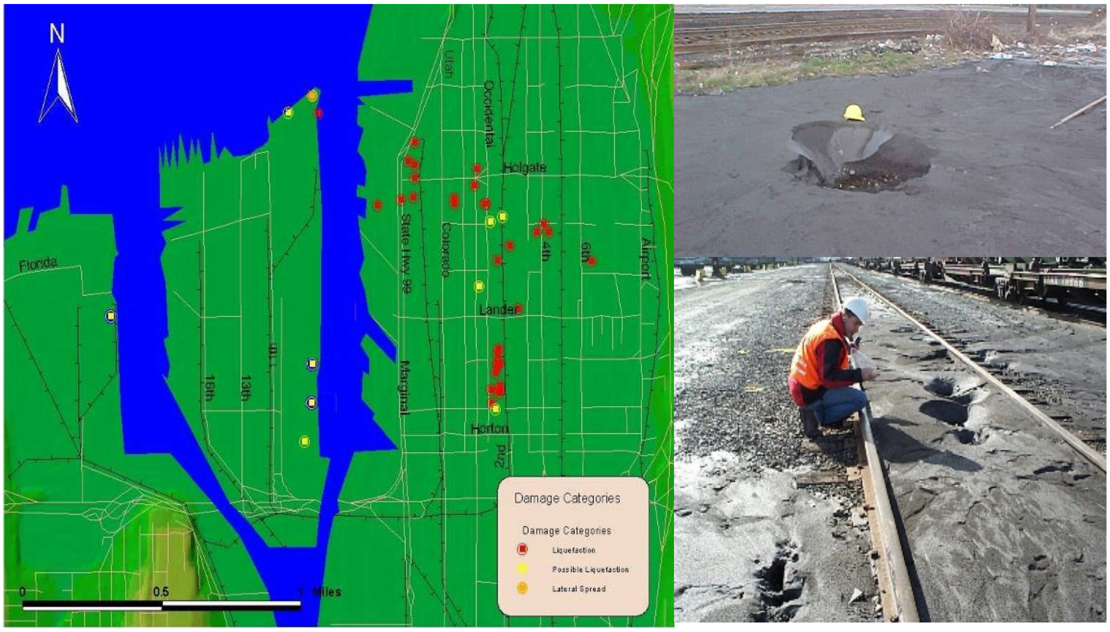
Geo-engineers after they have completed NSF-sponsored helicopter reconnaissance of the effects of the 1999 Chi-Chi, Taiwan earthquake. This event of magnitude 7.6 was well-recorded with hundreds of ground motion stations and provided an exceptional opportunity to learn about surface fault rupture, liquefaction, and landsliding.

Credit: *NSF-sponsored GEER Association*



Detailed mapping of surface fault rupture from the 1999 Chi-Chi, Taiwan earthquake that shows 2.8 m of vertical offset over a 20 m wide zone of deformation. This information is being used to develop mitigation design strategies for engineered systems, such as buried pipelines, that must cross active faults.

Credit: *NSF-sponsored paper by Kelson et al. (2001) "Fault-Related Surface Deformation," Chi-Chi, Taiwan, Earthquake of September 21, 1999 Reconnaissance Report, in Earthquake Spectra Journal, Suppl. A to Vol. 17, EERI, 2001, pp. 19-36.*



Map showing GPS-located incidents of liquefaction in the Seattle area and photographs of sand liquefaction resulting from the 2001 Nisqually, Washington earthquake. Geo-engineers were able to accurately locate areas of liquefied ground using hand-held GPS devices. Data were posted one week after the earthquake at http://gees.usc.edu/GEER/Nisqually/indexa.html

Credit: *NSF-sponsored GEER report by Bray et al. (2001) "Some Observations of Geotechnical Aspects of the February 28, 2001, Nisqually Earthquake in Olympia, South Seattle, and Tacoma, Washington," Pacific EQ. Engrg. Res. Cen.: <http://peer.berkeley.edu/nisqually/geotech/index.html>, March 8*.

This 5-story reinforced concrete building fell over when the silty soils liquefied beneath the shallow mat foundation of the building in Adapazari, Turkey during the 1999 Kocaeli Earthquake. This previously stable building was destroyed due to liquefaction below its foundation. This observation was made as part of a NSF-GEER reconnaissance team effort and was made at N40.7841 E30.3998 on 8/25/99 at 1240.

Credit: *Youd, T.L., Bardet, J.P., and Bray, J.D., Technical Editors, Kocaeli, Turkey Earthquake of August 17, 1999 Reconnaissance Report, in Earthquake Spectra Journal, Suppl. A to Vol. 16, EERI, 2000, 461 pp. (with partial NSF support).*