

Geotechnical Extreme Events Reconnaissance (GEER)

Reconnaissance Overview: Importance, Organization & Safety

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Geotechnical Extreme Events Reconnaissance
Turning Disaster into Knowledge

www.geerassociation.org





IMPORTANCE OF FIELD STUDIES

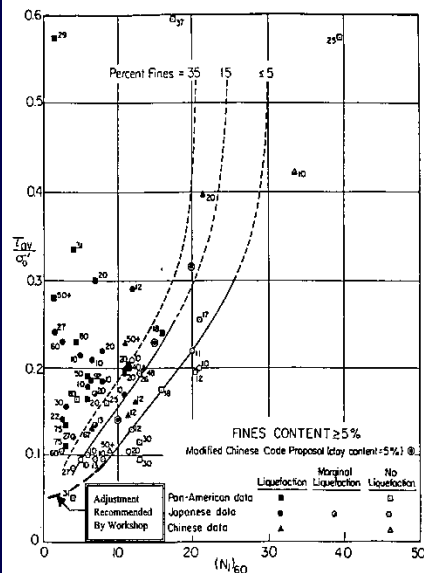


Geotechnical Engineering is an experience-driven field

Response of natural soil deposits cannot be replicated easily

Field observations shape our understanding

Provide the data that form design empirical procedures



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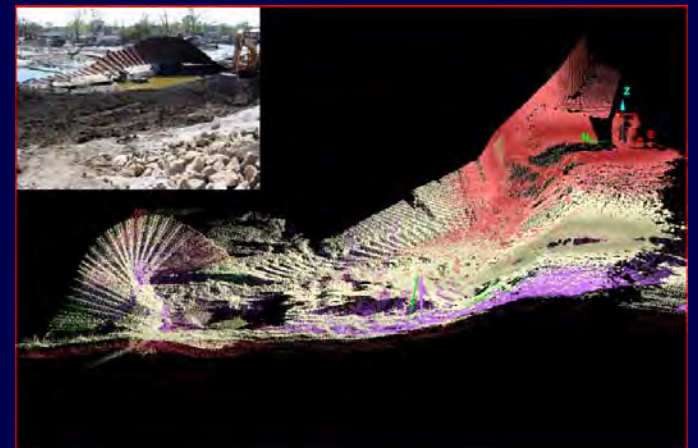


OBJECTIVES

Collect perishable data

Develop and implement new technologies

Document the geotechnical effects of extreme events to advance the profession's understanding





Geotechnical Extreme Events Reconnaissance



> 400 GEER Members & Volunteers

GEER Steering Committee



J. Bray
UCB



D. Frost
GaTech



E. Rathje
UT



S. Anderson
FHWA



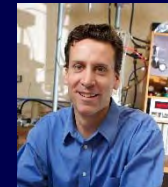
Y. Hashash
UI



L. Johnson
LJC



J. Keaton
AMEC



J. Wartman
UW



L. Wooten
GEI

GEER Advisory Panel

J.P. Bardet (UT-Arlington), R. Boulanger (UCD), M. Comerio (UCB; architect), M. Crawford (Purdue; satellite imaging), C. Davis (LADWP, lifelines), R. DesRoches (GT, structural engineer), C. Edwards (TCLEE), E. Fielding (NASA remote sensing), R. Gilbert (UT), R. Green (VT), L. Harder (HDR), T. Holzer (USGS), R. Kayen (USGS), A. Kammerer (NRC), E. Kavazanjian (ASU), S. Kramer (UW), W. Lettis (Lettis, geologist), S. Mahin (UCB, structural engineer), J. Martin (Clemson), S. Nikolaou (MRCE), R. Olsen (U.S. Corps of Engineers), T. O'Rourke (Cornell), A. Rosinski (CEC, geologist), N. Sitar (UCB), P. Somerville (URS; SCEC), K. Tierney (UC; Social Scientist), H. Yeh (OSU, Tsunami Researcher), L. Youd (BYU) & Y. Wang (OR Dept. of Geol. & Mining, geohazards)

GEER RECORDER: Estefan Garcia, UCB



NSF-Sponsored Geotechnical Extreme Events Reconnaissance



Recent GEER Reports

- 2013 Manitou Springs, CO Floods (Dashti et al. 2013)**
- 2014 Cephalonia, Greece EQs (Nikolaou et al. 2014)**
- 2014 Christchurch, New Zealand Flood (Allen et al. 2014)**
- 2014 Oso, Washington Landslide (Wartman et al. 2014)**
- 2014 South Napa EQ (Bray et al. 2014)**
- 2014 Iquique, Chile EQ (Rollins et al. 2014)**
- 2014 Southern California Storms (Keaton et al. 2015)**
- 2015 Central Texas Floods (Rathjet et al. 2015)**
- 2015 Gorkha, Nepal EQ (Hashash et al. 2015)**
- 2015 Illapel, Chile EQ (De Pascale et al. 2015)**
- 2015 Los Angeles Storms (Keaton 2015)**
- 2015 Midwest Floods (Rutherford et al. 2016)**
- 2015 Kfarnabrakh Landslide, Lebanon (El Mohtar et al. 2016)**
- 2015 South Carolina Floods (Fritz et al. 2016)**
- 2016 Meinong, Taiwan EQ (Sun et al. 2016)**
- 2016 Kumamoto, Japan EQs (Kayen & Dashti et al. 2016)**
- 2016 Central Italy EQs (Stewart et al. 2016)**
- 2016 Muisne, Ecuador EQ (Nikolaou et al. 2016)**
- 2016 Pawnee, OK EQ (Clayton et al. 2016)**
- 2016 Kaikoura, NZ EQ (Bradley et al. 2017)**



NSF-Sponsored GEER Response



GEER SC decision whether to respond or not considers:

- **Safety**
- **Will it add critical new data**
- **Opportunity to learn about new hypotheses or models**
- **Potential for a comparable event to occur in the US**
- **Availability of additional field data to supplement data gathered in the reconnaissance (e.g., strong ground motion instrumentation or pre-event survey data)**



NSF-Sponsored GEER Team Organization



1. **GEER SC identifies a Team Leader and provides a scope of the reconnaissance (e.g., budget)**
2. **Team Leader is responsible for the reconnaissance effort**
3. **Team Leader selects team members with input from SC. Diverse in terms of experience, age, gender, geographic location, etc. Provide opportunities to a wide range of researchers, so pool of experienced researchers grows. Invite local researchers and engineers (*our tent is large*).**
4. **GEER team performs reconnaissance *safely* adhering to *Ethics Protocol* and *Reconnaissance Guidelines***
5. **Publish initial PDF report within weeks after the event**

Safety

- Requires a culture of safety
- Plan for safety
 - First aid kit
 - Sturdy boots, rain gear, flashlight, etc
 - Extra everything (batteries, food)
 - Know locations of local hospital
 - Notify local US Embassy
- Do NOT take unnecessary risks!

Coordination

- Coordinated TEAM approach
 - Team leader establishes priorities in consultation with team members
 - Each day groups of 2-4 travel to the field
 - Evening meetings to share daily observations
 - Share KMZ files showing where each team went
 - Plan activities for the next day

Logistics

- Expenses
 - Reimbursable: travel costs (e.g., U.S. carrier airfare, hotel, food, incidentals)
 - Not Reimbursable: pre-travel clinic costs (shots, medication), field gear
- Travel
 - Coordinate arrival in country/city
 - Common hotel for team (generally)
- Field gear required
 - GPS, digital camera, laptop, cell phones, measurement devices, safety equipment, etc.

Part of a Coordinated NEHRP Response

GEER works with NEHRP organizations (FEMA, NIST, NSF, & USGS) and other organizations performing reconnaissance (e.g., ASCE TCLEE, DOTs, EERI LFE, NRC, PEER, USACE) and international collaborators to document the effects of extreme events

GEER focuses on geotechnical effects but works with other disciplines to address interdisciplinary fields such as seismology, tsunami, SSI, emergency response, and recovery





PRINCIPLES OF RECONNAISSANCE



- **Assess overall damage & identify key opportunities**
- **Will the documentation of effects advance profession?**
- **One well-documented case history > many photos of damage**
- **Team approach & systematic collection of perishable data**
- **Geocoded observations/measurements**
- **Employ remote sensing & digital data**
- **“Just the facts” - there is time later to figure out “why”**



Geo-engineering Extreme Events Reconnaissance
Turning Disaster into Knowledge



Systematic Documentation of Observations and Data



Ground Failure Index (Bray & Stewart 2000)

Index	Description	Interpretation
GF0	No observable ground failure	No settlement, tilt, lateral movement, or boils
GF1	Minor ground failure	Settlement, $\Delta < 10$ cm; tilt of > 3 -story buildings < 1 deg; no lateral movements
GF2	Moderate Ground Failure	$10 < \Delta < 25$ cm; tilts of 1–3 deg; lateral movements < 10 cm
GF3	Significant Ground Failure	$\Delta > 25$ cm; tilts of > 3 degrees; lateral movements > 25 cm.

GOOGLE EARTH™

Site Number -- RK38

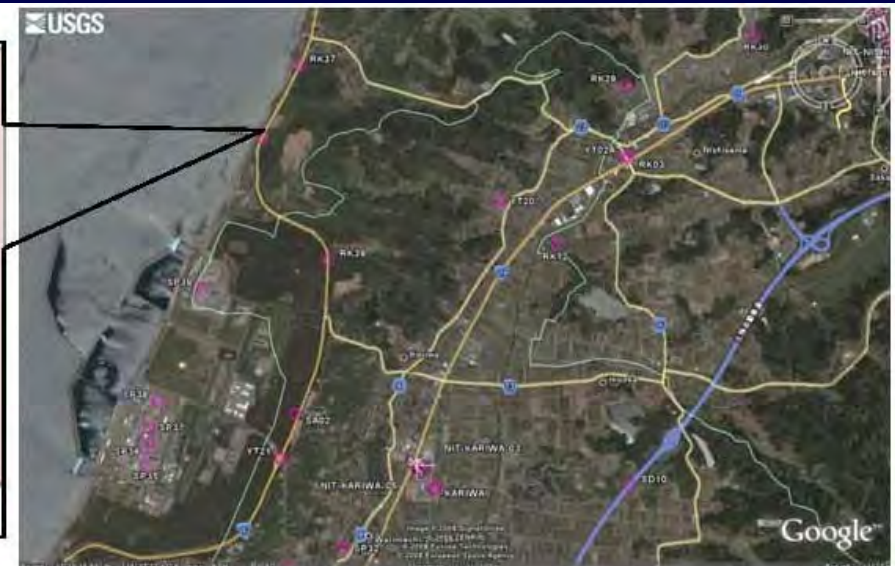
Name -- Coastal Road Embankment Failure - Failure of road fill and adjacent slope. Only upper 2m of slope moved, displacing one lane of the road. No debris was observed on the beach. Original fill-slope was inclined at 45°.

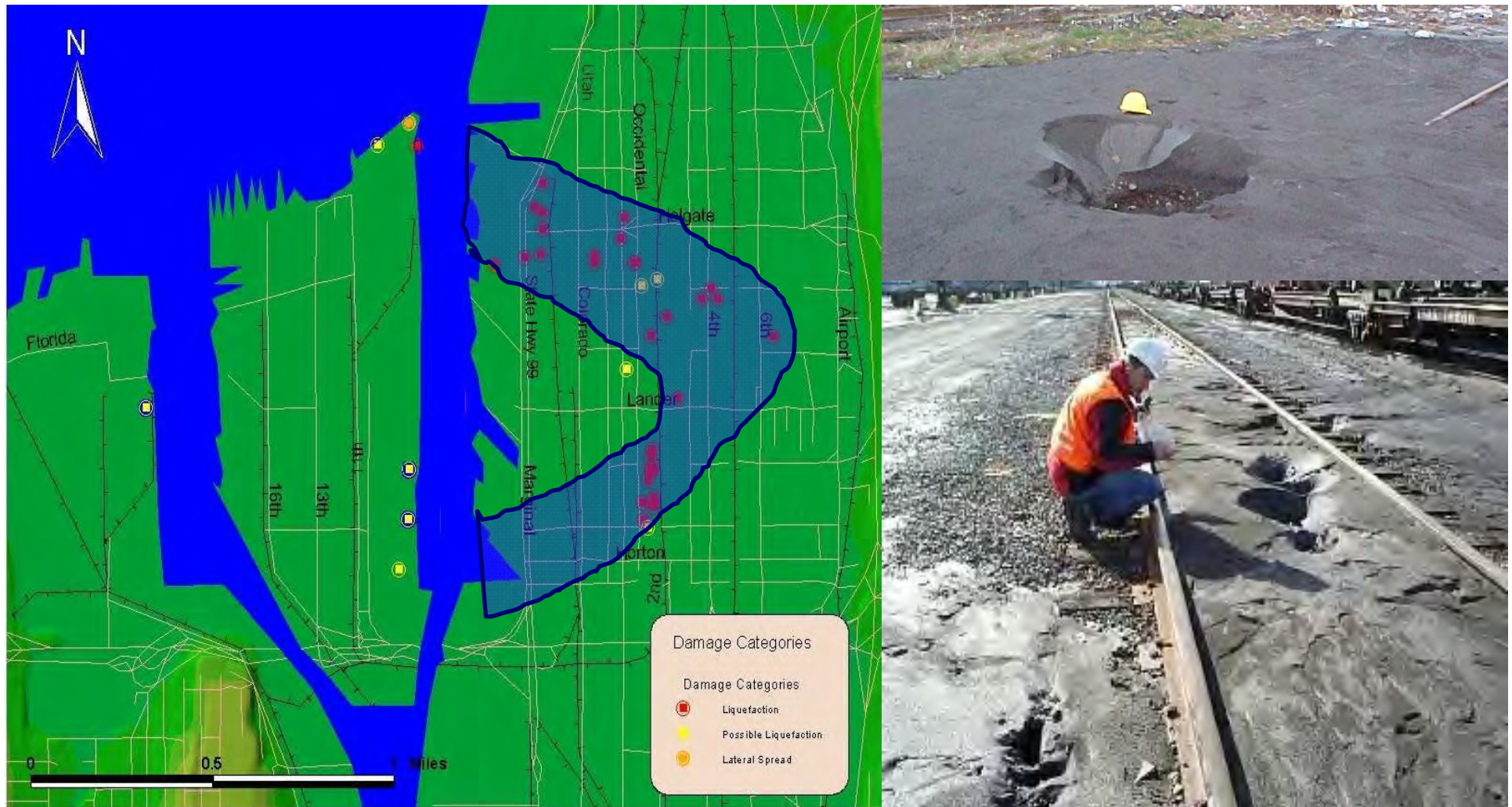
Lat (dec. deg.) -- 37.44927 Lon (dec. deg.) -- 138.60572



Road Embankment and Pavement Failure

Kayen et al. 2007

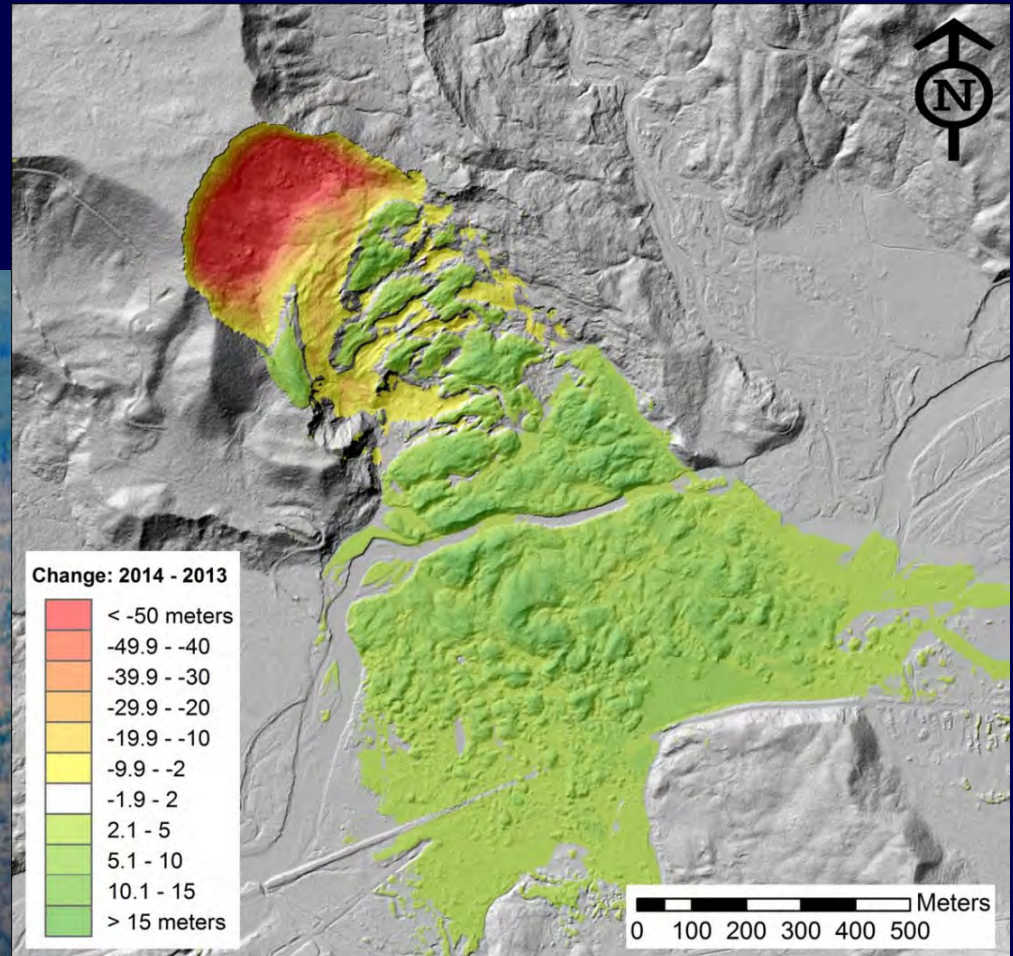




2001 Nisqually EQ: J. Bray, R. Sancio, A. Kammerer, S. Merry, A. Rodriguez-Marek, B. Khazai, S. Chang, A. Bastani, B. Collins, E. Hausler, D. Dreger, W. Perkins, & M. Nykamp; with J. Arnold, D. Booth, W. P. Grant, J. Hagedorn, M. Hamm, J. Hubbell, R. Hudson, S. Kramer, R. Mitchell, B. Muhunthan, S. Palmer, M. Vendetti, M. Wallinger, B. Topolski, K. Troost



Airborne LIDAR Survey *Light Detection and Ranging*



2014 Oso Landslide, Washington

Keaton & Wartman (2014) GEER Report No. GEER-036



Ground-Based LIDAR



**Optical & LIDAR Images: failed embankment on Ruta 5
(2010 Chile EQ - Kayen in Bray & Frost 2010)**





Aerial Reconnaissance



1999 Kocaeli, Turkey EQ



1999 Chi-Chi, Taiwan EQ





'Safest Ride' - 2014 South Napa EQ



California Highway Patrol



'Recent Ride' - 2016 Kaikoura EQ



GNS Science New Zealand

'Virtual Ride' - UAV (drone)

Flyover of 2014 S Napa EQ Fault - Z-Q Chen & M Chen of UMKC



80 high-resolution 4000 x 3000 pixel images provide 2.4 cm/pixel detail



Google Earth™



Central Business District, Christchurch, New Zealand



Google Earth™



15 FEB 2011



26 FEB 2011



26 APR 2012



22 MAR 2013

Central Business District, Christchurch, New Zealand

Geotechnical Effects of the 2010 Chile Earthquake

Jonathan Bray, UC Berkeley; David Frost, Georgia Tech; Ramon Verdugo, Universidad de Chile;
Christian Ledezma, Pontificia Universidad Catolica de Chile; Terry Eldridge, Golder Assoc.

Pedro Arduino, Univ. of Washington; Scott Ashford, Oregon State Univ.; Dominic Assimaki, Georgia Tech; David Baska, Terracon; Jim Bay, Utah State Univ.; R. Boroschek, Universidad de Chile; Gabriel Candia, UC Berkeley; Leonardo Dorador, Univ. de Chile; Aldo Faúndez, Servicio de Salud Arauco; Gabriel Ferrer, Pontificia Univ. Catolica de Chile; Lenart Gonzalez, Golder Assoc.; Youssef Hashash, Univ. of Illinois; Tara Hutchinson, UC San Diego; Laurie Johnson, Laurie Johnson Consulting; Katherine Jones, UC Berkeley; Keith Kelson, Fugro William Lettis & Assoc.; Rob Kayen, US Geological Survey; Gonzalo Montalva, Universidad de Concepcion; Robb Moss, Calif. Polytechnic Univ. SLO; Sebastian Maureira, Universidad de Chile; George Mylonakis, Univ. of Patras; Scott Olson, Univ. of Illinois; Kyle Rollins, Brigham Young Univ.; Nicholas Sitar, UC Berkeley; Jonathan Stewart, UC Los Angeles; Mesut Turel, Georgia Tech; Alfredo Urzúa, Prototype Engineering; Claudia Welker, Golder Assoc.; Rob Witter, DOGAMI; & **Chilean Air Force**

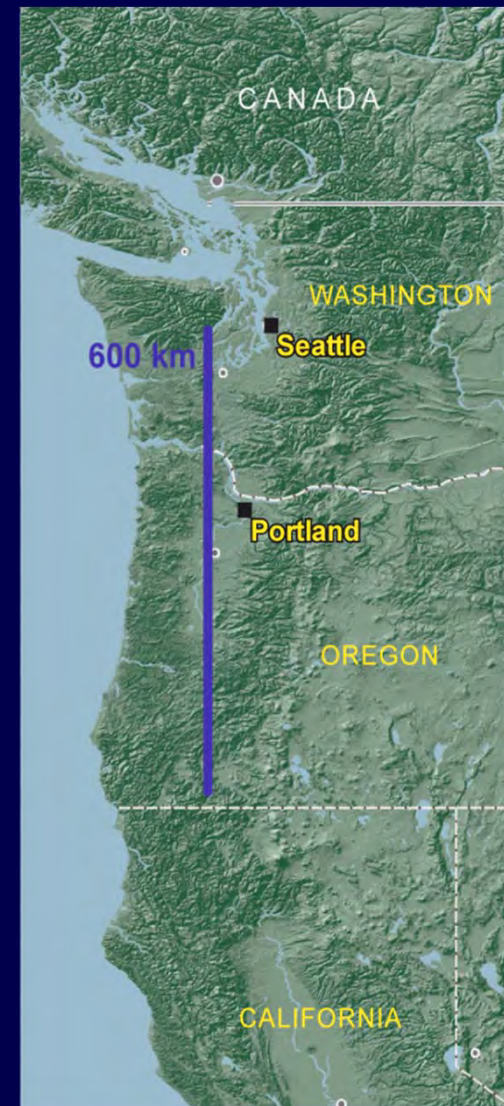
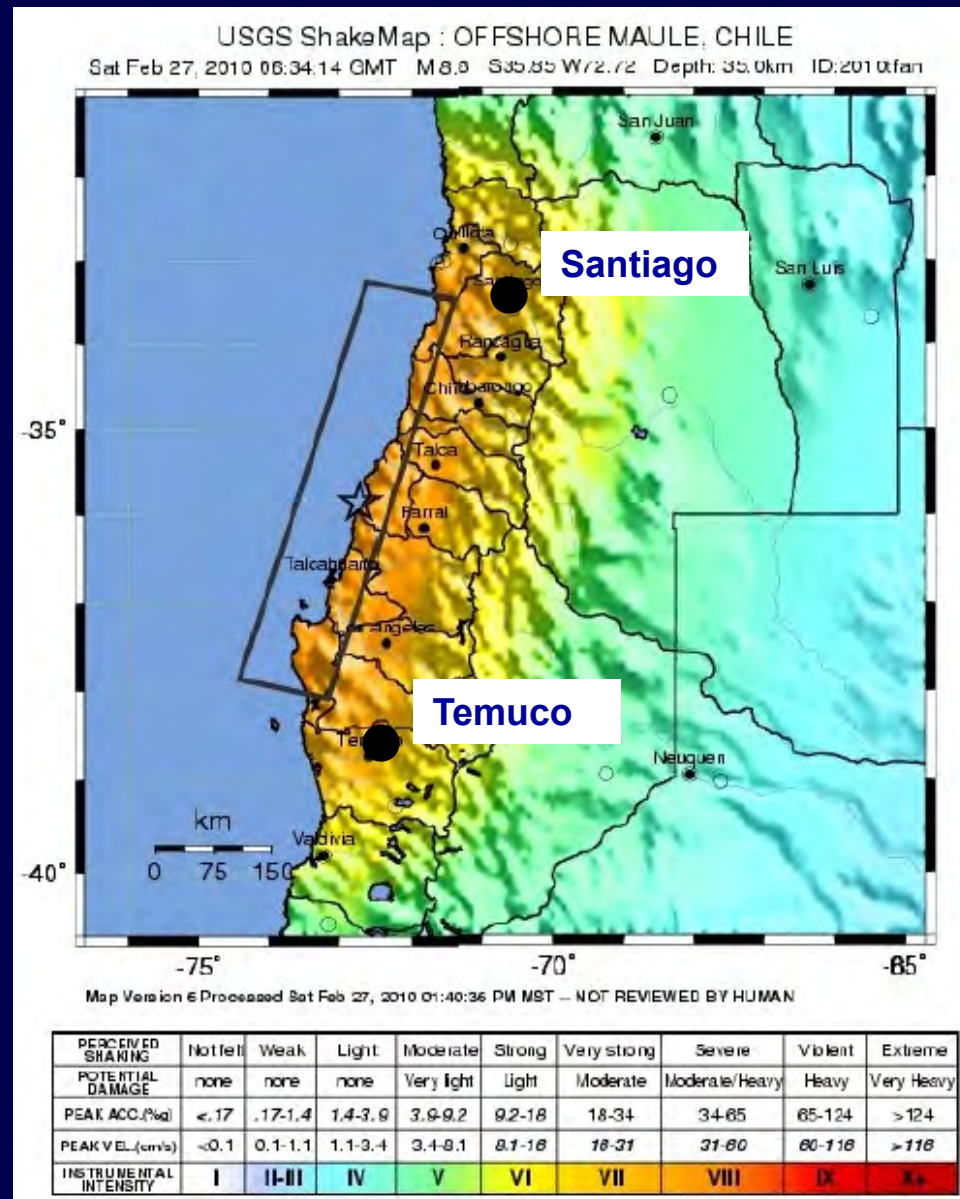


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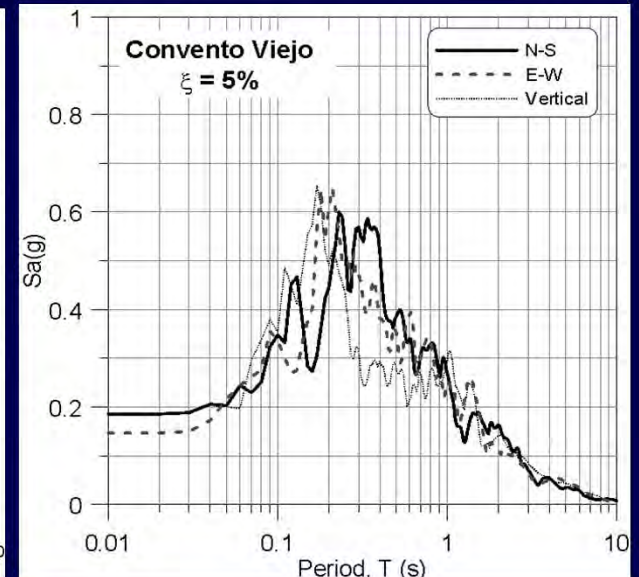
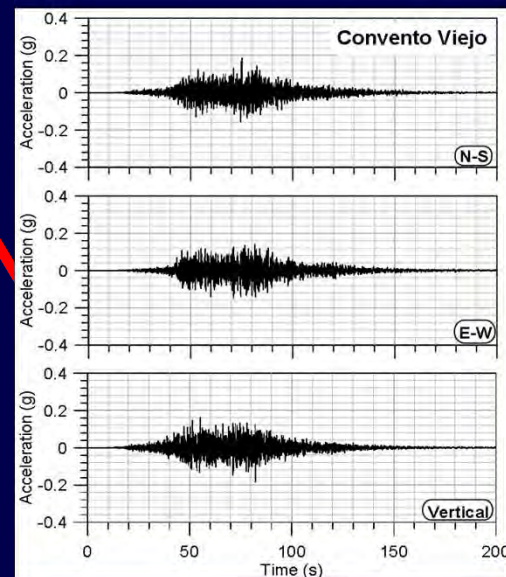
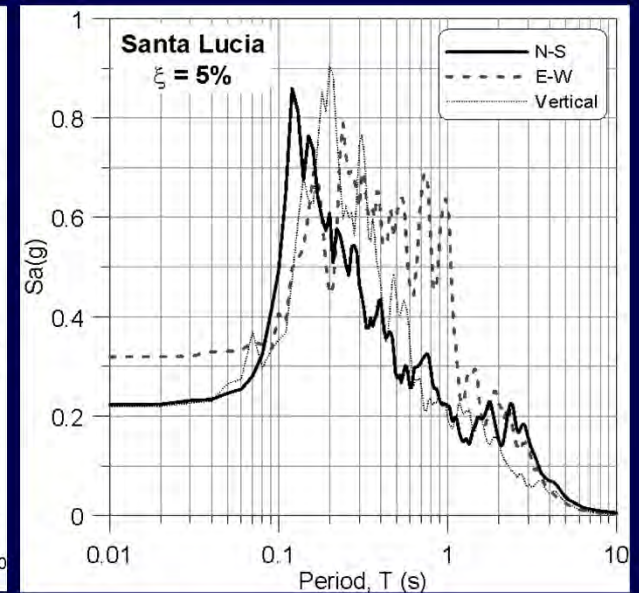
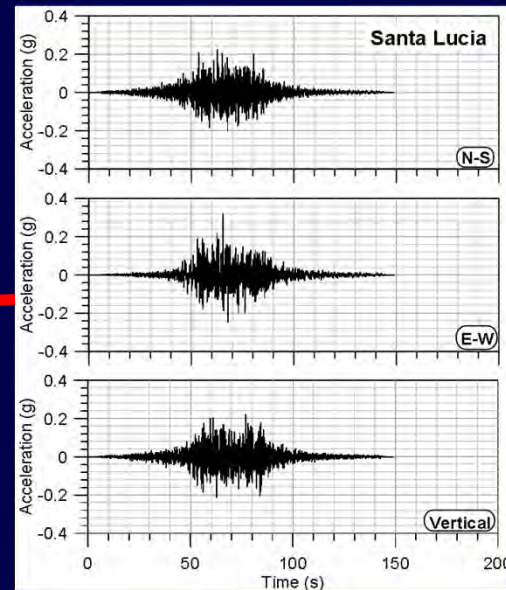
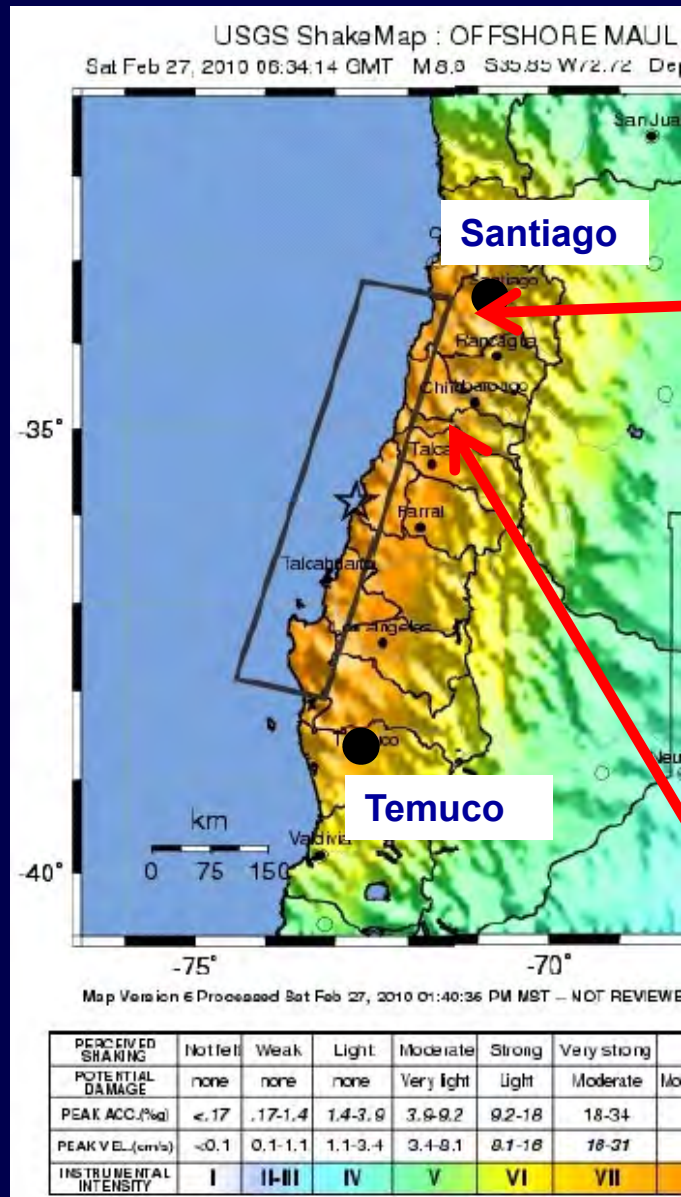
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M = 8.8 Chile Earthquake



M = 8.8 Maule Chile EQ Ground Motions



Verdugo et al. 2012

Significant Geotechnical Observations: (e.g., Chile's Port Facilities)



San Antonio

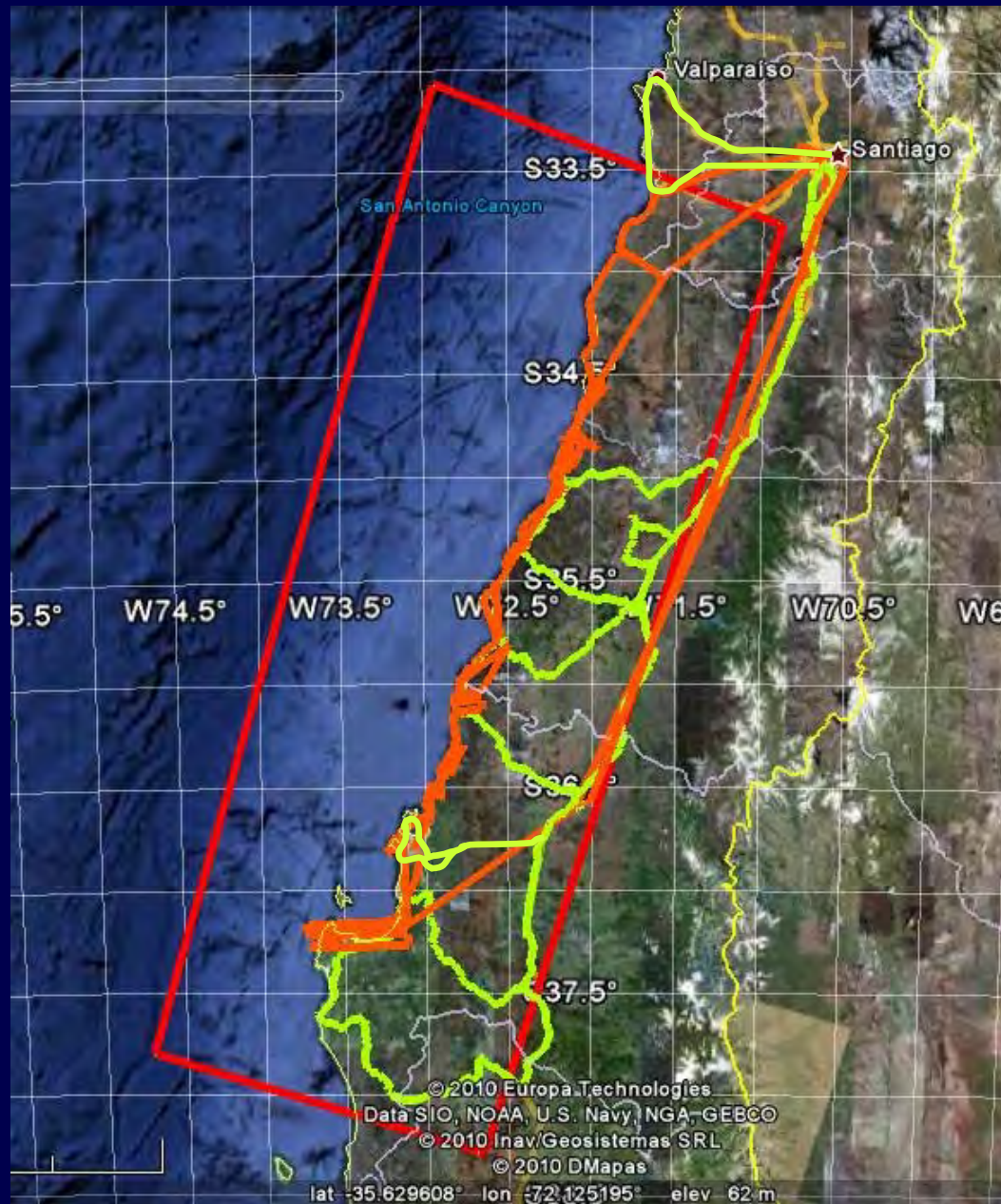


Valparaiso



Coronel : a) Lateral Spreading/Settlement, b) Sediment Ejecta/Sinkholes, & c) Pile Damage

NSF-Sponsored GEER Reconnaissance



Chile-US
Partners



Aerial
Recon



Ground
Recon



2010 Chile EQ Reconnaissance Organization

US GEER Chile Team Members Timeline				X denotes anticipated "on the ground" days																				
		Fri	Sat	Sun	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Mon	Tues	Wed	Thurs		
		5-Mar	6-Mar	7-Mar	8-Mar	9-Mar	10-Mar	11-Mar	12-Mar	13-Mar	14-Mar	15-Mar	16-Mar	17-Mar	18-Mar	19-Mar	20-Mar	21-Mar	22-Mar	23-Mar	24-Mar	25-Mar		
David Frost	A Lead			x	x	x	x	x	x	x														
Rob Moss (S)	A	x	x	x	x	x	x																	
Alfredo Urzua (S)	A			x	x	x	x	x	x															
Gonzalo Montalva (S)	A	x	x	x	x	x	x	x	x	x														
Keith Kelson (~s)	A			x	x	x	x	x	x	x														
Nick Sitar	A					x	x	x	x	x														
Jon Bray	B Lead									x	x	x	x	x	x									
Rob Witter (~s)	B									x	x	x	x	x	x									
Jon Stewart	B									x	x	x	x	x	x									
Kyle Rollins	B									x	x	x	x	x	x									
Pedro Arduino (S)	B									x	x	x	x	x	x									
Tara Hutchinson	B									x	x	x	x	x	x									
Dominic Assimaki	B									x	x	x	x	x	x									
George Mylonakis	B									x	x	x	x	x	x									
Laurie Johnson	B									x	x	x	x	x	x									
Scott Ashford	EERI										x	x	x	x	x	x								
Rob Kayen	C																			x	x	x		
Scott Olson (~s)	C																			x	x	x		
Youssef Hashash	D																							
Jim Bay	D																							
Others																								



2010 Chile EQ Reconnaissance Organization

GEER Team C: LiDAR , SASW, DCPT Sites – Draft 3/22/10 (partial list)

Rank	Name	Category	Issue	Lat	Long	Lidar	SASW	DCPT
	Coihueco Dam	Dams	Liquefaction slumping	-36.637166°	-71.797530°	yes	yes	yes
	Middle Bio Bio Bridge Concepcion	Bridges	Liquefaction lateral spread	-36.830108°	-73.067991°	yes	yes	yes
	Bridge parallel to Bio Bio Concepcion	Bridges	Slope instability	-36.846841°	-73.055496°	yes	yes	yes
	4-story apartment building Concepcion	Buildings	Liquefaction, settlement	-36.791026°	-73.081235°		yes	yes
	Embankment South of Concepcion	Road/railroad	Translational failure	-37.073306°	-73.147825°	yes	yes	yes
	Hospital Curanilahue	Hospital	Liquefaction settlement	-37.473219°	-73.348168°		yes	yes
	Coronel	Port	Settlement, lateral spreading	-37.678012°	-73.225557°		yes	yes



Post-Reconnaissance Report

- Report as important as fieldwork
- Quick report on GEER website weeks after event
- Often GEER report is the first and only comprehensive geotechnical report

GEO-ENGINEERING EXTREME EVENTS RECONNAISSANCE (GEER) ASSOCIATION

Turning Disaster in Knowledge

Geo-engineering Reconnaissance of the 2010 Maule, Chile Earthquake

Report of the NSF Sponsored GEER Association Team

Editors:

Jonathan Bray and David Frost

GEER Team Leaders:

Jonathan Bray, UC Berkeley; David Frost, Georgia Tech; Ramon Verdugo, Universidad de Chile; Christian Ledezma, Pontificia Univ. Católica de Chile; and Terry Eldridge, Golder Associates

Lead Authors:

Pedro Arduino, Univ. of Washington; Scott Ashford, Oregon State Univ.; Dominic Assimaki, Georgia Tech; Jonathan Bray, UC Berkeley; Terry Eldridge, Golder Assoc.; David Frost, Georgia Tech; Tara Hutchinson, UC San Diego; Laurie Johnson, Laurie Johnson Consulting; Keith Kelson, Fugro William Lettis & Assoc.; Robert Kayen, US Geological Survey; Christian Ledezma, Pontificia Univ. Católica de Chile; Robb Moss, California Polytechnic State Univ. San Luis Obispo; George Mylonakis, Univ. of Patras; Scott Olson, Univ. of Illinois; Kyle Rollins, Brigham Young Univ.; Nicholas Sitar, UC Berkeley; Jonathan Stewart, UC Los Angeles; Alfredo Urzúa, Prototype Engineering Inc.; Ramon Verdugo, Universidad de Chile; Rob Witter, DOGAMI; and Nick Zoa, Univ. of Maryland

Contributing Authors:

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GEER Association Report No. GEER-022

Version 1: April 15, 2010



GEER Accomplishments



- 1. Use of new technologies for reconnaissance**
- 2. Use of existing technologies in an improved coordinated manner to document performance**
- 3. Better training of those involved in reconnaissance efforts, both in terms of effectiveness and safety; access to equipment required for state-of-the-art surveying**
- 4. Timely and accurate documentation in terms of web-based short reports, data files, final reports, and papers**
- 5. A systematic mechanism for geotechnical engineers to respond effectively to extreme events**



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Opportunities

- **Advanced reconnaissance tools: SfM, Lidar, GIS integration, GoogleEarth, GPS/video/picture, remote sensing, digital topographic and geologic maps, & electronic collection**
- **Development of quantitative data**
- **NEHRI RAPID & NEHRI DesignSafe Cyberinfrastructure**

Challenges

- **Funding**
- **Site access and data sharing**
- **Rapid dissemination**
- **Archiving of post-event data**

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