

NGL: Open Source Global Database and Model Development for Next-Generation of Liquefaction Assessment Procedures

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Acknowledgments

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- Russell Green & Kristin Ulmer
- Other international collaborators: Tokimatsu, Cubrinovski, etc.

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Outline

- Project need and vision
- Data resources
- Supporting studies
- Model development

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Project Need

Steps in liquefaction risk assessment:

- (1) Susceptibility;
- (2) Triggering;
- (3) Effects

Each is *empirical* or *semi-empirical*, and hence is reliant on available data.

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Project Need

Small data sets – a few sites are especially consequential

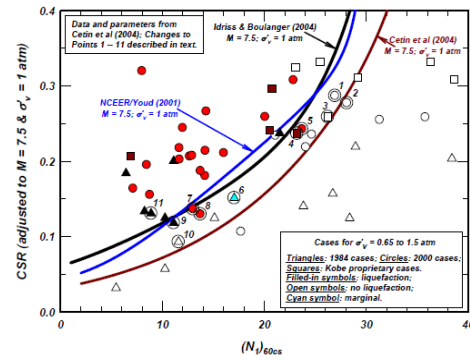


Figure: Idriss and Boulanger, 2010

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Project Need

Small data sets – a few sites are especially consequential

Existing data sets are necessarily incomplete, especially:

Depth > 10 m

M > 7.5

FC > 30%

CSR > 0.4

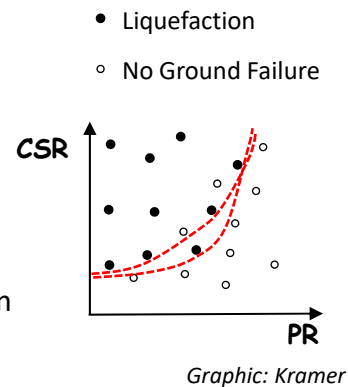
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Present situation

Alternate liquefaction models provide different outcomes.

Why?

1. Inconsistent data sets
2. Different methods for data interpretation
3. Different models for extrapolation beyond data range
4. Potential errors in data analysis
5. Minimal between-developer interaction



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Project Vision

- Community field **case history database**
- **Supporting studies** of critical effects poorly constrained by data
- **Model development:** team meetings, common resources, required parameter space

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Outline

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Data Resources

- Database
- Flatfile

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Database: GIS platform with liquefaction, ground failure, and non-ground failure case histories.

Intent is that database contains *objective* data.

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Database: GIS platform with liquefaction, ground failure, and non-ground failure case histories.

Intent is that database contains *objective* data.

Flatfile: Synthesis of parameters used for model development.

Involves higher degree of interpretation and is necessarily *subjective*.

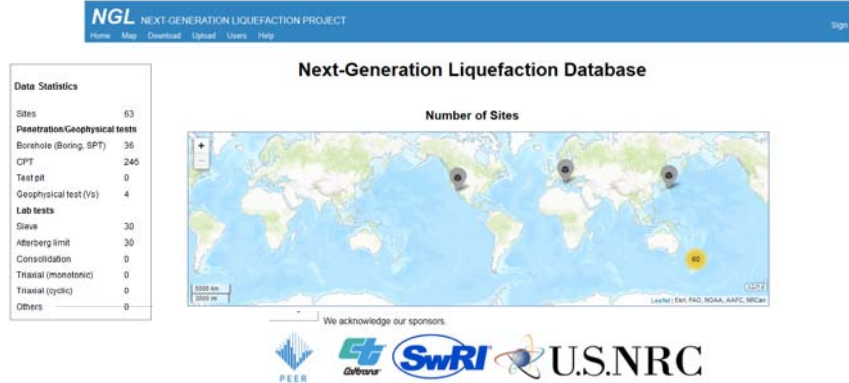
NGL Database

Original development by Kwak, Brandenburg, Stewart

PHP platform, GIS-based mapping tool, AGS4 database format

To be hosted at DesignSafe (UT NHERI site)

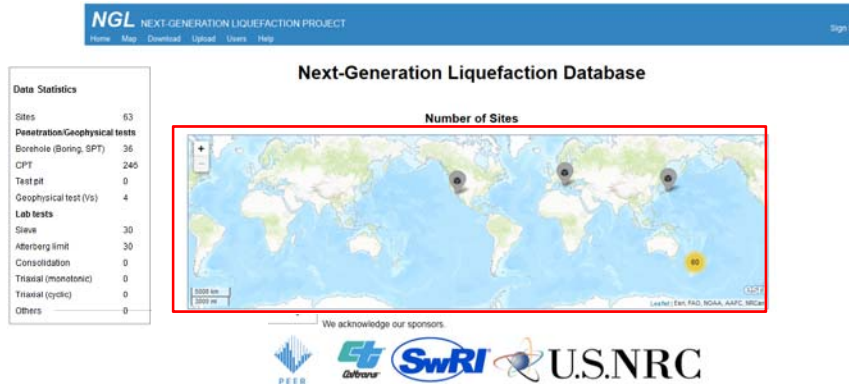
Data uploads to date by DYK, PZ, ML, KU... 63 sites



<http://uclageo.com/NGL/database/index.php>

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NGL Database



Site locations

<http://uclageo.com/NGL/database/index.php>

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NGL Database

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Sign In


Home Map Download Upload Users Help

Data Statistics





- Sites 63
- Penetration/Geophysical tests**
- Borehole (Boring, SPT) 36
- CPT 245
- Test pit 0
- Geophysical test (Vs) 4
- Lab tests**
- Sieve 30
- Aberberg limit 30
- Consolidation 0
- Triaxial (monotonic) 0
- Triaxial (cyclic) 0
- Others 0

Next-Generation Liquefaction Database

Number of Sites



We acknowledge our sponsors:

Data count overview

<http://uclageo.com/NGL/database/index.php>

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NGL Database

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Home Map Download Upload Users Help

Field Performance

Measured Disp. Lateral Def.

Settlement Sand Boil

Post-event def.

Observation Type

Field Note Field Mapping

Recon. Photo Satel. Image

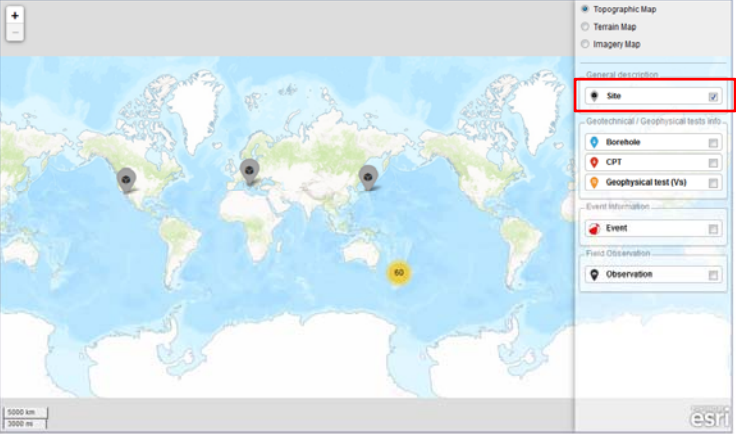
Repair Report Other

Earthquake

Event Name: _____ Magnitude: _____

Measured Ground Motion

PGA (g): _____ PGV (cm/s): _____



Topographic Map

Terrain Map

Imagery Map

General observations

Site

Geotechnical / Geophysical tests info

Borehole

CPT

Geophysical test (Vs)

Event information

Event

Field Observation

Observation

<http://uclageo.com/NGL/database/index.php>

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NGL Database

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Field Performance

- Measured Disp. Lateral Def.
- Settlement Sand Boil
- Post-event def.

Observation Type

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Earthquake

Event Name: _____ Magnitude: _____

Ground Motion

- Measured Ground Motion

PGA (g): _____ PGV (cm/s): _____

Map Layers:

- Topographic Map
- Terrain Map
- Imagery Map

Geotechnical / Geophysical tests info:

- Borehole
- CPT
- Geophysical test (Vn)

Event Information:

- Event

Field Observation:

- Observation

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NGL Database

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Field Performance

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Field Observation:

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<http://uclageo.com/NGL/database/index.php> 19

NGL Database

<http://uclageo.com/NGL/database/index.php>

What constitutes a case history?

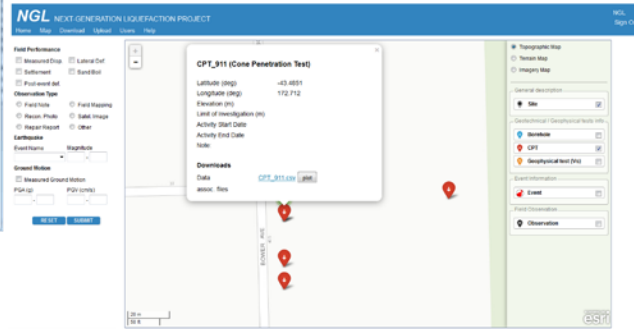
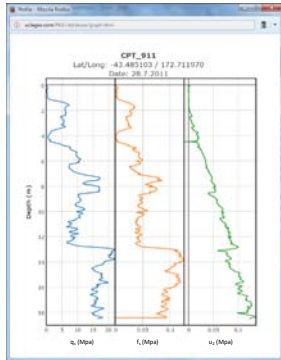
- Site information
- Event information
- Ground performance

What constitutes a case history?

Site information

Minimum requirements:

- Soil stratigraphy
- Ground water depth
- Details pertaining to soil type
- Penetration resistance or V_s



What constitutes a case history?

Site information

Event information



Site Name: City 20 445 Lower Ave

Search event name: Christchurch, New Zealand

Select an earthquake from database

Event Name	Epicenter Latitude (deg)	Epicenter Longitude (deg)	Hypocenter Depth (km)	Magnitude	Date and time (mm/dd/yyyy)	Remarks
Christchurch, New Zea	-43.371	172.713	6	6.2	2011-02-21-2351	

Earthquake Event Information - General

Earthquake Event Information - Fault Solution

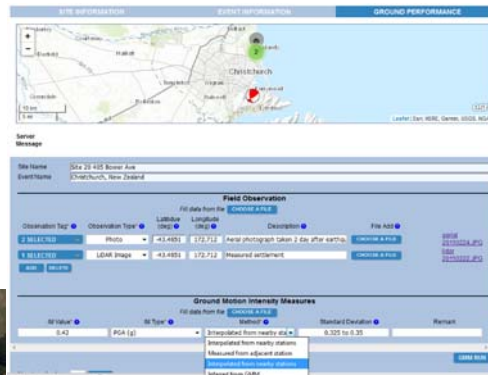
Fault Segment Number	Strike (deg)	Dip (deg)	Rate (deg/yr)	Fault Length (km)	Fault Width (km)	Latitude of F/C (deg)	Longitude of F/C (deg)	Depth of F/C (km)
1	59	67	135	7	13	-43.3277	172.6775	0.5

Minimum requirements:

- Horizontal, median-component, PGA
- Moment magnitude, M

What constitutes a case history?

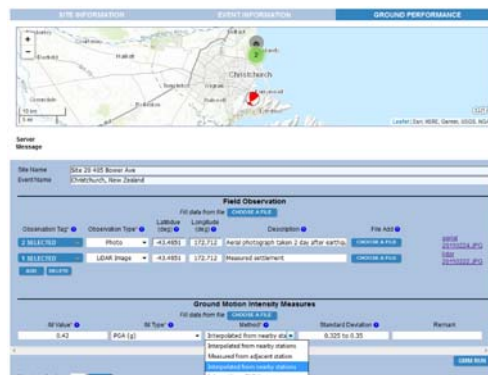
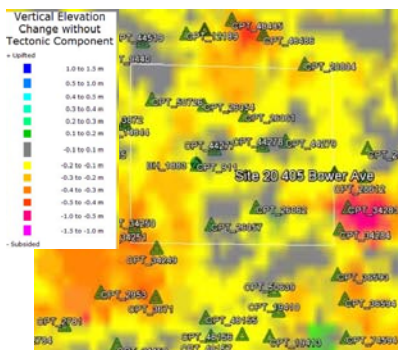
- Site information
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- Minimum requirements:**
- Written, mapped, or imaged observations
 - Date/time of reconnaissance
 - Location (lat/long)

What constitutes a case history?

- Site information
- Event information
- Ground performance



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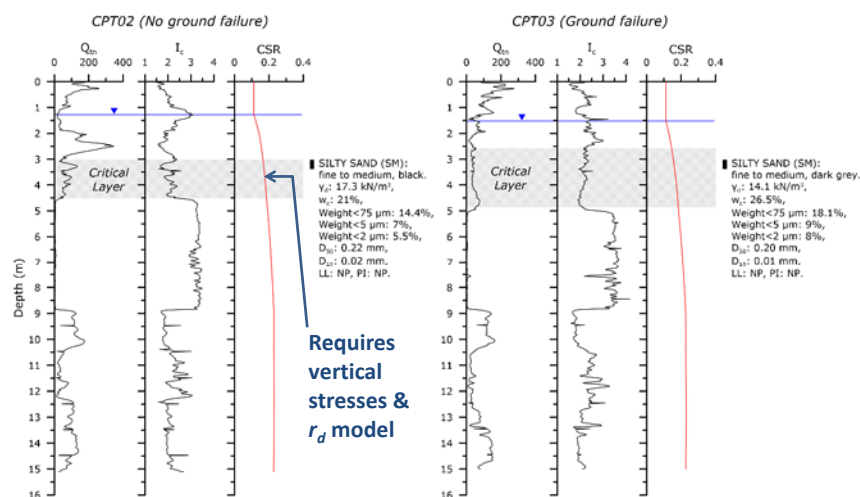
NGL database: GIS platform with liquefaction, ground failure, and non-ground failure case histories.

NGL flatfile: Synthesis of parameters used for model development.

- Selection of critical layer
- Demand characterization
- Penetration resistance (or V_s)

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Location of critical layer Shear demands in that layer



Location of critical layer
Shear demands in that layer

Demand modified to CSR*

$$CSR^* = 0.65 \frac{\sigma_v PGA/g}{\sigma'_v} r_d \frac{1}{K_\sigma K_\alpha C_M}$$

Each comprises a model.

Subjectivity

Case Histories Targeted for Uploading

Christchurch sites

- 2010-2011, 2016 events
- TT, VT, UCB-UC, etc.

Japan sites

- 2003, 2004, 2007, 2011 events
- MLIT, Tokimatsu group, UCLA

Critical data collection was NGL supported, 2013-2015

Case Histories Targeted for Uploading

Lateral spread sites

- Pool-funded (Utah, California, Washington)
- PIs: Bartlett, Franke, Kramer

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Case Histories Targeted for Uploading

Data sets used in development of existing models:

- SPT-based models:
Cetin et al 2000; Boulanger et al. 2012 (230)
- CPT-based models:
Moss et al. 2003; Boulanger and Idriss, 2014 (268)
- V_s -based models:
Kayen et al. 2013 (422)
- Flow slides:
Olson and Stark, 2002 (33)

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Case Histories Targeted for Uploading

M 7.4 1999 Kocaeli event case history sites

<http://peer.berkeley.edu/publications/turkey/adapazari/>

M 7.6 1999 Chi-Chi event case history sites

http://peer.berkeley.edu/lifelines/research_projects/3A02/index.html

Both:

- PEER projects with strong local collaboration
- Most sites have high FC
- Well-documented effects on buildings

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Case Histories Targeted for Uploading

Others:

2010 **M8.8** Maule and 2015 **M8.3** Illapel (Chile)

2010 **M7.2** El Mayor-Cucapah

CPT re-testing (Moss)

2012 Emilia **M5.9** and 1980 **M6.9** Irpinia (Italy)

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Supporting Studies

- **Need:** Models must be applicable over range of conditions required for applications:
 - Stress conditions: depths of 1-100 m; $\alpha = 0-0.3$.
 - Seismic demands: **M** 5-9.5, PGA 0-1.0 g
 - Soil types: FC 0-100%; nonplastic to limiting plasticity for liquefaction susceptibility; gravels; non-quartz mineralogies of coarse particles
- Parameter space covered by case histories is narrower
- Extrapolation guided by supporting studies

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Supporting Studies

- Laboratory:
 - Stress effects on triggering, deformations
 - Soil compositional factors (plasticity, mineralogy, etc.)
 - Ageing
- Wave propagation analysis:
 - Stress reduction factor, r_d
 - Leverage significant advances in nonlinear site response

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Supporting Studies

- Physical model test data:
 - Centrifuge, shake table, etc.
 - Possible applications: lateral spreading, S_{u-liq} , partial drainage effects
- Critical layer selection

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Model Development

- Modeler participation:
 - Generally unrestricted
 - Meeting attendance required
 - Must share results with other modelers
 - Coordinated publication

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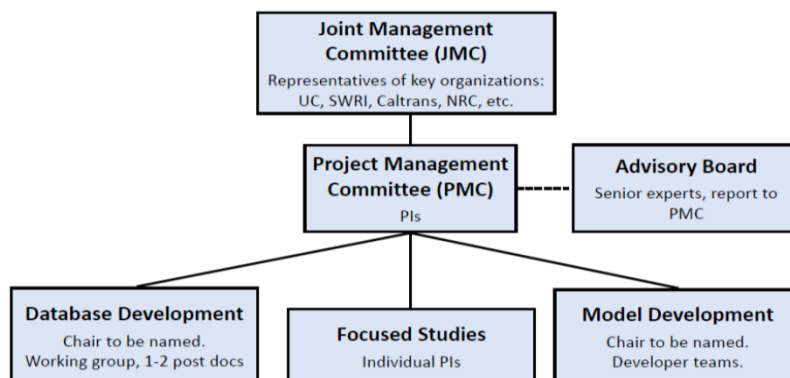
Model Development

- Model types:
 - Susceptibility, triggering
 - S_{u-liq}
 - Deformations: ε_v , γ_{max} , lateral spread disp.
- Applicability:
 - ‘Average’ soil conditions at case history sites (ergodic)
 - Expected to correspond to quartz sands with various fines
 - Subsequent work to focus on ‘material-specific models’ (non-ergodic)

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Closing Thoughts

- Project organization



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Closing Thoughts

- Project organization
- National Academies endorsement
 - Database (Rec 1)
 - Judicious use of supporting studies (Recs 4, 7, 9)
 - Model development activities, including consideration of uncertainties (Rec 8)
- In process of outreach to national & international potential funding agencies

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Next-Generation
NGL
Liquefaction



Interim NGL web site

<http://uclageo.com/NGL/>

Summary paper in [SDEE \(2016\)](#)

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