University of Texas at Austin
Large Mobile Shakers

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Professor, UT Austin

Co-PI
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Professor, Utah State Univ.

Co-PI
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Chair & Prof., UT Austin

Site Manager
Sungmoon Hwang
Research Assoc, UT Austin

Natural Hazards Engineering Research Infrastructure

7 Experimental Facilities with Large-Scale Equipment
1 Cyberinfrastructure Facility for Archiving and Sharing Data
1 Computational Modeling/Simulation Center
1 Post-disaster Rapid Response Facility
1 Network Coordination Office

NATURAL HAZARDS ENGINEERING RESEARCH INFRASTRUCTURE (NHERI)

PURDUE UNIVERSITY
Network Coordination Office
NSF Award #2129782

UNIVERSITY OF COLORADO BOULDER
CONVERGE
Social Science/Interdisciplinary Resources
NSF Award #1841338

UNIVERSITY OF CALIFORNIA, BERKELEY
SimCenter
Computational Modeling and Simulation
NSF Award #2131111

UNIVERSITY OF WASHINGTON
Natural Hazard
Reconnaissance (RAPID) Facility
NSF Award #2130997

UNIVERSITY OF TEXAS, AUSTIN
DesignSafe
Community Cyberinfrastructure
NSF Award #2022469

OREGON STATE UNIVERSITY
Large Wave Flume and
Directional Wave Basin
NSF Award #2037914

LEHIGH UNIVERSITY
Large-Scale Multi-Directional
Hybrid Simulation Testing
NSF Award #2037771

UNIVERSITY OF TEXAS, AUSTIN
Mobile Field Shakers
NSF Award #2037900

UNIVERSITY OF FLORIDA
Boundary Layer Wind Tunnel
NSF Award #2037725

NEWRITE

IOWA STATE UNIVERSITY
Planning for the new, shared-use National Testing Facility for Enhancing Wind Resiliency of Infrastructure in Tornado-Downburst-Gust Front Events (NEWRITE)
NSF Award #2330150

UNIVERSITY OF CALIFORNIA, DAVIS
Geotechnical
Centrifuges
NSF Award #2037883

UNIVERSITY OF CALIFORNIA, SAN DIEGO
Large High-Performance
Outdoor Shake Table
NSF Award #2227407

FLORIDA INTERNATIONAL UNIVERSITY
Wind Simulation
NSF Award #2037899

NICHE

FLORIDA INTERNATIONAL UNIVERSITY
Planning for the new, shared-use National Full-Scale Testing Infrastructure for Community Hardening in Extreme Wind, Surge, and Wave Events (NICHE)
NSF Award #2131961

For more information, visit the NHERI DesignSafe website: DesignSafe-ci.org

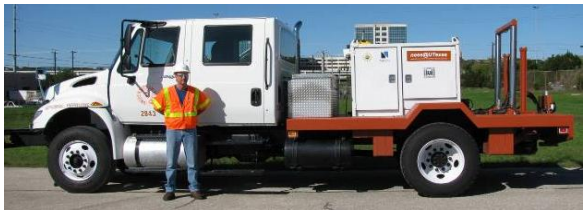
Outline

- Shakers and Instrumentation
- Distributed Acoustic Sensing (DAS) Interrogator
- Science Plan
  - 2D and 3D Subsurface imaging
  - In-Situ Nonlinear Testing
  - Soil Structure Interaction
- Example Projects

Shakers & Other Equipment

T-Rex (Tri-axial Shaker)
- Three vibrational orientations
- Shear mode Peak Force = 30,000 lbs
- Vertical mode Peak Force = 60,000 lbs

Liquidator (Low Frequency Shaker)
- Two vibrational orientations
- Shear mode Peak Force = 20,000 lbs
- Vertical mode Peak Force = 20,000 lbs



Thumper (Urban Shaker)
- Three vibrational orientations
- Shear mode Peak Force = 6,000 lbs
- Vertical mode Peak Force = 6,000 lbs

Raptor (Mid-Size Shaker)

Rattler (Horizontal Shaker)

Big-Rig

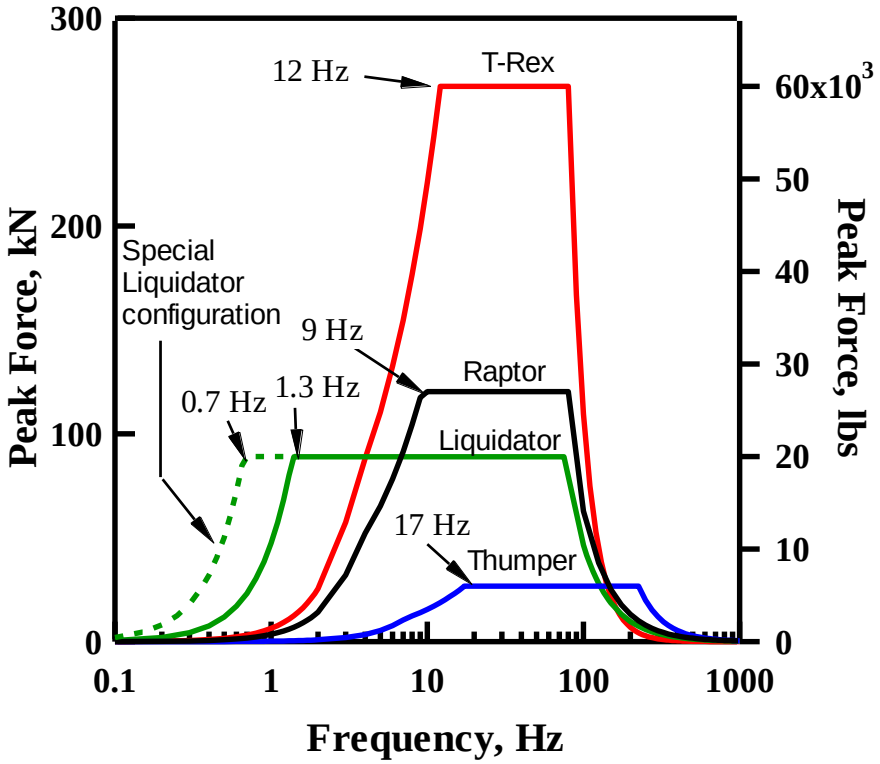
Field-Support Truck

Instrumentation Van & Trailer

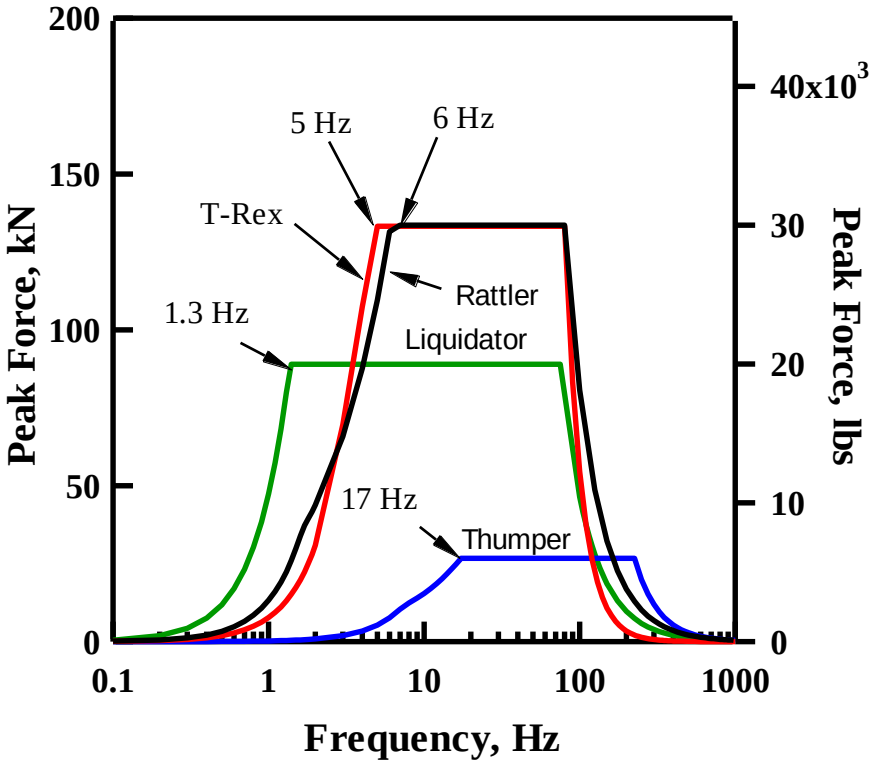
Hydraulic Cylinder with Adjustable Platform

Information on force vs. frequency output for all shakers is provided at
https://utexas.designsafe-ci.org/equipment-portfolio/

Theoretical vertical force outputs of the five mobile



Vertical force output



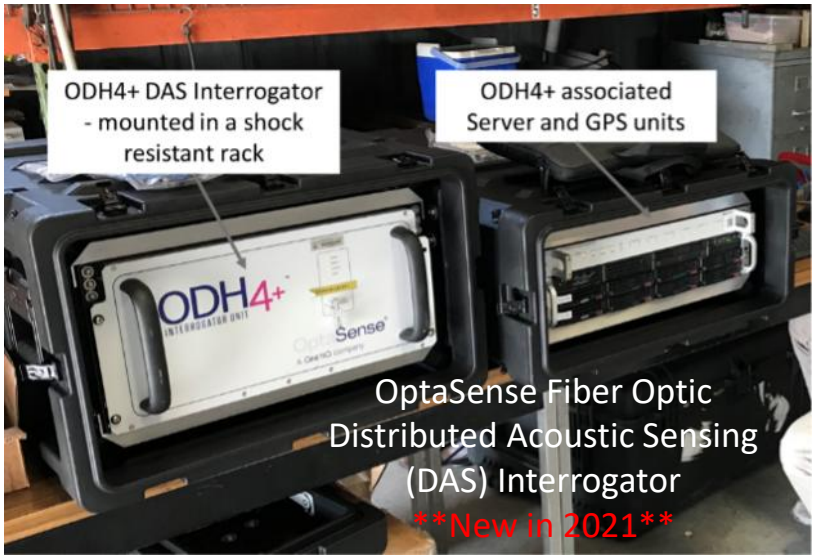
Horizontal force output

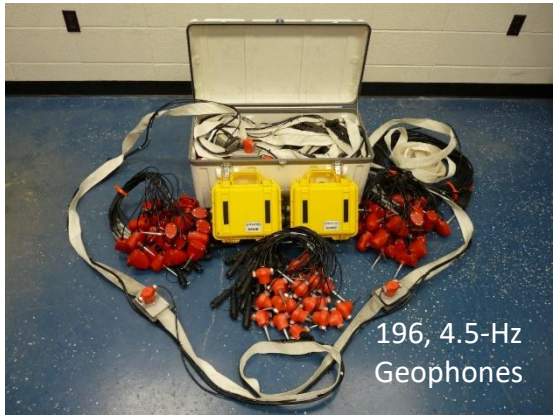
T-Rex – Horizontal Shaking

Liquidator – Standard Configuration

Liquidator – Special Configuration

Instrumentation - Sensors





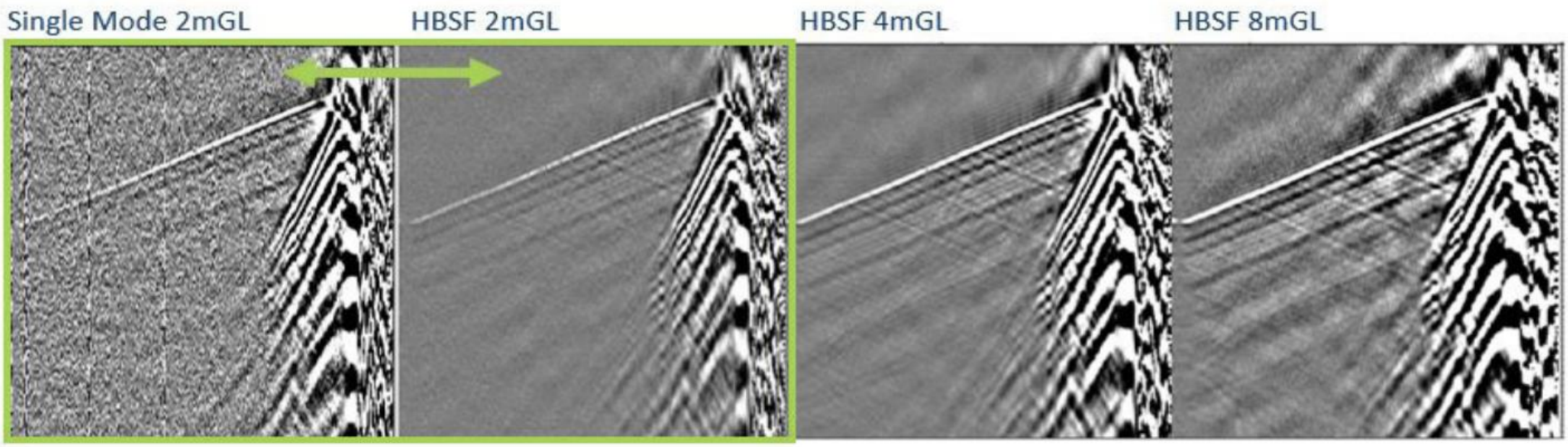
Not shown:

- Triaxial MEMS accelerometers
- Dynamic load cells
- CPT equipment
- Liquefaction sensors (pore pressure)
- 168 channels of data acquisition

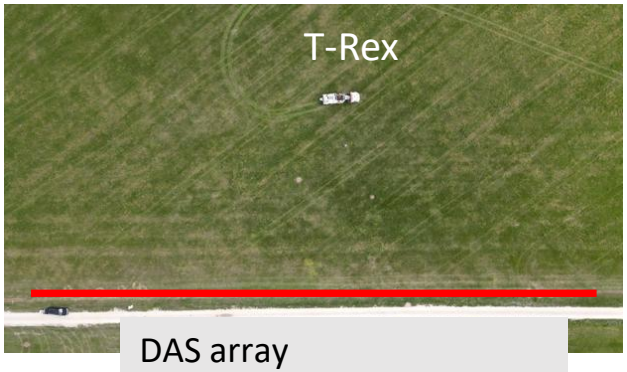
Instrumentation – DAS Interrogator

- <u>OptaSense ODH4+ DAS Interrogator</u>
- Fiber Optic Distributed Acoustic Sensing (DAS)
- Capable of measuring with ANY fiber from ANY vendor (single mode, multi-mode or enhanced high backscatter)
- Sample rate up to 100 kHz
- Selectable gauge length (2m – +30m)
- 1-m channel/trace separation

High Backscatter Single Fiber 2m Gauge Length

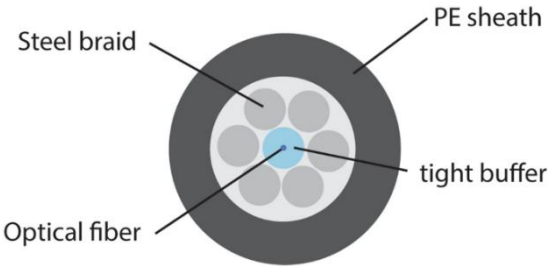


Distributed Acoustic Sensing (DAS)

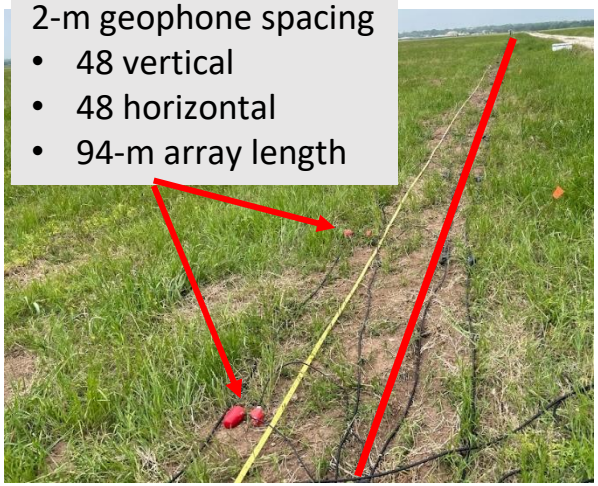


DAS array
- 200-m long
- 2-m gauge length
- 1-m channel separation

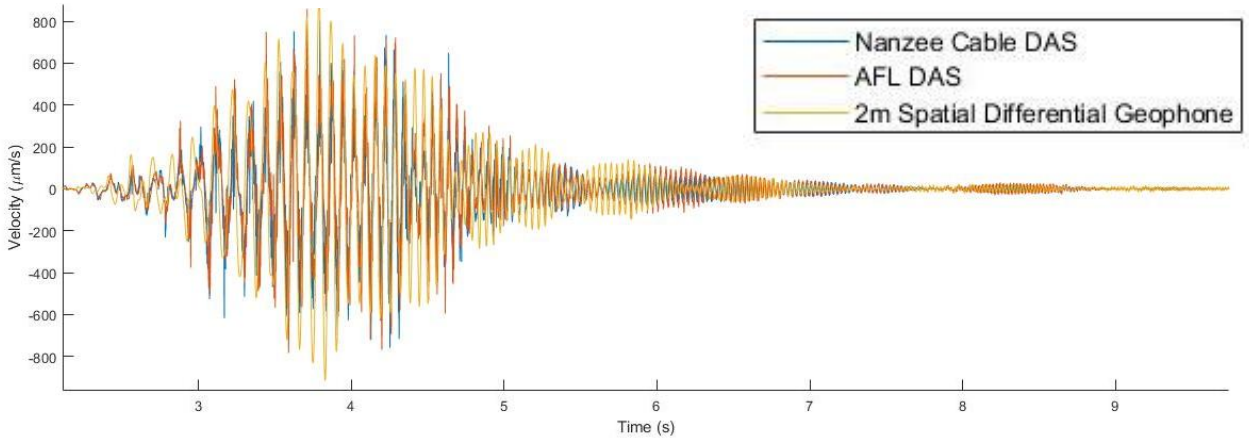
Installation quality and cable selection are key!



2-m geophone spacing
- 48 vertical
- 48 horizontal
- 94-m array length



Relative Velocity 50m along array



Credit: Peter Hubbard (UC Berkeley)

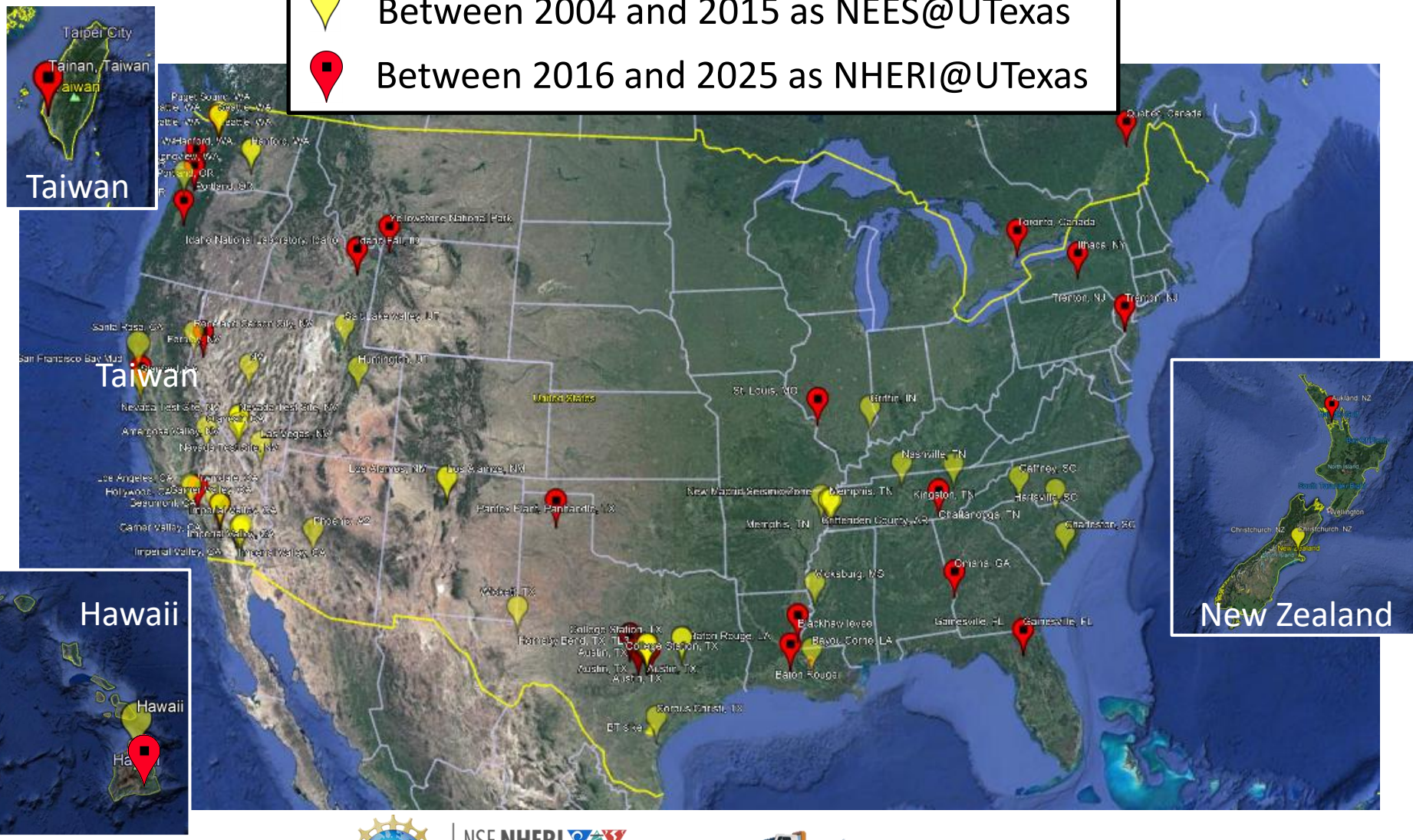
More information in videos from October 2021 DAS Workshop

https://utexas.designsafe-ci.org/workshops/

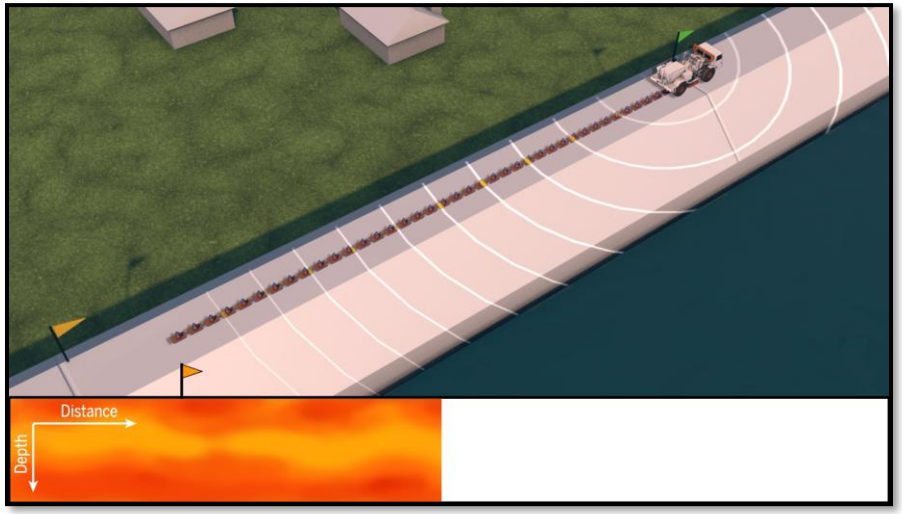
Published DAS Datasets

- Workshop on a section of Mississippi River levee in Black Hawk, Louisiana
  - https://www.designsafe-ci.org/data/browser/public/designsafe.storage.published/PRJ-3317
- Site characterization of Hornsby Bend site in Austin, TX
  - https://www.designsafe-ci.org/data/browser/public/designsafe.storage.published/PRJ-3398

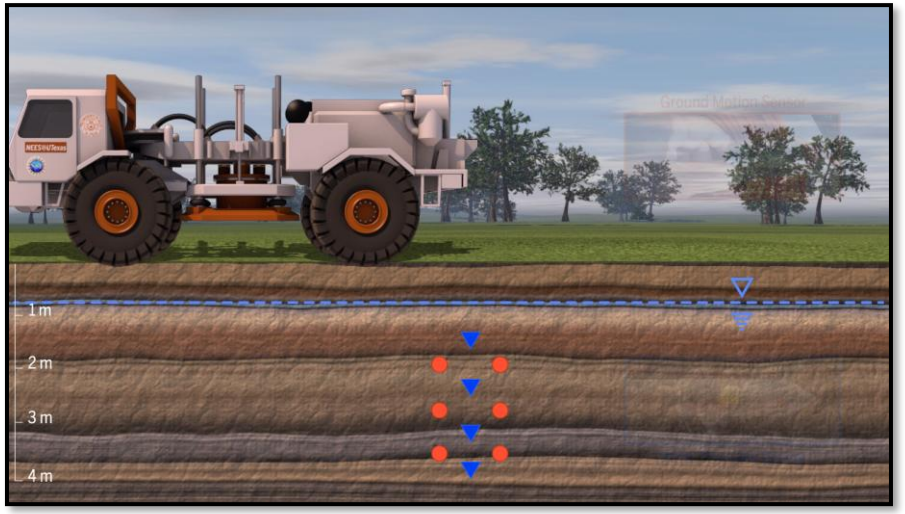
Have shaker trucks, will travel…



NHERI@UTexas Science Plan



Improved Subsurface Imaging (2D & 3D)



In-Situ Liquefaction/Nonlinear Testing

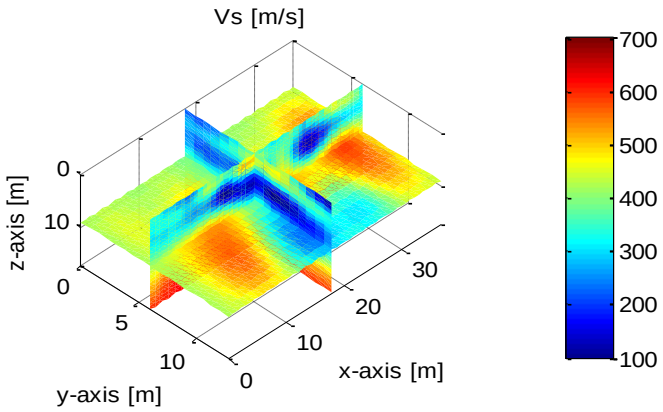
Structural Health Monitoring/Soil-Structure Interaction

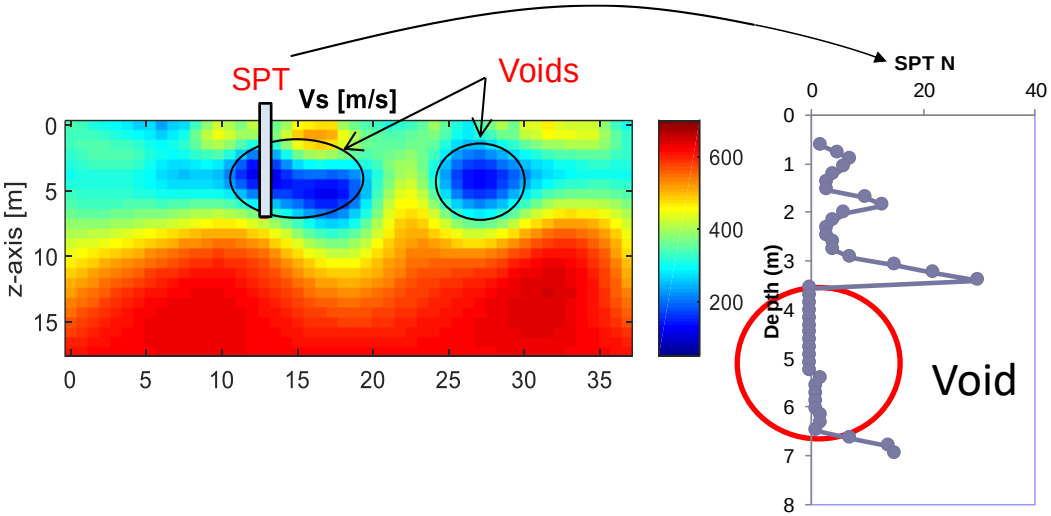
Project Highlight - Subsurface Imaging

"Geotechnical Site Characterization with 3-D Seismic Waveform Tomography"
(CMMI-1637557; PI: K. Tran, Univ. of Florida)

"3D Ambient Noise Tomography (3D ANT) for Natural Hazards Engineering"
(CMMI-193069/1931162; PI's: K. Tran, Univ. of Florida; B. Cox Utah State Univ.)

The goal of these projects are to **characterize 2D/3D shear wave (S-wave) and compression wave (P-wave) velocity models** from surface-based seismic wave fields and ambient noise. Ambient noise tomography shows potential for developing 3D models down to 50- to 100-m depth.





Results above used array of 48 geophone and Thumper shaking at 65 locations

Project Highlight - Subsurface Imaging

"Active and Passive Seismic Imaging of the Three-Dimensional Structure and Magma System beneath the Summit of Kilauea Volcano"
(EAR-2218645/2218646; PI: G. Lin, U. of Miami, R. Denlinger, USGS)

The goal of these projects are to **image the 3-D structure and magma system** beneath the summit of Kilauea volcano in Hawaii.

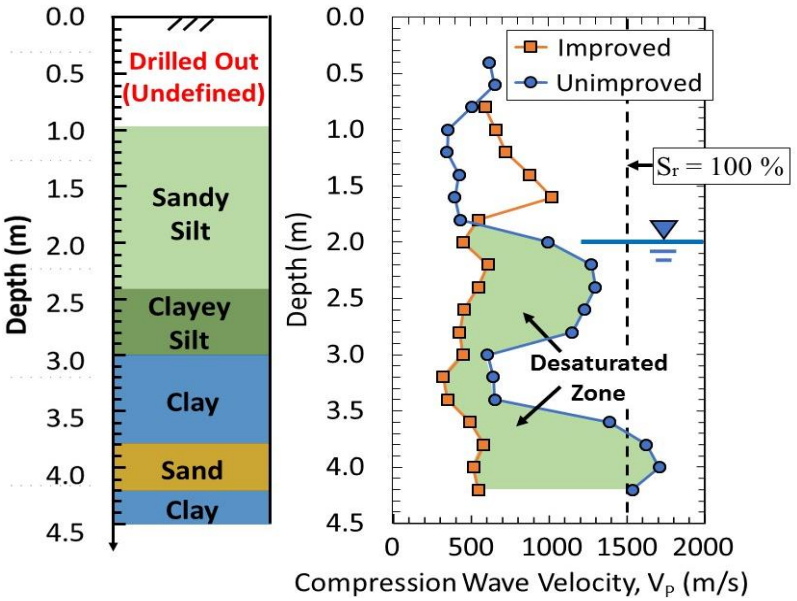
Included shaking at 396 location and deployment of 1800 sensors

Project Highlight – In-situ Liquefaction Testing

"RAPID Liquefaction Mitigation of Silts using MIDP and Field Testing with NHERI@UTexas Large Mobile Shakers"
(CMMI-1935670; PI: A. Khosravifar, Portland State Univ.)

"RAPID Field Assessment of MICP/MIDP Test Sections"
(EEC-1449501; PI: E. Kavazanjian, Arizona State Univ.)

These studies aims to evaluate the potential for a **microbially induced desaturation soil liquefaction mitigation** technique in relatively fine-grained soils.

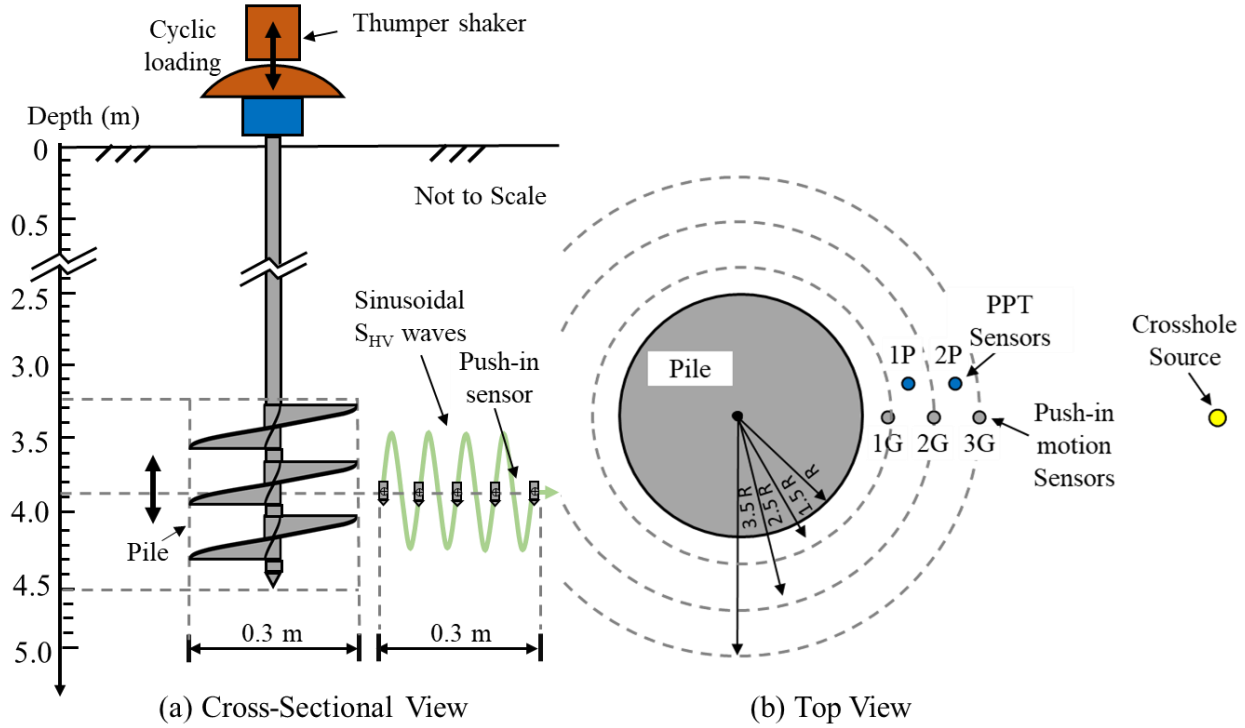


Project Highlight – In-situ Liquefaction Testing

Embedded helical piles used **transmit shaker seismic energy to the depths of interest**

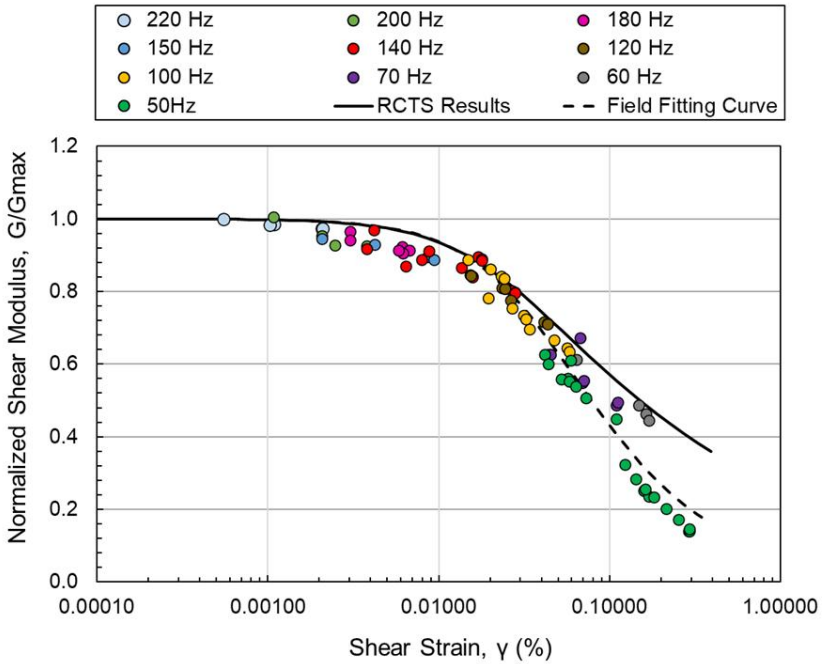
"RAPID Investigating the Liquefaction Susceptibility of Calcareous Sand in Hawaii with an Enhanced NHERI@UTexas Large Mobile Shaker"
(CMMI-2317660; PI: Diane Moug, Portland State Univ.)

"Field Assessment of the Liquefaction Susceptibility of the Microbially Induced Desaturation (MID) Method"
(EEC-1449501; PI: E. Kavazanjian, Arizona State Univ.)

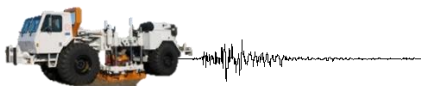


Project Highlight – In-situ Liquefaction Testing

Embedded helical piles used **transmit shaker seismic energy to the depths of interest**



NSF NHERI LARGE MOBILE SHAKERS

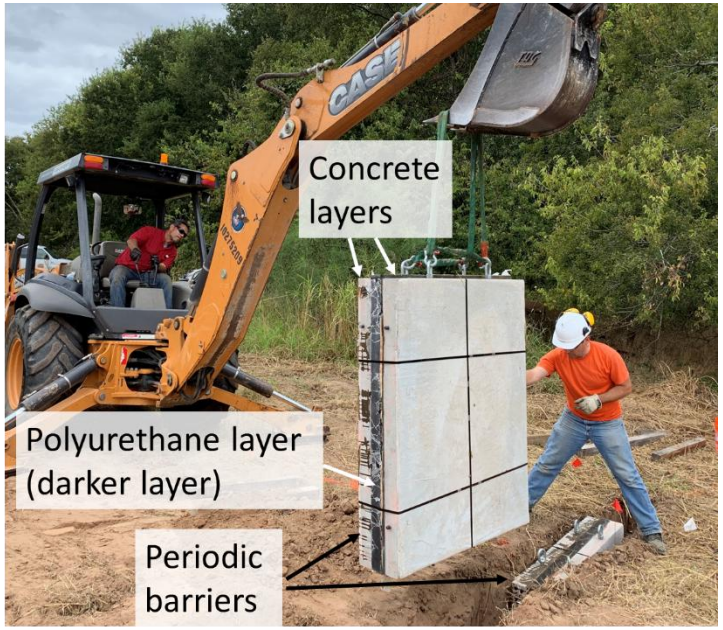


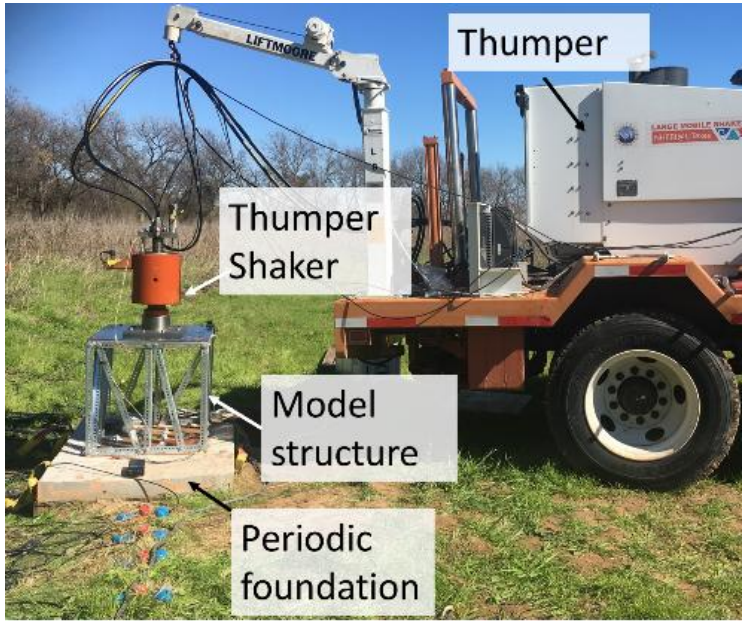
Project Highlight – Soil-Foundation Interaction

"Collaborative Research: Seismic Isolation of Embedded Foundations Using Periodic Meta-material Barriers to Create Resilient Structures"

(CMMI-1761659; PI: Yi-Lung Mo , University of Houston)

The objective of this project is to develop **periodic material-based seismic isolators** that possess distinct frequency band gaps which block, filter, and reflect incoming ground vibrations at that are most harmful to structures.





Testing conducted at Hornsby Bend site near UT-Austin

National Science Foundation

Contact Operations Manager, Sungmoon Hwang (sungmoon@utexas.edu) with inquiries

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