Field Trials with NHERI@UTexas T-Rex to Evaluate Microbially Induced Desaturation for Silt Liquefaction Mitigation

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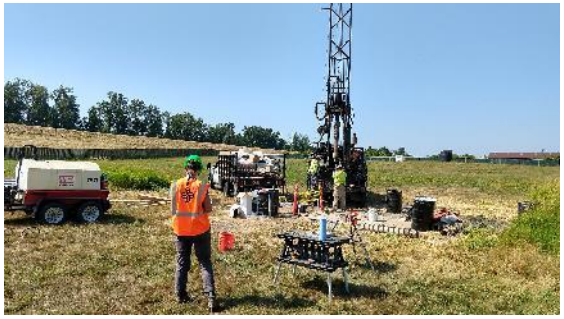
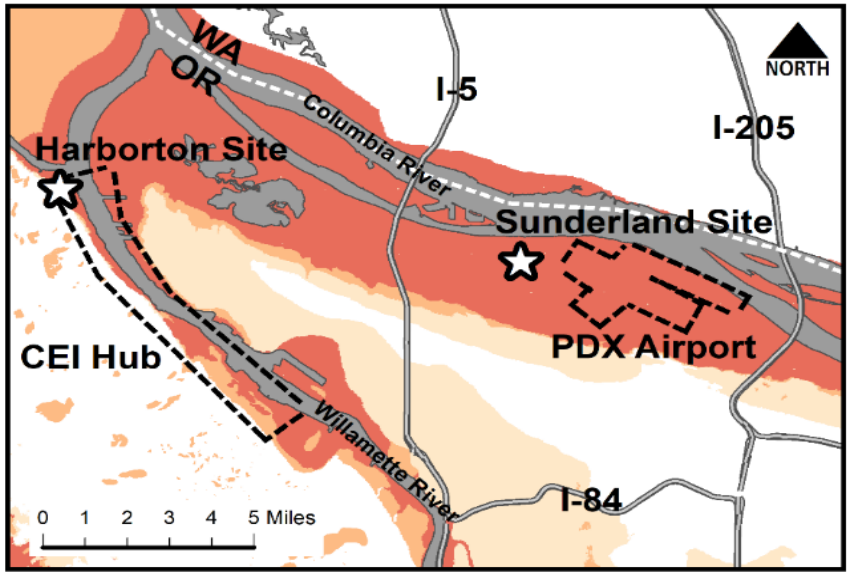
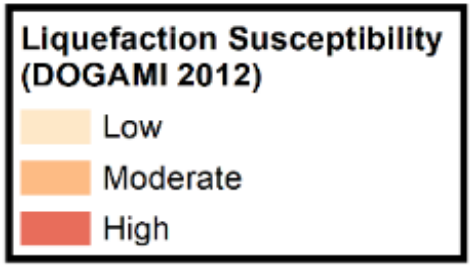
Field Trials of MID for Liquefaction Mitigation

- Field trials of microbially induced desaturation (MID) performed July to September 2019 in Portland, OR



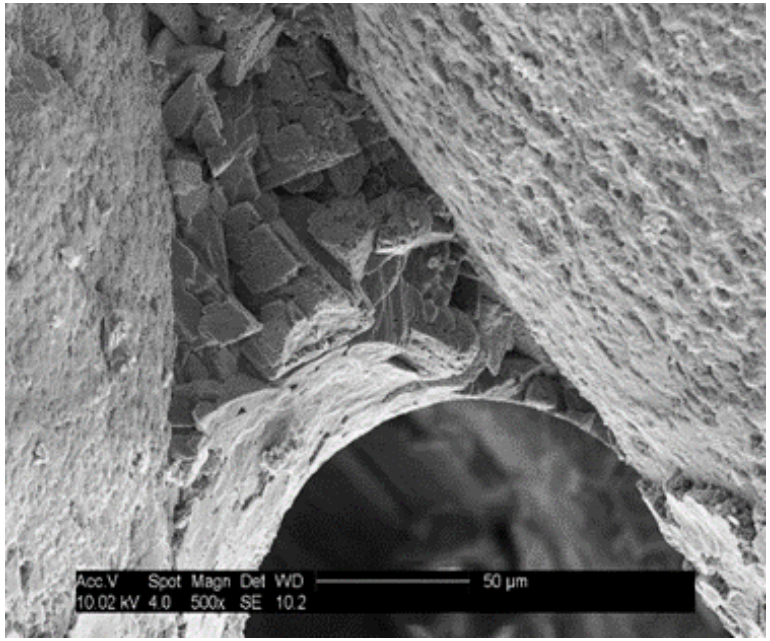




- The objectives were to:
  - Examine MID performance at the field scale
  - Examine MID performance in silty soils

Microbially Induced Desaturation for Liquefaction Mitigation

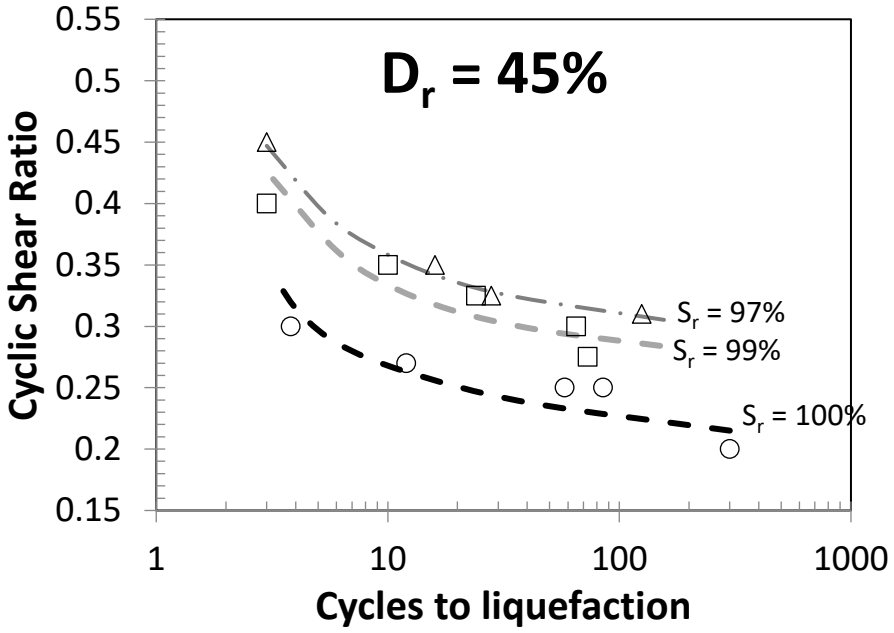
- Potential non-invasive treatment for fine-grained liquefiable soils
- Treatment solution stimulates native denitrifying microbes
- Denitrification reaction yields N_2 and CO_2 gas



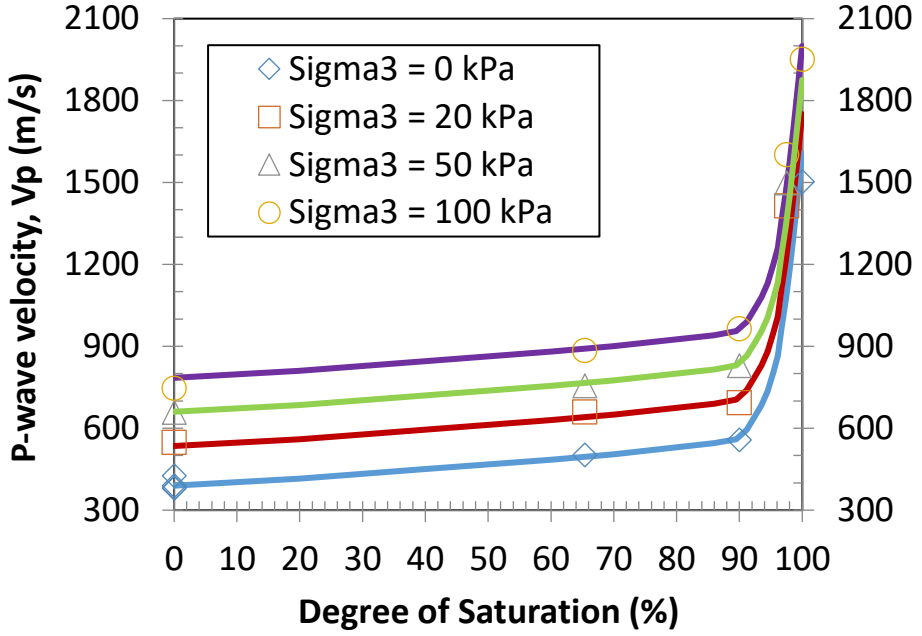
SEM image of gas bubble remnant (O'Donnell 2015)

Soil Desaturation for Liquefaction Mitigation

- Studies of sands & sands with non-plastic fines:
  - Δu generation inhibited by reduced S_r
  - Cyclic resistance ratio increases as S_r decreases



O'Donnell et al. (2017)



O'Donnell (2016), data from Ottawa Sand

Study Approach

- Treat a fine-grained soil site with MID
- Monitor treatment area to evaluate changes in S_r
  - $S_r > 99.5\%$, $V_p \approx 1500$ m/s
  - $S_r < 98.5\%$, $V_p \approx 400$ m/s
- Compare $\Delta u - \gamma$ response of untreated soil to MID treated soil
  - Expect Δu to be notably reduced as S_r decreases below 99.5%

RAPID Project

RAPID/Collaborative Research: Liquefaction Mitigation of Silts using MIDP and Field Testing with NHERI UTexas Large Mobile Shakers

- NHERI@UTexas was in the Portland area for an ongoing NSF project

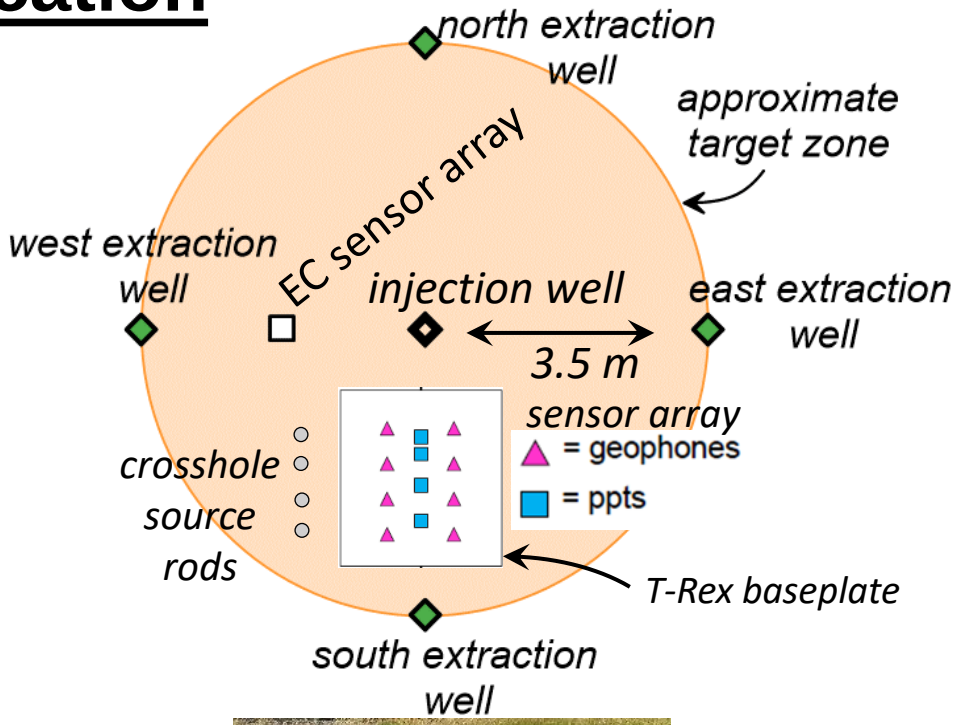
- NSF RAPID grant allowed us to leverage NHERI@UTexas resources without expensive transportation costs

Collaborative Project

- NHERI@UTexas: Field shaking with T-Rex and Thumper & instrumentation
- Center for Bio-mediated & Bio-inspired Geotechnics and Arizona State University: MID treatment design, implementation & instrumentation
- Condon Johnson & Associates: MID treatment design, equipment & logistics
- ConTec: SCPT site investigation and post-MID treatment evaluation
- Portland Bureau of Transportation: Research site

Treatment Solution Application

- Treatment solution fed through a central injection well
- Four extraction wells provided water for treatment solution
- Treatment solution injected over 4.5 weeks

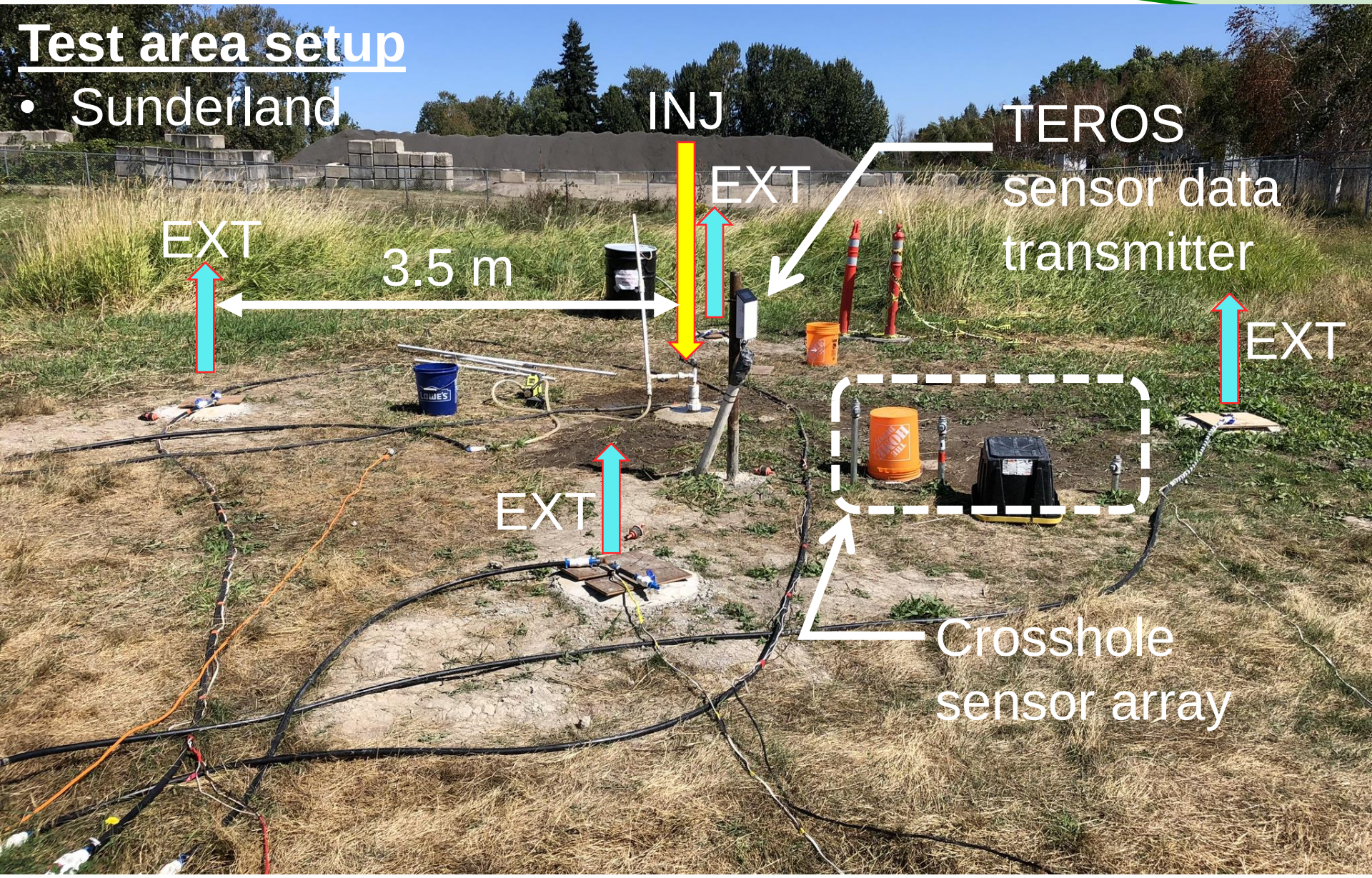


Sunderland mixing tote and injection tank

Sunderland injection well

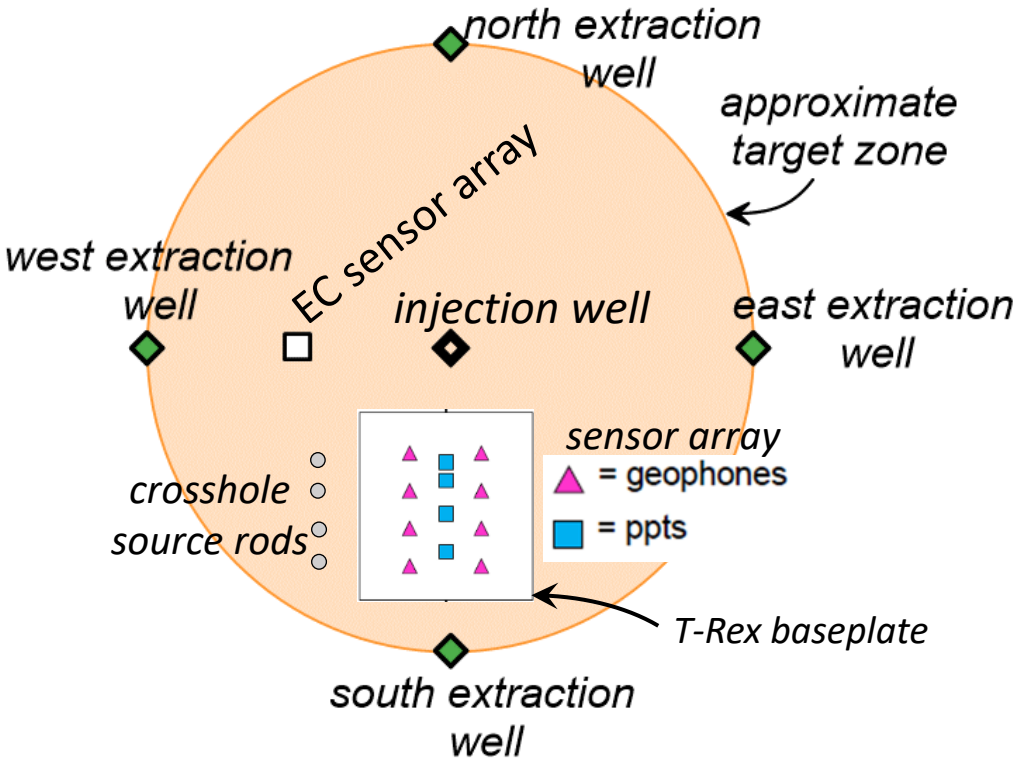
Test area setup

- Sunderland

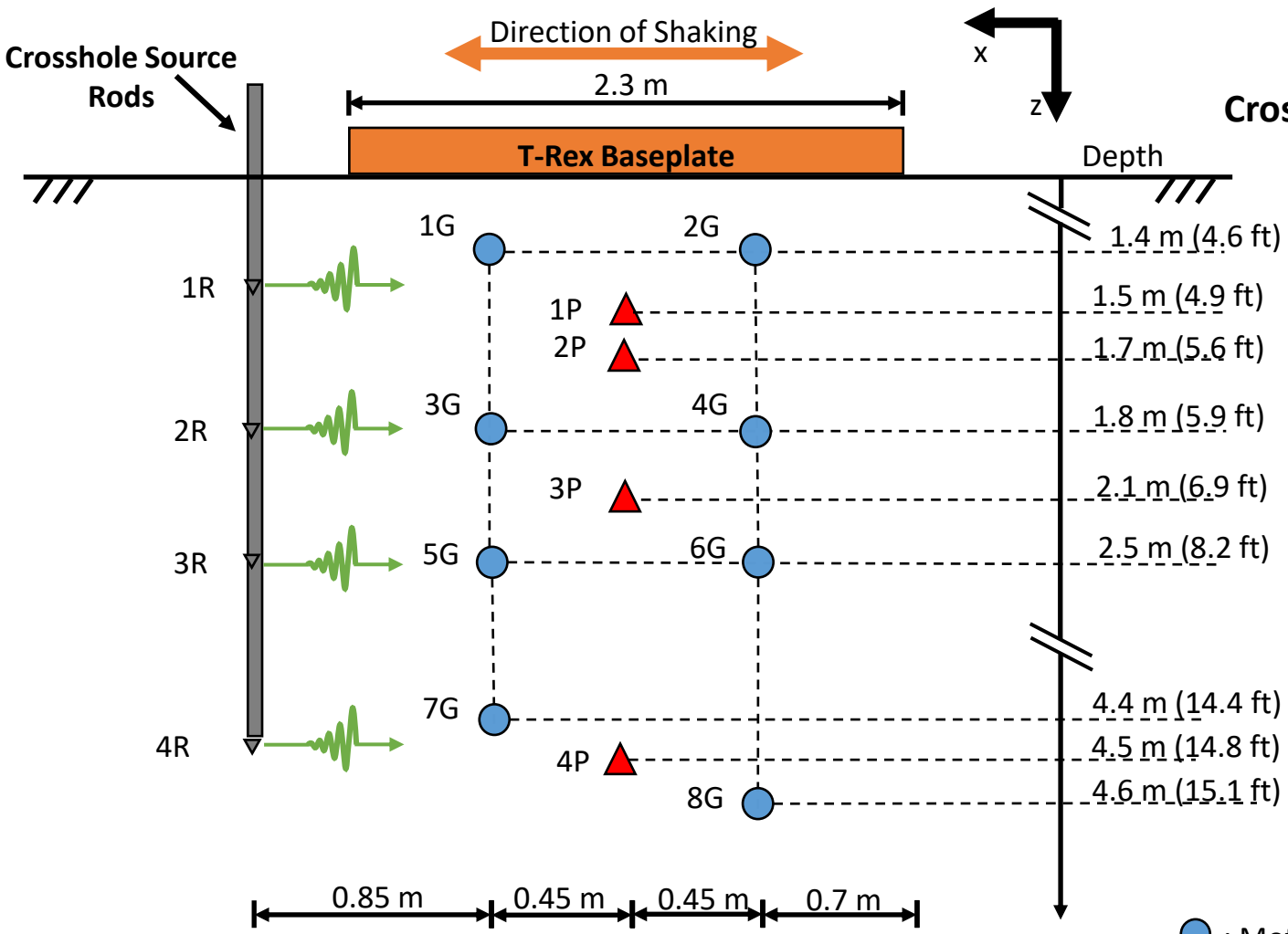


S_r Monitoring via Pressure Wave Velocity

- Direct push crosshole for pre-treatment V_p profile
- Crosshole array for regular V_p measurements
- SCPT-measured V_p profiles before and after treatment



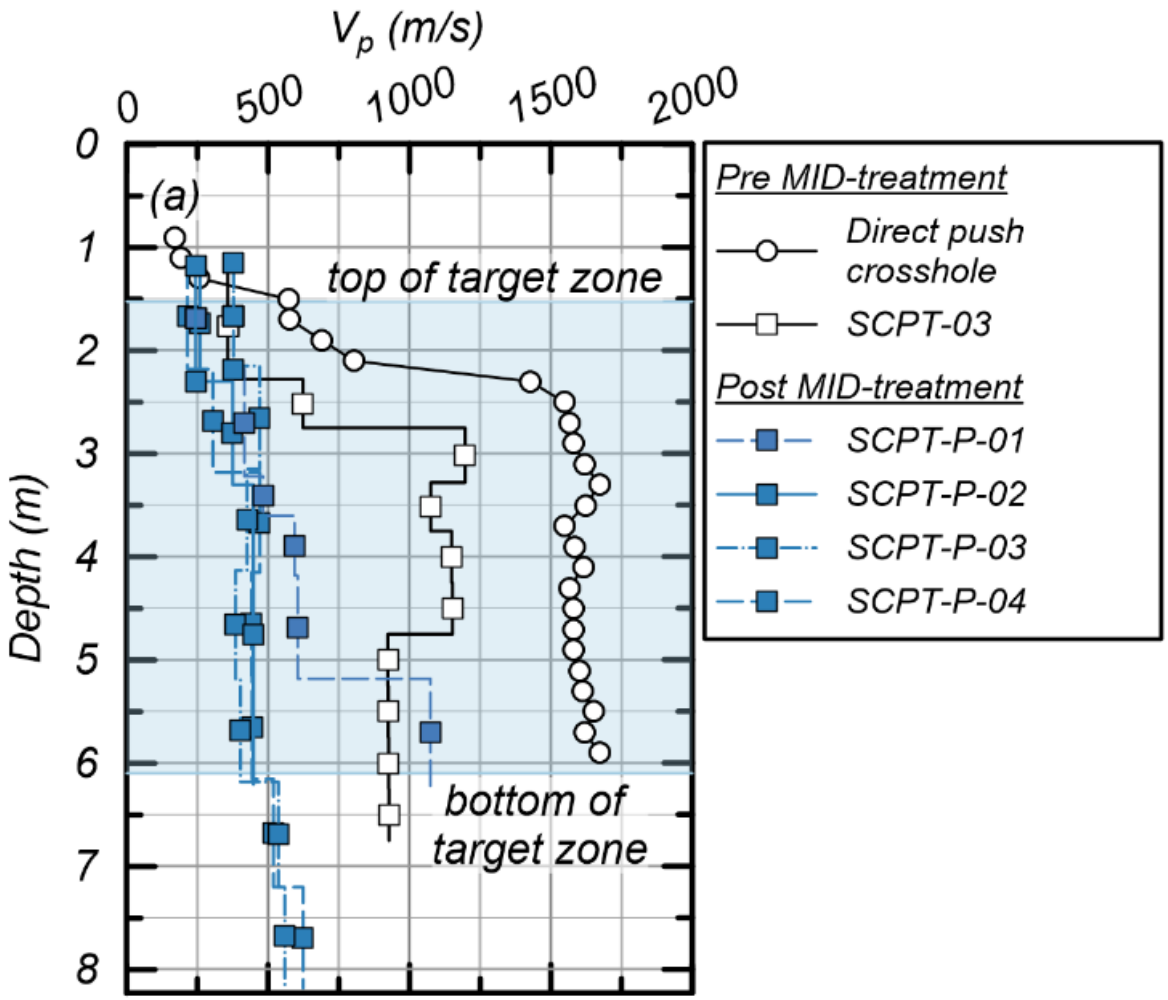
T-Rex Sensor Array



Depth based on Screening Test 2 Cross-section View (x-z)

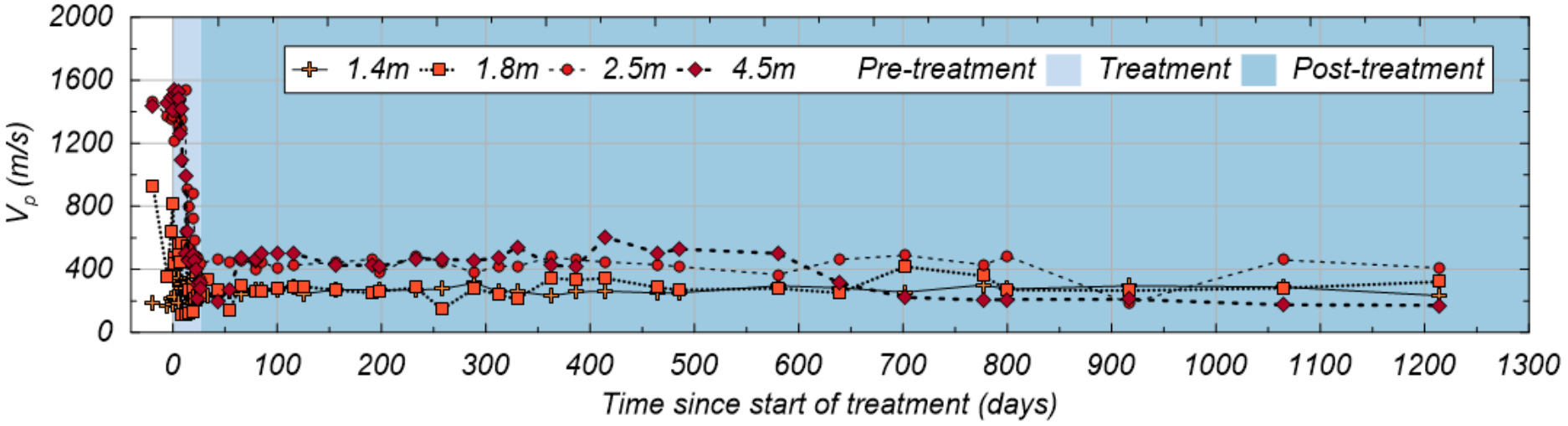
V_p Profiles

- Pre-treatment and 2 months after treatment



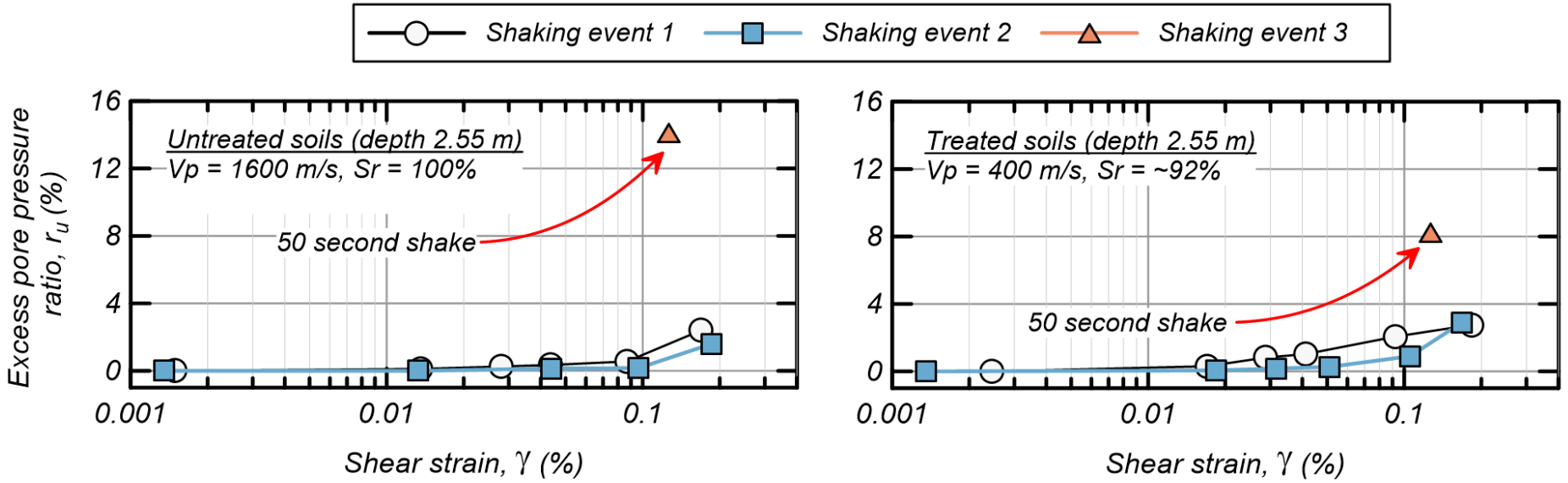
V_p Crosshole Measurements at Sunderland

- Regular V_p measurements indicate S_r < 98.5% over 3 years after treatment



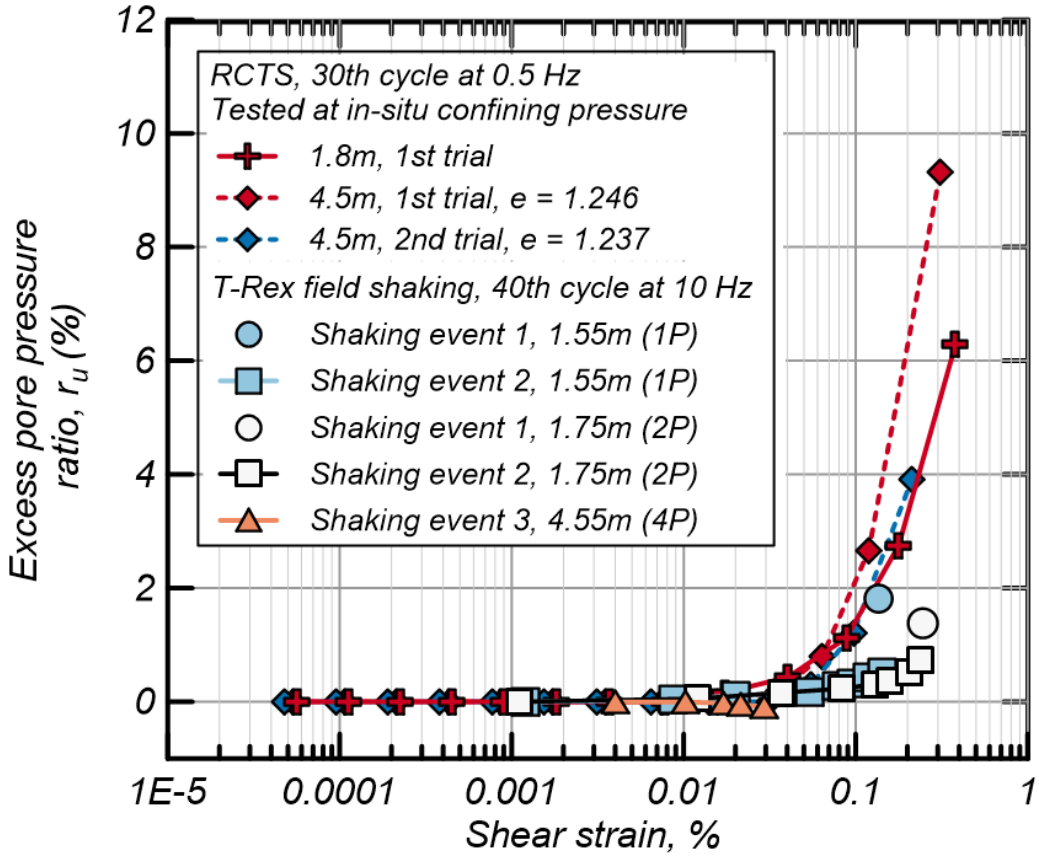
Δu - γ from T-Rex Shaking

- T-Rex shaking at 2.55 m depth does not indicate that Δu is notably reduced by MID in these soils at these cyclic shear strains



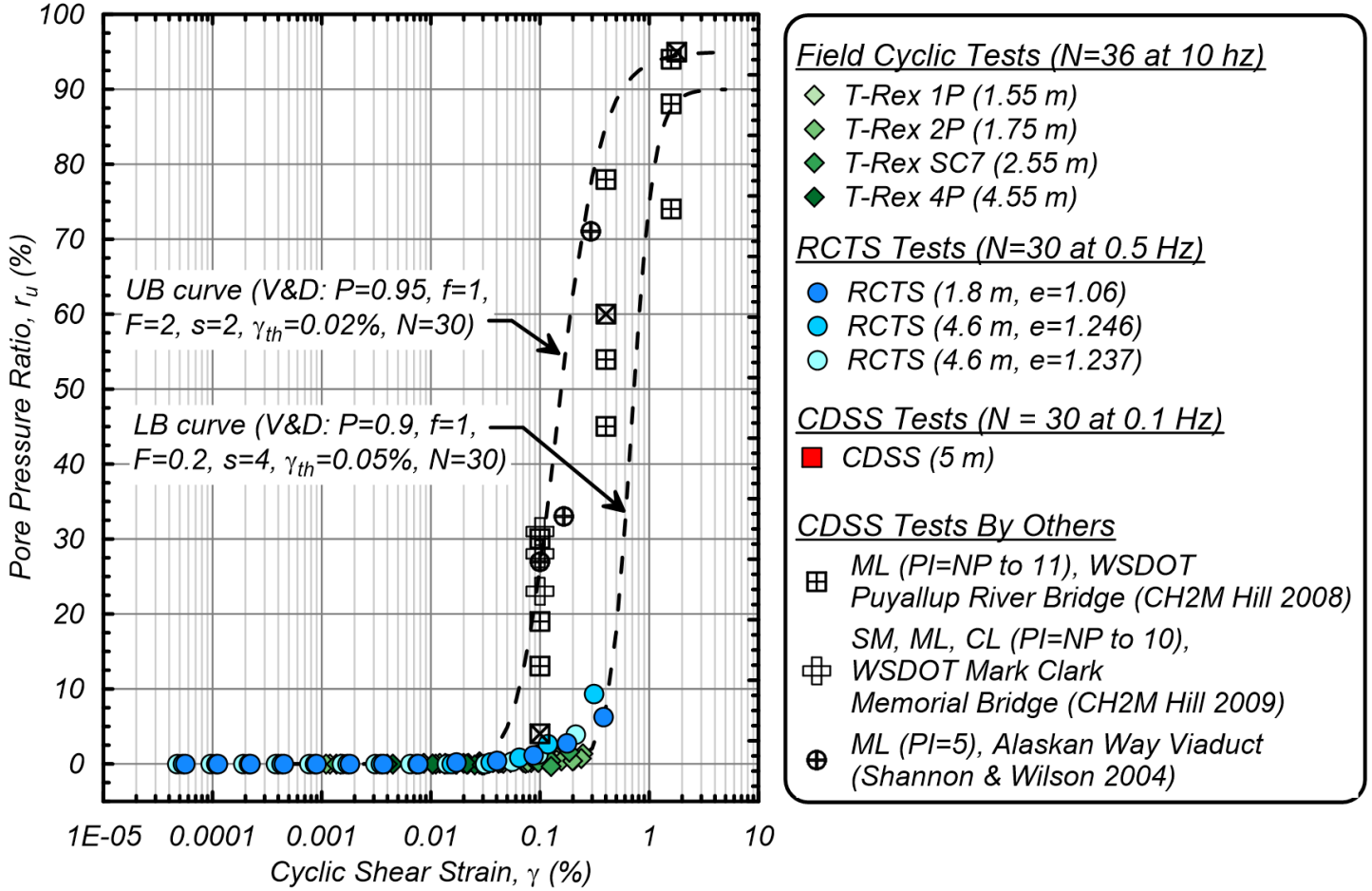
Pore pressure vs. cyclic shear strain

- Cyclic shear strains imparted by T-Rex remain < 0.3% for instrumented depts
- RCTS tests indicate larger cyclic shear strains will generate larger Δu



Pore pressure vs. cyclic shear strain

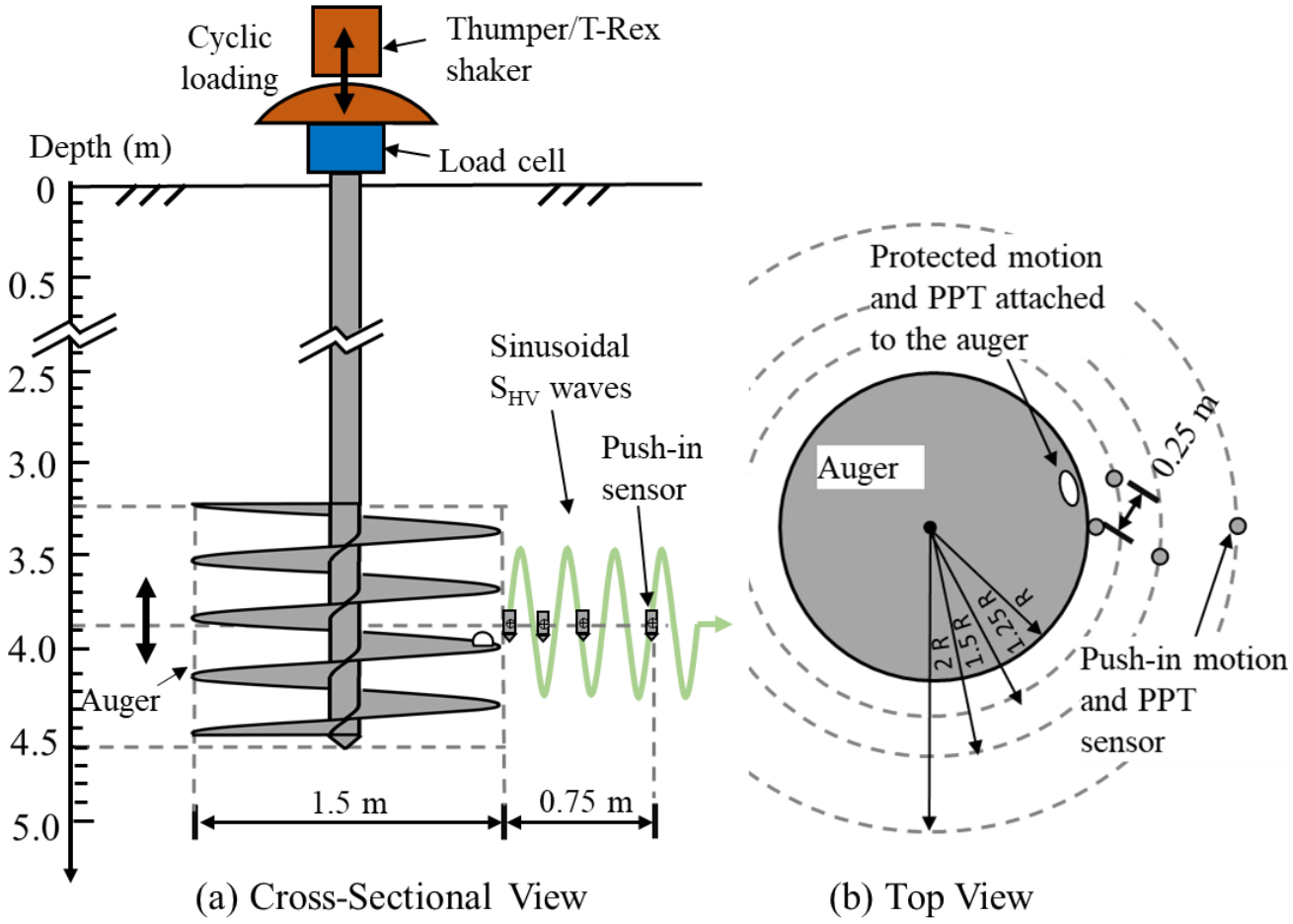
- Larger cyclic shear strains supported by regional fine-grained soil data



Preciado et al. 2022 & Khosravifar et al. 2022

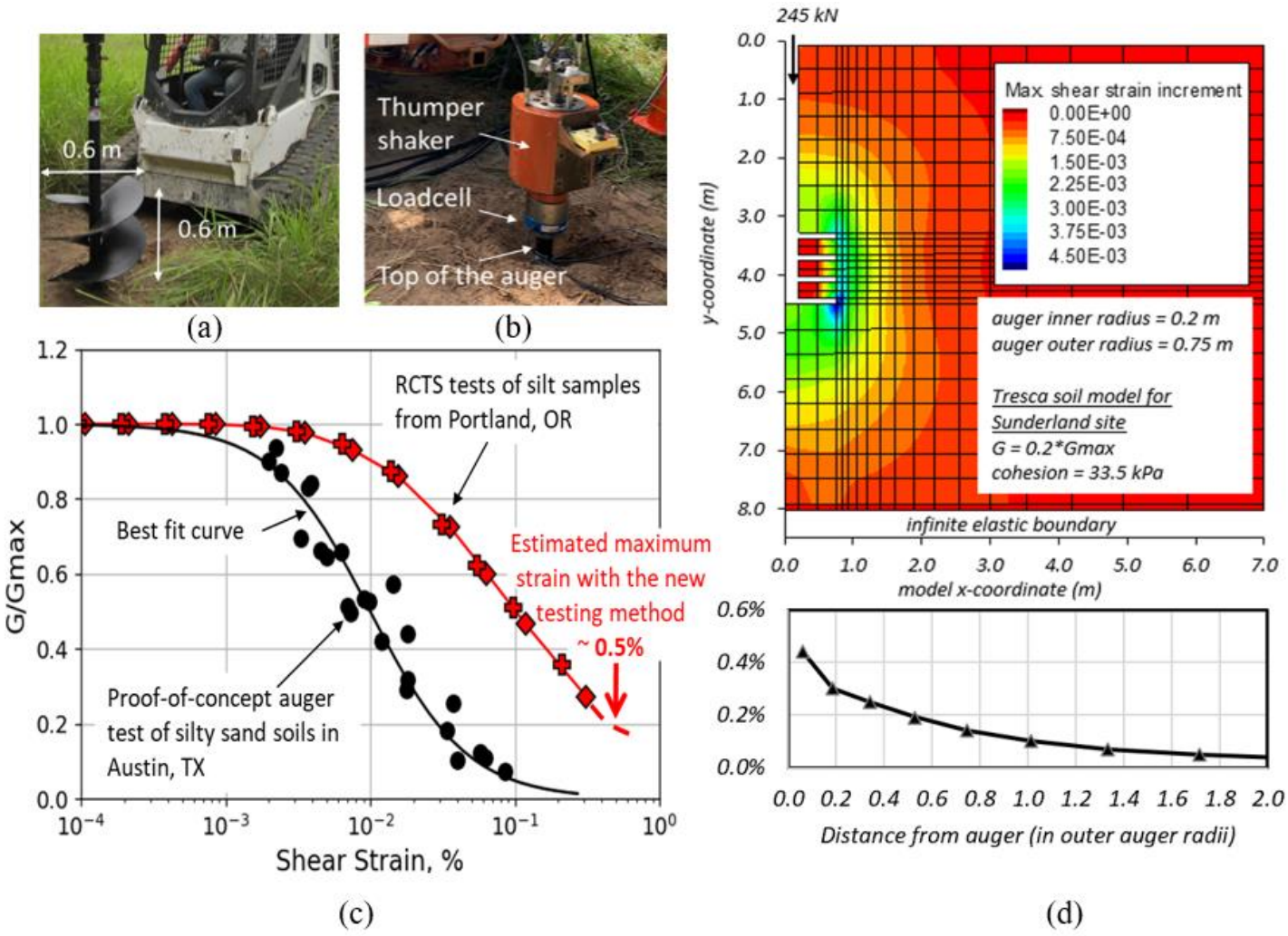
Enhanced mobile shaker truck shaking

- Potential to enhance cyclic shear strains imparted at depths of interest with an embedded auger



Enhanced mobile shaker truck shaking

- Preliminary testing performed by NHERI@Utexas and FLAC modeling



Conclusions

- Microbially Induced Desaturation for fine-grained liquefiable soil mitigation investigated through a collaborative project with PSU, NHERI@UTexas, ASU CBBG and industry partners
- Targeted soils were successfully desaturated
  - V_p measurements indicate desaturation throughout the treated soil
  - V_p reductions sustained for >3 years at the Sunderland site
- Δu vs. γ from mobile shaker trucks do not show a notable change in Δu between untreated and treated soils
  - γ does not appear to be sufficiently large at depths of interest
  - Potential to enhance γ through an imbedded auger

Acknowledgements

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