

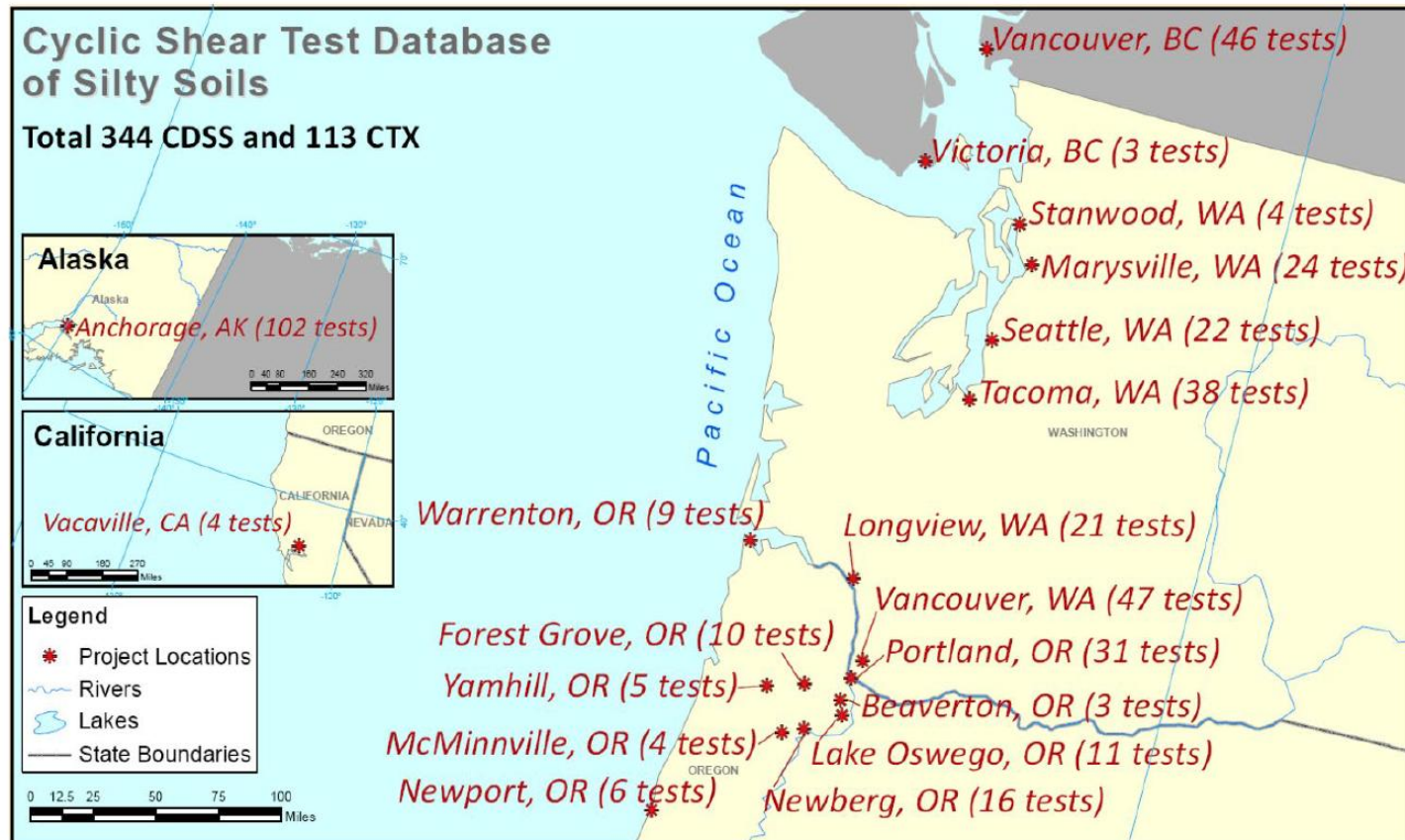
# Comparison of Laboratory Cyclic Shear Tests and Advanced Field Shaking Tests on Low Plasticity Silts

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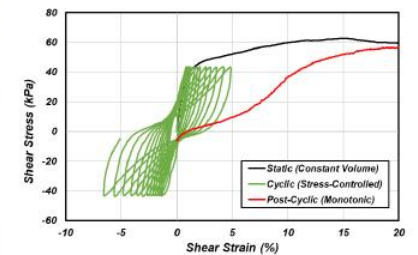
*NHERI@UTexas Workshop, Portland, Oregon  
September 11, 2025*

# Background - Cyclic Shear Behavior of Silt-rich Soils in PNW

- 2022 Data Report to ODOT by Dickenson et al.
- <https://silt.cee.pdx.edu/>



Cyclic and Post-Cyclic Behavior of Silt-Rich, Transitional Soils of the Pacific Northwest:  
A Data Archive for Geo-professionals in Practice and Research



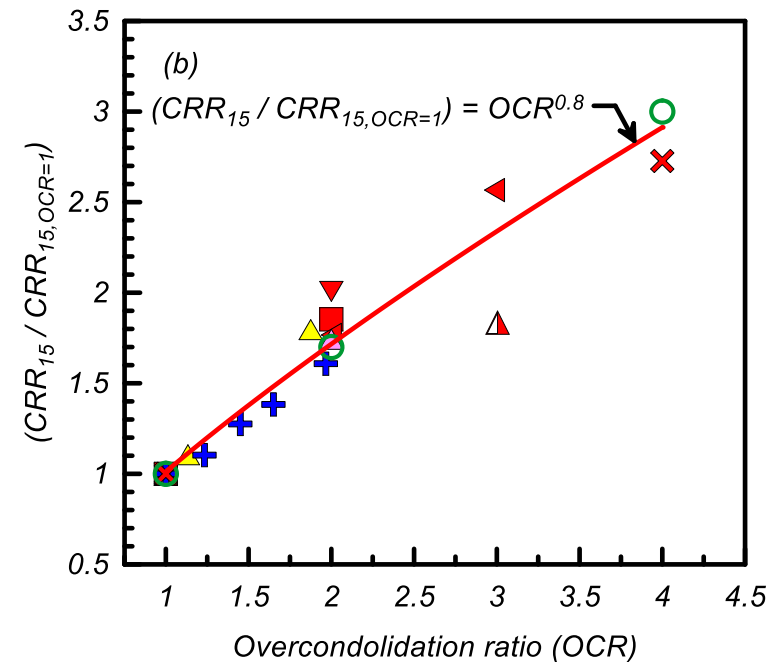
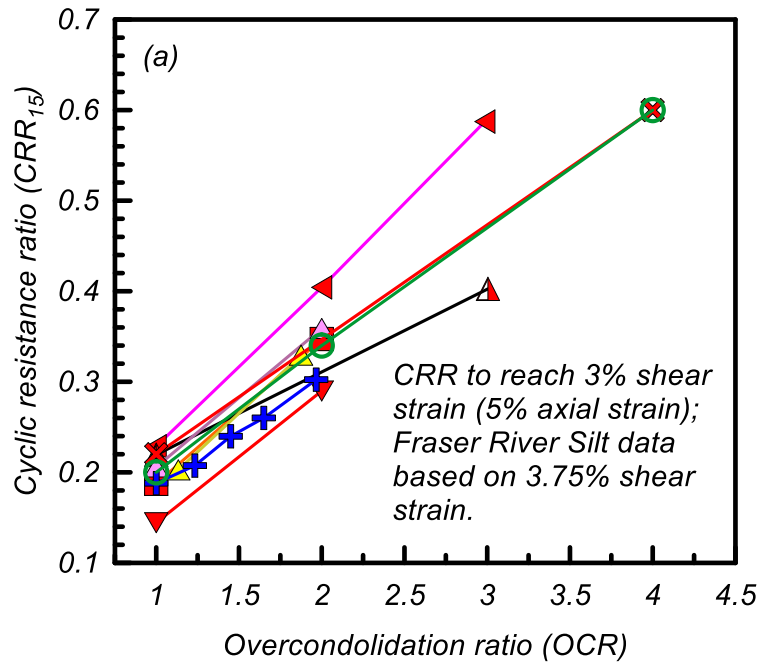
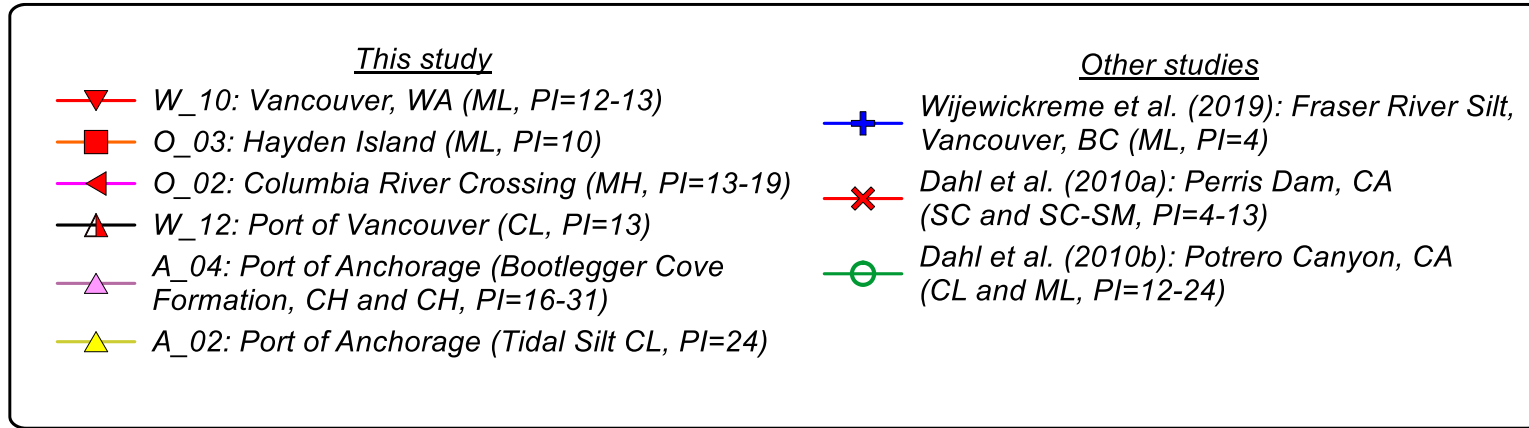
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Prepared for  
Oregon Department of Transportation  
Bridge Engineering Section  
Salem, Oregon

Prepared by

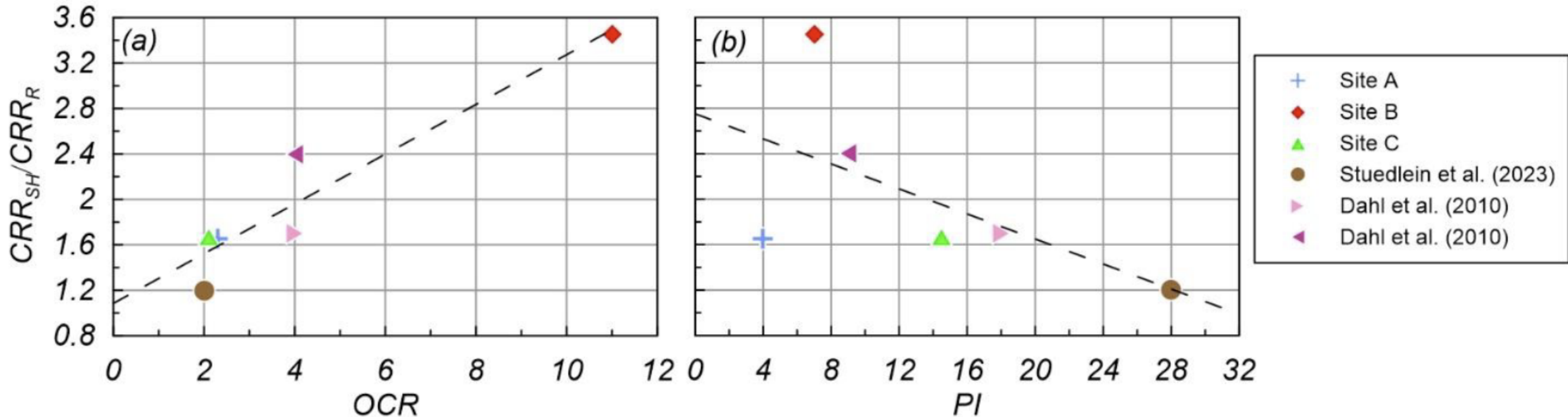


# Effect of Stress History on Cyclic Shear Resistance



# Practical Questions in Performing Lab CDSS tests

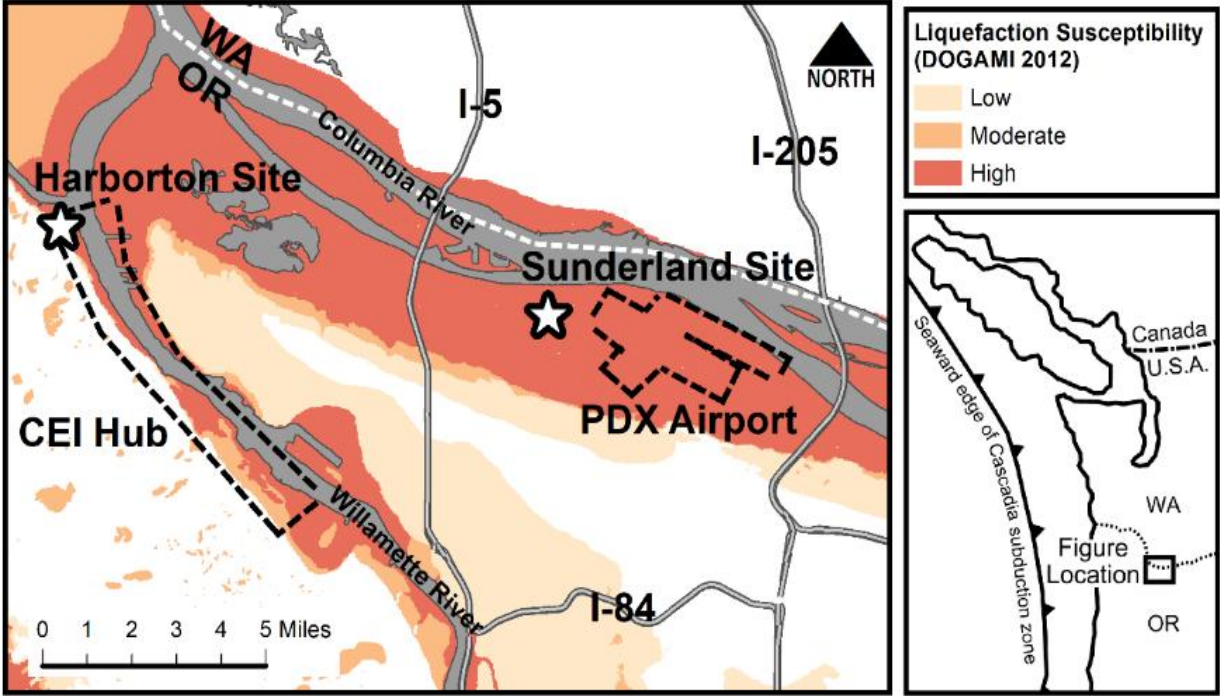
- How best to estimate preconsolidation stress ( $\sigma'_p$ )?
- Consolidation approach prior to cyclic loading (recompression vs. SHANSEP)



*Barati-Nia et al. (2025)*

# Sunderland Site NE Portland

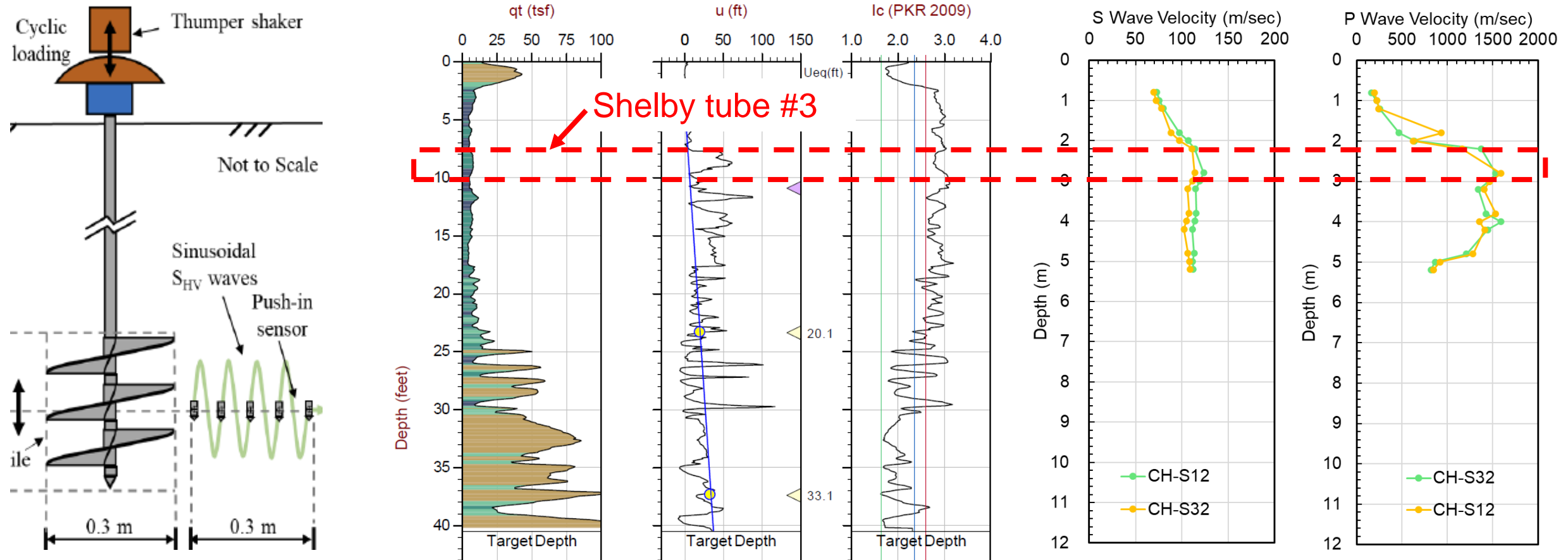
- Advanced field shaking (Thumper and helical pile from NHERI@UTexas)
- Shelby tubes for CDSS tests in lab



Untreated pad

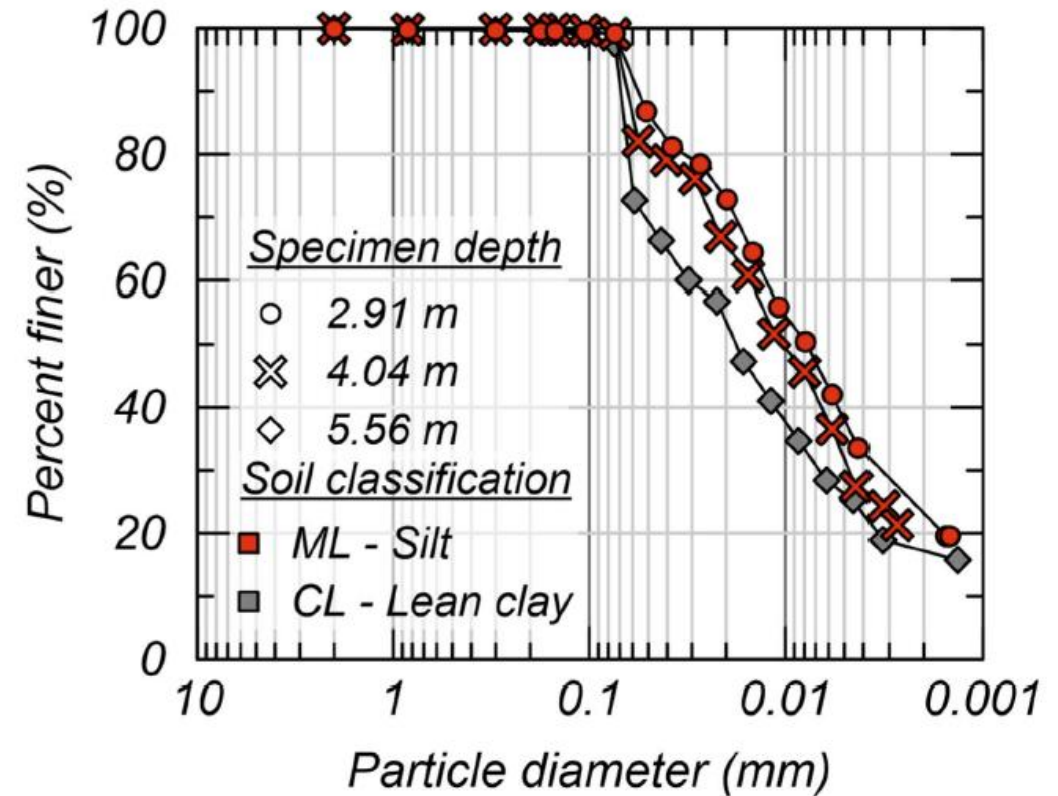
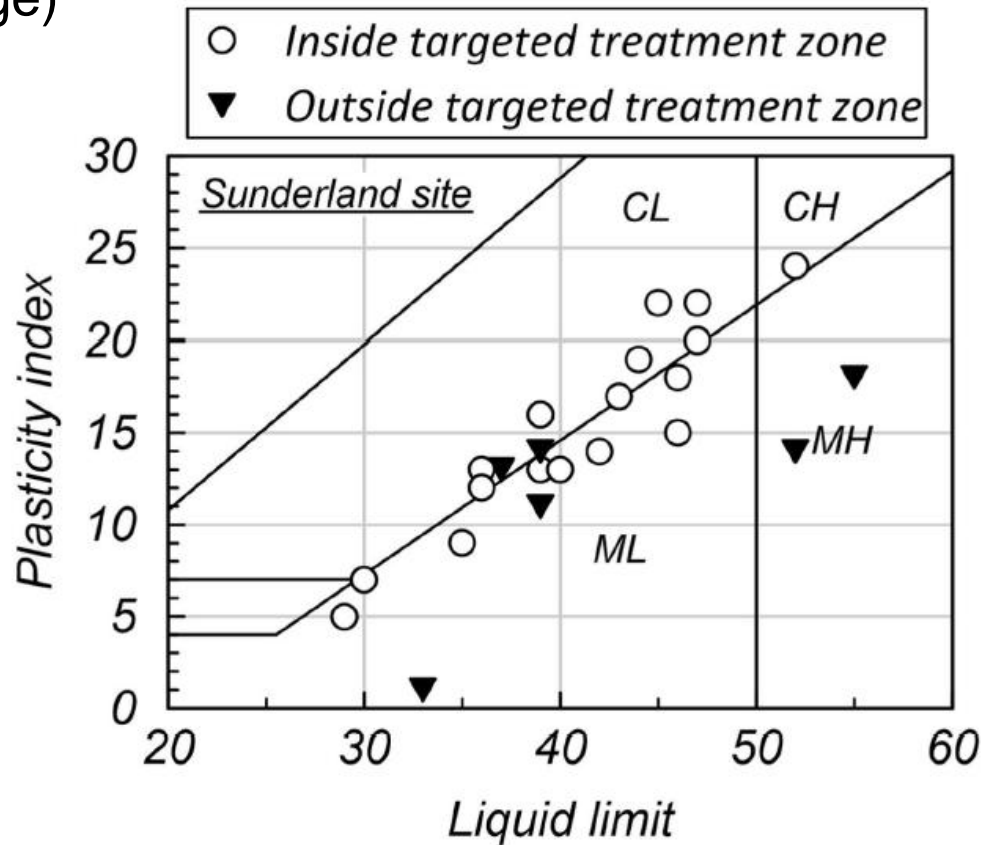
# Subsurface Conditions

- NHERI@UTexas installed a helical pile at 2.9 m (9.5 ft) for advanced field shaking in 2024
- Shelby tubes were obtained for lab testing CDSS at PSU and RCTS at UT)



# Soil Properties at 2.9 m

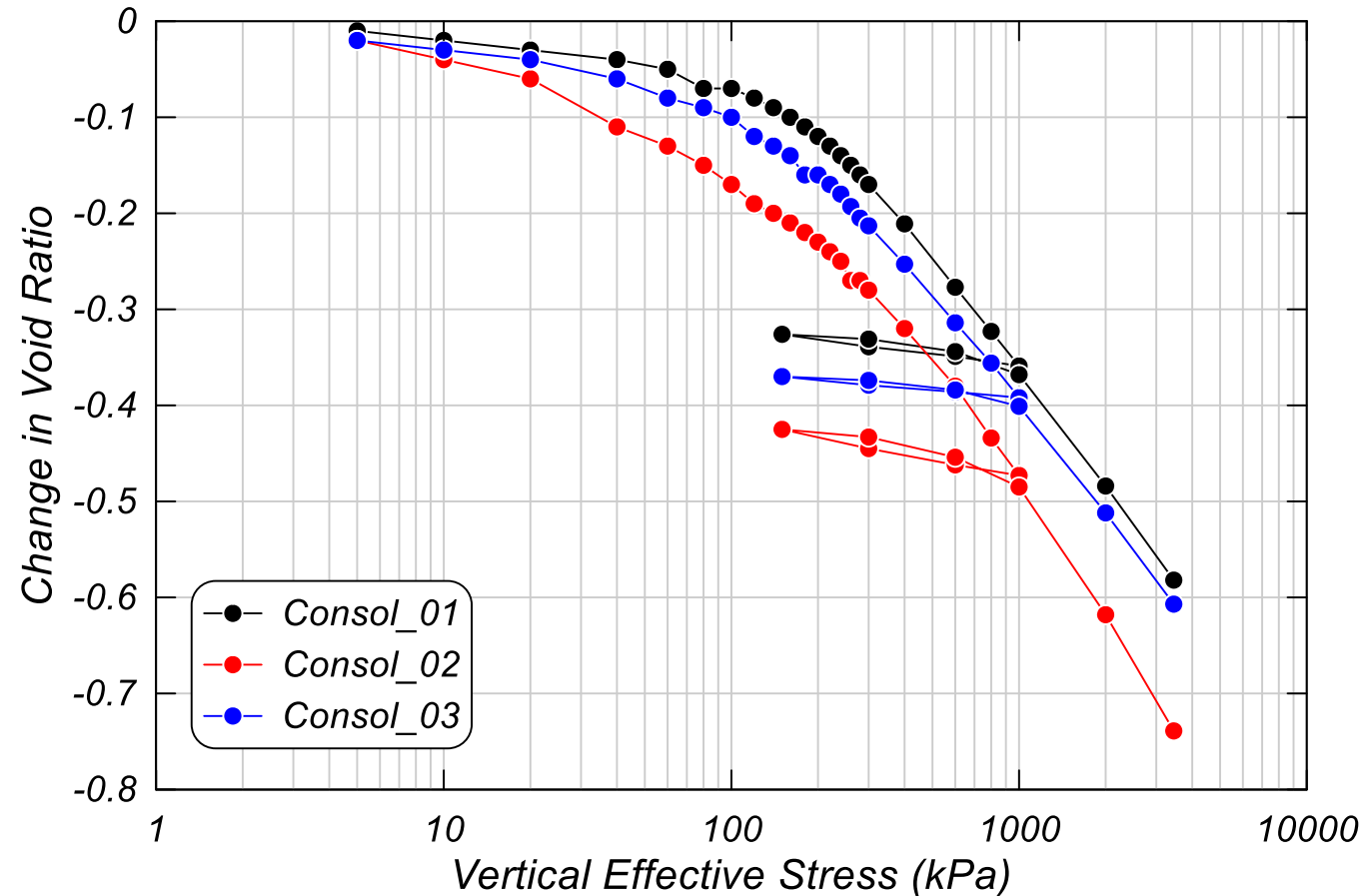
- ✓ Low plasticity silts (ML)
- ✓  $PI=16$  (average)
- ✓  $FC=90-95\%$
- ✓ Silt=70-75%



Moug et al. (2022)

# 1D Consolidation Test

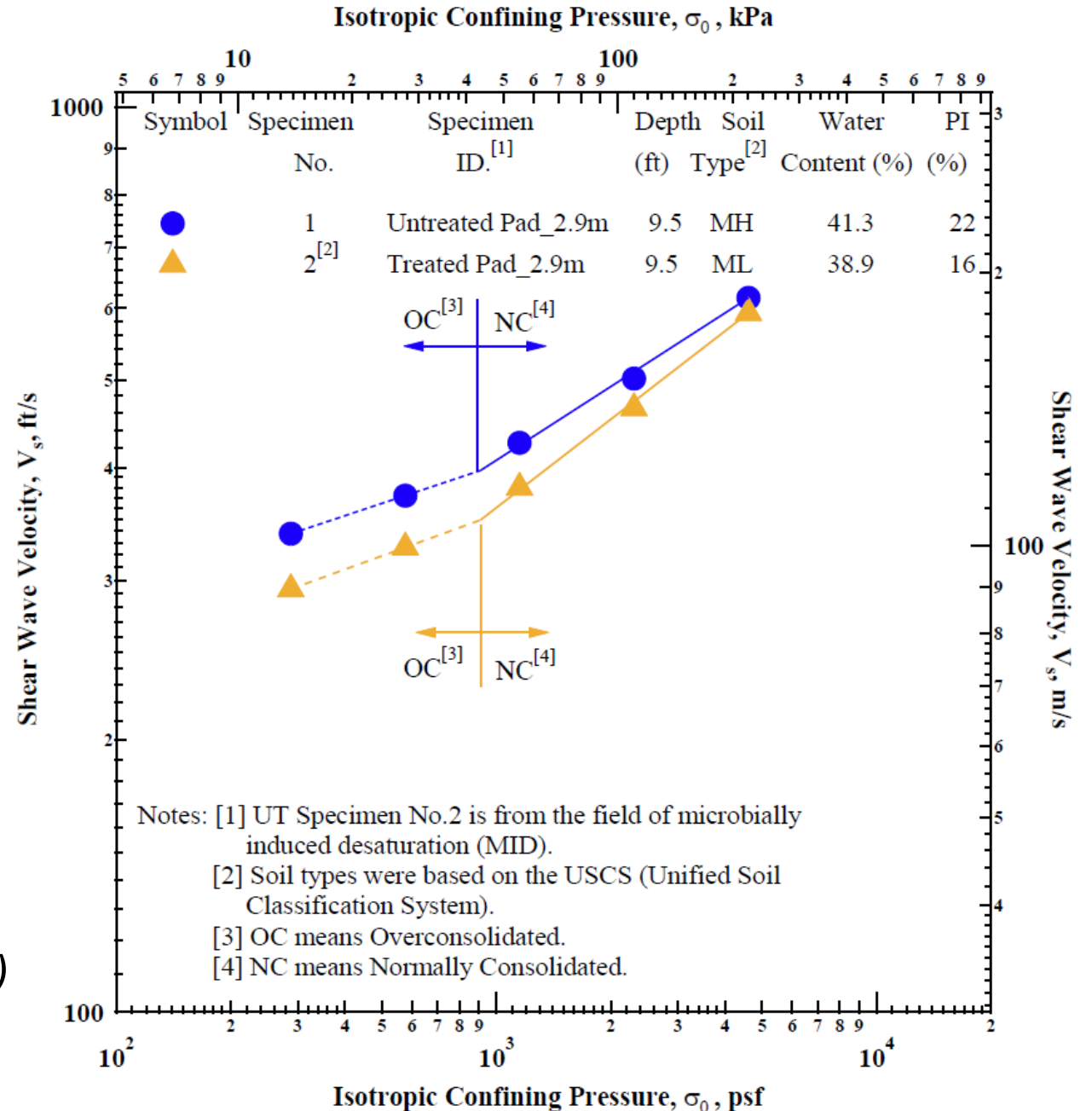
- Casagrande method:  $\sigma_p = 230$  kPa (best estimate) (OCR=7.5)
- Strain energy method:  $\sigma_p = 75$  kPa (OCR=2)



# Preconsolidation stress implied from RCTS at UT

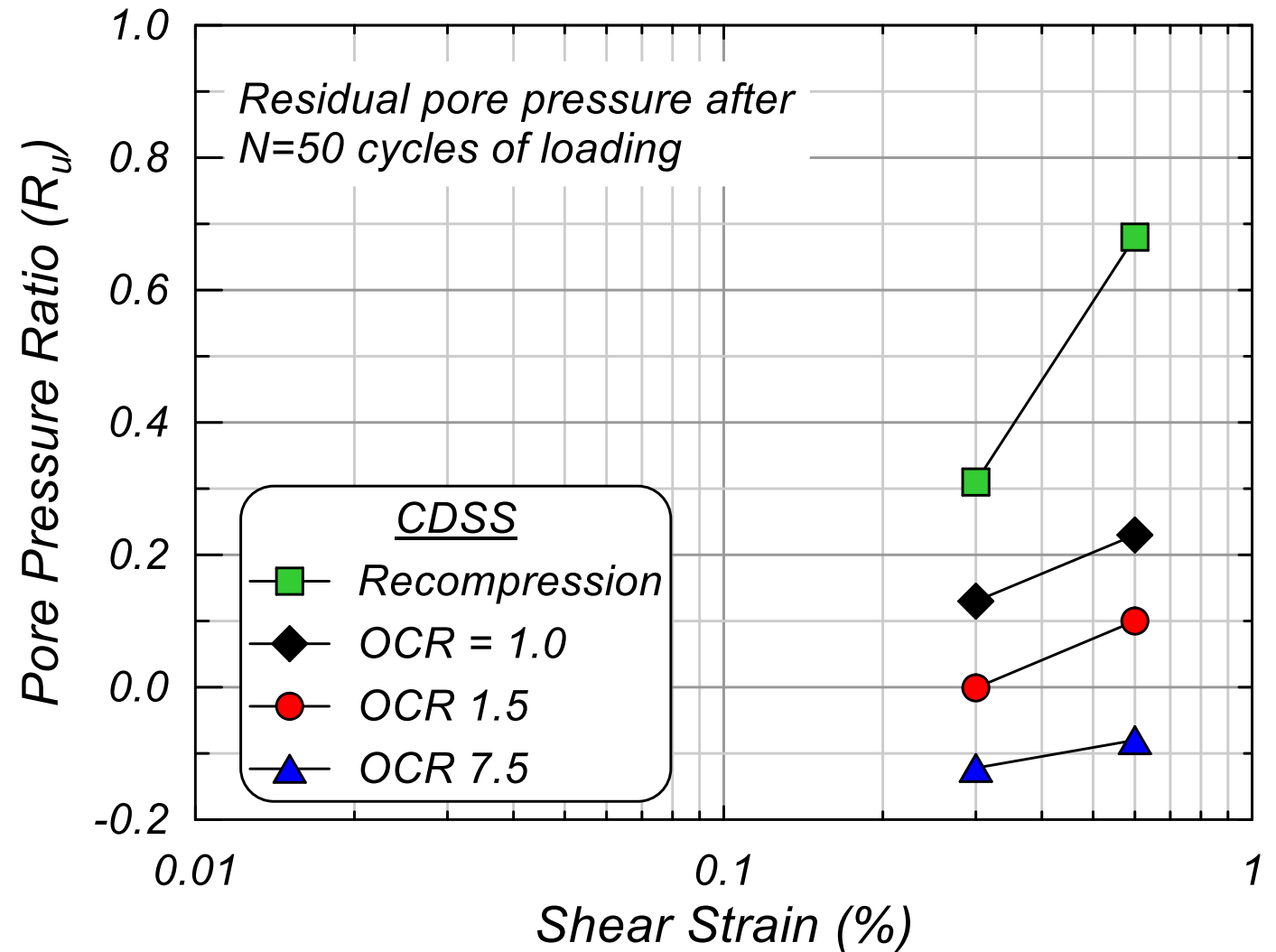
- Resonant Column Torsional Shear (RCTS)
- Isotropic preconsolidation confining pressure,  $\sigma_o = 45$  kPa
- $\sigma_{vp} = 67$  kPa (assuming  $k_o=0.5$ )

*Stokoe et al. (2024)  
Report GR24-07*



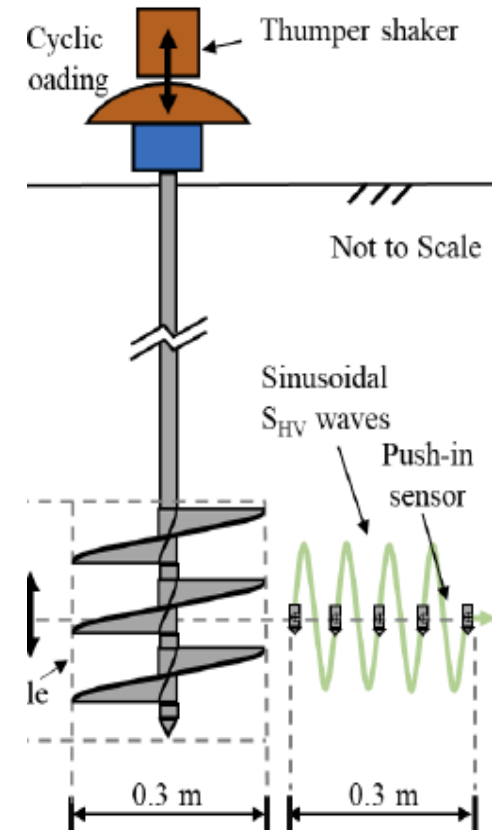
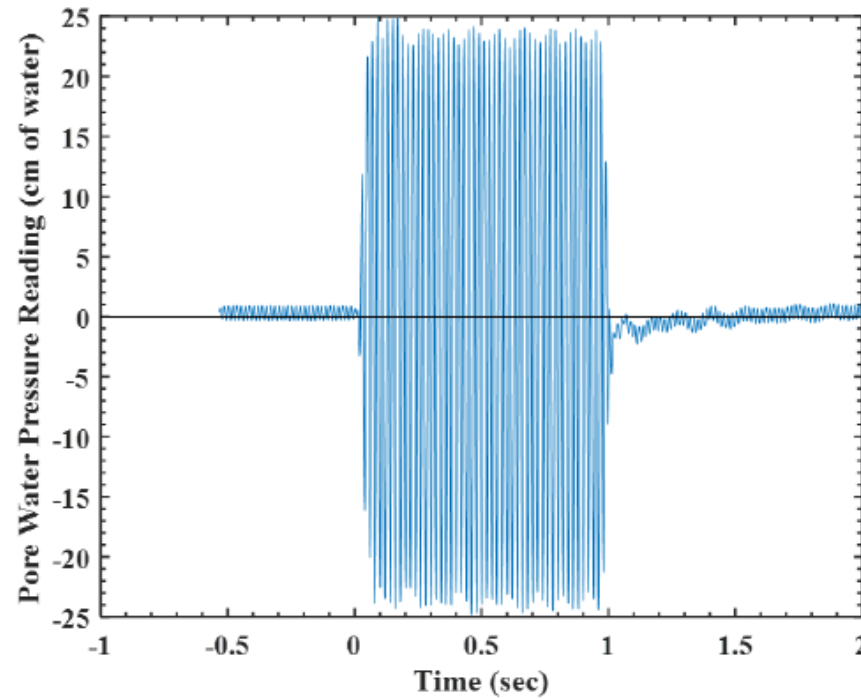
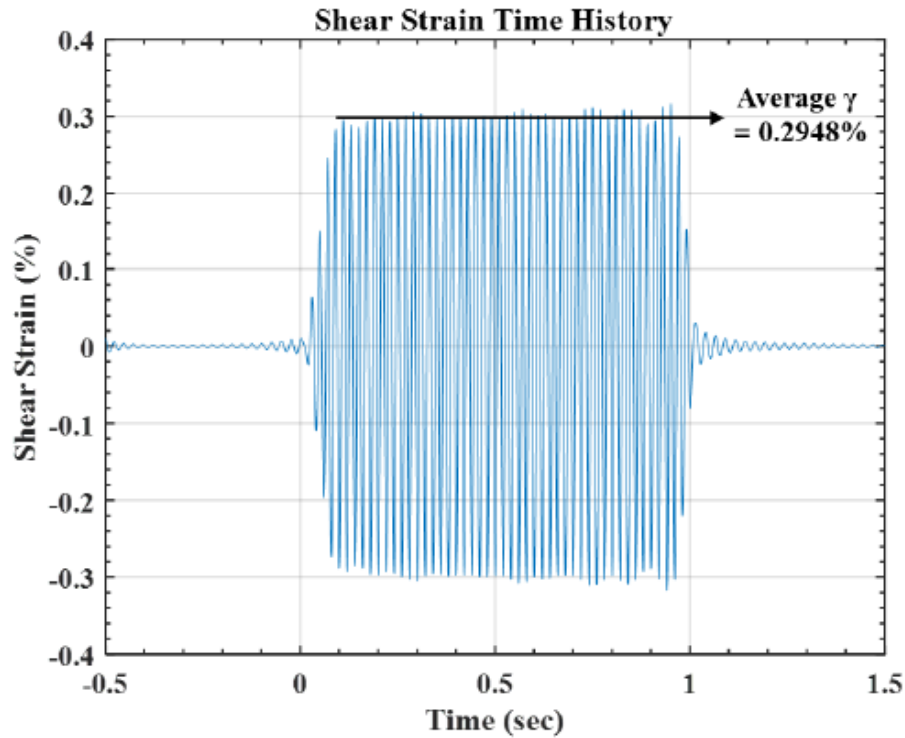
# Strain-Controlled Cyclic Direct Simple Shear (CDSS)

- Constant volume conditions, at 0.3% and 0.6% shear strain, loading frequency of 0.1 Hz
- OCR 7.5, Load to  $\sigma_v=255$  kPa, unload to  $\sigma_v=34$  kPa
- OCR 1.5, Load to  $\sigma_v=255$  kPa, unload to  $\sigma_v=170$  kPa
- OCR 1, Load to  $\sigma_v=255$  kPa
- Recompression, Load to  $\sigma_v=31$  kPa (in-situ effective vertical stress)



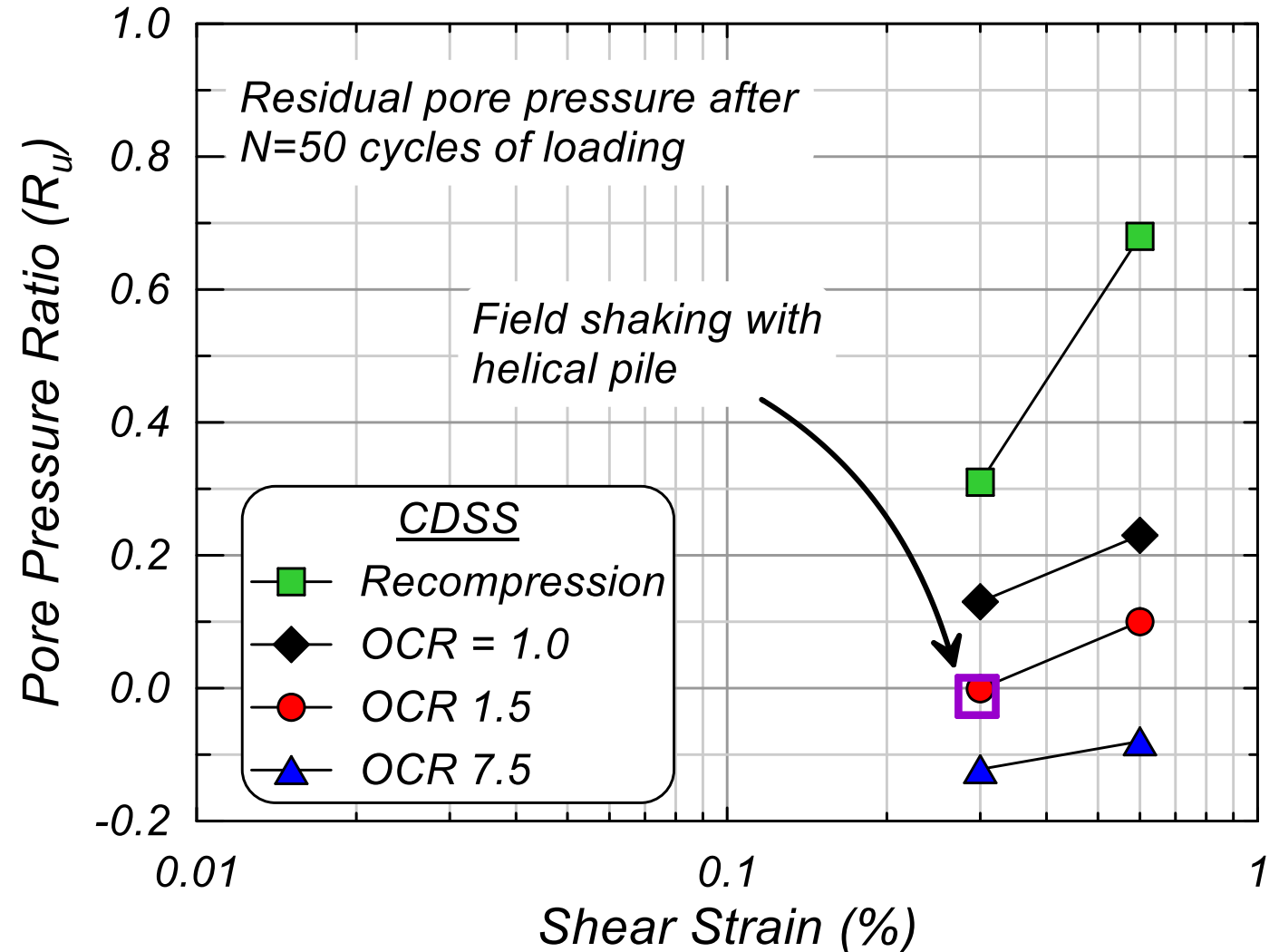
# Advanced Field Shaking with Helical Pile @ 2.9m

- $R_u=0$  at  $\gamma=0.3\%$  after  $N=50$  cycles, loading frequency=50 Hz



# Strained-Controlled Cyclic Direct Simple Shear (CDSS)

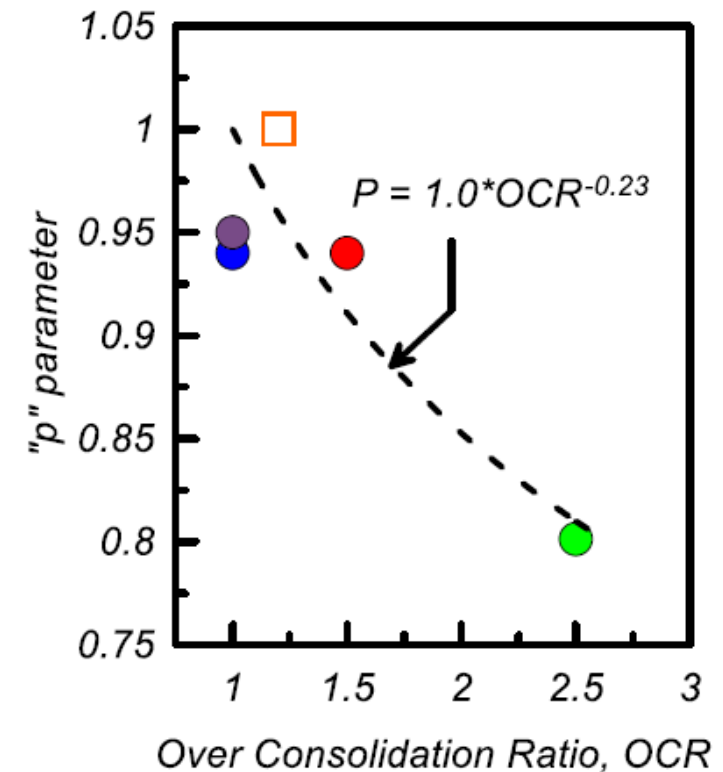
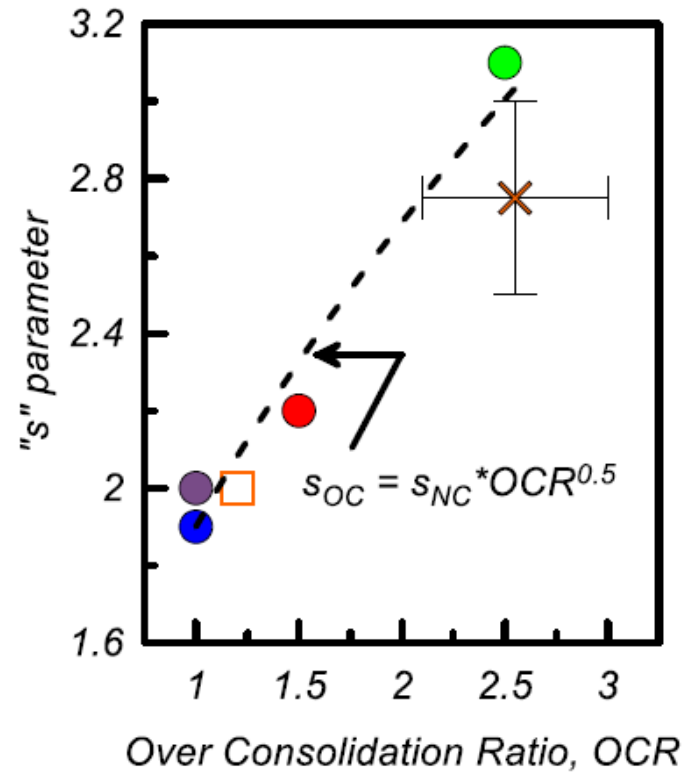
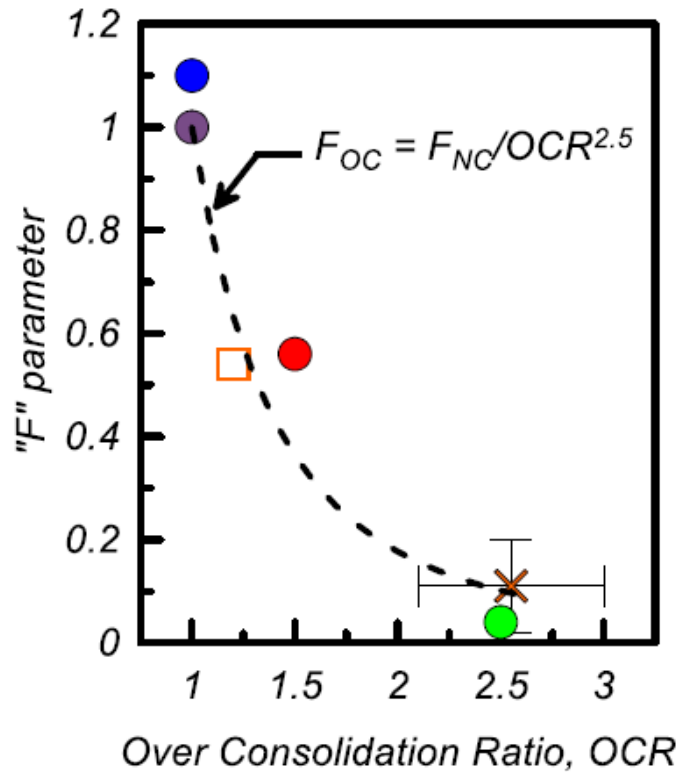
- CDSS specimens consolidated mechanically (SHANSEP) to OCR estimated from Casagrande method (OCR=7.5) underestimated  $R_u$  from field shake
- ...OCR estimated from dissipated strain energy method closely followed  $R_u$  from field shake
- Recompression method overestimated  $R_u$  from field shake



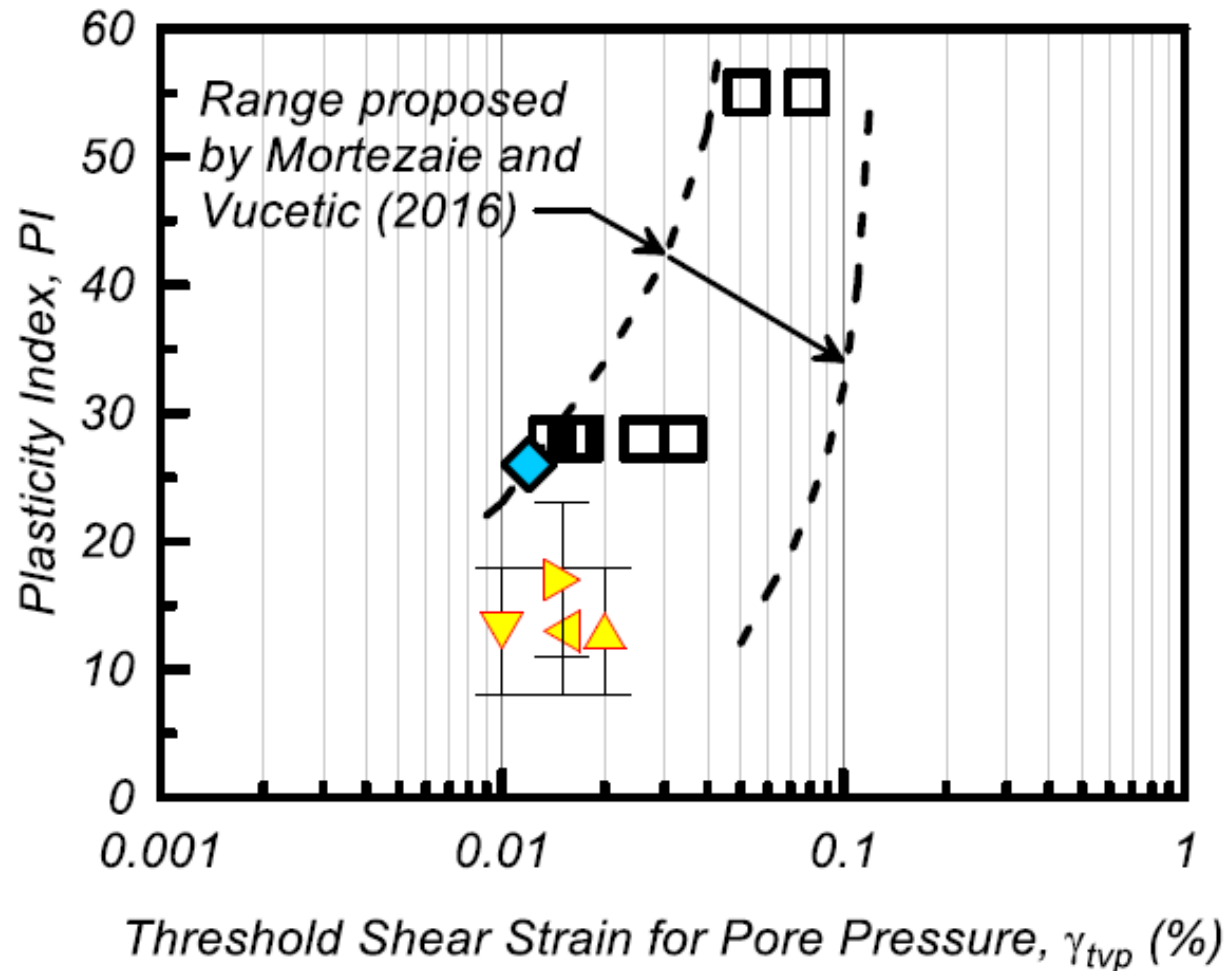
# Projection of Ru to larger shear strain

- Vucetic and Dobry pore pressure model for sand
- Input parameters for silt per Khosravifar et al. (2022)

$$R_u = \frac{PfNF(\gamma_c - \gamma_{tvp})^s}{1 + fNF(\gamma_c - \gamma_{tvp})^s}$$



# Threshold Shear Strain for Pore Pressure



Data from field shaking on Columbia River Silt from Portland, OR (this study)

- ◀ 1.55m, OCR=2.1
- ▶ 1.75m, OCR=2.2
- ▼ 2.55m, OCR=3
- ▶ 4.55m, OCR=2.1

- ◻ Mortezaie and Vucetic (2016)  
OCR=1-4
- ◼ Jana and Stuedlein (2021)  
OCR=1.8-2

# V&D Sand Model for Silt Soil

- V&D sand model, input parameters for silt per Khosravifar et al. (2022)

$$\gamma_{tvp}[\%] = 0.01 + PI/900$$

(based on average of the recommended range by Ref. [44] (based on average of the recommended range by [44])

$$P = 1.0 \times OCR^{-0.23} \quad (4)$$

$$F_{NC} = 0.7 \text{ (mean value for NC silt)} \quad (5a)$$

$$F_{OC} = F_{NC} \times OCR^{-2.5} \quad (5b)$$

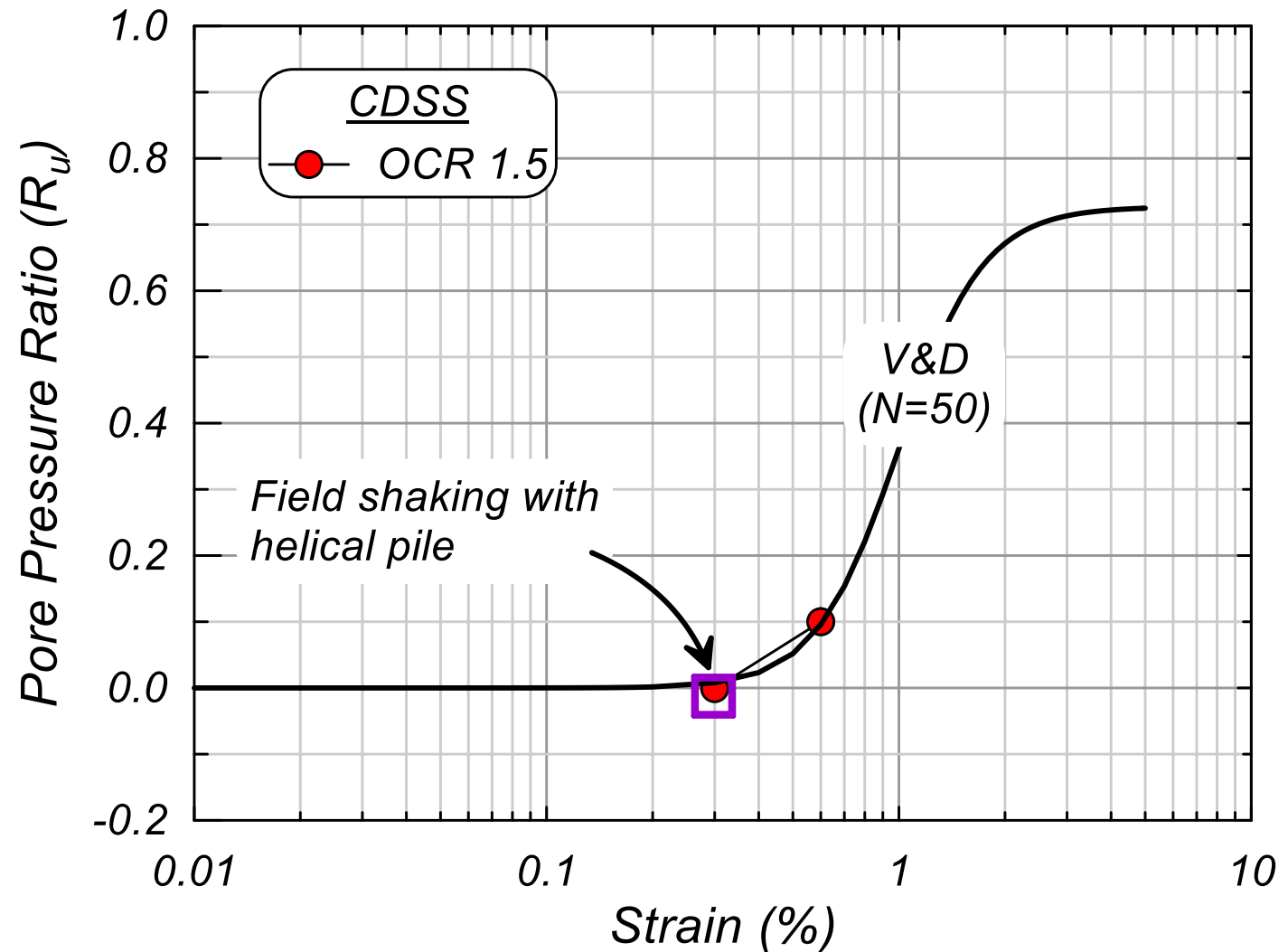
$$s_{NC} = (1 + FC)^{0.1252} \text{ (the relationship proposed by Carlton 2014)} \quad (6a)$$

$$s_{OC} = s_{NC} \times OCR^{0.5} \quad (6b)$$

$$R_u = \frac{PfNF(\gamma_c - \gamma_{tvp})^s}{1 + fNF(\gamma_c - \gamma_{tvp})^s} \quad (3)$$

# Projection of $R_u$ to larger shear strain

- V&D sand model
- Input parameters for silt per Khosravifar et al. (2022)
  - ✓  $P=0.7$
  - ✓  $f=1$
  - ✓  $F=0.02$
  - ✓  $s=3.5$
  - ✓  $\gamma_{th}=0.027\%$



# Conclusions

- Mechanical consolidation in CDSS (SHANSEP) to OCR estimated from Casagrande method underestimated  $R_u$  from field shake
- Estimating OCR from the dissipated strain energy method resulted in  $R_u$  values that closely followed field shake
- Recompression method overestimated  $R_u$  from field shake

# Potential Future Work

- Additional Shelby tubes distributed with workshop participants
- Collaborative work to evaluate repeatability of test results from different labs, constant-volume vs truly undrained, different consolidation approaches, constant rate of strain vs incremental load method

# References

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