

Site-Specific Approach for Developing Profiles of Critical State Soil Mechanics Parameters in Mine Tailings Deposits

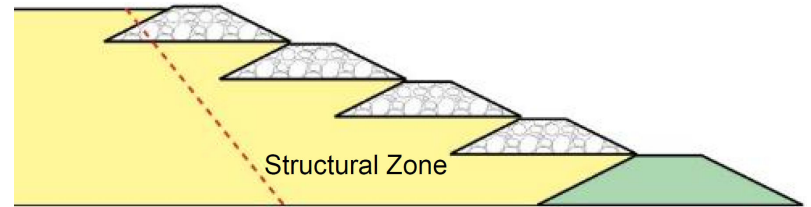
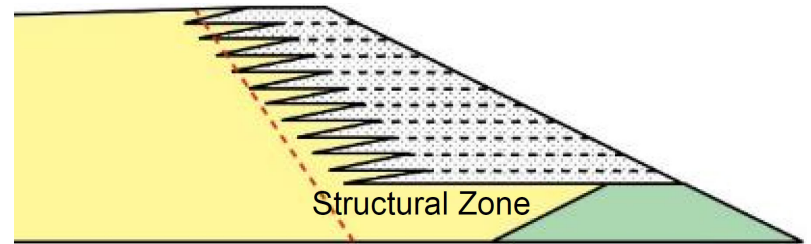
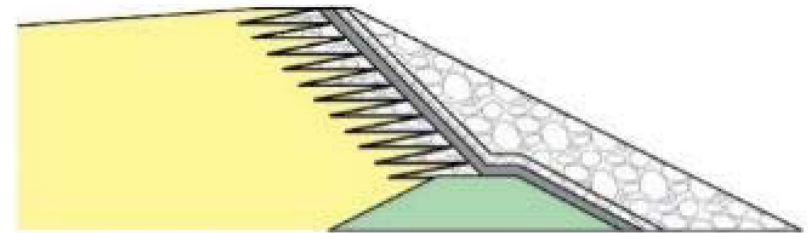
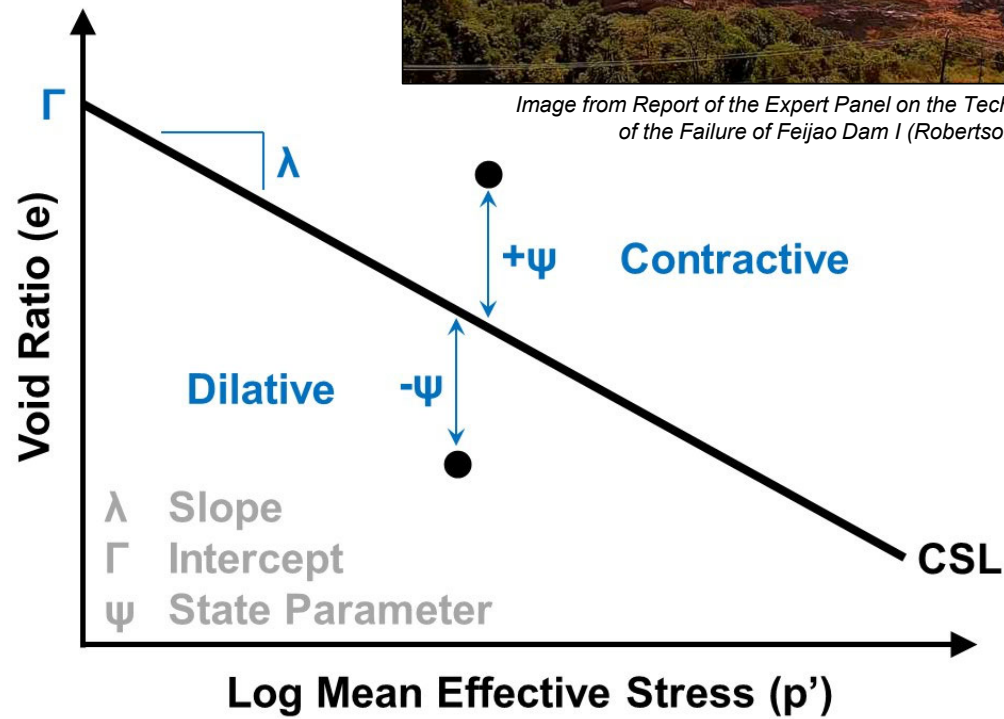
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Barr Engineering Co., Minneapolis, MN, USA*

Introduction



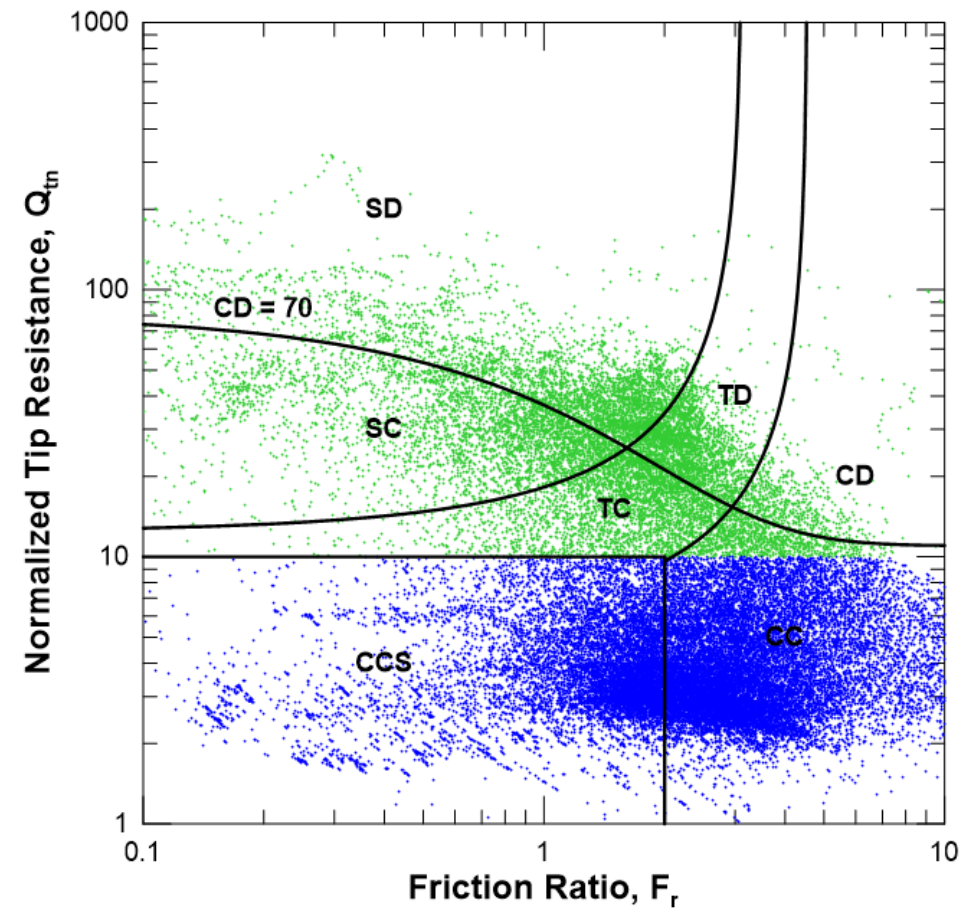
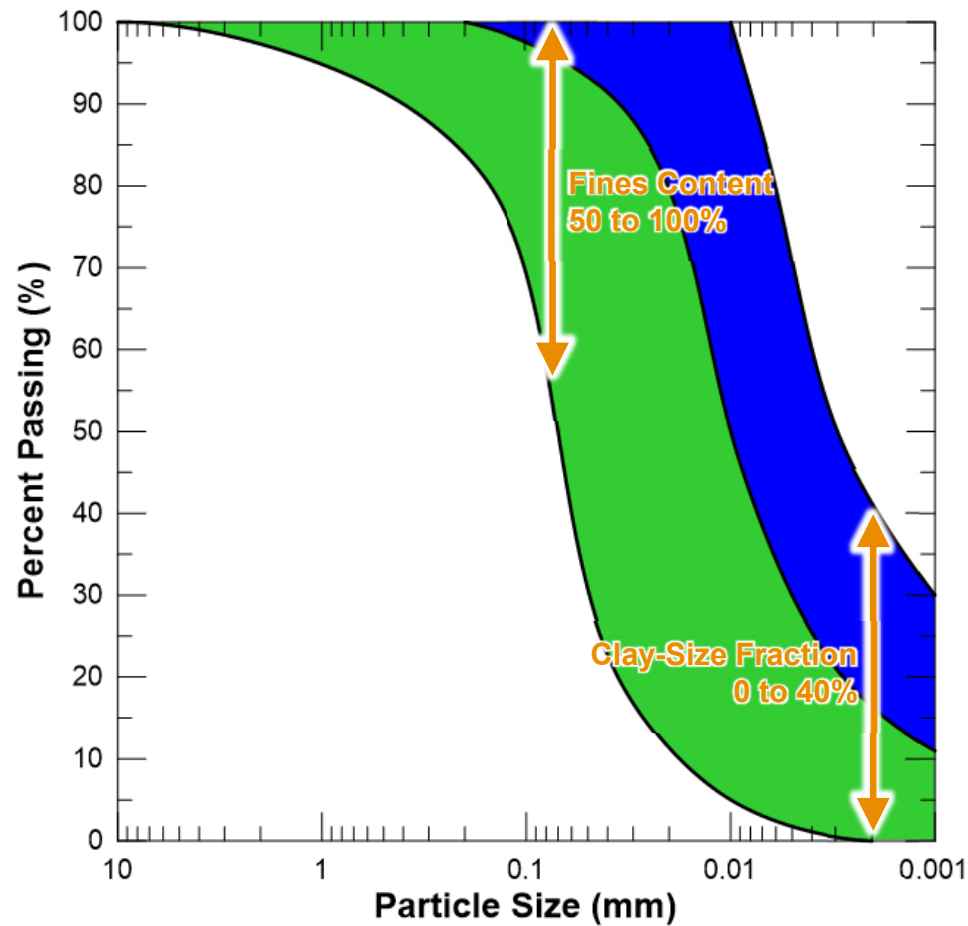
Image from Report of the Expert Panel on the Technical Causes of the Failure of Feijao Dam I (Robertson et al., 2019)



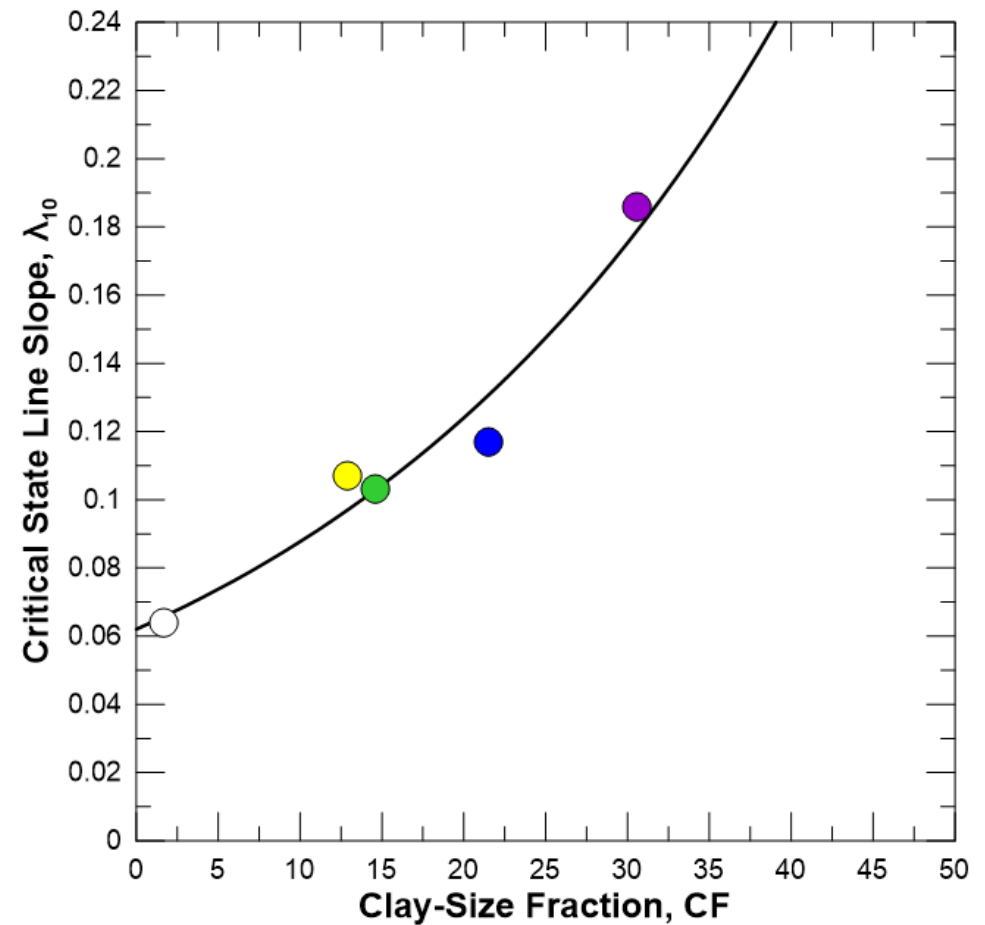
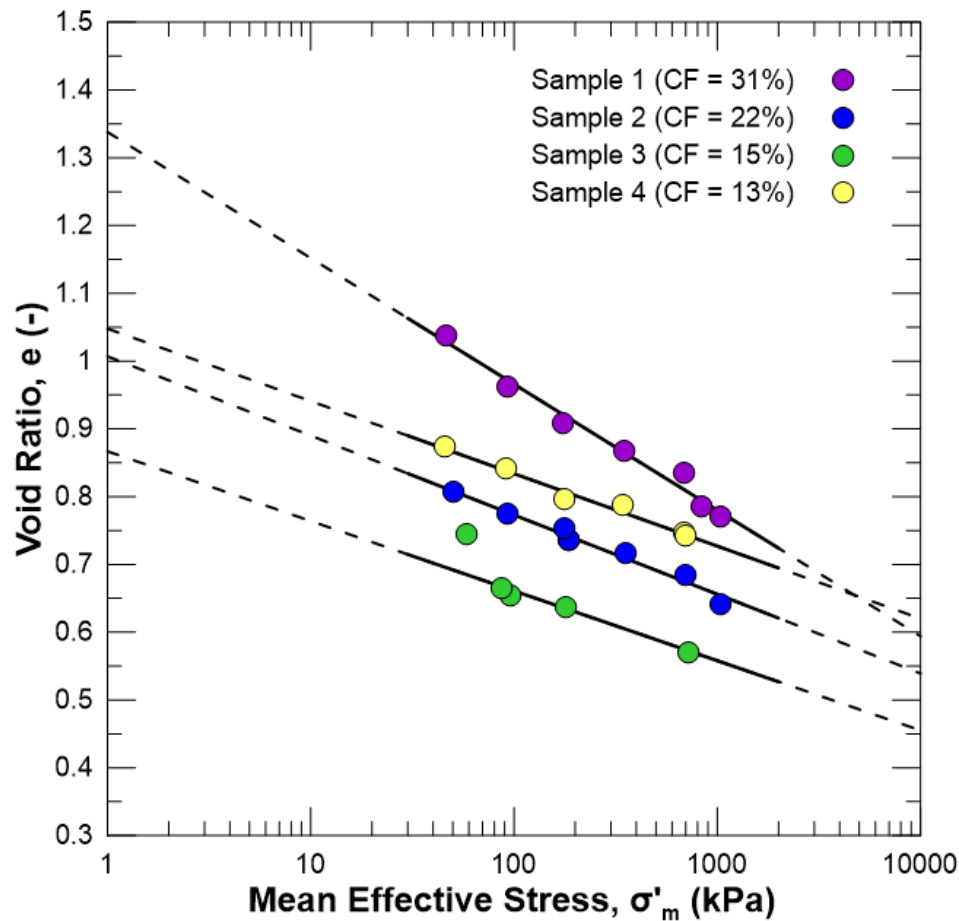
Images from ICOLD (2019) Bulletin 181: Tailings Dam Design Technology Update

Tailings Characterization

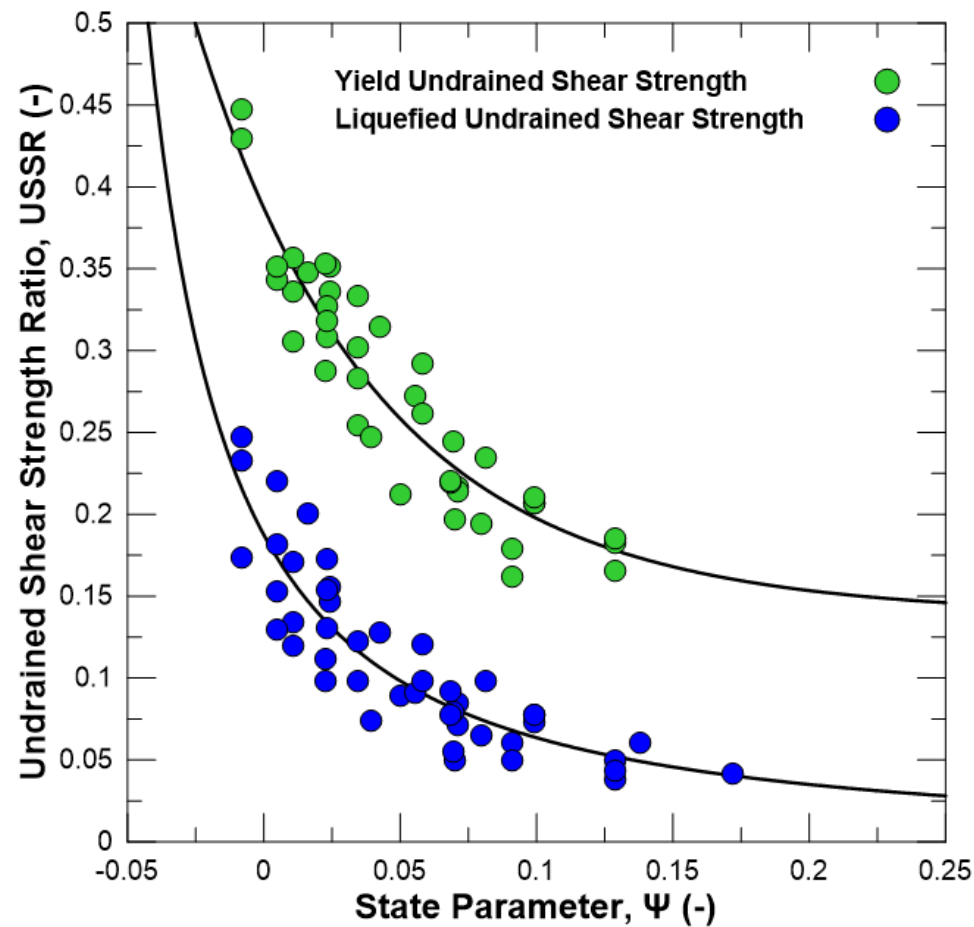
Fine Tailings Gradation and Soil Behavior Type Index



Fine Tailings Gradation and Soil Behavior Type Index

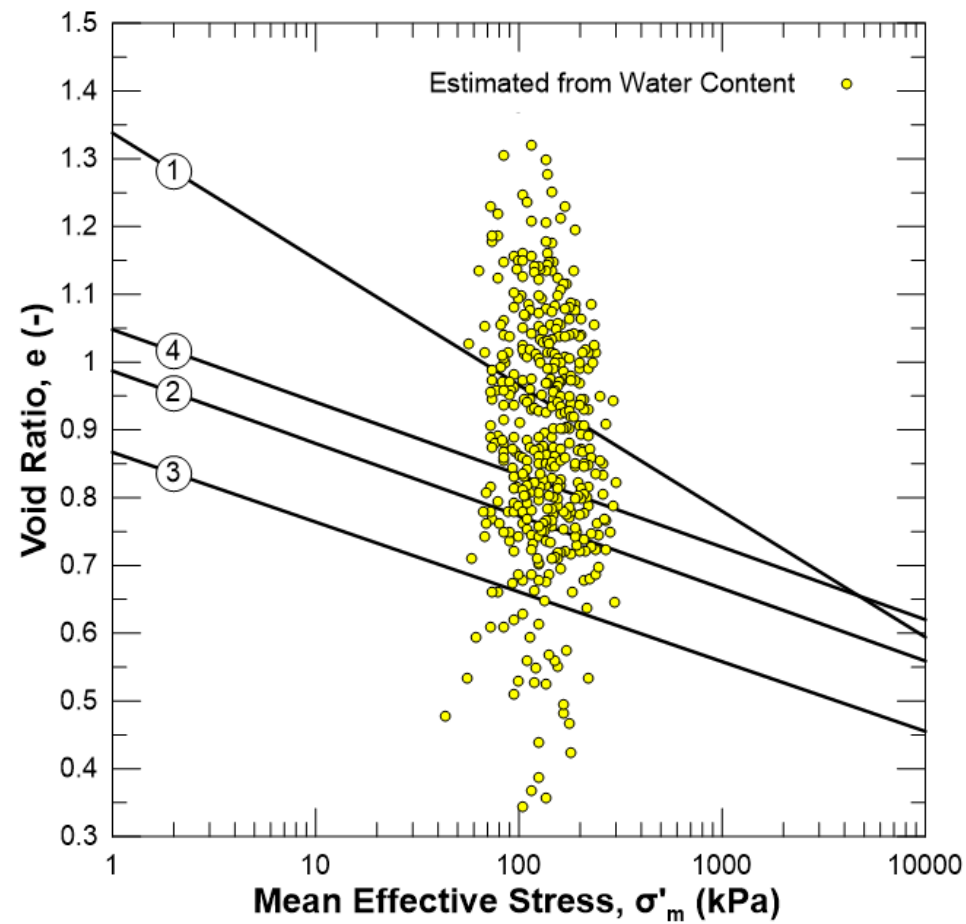


Fine Tailings Critical State Soil Mechanics Parameters

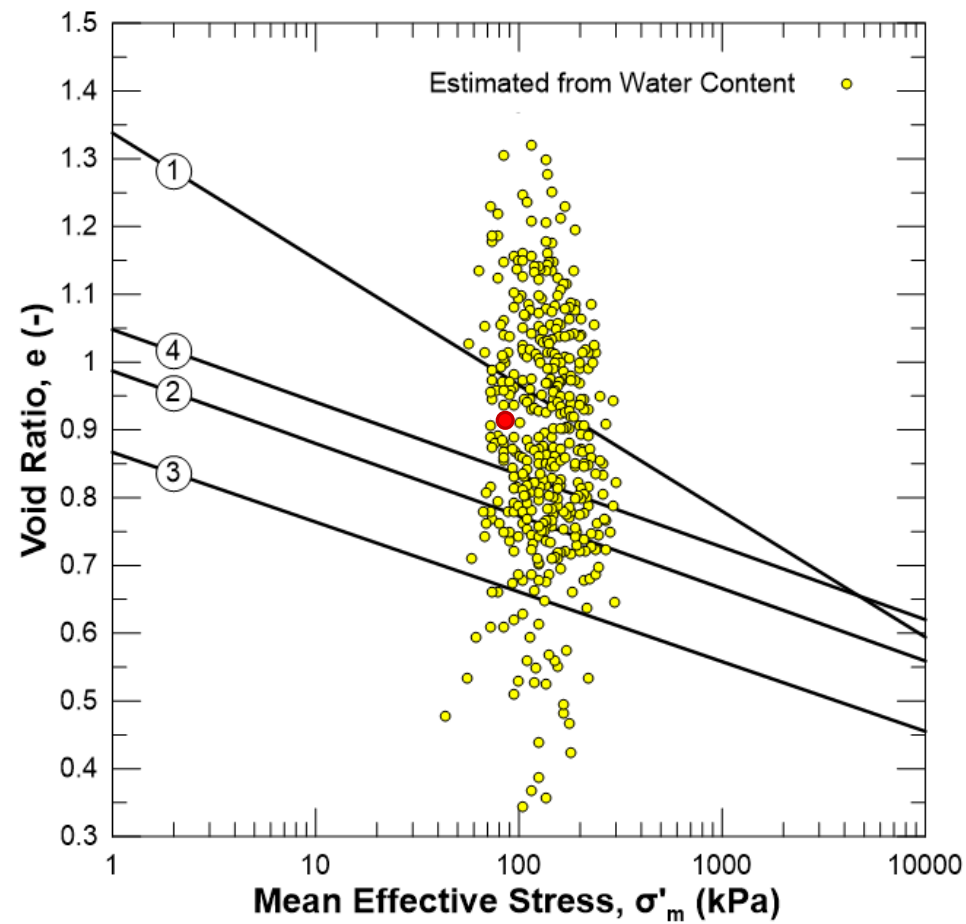


Estimating In-Situ State Parameter

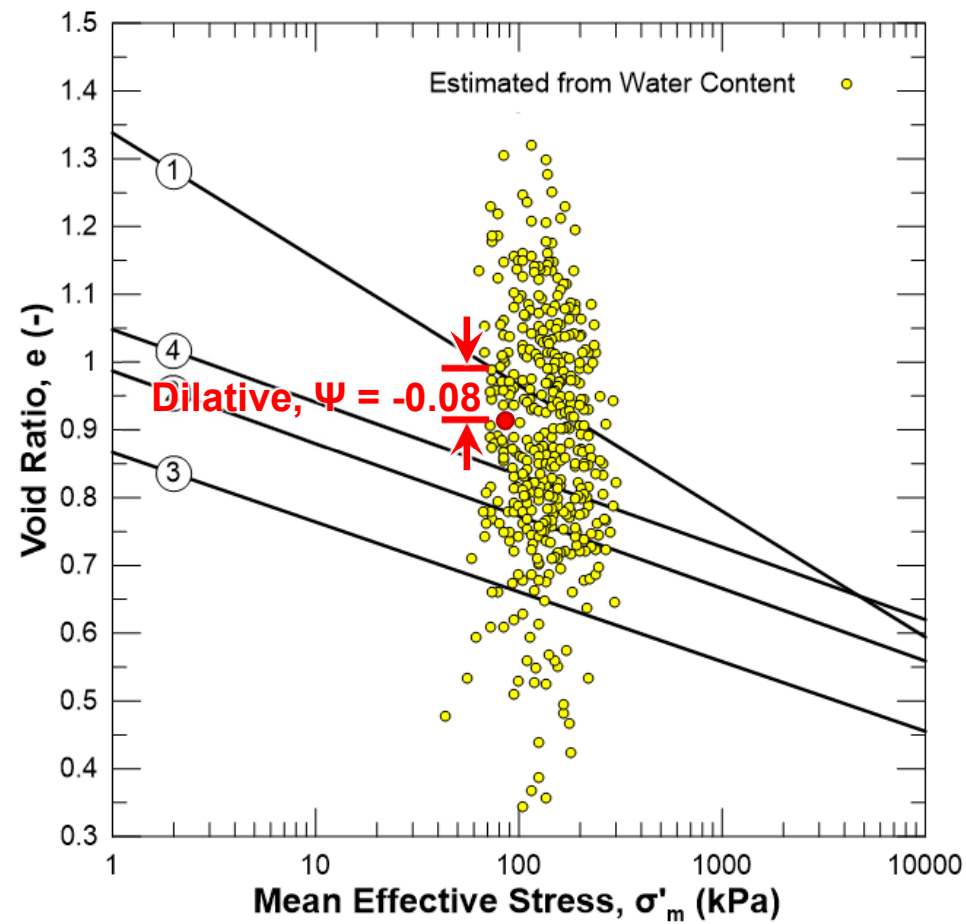
Water Content & Void Ratio Measurements



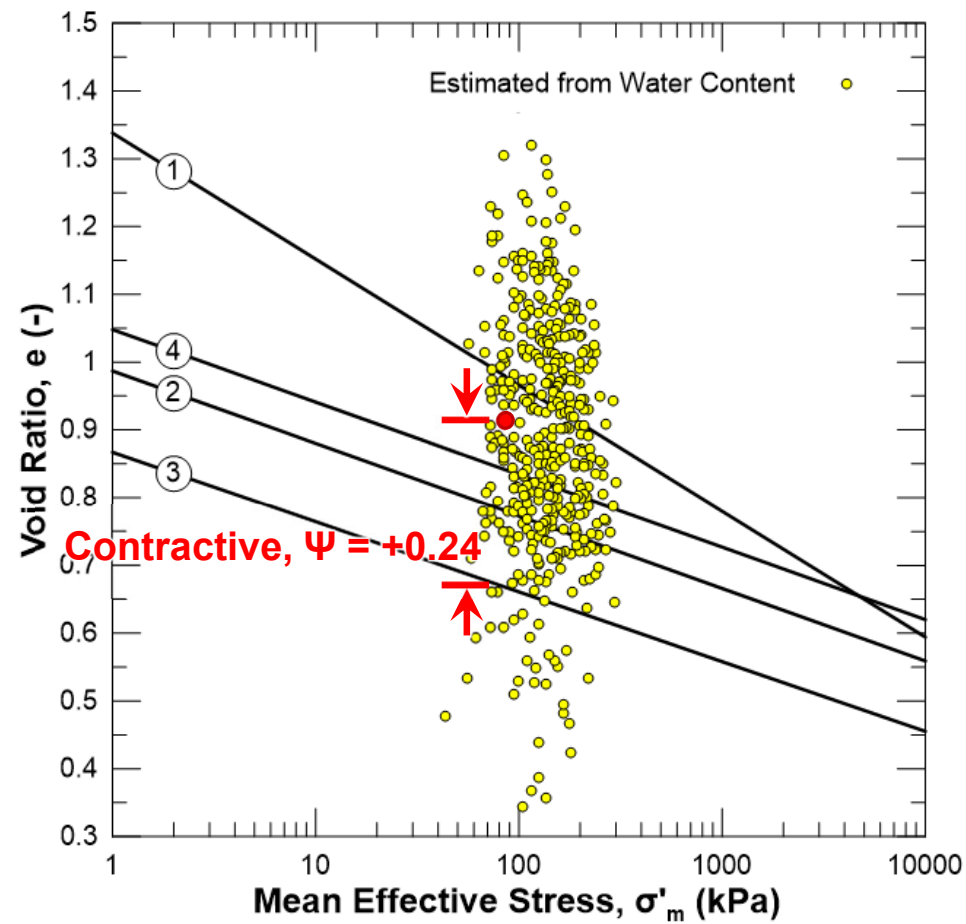
Water Content & Void Ratio Measurements



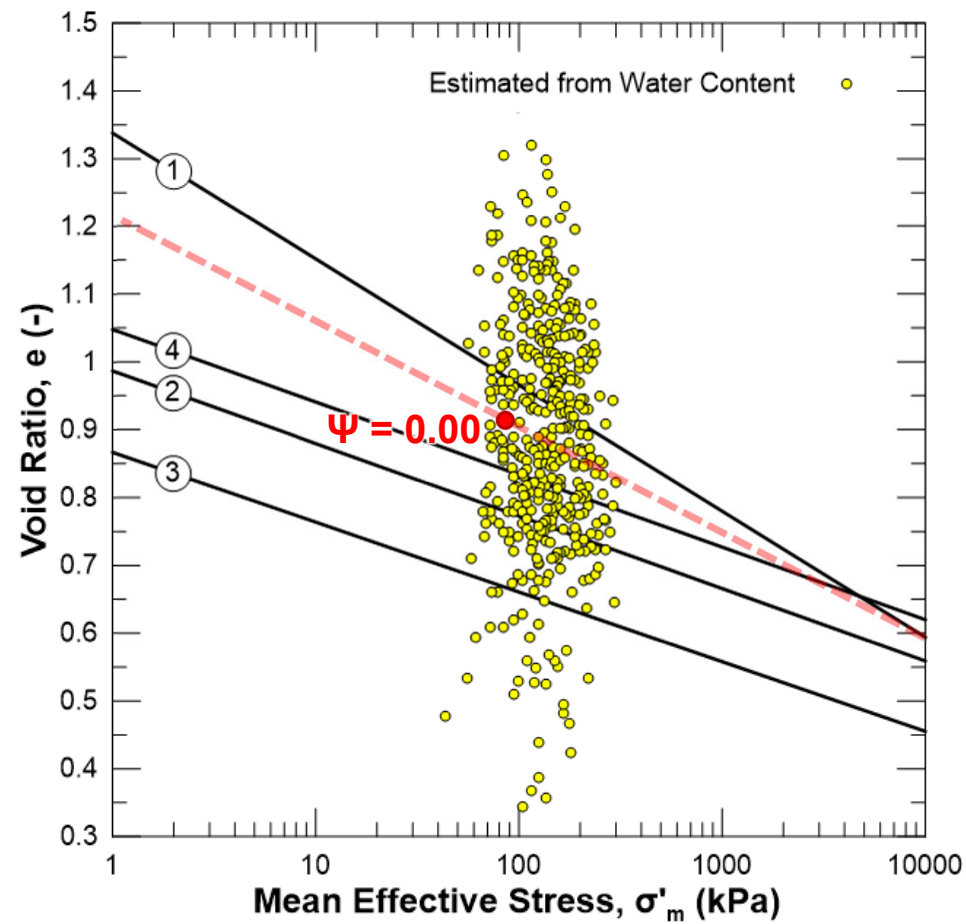
Water Content & Void Ratio Measurements



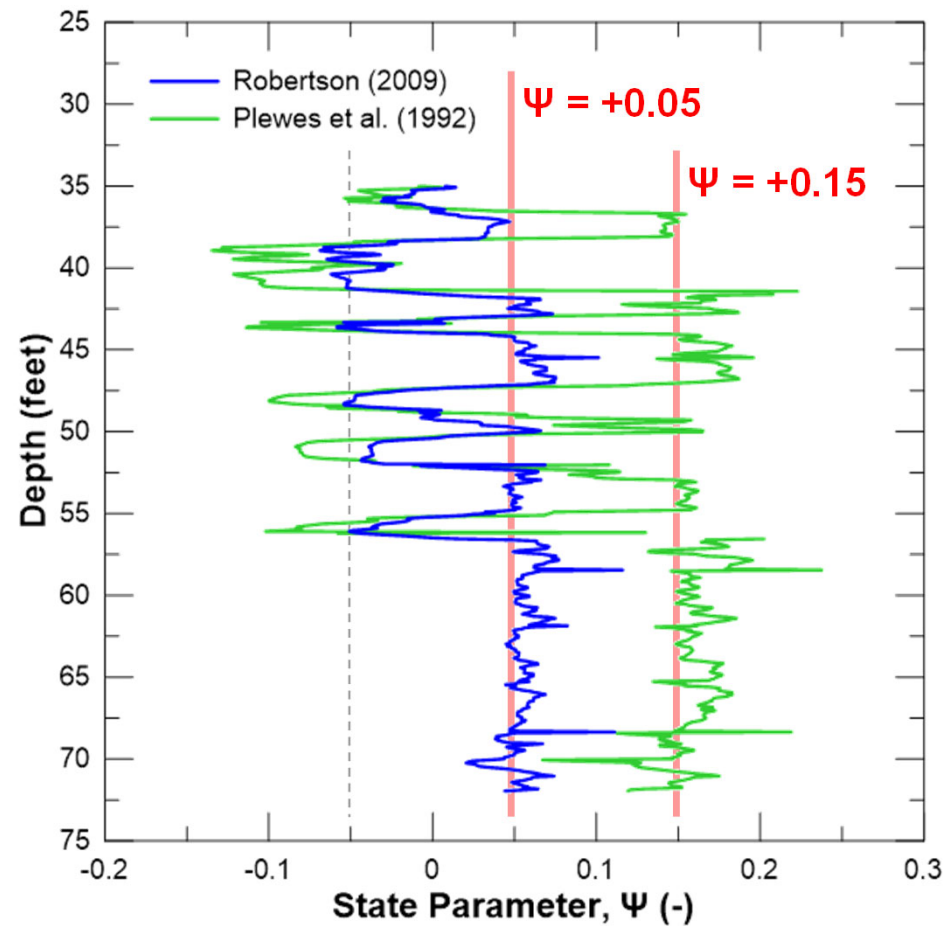
Water Content & Void Ratio Measurements



Water Content & Void Ratio Measurements

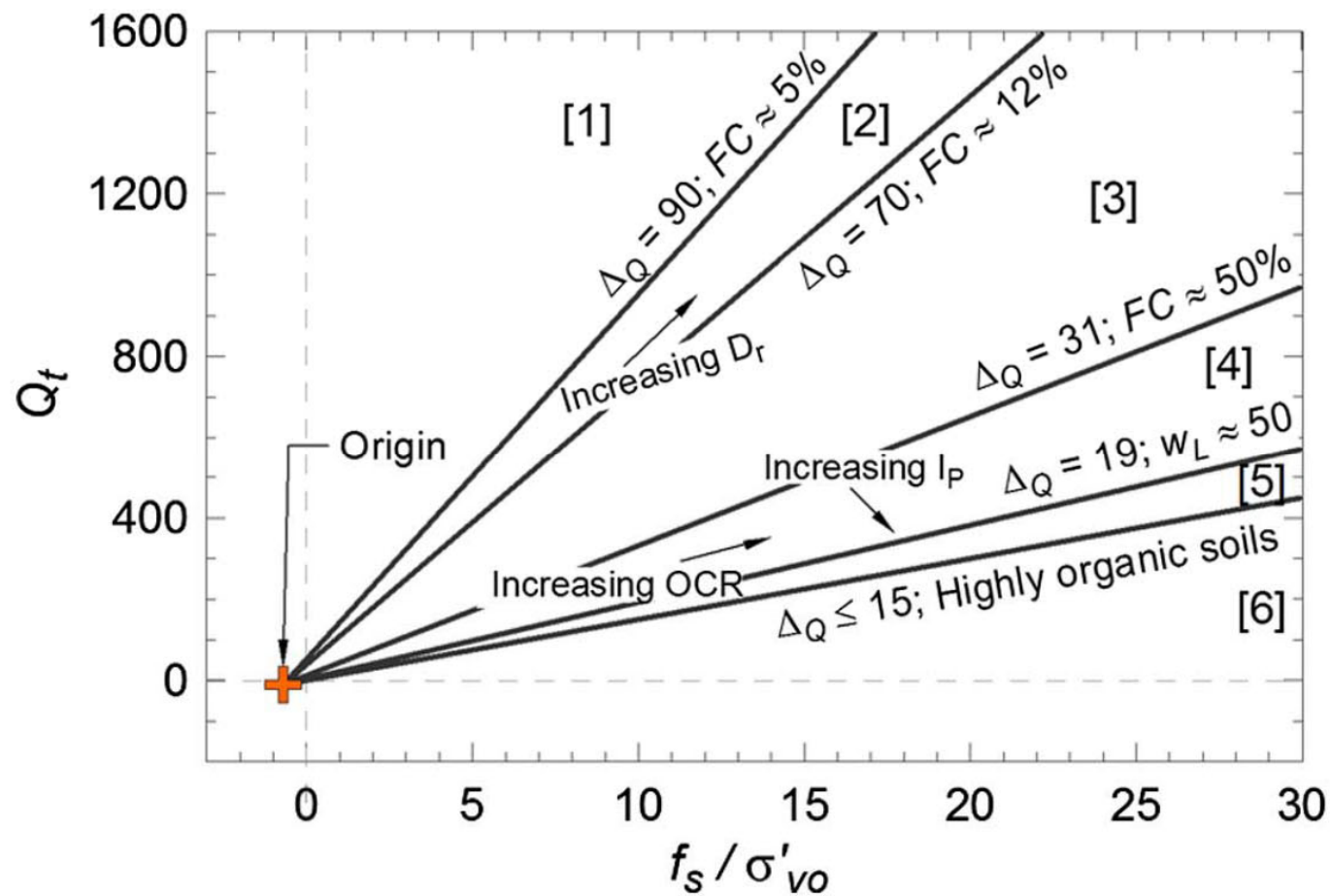


Cone Penetration Test (CPT) Correlations



Site-Specific Prediction of Clay-Size Fraction

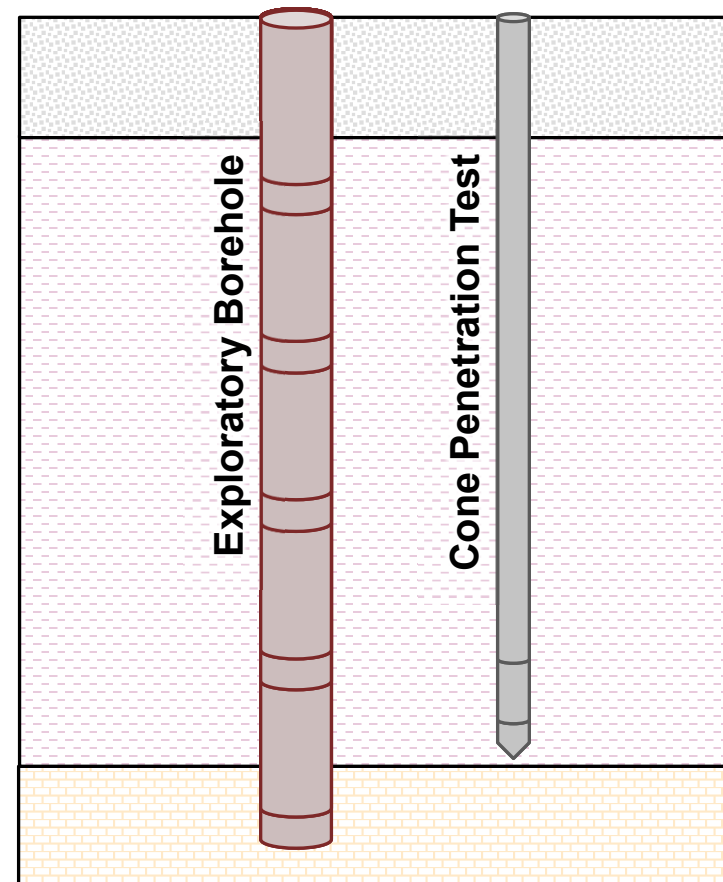
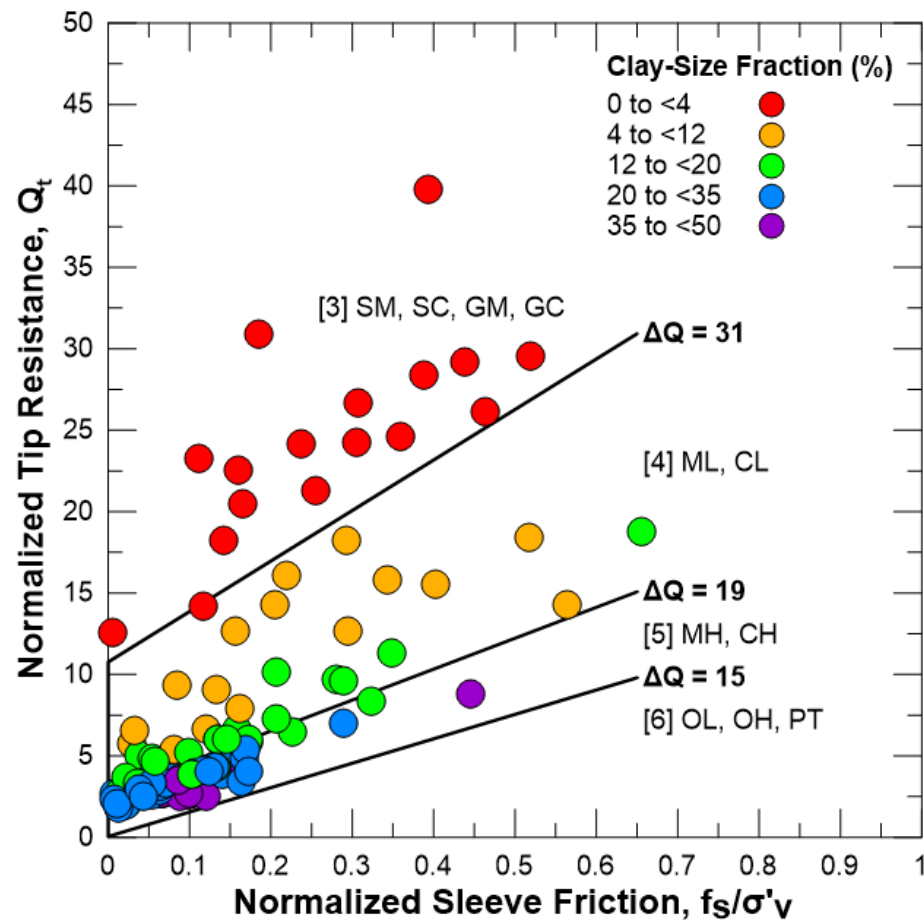
ΔQ Soil Classification from Cone Penetration Testing



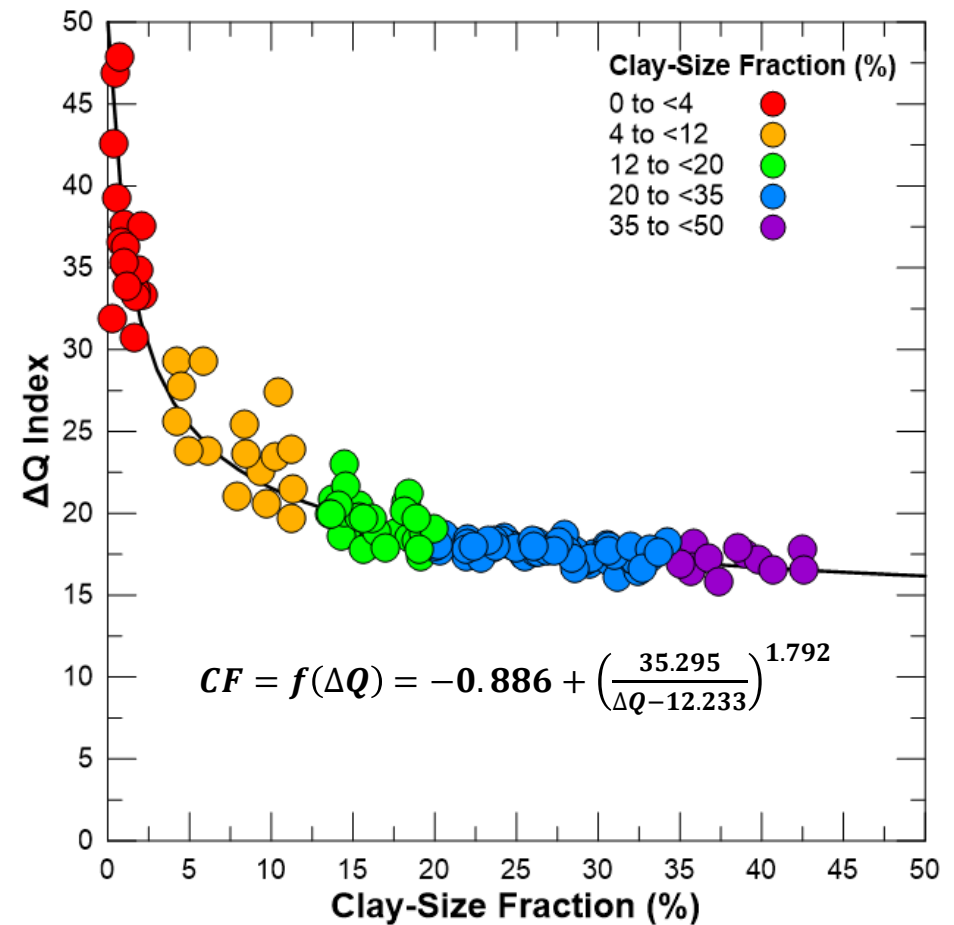
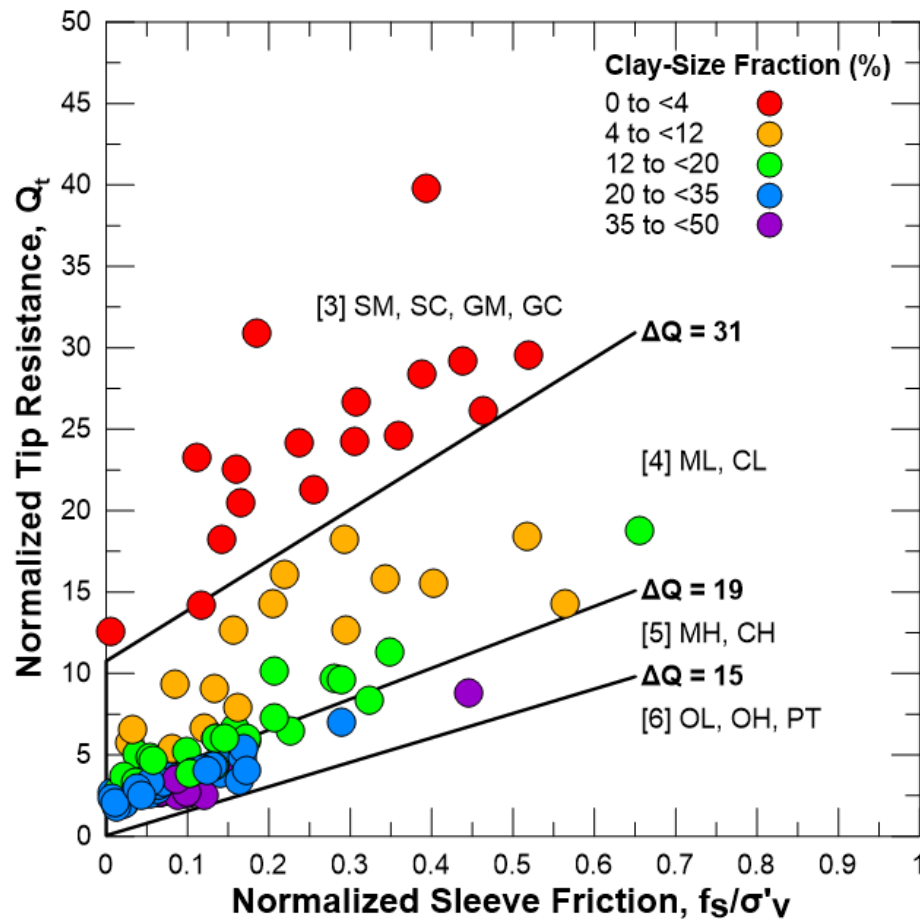
Typical USCS	
[1]	SP, SW
[2]	SP-SM, SP-SC
[3]	SM, SC, GM, GC
[4]	ML, CL
[5]	MH, CH
[6]	OL, OH, Pt

Image from Linear Trendlines to Assess Soil Classification from Cone Penetration Test Data (Saye et al., 2017)

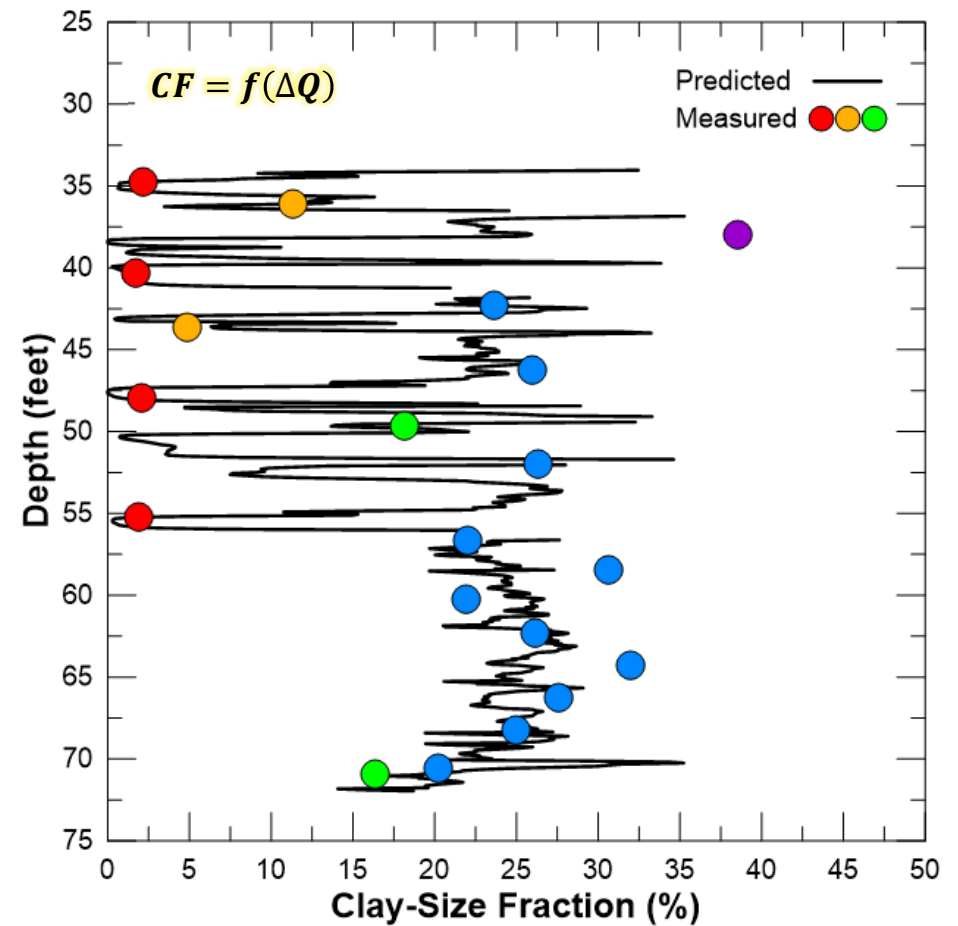
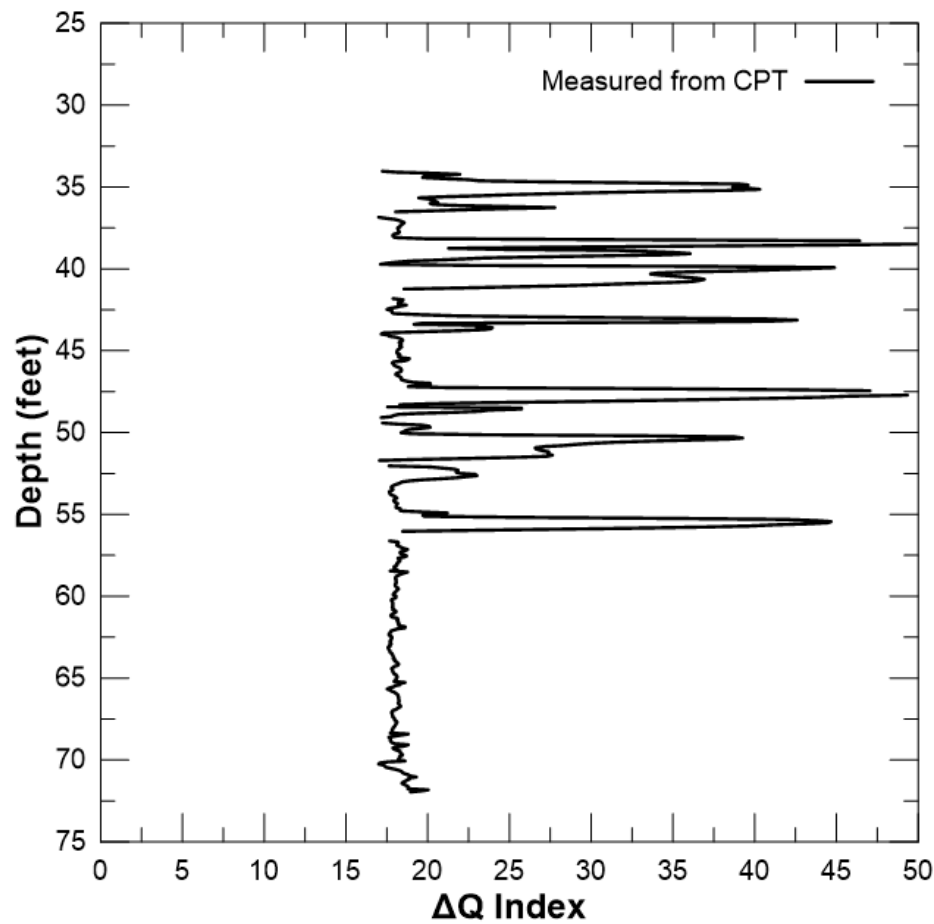
Site-Specific Relationship of ΔQ and Clay-Size Fraction



Site-Specific Relationship of ΔQ and Clay-Size Fraction

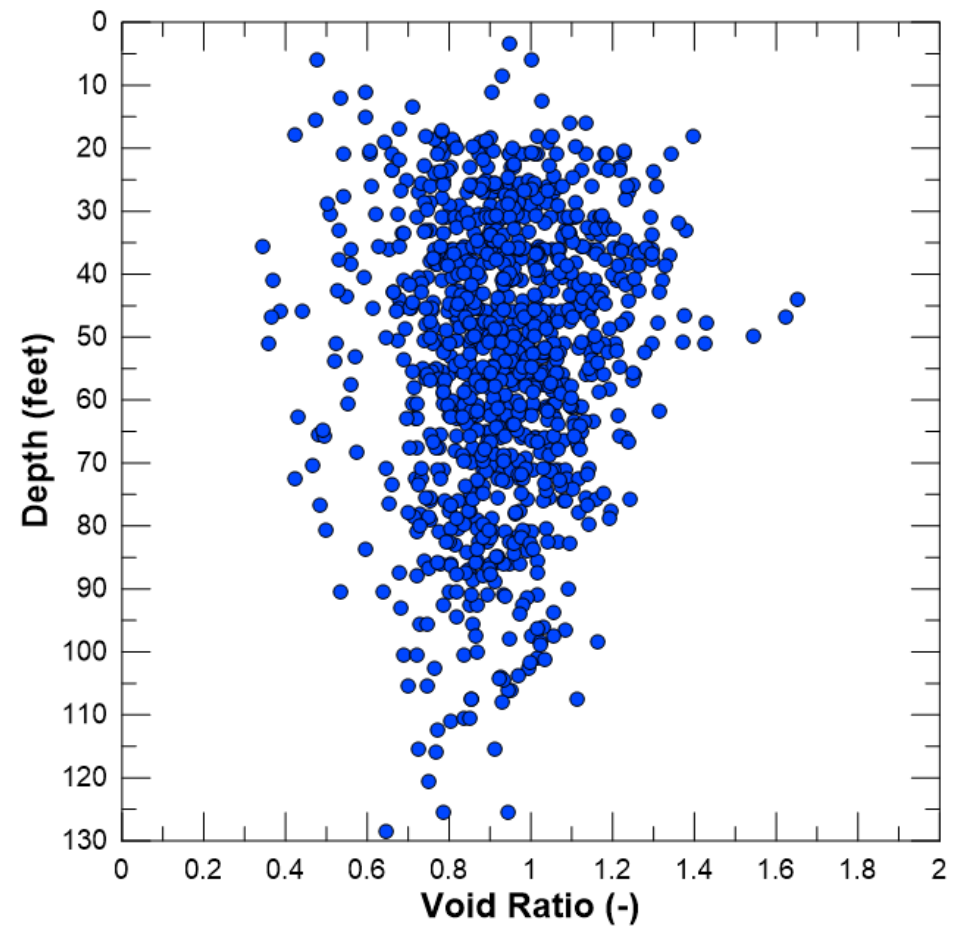
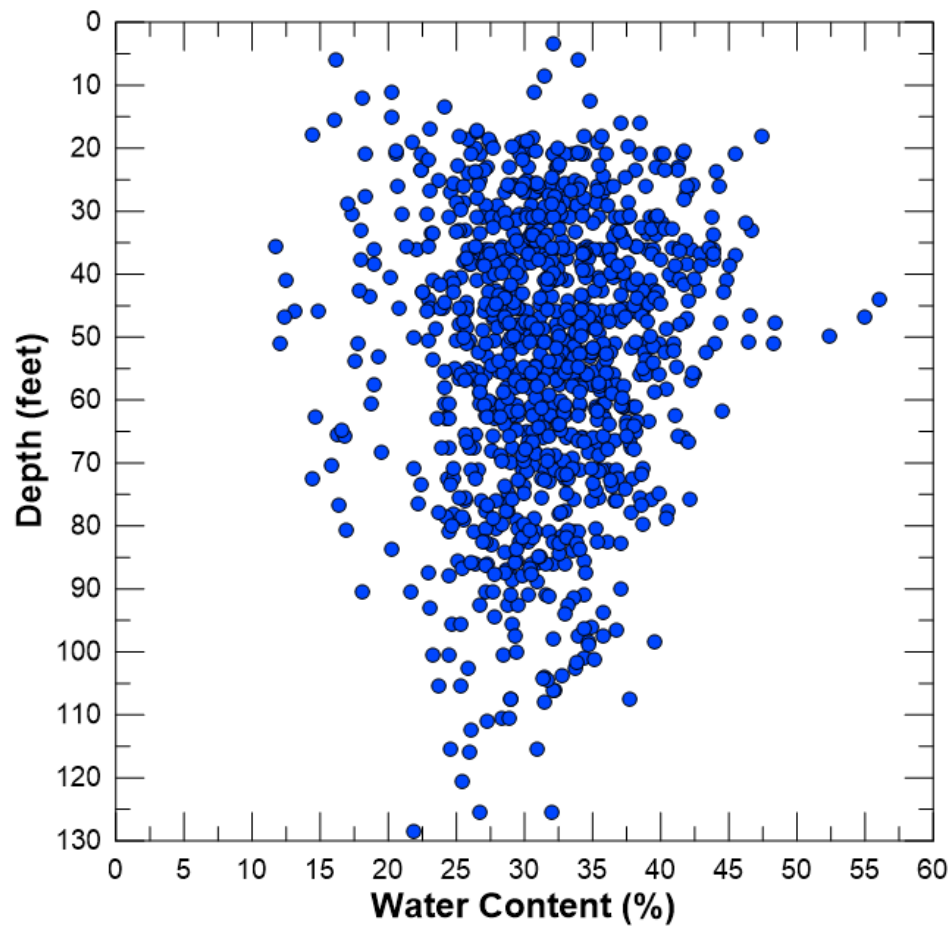


Site-Specific Prediction of Clay-Size Fraction from ΔQ

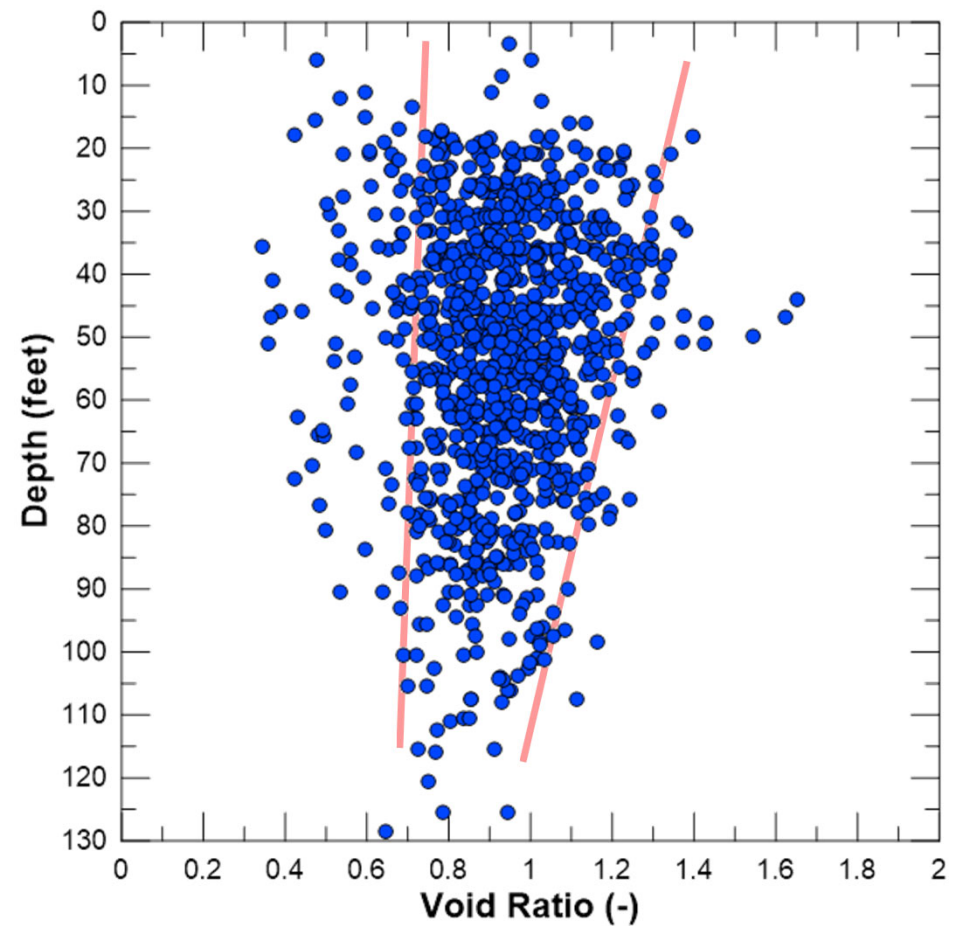
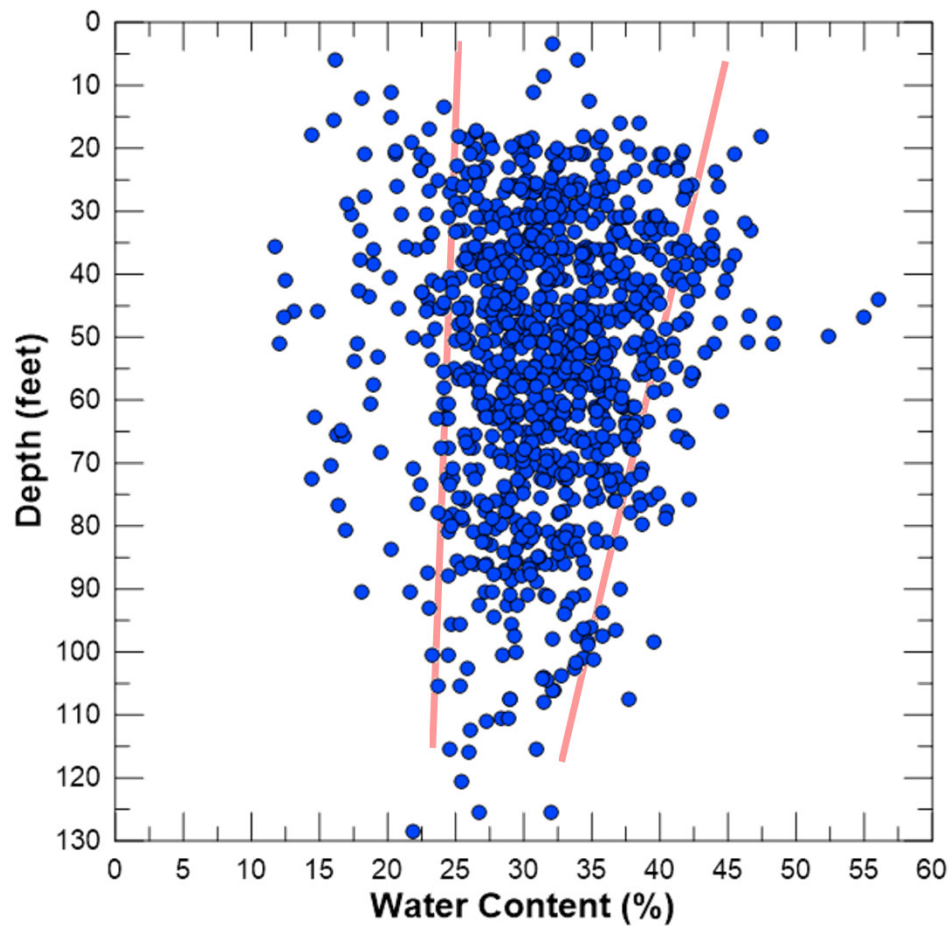


Site-Specific Prediction of Water Content & Void Ratio

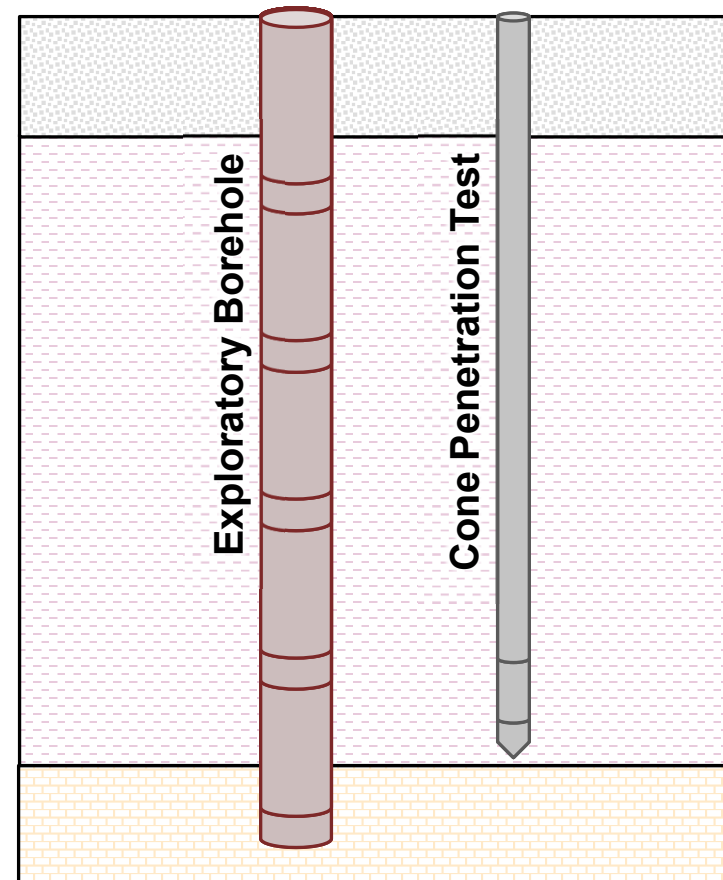
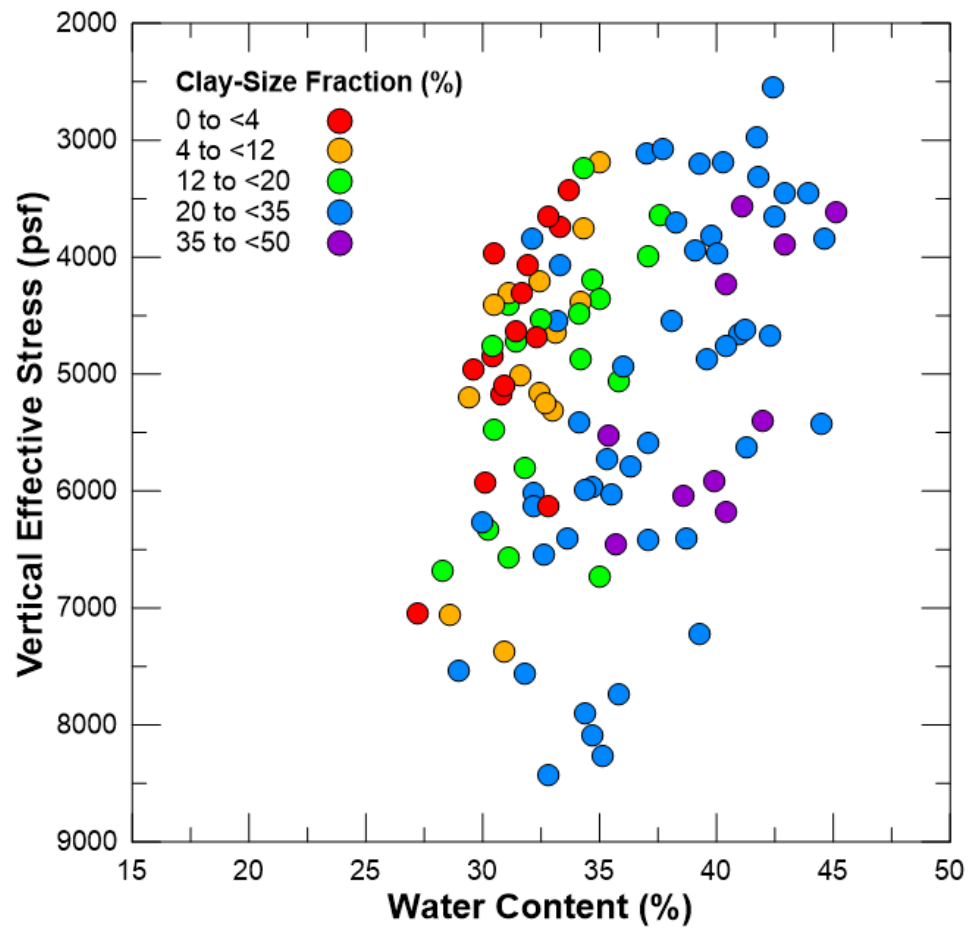
Available Water Content & Void Ratio Dataset



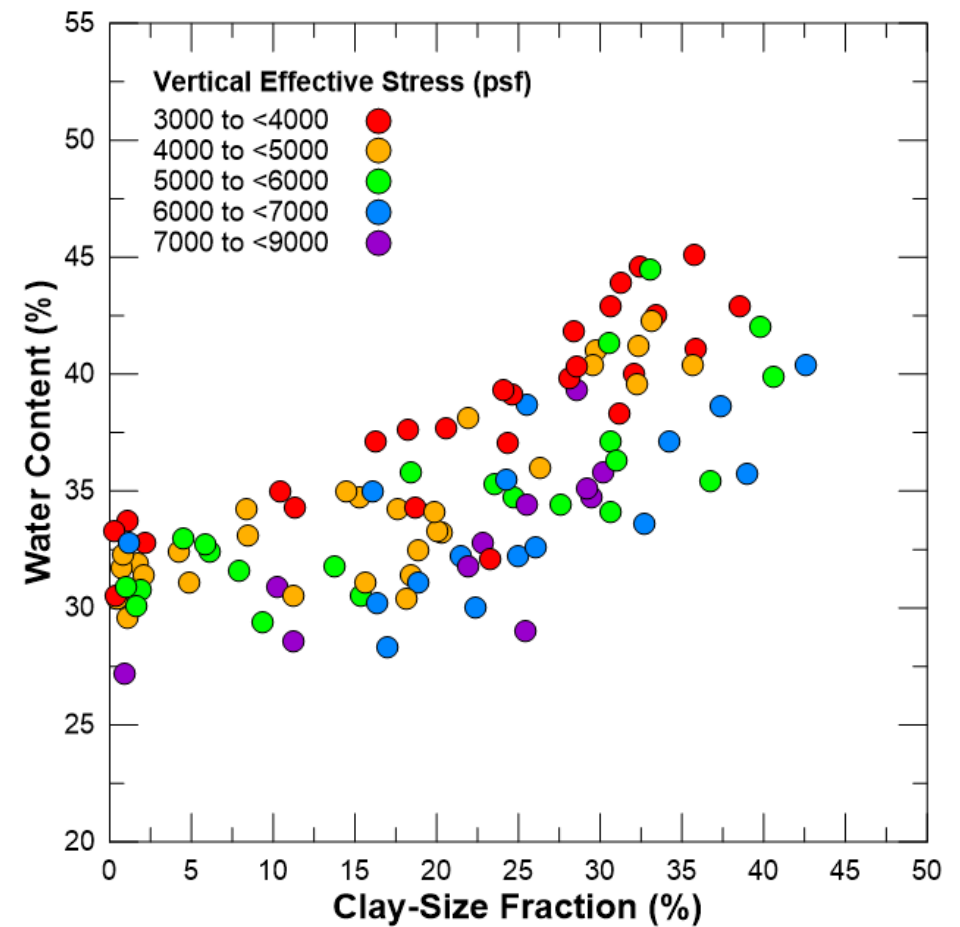
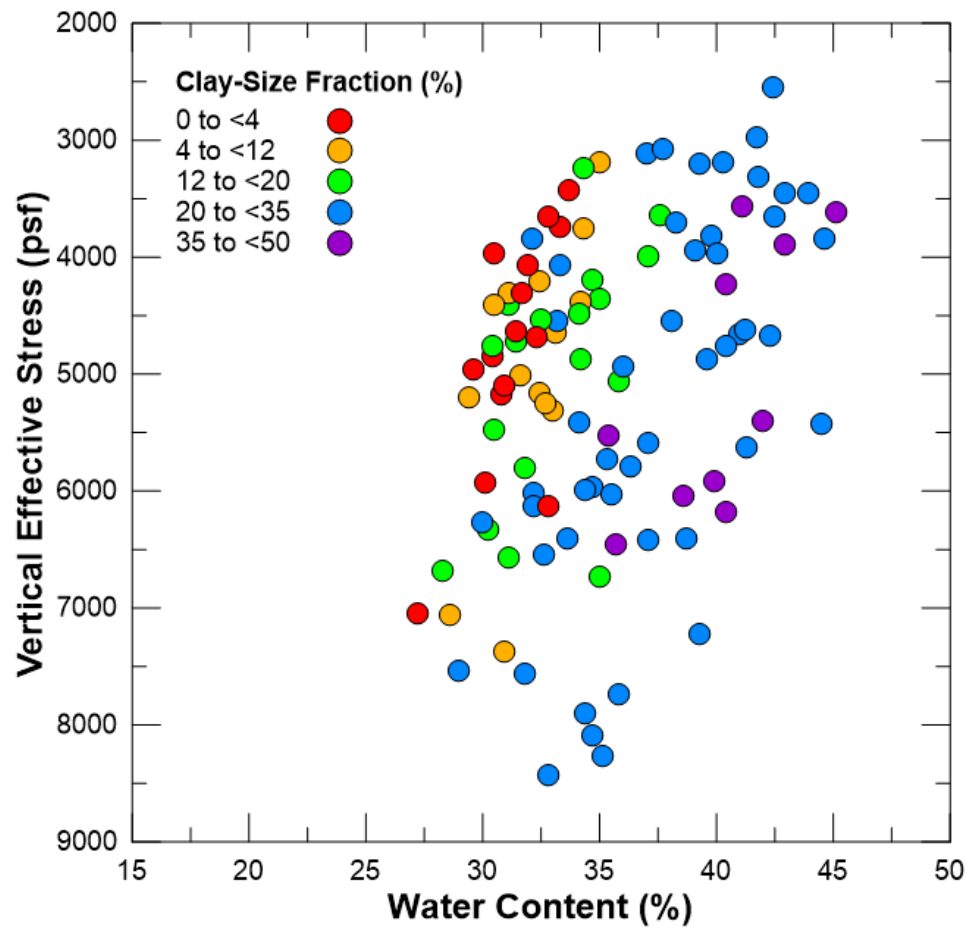
Available Water Content & Void Ratio Dataset



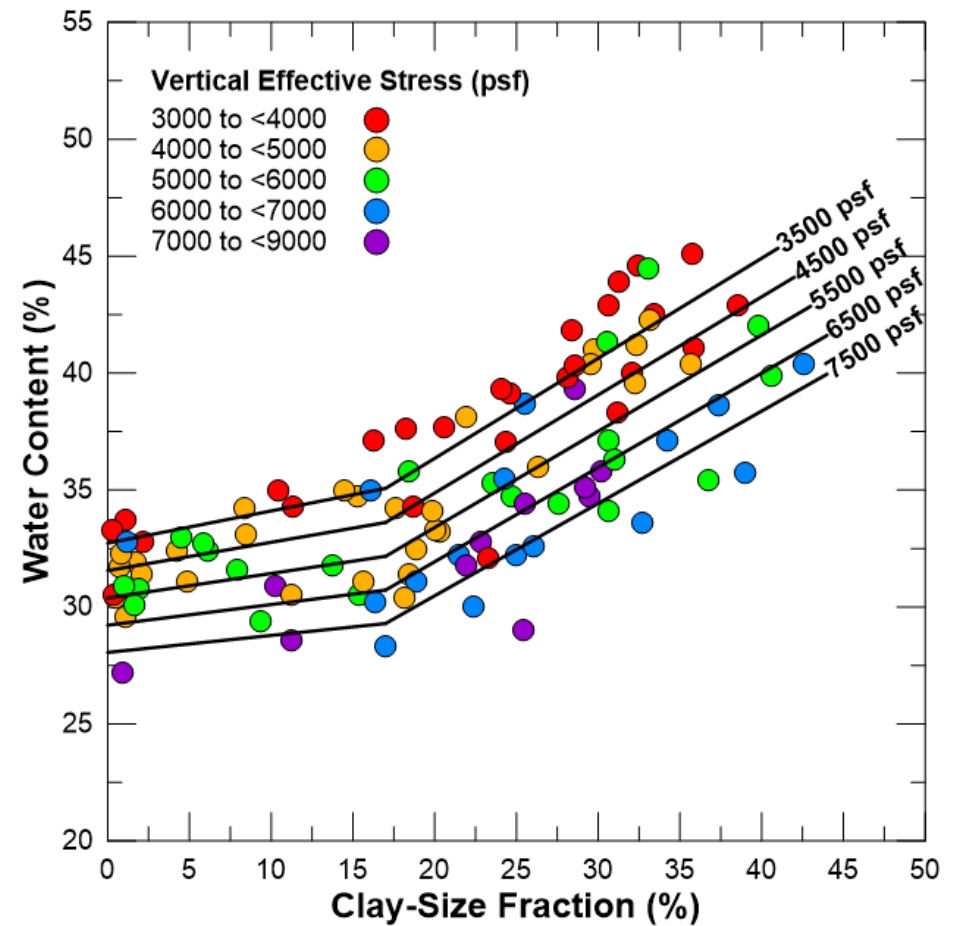
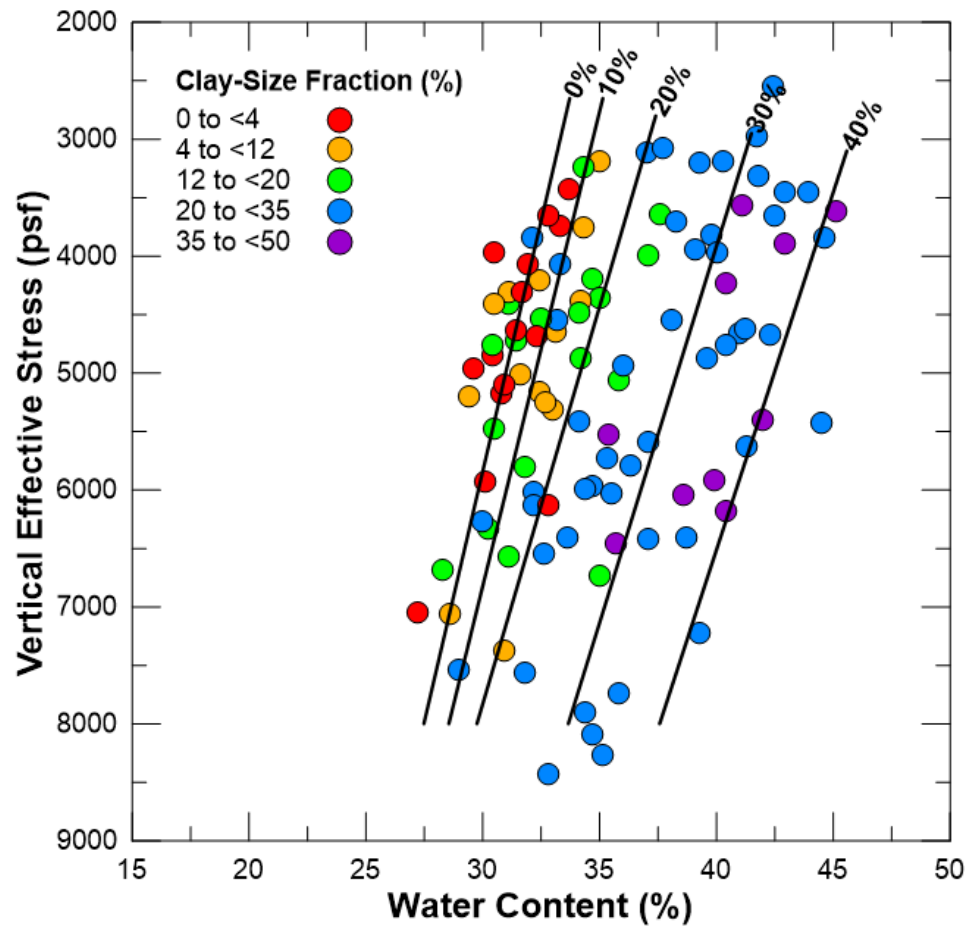
Filtered Water Content Dataset



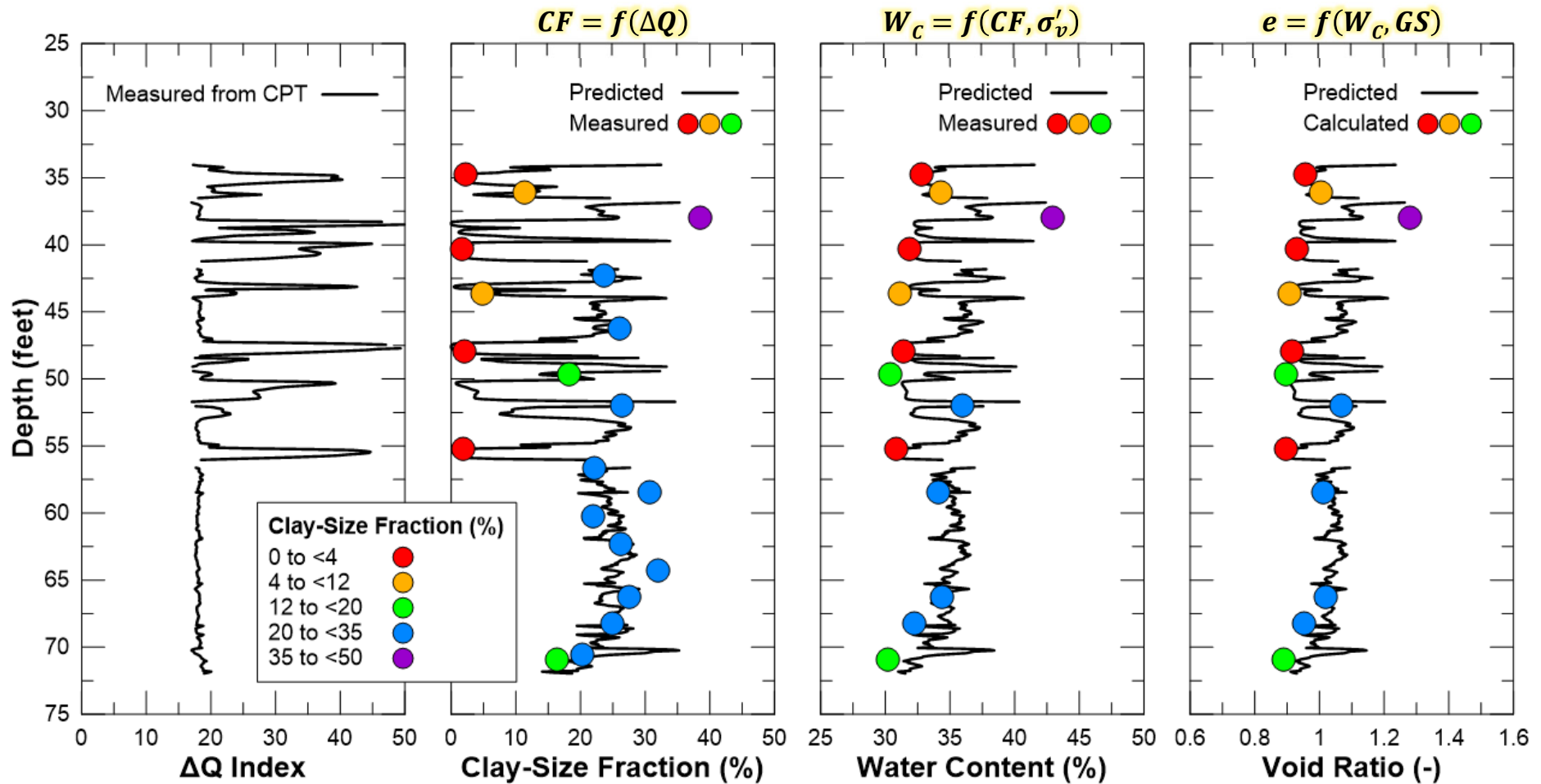
Site-Specific Relationship of Water Content



Site-Specific Relationship of Water Content

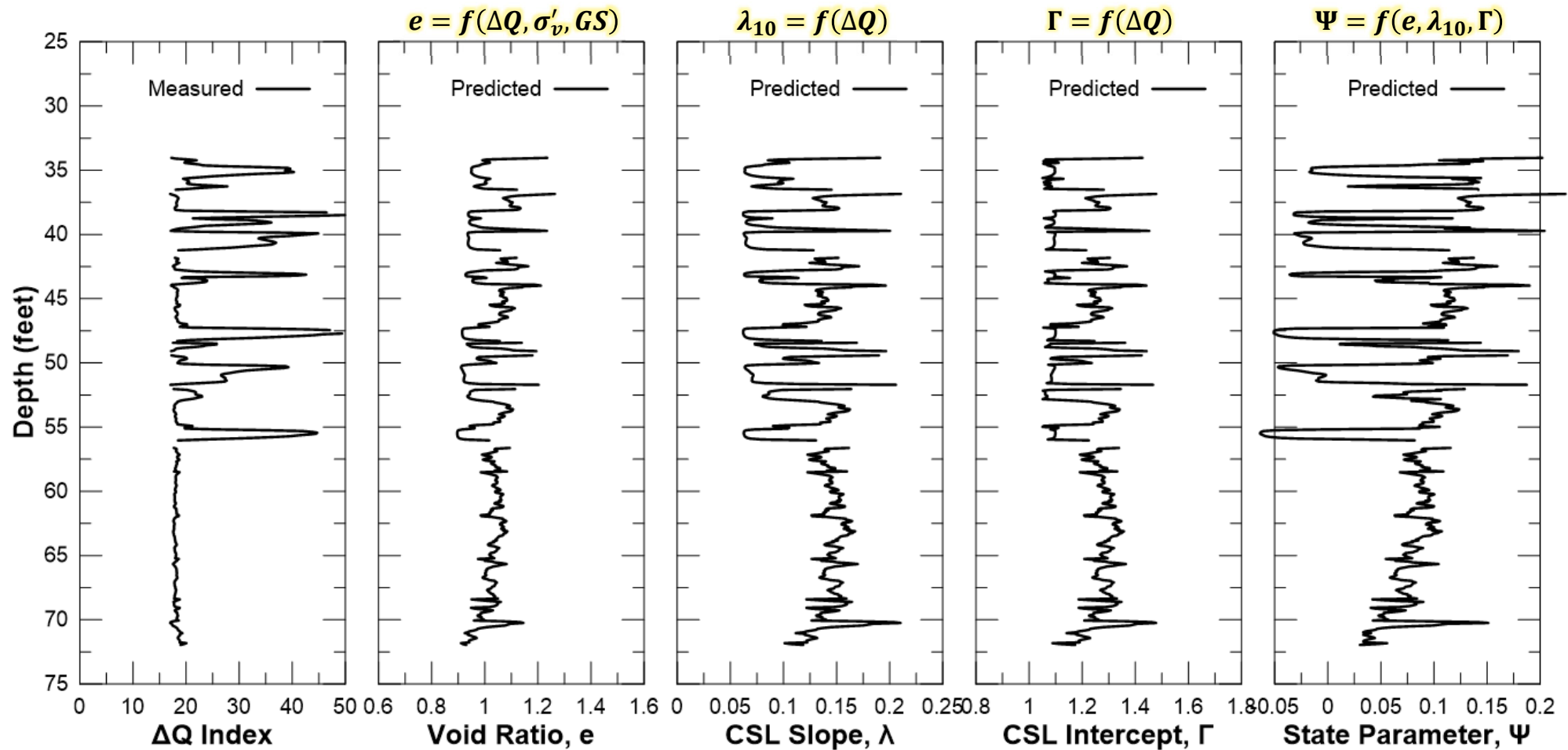


Site-Specific Prediction of Water Content & Void Ratio



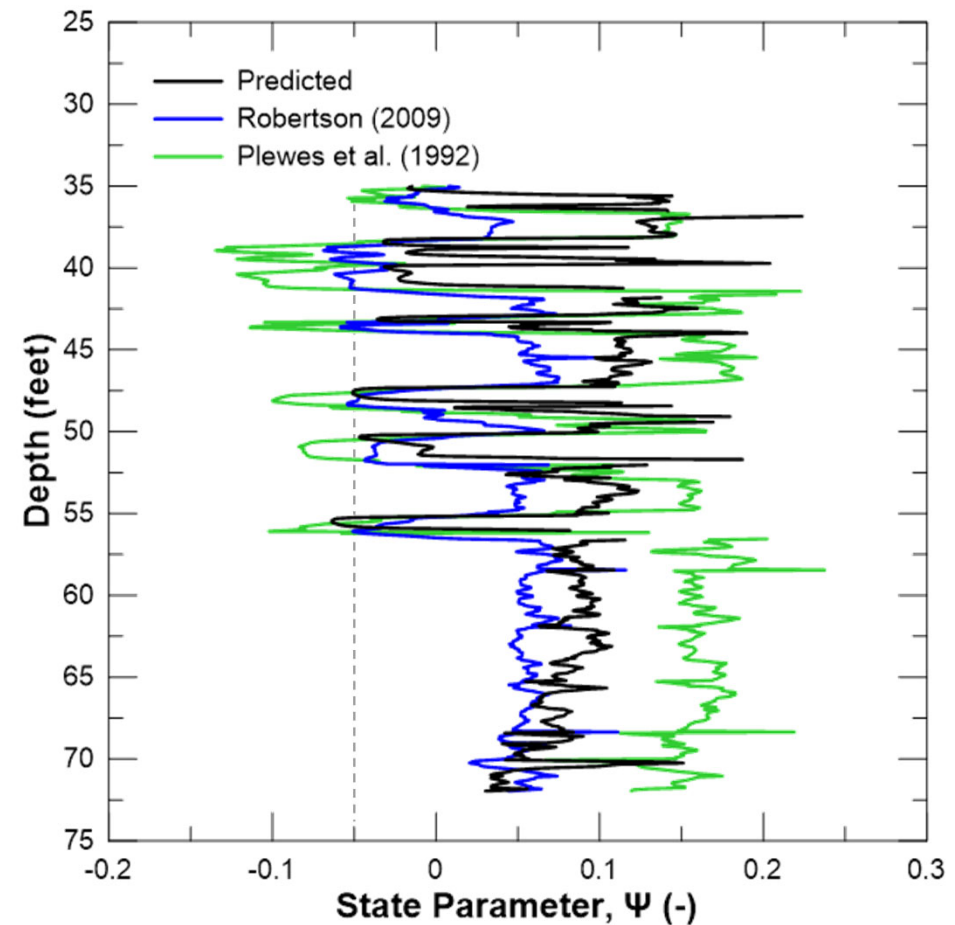
Site-Specific Prediction of In-Situ State Parameter

Site-Specific Prediction of State Parameter



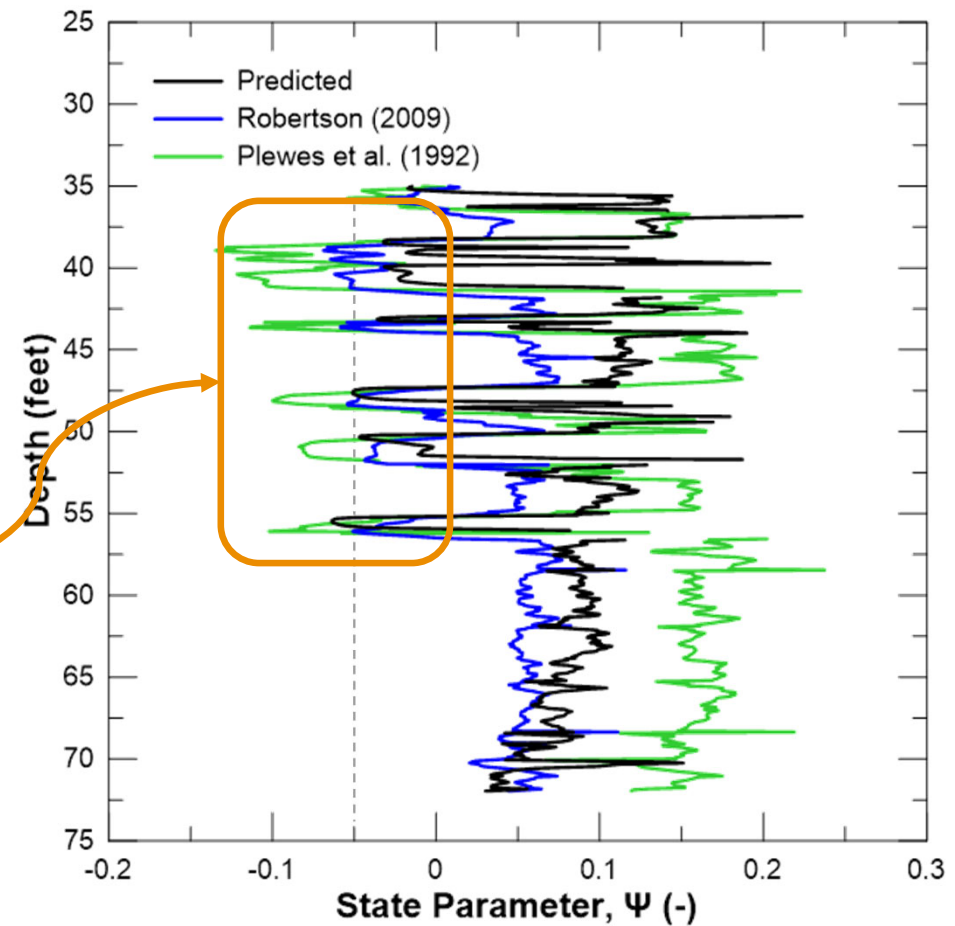
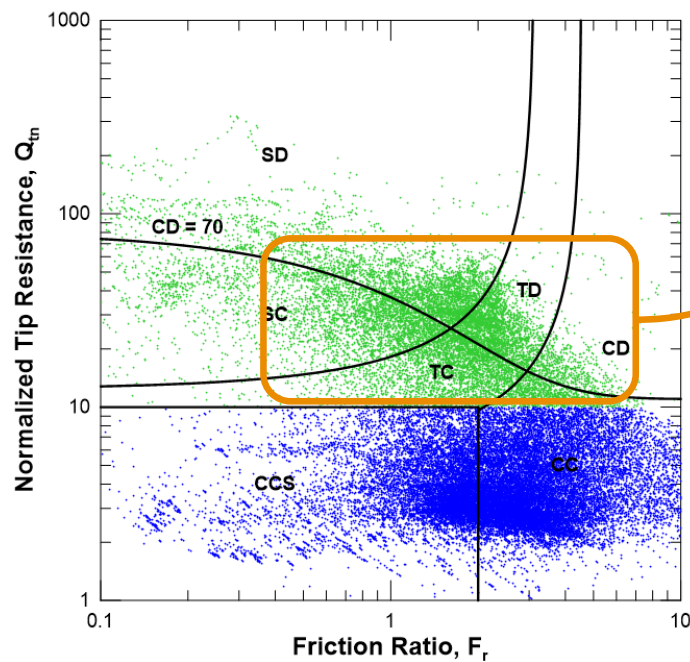
Conclusions and Comparisons

- Extends our ability to estimate CSSM parameters at CPT sounding locations (limited borehole sampling to verify)
- Improved confidence compared to the "screening methods"



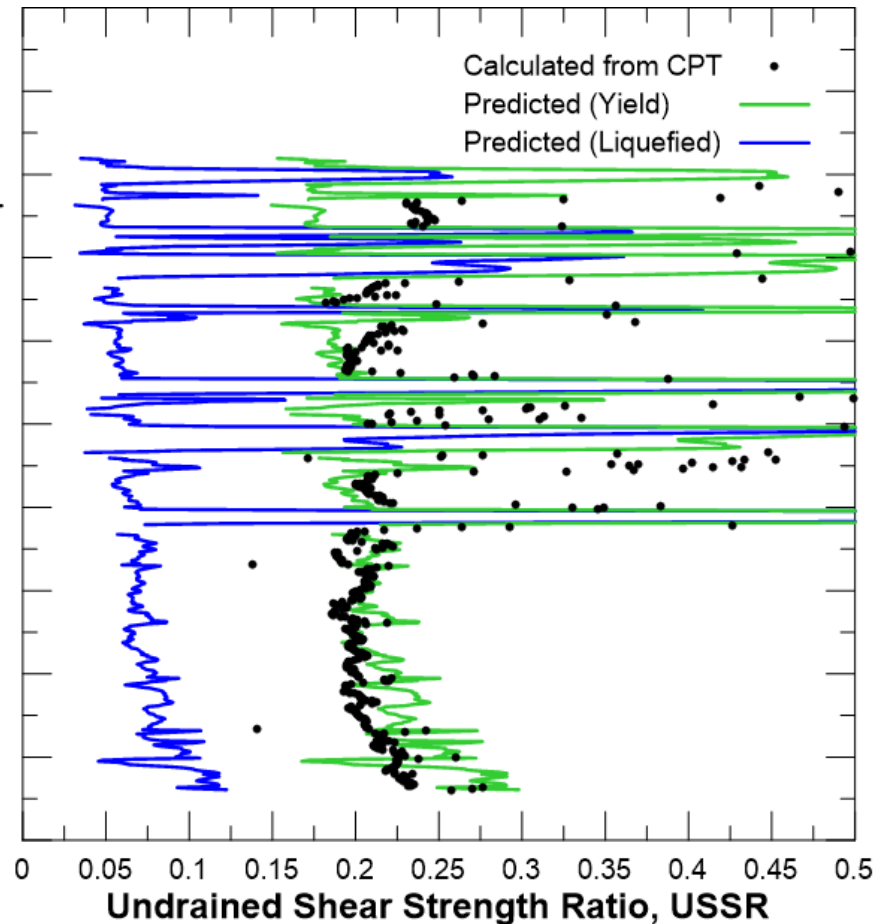
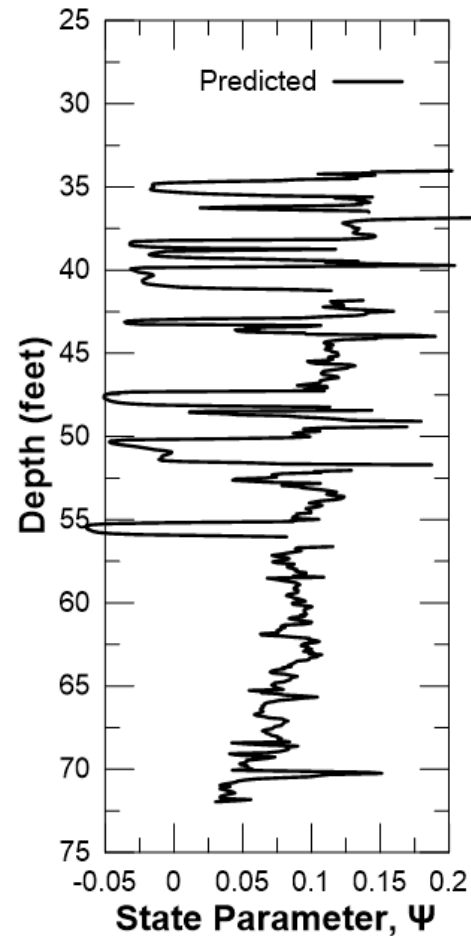
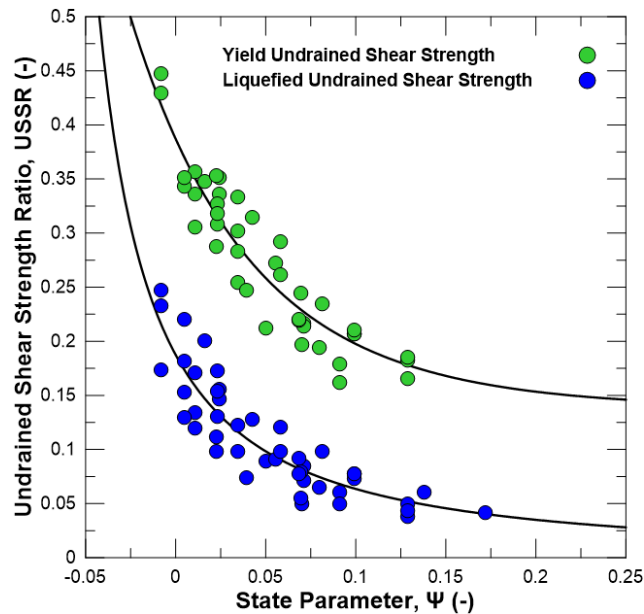
Conclusions and Comparisons

- State parameter estimation for “transitional” soil behavior types near contractive-dilative boundary



Conclusions and Comparisons

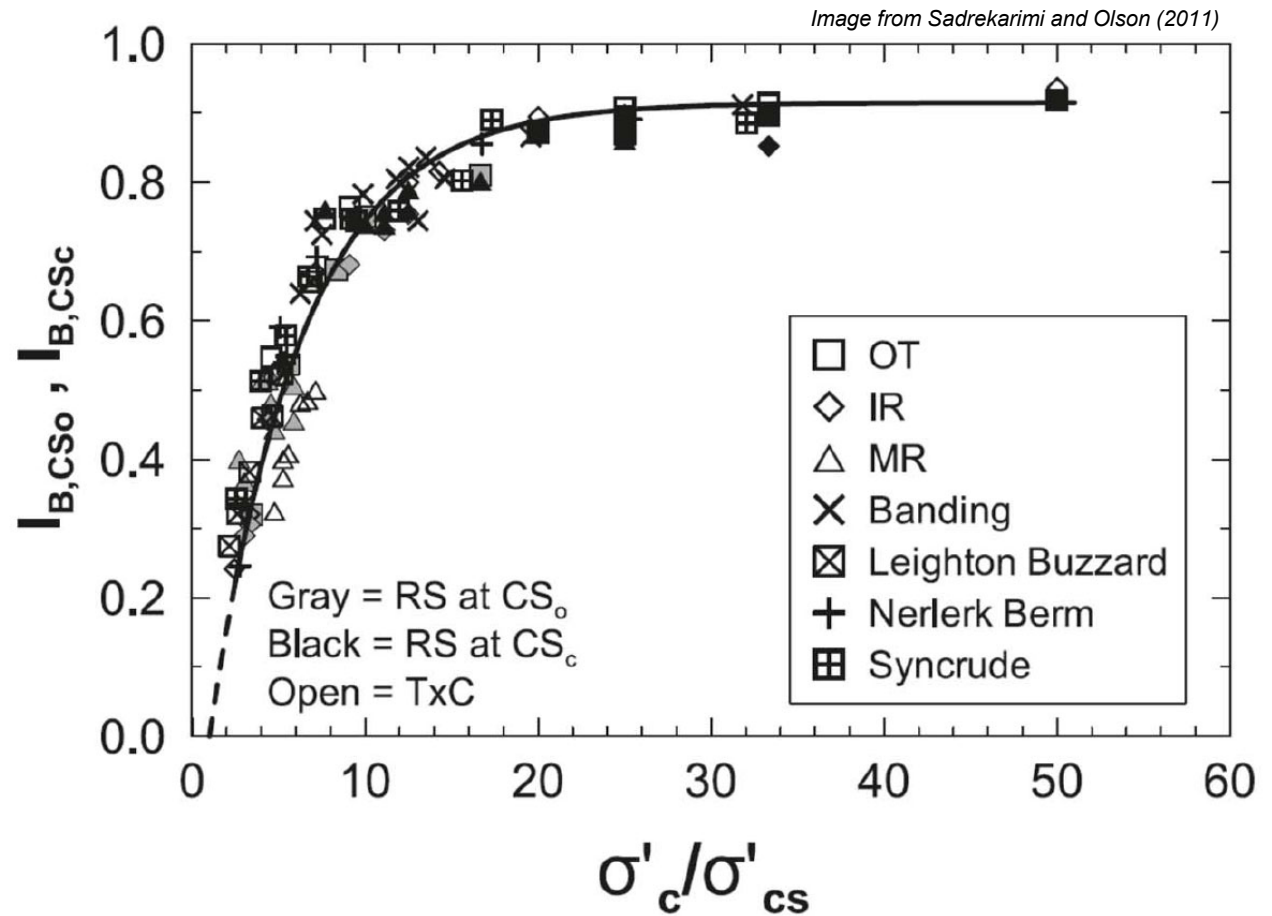
- Estimation of undrained shear strength based on laboratory correlation



Conclusions and Comparisons

- Estimation of the initial state ratio (r_c) and the brittleness index (I_B)

$$r_c = \frac{\sigma'_c}{\sigma'_{cs}} = 10^{-\psi/\lambda}$$





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