Developing Design Data: Field Sampling to Lab Testing

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Presentation Outline

- *Geotech Investigations*
  - *Design Data Needs*
  - *Sample Types*
  - *Intact Sampling*
- Rock Lab Testing
  - Lab Tests
  - Design Data
- Soil Lab Testing
  - Lab Tests
  - Design Data
- Wrap-Up

Geotech Investigations

- Outcome based
  - New Construction
    - Foundation Design
    - Anticipated Construction Conditions
  - Existing Structures
    - Resilience to Failure Modes
    - Modifications
- Soil and Rock behavior
  - Lab boundary -> mimic field boundary
  - Material Properties
  - Index Properties

Geotech Investigations 2

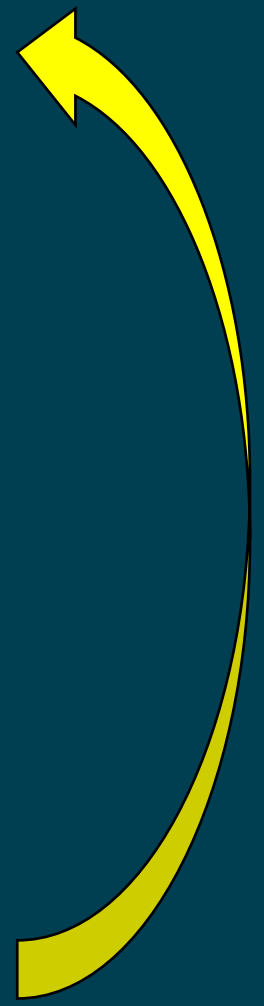
Need/Purpose for Geotech Design Data

Required Field and Lab Testing

Drilling and Sample Types

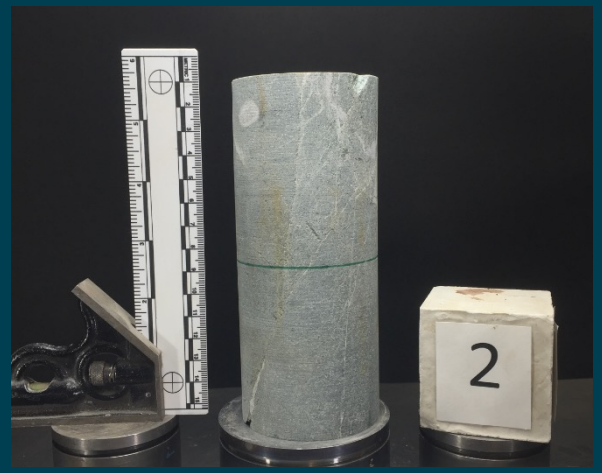
Quality Samples = Quality testing

Reliable Design Data!



Sample Types

- In-situ conditions + What Lab Testing? (i.e., Design Data)
  - Sample Type -> Suit Lab Test
    - Borrow
    - Intact
- Work with the Labs prior to and during sampling



Rock Sample Inspection & Testing Program

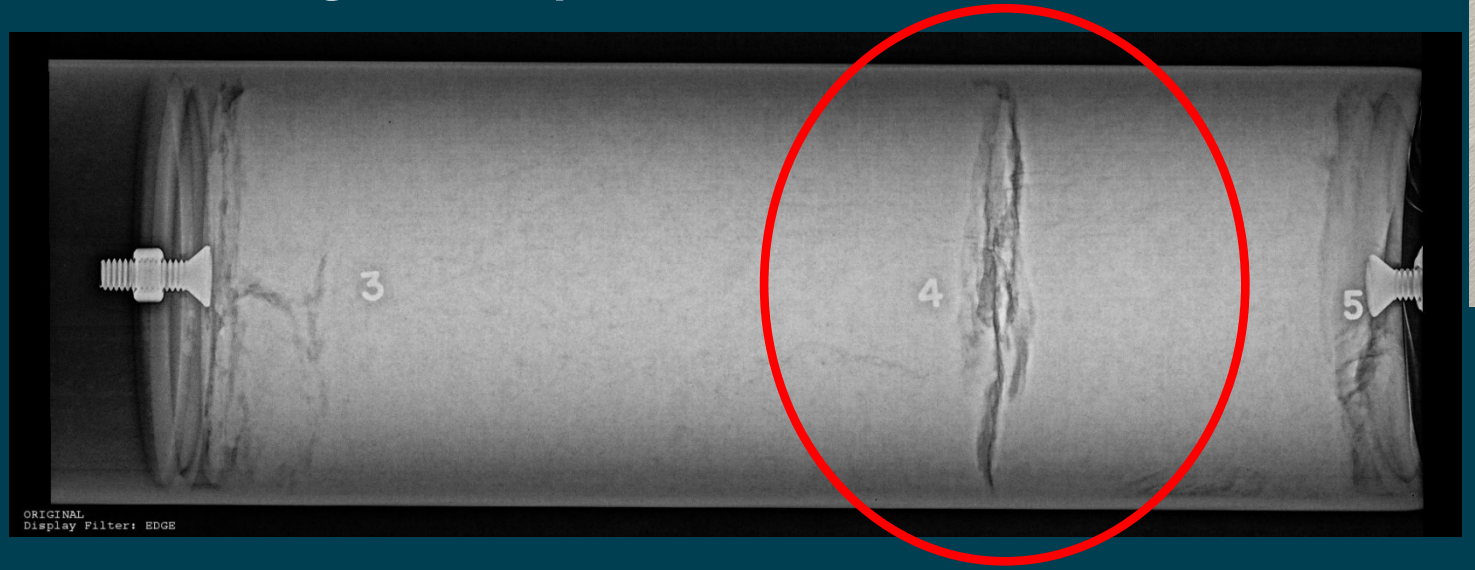
- Rock Samples
  - Wireline core
  - N-, H-, P-sized
- Geologic Units of interest

Soil Samples

- Bulk
- Thin-Walled Tubes (a.k.a. Shelby)
  - Highest Quality….not all soil types
  - Typically, 3” and 5” diameter
    - “Thin” walls
    - Larger is better
- Acrylic Tubes (a.k.a Lexan)
  - Good Quality
    - “Thick” Walled Sampler
    - Quality requires diligent setup and patience
- Block Samples
  - High Quality
    - Shallow Deposits, timely

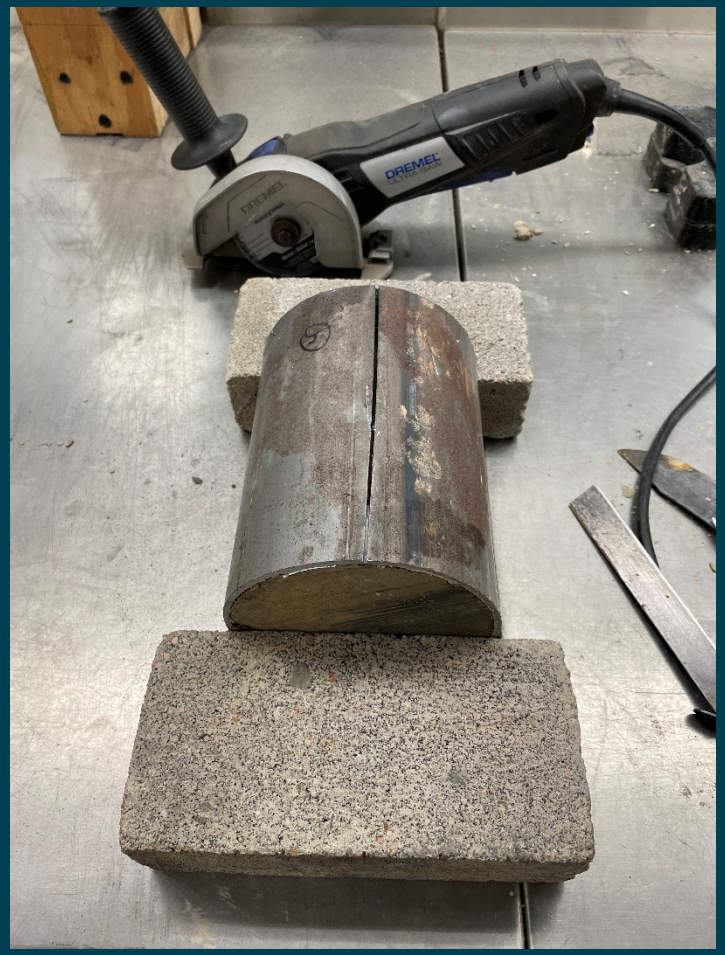
Intact Sample Inspection

- X-ray Shelby Tubes
  - Tension Cracking
  - Natural Cracking/Desiccation
  - Stress Relief
- Visually look through Acrylic Tubes
  - Gravel interference
  - Cracking/void space



Intact Specimen Size and Prep

Intact Specimen Size and Prep 2



Intact Specimen Size and Prep 3

Intact Specimen Size and Prep 4

Intact Specimen Size and Prep 5

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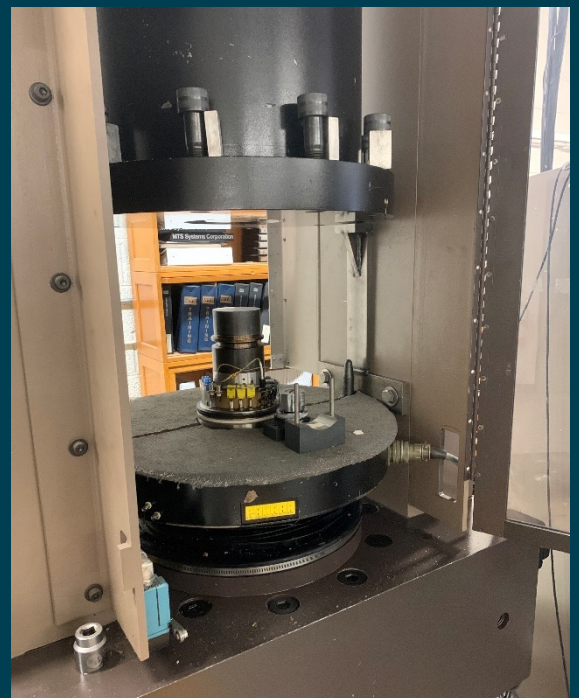
Rock Testing 1/2

- Physical Properties
  - SpG, Abs., PI
- Slake Durability
  - Water decomp.
- Swell/Consolidation
  - Water exp.
- Indirect Tension (Brazilian) – (IT)
  - Tensile
- Point Load
  - Field ~UCS

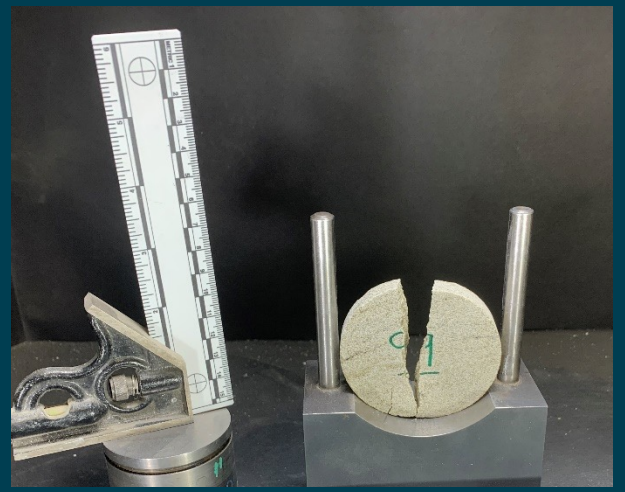
Rock Testing 2/2

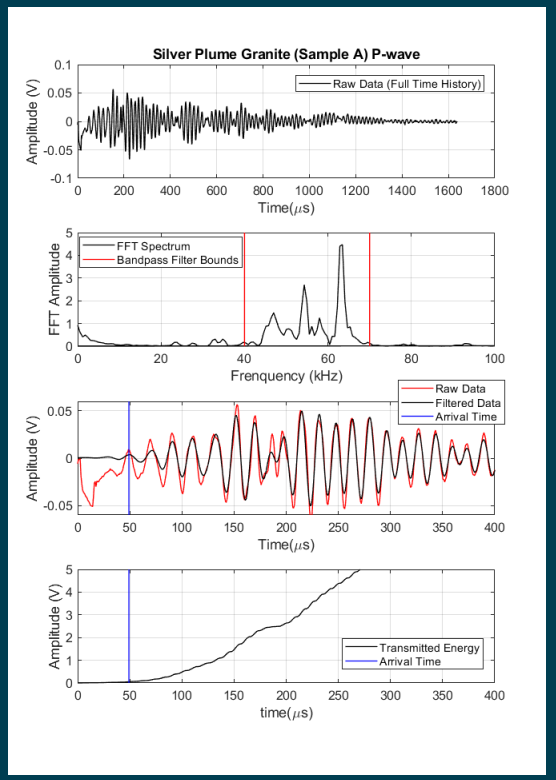
- Unconfined Compressive Strength (UCS)
  - σ_c, E
- Triaxial Compressive Strength (Triax)
  - + $\sigma_{2,3}$ ->τ in (ϕ,c)
- Direct Shear (DS)
  - Joint τ (ϕ,c)
- Ultrasonic Pulse Velocity (UPV)
  - $E_{small\ strain}$
- Mode I Fracture Toughness
  - K_{IC}
- Normal Stiffness of Joints
  - σ_n
- CERCHAR



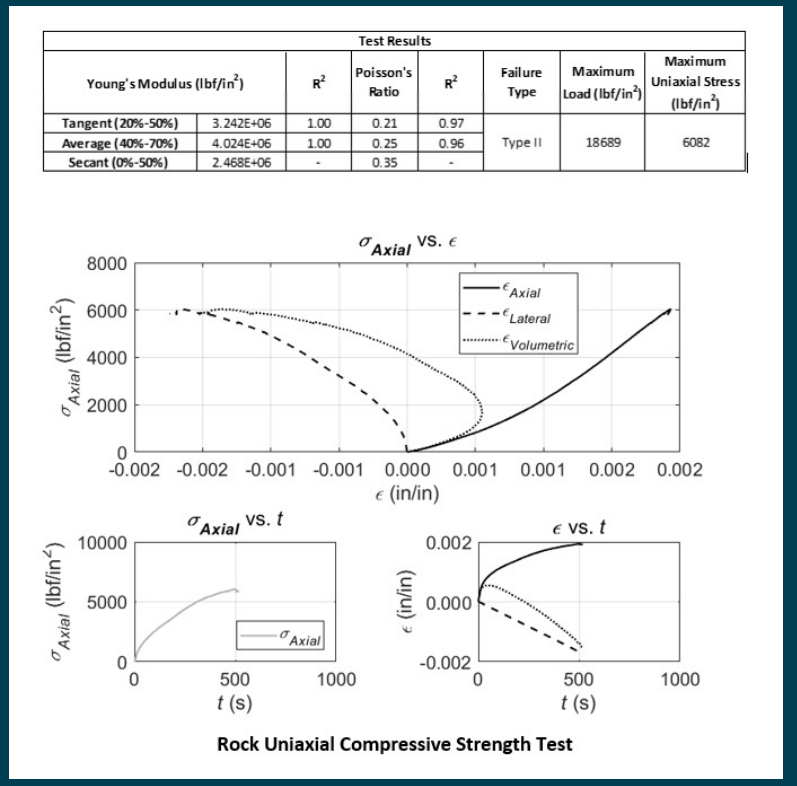
Rock Testing – End Uses 1/3

- Bearing Capacity/Stability
  - UCS, Triax, Mode I, Normal Stiffness, DS, UPV
- Excavatability
  - UCS, IT, UPV, CERCHAR



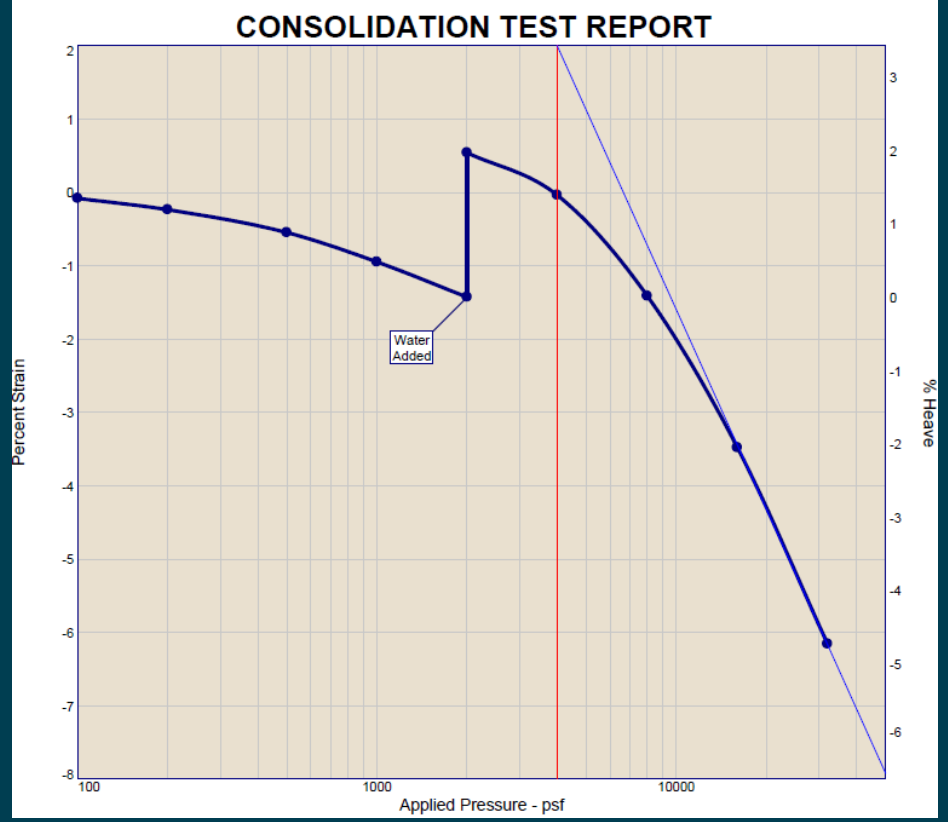


Test Results							
Young's Modulus (lbf/in^2)		R^2	Poisson's Ratio	R^2	Failure Type	Maximum Load (lbf/in^2)	Maximum Uniaxial Stress (lbf/in^2)
Tangent (20%-50%)	3.242E+06	1.00	0.21	0.97	Type II	18689	6082
Average (40%-70%)	4.024E+06	1.00	0.25	0.96			
Secant (0%-50%)	2.468E+06	-	0.35	-			



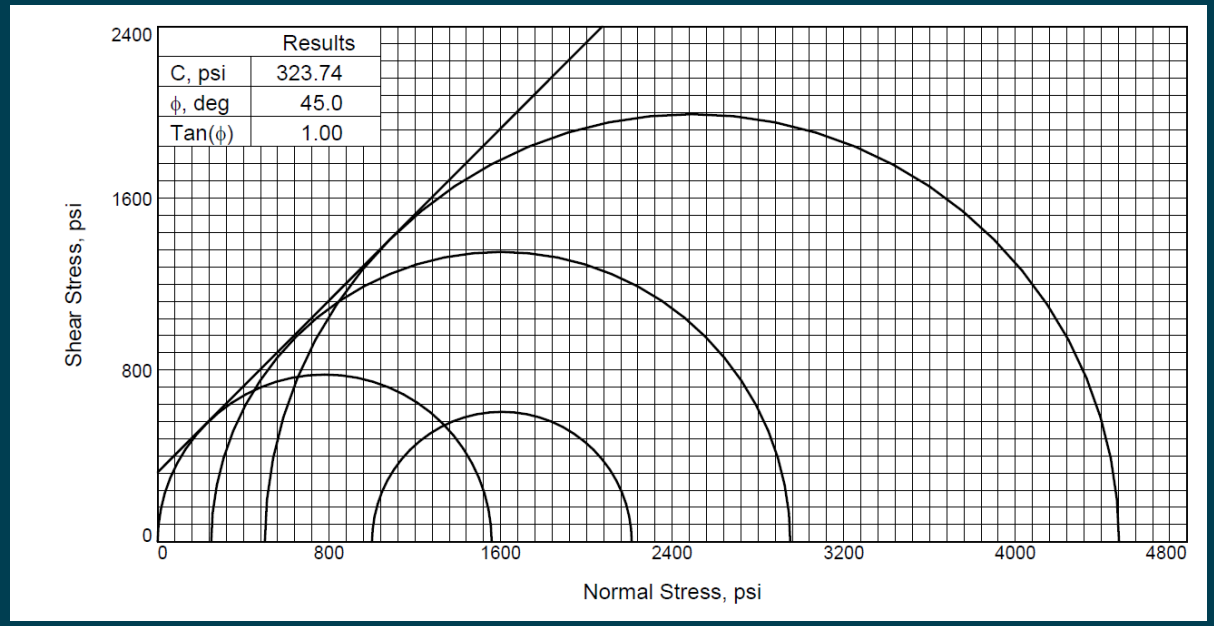
Rock Testing – End Uses 2/3

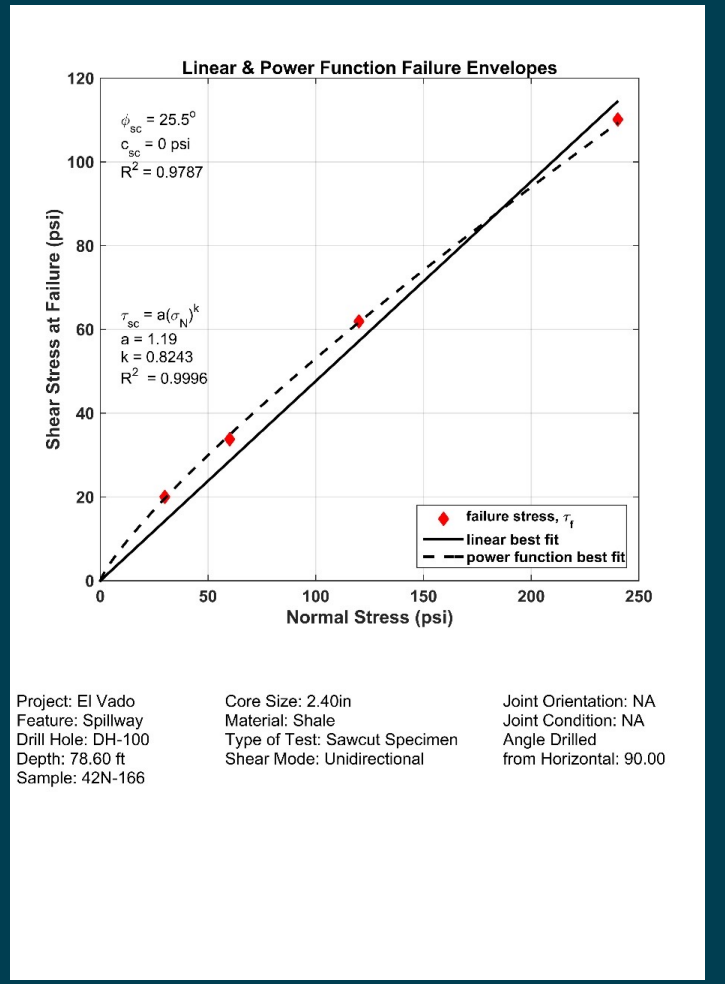
- Trenchless Crossing
  - UCS, IT, UPV, CERCHAR, Slake
- Swell/Consol
  - S/C, PI, Slake



Rock Testing – End Uses 3/3

- Rock Slope – Kinematics
  - DS
- Anchors
  - Triax





Project: El Vado
Feature: Spillway
Drill Hole: DH-100
Depth: 78.60 ft
Sample: 42N-166

Core Size: 2.40in
Material: Shale
Type of Test: Sawcut Specimen
Shear Mode: Unidirectional

Joint Orientation: NA
Joint Condition: NA
Angle Drilled
from Horizontal: 90.00

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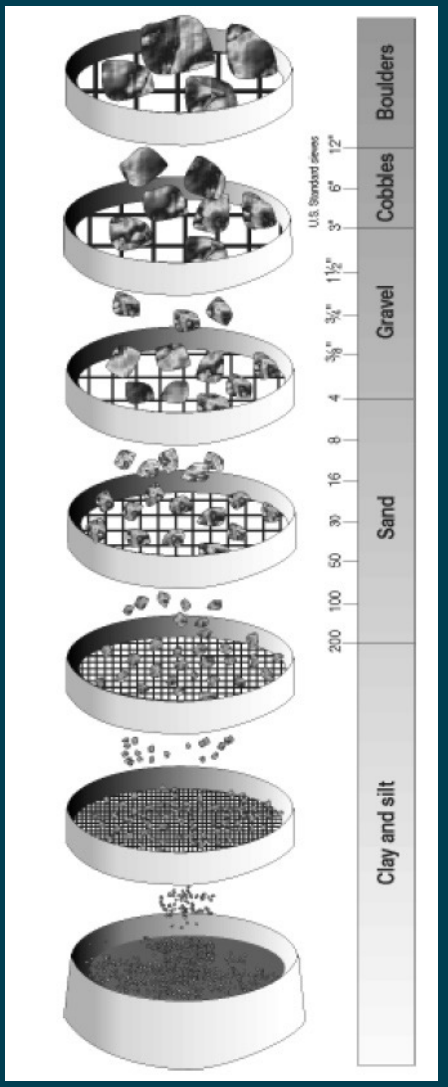
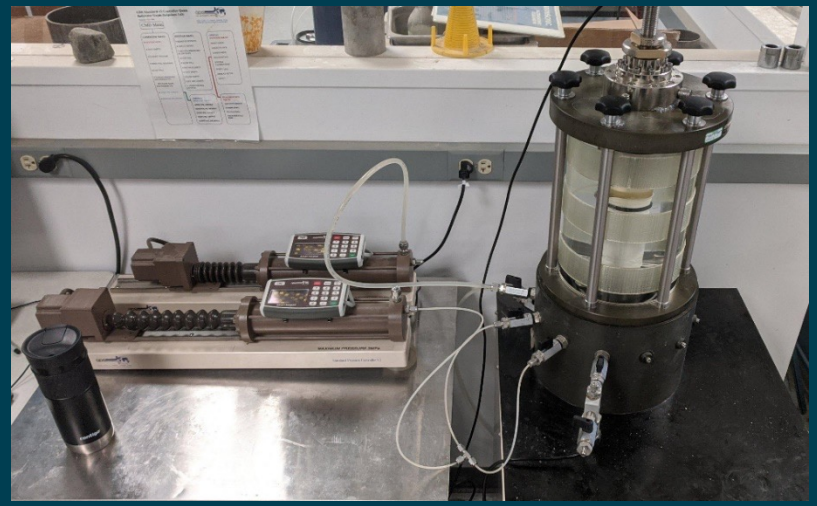
Soil Lab Testing

- Physical Properties
  - What "*IS*" the Soil?
    - Index Testing – Classifications
    - Soil "DNA"
    - Bulk/Disturbed Samples OK



- Engineering Properties
  - How does the soil "*Behave*"?
    - Shear Strength
    - Compressibility
    - Permeability
    - .....more
  - Sampling requirements more complex!

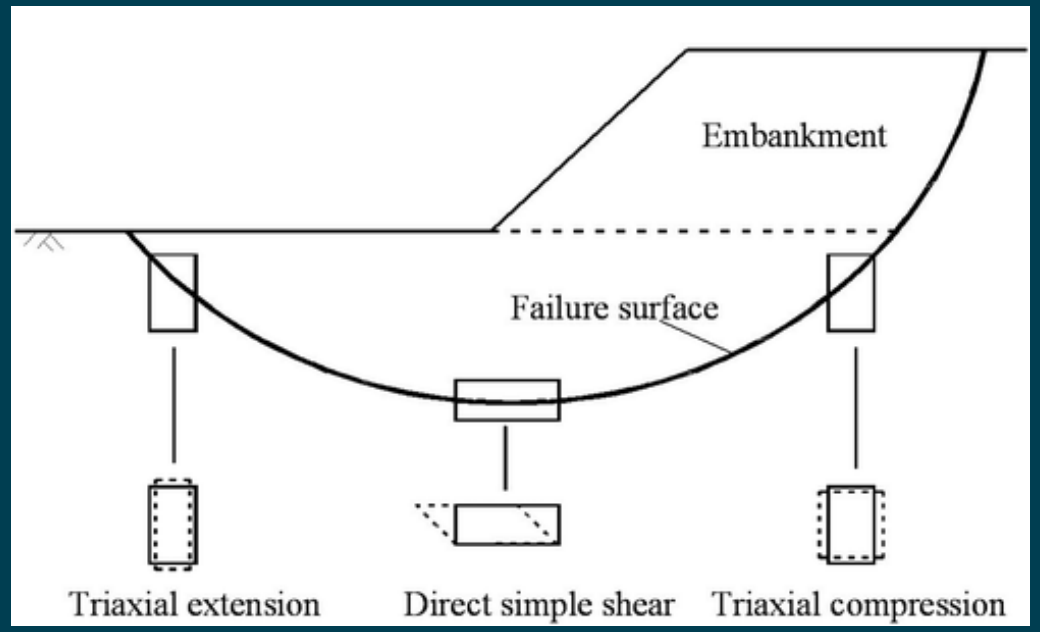


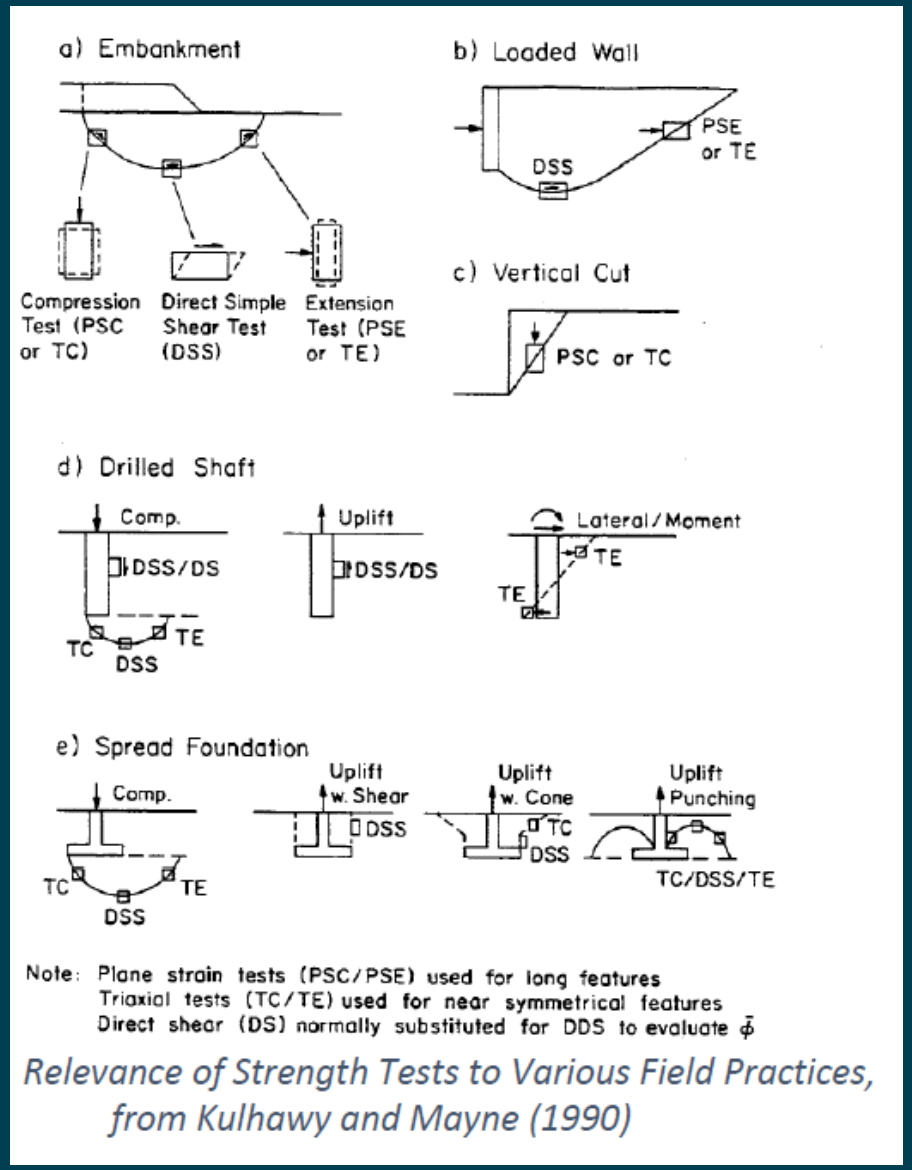
Soil Engineering Properties Testing

- Intact Sample Testing
  - In-situ Conditions
    - Test in its most natural state
    - Sample Quality is Paramount
    - Density and water content Important
- Reconstituted Sample Testing
  - Future Conditions
    - Bulk/Disturbed Samples OK
    - New Fill – Borrow Areas
    - Post – Earthquake
  - When Intact sample is not possible

Design Data from Lab Testing

- Loading Conditions?
  Rapid? Slow?
- Drainage Conditions?
  - Pore Pressures

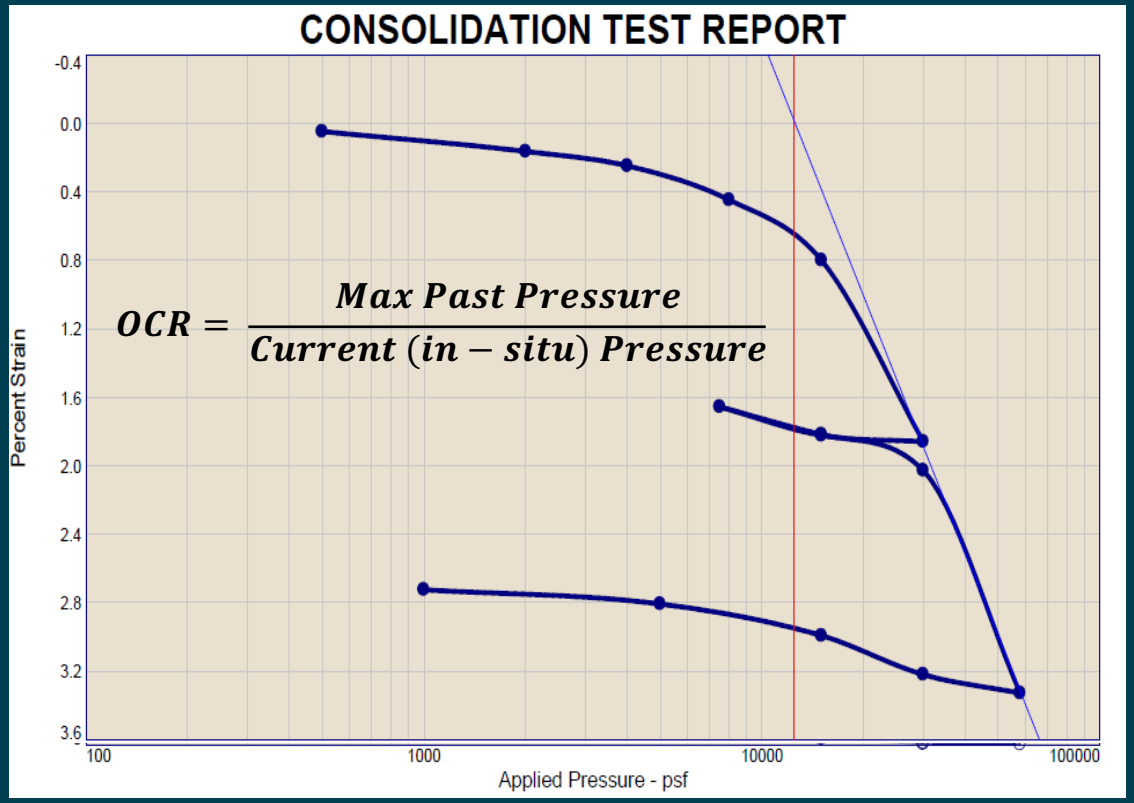




Relevance of Strength Tests to Various Field Practices, from Kulhawy and Mayne (1990)

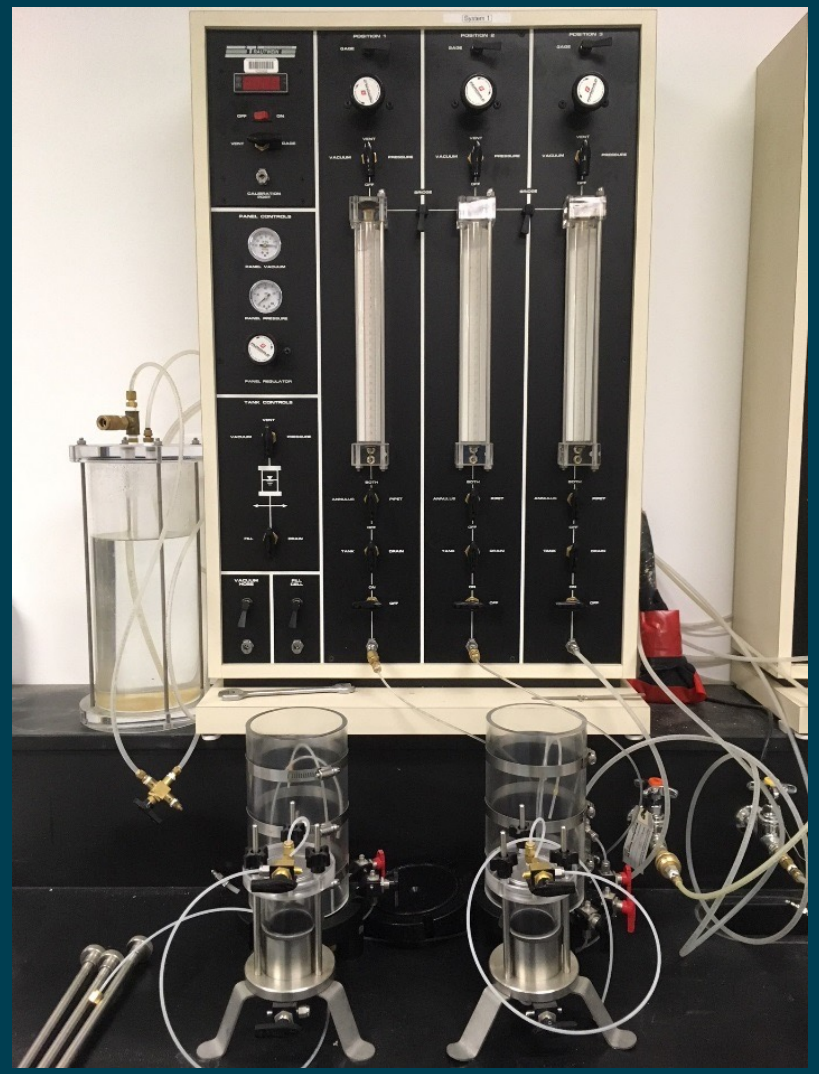
Design Data from Lab Testing 2

- Consolidation: Change in Soil Volume from increased stress
  - 1D Incr. Load Test
  - CRS Test
  - Maximum past pressure
    - Overconsolidation Ratio (OCR)
    - Highly affected by disturbance
  - Settlement Analysis (rate and mag)
  - OCR: Affects on Strength and Modulus
    - Stress History And Normalized Soil Engineering Properties (SHANSEP)



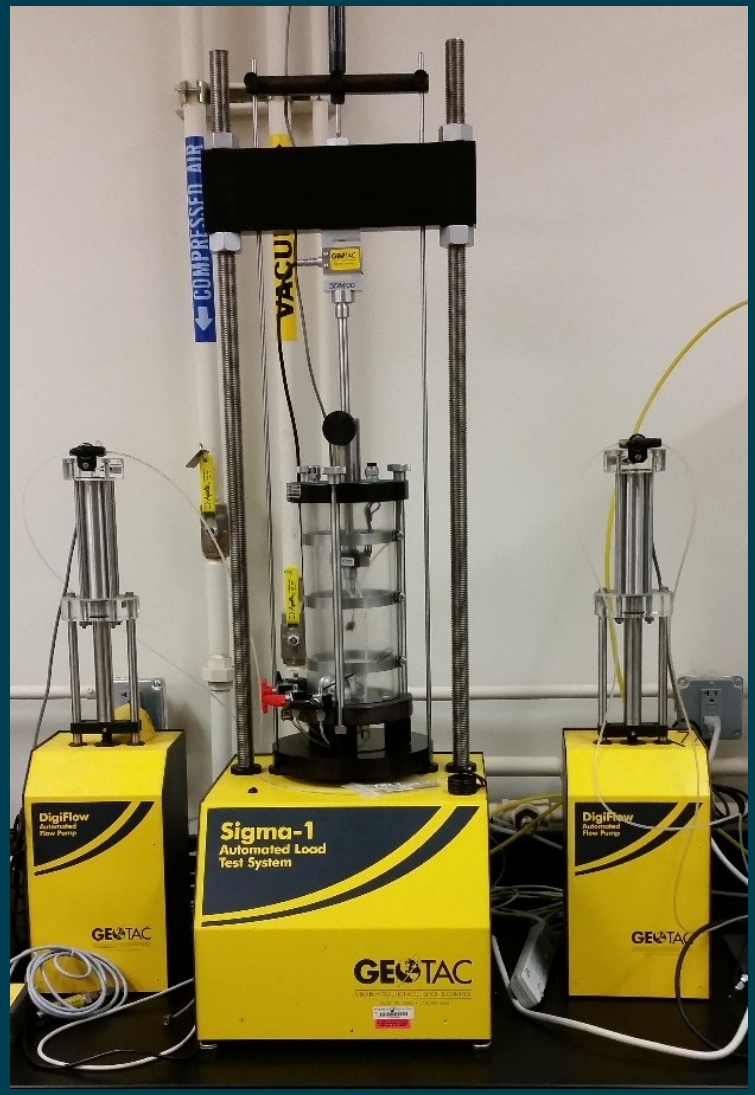
Design Data from Lab Testing 3

- Permeability (K): Rate of water flow through soil
  - Flexible Wall Perm Test (low K)
  - Rigid Wall Perm Test (High K)
  - Internal Erosion Permeameter
  - Seepage Analysis
  - Effective Stresses for modeling
  - Critical Gradients



Design Data from Lab Testing 4

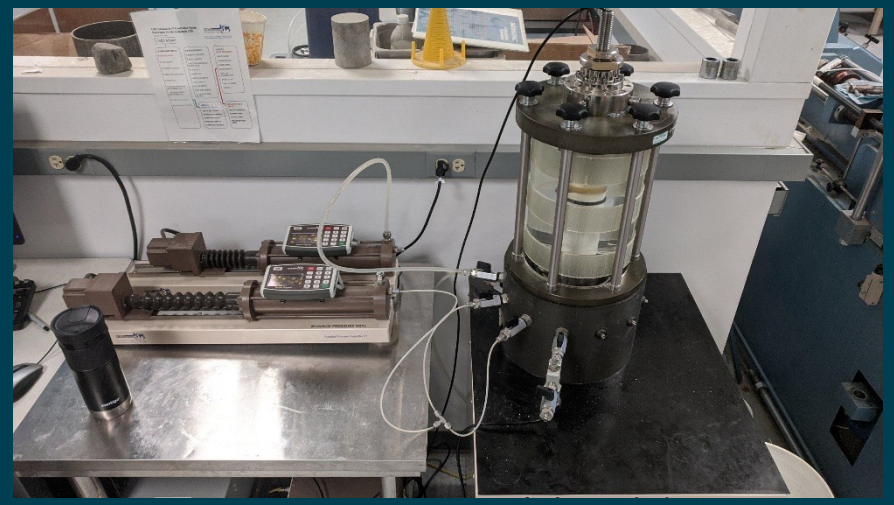
- Static Strength Testing: Mimic Stress and non-dynamic Loading conditions
  - Triaxial Compression
  - Direct Shear
  - Direct Simple Shear
  - Unconfined Compression

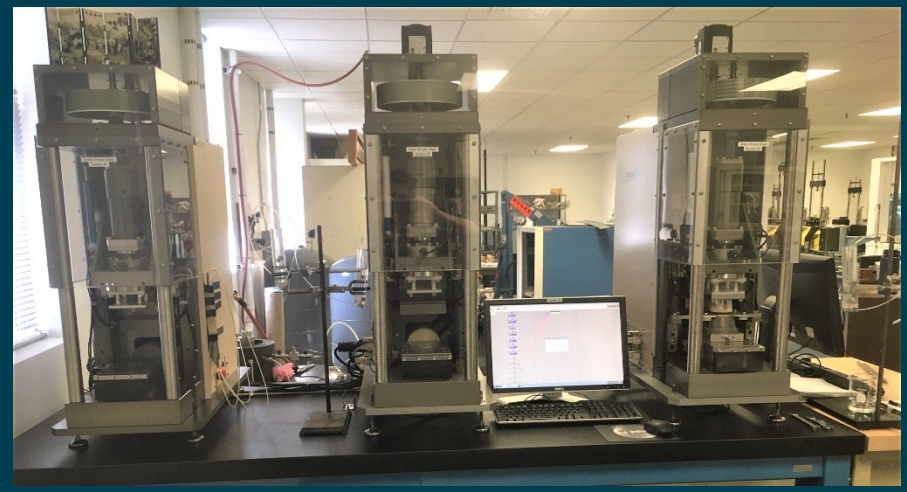


- Slope Stability Analyses
- FLAC Modeling
- Excavation Design
- Bearing Capacity/Foundation Design

Design Data from Lab Testing 5

- Cyclic Strength Testing: Mimic Ground Motions during Earthquake
  - Cyclic Triaxial Compression
    - Vertical Oscillation
  - Cyclic Direct Simple Shear
    - Horizontal Oscillation





- Cycles to “failure” (time)
- Site response modeling
- Liquefaction
- Post-earthquake Stability analyses

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Wrap-Up: Field to Lab Data

- Quality Samples = Quality Testing = ***Reliable Design Data***
  - Sample Type Based on Anticipated Testing
  - Intact Sample Preservation/transport, Specimen Prep Techniques are critical
  - Specimen Selection – Geologic Logs/Field Data, Sample Inspection
- Lab testing
  - Need right boundary condition
  - Understand uncertainty
  - Procedure nuance
  - Interpretation of results

Wrap Up: Analysis & Reporting

- Overall Data Analysis
  - Incorporating Field and Lab data
- Reporting
  - Tie the interpretation to the data
  - Field to lab
  - Uncertainty
  - Variability
  - The “Why?” in the data
- Upscale

Thank you!

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