Field Testing to Determine Realistic Geotechnical Parameters

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Agenda

- Why direct measurement methods might be appropriate?
- Background on plate load test (PLT)
- Some limitations to the PLT
- A case history on the UC Berkeley Campus for use of the Footing Load Test (FLT)
- Concluding remarks

Applicability

- Projects increasingly using more demanding modeling that require greater accuracy.
- Highly variable subsurface conditions can make it difficult to estimate foundation stiffness and bearing capacities.

Plate Load Test

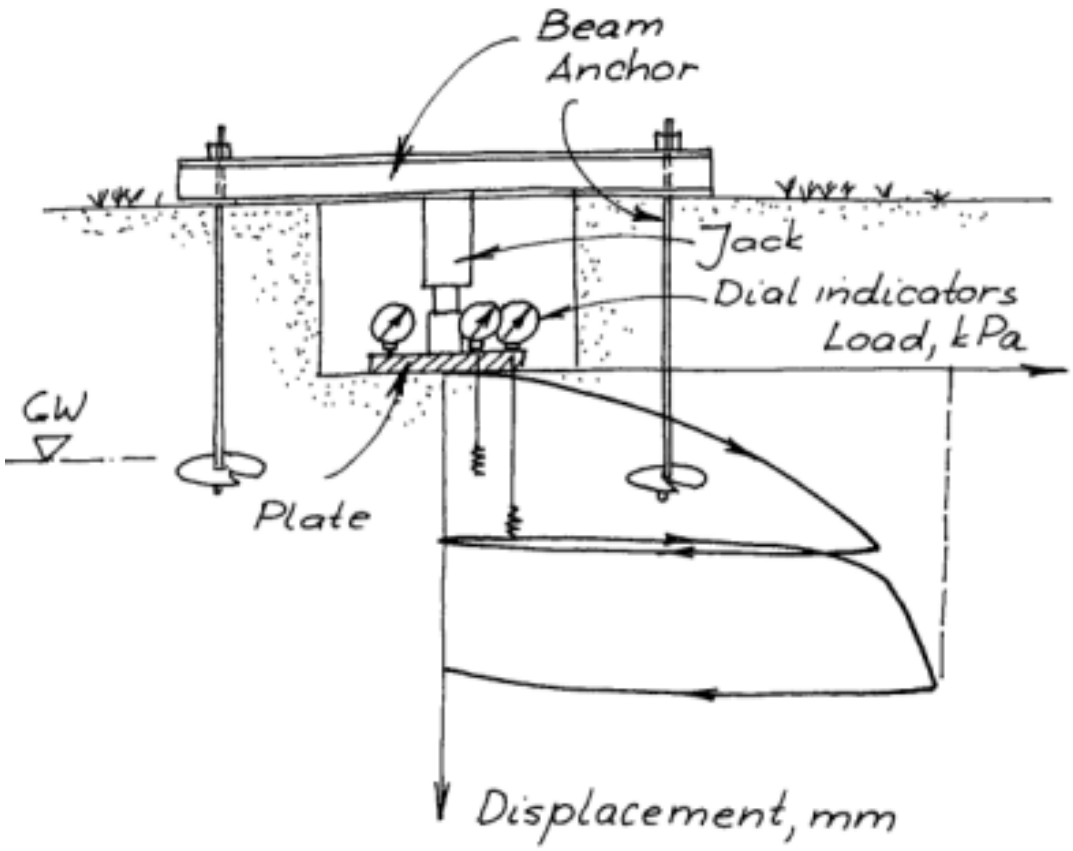


Plate Size Typically 1'X1'

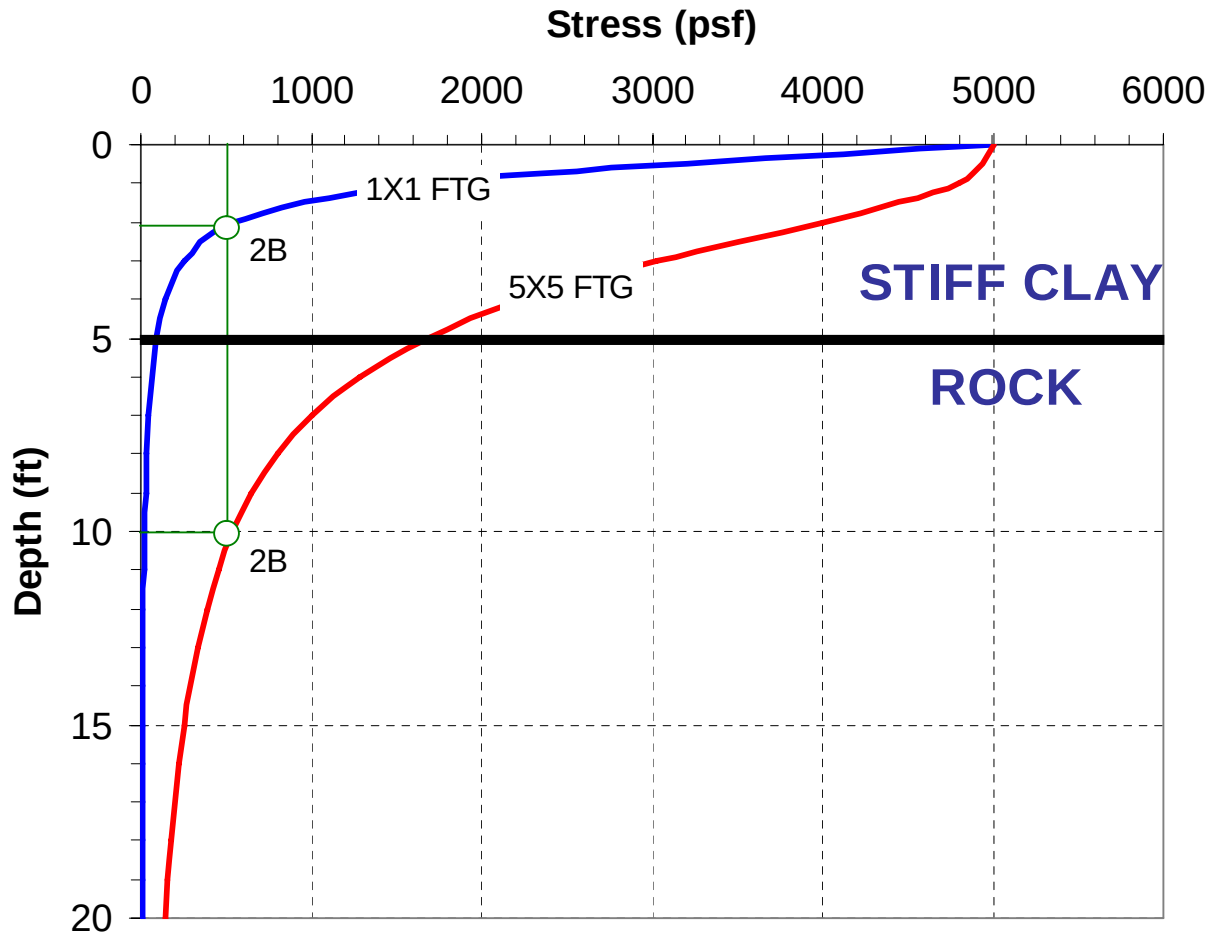
Good Applications of PLT

- Fairly uniform subsurface conditions within the influences of planned foundations (2B to 3B)
- Plate is seated at expected foundation levels
- Program should include variable plate sizes and depths for extrapolation to larger footing sizes and different depths
- Economical approach for direct measurement method

Limitations of PLT

- Limited stress influence due to small plate sizes
- Sites with variable or stratified subsurface conditions (i.e. compressible layer just below stress influence of PLT)
- Does not fully capture real footing behavior

Example of Stress Influence



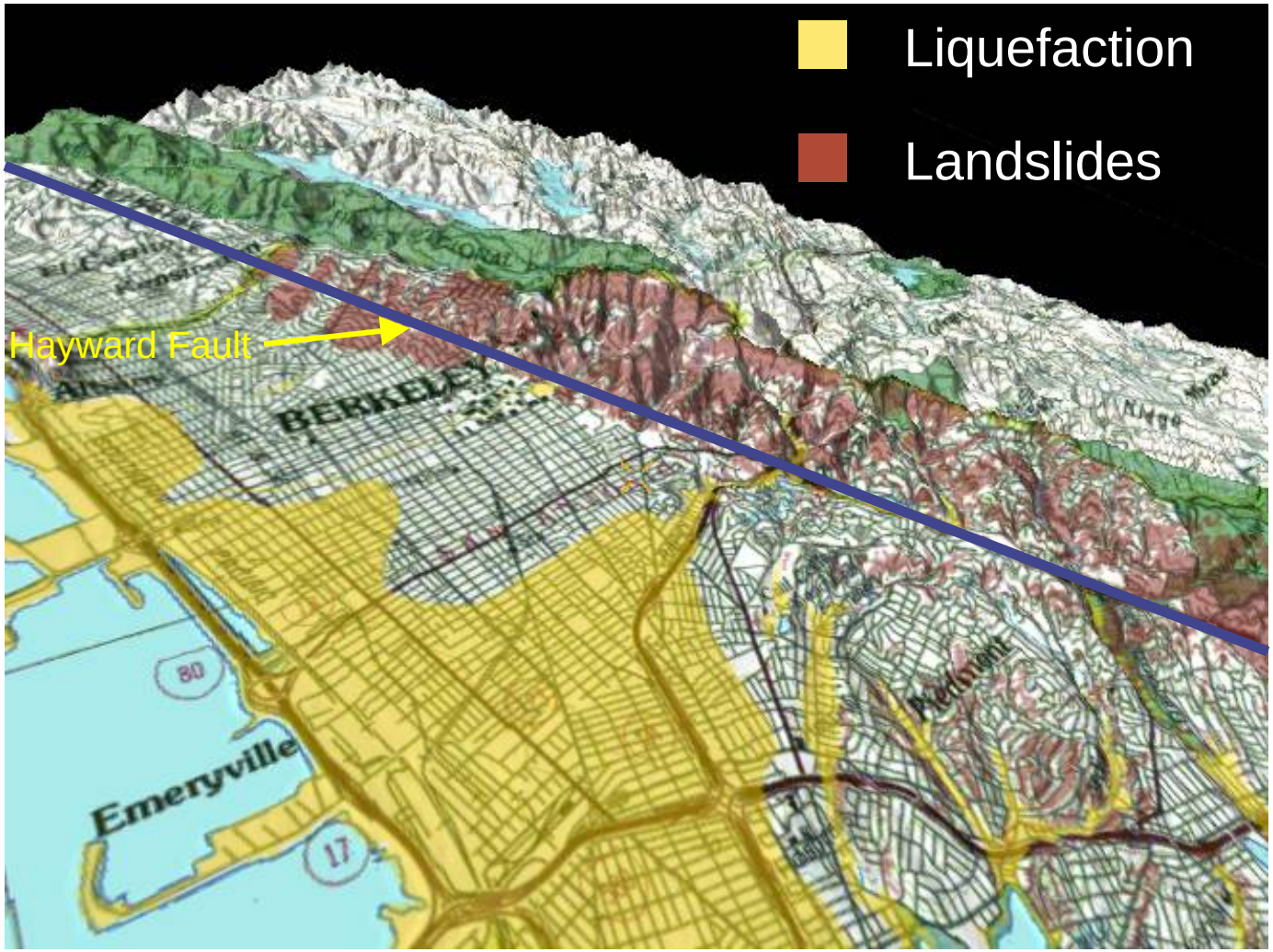


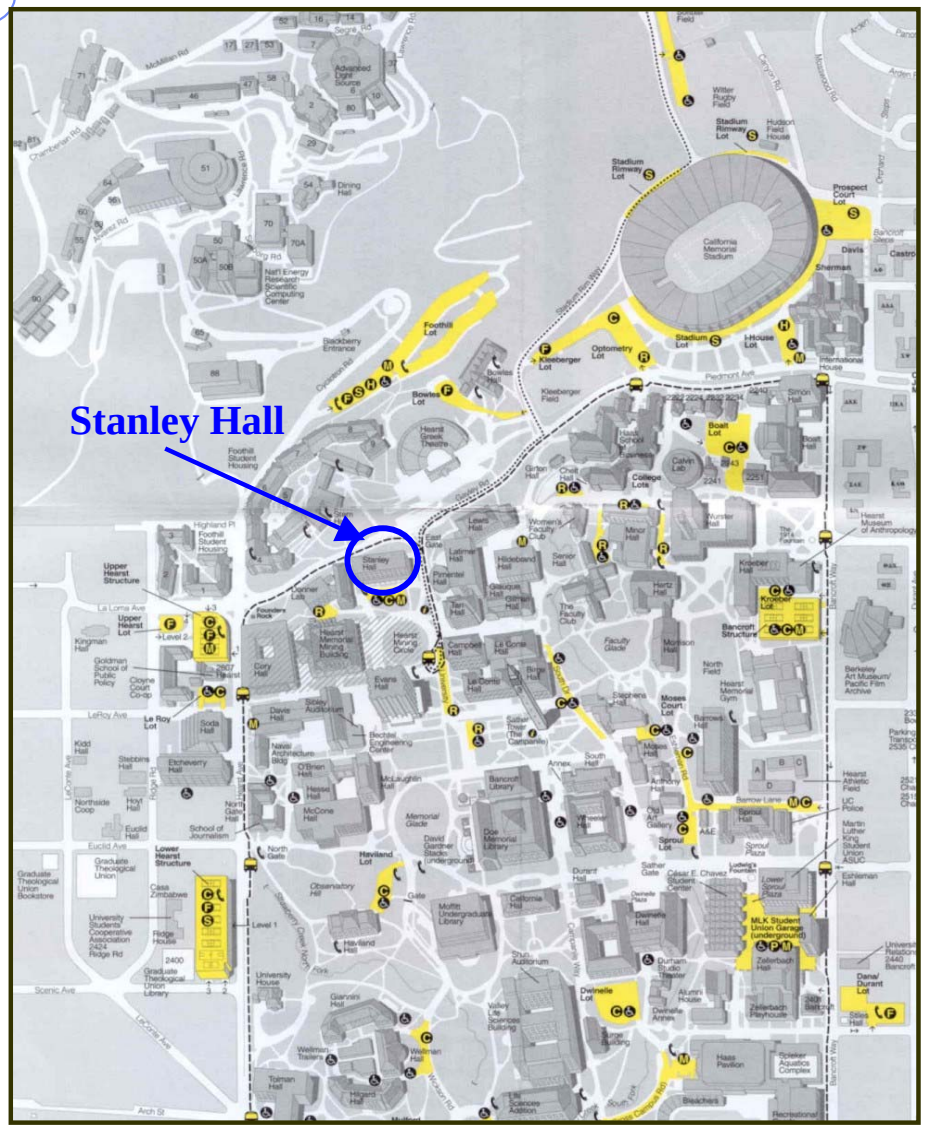


Case History

- UC Berkeley Stanley Hall Biosciences Facility

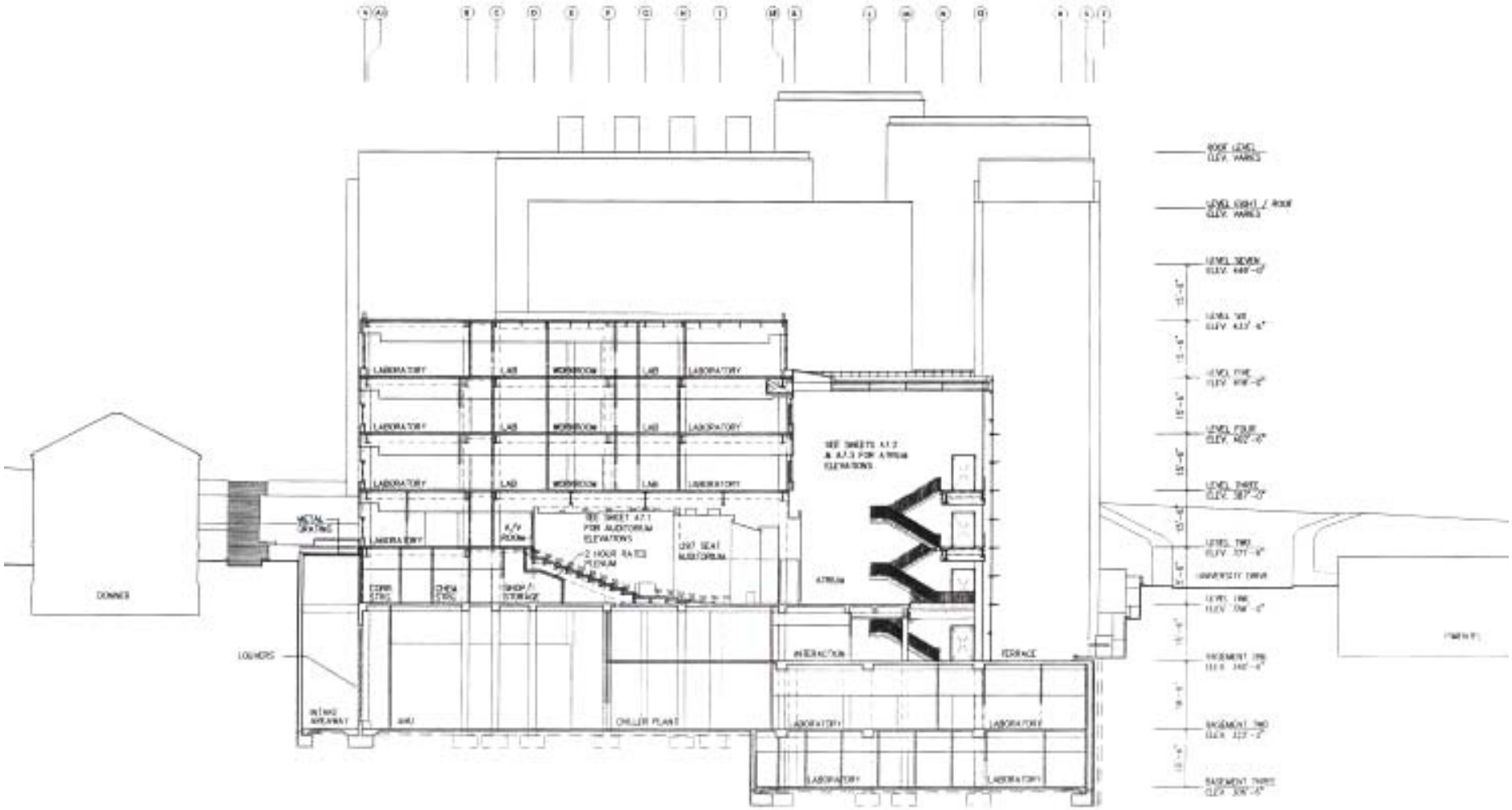
Seismic Setting





UC Berkeley Campus

Stanley Hall Looking East

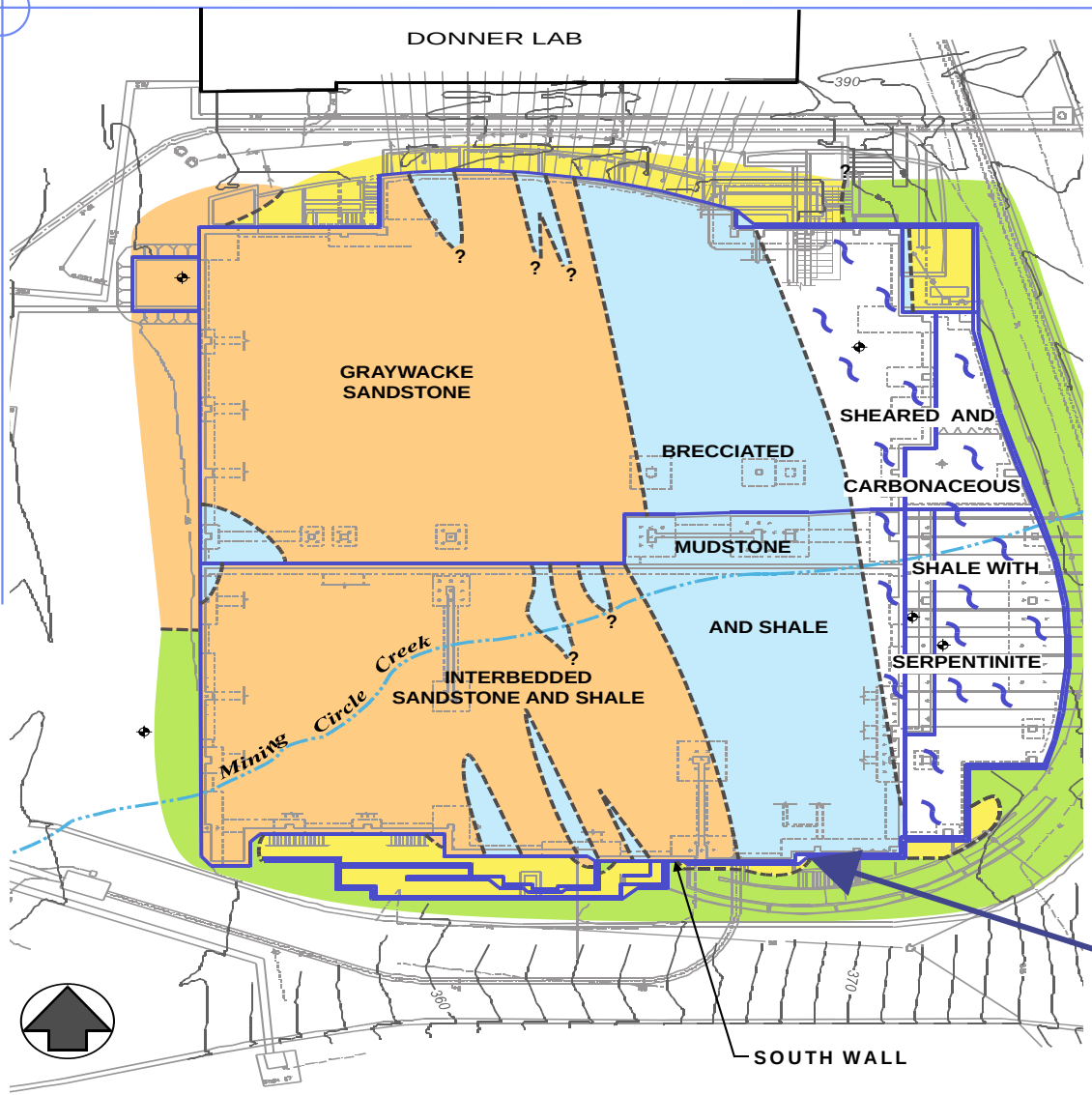




Site Conditions

- Fill and colluvium over Franciscan Bedrock (shale and graywacke sandstone)
- Shale bedrock predominantly in the east, very fractured and weathered, and generally soft rock
- Graywacke sandstone in the west becoming hard and more competent with depth
- Old Strawberry Creek stream channel
- Shallow groundwater
- About 500 feet to Hayward Fault

Geologic Mapping of Bottom of Basements

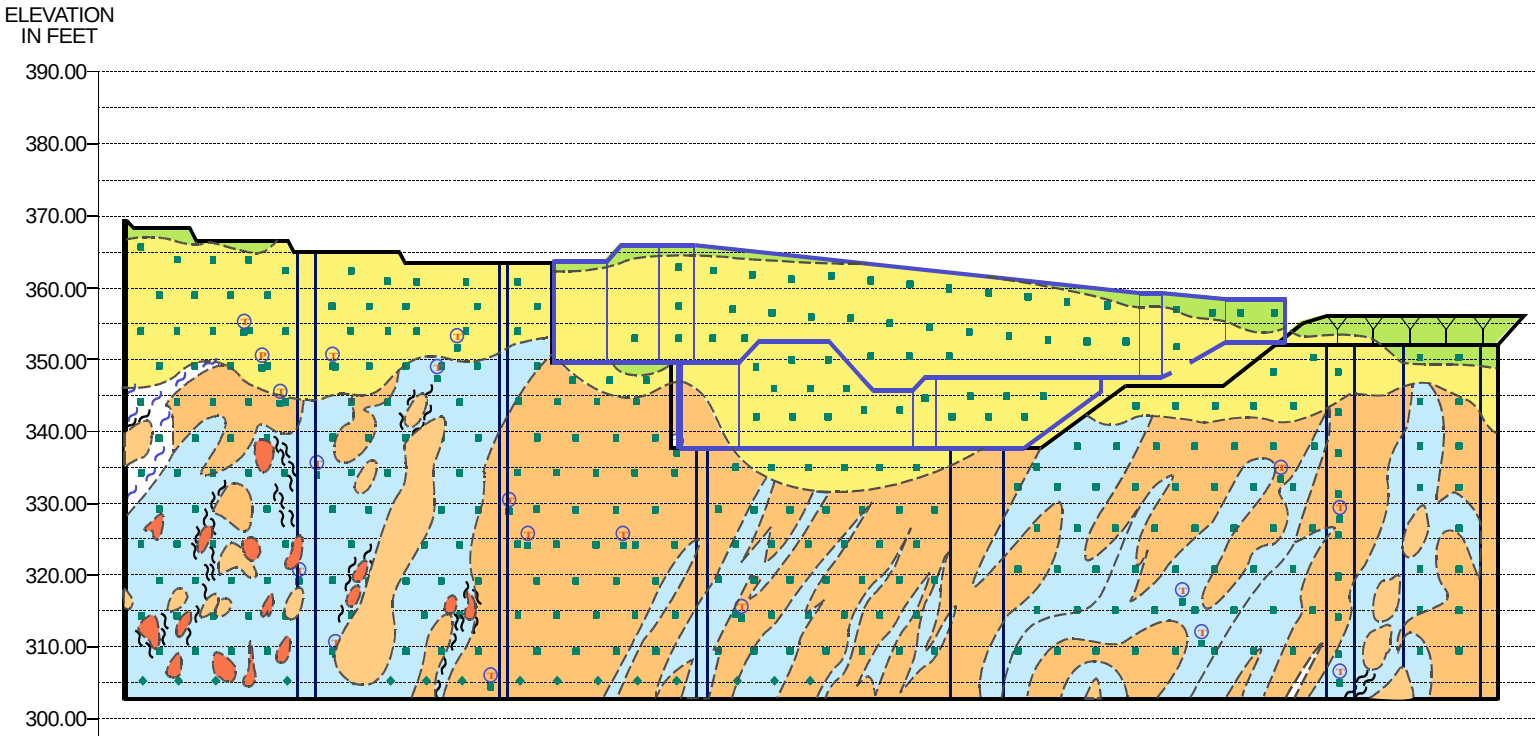


Legend:

- Fill
- Colluvium
- Mudstone/Shale
- Graywacke Sandstone

South Wall

Geologic Mapping



SOUTH WALL ELEVATION

Legend: Fill Colluvium Mudstone/Shale Graywacke Sandstone

Geotechnical Uncertainties - Franciscan Rock

- Difficult to estimate engineering properties of highly heterogeneous rock based on traditional boring data and laboratory tests
  - Subgrade modulus (foundation stiffness)
  - Bearing capacity

Foundation Stiffness Relationships

Relationships Used (NFEC Design Manual 7.02)

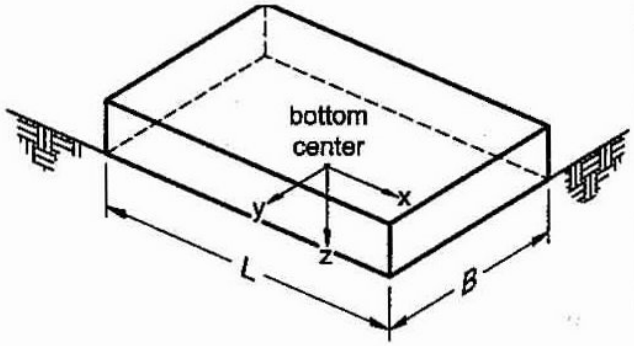
Cohesive Soil $k_s = \frac{k_{v1}}{B}\left(\frac{m+0.5}{1.5m}\right)$

Cohesionless Soil $k_s = k_{v1}\left(\frac{B+1}{2B}\right)^2$

FEMA 356 Relationship

$$K_{z,\,sur} = \frac{GB}{1-\nu}\left[1.55\left(\frac{L}{B}\right)^{0.75} + 0.8\right]$$

Translation along z-axis



Orient axes such that $L \geq B$

Bearing Capacities

- Conservatively based on historical, presumptive, and/or empirical values
- Difficult to assign material properties to Franciscan sandstone and shale that can be incorporated into traditional bearing capacity relationships

Implications?

- What is a conservative subgrade modulus?
  - Actual modulus is stiffer may result in damage to shear wall elements
  - Actual modulus is softer may result in damage to building frame
- Conservative bearing capacities that will likely perform well but may be costing the project with larger footings with increasing seismic demands

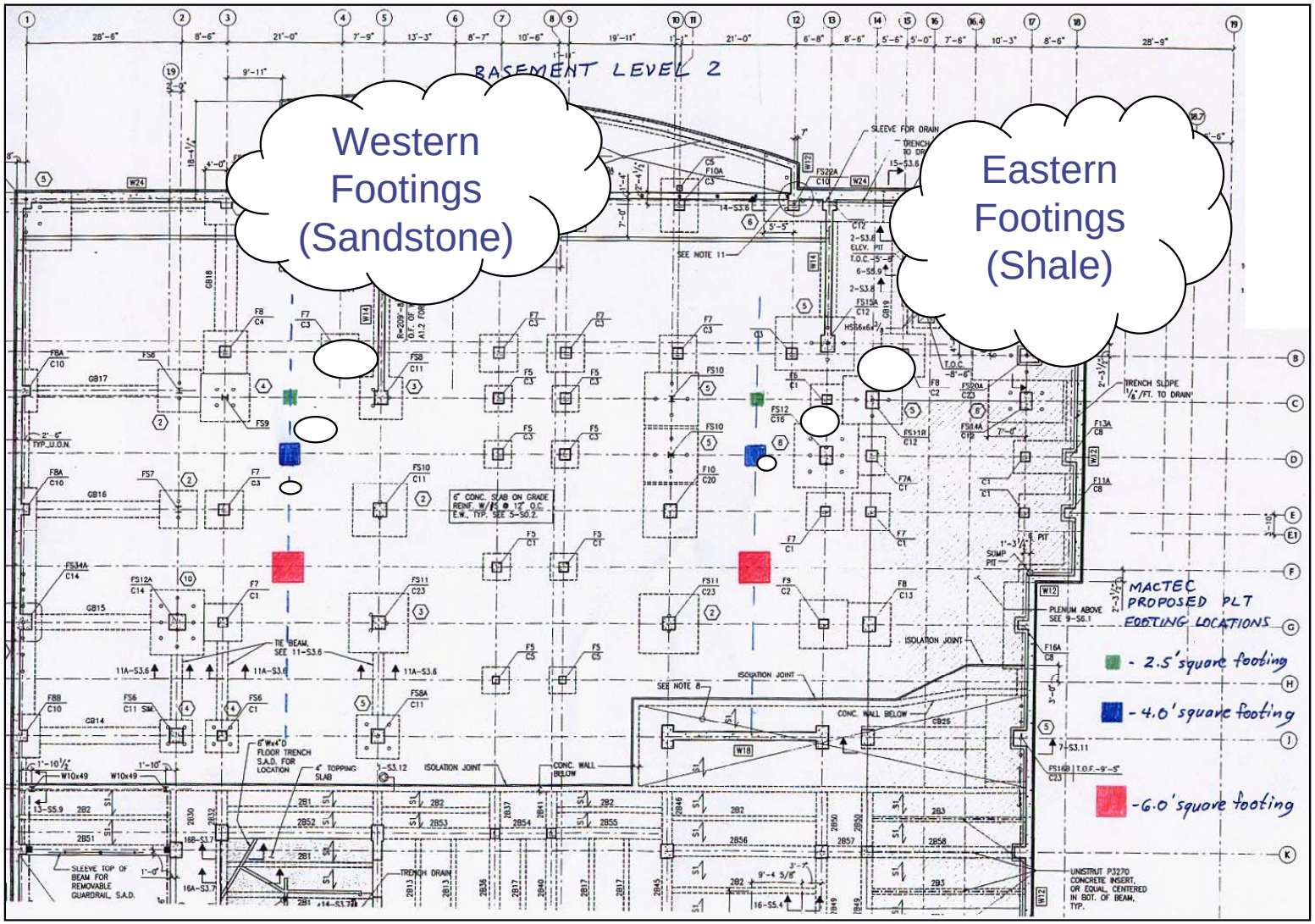
Why the Footing Load Test (FLT) was conceived?

- Large seismic demands
- Difficult to determine the stiffness and bearing capacity for heterogeneous Franciscan sandstone and shale
- Many buildings on campus are founded in Franciscan rock
- Improve design for future campus buildings with direct measure of stiffness and bearing capacity of full size footings founded in Franciscan rock

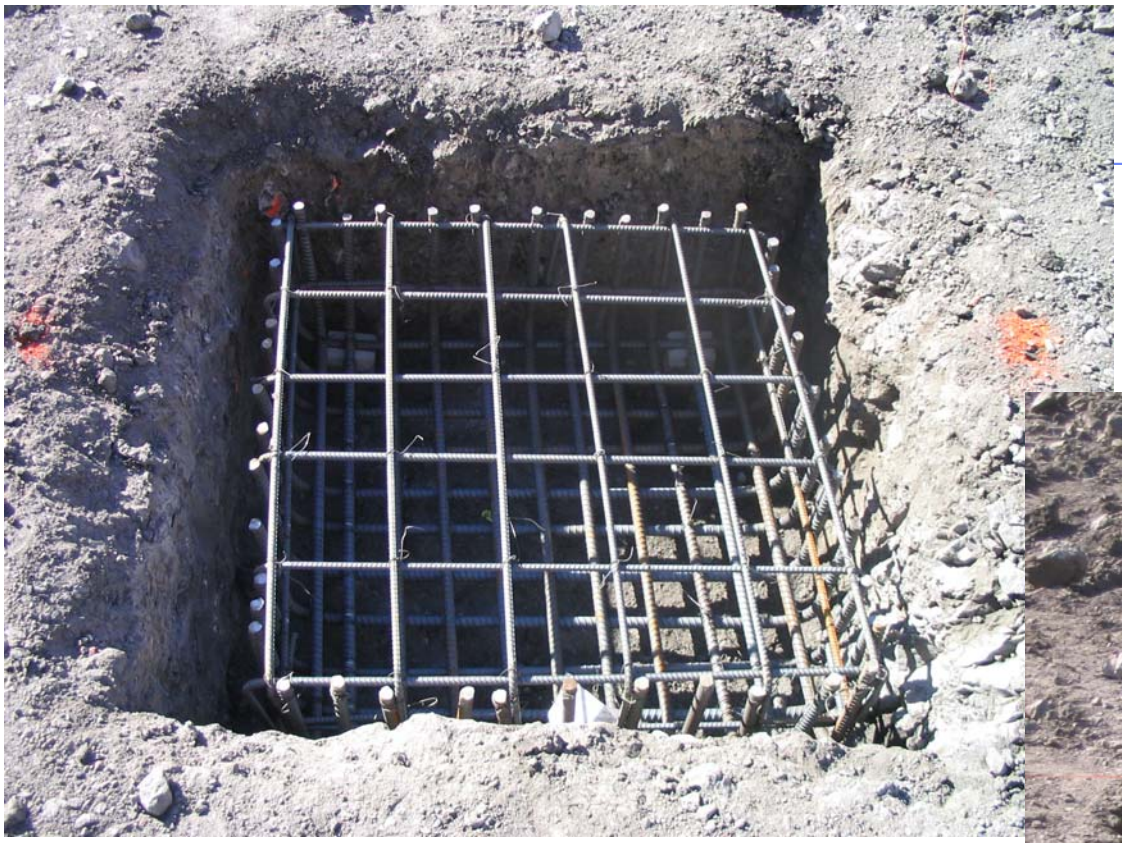
The Plan

- Construct full size square footings (2.5, 4, and 6 feet) founded in sandstone and shale in basement levels of the active excavation of Stanley Hall
- Perform load tests to cyclically impact footings using a Pile Load Tester (PLT) with loads up to 800 kips

FLT Location Plan

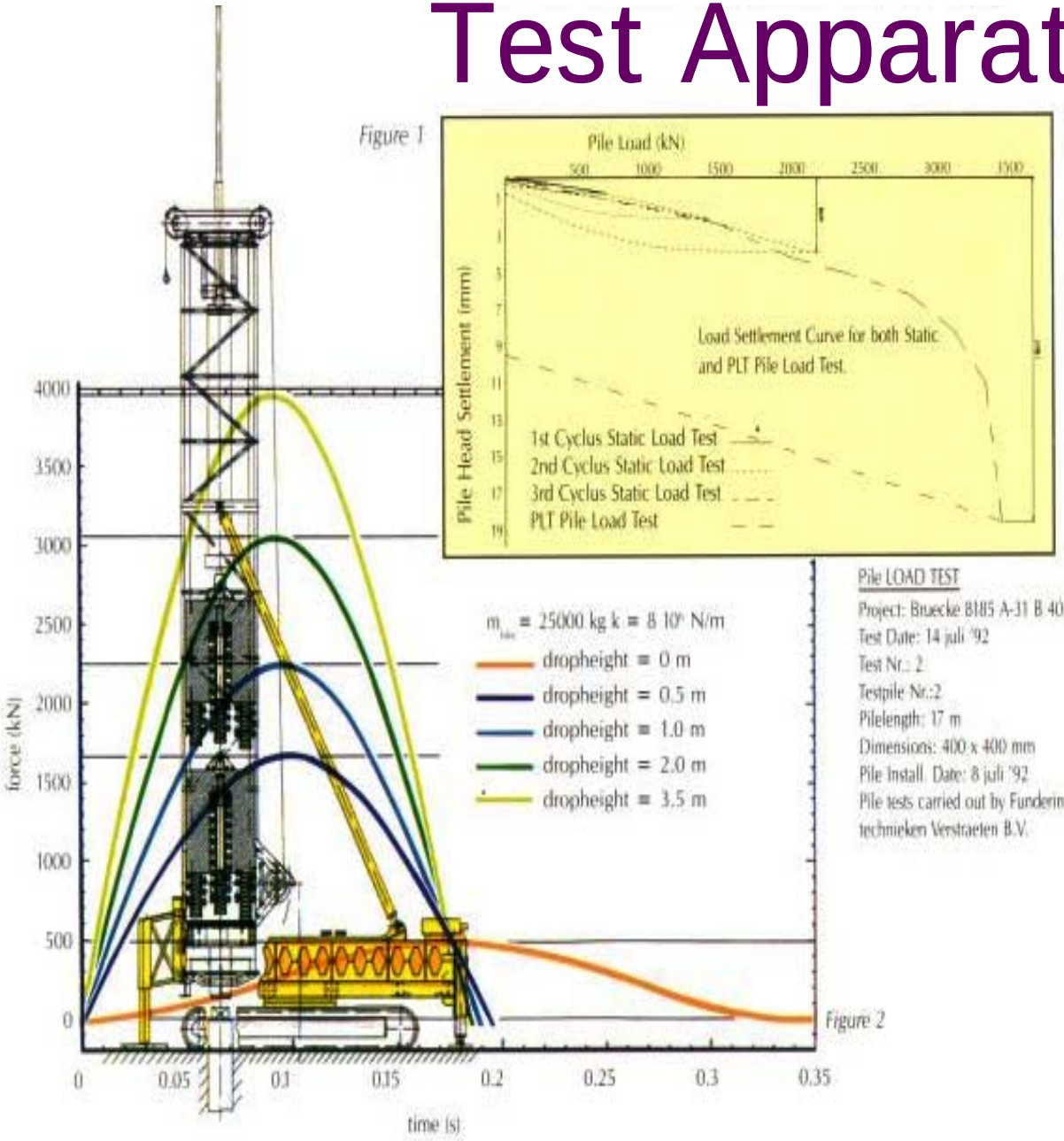



FLTs Amidst Construction





Test Apparatus

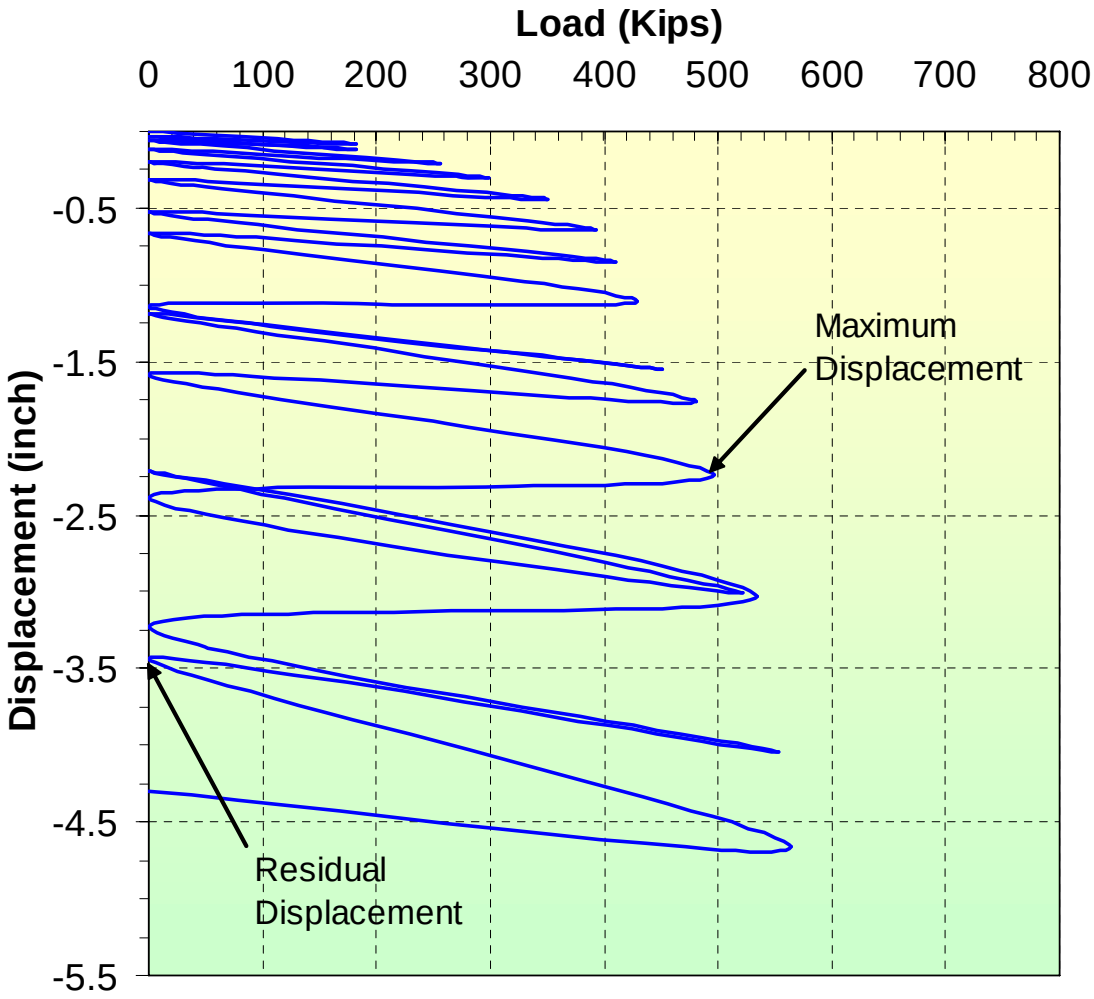


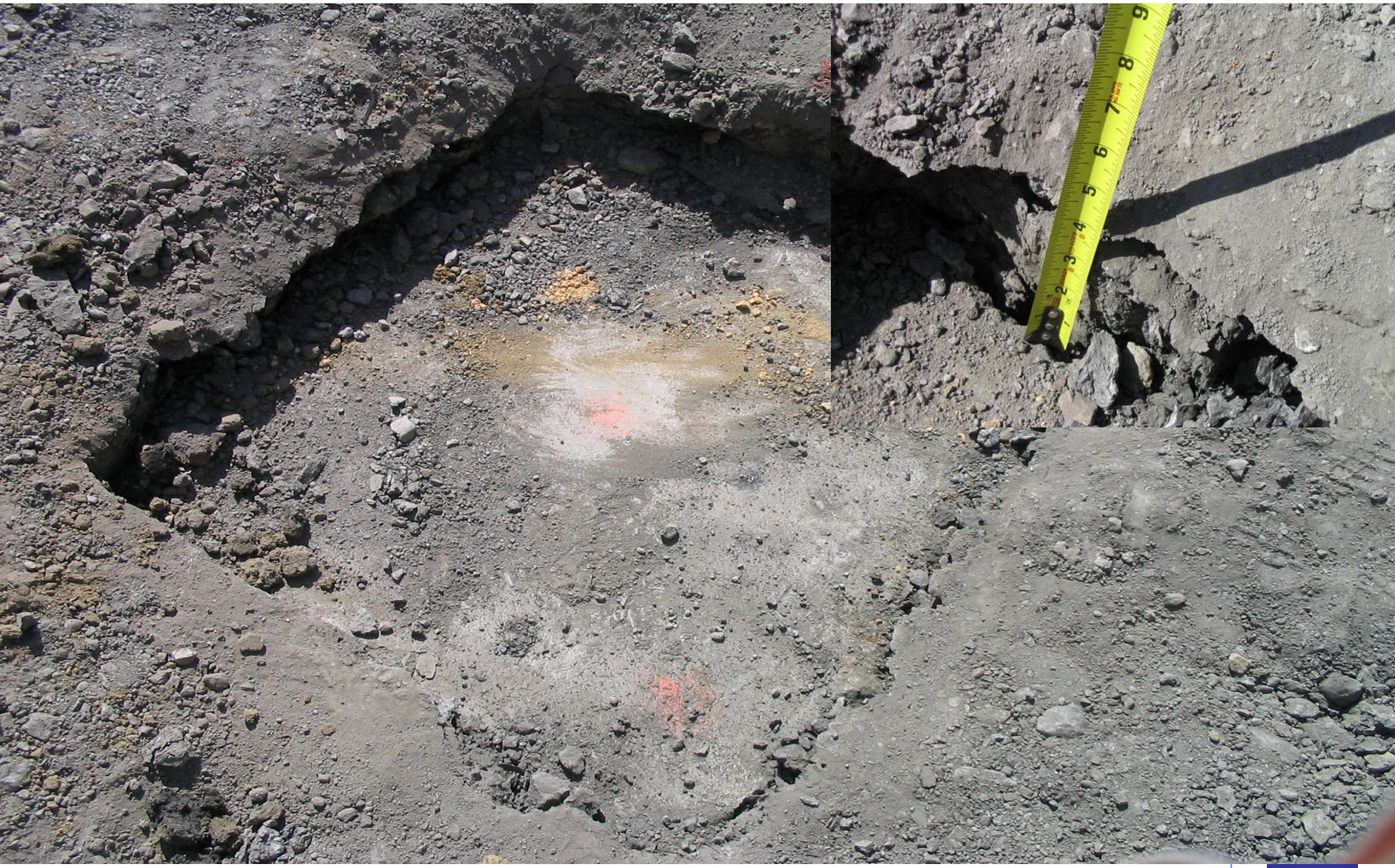



25,000kg
mass on
heavy
coiled
springs

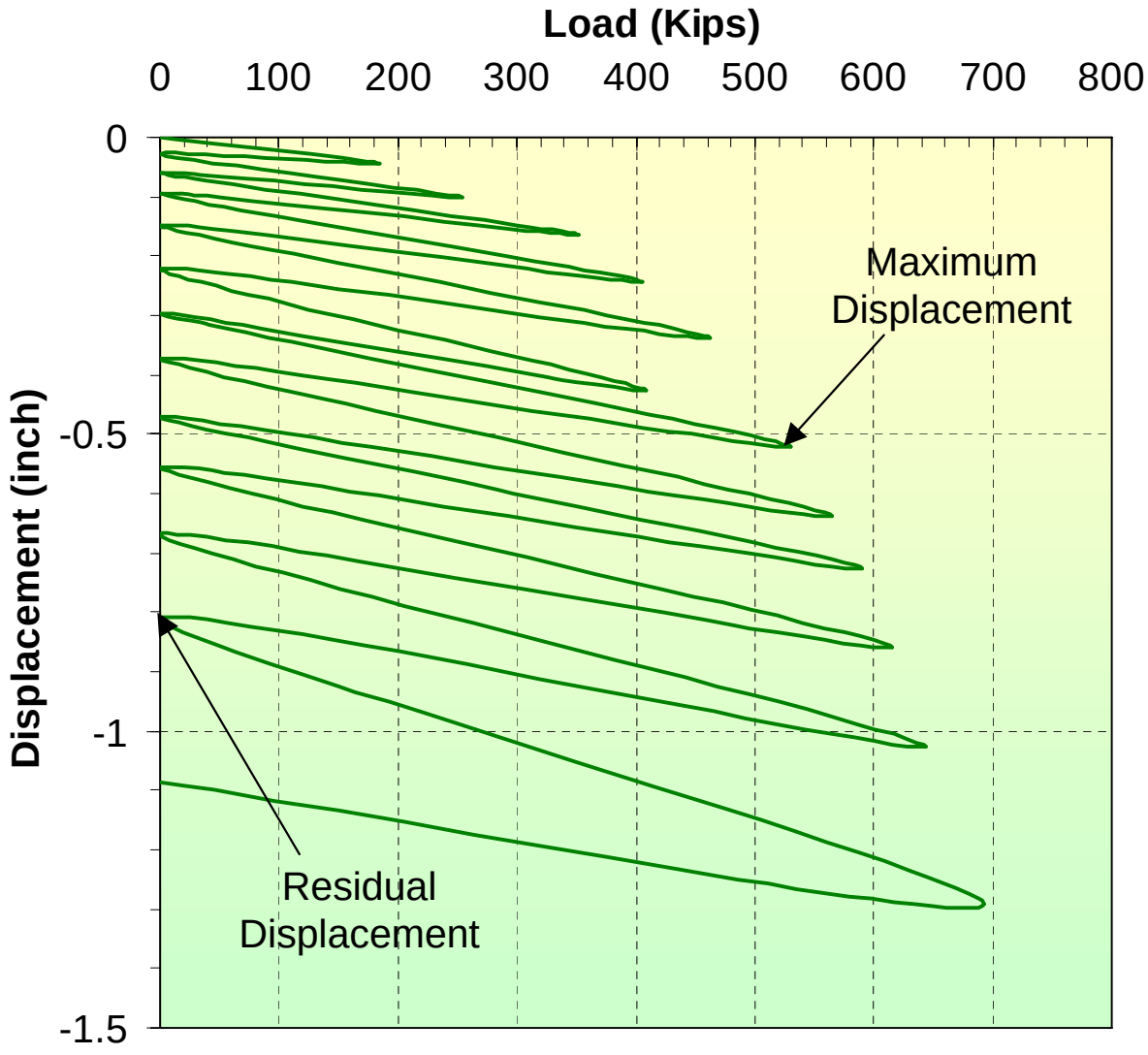

MALCOLM
4'X4'
6'X6'

Load Versus Displacement (2.5' x 2.5')

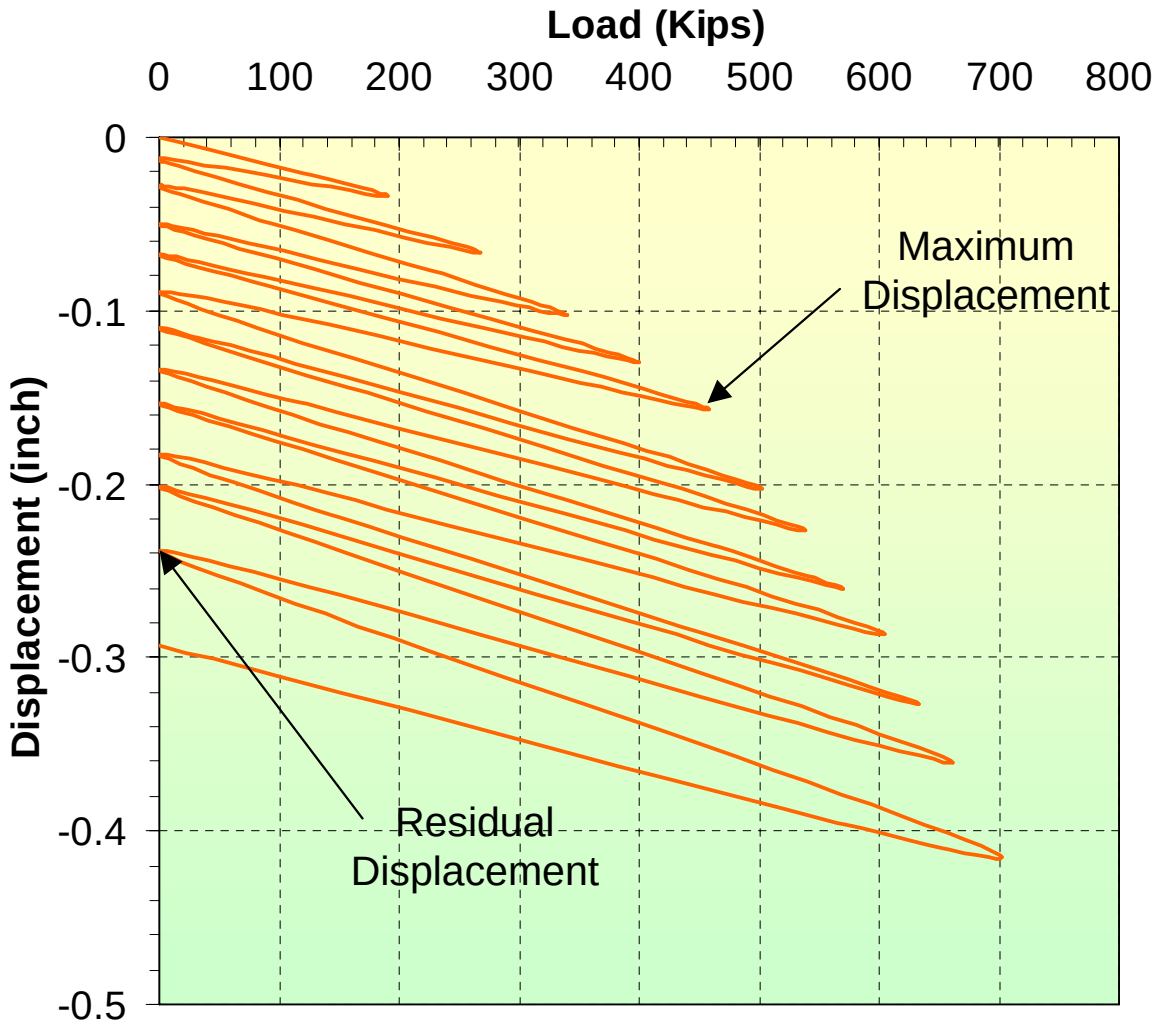




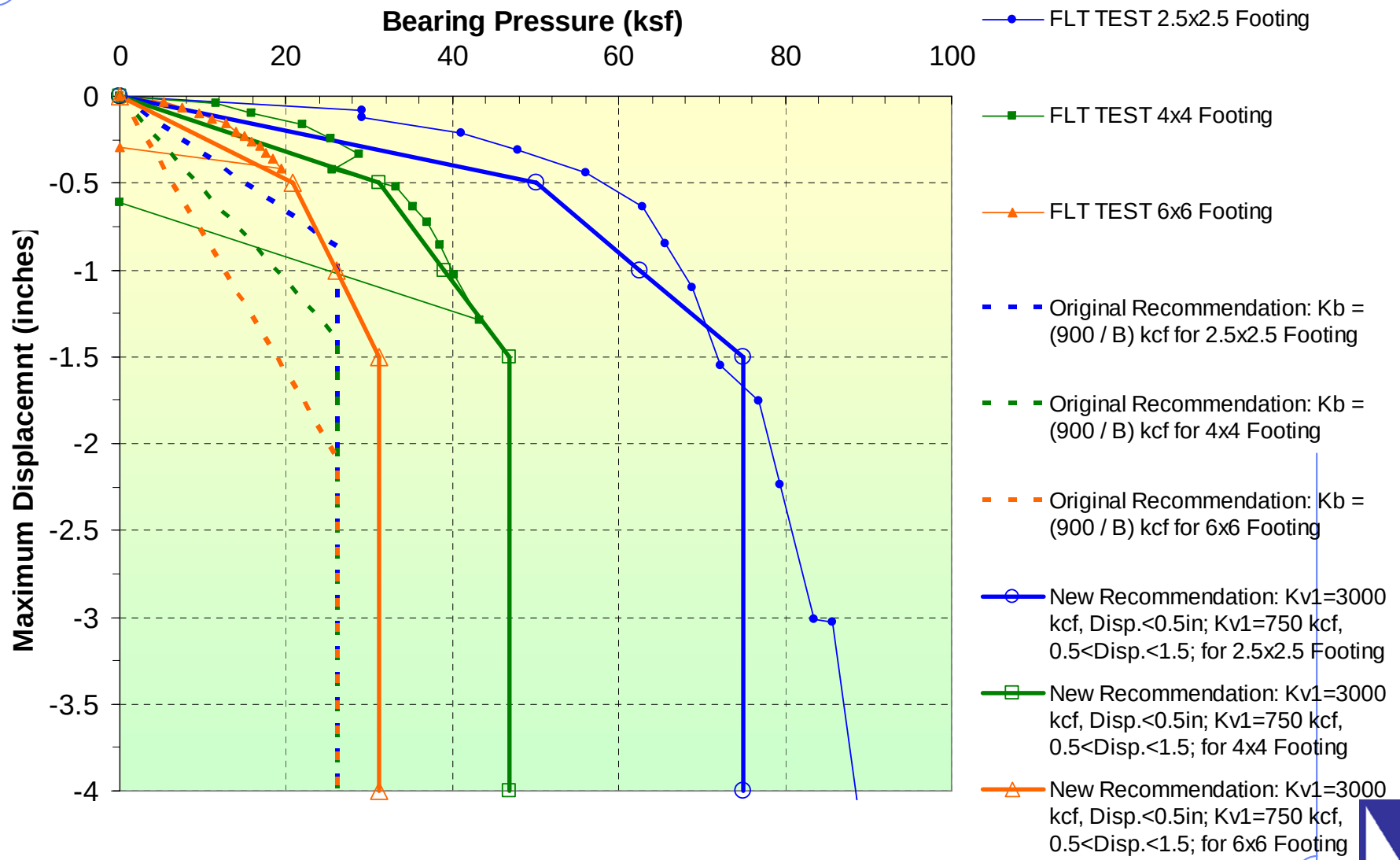
Load Versus Displacement (4' x 4')



Load Versus Displacement (6' x 6')



Summary of Load Tests



What Was Gained?

- Original Recommendation: Kv1=900 kcf
- After FLT: Kv1=3000 kcf (<1/2 inch), 750 kcf (1/2 to 1.5 inch), plastic after 1.5 inch
- Original Recommendation: Ultimate Bearing Capacity (UBC) = 26,000 psf
- After FLT: UBC = 30,000 to 70,000 psf
- Cost Savings to Next Campus Building

Concluding Remarks

- As seismic modeling and demands increase there is a shift towards ultimate load vs. displacement.
- Provide more realistic geotechnical recommendations because often it is not clear what is conservative.
- Direct measurements methods such as the PLT or FLT can help achieve these goals.

THE END