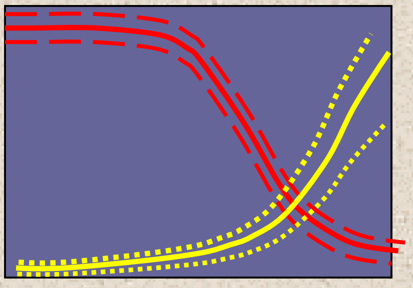
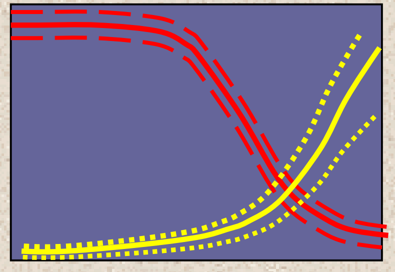


International Workshop on the Uncertainties in Nonlinear Soil Properties and their Impact on Modeling Dynamic Soil Response

Emerging Trends in Cyclic Triaxial Testing
(and addressing Sampling Disturbance)

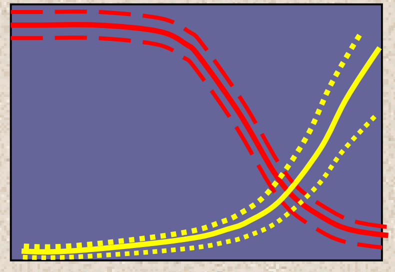
Michael Riemer

University of California, Berkeley



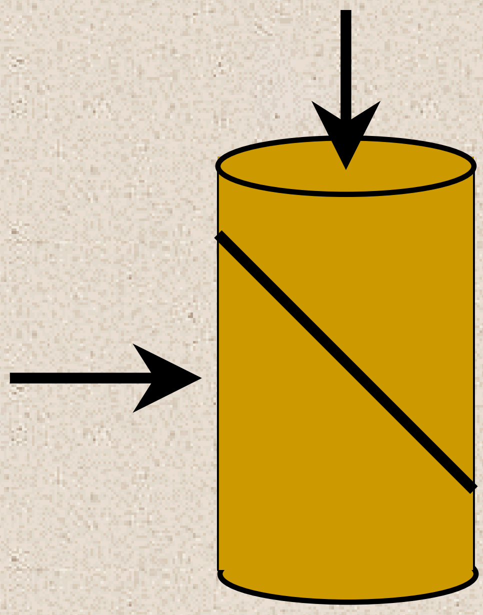
Background on Cyclic Triaxial (CTX)

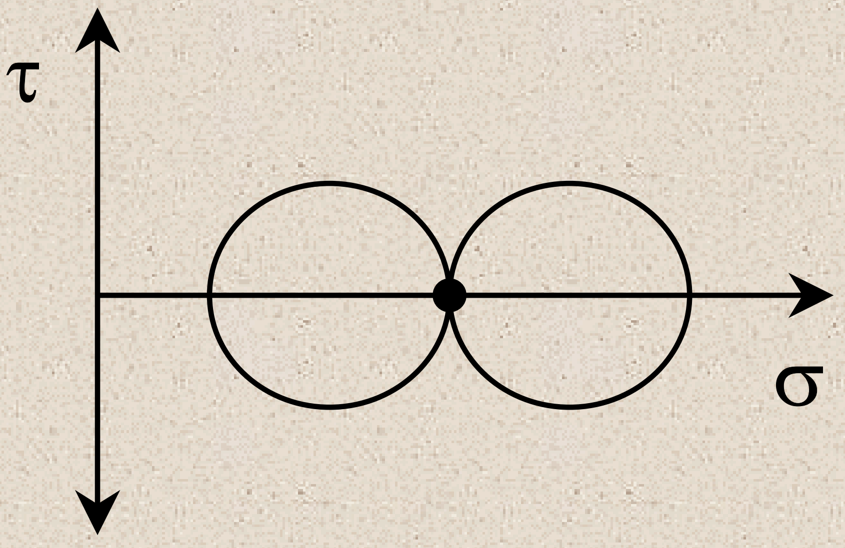
- Among the earliest methods for measuring cyclic stress-strain response of soils
- Originally limited to moderate and large strain ranges, due to limitations in sensors
- Widely used in liquefaction assessment
- Consistent improvement in measurement techniques: strain resolution of $\sim 10^{-3}$ % enables use in dynamic property evaluation

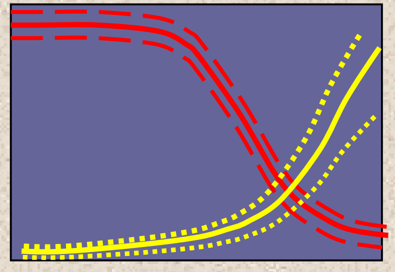


CTX Limitations for Dynamic Properties

- Reversal of Principal stresses
- Orientation of applied shear
- Direct measurement of E, not G

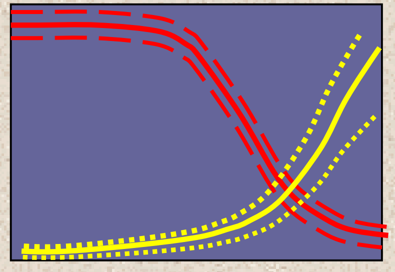






Advantages of CTX Methods

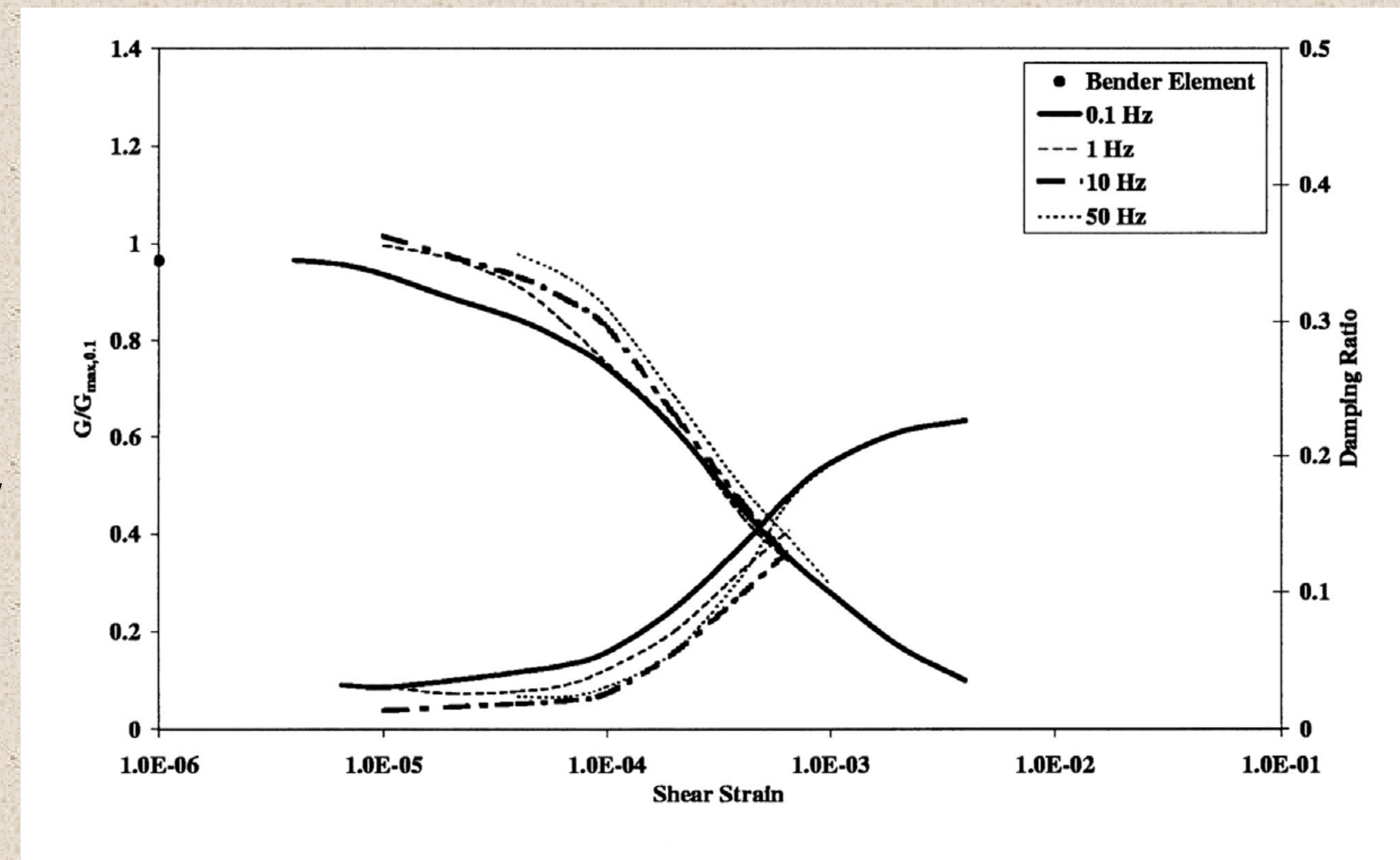
- Capable of wide range of strains, strain rates, pressures
- Independent control and measurement of consol stresses
- Suitability for large scale testing
- Capability for true saturation, pore pressure measurement
- *Relatively* simple in design, use, and adaptation

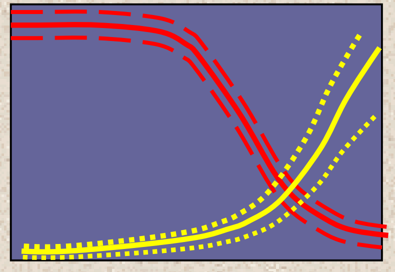


Advantages of CTX Methods

- Capable of wide range of strains, strain rates, pressures

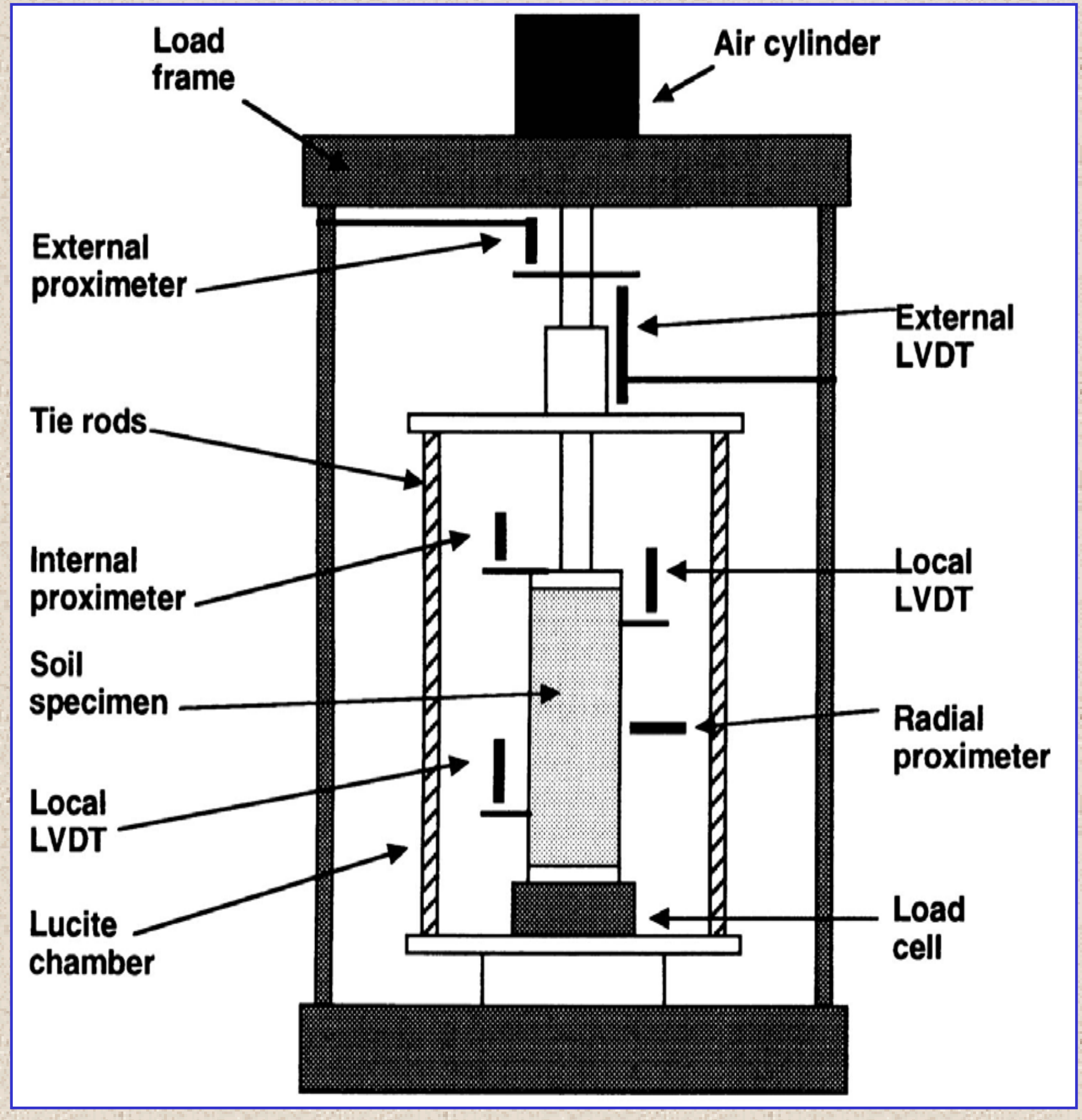
Gookin et al (1999)



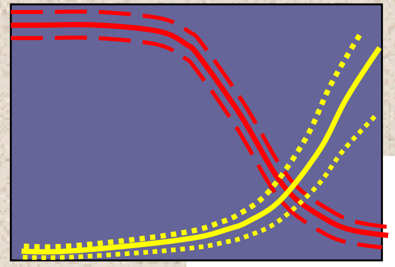


Locations of instrumentation

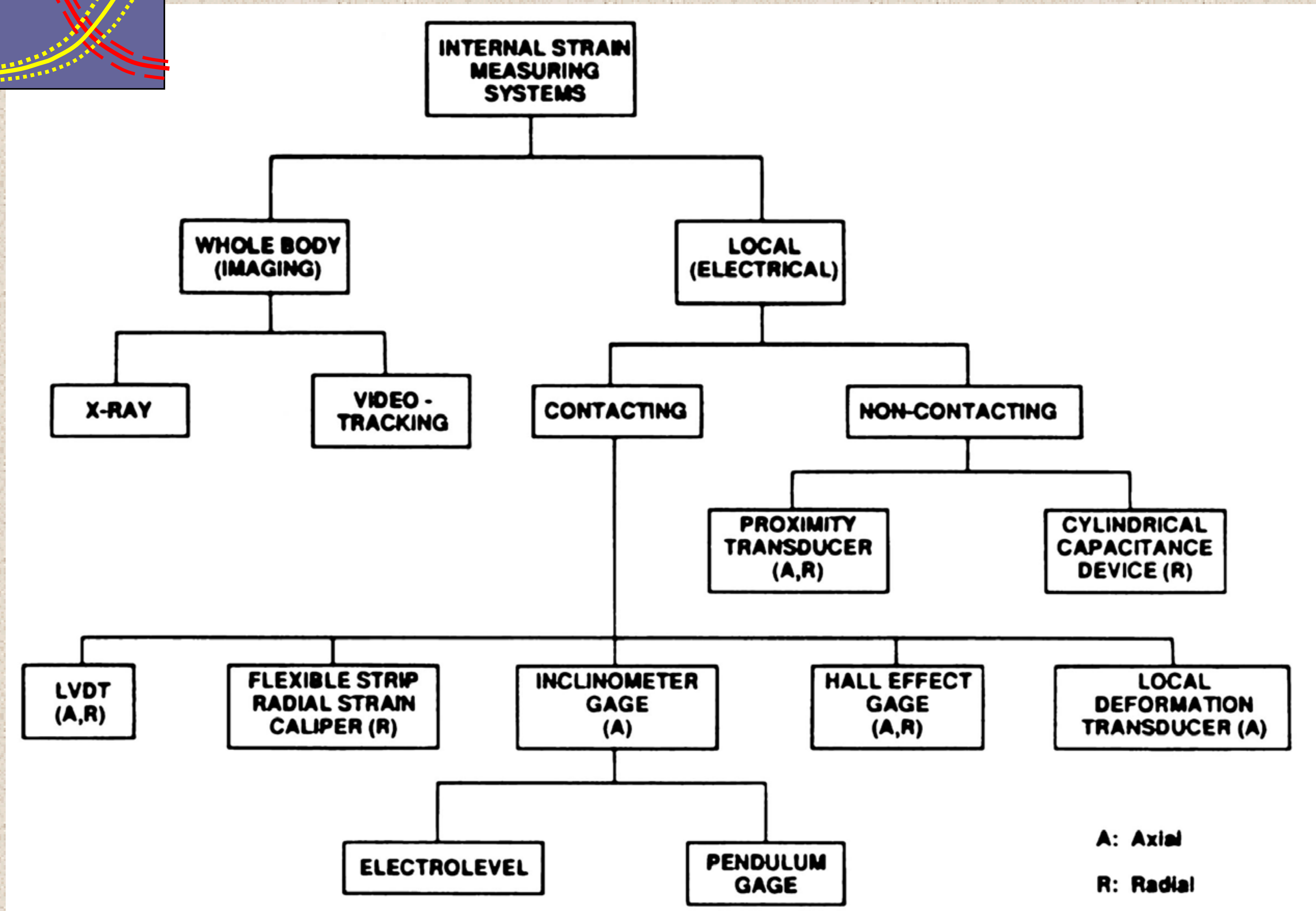
- External
- Internal
- Local



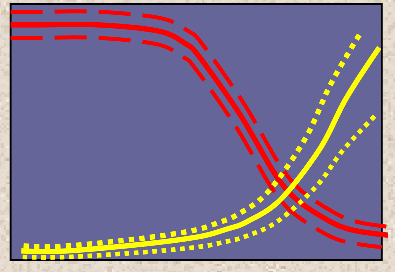
Scholey et al (1995)



Types of local instrumentation

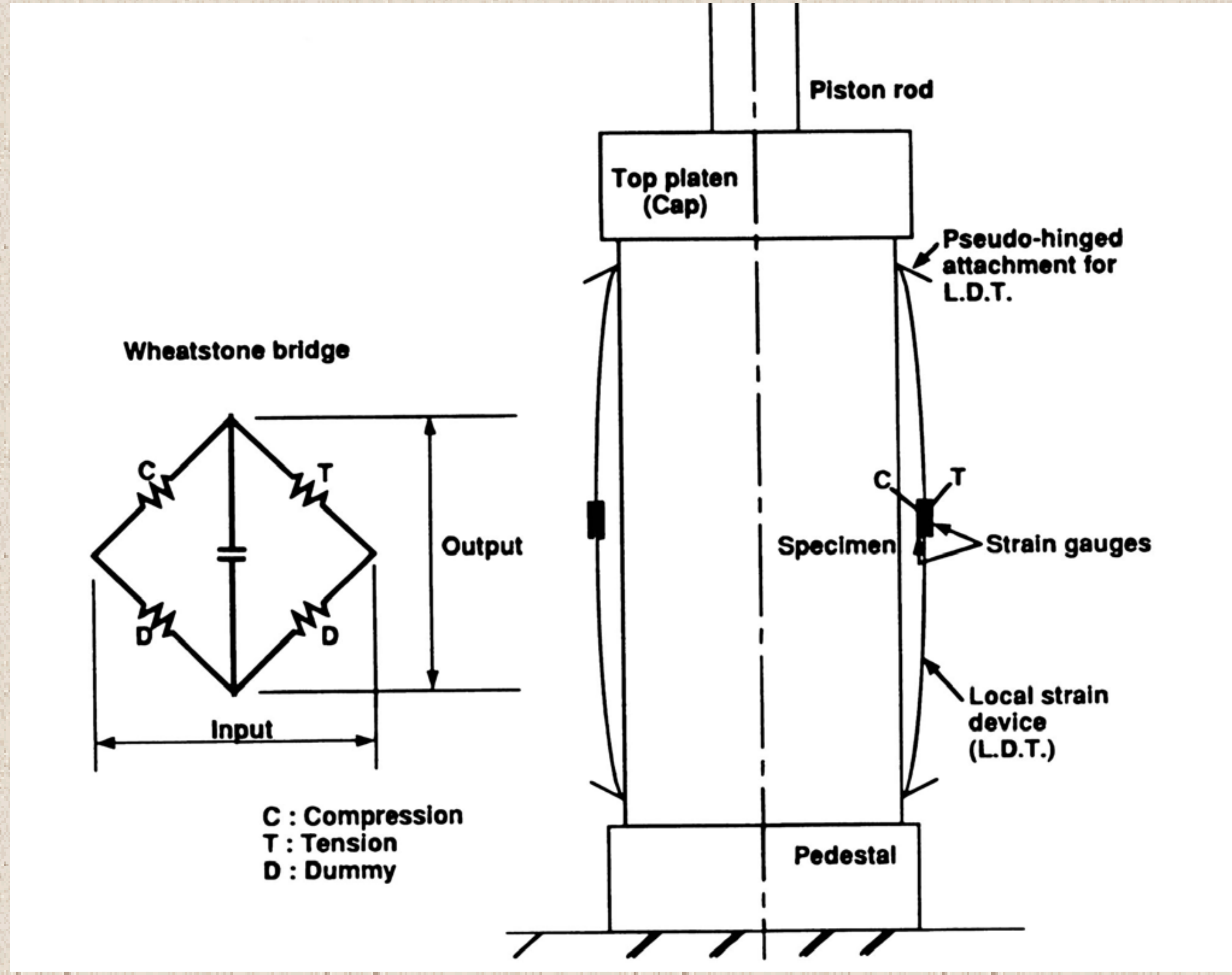


Scholey et al (1995)



Types of local instrumentation

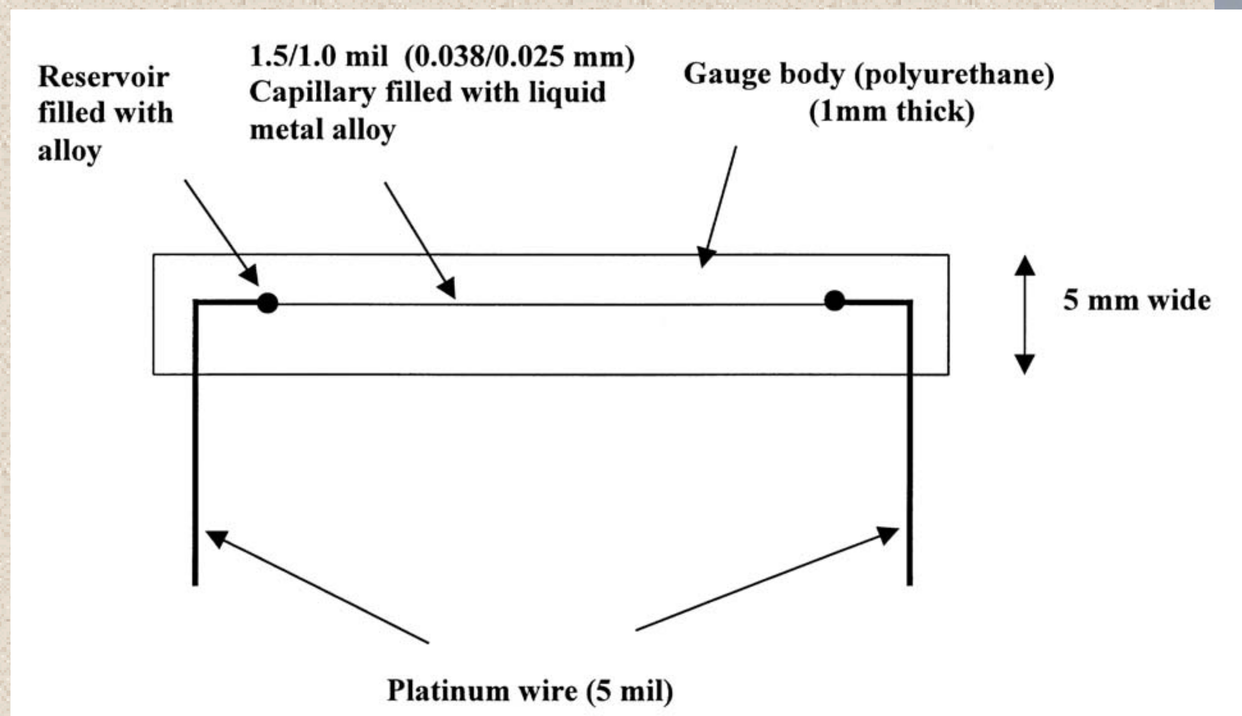
Local
Deformation
Transducer
("LDT")

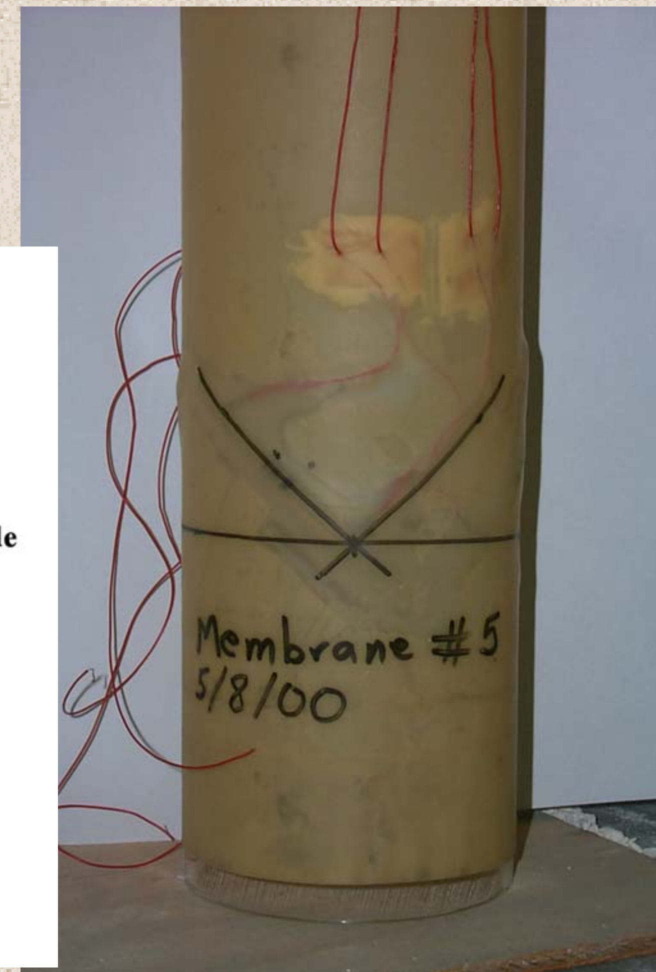


After Tatsuoka (1988)

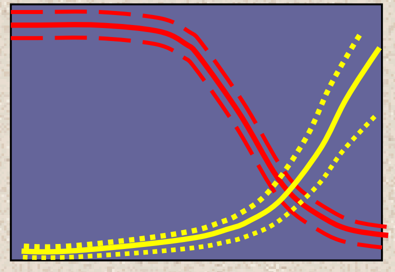
Types of local instrumentation

Elastomer Gauge



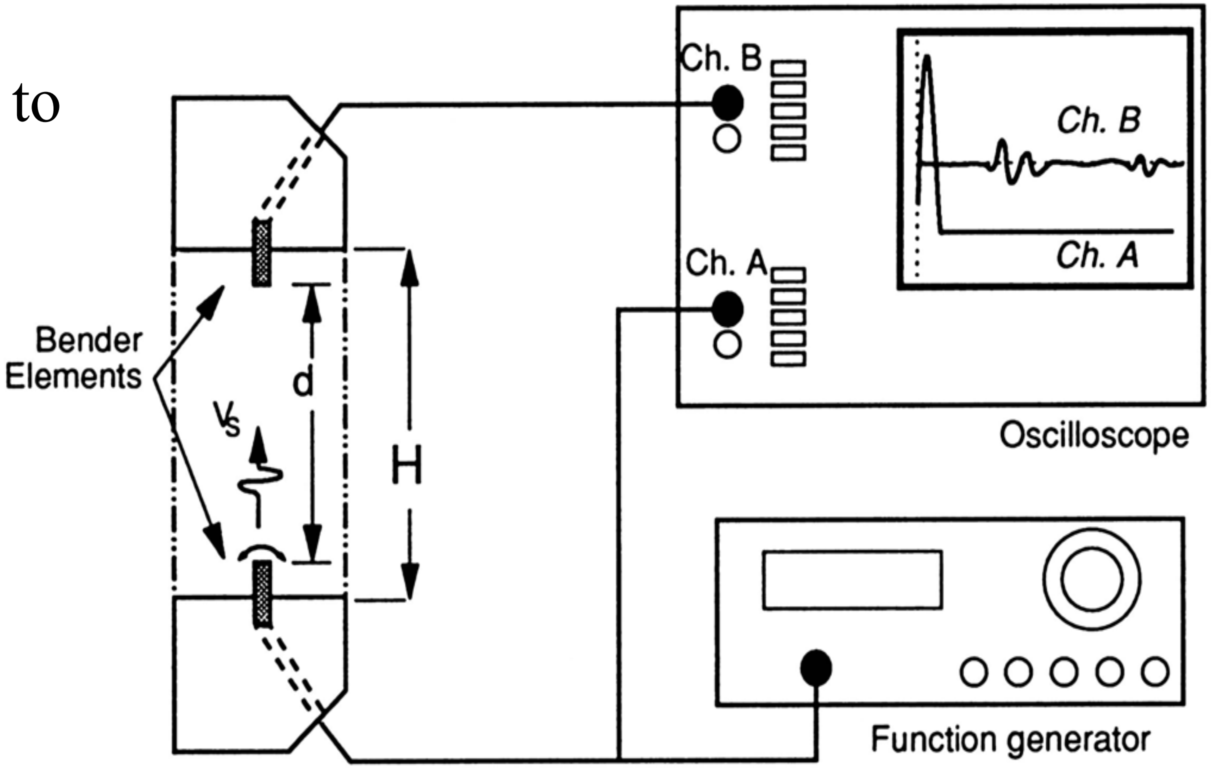


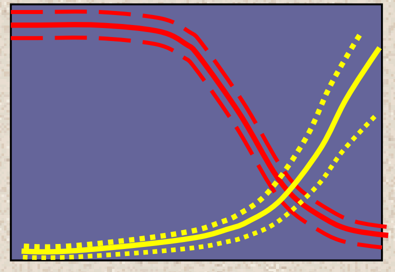
After Safaqah (2003)



Wave velocity transducers

- Small strains, for G_{max}
- Variable orientation
- Method comparable to field techniques

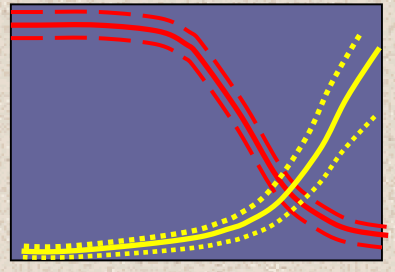




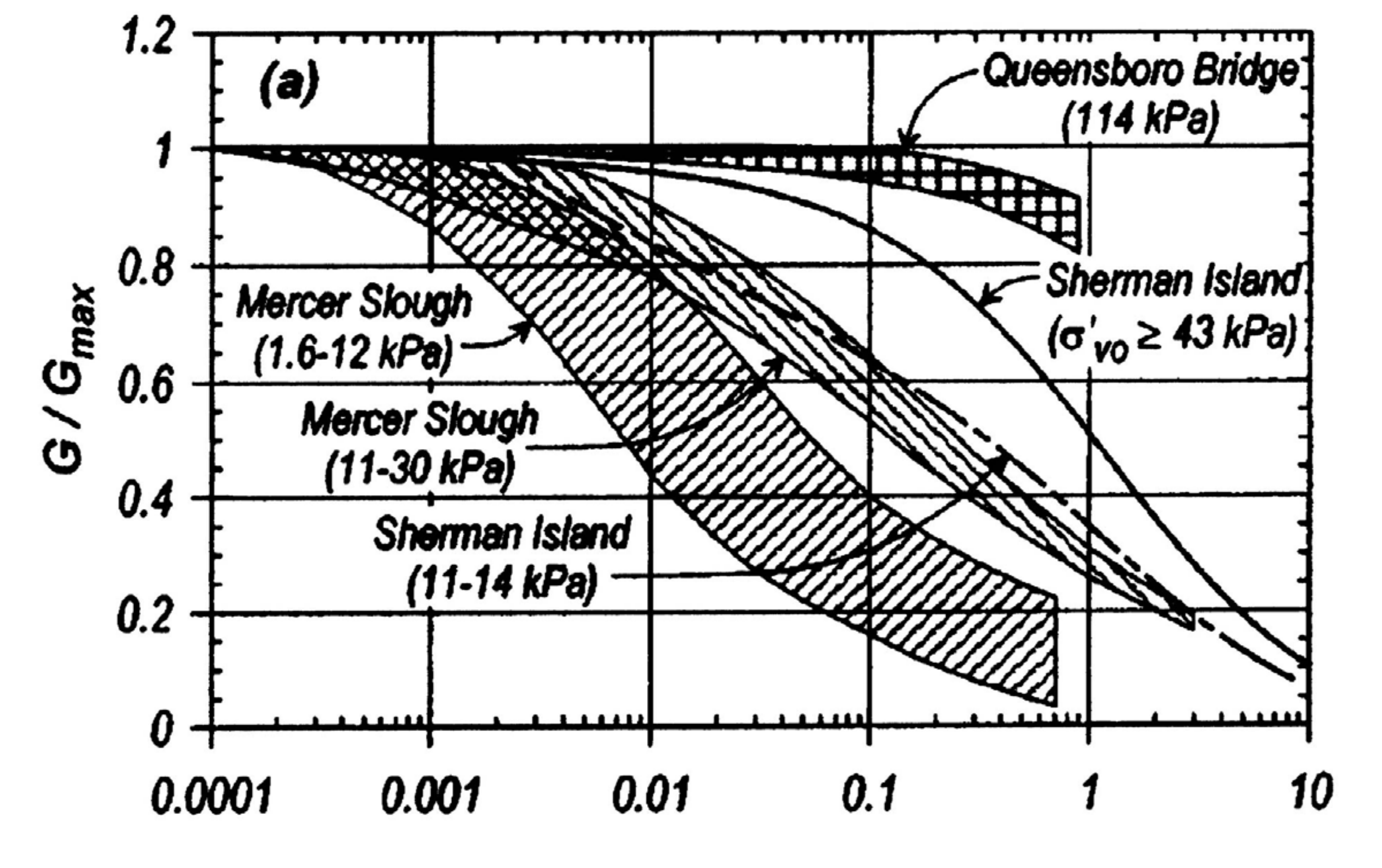
Testing of "special soils"

- ➢Peats (Stokoe, Boulanger, Kramer)
- ➢Calcareous sands (Sharma)
- ➢Clay treated with lime (Fahoum)
- ➢Silicate-grouted Sand (Vipulanandan)
- ➢Municipal Solid Waste (Zekkos)
- ➢GeoFoam (Athanasopoulos)

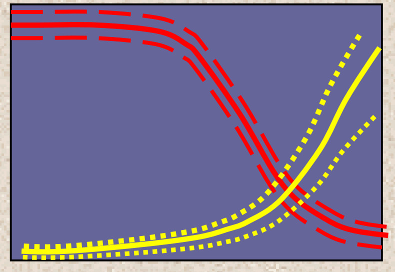
…. among others



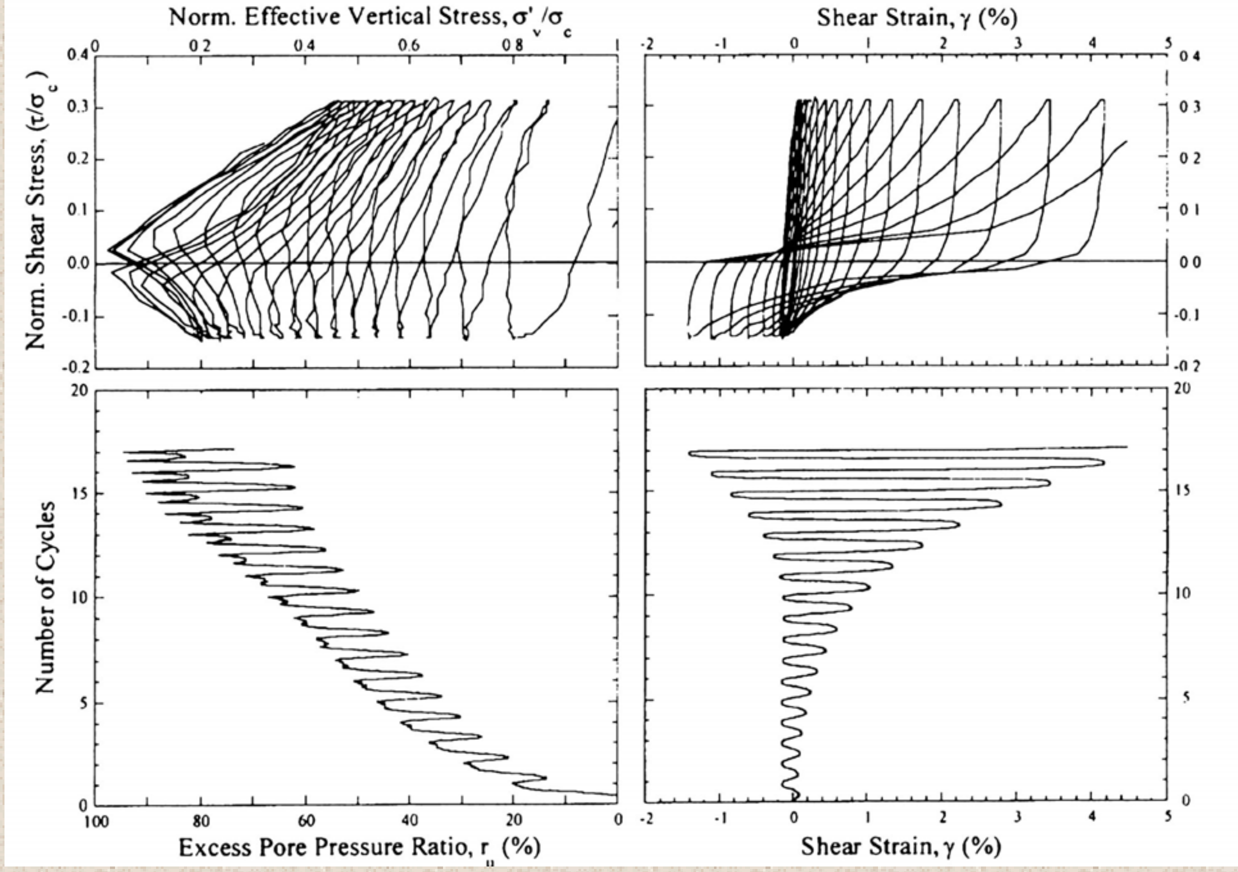
Testing of "special soils"



Wehling et al (2003)

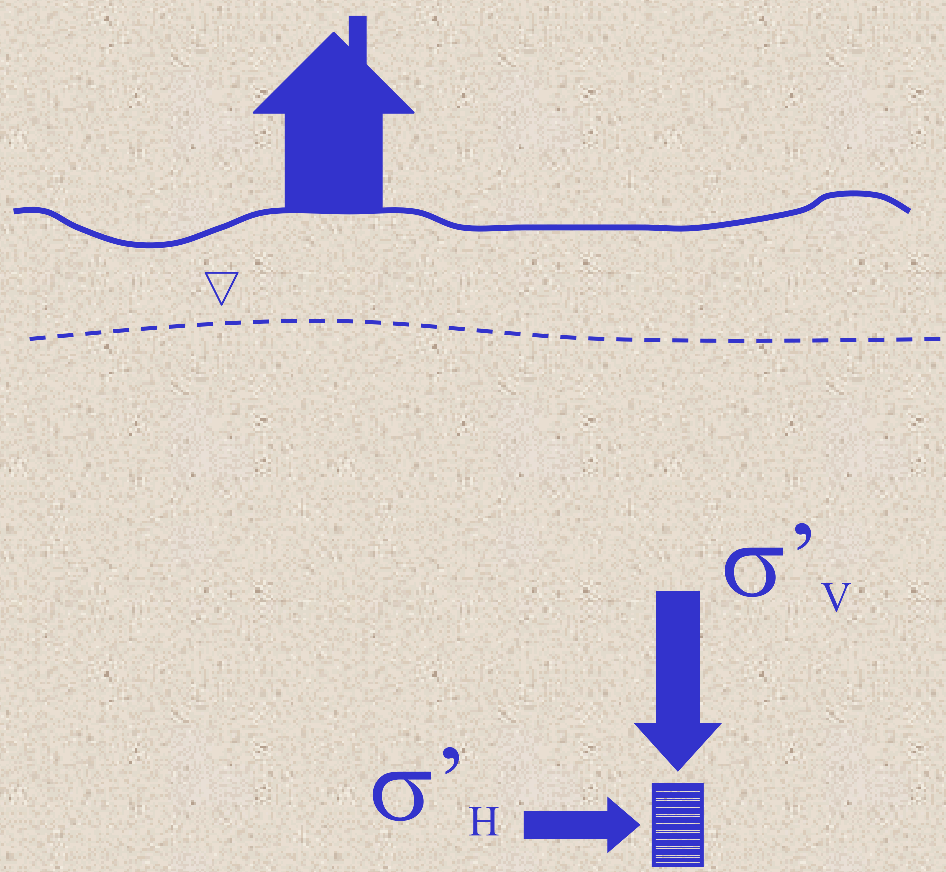


Cyclic Softening of Saturated Soils



Kammerer et al (2001)

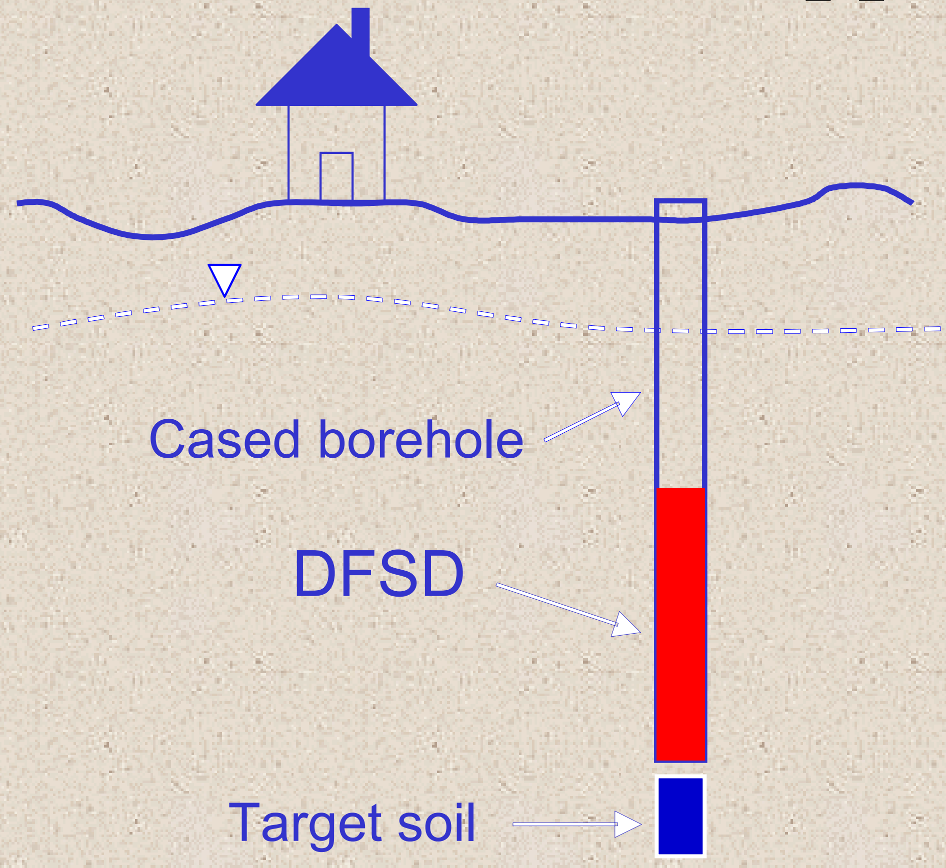
Sampling Disturbance



Unloading Disturbance

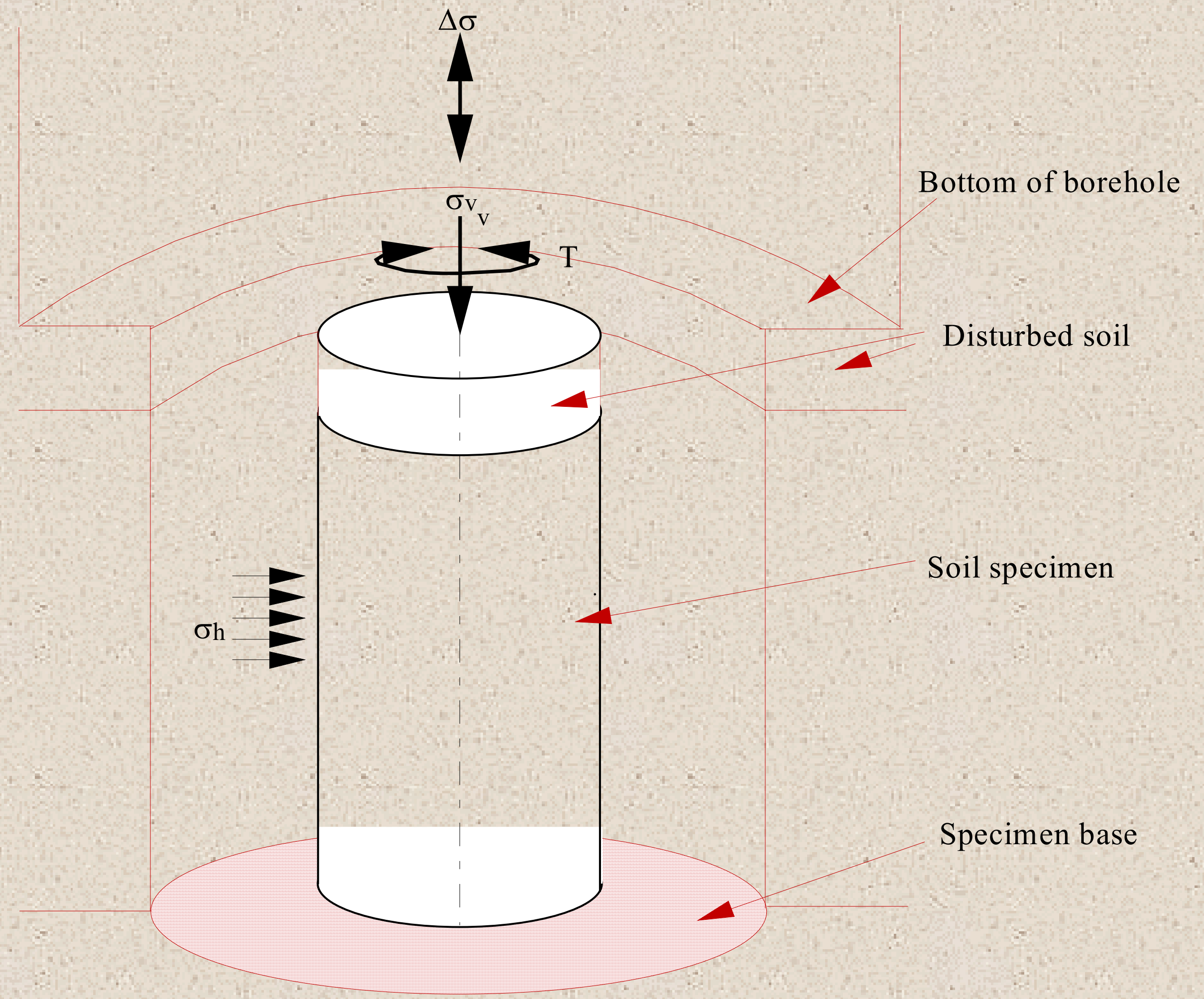
- In situ stresses at depth are likely to be large and anisotropic.
- Sampling and extrusion causes redistribution and unloading of stress, results in preshearing.

Downhole Freestanding Shear Device: Approach



- Perform a "laboratory quality" torsional shear test *in situ.*
- Never allow the stress state to vary significantly from original values

Downhole Testing Concept



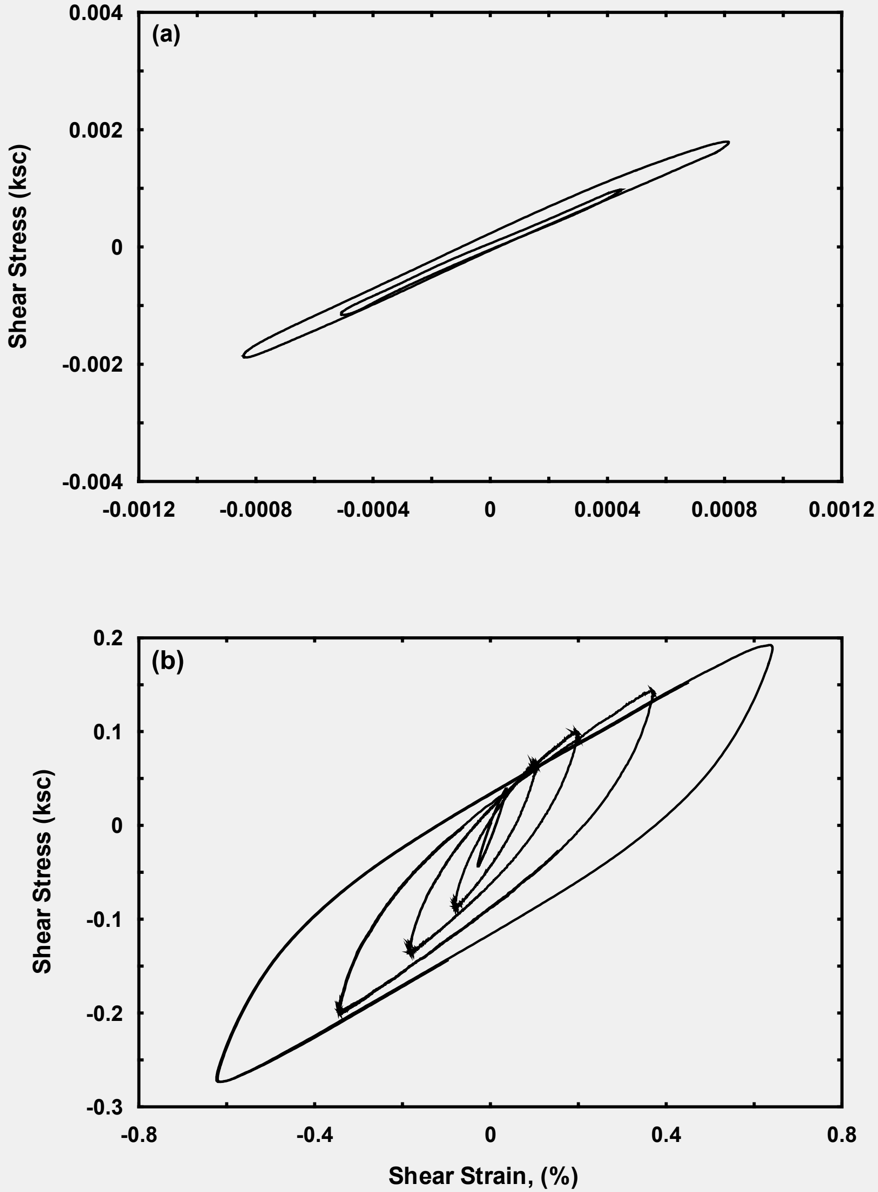
But can you really "carve" such a specimen ?

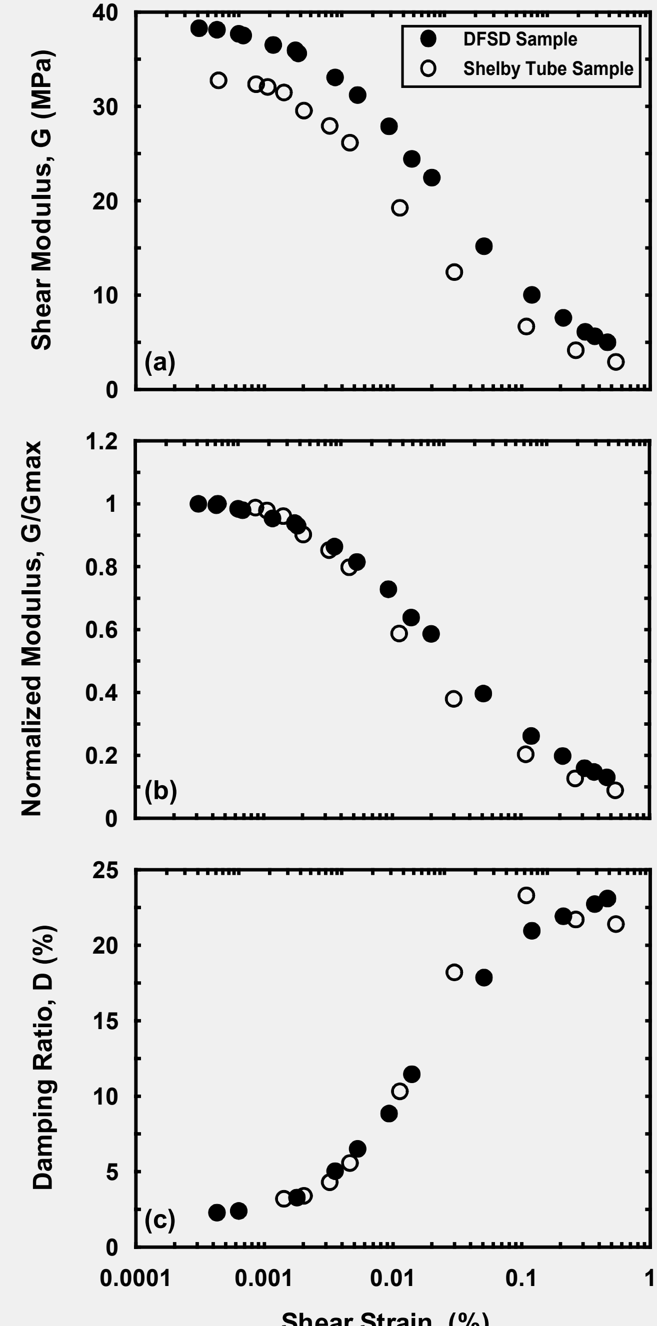
OBJECTIVES

1) In-Situ Measurement of the Dynamic Soil Properties of Cohesive Soils

2) Use the device to evaluate effects of disturbance due to conventional sampling and testing techniques

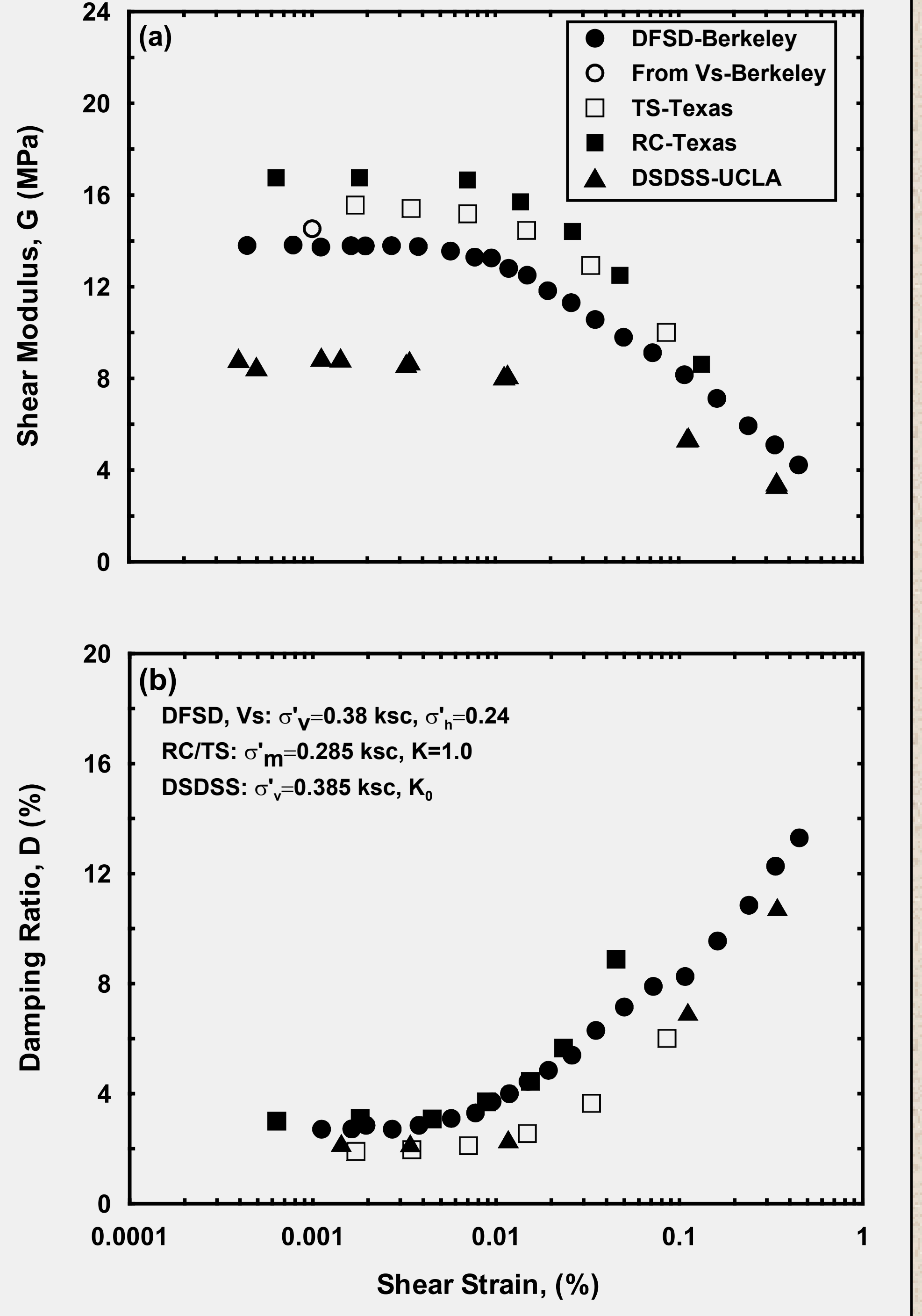
3) Compile a database of dynamic properties at approximately 20 sites in California using this method


(a)
(b)
Shear Stress (ksc)
Shear Strain, (%)
0.004
0.002
0
-0.002
-0.004
-0.0012
-0.0008
-0.0004
0.0004
0.0008
0.0012
0.2
0.1
-0.1
-0.2
-0.3
-0.8
-0.4
0.4
0.8

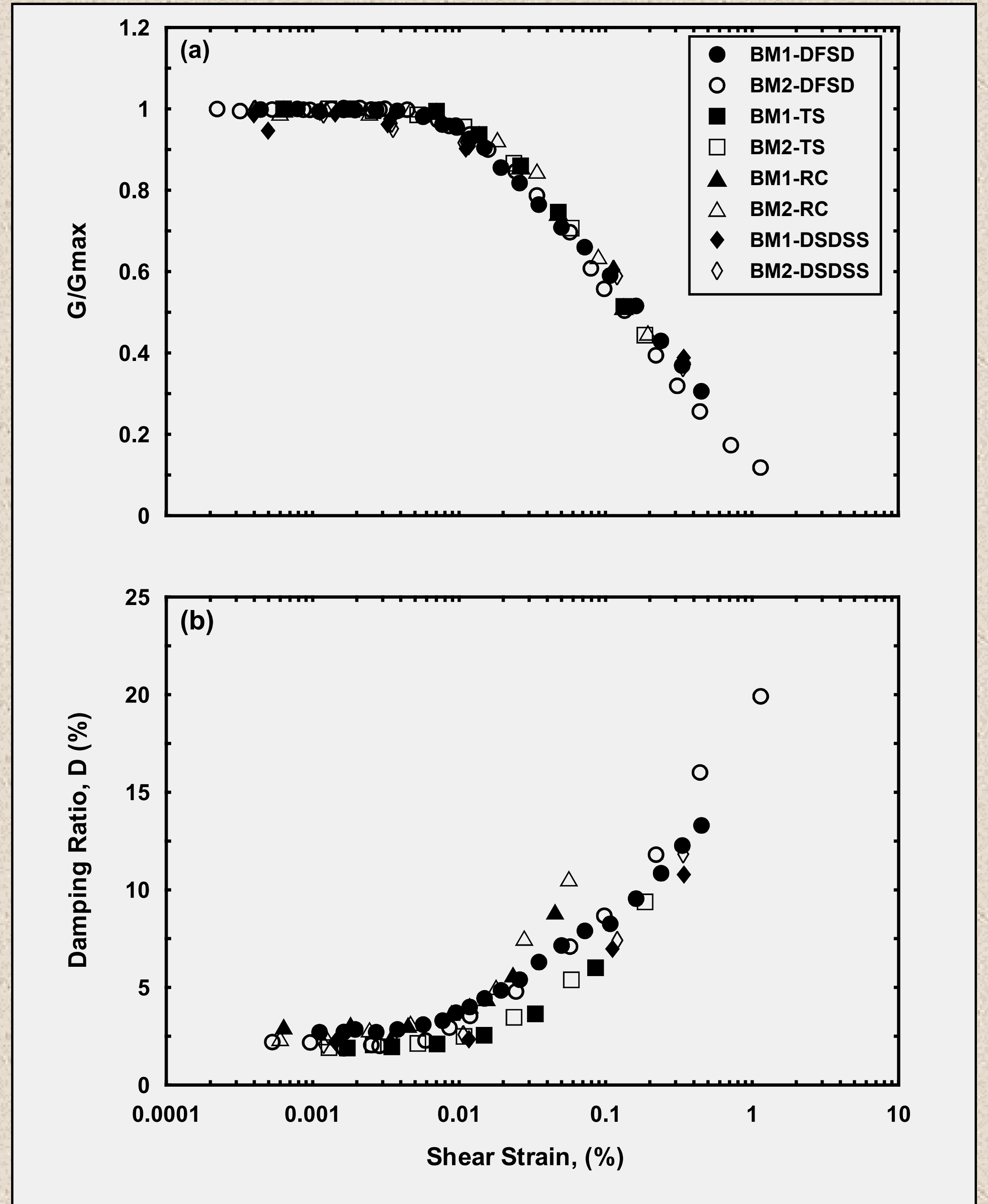

DFSD Sample
Shelby Tube Sample
Shear Modulus, G (MPa)
Normalized Modulus, G/Gmax
Damping Ratio, D (%)
Shear Strain, (%)
(a)
(b)
(c)
40
30
20
10
0
1.2
1
0.8
0.6
0.4
0.2
25
15
5
0.0001
0.001
0.01
0.1

DFSD Validation Tests on Bay Mud, BM1 Tests

Device	G_{max} (MPa)
DFSD	13.8
TS	15.5
RC	16.7
DSDSS	7.4
Vs	14.5



Normalized modulus for Bay Mud, tests at multiple stresses in different devices



Outlook

- The Downhole Freestanding Shear Device has been developed, fabricated, and validated in the laboratory
- Field validation is the next major step
- Once validated, it can be applied to examine the magnitude of disturbance effects as a function of depth, field values of damping, and provide greater confidence in correcting conventional lab data to field conditions