# Post-Cyclic Behavior of Sherman Island Peat


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# *Outline*

- Levees: critical components of Delta system
- Field sampling
- Laboratory test devices
- Test results
- Range of possible settlement: example
- Future work

# *Levees: critical components*

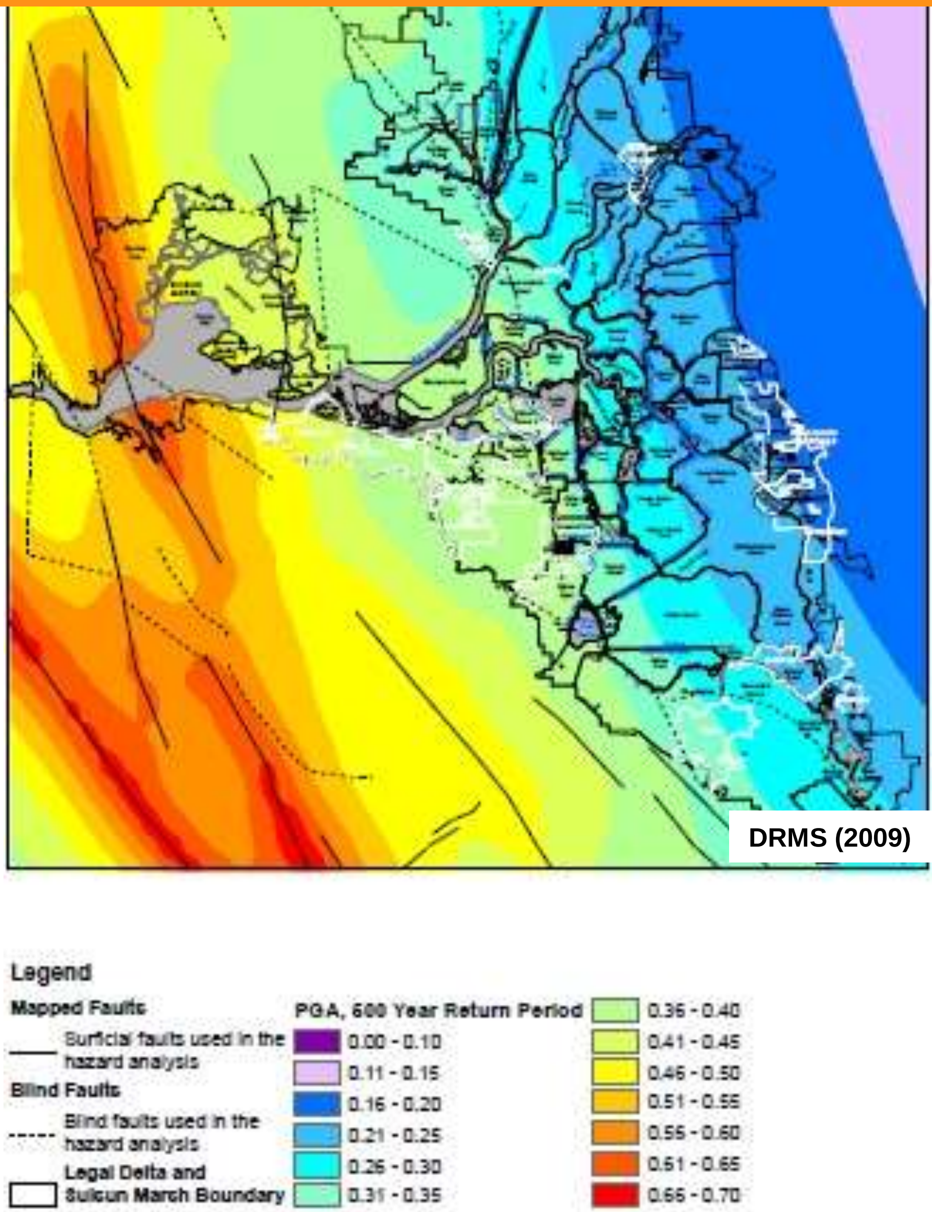
- **1115 miles of levees protect lowlands**
- **uncompacted to poorly compacted soils on peaty organic soils**
- **about 1.0-1.5 m of freeboard above the water level at high tide**

DRMS (2009)

# *Levees: critical components*

## *Seismic Hazard*

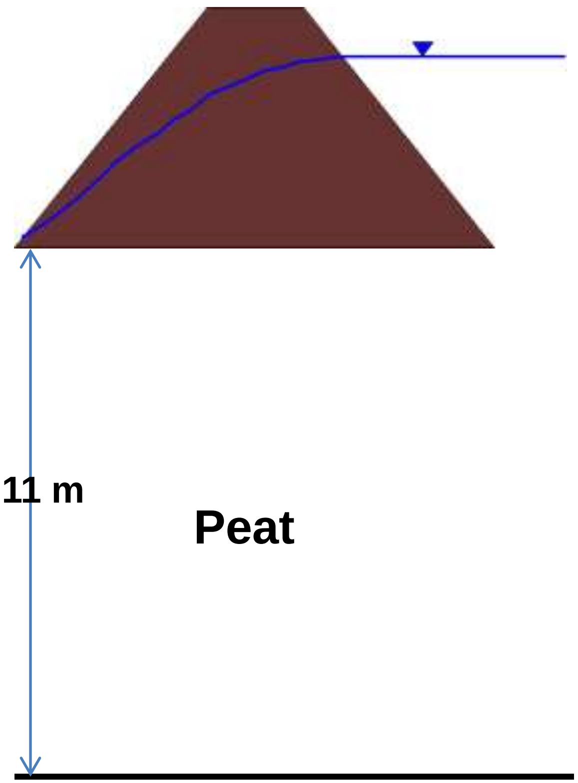
- **seismic hazard: potential for multiple simultaneous breaches inundating many islands**
- **Levees failure: up to 28 months of time fresh water deliveries from the Delta would not be possible**



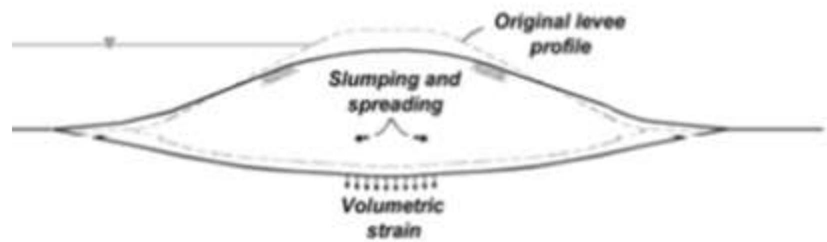


*Animation courtesy MWD and Curt Schmutte*

# *Levees: critical components*

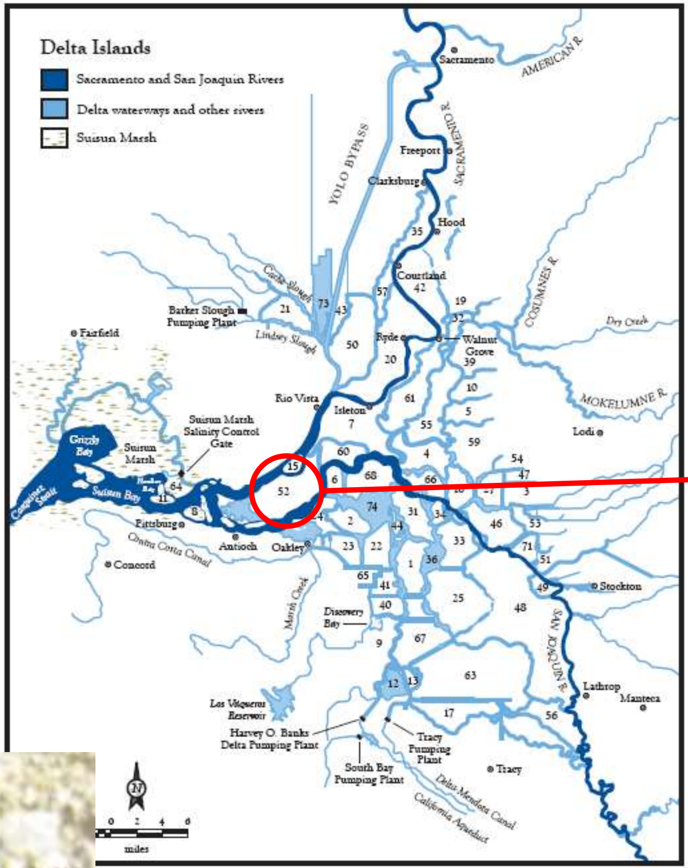



## Potential Failure Mechanism




**Peat**

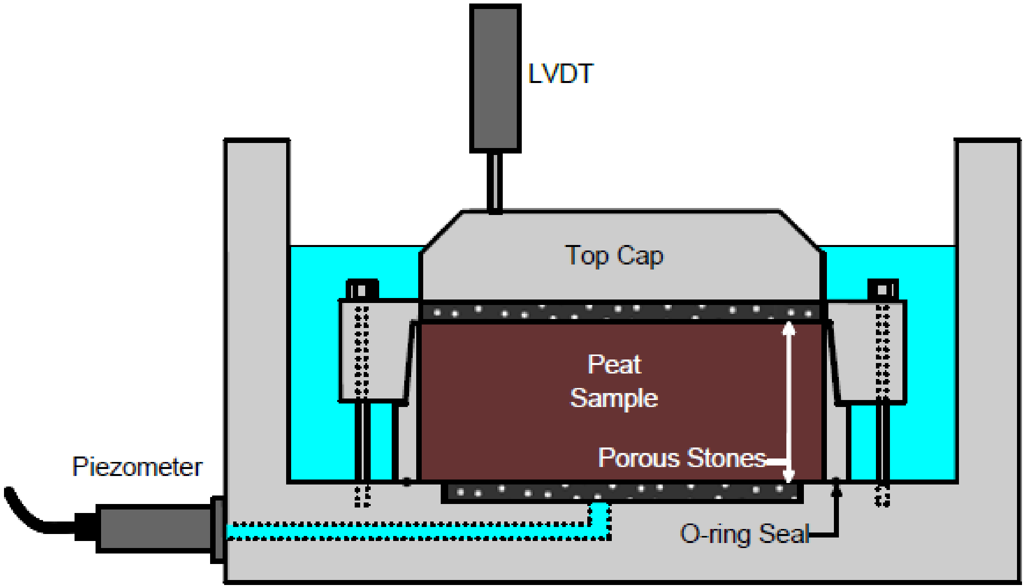
# *Field Sampling*

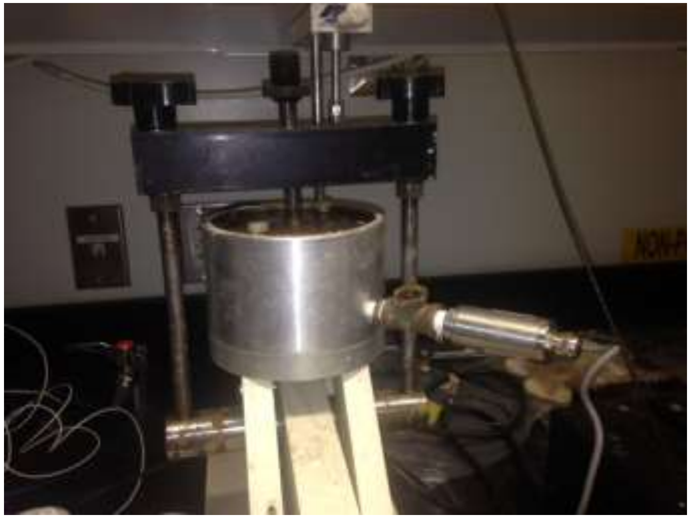


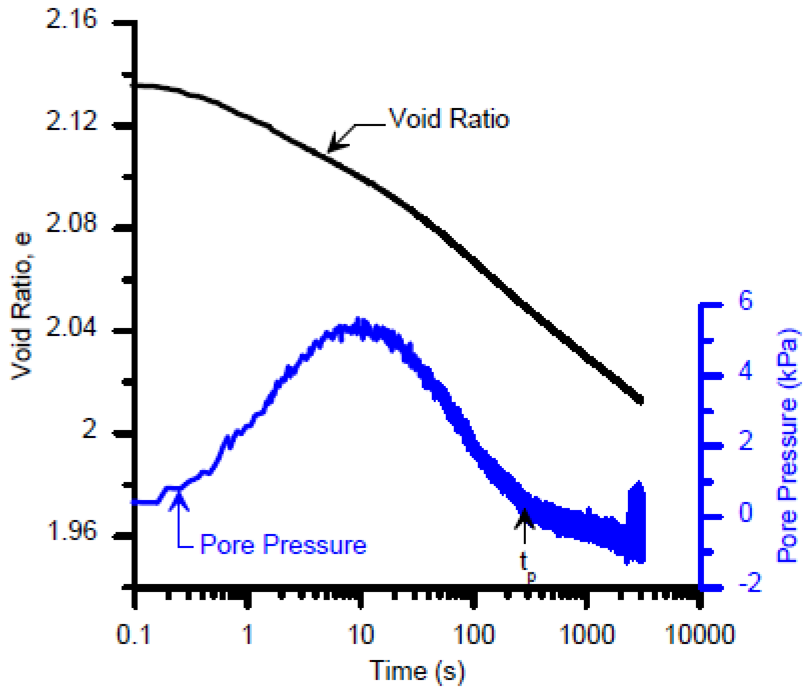

Sherman Island

# *Laboratory Test Devices*

## *Consolidation cell with pore pressure measurement*

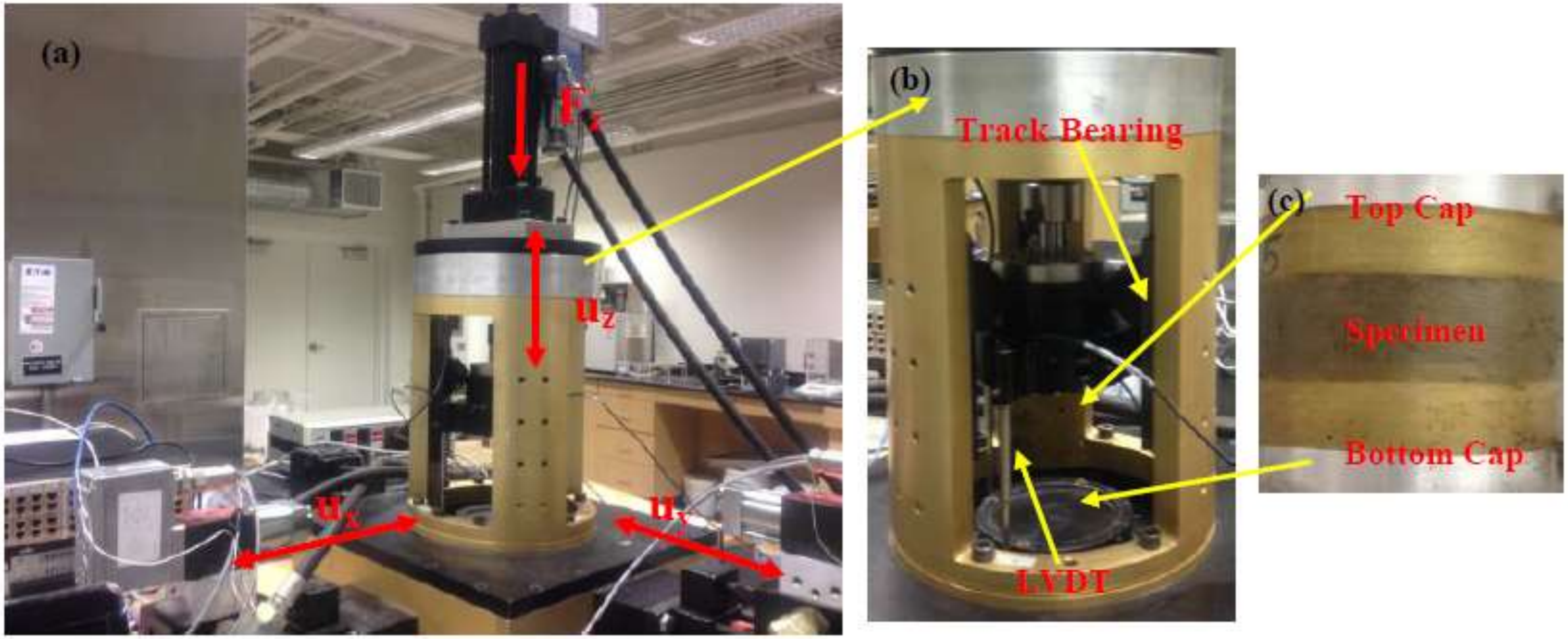




# Laboratory Test Devices

## *Digitally-controlled simple shear device*

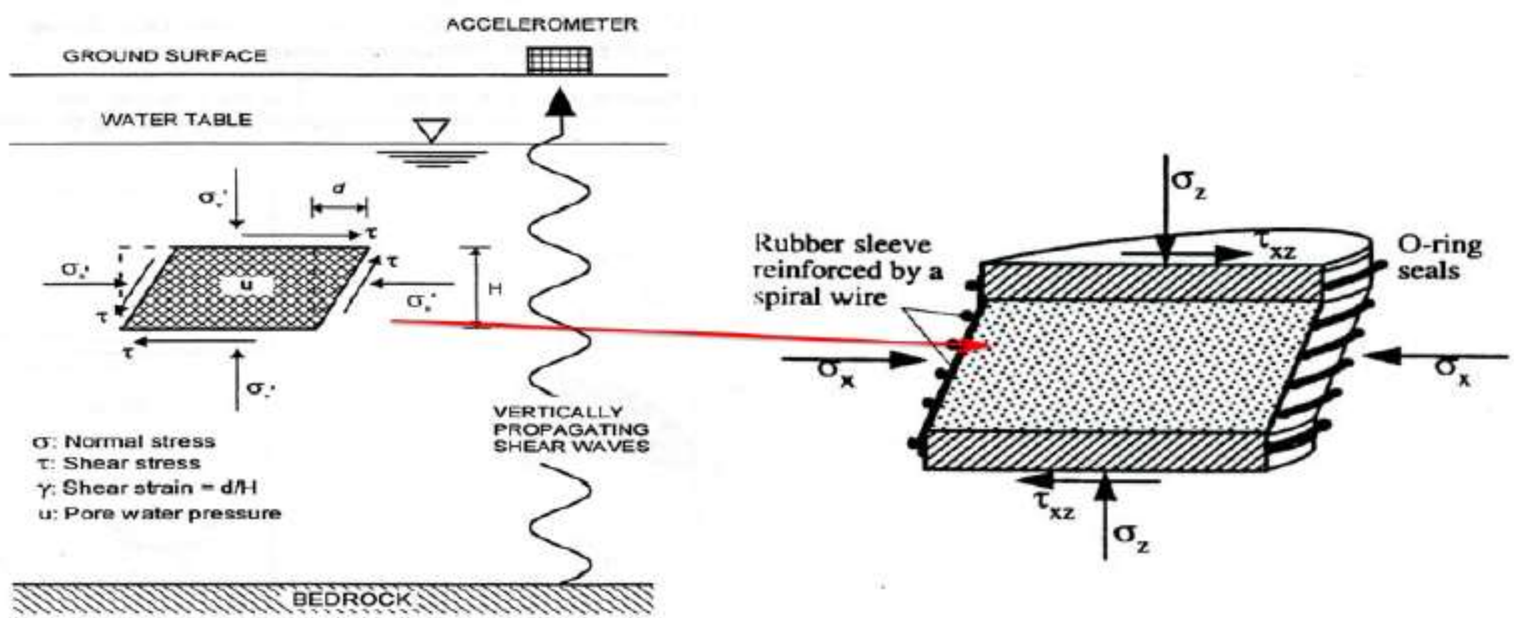



***Attributes:***

- Specimens: $K_0$-conditions due to wire-reinforced membranes. Diameter up to 10.2 cm
- Vertical direction: capabilities for stress/strain controlled consolidation, and constant load (drained) or constant height (undrained) control during shear
- Horizontal direction: cyclic or broadband demands; two horizontal directions; strain-controlled or stress-controlled testing
- Uses servo hydraulic actuators

# Laboratory Test Devices

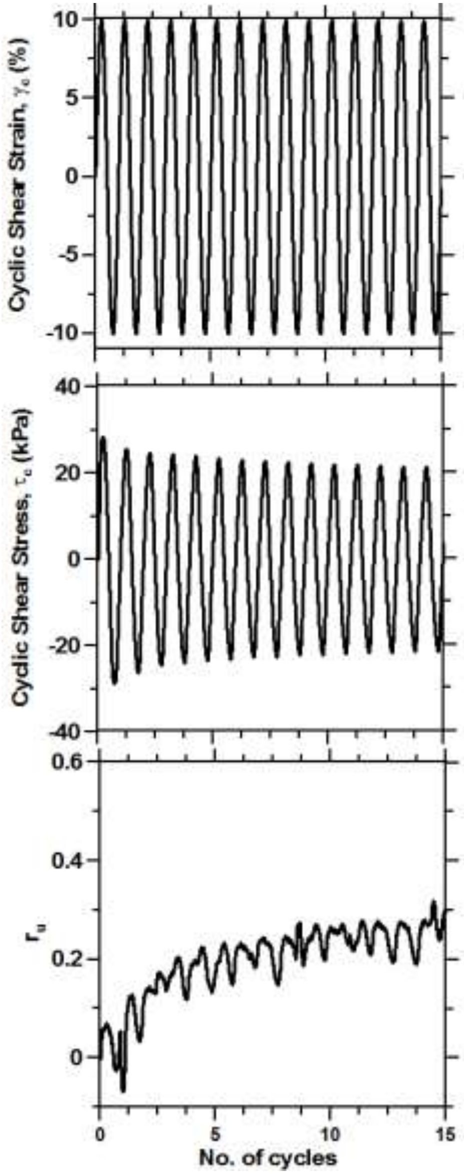
**Simple shear testing simulates vertical shear wave propagation**

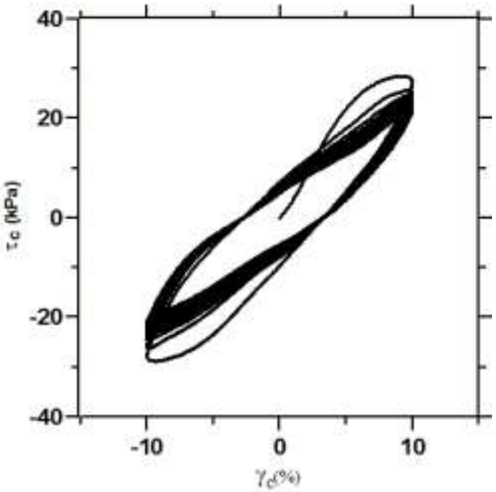



Chu-Chang (2002)

# Simple Shear Testing

Typical result of constant volume cyclic strain-controlled test



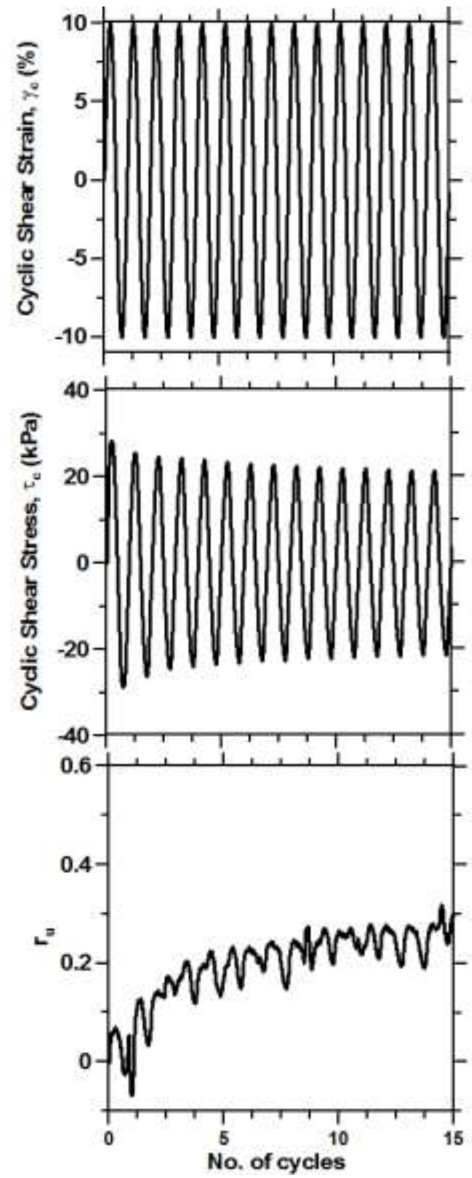



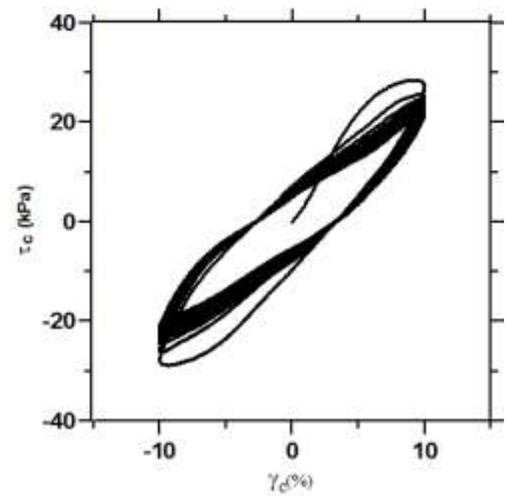

**OCR=1.33**
**OC=67%**
**$\sigma'_{v0}$=65 kPa**

# Simple Shear Testing

Typical result of constant volume cyclic strain-controlled test

Pore pressure is generated



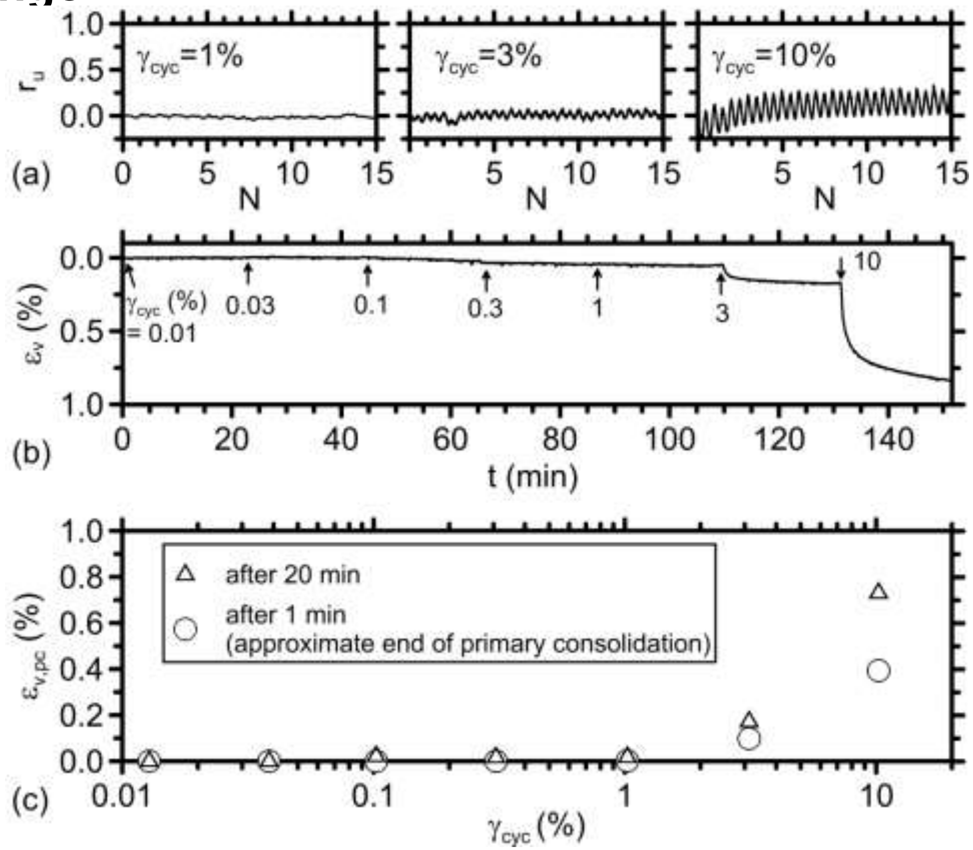

**OCR=1.33**
**OC=67%**
**$\sigma'_{v0}$=65 kPa**

$r_u = \Delta u/\sigma_{v0}'$

# *Influence of Cyclic Strain on Secondary Comp.*

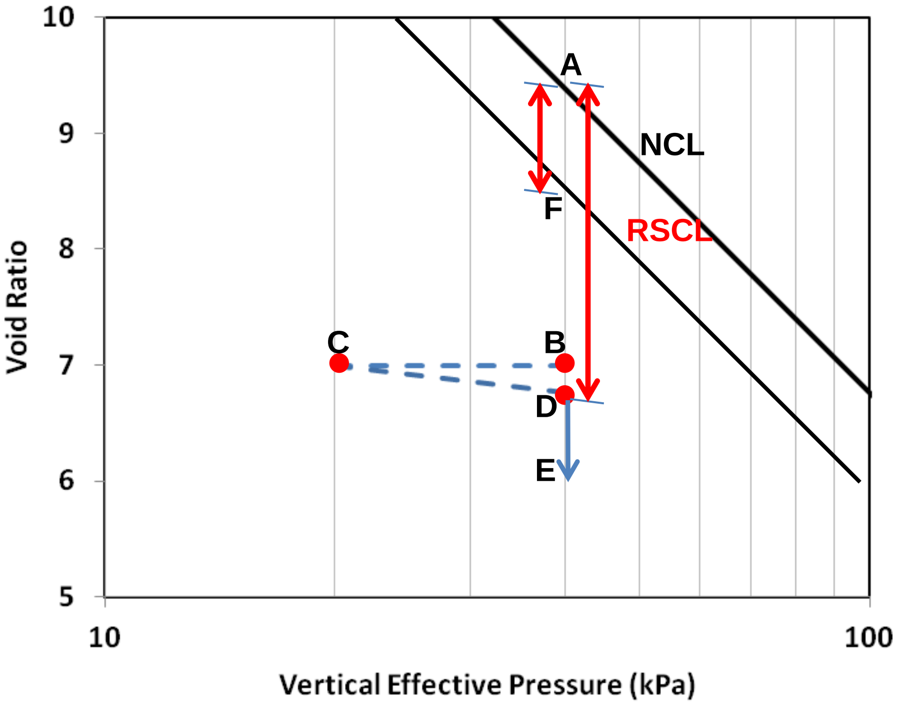
**Sherman Island Peat**
**$\sigma'_{v0}$=12 kPa**
**OCR=4.9**
**OC=55%**

- **Sequence of constant volume strain-controlled simple shear test at varying $\gamma_{cyc}$ followed by post-cyclic volume change**
- **$r_u$ increases with $\gamma_{cyc}$**
- **Rate of secondary compression increases with $\gamma_{cyc}$**
- **Post-cyclic volumetric strain ($\varepsilon_{v,pc}$) increases with $\gamma_{cyc}$**



# Reset Index

- **Kutter and Sathialingam (1992) postulated that (de/dt) is a function of distance from the NCL**
- **Increase in strain rate means the distance from NCL has been decreased**




**Reset Index=** $\frac{AF}{AD}$

**Reset Index=0, No Reset at all**

**Reset Index=1, Fully Reset**

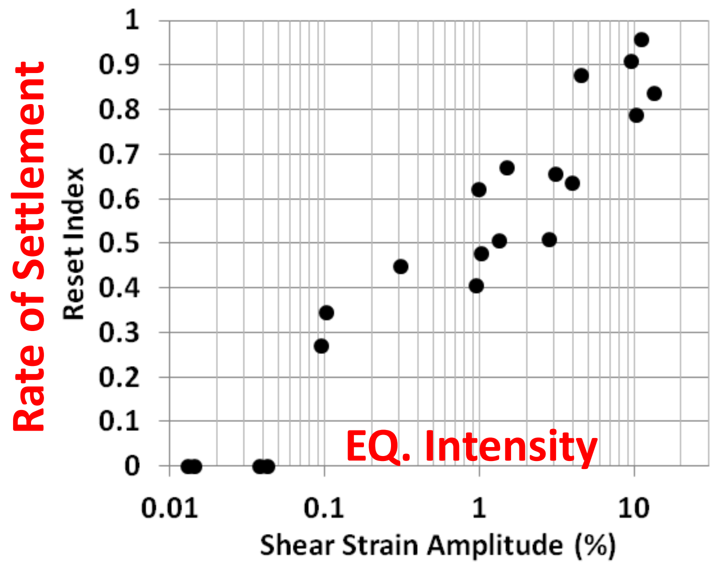
**RSCL: Reference Secondary Compression Line**

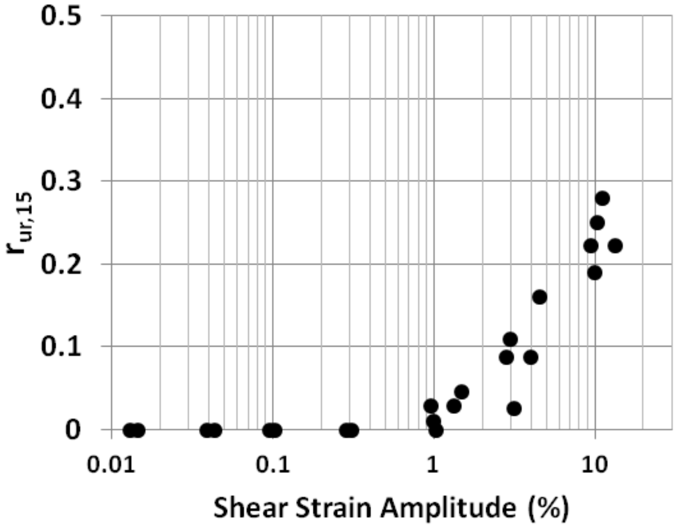
# Reset Index

- Reset index is mostly correlated with $\gamma_{cyc}$

- Secondary compression and $r_u$ both have a threshold shear strain below which no secondary compression and pore pressure happens

- Threshold shear strain for secondary compression is less than that of $r_u$




$$r_{ur} = \frac{\Delta u_r}{\sigma'_{vc}}$$

# *Range of Possible Settlement: An Example*

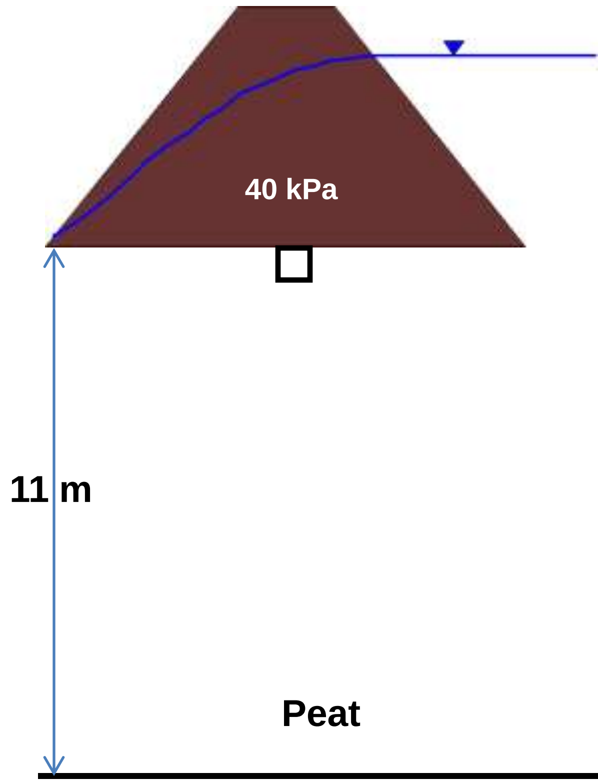
**Sherman Island Peat :**
**$C_c$=6.6**
**$C_r$=0.57**
**$C_\alpha$=0.3**
**Layer Thickness=11.0 m**

**Levees were built 150 years ago**

**Objective:**
**Estimation of settlement following earthquake:**

1) **$r_u$=0 , no earthquake, no reset (No. EQ)**
2) **$r_u$=0.3, no reset**
3) **$r_u$=0.3, fully reset (R.I.=1.00) (Strong EQ)**
4) **$r_u$=0.2, partially reset (R.I.=0.80)**
5) **$r_u$=0.1, partially reset (R.I.=0.55) (Small to Medium EQ)**
6) **$r_u$=0.0, partially reset (R.I.=0.30)**

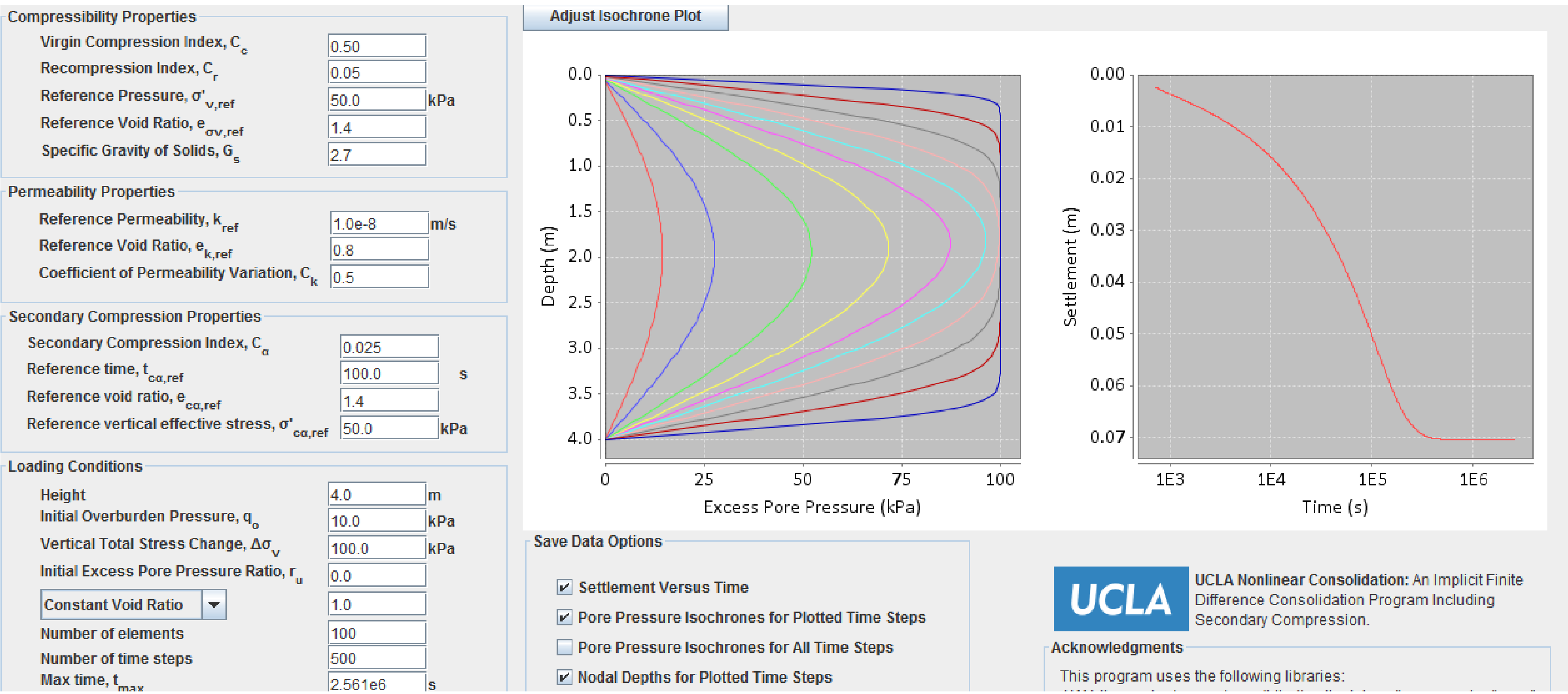
**R.I.: Reset Index**



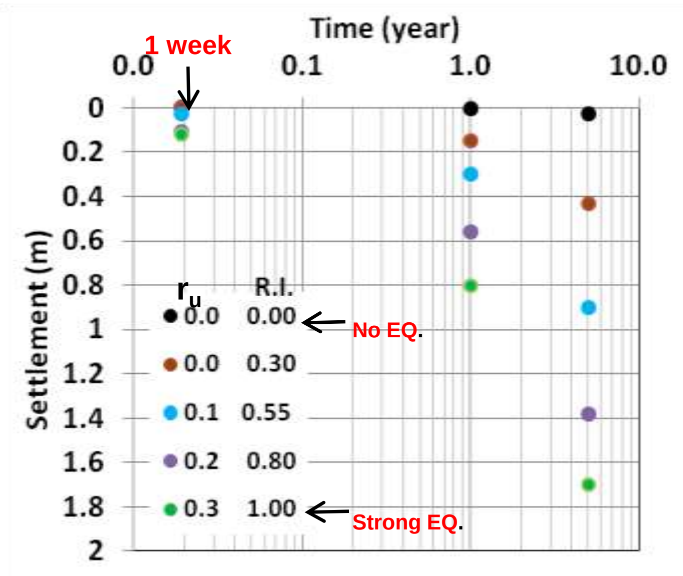
# Range of Possible Settlement: An Example

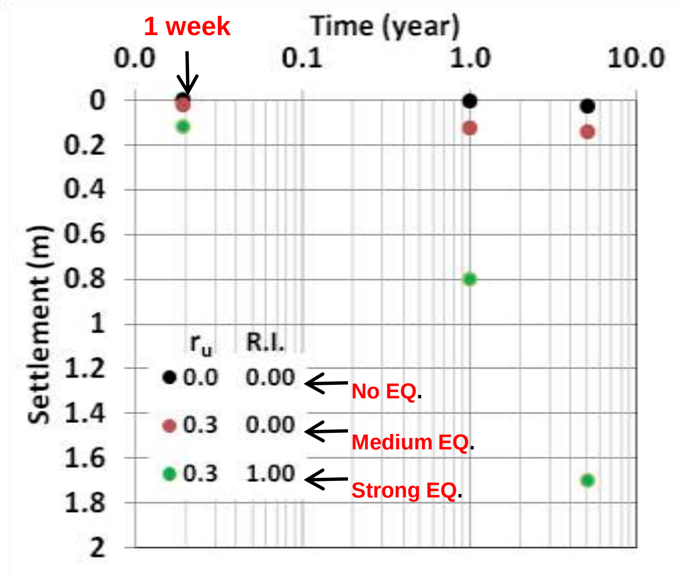
## Non-linear consolidation computer program

### (considers volumetric strains from secondary compression during consolidation)



# Range of Possible Settlement: An Example




R.I.=Reset Index

# *Future Work*

- **Developing a webpage for the project that includes all the raw and processed data**
- **Continuation of 1-D consolidation, monotonic tests, cyclic strain-controlled tests, cyclic stress-controlled at different organic contents and OCRs.**
- **Broadband dynamic consolidated-undrained tests**

# *Acknowledgement*

**Support for this research has been provided by**

**DWR**

**and**

**USGS**

***Thank You for Your Attention***