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
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

DRMS (2009)
Animation courtesy MWD and Curt Schmutte
Levees: critical components

Potential Failure Mechanism

11 m

Peat

Peat
Field Sampling

Sherman Island

Delta Islands
- Sacramento and San Joaquin Rivers
- Delta waterways and other streams
- San Francisco Marsh

Map showing the location of Sherman Island in the Delta Islands.
Laboratory Test Devices

Consolidation cell with pore pressure measurement
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
Simple shear testing simulates vertical shear wave propagation

Chu-Chang (2002)
Typical result of constant volume cyclic strain-controlled test

OCR=1.33
OC=67%
$\sigma'_v0=65$ kPa
Typical result of constant volume cyclic strain-controlled test

Pore pressure is generated

\[ \text{OCR} = 1.33 \]
\[ \text{OC} = 67\% \]
\[ \sigma'_{v_0} = 65 \text{ kPa} \]

\[ r_u = \Delta u / \sigma'_{v_0} \]
Influence of Cyclic Strain on Secondary Comp.

- 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 $\gamma_{cyc}$

Sherman Island Peat
- $\sigma'_0=12$ kPa
- OCR=4.9
- OC=55%
• Kutter and Sathialingam (1992) postulated that \((\frac{de}{dt})\) 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 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 $r_u$

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

EQ. Intensity

Shear Strain Amplitude (%) vs Reset Index

Rate of Settlement

Reset Index vs EQ. Intensity

Shear Strain Amplitude (%) vs $r_{ur,15}$
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
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Thank You for Your Attention