Title
Reset of Secondary Compression Clock for Peat by Cyclic Straining

Journal
Journal of Geotechnical and Geoenvironmental Engineering, 141(3)

ISSN
1090-0241

Authors
Shafiee, Ali
Stewart, Jonathan P
Brandenberg, Scott J

Publication Date
2015-03-01

DOI
10.1061/(asce)gt.1943-5606.0001286

Peer reviewed

http://ascelibrary.org/doi/abs/10.1061/%28ASCE%29GT.1943-5606.0001286

Reset of Secondary Compression Clock for Peat by Cyclic Straining

Ali Shafiee, S.M.ASCE[1]; Jonathan P. Stewart, F.ASCE[2]; and Scott J. Brandenberg, M.ASCE[3]

Peat soils are widely recognized as being highly compressible. The virgin compression index, C_c, is often 5 to 20 times larger than for soft clay, and the secondary compression index, C_{α}, is in the range of (0.05 to 0.07)C_c, which is also higher than for typical clays (Mesri and Ajlouni, 2007). Secondary compression is often the dominant source of volume change in peat over time. The compressibility of peat has typically been investigated due to total stress increase imposed by static loads. This manuscript discusses time-dependent volumetric strains due to cyclic shear straining.

A multi-stage cyclic simple shear laboratory testing program using the UCLA digitally controlled direct simple shear device (Duku et al. 2007), modified for constant height testing,

[1] PhD Candidate, Department of Civil and Environmental Engineering, University of California, Los Angeles, CA 90095.

[2] Professor and Chair, Department of Civil and Environmental Engineering, University of California, Los Angeles, CA 90095.

[3] Associate Professor and Vice Chair, Department of Civil and Environmental Engineering, University of California, Los Angeles, CA 90095.

was used to investigate post-cyclic volume change of relatively undisturbed specimens of fibrous peat from Sherman Island in the Sacramento / San Joaquin Delta. During each stage, 15 strain-controlled cycles (1 Hz) were imposed on peat specimens while maintaining constant height by varying the vertical stress, after which specimens were reconsolidated to the initial vertical stress (σ_{vc}'). Post-cyclic reconsolidation was monitored for approximately 20 min. following each loading stage. Oedometer tests indicate primary consolidation was complete after 1 min, leaving the remaining time to record the rate of secondary compression.

Test results for a peat specimen with 55% organic content, σ_{vc}' = 12 kPa, OCR = 4.9, C_c =2.21, and C_r =0.14 are shown in Fig. 1. Part (a) shows that excess pore pressure ratios (r_u) are non-zero when γ_{cyc}>3%, with a residual r_u = 0.2 for γ_{cyc}=10%. As shown in part (b), although these r_u values are modest, post-cyclic volumetric strains are significant when γ_{cyc}>1% because of the peat's high compressibility. Part (c) shows that the secondary compression rate, which is related to the difference between ε_v at 1 and 20 min, increases with γ_{cyc}. This suggests that cyclic straining can increase the secondary compression rate, which has not been previously recognized. Similar increases in secondary compression rate are routinely observed when total stress is increased in laboratory oedometer tests, which can be viewed as re-setting the "clock" to zero at the time the load is applied. The data in Fig. 1 indicates that cyclic straining can at least partially reset the secondary compression clock, without total stress increase.

Implications

Seismic risk is a significant issue for the Sacramento / San Joaquin Delta because levees are composed of saturated, often liquefiable soils that rest atop soft compressible peats and organic soils. If seismic ground failure were to occur in or beneath a levee, the interior islands could flood. If repeated over a sufficient number of islands, this process would likely draw saline water into the Delta from the San Francisco Bay, compromising fresh water delivery via several of California’s major aqueduct systems.

Liquefaction of saturated loose cohesionless levee fill and foundation soil is recognized as a significant driver of ground failure risk in the Delta. This work identifies a new mechanism by which levees that do not fail during shaking may experience increased settlement rates due to secondary compression following an earthquake, possibly causing overtopping. Further study is required to better characterize this potential hazard. Although γ_{cyc} as high as 10% is considered very large for typical inorganic soils, the Delta peats are unusually soft and such large shear strains are feasible during design-level shaking.

Acknowledgments

Support for this research has been provided by the Department of Water Resources (DWR) under contract number 4600010406, and the US Geological Survey under contract number G11AP20169.

References

Duku, P.M., Stewart, J.P., Whang, D.H., and Venugopal, R. (2007). “Digitally controlled simple shear apparatus for dynamic soil testing.” *Geotech. Test. J.*, 30(5) 368-377.

Mesri, G., and Ajlouni, M. (2007). “Engineering properties of fibrous peats.” *J. Geotech. Geoenviron. Eng.*, 133(7), 850–866.

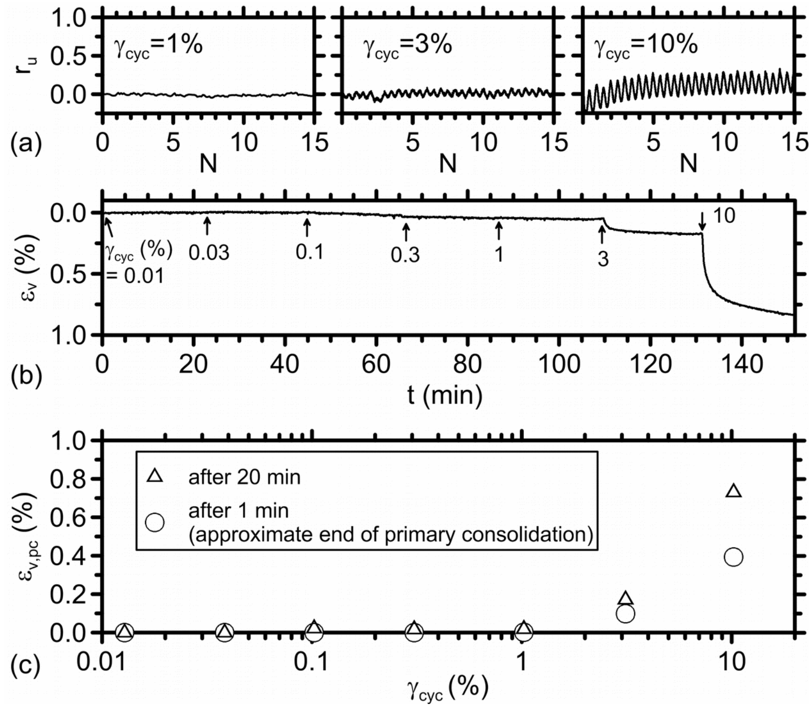

Fig. 1. Cyclic direct simple shear test results of Sherman Island peat (a) pore pressure ratio (r_u) versus number of cycles (N), (b) volumetric strain (ε_v) versus time (t), and (c) ε_v versus cyclic shear strain amplitude (γ_{cyc}).