The Effect of Plasticity on Intermediate Soil Compressibility

PEER Internship Program – Summer 2012

Undergraduate Intern: Nicole C. McCurdy, UC Davis

Faculty Advisor: Dr. Ross W. Boulanger, UC Davis

Intern Mentor: Adam Price, UC Davis

University of California Davis

Motivation

Earthquake induced liquefaction has the potential to cause devastating ground deformations, as seen in Figure 1. Empirical correlations exist between liquefaction potential and in-situ test measurements, such as Cone Penetration Test (CPT) tip resistance. Compressibility, strength, dilatancy, and stiffness affect measured tip resistance. Understanding the affect of fines and plasticity of fines on soil behavior under cyclic and compressive conditions is necessary for earthquake resilient design.

Figure 1

Background

Triggering curves are used in practice to predict liquefaction susceptibility. These curves must account for the affect of plasticity on cyclic resistance and CPT tip resistance to be implemented in practical design.

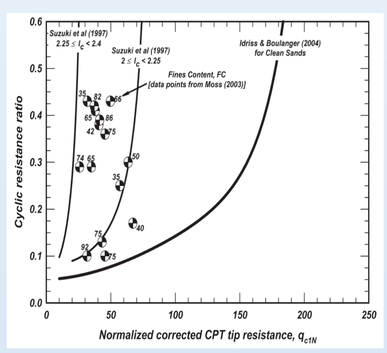


Figure 2

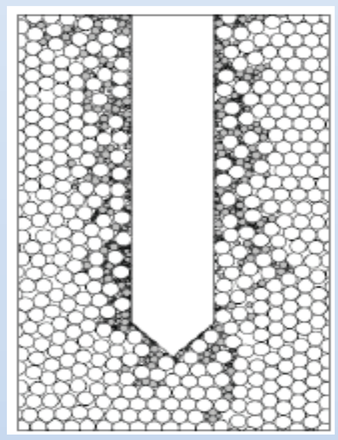


Figure 3

Soil compresses as the CPT rod pushes it aside. At standard penetration rates, there is a potential for particle crushing in granular soils.

A limiting compression curve (LCC) measures compressibility during particle crushing. It is a key parameter of the constitutive model by Pestana and Whittle (1995).

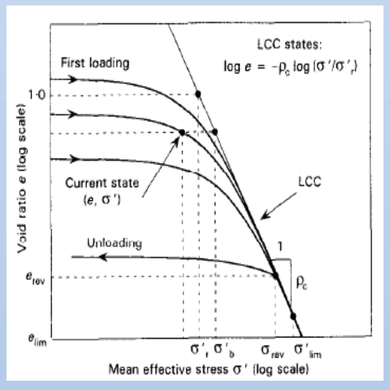


Figure 4

Method

1) Ground Silica silt (Plasticity Index, PI=0) mixed with fine Kaolin clay (PI=27) at 30%, 40%, and 50% dry weight Kaolin.

2) Soil samples prepared at liquid limit for one dimensional compression testing (Figure 5, 6).

3) Load and displacement during compression used to calculate void ratio with respect to stress.

Figure 5
Soil placed in steel mold with drainage screens in preparation for compression.

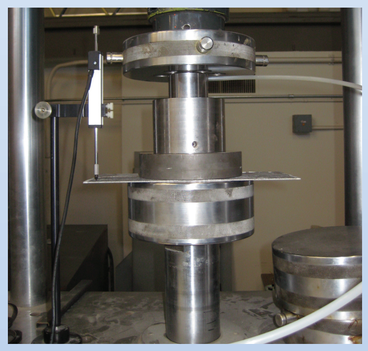
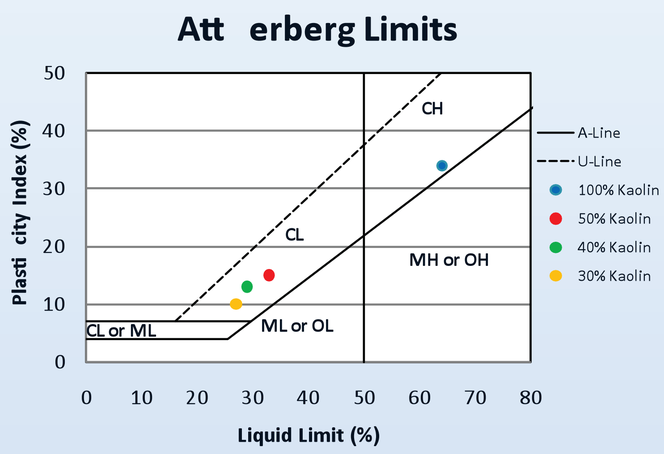
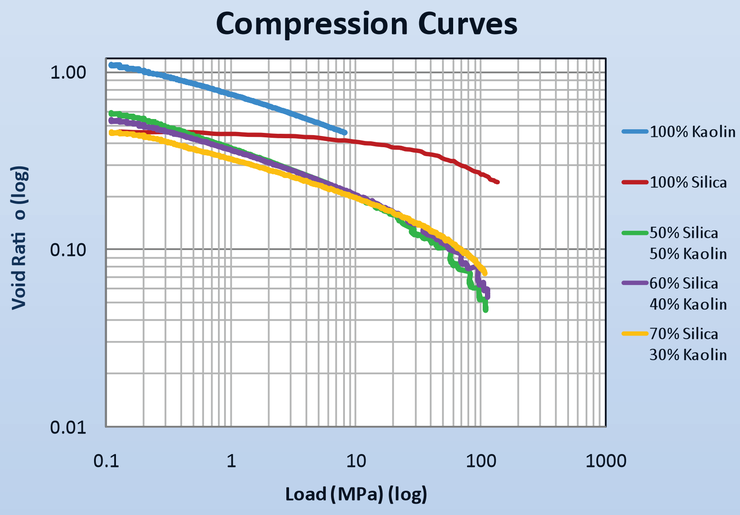


Figure 6
Lower arm of MTS compression frame moves upward to compress soil sample.

Results



100% Kaolin classified as a clay with high plasticity. Intermediate soils classified as clays with low plasticity

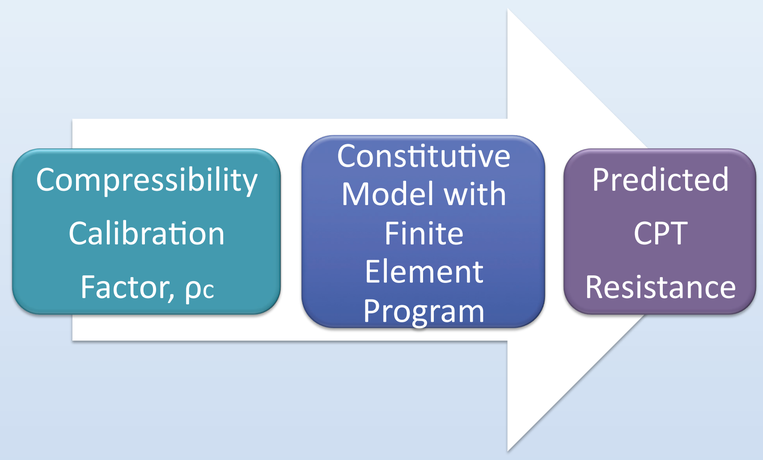


Compression behavior for intermediate soils is similar to high plasticity soils at low stresses, and similar to nonplastic soils after crushing begins.

Conclusions

- Increasing clay content increases the range over which soil behaves plastically
- No definitive yield point exists for kaolin over the stresses tested. Consolidation occurs throughout the compression test, allowing for continued void ratio change.
- Ground silica has little void ratio change until significant stress causes particle crushing, shown as the yield point of an LCC.
- Ground silica yields at higher stresses than silica sand (as shown by previous research on Nevada sand) because weaker planes and angularities have already been eliminated
- Silica and kaolin mixtures behave like clay at low stresses because silica grains are suspended in clay matrix. When clay has compressed so that silica grains are in contact, soil behavior is a function of granular skeleton.

Future Research



LCC yield point and slope will be used with monotonic DSS test results to calibrate the constitutive model, MIT-S1. This model will be implemented into FLAC, a finite element program, to model a CPT rod pushed into the ground through cylindrical cavity expansion. Predicted tip resistances will later be compared to cyclic strength of the same soil mixtures.

Acknowledgements

I would like to thank Dr. Ross Boulanger and Dr. Jason DeJong for their guidance and invaluable knowledge, Adam Price for his generous instruction and patience, and Bill Sluice and Daret Kehlet for their knowledge and use of lab equipment. This research was made possible through the PEER Center by funding from the National Science Foundation (NSF).