Research Project Summary

Project Details

Author: Kristin Shelton
Mentor(s): Dr. Ed Kavazanjian, Farideh Ehsasi, Xi Yu, Logan Tsosie
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Background and Rationale

The CBBG (Center for Bio-mediated, Bio-Inspired Geotechnics) at ASU (Arizona State University) studies a variety of ways to use Bio-Geo-Technics (life, Earth, art/skills) to improve environmental pollution issues. CBBG research alters Earth's crust surface using an enzyme mixture, innovations, and underground robots to strengthen, stabilize, and excavate soil. Using EICP (Enzyme Induced Carbonate Precipitation) sand turns to sandstone. The goal is to minimize our 'Carbon Footprint' while performing mainstream industrial practices.
What is the best way to strengthen soil and develop nature-compatible methods for its use?

Research Objectives

- To test EICP strength in soils OTAWA 20/30 B-2.5 and B-1 soil samples.
- To quantify the strength of EICP in OTAWA 20/30 B-2.5 and B-1 soil samples by performing Unconfined Compression Strength (UCS) testing and other micro-scale measurements.
- To examine OTAWA 20/30 B-2.5 and B-1 soil samples by scanning electron microscopy (SEM)
- To test the strength of different EICP solution concentrations in soil samples using iron mine tailings
- To quantify the strength of different EICP solution concentrations in soil samples from iron mine tailings by conducting SWERL and penetrometer testing of soil pans
- To quantify the strength of different EICP solution concentrations in soil samples from iron mine tailings by using Carbonate, Ammonium, and penetrometer measurements on pan crust
- To determine the feasibility of conducting experimentation on column treatment or on pan treatment in a Biology for Majors (BIO 181) undergraduate lab course.

Methods and Materials

The summer CBBG (Center for Bio-mediated Bio-Inspired Geotechnics) program uses many demonstrations and experiments on soil treated with an EICP (Enzyme Infused Carbonate Precipitation). EICP was placed in soil pans to test the impact of wind erosion and depth of penetration. Sand column tubes treated with EICP were for compaction. We used (SEM) samples were also prepared for later visualization. To test the efficacy of EICP solution concentrations in Minnesota iron mine tailings, three pans were prepared: Pan 1 (control) was untreated; Pan 2 was treated with a 1M urea, 0.67M $CaCl_2$ EICP solution; Pan 3 was treated with a 1.5M urea, 1M $CaCl_2$ EICP solution. Samples were let dry for 72h. Carbonate and penetrometer measurements were performed on each soil sample pan.

Experimental Results

B-2.5 and B-1 treated soil sample columns showed significantly different stress responses as measured by UCS testing. B-2.5 (EICP milk B-2.5) samples supported less stress (x= 253.67 kpa) than B-1 (EICP milk B-1) samples (x= 462.12 kpa). Examination of B-1 (EICP milk B-2.5) SEM prepared samples revealed carbonate precipitate crystals (Fig. 1), which were not visible in untreated samples. Pan crust soil sample penetration test results showed that EICP treatment is three to four times stronger in treated iron mine tailing soils (Fig.2). Untreated soil (Pan 1) supported the least stress (20 kpa); EICP 1.5M urea, 1M CaCl2 EICP treated soil (Pan 3) supported less stress (80 kpa) than EICP 1M urea, 0.67M CaCl2 treated soil (Pan 2) (105 kpa). Untreated soil showed the least displacement (0.01 cm) when compared to treated soils (0.2 cm).

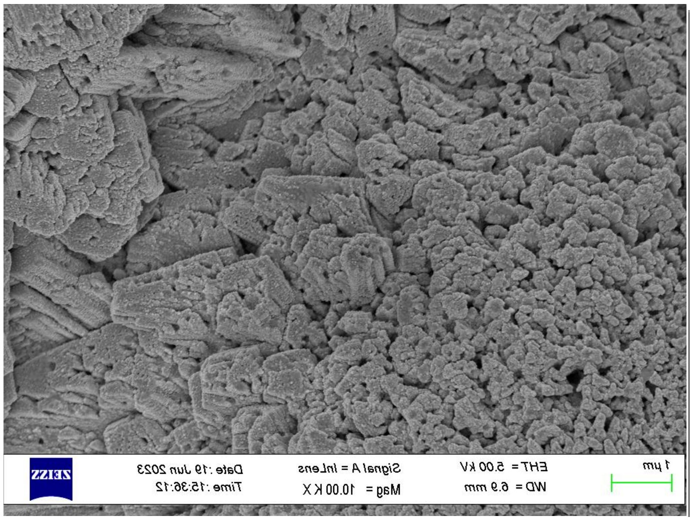

Figure 1: SE micrograph of carbonate precipitate crystals in treated Otawa 20/30 EICP-milk B-2.5 soil samples

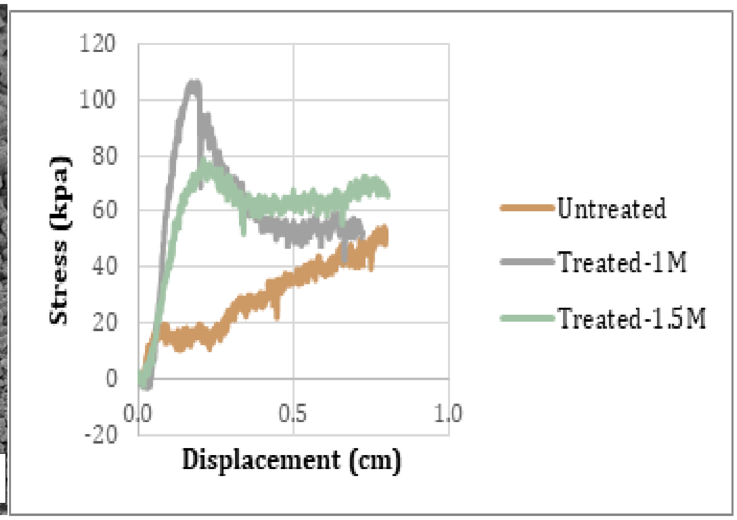

Figure 2: Stress values (kpa) for untreated and treated Minnesota iron mine tailings soils

Research Conclusions

Soil loss occurred more in fine-grained sand than in heavier sand particles. Steep angles Soil treated with EICP. EICP treatment is 3-4 times stronger in penetration tests compared to untreated soil. B-1 EICP-treated soil sample columns exhibited a much higher stress response (x= 462.12 kpa) to unconfined compression than B-25 EICP-treated samples (x= 253.67 kpa). Iron mine tailings soil pan crust untreated samples were three to four times less strong than EICP-treated samples. 1M urea, 0.67M $CaCl_2$ EICP solution soil samples exhibited the highest stress response (105 kpa), as determined by penetrometer testing.

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References

(1) Kavazanjian Jr. E & Iglesias E (2009). Biopolymer soil stabilization for wind erosion control. *Proceedings, 17th International Conf. Soil Mechanics and Geotechnical Engineering*, Alexandria, IOS Press - Mill Press, Vol. 2: 881-884