Research Project Summary

Project Details

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Title: **Permeability of bio-cemented sand mixtures**
Keywords (3-5 words): Bio-stimulation, Bacteria, Calcite, Cementation, Ground improvement, Permeability

Background and Rationale

DESCRIBE THE BACKGROUND AND PROBLEM BEING ADDRESSED IN THE RESEARCH (ONE PARAGRAPH IN PRESENT TENSE)

Microbially induced calcite precipitation (MICP) is an interdisciplinary research across microbiology, geochemistry, and geotechnical engineering disciplines. It involves the precipitation of calcite under a high pH medium created by bacteria through their urea hydrolysis. Stocks-fisher et al. (1999) showed that the Bacillus pasteurii, another alkalophilic bacteria with a highly active urease enzyme, were capable of hydrolyzing urea, and increasing the pH of the medium. Providing a calcium source in the next step resulted in the precipitation of calcite crystals. This microbial pathway has been the fundamental principle in this research.

MICP is currently one of the emerging sustainable ground improvement solutions to conventional cement grouting. It falls under the 'Thrust 1' category of CBBG research on hazard mitigation. The goal is that the fundamental research and optimization of MICP done through the center will make MICP a cost-effective,sustainable alternative for industry.

Research Objectives

LIST AT LEAST ONE OBJECTIVE GUIDING THE RESEARCH (START WITH ACTION VERB)

The objective of the research plan is to investigate the effect of MICP on permeability of sand mixtures by conducting the falling head permeability test.

Different soil mixtures with different intrinsic permeability will be used for MICP experiments. By using different soil mixtures, the effect of grain size, soil packing characteristics, cementation bonds, calcite content, and microbial biomass on permeability will be elucidated.

Methods and Materials

DESCRIBE RESEARCH CONDUCTED DURING THE SUMMER PROGRAM (ONE PARAGRAPH IN PRESENT TENSE)

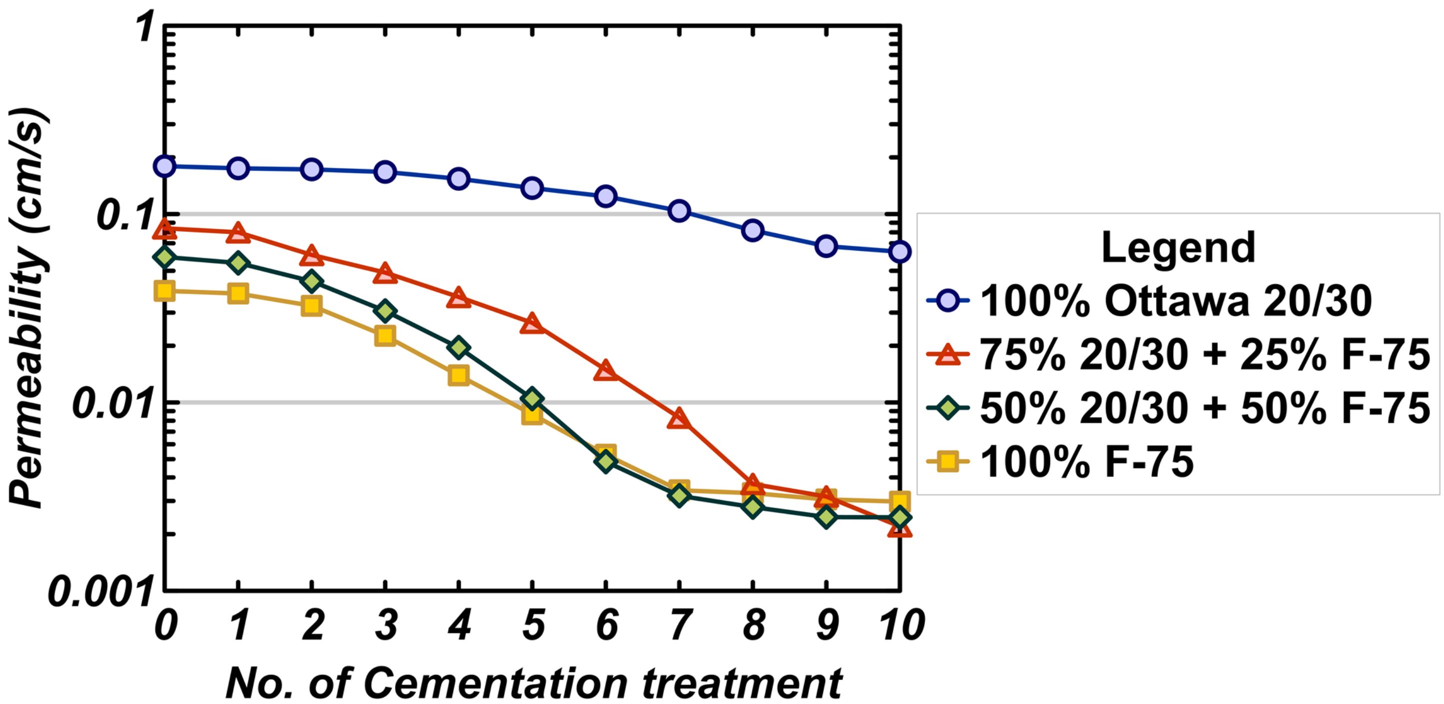
Materials required:
1. 100 ml Syringe,
1. Burette stand,
2. Beakers

Chemicals required:
1. Urea
2. Ammonium chloride
3. Sodium acetate trihydrate
4. Sodium hydroxide

5. Calcium chloride
6. Yeast extract

Experimental Results

DESCRIBE RESULTS FROM SUMMER RESEARCH EXPERIENCE (ONE PARAGRAPH IN PAST TENSE)



The obtained results from MICP experiments are shown in the figure above.

1. It may be observed that the permeability reduces for all soil samples with increasing cementation treatments. This is because of calcite precipitation and the cementation of soil particles at particle contacts. Because of this interparticle bonding, the flow path of pore fluid is restricted and hence the permeability of the soil reduces.
2. Except for Ottawa 20/30 sand, all the other sand mixtures showed similar permeability reduction profiles, and at the end of 10th cementation treatment, they also showed similar final permeability values. This may be due to the effect of smaller particle size of F-75 sand. When F-75 was included with Ottawa 20/30 sand in sample preparation, smaller lenses of F-75 formed during wet deposition. This caused localized cementation which would explain similar reduction in permeability because fluid flow would reduce at these layers.
3. The mixture 75% Ottawa 20/30 sand and 25% F-75 showed the highest reduction in permeability. This may be because of soil packing. Because F-75 is smaller, when mixed in the right proportion with a bigger sand size such as Ottawa 20/30, the smaller particles can fill the pore space occupied by bigger size particles. In this manner, more particle contacts and higher density packing can be achieved. Therefore, more no. of contacts would lead to more cementation at such contacts and therefore greater reduction in permeability.

Research Conclusions

DESCRIBE CONCLUSIONS FORMED DURING SUMMER RESEARCH EXPERIENCE (ONE PARAGRAPH IN PAST TENSE)

1. MICP is a novel bio-mediated technique of improving the stiffness and strength of soil. However, the cementation of soil particles can also cause reduction of permeability of soil. This has been explored for different soil mixtures in this research study.
2. Permeability reduction was observed for all samples with increase in cementation treatment.
3. 3 soil mixtures which included F-75 showed similar permeability values at the end which shows the effect of localized cementation on permeability.

4. The highest reduction in permeability was found to be for the mixture containing 75% Ottawa 20/30 sand and 25% F-75, which shows the effect of soil packing and particle contacts on cementation bonds and hence on permeability reduction.
5. Permeability was found to be a function of grain size, packing, calcite content, and microbial biomass.

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