CBBG Center for Bio-mediated & Bio-inspired Geotechnics

GT2 Permeability of bio-cemented sand mixtures

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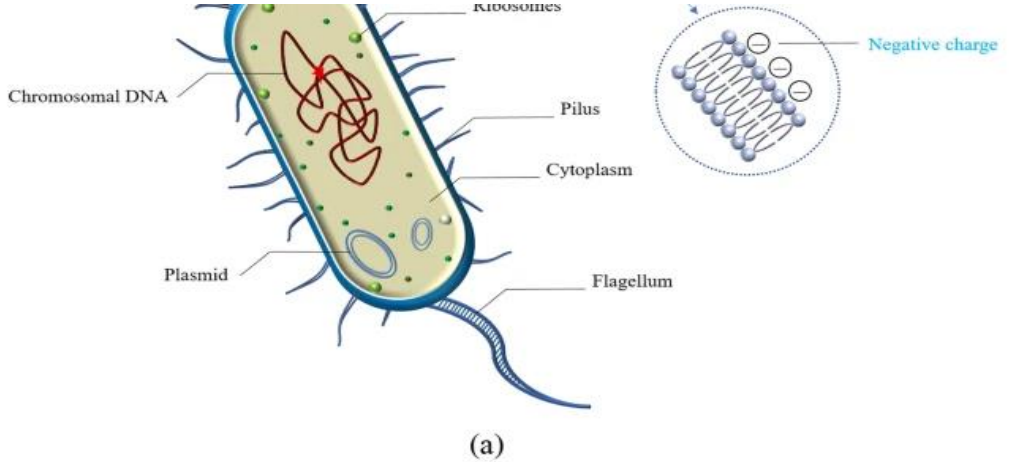
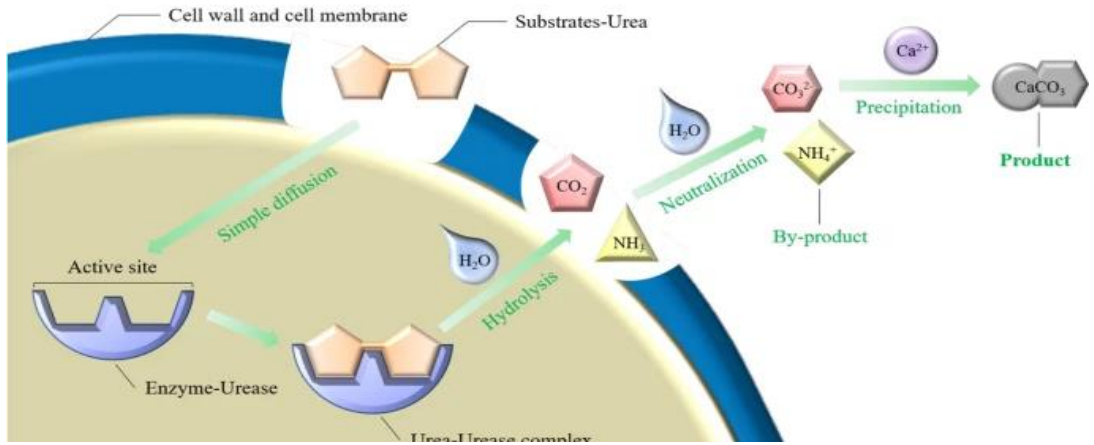
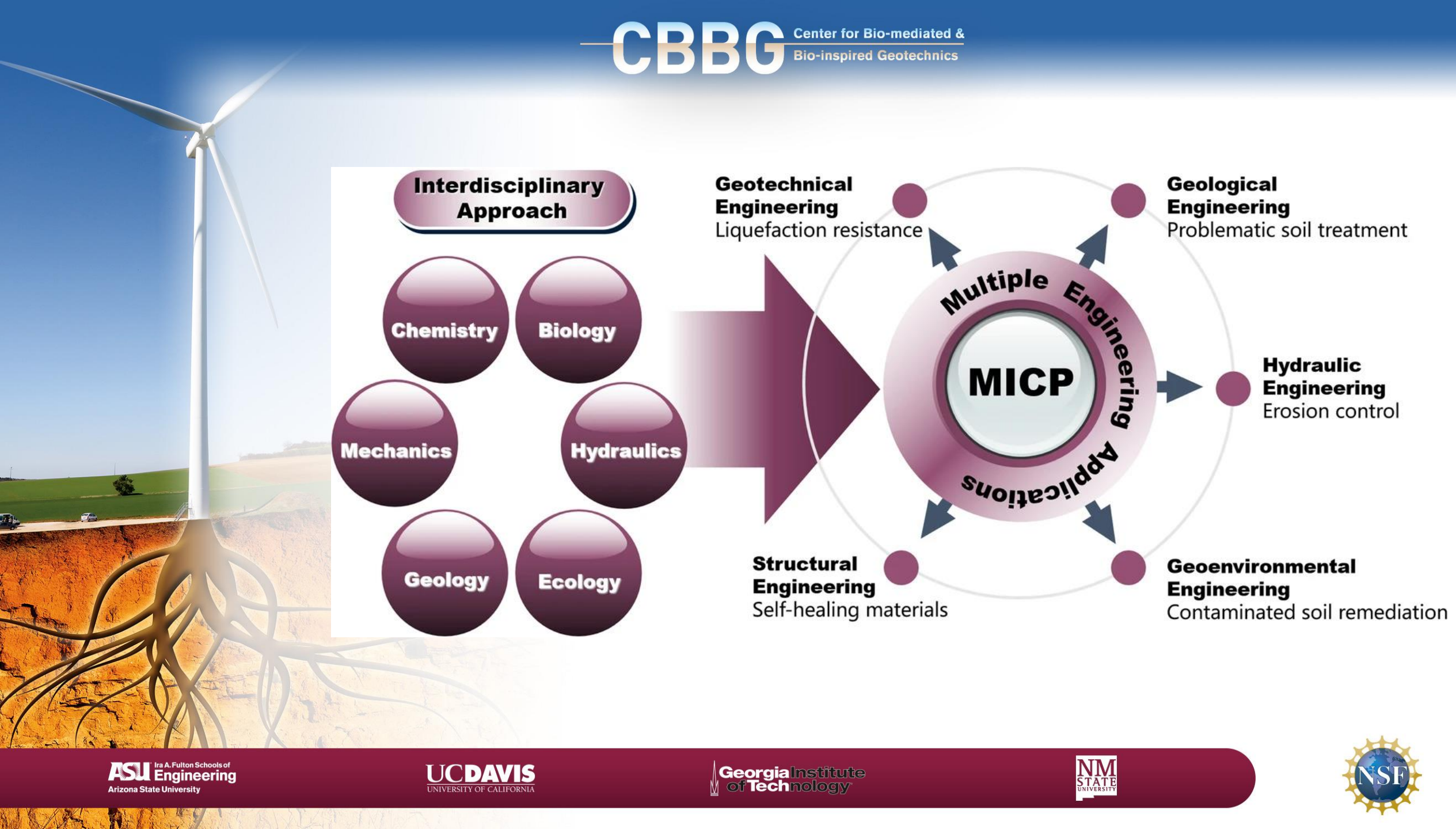
RET Lab Experience Research Summary

Research Background

- Microbially induced calcite precipitation (MICP) is an interdisciplinary research topic spanning microbiology, geochemistry, and geotechnical engineering disciplines. It involves the precipitation of calcite in a high pH medium created by bacteria through urea hydrolysis.
- Bacteria with a highly active urease enzyme can hydrolyze urea and increase 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.






Interdisciplinary Approach
Chemistry
Biology
Mechanics
Hydraulics
Geology
Ecology
MICP
Multiple Engineering Applications
Geotechnical Engineering
Liquefaction resistance
Geological Engineering
Problematic soil treatment
Hydraulic Engineering
Erosion control
Structural Engineering
Self-healing materials
Geoenvironmental Engineering
Contaminated soil remediation

RET Lab Experience Research Summary

Research Objectives

- The objective of this 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 were used for MICP experiments. Using different soil mixtures, the effects of grain size, soil packing characteristics, cementation bonds, calcite content, and microbial biomass on permeability were observed.

RET Lab Experience Research Summary

Research Conclusions

1. The permeability reduces for all soil samples with increasing cementation treatments. Due to calcite precipitation and the cementation of soil particles at particle contacts. This interparticle bonding causes the flow path of pore fluid to become restricted and hence the permeability of the soil reduces.

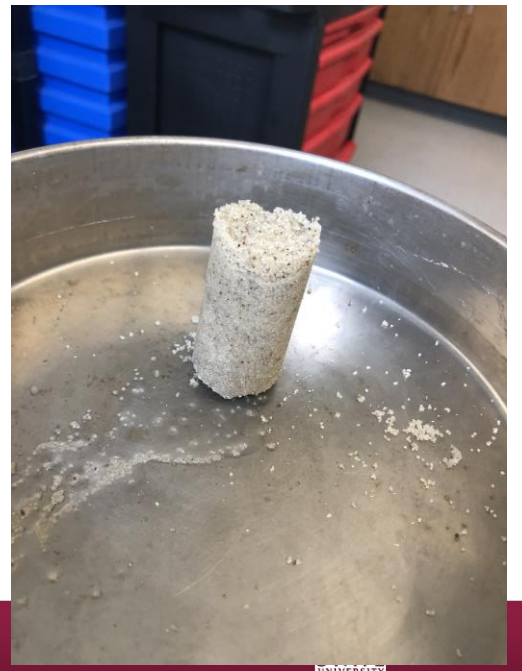
2. MICP is a novel bio-mediated technique of improving the stiffness and strength of soil. However, the cementation of soil particles can also cause reduction of permeability of soil. This has been explored for different soil mixtures in this research study.

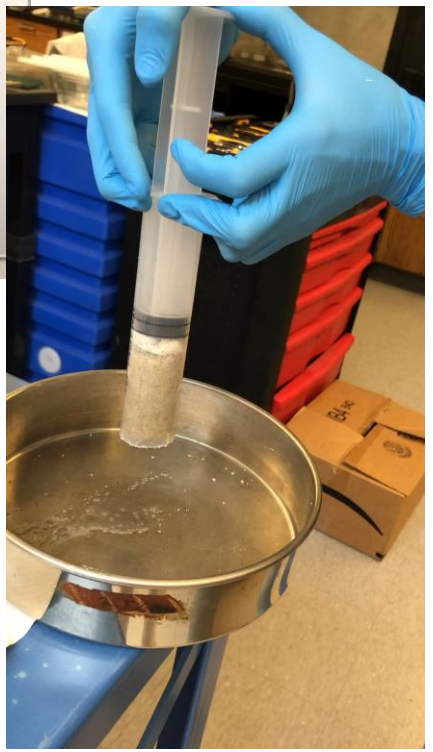
3.Permeability reduction was observed for all samples with increase in cementation treatment.

4. The 3 soil mixtures which included F-75 showed similar permeability values, showing the effect of localized cementation on permeability.

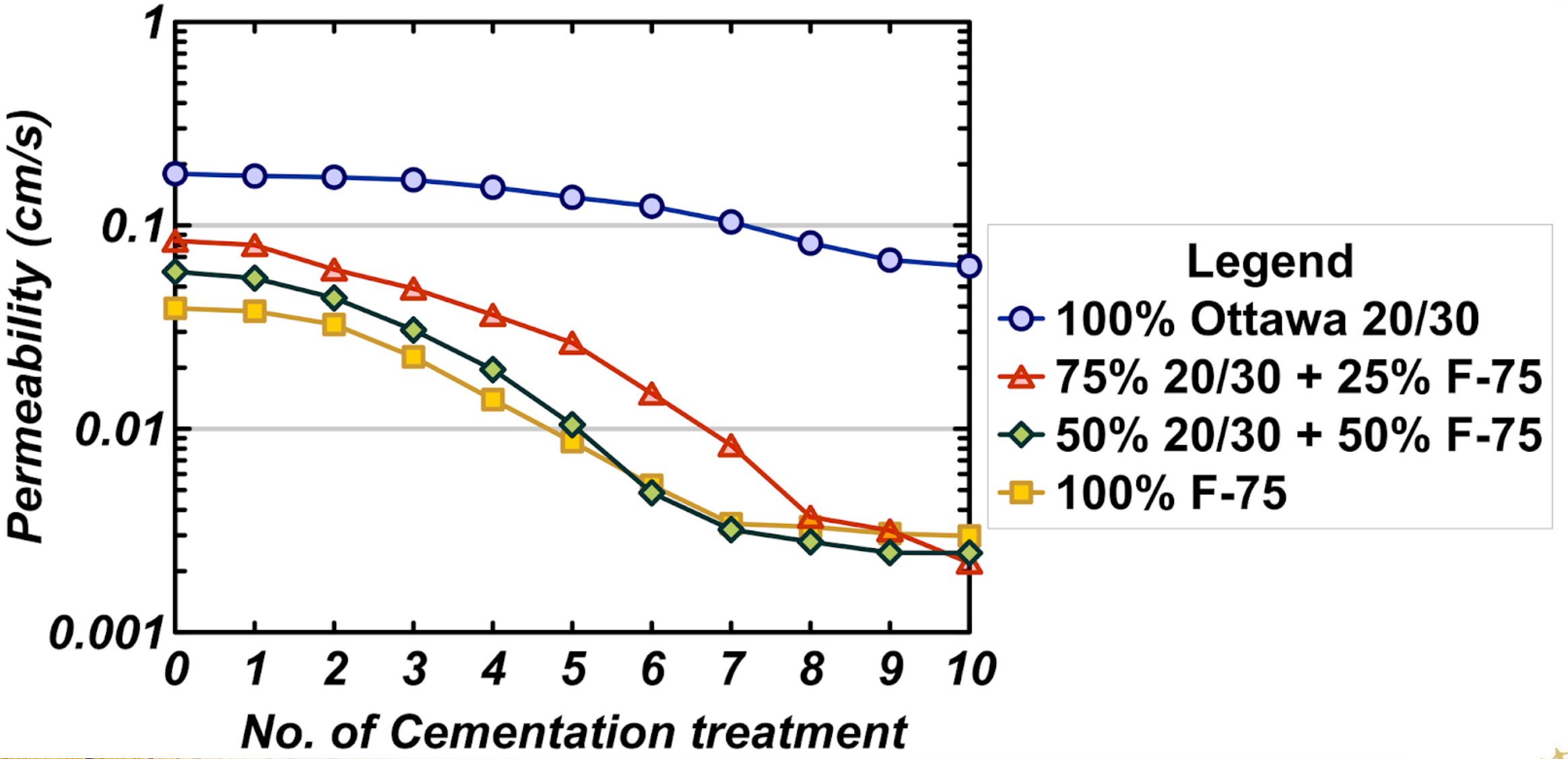
5. The highest reduction in permeability was found for the mixture containing 75% Ottawa 20/30 sand and 25% F-75, showing the effect of soil packing and particle contacts on cementation bonds and hence on permeability reduction.

6. In conclusion, Permeability is a function of grain size, packing, calcite content, and microbial biomass.





Results & Conclusion



RET Instructional Lesson Implementation

Lesson Description

- Students will engage in a 3 weeklong lab investigation to propose sustainable solutions to problems related to soil types and improving the shear strength and stiffness of soil for civil engineering with “Microbially Induced Calcite Precipitate”(MICP) method.
- Students will use urease hydrolysis by microbes to cement sand/soil mixtures. Students will use the lab protocol developed by the MICP research team at GT.
- Students will explain the beneficial role of microbes in soil improvement for sustainable development and to solve problems.
- Students will describe the role of soil microbes in the urea hydrolysis reaction.
- Students in this lab investigation will use engineering practices like asking questions, developing models, collecting and analyzing data in order to construct an explanation[Claim, Evidence and Reasoning].

RET Instructional Lesson Implementation

Lesson Objectives

- Global increase in population and civil infrastructure demands the availability of suitable soil sites for construction. Ground improvement is now an integral part of **sustainable modern development projects.**
- Students will **make connections** with the lesson and the lab by writing a Claim, Evidence & Reasoning based explanation.
- Real world sustainable application - Video PBS - These cement-making bacteria could build the cities of the future.
- Students will write the different sustainable applications of MICP after watch the video & the poster on the right to explore and extend their understanding.

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Thank you!
Questions?

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