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Microbial Induced Calcite Precipitation (MICP) in Stabilizing Expansive Soils

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Abstract

A sustainable and economic method of treating expansive soils could be through Microbial Induced Calcite Precipitation (MICP). Clayey soils are a natural habitat for bacteria and are therefore a promising source for biological calcite precipitation. Evidence of calcite precipitation in natural clays has been seen in laboratory studies. The application of these methods in the field are however yet to be developed. An attempt to implement MICP in the field show promising observations. Further readings are necessary to determine the homogeneity and spatial effects of the treatment in the ground.

Keywords

expansive soils, calcite precipitation, soil stabilization

MICROBIAL INDUCED CALCITE PRECIPITATION (MICP) IN STABILIZING EXPANSIVE SOILS

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FIELD IMPLEMENTATION OF MICROBIAL INDUCED CALCITE PRECIPITATION

BACKGROUND

- Expansive soils undergo vast changes in volume when subject to change in water content and cause damage to civil structures.

Image source: caternews.com

Differential settlement in foundation of a house built on expansive soil


Image source: margopare.blogspot.com

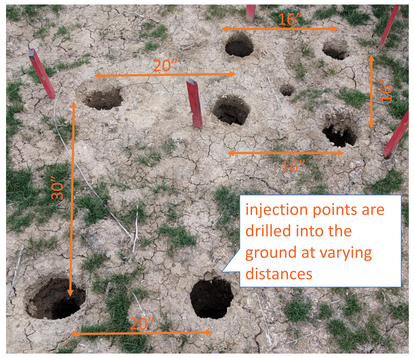
Cracks seen on a pavement surface built on expansive soil

- Traditional methods to tackle expansive soils involve adding cement or lime to the soil, which are not the most environmentally friendly solutions.
- Studies have shown that urease producing bacteria, which are naturally found in expansive soils, are capable of producing calcite ($CaCO_3$) in the soil.
- Laboratory tests done with natural clays in the SuRGE lab at Boise State University showed that MICP can significantly improve strength and reduce swelling of expansive soils.
- MICP in a natural soil could be achieved using injections of enrichment solution - to help bacterial growth, and cementation solution - to induce precipitation of calcite.

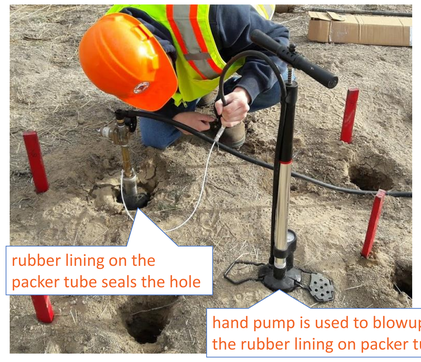
OBJECTIVES

- To understand the feasibility of microbial induced calcite precipitation in field.
- To study the effects of enrichment and cementation injections through calcite content and swelling potential.

INJECTION METHOD



- 2” diameter holes were drilled into the ground up to a depth of 4 feet.
- Two grids were used to inject solutions into the ground.



- A pneumatic packer tube was inserted into the injection point to seal and prevent the leakage of solution on the surface

- Solutions were injected through the packer into the ground at a pressure of 20 psi.

- Total of 22 gallons of the solution was injected (4-6 gallons per each injection point)

INJECTED SOLUTION

Enrichment solution – To help bacterial growth in soil

(Urea 20 gm/ltr, Sodium Acetate Anhydrous 8.2 gm/ltr, Solulys 0.5 gm/ltr)

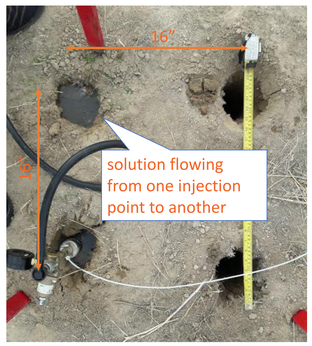
Cementation solution – To induce precipitation of calcite

(Calcium Chloride 27.74 gm/ltr, Urea 20 gm/ltr, Sodium Acetate Anhydrous 4.1 gm/ltr, Solulys 0.5 gm/ltr)

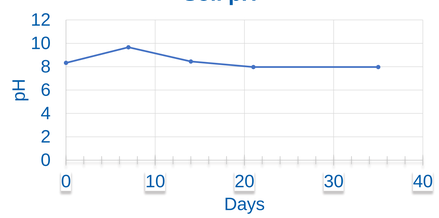
INJECTION TIMELINE

- Day 0 – Enrichment Solution
- Day 7 – Cementation Solution 1
- Day 14 – Cementation Solution 2
- Day 21 – Cementation Solution 3
- Day 35 – Cementation Solution 4

FIELD OBSERVATION

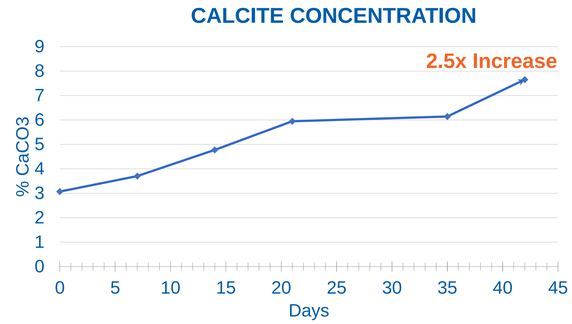


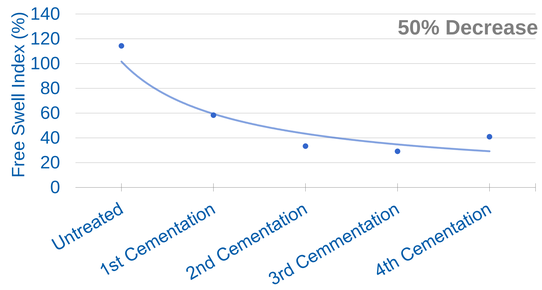
- Flow of solution was seen into neighboring injection points within distance of 16 inches.
- This indicates lateral flow of solution up to at least 16 inches.



- The initial increase in pH level indicates presence of urease producing bacteria are active.

RESULTS





CONCLUSION

- The calcite content increased significantly with each successive injection of cementation solution and reduced swelling potential.
- Microbial induced calcite precipitation can be successfully replicated in the field through successive injections of enrichment and cementation solutions into the soil.

ACKNOWLEDGEMENTS

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