ENGINEERING WITH NATURE

PROJECT FACT SHEET

Evaluation of Microbial Induced Calcite Precipitation (MICP) and Biostabilization on Soil Structure Rehabilitation

Background

Microbially induced calcite precipitation (MICP) is a form of biomediated geotechnical soil improvement that has been proposed to enhance the strength and hydraulic conductivity characteristics of soils applied to a range of geotechnical applications (DeJong et al. 2006; 2014). MICP enhances geotechnical properties through the bacterial precipitation of calcite, which acts as a binding agent between particles in a soil mass. Practical geotechnical applications of MICP that have been explored previously include in earthquake liquefaction mitigation (e.g., Montoya et al. 2014), dune erosion resistance (Shanahan & Montoya, 2014), and soil erosion resistance (e.g., Jiang & Soga 2019).

Although lab and field scale research has increasingly shown the positive impact of MICP on engineering properties, little is known about the interaction of an MICP-treated soil mass with vegetation and vegetative regrowth, which are important aspects for usability and sustainability of soil improvement techniques on US Army Corps of Engineers (USACE) infrastructure projects. Prior research has shown that MICP treated soils exhibited seedling growth but heavily treated MICP soils exhibited sparse vegetation growth (Montoya, 2018). These findings suggest that a balance is needed between the biomediation to increase engineering properties and the concentration of MICP that inhibits vegetation growth. Understanding this balance is important for informing the potential for MICP to be applied to USACE project, particularly in light of the increasing importance of not only nature-based engineering solutions like MICP but also ensuring that engineered infrastructure are nature-inclusive.

Objective

This research aims to answer three key research questions about MICP to inform its use in USACE application – (1) what USACE application areas can MICP be applied to as a nature-based solution, (2) how do MICP-treated soils interaction with vegetation and vegetative regrowth, and (3) what is the long-term sustainability and resilience of MICP treatment and vegetation in treated soil areas?

Expected Impact

A majority of publications related to the effect of MICP on the soil structure is focused on the contribution of soil strength for the purpose of mitigating a potential failure mode, specifically liquefaction to the greatest extent. However, little attention has been given to using bioaugmentation methods, such as MICP, for soil structure rehabilitation following an event that has caused adverse effects to soil properties. Bioaugmented soil stabilization could present a resilience and expedient solution to a damaged soil structure that could limit the exacerbation of geohazards.

Despite being natural and abundant, sediment presents many environmental management challenges. Natural disasters often have aspects of damage caused by the movement of sediment. Since USACE is committed to tackling the most difficult engineering tasks to “secure our Nation, energize our economy, and reduce disaster risk” it is fitting that through our EWN program that sustainable MICP procedures can be investigated to potentially be solution for challenging problems related to sediment stabilization. Microbial engineering is one of the current forefronts of scientific interest and investigation since these techniques use biologic processes to the advantage of the environment and human labor costs. Results of the project will benefit the agency, the nation, and the greater scientific community through the expansion of understanding of bioremediation techniques, MICP, and its applicability.

Point of Contact:

Allison Scates (ERDC GSL),
Allison.r.scates@usace.army.mil, 6016347650

References

J.T Dejong, M.B. Frtizges, K. Nüsslein, 2006, Microbially Induced Cementation to Control Sand Response to Undrained Shear Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 11, https://ascelibrary.org/doi/10.1061/%28ASCE%291090-0241%282006%29132%3A11%281381%29

J. T. Dejong, K. Soga, E. Kavazanjian, S. Burns, L. A. Van Paassen, A. Al Qabany, A. Aydilek, S. S. Bang, M. Burbank, L. F. Caslake, C. Y. Chen, X. Cheng, J. Chu, S. Ciurli, A. Esnault-Filet, S. Fauriel, N. Hamdan, T. Hata, Y. Inagaki, S. Jefferis, M. Kuo, L. Laloui, J. Larrahondo, D. A. C. Manning, B. Martinez, B. M. Montoya, D. C. Nelson, A. Palomino, P. Renforth, J. C. Santamarina, E. A. Seagren, B. Tanyu, M. Tsesarsky, And T. Weaver, Biogeochemical processes and geotechnical applications: progress, opportunities and challenges, January 2014, Bio- and Chemo-Mechanical Processes in Geotechnical Engineering, Conference Proceedings, pg. 143-157, https://www.icevirtuallibrary.com/doi/full/10.1680/bcmpge.60531.014

Dejong, J., Montoya, B. & Boulanger, R., 2013, Dynamic response of liquefiable sand improved by microbial-induced calcite precipitation, Géotechnique, Vol. 63, pg. 302-312. DOI:10.1680/geot.SIP13.P.019, https://www.researchgate.net/publication/277424955_Dynamic_response_of_liquefiable_sand_improved_by_microbial-induced_calcite_precipitation

C. Shanahan, B.M. Montoya, 2014, Strengthening Costal Sand Dunes Using Microbial-Induced Calcite Precipitation, March 2014, Geo-Congress 2014 Technical Papers, pg. 1683-1692, https://ascelibrary.org/doi/abs/10.1061/9780784413272.165.