Investigation of mechanical and microstructural properties of MICP treated soils: Application to soil erosion in saline environment

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The research unit RECOVER from INRAE is pleased to invite applications for a postdoc position on the Investigation of mechanical and microstructural properties of MICP treated soils: Application to saline environment. This Post-doc proposal is part of the project BIGALPS (Bio-Inspired Geotechnical Applications to Launch Pan-European Solutions, 2023-2026), an EIC (European Innovation Council) Transition project, aiming at revolutionizing the soil stabilization field.

Context and motivations

In last decades, climate changes induce an increase of extreme phenomena such as storms, heavy rainfalls, flash-floods, which could lead to disasters such flooding, landslides, etc. Therefore, it become crucial to improve soil/earthen structures resilience against such events. Various techniques were developed to tackle this challenging task by improving the engineering properties of soil. Among them, the bio-cementation technique which is a sustainable biological ground improvement technology, environmentally friendly, non-polluting and cost-effective, with the ability to address some of the most critical issues related to soil stability, such as landslides, liquefaction, erosion, and intricate soils for foundations construction. The bio-cementation is based on the microbial-induced calcite precipitation (MICP) process that results in the precipitation and accumulation of calcium carbonate in the soil pores, bonding soil particles together (Fig. 1-2) ([1]-[4]). As a consequences, the soil porosity and permeability will be reduced and soil strength and stiffness will be increased ([5], [6]).

In the framework of the BIGALPS project[1], an experimental platform, Digue2020[2] (situated in Camargue region, south France) was chosen to experiment the bio-cementation technology in a real marine environment to mitigate the dike vulnerability against erosion phenomena and instability. The present research proposal aims to investigate in the laboratory the effectiveness of bio-cementation in stabilising hydraulic earthen works with respect to erosion phenomenon and instability phenomenon. It will focus on establishing correlations between product characteristics (concentration, bonds form and thickness, contacts, etc) and hydro-mechanical properties.

Project work

The present postdoctoral project is mainly experimental. It will use untreated and treated materials by MICP collected at Digue2020 experimental platform, and aims at:

i) Investigating and quantifying the MICP impact on the erosion vulnerability as well as on the hydro-mechanical properties of treated materials. UCS and triaxial tests will be conducted for the mechanical characterisation, HET and JET for assessment of the erosion resistance, suffusion permeameter for hydraulic conductivity assessment, etc.

ii) Characterizing the induced microstructure by MICP treatment, with a focus on the calcite bonds (quantity, size, type, form, etc). To do, analytical techniques such as Scanning Electron Microscopy (SEM), X-Ray Diffraction, X-Ray tomography will be used. Mercury porosimetry for porosity characterization will also be considered.

iii) Using the results obtained in the laboratory to better interpret in situ measurements on the treated zones of Digue2020.

[1] https://www6.paca.inrae.fr/recover/Nos-projets/BIGALPS
[2] https://www.digue2020.fr/plateforme-digue2020-2/

To carry out the experimental work, the post-doc will use the facilities of the geomechanics lab of INRAE such the static/dynamic triaxial apparatus, the hole erosion test device (HET), the jet erosion test device (JET), the suffusion permeameter (SEPT), etc. She/he will benefit from the support of the technical team of the geomechanics lab.

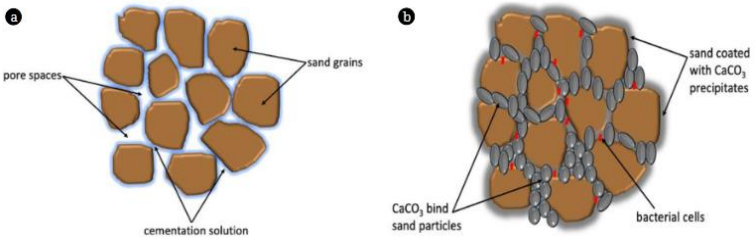

Figure 1. Sketch of soil grains during biocementation treatment (after Omoregie et al. 2021)

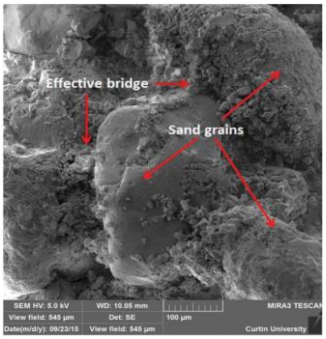

Figure 2. SEM image showing the effective bridge formation (after Mujah D. et al, 2016)

Required knowledge and skills

The candidate should have a PhD in geotechnics, geomechanics, or civil engineering and should have a previous experience in experimental work. A theoretical background in continuum mechanics and/or chemical engineering will be appreciated. A previous experience with advance imaging techniques and/or discrete element modelling would be a bonus. A good level of scientific English (speaking and writing) is mandatory.

Application

In order to apply for this position, CV and cover letter (in English or French) must be sent by e-mail to all members of the supervising team (nadia.benahmed@inrae.fr, pierre.philippe@inrae.fr and antoine.wautier@inrae.fr).

Terms and contract

The postdoc candidate will be located at Aix-en-Provence, France, within the research unit RECOVER from INRAE. She/He will benefit from an INRAE contract that is scheduled to start in January 2025 for a period of 18 months. The gross salary is expected to be between 3150 and 3550 €/month depending on past experience.

References

[1] Fu, T., Saracho, A. C., & Haigh, S. K. (2023). Microbially induced carbonate precipitation (MICP) for soil strengthening: a comprehensive review. Biogeotechnics, 100002. https://doi.org/10.1016/j.bgtech.2023.100002

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[3] Jia He, Yang Liu, Lingxiao Liu, Boyang Yan, Liangliang Li, Hao Meng, Lei Hang, Yongshuai Qi, Min Wu, Yufeng Gao, Recent development on optimization of bio-cementation for soil stabilization and wind erosion control, Biogeotechnics, Volume 1, Issue 2, 2023, 100022, ISSN 2949-9291, https://doi.org/10.1016/j.bgtech.2023.100022.

[4] Dadda, A. Mechanical and microstructural study of biocemented soils: application to hydraulic earthworks. Solid mechanics [physics.class-ph]. Université Grenoble Alpes, 2017. English. NNT: 2017GREAI103. Tel-03934613.

[5] Harran R., Terzis D. and Laloui L. (2022). Characterizing the Deformation Evolution with Stress and Time of Biocemented Sands. Journal of Geotechnical and Geoenvironmental Engineering. 148. 10.1061/ (ASCE) GT.1943-5606.0002871.

[6] Terzis, D., and Laloui L. 2019. Cell-free soil bio-cementation with strength, dilatancy and fabric characterization. Acta Geotech. 14 (3): 639–656. https://doi.org/10.1007/s11440-019-00764-3