ENAC – School of Architecture, Civil and Environmental Engineering
SGC – Civil Engineering Section
LMS – Soil Mechanics Laboratory
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Pre-study and Master's Project
Fall Semester 2023

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Evaluation of the performance of a modelling framework for biocementation with ex-situ hydrolysis

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Motivation of the project

Biocementation of soils is an innovative technology that is gaining attention in the soil-strengthening sector. Microbially induced calcite precipitation (MICP) creates a cemented, more densified soil with improved mechanical properties, like stiffness and strength (e.g., Terzis, 2017). Numerical modelling of this soil-strengthening technology serves two important purposes, it allows testing of theoretical models proposed for MICP and it can be valuable as a predictive tool for optimizing treatment strategies. Efforts of many authors have resulted in the development of models and validation with experimental results (Minto et al., 2019; van Wijngaarden et al., 2016; Zeng et al., 2021). However, for a novel developed MICP treatment strategy (Terzis & Laloui, 2021), these frameworks are not suitable.
A modelling framework for the evaluation of large-scale experiments with this specific treatment strategy is developed but needs to be critically evaluated. This project aims to strengthen the interpretation of performed modelling activities, after which the performance of the modelling framework will be evaluated using a recently performed upscaling experiment of biocementation.

Keywords

Biocementation, Numerical modelling, large scale experiment, upscaling

References

Minto, J. M., Lunn, R. J., & El Mountassir, G. (2019). Development of a Reactive Transport Model for Field-Scale Simulation of Microbially Induced Carbonate Precipitation. Water Resources Research, 55(8), 7229–7245. https://doi.org/10.1029/2019WR025153
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van Wijngaarden, W. K., van Paassen, L. A., Vermolen, F. J., van Meurs, G. A. M., & Vuik, C. (2016). A Reactive Transport Model for Biogrout Compared to Experimental Data. Transport in Porous Media, 111(3), 627–648. https://doi.org/10.1007/s11242-015-0615-5
Zeng, C., Veenis, Y., Hall, C. A., Young, E. S., van der Star, W. R. L., Zheng, J., & van Paassen, L. A. (2021). Experimental and Numerical Analysis of a Field Trial Application of Microbially Induced Calcite Precipitation for Ground Stabilization. Journal of Geotechnical and Geoenvironmental Engineering, 147(7), 05021003. https://doi.org/10.1061/(ASCE)GT.1943-5606.0002545

Goal of the project and tasks to carry out

- Understand better the precipitation rate of the novel strategy, influenced by the precipitation kinetic constant

In the current performed modelling activities, the influence of the precipitation kinetic constant on the model results remains poorly understood. In a first stage of the project, reflections on the current modelling activities and results should be used, together with literature evaluation and if needed some experimental evaluation to develop a realistic estimate of this parameter.
Activities: literature evaluation, numerical modelling, evt. some experimental work

- Evaluate the relation between calcite content (%) and dynamic tip resistance qd (MPa)

Results of the modelling framework are currently given as a distribution of calcite content in the soil domain while experimental results are obtained in terms of dynamic tip resistance. Making the link between calcite content and dynamic tip resistance through the soils improved mechanical behaviour helps evaluate the model performance with the knowledge obtained from two completed large-scale experiments.
This can be done using literature evaluation, by including mechanics in the current developed COMSOL model or by creating a model in a different software tool (zsoil, plaxis) where a soil profile with differentiated properties is used.
Activities: literature evaluation, numerical modelling

- Evaluate the capabilities and limitations of the modelling framework for biocementation with ex-situ hydrolysis.

A new performed large-scale experiment can be evaluated using the results from the two previous steps. Numerical models from previous experiments (2D & 3D) and the experimental measurements will be available. Based on the results the performance of the modelling framework can be assessed, creating an overview of its capabilities and limitations.

Deliverables

- Report

The student will have to prepare a technical report containing the introduction and motivation for the project, the description of the accomplished work and related results as well as conclusions. The technical report will have to be prepared in an electronic format and send to the supervisor and the responsible of the project by the end of the semester.

- Final Presentation

The student will have to present his work during a presentation at the end of the semester. The day and the place of the presentation will be communicated to the student.

Planning

- Meetings and presentations

A weekly meeting (on Friday pm) with the assistant is suggested to discuss the progress of the project. One meeting per month will be organised with Prof. Laloui (dates will be communicated to the student).
During the meetings with the assistant, the student will have to present (i) the progress of the work, (ii) possible questions and remarks and (iii) a summary of the next steps for the project. During these meetings, the supervisors may vary the foreseen goals of the project, if necessary. The student will have to prepare all the possible questions before the meeting in written form and a summary of each meeting for the next fixed meeting.

- **Electronic files**

At the end of the project, the student will have to send to the supervisors a folder containing a clear classification of all the electronic files developed during the project, including those related to the reports, obtained data, presentations, poster and graphs.

Grading

The final grade will be assigned considering the following proportions of contribution:

- Technical report 70%
- Oral presentation 30%

The evaluation will also consider the work methodology, discipline and resourcefulness of the student.

General rules of the project

The schedule of the project is defined by the EPFL Academic Calendar:
https://memento.epfl.ch/academic-calendar/?period=180

The student signature on the submitted report certifies that the work is original and developed by him/herself. This work is property of the EPFL and cannot be disseminated without the approval of the considered Institution.

Contacts

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